Preliminary assessment of the potential of aquifer storage and recovery – Cheltenham Racecourse

PIRSA RB 2000/00029

by

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Department for
Water Resources

PRIMARY INDUSTRIES AND RESOURCES SOUTH AUSTRALIA

REPORT BOOK 2000/00029

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PRELIMINARY ASSESSMENT OF THE POTENTIAL OF AQUIFER STORAGE AND RECOVERY – CHELTENHAM RACECOURSE

X. Sibenaler and N.Z. Gerges

INTRODUCTION

The Groundwater Program of the Department for Water Resources (DWR – previously with PIRSA) was engaged by the Torrens Catchment Water Management Board to assess the aquifer storage and recovery (ASR) potential at the Cheltenham Racecourse, using wetland treated stormwater run off (Fig. 1).

This assessment was based on evaluating the hydraulic properties of the aquifer, at the site, by testing the nearby existing St Clair well. This well, completed as an open hole, penetrates the full sequence of the T–1 aquifer. Given that the aquifer is homogenous and continuous over the Adelaide metropolitan area, the aquifer properties derived from those tests should be indicative of those at the Cheltenham Racecourse.

The St Clair well was subsequently discharge tested by DWR Groundwater Technical Services on the 23rd February, 2000. Due to oval watering requirements the well was not available for the injection component of the testing until the 10 May, 2000.

HYDROGEOLOGICAL SETTING

The Cheltenham Race Course is located within the Adelaide Embayment, which is a section of the St Vincent Basin. The area is underlain by a thick sequence of sedimentary deposits of Quaternary and Tertiary age, which in turn overlays Precambrian basement (Fig. 2).

The area of concern contains five to six Quaternary aquifers and also three to four, almost flat lying, Tertiary aquifers. The first and second Tertiary aquifers are the thickest and the most productive, with relatively low salinity. The greatest proportion of abstracted groundwater for industrial and recreational use comes from the first Tertiary aquifer.

At present there are no production wells situated within the racecourse. The nearest well to the racecourse is located in the St Clair Oval (6628 13368). This well, located along the boundary of the racecourse, is completed in the lower part of the First Tertiary aquifer.

QUATERNARY AQUIFERS

The main lithology of the Quaternary sediments is mottled clay and silt with interbedded sand, gravel and thin sandstone. The sands, gravels and sandstones represent aquifers. Up to six thin aquifer zones can be recognised over most of the region from drill log and geophysical log interpretation. These are designated Q1 to Q6 in order of increasing depth.

The numerous Quaternary aquifers occur at depths ranging from 5 m to 100 m below ground. Groundwater salinities vary from 2000 to 5000 mg/L and an average yield of 150 m^3/day/well (1.7 L/sec) is anticipated. These Quaternary aquifers vary greatly in thickness (from 1 m to 18 m), lithology and permeability.

The majority of the Quaternary aquifers are thin and insignificant and are not usually used for commercial irrigation because of low yields and high salinities.

TERTIARY AQUIFERS

The Tertiary sediments contain several aquifer systems, each of which may comprise various sub-aquifers.

Groundwater occurs mainly in four, mostly confined aquifers, designated T1, T2, T3 and T4 in order of increasing depth.

The First Tertiary aquifer

The First Tertiary aquifer (T1 aquifer) generally lies 100 m below ground. This aquifer has a water salinity ranging between 1500 to 2000 mg/L. Standing water level ranges between 12–20 m below ground. Supply averages 1500 m^3/day/well (17 L/sec).

The aquifer consists mainly of two subaquifers: Hallett Cove Sandstone/Dry Creek Sand (Subaquifer T1A) and the Upper Port Willunga Limestone (subaquifer T1B).

The two subaquifers are separated by the Croydon Facies, which acts as a semi-confining bed.

Subaquifer T1B has the potential for large yields of sand free water, while the highly permeable subaquifer T1A requires intensive development for sediment free yields.

The confining bed between T1 and T2 aquifers

The Munno Para Clay Member consists of 6–8 m of dark grey clay interbedded with two bands of pale grey limestone. Laboratory testing of cores taken from the clay in several locations suggests that the clay is of very low permeability. Recent drilling at several locations in the Adelaide Plains shows a variation in vertical permeability, ranging between 10^{-6} and 10^{-7} m/day (Gerges, 1997).

The Second Tertiary Aquifer

The Second Tertiary aquifer lies at a depth of some 200 m below ground with salinities higher than to those of the First Tertiary aquifer. Standing water level is expected to be 2–4 m below ground.

The Third/Fourth Tertiary

The Third/Fourth Tertiary aquifer lies at approximately 500 m below ground and contains groundwater of high salinity (over 70 000 mg/L).

TARGET AQUIFERS FOR ASR OF STORMWATER RUNOFF

RECHARGE POTENTIAL TO THE QUATERNARY AQUIFERS

In terms of depth considerations and well design, the Quaternary aquifer appears the most practical. However, in the area underlying the race course, it is unlikely that large scale artificial recharge and recovery operations can be sustained as most of the aquifers are thin and will not store large amounts of water, except in certain areas.

Additionally, most of these aquifers generally have low permeability, exacerbated by high standing water levels during winter. It is expected that in most cases, aquifers will accept only 100–170 m^3/day/well (1–2 L/sec).

RECHARGE POTENTIAL TO THE TERTIARY AQUIFERS

The Tertiary aquifer system, and particularly limestone in the upper Port Willunga Formation (T1 aquifer) and also the second Tertiary aquifer (T2 aquifer) provides an excellent target for aquifer storage and recovery. Aquifer parameters, thickness and method of well completions (open hole) are favourable.

The first Tertiary aquifer contains several sand layers hence more complex well completions will be required. Open completion is possible only in the bottom 20–25 m of the aquifer.

Although a greater recharge efficiency is possible with complex well completion methods, which require the use of a combination of well screening and open hole methods, this approach is not recommended at this stage.

Information on the Second Tertiary aquifer indicates the suitability of this aquifer for artificial recharge as the aquifer consists of approximately 110 metres of moderately cemented limestone. However, the high standing water level of this aquifer will reduce recharge efficiency under natural drainage conditions and injection with positive head above ground will be required.

Salinity of this aquifer is expected to be higher than from the overlying First Tertiary aquifer.

The greater depth (approximately 450 metres) of the Third and Fourth Tertiary aquifers and their high groundwater salinity excludes them from any further consideration for aquifer storage and recovery at this stage.

Accordingly, the T1b limestone aquifer offers the best prospect for ASR at this site.

One issue which has not been quantitatively addressed is the water quality aspect – although it is expected that stormwater (via the wetland) would improve the salinity of the aquifer water, pre-treatment may be required depending on the physical (eg turbidity) and chemical (eg heavy metals, hydrocarbons etc) quality of stormwater.

SUMMARY OF THE SITE INVESTIGATION

The recommended work program was designed to:

- Assess the well efficiency of the bore by undertaking a step drawdown test
- Determine indicative properties of the aquifer (transmissivity discharge boundaries, degree of confinement) by undertaking a constant discharge test of relatively short duration
- Assess the injection capacity of the well by undertaking a step injection test. As source water (wetland treated stormwater) was not available, mains water was used.

A three stage step discharge test of six hours duration at discharge rate of 3 L/sec (1 hour), 6 L/sec (1 hour) and 9.5 L/sec (4 hours) was accordingly carried out on 23 February 2000. Given that the testing of the St Clair well was designed to provide indicative aquifer properties, the recommended constant discharge test was carried out as part of the third stage of the step test. This resulted in significant cost savings without compromising the objectives of the test. The maximum drawdown after the six hours of pumping was some 34 metres.

This was followed on 24 February 2000 by a three stage step injection test, using mains water, at rates of 1 L/sec (for 100 minutes), 2 L/sec (100 minutes) and 3 L/sec (160 minutes). As the well is equipped, injection was through the pump, limiting the rate to a maximum of 3 L/sec resulting in a rise of 10.8 m after six hours.

After two days residence time, the well was pumped for irrigation purposes and the water salinity monitored to provide indicative estimate of recovery efficiency.

It was considered prudent to repeat the irrigation test at a higher rate, which required removing the pump in the well.

Using mains water, a three stage step injection test was subsequently carried out on 10 May 2000 (when the well was temporarily not required for oval watering), at rates of 3 L/sec (60 minutes), 6 L/sec (60 minutes) and 9 L/sec (240 minutes).

WELL TESTING RESULTS

WELL EQUATIONS

The general well equation to the drawdown/build-up in a discharging/injection well is described by the function, s(t),

$$s(t) = [aQ + cQ^2] + bQ\log(t) \qquad (1)$$

where
s(t) is the drawdown or rise, (m)
t time, (minutes)
Q pumping/injection rate, (m^3/min)
a is linear well loss
b is aquifer loss
c is non linear well loss due to turbulent flow

Well equation for discharge

Based on the data from the step drawdown test carried out on 23 February 2000 (Appendix 1), the following well drawdown equation was derived (Fig. 3):

$$S = 45.4\,Q + 3.8\,Q\log_{10}t + 8.8\,Q^2 \qquad (1)$$

The reliability of the equation to relate drawdowns at various pumping rates and periods can be qualified by comparing observed drawdowns with drawdowns calculated using the above equation.

eg for Q = 9.5 L/sec, t = 360 minutes
s observed = 38 m
s calculated = 34 m

The well drawdown equation is therefore useful to predict the performance of the well for pumping periods envisaged for parkland irrigation.

This type of equation represents the base line condition of the well and is useful in monitoring any clogging and in assessing the effectiveness of well rehabilitation.

The well efficiency can also be estimated by the following equation:

$$\text{Pumping Well Efficiency} = \frac{bQ \log_{10}t \times 100\%}{aQ + bQ \log_{10}t + cQ^2}$$

eg for Q = 9.5 L/sec = 0.57 m^3/minutes
t = 100 minutes
WE = 13%

Well Injection Equation

a) Based on the injection test carried out on 24 February 2000 (Appendix 1, Fig. 4)

$$S = 37.6Q + 9.3Q \log_{10}t + 2.9Q^2 \qquad (2)$$

Reliability of equation:

For Q = 9 L/sec, t = 360 minutes
Rise in water level s observed (*) = 43 m
s calculated = 34 m

(*) water level rise observed in injection test carried out on 10th February, 2000.

The above equation therefore significantly underestimates the rise in water level at injection rates greater than the above test rate (3 L/sec). This suggests that the non-linear well loss component has not reliably been calculated.

Based on the injection test carried out on 10 May, 2000 Appendix 1, Fig. 5) at higher rate and with pump removed.

$$S = 55.0Q + 8.6Q \log_{10}t + 5.4Q^2 \qquad (3)$$

Reliability of equation:

For Q = 9 L/sec, t = 360 minutes
Rise in water level s observed = 43 m
s calculated = 43 m

Comparing equations 1 and 3, the aquifer loss component and, to a lesser extent, the linear well loss component for the injection are significantly greater than for the drawdown cycle.

eg for Q = 9 L/sec, t = 360 minutes
s drawdown = 34 m
s injection = 43 m

ie, injection is 75% as efficient as pumping

This could be due to temperature difference between the injection water and native groundwater and possibly air entrapment.

AQUIFER TRANSMISSIVITY

a) based on step drawdown test, T = 75 m^2 /d/m

b) based on step injection carried out on 24 February 2000
T = 30 m^2 /d/m

c) based on step injection carried out on 10 May, 2000
T = 30 m^2 /d/m

RECOVERY EFFICIENCY

Based on the very limited residence time (2 days), up to 200% of the injected volume could be pumped until the salinity level of the original groundwater is reached (Appendix 2).

Although the recovery efficiency will decrease with increasing residence time, a recovery efficiency of at least 150% can be expected.

POTENTIAL WELL RECHARGE RATES

Whilst the assessment of the ASR potential is based on testing of the St Clair well, it is considered that the results would generally apply to a (proposed) well near the wetland, given the homogenous nature of the aquifer.

GRAVITY DRAINAGE RATE

It is assumed that aquifer storage would be carried out over some 100 days during the winter months.

Given a depth to water of 21 m and using equation (3), a gravity drainage rate of 4.6 L/sec can be sustained, with mains water, assuming no clogging of the aquifer.

Based on our ASR experience elsewhere, in similar conditions, injection with wetland water could be 60% as efficient as injection with mains water.

A sustainable gravity drainage rate of 2.5–3 L/sec is therefore considered to be more realistic for wetland treated water.

OPTIMUM INJECTION RATE

The optimum recommended injection head above ground level is 60 m. With the standing water level in the T1b sub-aquifer in the area of about 21 m, the available injection head is therefore some 80 m.

Based on the injection equation, the sustainable injection rate, assuming no clogging, is therefore of the order of 15 L/sec, with mains water. In estimating the sustainable recharge rate, it was assumed that clogging is not a factor. In fact, experience in similar conditions suggests that the recharge performance of the well will deteriorate steadily to a point where the well will require developing after 1–2 weeks of injection. This is easily effected by pumping to scour the well for about half an hour.

As flagged above, the efficiency of injection with wetland water is expected to be of the order of 60% of the mains water efficiency. An injection rate of 9–10 L/sec from 100 day irrigation periods is therefore considered to be more realistic.

The efficiency of injection rate may however be increased by up to 40%, using aquifer acid treatment, similar to the process at Salisbury Paddocks well.

In the above calculations only the properties of the aquifer and the well were taken into account.

CONCLUSION

The Quaternary aquifers are thin and insignificant for the scale of ASR operation envisaged.

The target for extraction is therefore the T1 and T2 aquifers within the Tertiary aquifer system. Both the T1 and T2 aquifers are stable and there is potential for large yields of sand-free water with open hole completion.

The aquifer investigated at St Clair Oval (T sub-aquifer) is homogenous and continuous over the Adelaide Metropolitan area including Cheltenham Race Course. Therefore, the hydraulic information obtained from testing the St Clair well should be applicable to a well near the proposed wetland.

Based on the results of the pumping and injection tests on the St Clair well, and allowing for the anticipated reduced efficiency of injection with wetland water, an ASR well completed in the T1 aquifer in the Cheltenham Racecourse area should be able to sustain over 100 day cycles:

- a gravity drainage rate of 2.5–3 L/sec
- an injection rate of 9–10 L/sec against a head of 80 m, assuming no clogging
- a pumping rate of 10–12 L/sec

Acidisation of the well will significantly improve the injection efficiency and should be considered.

Based on previous experience in similar conditions, it is anticipated that the well recharge rate will decrease with time due to clogging. Pump development/back flushing will possibly be required on a weekly basis. It is therefore recommended that the well be completed as a dual recharge/production well and equipped accordingly.

Figures

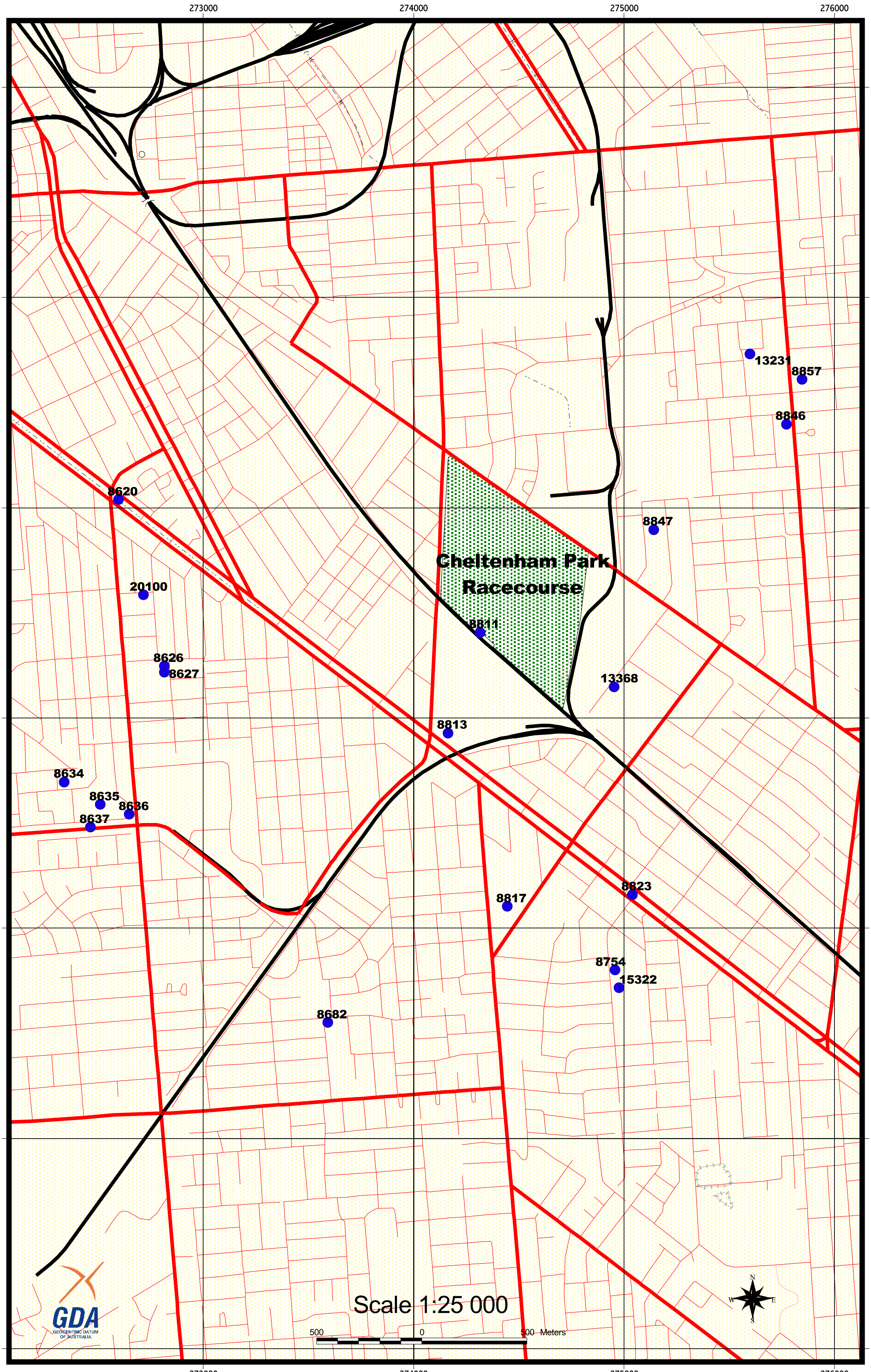


figure 1 **Bore Location Plan - Tertiary Aquifer - Cheltenham Park Rececourse**

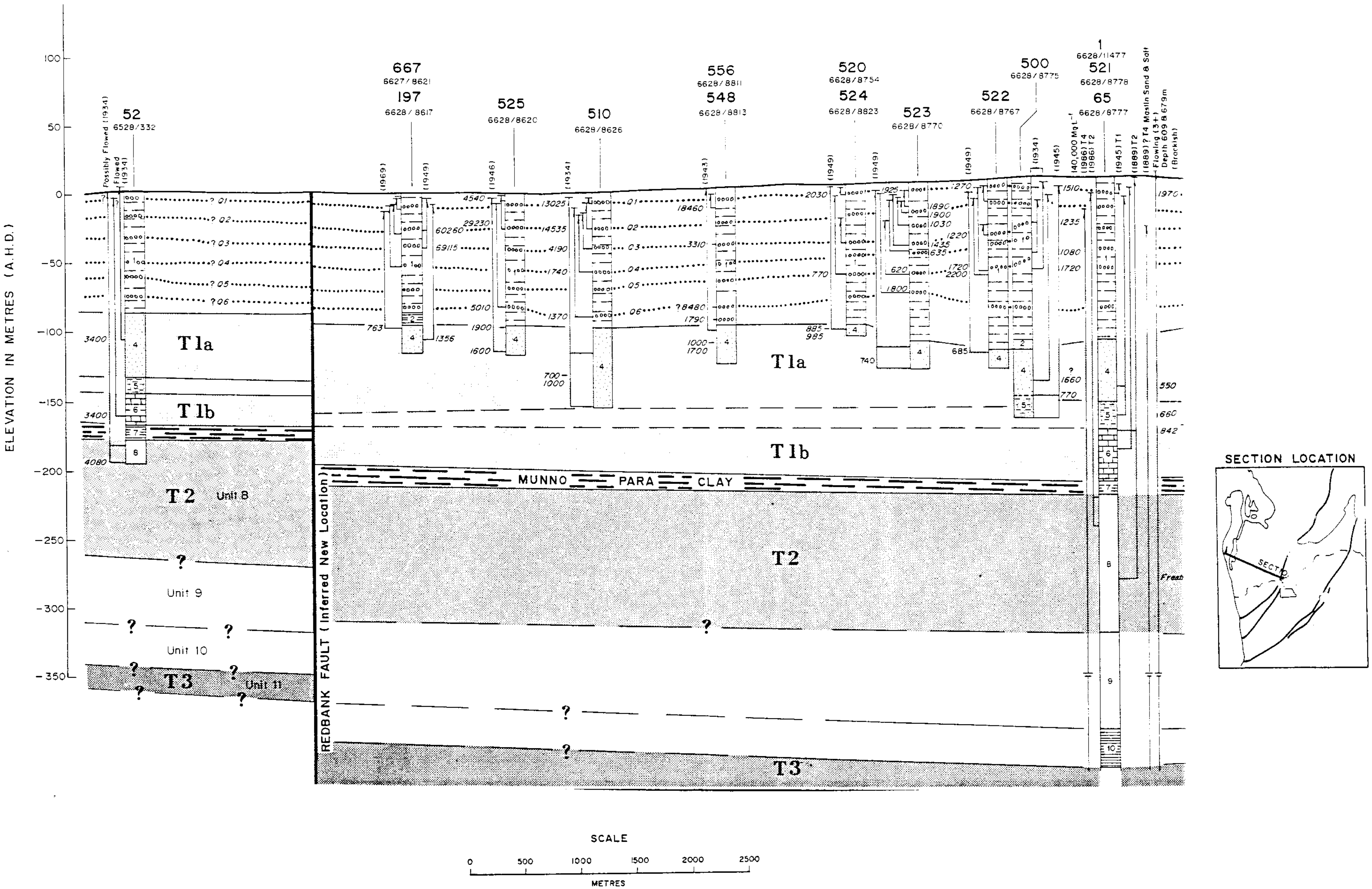
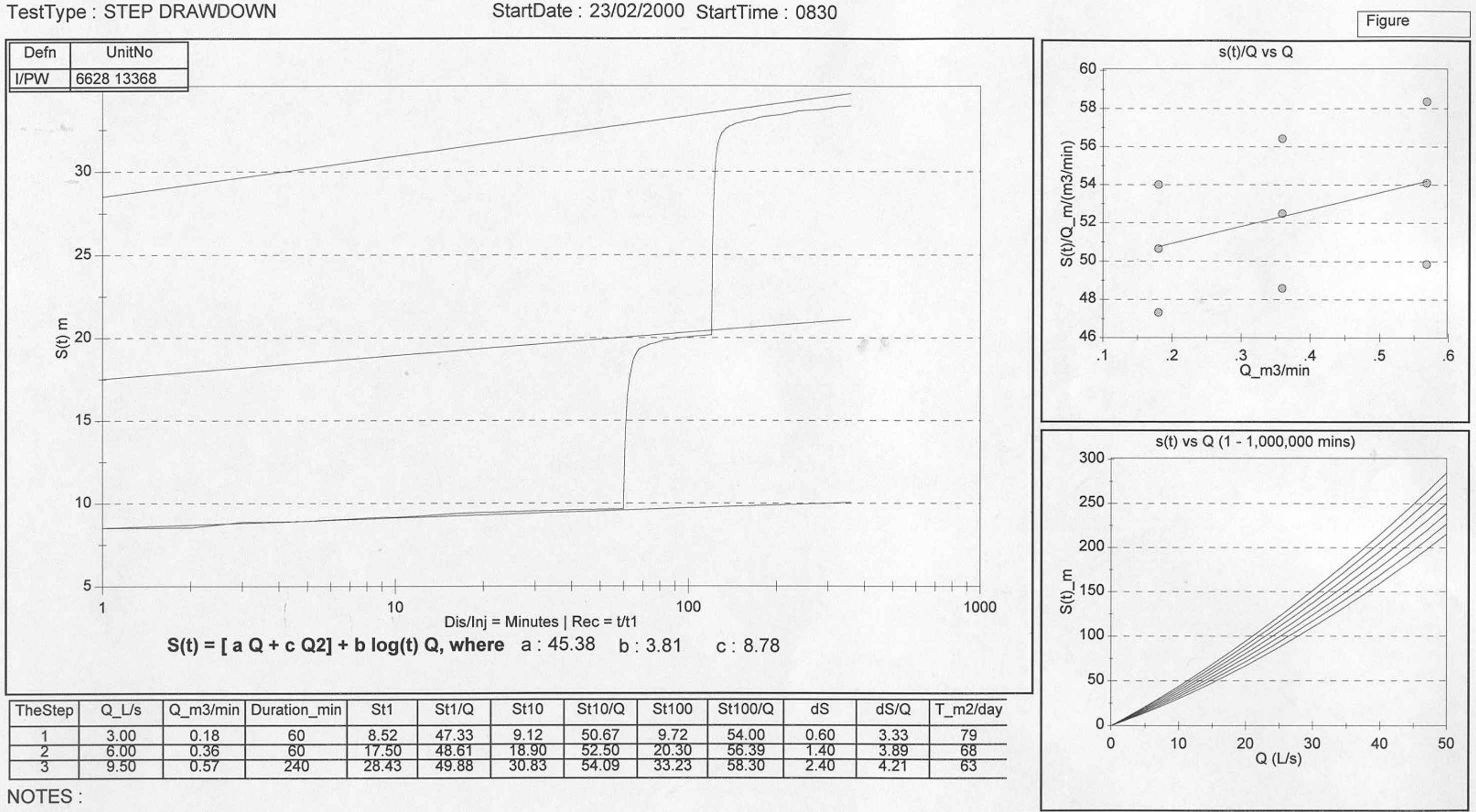


Figure 2 Geological and hydrogeological section

INDEXX : 3027 Project : ST. CLAIR, CHARLES STURT

TestType : STEP DRAWDOWN StartDate : 23/02/2000 StartTime : 0830



TheStep	Q_L/s	Q_m3/min	Duration_min	St1	St1/Q	St10	St10/Q	St100	St100/Q	dS	dS/Q	T_m2/day
1	3.00	0.18	60	8.52	47.33	9.12	50.67	9.72	54.00	0.60	3.33	79
2	6.00	0.36	60	17.50	48.61	18.90	52.50	20.30	56.39	1.40	3.89	68
3	9.50	0.57	240	28.43	49.88	30.83	54.09	33.23	58.30	2.40	4.21	63

NOTES :

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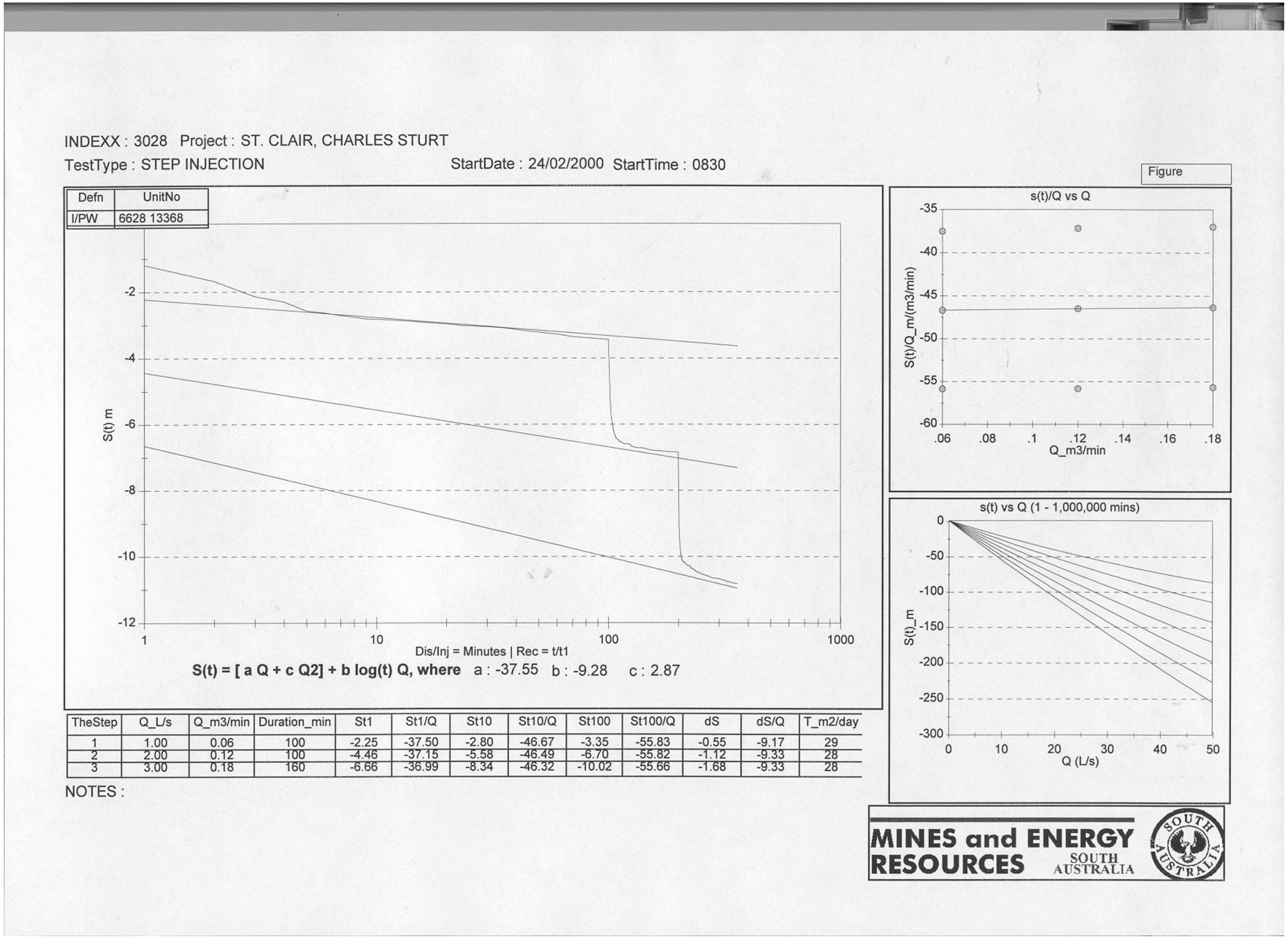
Figure 3 *Step drawdown test result 23/02/2000*


INDEXX : 3028 Project : ST. CLAIR, CHARLES STURT

TestType : STEP INJECTION StartDate : 24/02/2000 StartTime : 0830

Defn	UnitNo
I/PW	6628 13368

S(t) = [a Q + c Q2] + b log(t) Q, where a : -37.55 b : -9.28 c : 2.87

TheStep	Q_L/s	Q_m3/min	Duration_min	St1	St1/Q	St10	St10/Q	St100	St100/Q	dS	dS/Q	T_m2/day
1	1.00	0.06	100	-2.25	-37.50	-2.80	-46.67	-3.35	-55.83	-0.55	-9.17	29
2	2.00	0.12	100	-4.46	-37.15	-5.58	-46.49	-6.70	-55.82	-1.12	-9.33	28
3	3.00	0.18	160	-6.66	-36.99	-8.34	-46.32	-10.02	-55.66	-1.68	-9.33	28

NOTES :

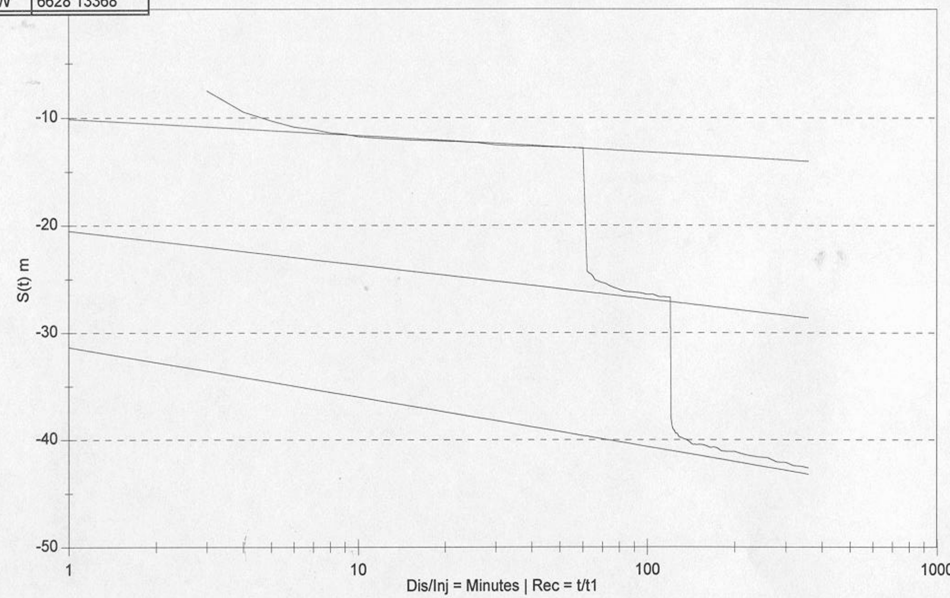
Figure 4 *First step injection test results 24/02/2000*

INDEXX : 3026 Project : ST. CLAIR, CHARLES STURT

TestType : STEP INJECTION StartDate : 10/05/2000 StartTime : 0830

Figure

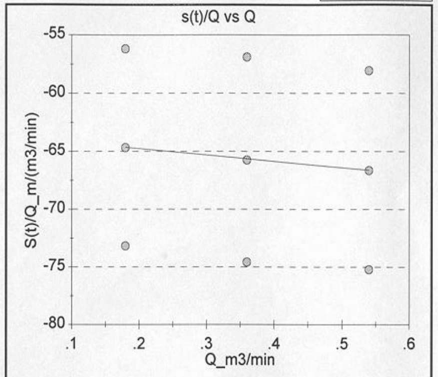
Defn	UnitNo
I/PW	6628 13368



S(t) = [a Q + c Q2] + b log(t) Q, where a : -55.04 b : -8.64 c : -5.44

TheStep	Q_L/s	Q_m3/min	Duration_min	St1	St1/Q	St10	St10/Q	St100	St100/Q	dS	dS/Q	T_m2/day
1	3.00	0.18	60	-10.11	-56.17	-11.64	-64.67	-13.17	-73.17	-1.53	-8.50	31
2	6.00	0.36	60	-20.48	-56.89	-23.66	-65.73	-26.84	-74.56	-3.18	-8.83	30
3	9.00	0.54	240	-31.35	-58.05	-35.98	-66.63	-40.61	-75.20	-4.63	-8.57	31

NOTES :



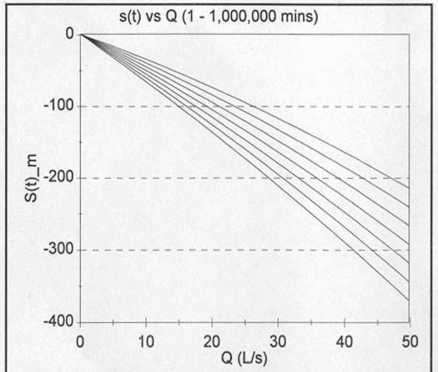


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Figure 5 *Second step injection test results 10/05/2000*

Appendix 1

Step drawdown test results	23-02-2000
Step injection test results	24-02-2000
Step injection test results	10-05-2000

ANNEX 2

DRAWDOWN SHEET

Sheet No. **1 of 4**

Measured Well	Owner	Well No.
	Address	Site
Pumped Well	Owner Charles Sturt Council	Well No.
	Address St Clair	Site
Test Details	Date pumping commenced……23-2-00…….... time…8:30………am Date pumping ceased………………………………..time……………….. am/pm	Test No. Steps
Are the measurements below for the pumped well? Yes	Distance from the pumped well………………………………m	
Standing water level ………20.98……..m below/above measuring pt. Or Static pressure	Measuring point ~~below~~ / above ground level……0.15……. m	

Watch Time			**ELAPSED** TIME min.	DRAWDOWN metres	**WATER LEVEL PRESSURE** metres	DISCHARGE		REMARKS etc
h	Min	am pm				**Piezometer** mm	L/s	
8	30	am	0	0	20.98			
			1	8.52	29.50		3	259.2
			2	8.53	29.51			
			3	8.88	29.86			
			4	8.89	29.87			
			5	8.93	29.91			
			6	9.02	30.00		3	
			7	9.07	30.05			
			8	9.12	30.10			
			9	9.16	30.14			
			10	9.17	30.15			
			12	9.23	30.21			
			14	9.32	30.30			
99			16	9.38	30.36		3	
			18	9.42	30.4			
			20	9.45	30.43			
			22	9.47	30.45			
			24	9.49	30.47			
			26	9.50	30.48			
			28	9.52	30.50			
			30	9.53	30.51			
			35	9.56	30.54			
			40	9.60	30.58			

ANNEX 2

DRAWDOWN SHEET

Sheet No. **2 of 4**

Watch Time			**ELAPSED** TIME min.	DRAWDOWN metres	**WATER LEVEL PRESSURE** metres	DISCHARGE		REMARKS etc
h	Min	am pm				**Piezometer** mm	L/s	
			45	9.62	30.60		3	
			50	9.63	30.61			
			55	9.64	30.62			
9	30		60	9.66	30.64		3	
			61	14.27	35.25		6	518.4
			62	16.52	37.5			
			63	17.52	38.5			
			64	18.17	39.15			
			65	18.67	39.65			
			66	18.93	39.91			
			67	19.14	40.12			
			68	19.27	40.25			
			69	19.35	40.33			
			70	19.4	40.38		6	
			72	19.48	40.46			
			74	19.57	40.55			
			76	19.62	40.60			
			78	19.67	40.65			
			80	19.74	40.72		6	
			82	19.79	40.77			
			84	19.84	40.82			
			86	19.87	40.85			
			88	19.87	40.85			
			90	19.91	40.89		6	
			95	19.97	40.95			
			100	20.02	41.00			
			105	20.05	41.03			
			110	20.08	41.06		6	
			115	20.11	41.09			
			120	20.13	41.11			
			121	25.51	46.49		9.5	820.8
			122	28.22	49.20			
			123	29.87	50.85			
			124	30.71	51.69			

ANNEX 2

DRAWDOWN SHEET Sheet No. **3 of 4**

Watch Time			**ELAPSED** TIME min.	DRAWDOWN metres	**WATER LEVEL PRESSURE** Metres	DISCHARGE		REMARKS etc
h	Min	am pm				**Piezometer** mm	L/s	
			125	31.18	52.16		9.5	
			126	31.56	52.54			
			127	31.74	52.72			
			128	31.97	52.95		9.5	
			129	32.07	53.05			
			130	32.21	53.19			
			132	32.33	53.31			
			134	32.47	53.45			
			136	32.53	53.51		9.5	
			138	32.61	53.59			
			140	32.66	53.64			
			142	32.70	53.68			
			144	32.76	53.74			
			146	32.79	53.77			
			148	32.81	53.79			
			150	32.83	53.81			
			155	32.91	53.89			
			160	32.95	53.93		9.5	
			165	32.98	53.96			
			170	33.07	54.05			
			175	33.13	54.11			
			180	33.17	54.15		9.5	
			190	33.23	54.21			
			200	33.27	54.25			
			210	33.32	54.30			
			220	33.39	54.37		9.5	
			240	33.53	54.51			
			260	33.57	54.55		9.5	
			280	33.6	54.58			
13	30		300	33.67	54.65		9.5	
			320	33.77	54.75			
			340	33.8	54.78		9.5	
14	30		360	33.84	54.82			
						TOTAL PUMPED 169 340 L		

Department of Mines and Energy

South Australia

Well No: 6628–13368
PRODUCTION/OBSERVATION

D = A + B + C
D = calculated head above SWL (-ve value)
A = depth to water level below TOC
C = actual water level below TOC

WATER WELL INJECTION TEST

PROJECT/OWNER………Charles Sturt Council, St Clair Bore……………………………………………..	
HUNDRED AND SECTION:	INJECTION STARTED AT…8:30 am……
WELL OPEN/SLOTTED/SCREENED	ON…24-2-00…………
FROM……………….TO……………..(m)	INJECTION STOPPED AT…………
TOP OF CASING (TOC)	ON……………..
ABOVE GL ……0.15………….(m)	MAINS PRESSURES STARTED AT…….
WATER LEVEL BELOW TOC AT START	ON ……………
……20.85……….(m)	SALINITY ON MAINS STARTED AT …..
INJECTION LINE SETTING BELOW TOC	ON ……………
………80…….(m)	

Time	**B**	**C** W/L	**D**	**DISCHARGE**			**Mains h (m)**	**Mains press.**	
	(m)	(m)	(m)	Meter Readings	Difference	Rate in L/sec			Remarks
0		20.85		0					
1		19.62	1.23			1			
2		19.14	1.71						
3		18.68	2.17						
4		18.52	2.33						
5		18.25	2.6						
6		18.19	2.66						
7		18.11	2.74						
8		18.06	2.79						
9		18.01	2.84						
10		18.00	2.85			1			
12		17.97	2.88						
14		17.94	2.91						
16		17.91	2.94						
18		17.88	2.97						
20		17.86	2.99			1			
22		17.83	3.02						
24		17.80	3.05						
26		17.80	3.05						
28		17.78	3.07			1			
30		17.77	3.08	1796					
35		17.74	3.11						
40		17.69	3.16			1			
45		17.64	3.21						
50		17.61	3.24						
55		17.51	3.28						

60		17.55	3.31	3603		1			
70		17.47	3.38						
80		17.44	3.41						
90		17.41	3.44	5450		1			
100		17.39	3.46	6055					
101		16.37	3.48			2			
102		15.51	5.34						
103		15.05	5.80						
104		14.84	6.01						
105		14.70	6.15						
106		14.58	6.27						
107		14.49	6.36						
108		14.42	6.43						
109		14.39	6.46						
110		14.38	6.47			2			
112		14.31	6.54						
114		14.30	6.55						
116		14.26	6.59						
118		14.24	6.61						
120		14.24	6.61			2			
122		14.24	6.61						
124		14.22	6.63						
126		14.17	6.68						
128		14.16	6.69						
130		14.14	6.71	9675		2			
135		14.12	6.73						
140		14.12	6.73						
145		14.10	6.75						
150		14.06	6.79			2			
155		14.05	6.80						
160		14.04	6.81	13 266					
170		14.03	6.82						
180		14.01	6.84						
190		14.00	6.85						
200		13.99	6.86						
201		12.52	8.33	18 062					
202		11.75	9.10						
203		11.37	9.48						
204		11.12	9.73						
205		10.95	9.90						
206		10.87	9.98						
207		10.78	10.07						
208		10.74	10.11						
209		10.73	10.12						
210		10.70	10.15						
212		10.68	10.17						
214		10.65	10.20						
2146		10.64	10.21						
218		10.59	10.26						
220		10.58	10.27						
222		10.57	10.28						
224		10.56	10.29						

226		10.55	10.30						
228		10.50	10.35						
230		10.48	10.37						
235		10.45	10.40	23 411					
240		10.39	10.46						
245		10.37	10.48						
250		10.34	10.51						
255		10.31	10.54						
260		10.29	10.56						
270		10.26	10.59	28 852					
280		10.21	10.64						
290		10.20	10.65						
300		10.18	10.67						
320		10.12	10.73	35 990					
340		10.07	10.78						
360		10.03	10.82	46 743					

Amount	injected during test	46 743 L
	injected during set up	<u>10 000 L</u>
TOTAL		<u>56 743 L</u>

Department of Mines and Energy
South Australia

Well No:…6628–13368..
PRODUCTION/OBSERVATION

D = A + B + C
D = calculated head above SWL (-ve value)
A = depth to water level below TOC
C = actual water level below TOC

WATER WELL INJECTION TEST

PROJECT/OWNER……………Charles Sturt Council - St Clair Bore…………..	
HUNDRED AND SECTION:	INJECTION STARTED AT…8:30……
WELL OPEN/SLOTTED/SCREENED	ON……………
FROM……………….TO……………..(m)	INJECTION STOPPED AT…………
TOP OF CASING (TOC)	ON……………..
ABOVE GL ……………0….(m)	MAINS PRESSURES STARTED AT…….
WATER LEVEL BELOW TOC AT START	ON ……………
……18.45……….(m)	SALINITY ON MAINS STARTED AT …...
INJECTION LINE SETTING BELOW TOC	ON ……………
……25……….(m)	

Time	**B**	**C**	**D**	**DISCHARGE**			**Mains h (m)**	**Mains press.**	
	(m)	(m)	(m)	Meter Readings	Difference	Rate in L/sec			Remarks
0	18.45		0						
1	13.91		4.54			3			
2									
3	10.93		7.52						
4	9.0		9.45						
5	8.17		10.28						
6	7.62		10.83						
7	7.38		11.07						
8	7.07		11.38						
9	6.95		11.50			3			
10	6.7		11.75						
12	6.53		11.92						
14	6.45		12.00						
16	6.36		12.09						
18	6.33		12.12						
20	6.27		12.18			3			
22	6.23		12.22						
24	6.18		12.27						
26	6.12		12.33						
28	6.02		12.43						
30	5.92		12.53			3			
35	5.84		12.61						
40	5.8		12.65			3			
45	5.73		12.72						
50	5.71		12.74			3			
55	5.66		12.79						
60	5.64		12.81						

61	0		18.45						
62		5.81	24.26			6			
63		5.99	24.44						
64		6.06	24.51						
65		6.28	24.73						
66		6.59	25.04						
67		6.68	25.13						
68		6.76	25.21						
69		6.82	25.27						
70		6.87	25.32			6			
72		6.95	25.40						
74		7.15	25.60						
76		7.29	25.74						
78		7.39	25.84						
80		7.48	25.93			6			
82		7.59	26.04						
84		7.68	26.13						
86		7.71	26.16						
88		7.73	26.18						
90		7.76	26.21			6			
95		7.82	26.27						
100		7.96	26.41						
105		7.96	26.41						
110		8.19	26.64			6			
115		8.19	26.64						
120		8.23	26.68						
121		19.6	38.05			9			
122		20.32	38.77						
123		20.58	39.03						
124		20.67	39.12						
125		20.88	39.33						
126		20.93	39.38						
127		20.97	39.42						
128		20.14	39.59						
129		21.25	39.70						
130		21.32	39.77			9			
132		21.35	39.80						
134		21.46	39.91						
136		21.5	39.95						
138		21.63	40.08						
140		21.73	40.18			9			
142		21.9	40.35						
144		21.99	40.44						
146		21.95	40.40						
148		22.00	40.45						
150		21.97	40.42			9			
155		21.98	40.43						
160		22.10	40.55						
165		22.26	40.71						
170		22.22	40.67			9			
175		22.31	40.76						
180		22.58	41.03			9			
190		22.62	41.07						

200		22.63	41.08			9			
210		22.81	41.26			9			
220		22.94	41.39						
240		23.12	41.57						
260		23.19	41.64						
280		23.60	42.05						
300		23.62	42.07			9			
320		23.95	42.40						
340		24.00	42.45						
360		24.15	42.60						

TOTAL AMOUNT INJECTED: 162 711 L

Appendix 2

Ambient groundwater salinity

Salinity of injected mains water

Salinity of recovered water

Well name: St Clair Bore

Well Unit No: 6628–13368

Depth of pump: 80 metres

Ambient Groundwater Salinity

Sampling Time (minutes after start of pumping)	E.C. Units	T.D.S. (mg/L)
Start	4070	2267
60	3170	1759
120	3710	2064
180	2880	1597
240	2850	1580
300	2820	1564
360	2820	1564

Salinity of injected mains water

Volume Injected: 567.43 litres
Conductivity: 680 E.C. units
Salinity: 374 mg/L

Salinity of recovered water

(after the injection of 56.7 kilolitres of mains water with salinity of 374 mg/L, and residence time of 2 days)

Sampling Time (minutes after start)	Volume of water recovered (kL)	% of Volume Injected	Salinity mg/L
10	4.8	8	611
20	9.6		550
30	14.4		699
40	19.2		600
50	24.0		589
80	38.4		705
100	48.0	85	832
120	57.6		1027
140	67.2		1205
160	76.8		1334
180	86.4		1390
210	100.8	203	1463
240	115.2		1496
270	129.6	228	1519