# **TECHNICAL REPORT** SOUTH EAST TOWN WATER SUPPLIES –

GERANIUM, BORDERTOWN AND PENOLA

2011/24

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**Government of South Australia** 

Department for Water

## SOUTH EAST TOWN WATER SUPPLIES— GERANIUM, BORDERTOWN AND PENOLA

**Paul Magarey and Scott Slater** 

Science, Monitoring and Information Division Department for Water

September, 2011

Technical Report DFW 2011/24

#### Science, Monitoring and Information Division

Department for Water							
25 Grenfell St	25 Grenfell Street, Adelaide						
GPO Box 283	4, Adelaide SA 5001						
Telephone	National (08) 8463 6946						
	International	+61 8 8463 6946					
Fax	National	(08) 8463 6999					
	International	+61 8 8463 6999					
Website	www.waterforgood.sa.gov.au						

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## FOREWORD

South Australia's Department for Water leads the management of our most valuable resource—water.

Water is fundamental to our health, our way of life and our environment. It underpins growth in population and our economy—and these are critical to South Australia's future prosperity.

High quality science and monitoring of our State's natural water resources is central to the work that we do. This will ensure we have a better understanding of our surface and groundwater resources so that there is sustainable allocation of water between communities, industry and the environment.

Department for Water scientific and technical staff continue to expand their knowledge of our water resources through undertaking investigations, technical reviews and resource modelling.

Scott Ashby CHIEF EXECUTIVE DEPARTMENT FOR WATER

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## 1. INTRODUCTION

In 2010, the Department for Water (DFW) was engaged by the South Australian Water Corporation (SA Water) to drill and complete five production wells for the townships of Geranium, Bordertown and Penola in the South East of South Australia (Fig. 1). The work was undertaken as part of the SA Water Bore Replenishment Program.

The new wells were required to replace existing wells at each of the towns. One new well was completed at Geranium, three at Bordertown and one at Penola. In addition one well was backfilled at Penola and three at Bordertown.

Kangarilla Drilling, based in McLaren Vale, were contracted to drill and construct the new wells. Drilling commenced in March 2011 and was completed in June 2011. DFW Assets and Services (Walkley Heights) conducted pumping tests following completion of the wells at each site. A summary table of the drilling and pump testing program is provided in Table 1.

#### INTRODUCTION

Specification	Geranium TWS 3	Bordertown TWS 10	Bordertown TWS 11	Bordertown TWS 12	Penola TWS 7
Unit number	6927-991	7025-3875	7025-3876	7025-3877	7023-7201
Permit Number	200364	200365	200366	200368	199140
Easting	423732	470168	469754	469747	485907
Northing	6084307	5982885	5982541	5982502	5864335
GDA 94 Zone	54	54	54	54	54
Well completion date	3 March 2011	9 March 2011*	27 May 2011	19/5/2011	22 June 2011
Well completion depth	77 m BNS	40 m BNS	37 m BNS	37 m BNS	154 m BNS**
Casing length Casing type	50 m Class 12 PVC	18 m Class 12 PVC	25 m Class 12 PVC	25 m Class 12 PVC	140 m Class 12 PVC
Casing inner diameter	253 mm	253 mm	254 mm	254 mm	254 mm
Production zone	50-77 m BNS (open hole)	16-40 m BNS (203 mm slotted liner)	25-37 m BNS (open hole)	25-37 m BNS (open hole)	140.8-151.8 m BNS (stainless steel screen)
Depth to water	42.35 m BTOC	16.68 m BTOC	15.52 m BTOC	15.41 m BTOC	22.47 m BTOC
CRD test date	12 April 2011	9 Aug 2011^	3 June 2011	5 June 2011	13/8/2011
Discharge rate (CRD test)	15 L/s	30 L/s	30 L/s	20 L/s	30 L/s
Duration (CRD test)	300 min	300 min	300 mins (+ 60 min recovery)	300 min	360 min (+ 60 min recovery)
Well efficiency	11%	34%	4.3%	6.3%	9.6%
Pumping Rate	5 L/s	30 L/s	20 L/s	20 L/s	30 L/s
Minimum pump intake	50 m BNS	27 m BNS	28 m BNS	31 m BNS	43 m BNS
Available drawdown	6.5 m	10.32 m	13.5 m	13.5 m	19.5
Predicted drawdown after 1000,000 minutes	3.0 m	1.5 m	12 m	12 m	17 m

 Table 1.
 Well construction details, constant rate discharge test summary and recommended pump setting.

Note: Regional groundwater decline of 1 m has been deducted prior to calculation of available drawdown

CRD (constant rate discharge); BNS (below natural surface); BTOC (below top of casing)

\*Rehabilitated from 27-28 May 2011; ^Repeat test; \*\*Max depth 160 m but completed to 154 m.

<sup>#</sup>Includes interference of ~1m from Bordertown TWS 12; <sup>##</sup>Includes interference of ~1 m from Bordertown TWS 11

## 1.1. GERANIUM TOWN WATER SUPPLY

Geranium is located approximately 170 km east-south-east of Adelaide and is reliant on groundwater from sedimentary aquifers (Murray Group Limestone) for its town water supply needs. One new well (Geranium TWS 3) was drilled to replace existing well Geranium TWS 2. Details for the new well and existing wells are listed in Table 2 and the well locations are shown in Table 2. Groundwater salinity at Geranium TWS 2 is approximately 1270 mg/L.

Well name	Unit number	Depth (m)	Completion date	DTW (m)	DTW date
Geranium TWS 1	6927-337	73.15	Dec-1958	43.58	1-Dec-1958
Geranium TWS 2	6927-591	77.00	Mar-1969	42.00	23-Mar-1984
Geranium TWS 3	6927-991	77.00	Mar-2011	40.50	3-Mar-2011

Table 2. Geranium town water supply well details

## **1.2. BORDERTOWN TOWN WATER SUPPLY**

Bordertown is located approximately 270 km south-east of Adelaide and is reliant on groundwater from sedimentary aquifers (Tertiary Unconfined Limestone) for its town water supply needs. Bordertown was upgraded with three new production wells: Bordertown TWS 10, Bordertown TWS 11 and Bordertown TWS 12. The new production wells replaced existing wells Bordertown TWS 2, Bordertown TWS 7 and Bordertown TWS 5, which were backfilled on 28 June 2011. Details of the new and historic production wells are listed in Table 3 and locations are shown in Figure 3. Groundwater salinity in the Tertiary Limestone Aquifer is approximately 550 mg/L.

#### INTRODUCTION

Well name	Unit number	Depth (m)	Completion date	DTW (m)	DTW date
Bordertown TWS 1	7025-868	40.00*	4-Oct-1948	4.88	24-Sep-1948
Bordertown TWS 1A	7025-2354	183.34	15-Oct-1937	25.00	10-Mar-1981
Bordertown TWS 2	7025-813	40.00^	18-May-1954^	15.00	24-Sep-1986
Bordertown TWS 2A	7025-2367	47.24	27-Jun-1945	25.49	10-Mar-1981
Bordertown TWS 3	7025-808	45.72	2-Mar-1960	12.55	4-Aug-1986
Bordertown TWS 4	7025-867	25.91	18-May-1962	8.53	8-May-1962
Bordertown TWS 5	7025-864	76.20	19-May-1968	10.77	22-May-1968
Bordertown TWS 6	7025-865	36.58	2-Jun-1968	10.67	2-Jun-1968
Bordertown TWS 7	7025-863	36.60	14-Jun-1968	12.19	16-Jun-1968
Bordertown TWS 8	7025-2615	26.30	30-July-1982	9.35	30-Jul-1982
Bordertown TWS 9	7025-3222	45.00	18-Mar-1996	11.50	18-Mar-1996
Bordertown TWS 10	7025-3875	39.50	9-Mar-2011**	16.00	9-Mar-2011
Bordertown TWS 11	7025-3876	37.00	27-April-2011	22.00	27-April-2011
Bordertown TWS 12	7025-3877	37.00	19-April-2011	22.00	19-April-2011

Table 3. Bordertown town water supply well details

\*Well deepened from 22.5 m to 40.0 m in Oct-1980

^Well deepened from 22.86 to 40.0 m in Sep-1980

\*\*Well rehabilitated on 28 May 2011

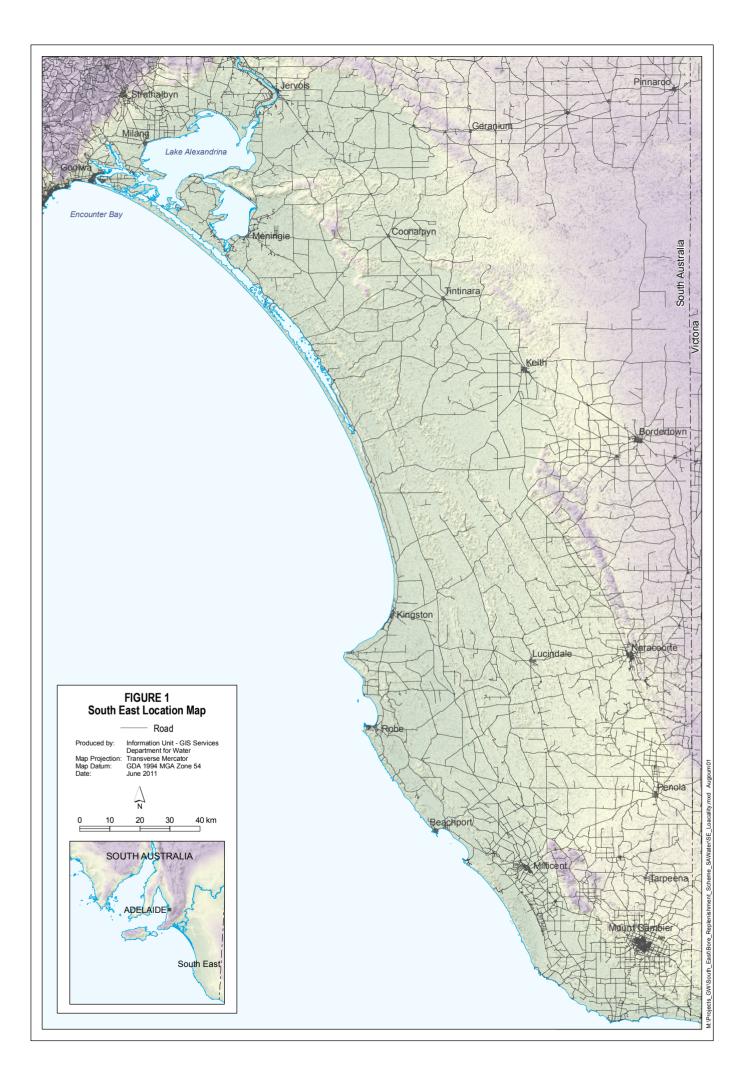
Note: Bordertown 2, 5 and 7 were backfilled on 28 June 2011.

### 1.3. PENOLA TOWN WATER SUPPLY

Penola is located 380 km south-east of Adelaide and is reliant on groundwater from the Tertiary Confined Sands Aquifer (Dilwyn Formation) and the Unconfined Tertiary Limestone Aquifer for its town water supply needs. One new well (Penola TWS 7) was drilled to replace existing well Penola TWS 4, which was backfilled. The well details for Penola TWS 7 are listed in Table 4, together with well information from historic production wells. Penola TWS 7 was drilled into the Dilwyn Formation which has a salinity of ~650 mg/L.

Table 4. Penola town water supply well details

Well name	Unit number	Depth (m)	Completion date	DTW (m)	DTW date
Penola TWS 1	7023-831	53.30	10-Mar-1954	4.27	10-Mar-1954
Penola TWS 2	7023-839	97.50	26-Jan-1967	4.27	26-Jan-1967
Penola TWS 3	7023-377	65.80	13-Apr-1962	-	-
Penola TWS 4	7023-3969	76.00	24-Oct-1984	3.29	10-Oct-1985
Penola TWS 5	7023-5280	75.00	15-Mar-1996	6.50	15-Mar-1996
Penola TWS 6	7023-6884	150.00	30-Jun-2008	8.53	29-Apr-2011
Penola TWS 7	7023-7201	153.80	22-June-2011	22.47	13-Aug-2011



## 2. WELL DESIGN AND CONSTRUCTION

The well designs for Geranium TWS 3, Bordertown TWS 10, Bordertown TWS 11 and Bordertown TWS 12 were identical to existing wells Geranium TWS 2, Bordertown TWS 2, Bordertown TWS 7 and Bordertown TWS 5, thus savings were made on materials, geophysics and standby time. Risk of poor yield was also reduced by completing over the same stratigraphic interval. The well design for Penola TWS 7 was tentatively based on well Penola TWS 6 (located ~500 m to the east), however the drillhole was geophysically logged prior to completion due to expected lithological variation in the Dilwyn Formation (Tertiary Confined Sands).

Final well positioning took the following into consideration:

- Whether the well needed to be located within the SA Water compound
- Proximity to power and the existing pipeline infrastructure
- Rig Access.

### 2.1. GERANIUM TWS 3 (UNIT NO. 6927-991)

Geranium TWS 3 was drilled as a production well under permit number 200364 and completed on 3 March 2011. The location of groundwater well infrastructure is provided in Figure 2, with the well construction diagram provided in Appendix A. The lithological logs and well completion reports are provided in Appendix B and C.

Geranium TWS 3 was mud drilled to a depth of 77 m, with strata samples collected at 2 m intervals. A 355 mm ID pre-collar was installed to 6 m, followed by 253 mm ID PVC casing to 50 m which was pressure cemented. A 248 mm diameter hole was then drilled to 77 m, with the completion interval left as open hole from 50-77 m below ground surface. The production casing extended 0.5 m above ground surface and was sealed with a flange plate. The driller indicated a water cut between 50-77 m, with a final depth to water of 40.5 m, an airlift yield of ~5 L/s, and salinity of 1513 mg/L TDS.



## 2.2. BORDERTOWN TWS 10 (UNIT NO. 7025-3875)

Bordertown TWS 10 was drilled as a production well under permit number 200365 and completed on 9 March 2011. The location of groundwater well infrastructure is provided in Figure 3, with the well construction diagram provided in Appendix A. The lithological logs and well completion reports are provided in Appendix B and C.

Bordertown TWS 10 was mud drilled to a depth of 40 m, with strata samples collected at 2 m intervals. A 355 mm ID pre-collar was installed to 5 m, followed by 253 mm ID Class 12 PVC casing to 18 m which was pressure cemented. A 248 mm diameter hole was then drilled to 40 m, with the completion interval left as open hole from 18-40 m below ground surface. The production casing extended 0.5 m above ground surface and was sealed with a flange plate. The driller indicated a water cut between 18-40 m, with a final depth to water of 16 m, an airlift yield of ~4 L/s, and salinity of 581 mg/L TDS.

After initial pump testing, it was found that a blockage developed between 20-25 m. The well was geophysically logged\* with a calliper and downhole televiewer, which revealed a cavity and limestone boulder at 25 m. Subsequently, the well was rehabilitated on 27-28 May 2011 by drilling the out blockage with air and inserting of 203 mm ID slotted casing (liner) from 16 to 40 m. The well was then developed for 2 hours by airlifting. As a result of the rehabilitation, repeat pumping tests were performed on the well.

\*Glenside Geophysics job no 8723

## 2.3. BORDERTOWN TWS 11 (UNIT NO.: 7028-3876)

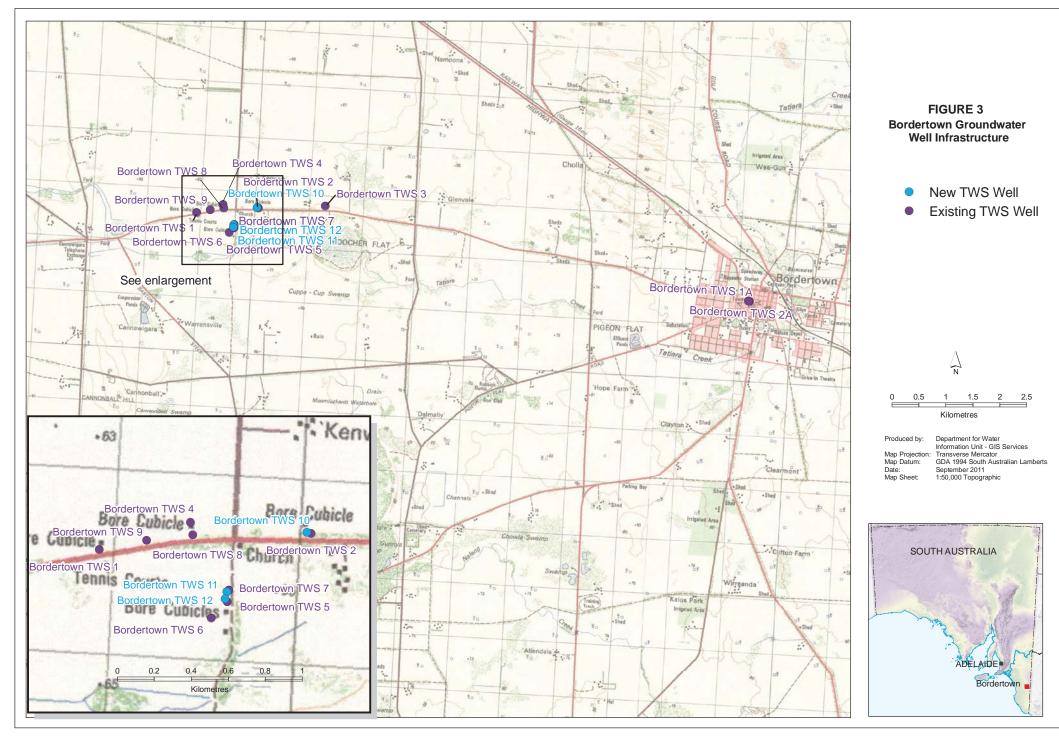
Bordertown TWS 11 was drilled as a production well under permit number 200366 and completed on 27 April 2011. The location of groundwater well infrastructure is provided in Figure 3, with the well construction diagram provided in Appendix A. The lithological logs and well completion reports are provided in Appendix B and C.

Bordertown TWS 11 was mud drilled to a depth of 37 m, with strata samples collected at 2 m intervals. A 355 mm ID pre-collar was installed to 6 m, followed by 253 mm ID class 12 PVC casing to 25 m which was pressure cemented. A 248 mm diameter hole was then drilled to 37 m, with the completion interval left as open hole from 25-37 m. The production casing extended 0.5 m above ground surface and was sealed with a flange plate. The driller indicated a water cut between 25-37 m, with a final depth to water of 15.52 m, an airlift yield of ~5 L/s, and salinity of 573 mg/L TDS.

## 2.4. BORDERTOWN TWS 12 (UNIT NO. 7028-3877)

Bordertown TWS 12 was completed under well permit number 200368 and completed on 19 May 2011. The location of groundwater well infrastructure is provided in Figure 3, with the well construction diagram provided in Appendix A. The lithological logs and well completion reports are provided in Appendix B and C.

Bordertown TWS 12 was drilled to a depth of 37 m, with strata samples collected at 2 m intervals. A 355 mm ID pre-collar was installed to 6 m, followed by 253 mm ID class 12 PVC casing to 25 m which was pressure cemented. A 248 mm diameter hole was then drilled to 37 m, with the completion interval left as open hole from 25-37 m below ground surface. The production casing extended 0.5 m above ground surface and was sealed with a flange plate. The driller indicated a water cut between 25-37 m, with a final depth to water of 15.41 m, an airlift yield of ~5 L/s, and salinity of 527 mg/L TDS.



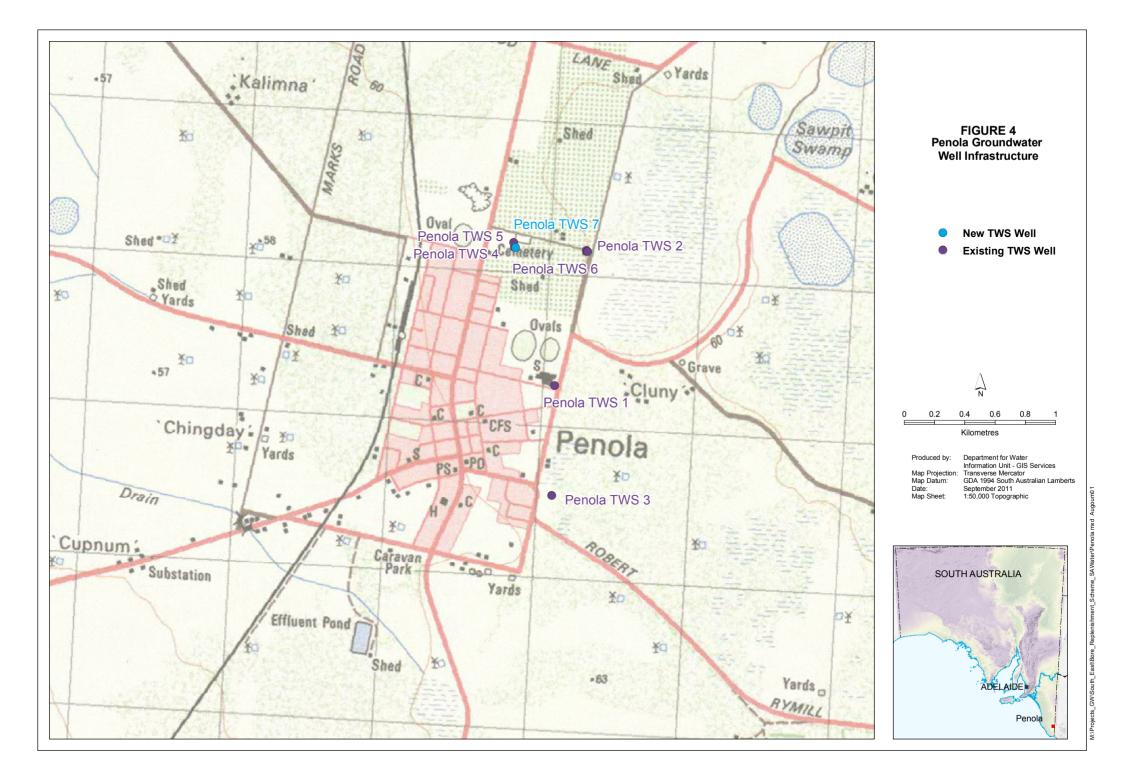
## 2.5. PENOLA TWS 7 (UNIT NO. 7023-7201)

Penola TWS 7 was drilled under well permit number 199140 and completed on 22 June 2011. The location of groundwater well infrastructure is provided in Figure 4, with the well construction diagram provided in Appendix A. The lithological logs and well completion reports are provided in Appendix B and C.

Penola TWS 7 was drilled to a depth of 160 m, with strata samples collected at 2 m through the unconfined sediments and then at 1 m intervals through the Dilwyn Formation. Due to elevated levels of arsenic in drilling returns, samples were disposed of as Intermediate Landfill Cover at Caroline Landfill, in accordance with EPA requirements. The specific source of this contamination has not been determined, but the sub-samples analysed were predominantly from unconfined sediments. This suggests the Bridgewater Formation or Greenpoint Member as the likely source.

The well was cased with 254 mm ID class 12 PVC casing to 140 m and pressure cemented. A preordered, 203 mm diameter, 0.6 mm aperture stainless steel screen was inserted from 140.8-151.8 m, with stainless steel sump from 151.8 to 153.8 m. The production casing extended 0.5 m above ground surface and was sealed with a flange plate. The driller indicated a water cut between 140-154 m, with a final depth to water of 22.47 m below top of casing, an airlift yield of >10 L/s, and salinity of 655 mg/L TDS.

Note: Geophysical logging identified the top sand unit of the Dilwyn Formation at 140 m. This is approximately 38 m deeper than the same unit at Penola TWS 6, 500 m to the east. The lithology of the Sand Unit at Penola TWS 7 was also much coarser than Penola TWS 6, with very coarse sands and gravels up to 12 mm in diameter. This should be noted for future drilling programs adjacent to Penola TWS 7, in particular when selecting screen size.



## 3. PUMPING TESTS

## 3.1. PUMPING TEST DESIGN

A pumping test (or aquifer test) is conducted by pumping a well and observing the aquifer 'response' (or drawdown) in the well and/or neighbouring observation wells. Pumping tests are carried out on wells to determine one or more of the following:

- the aquifer and aquitard hydraulic characteristics that are used to determine the ability of the aquifer to store and transmit water
- the existence and location of sub-surface hydraulic boundaries which may affect, beneficially or adversely, the long-term pumping performance of a particular well
- the long-term pumping rate for a particular well
- the performance of a particular groundwater basin
- the design efficiency of the well.

Pumping tests conducted on Geranium, Bordertown and Penola TWS wells consisted of a step drawdown test and a constant rate discharge test. As the pumping tests were not conducted for the purpose of resource definition, observation wells were not utilised during testing and storativity/specific yield was not calculated. SA Water required pumping tests to determine:

- the maximum sustainable pumping rate
- suitable depth to position a pump
- the effects of pumping on neighbouring wells
- whether de-watering of the aquifer was occurring.

The Assets and Services Group from DFW (Walkley Heights) conducted the pumping tests. Existing production wells at each township were switched off 24 hours prior to commencement of testing. Development of the well was then carried out while discharge rates and groundwater levels were monitored. From this data rates were selected for the step drawdown test.

Table 5 outlines the specification for each of the tests, including test date, pump setting, pumping rate and duration. Further information outlining the theory behind step drawdown tests and constant rate discharge tests is provided in Appendix D. The manually recorded hydraulic data for both the step drawdown test and the constant rate discharge test are provided in Appendix E.

### **PUMPING TESTS**

Well ID	Test type	Test date	Pump setting (m)	Step no.	Duration (min)	Discharge rate (L/s)
Geranium TWS 3	Step drawdown	11 Apr 2011	62	1	60	5
				2	100	10
				3	100	15
	Constant rate discharge	12 Apr 2011		-	300	15
Bordertown TWS 10	Step drawdown	10 Aug 2011	34.3	1	60	20
				2	60	25
				3	60	30
	Constant rate discharge	9 Aug 2011		-	300	30
Bordertown TWS 11	Step drawdown	2 June 2011	28.0	1	60	20
				2	100	25
				3	100	30
	Constant rate discharge	3 June 2011		-	300	30
Bordertown TWS 12	Step drawdown	4 June 2011	28.0	1	60	10
				2	60	15
				3	100	20
	Constant rate discharge	5 June 2011		-	300	20
Penola TWS 7	Step drawdown	12 August 2011	60.3	1	60	10
				2	60	15
				3	100	20
	Constant rate discharge	13 August 2011		-	300	30

#### Table 5. Details for Pumping Tests at Geranium, Bordertown and Penola

Note: Pump test flow rates provided by SA Water.

## 3.2. GROUNDWATER QUALITY TEST

Groundwater for use in potable domestic application should be tested for the following suite of chemical parameters for comparison with Australian Water Quality Drinking Guidelines (AWQDG):

- basic chemistry: TDS, Na, Ca, Mg, K, CO3, HCO<sub>3</sub>, Cl, F, SO<sub>4</sub>, hardness and alkalinity
- pH, colour and turbidity
- nutrients: NH<sub>4</sub>, NO<sub>3</sub>, NO<sub>2</sub>, soluble P and DOC
- metals (total and soluble): Al, Cd, Sb, Ni, Cu, Zn, Pb, Cr, Mn, Fe, As, Ba, Mo, Se, Hg, B, Ag, Be, I, CN, Sn, Zn, Br and U
- radioactivity.

During the pumping tests, groundwater samples were collected for laboratory analysis by SA Water staff. The chemical analysis of the groundwater for each well is provided in Appendix F

## 4. TEST RESULTS

The following summarises the results of pumping tests conducted at the production wells constructed at Geranium, Bordertown and Penola. Step test data were analysed using the DFW application developed in *Paradox 7* software while data from the constant rate discharge tests were analysed using *Aquifer Test Pro* (Version 4.2). Note that analysis plots from *Aquifer Test Pro* has not been incorporated into the results, however calculated transmissivity has been reported for comparison with step testing.

## 4.1. GERANIUM TWS 3

#### 4.1.1. STEP DRAWDOWN TEST

The following parameters were measured and recorded prior to the commencement of the step drawdown test conducted on Geranium TWS 3:

- initial (non-pumping) depth to water (DTW) = 42.35 m
- pump setting = 62 m
- available drawdown (DD) = 19.65 m.

Groundwater level measurements were recorded throughout the step drawdown test. A time series plot of the water level drawdown is shown in Figure 5.

The data from the step drawdown test and the parameters specified above were used as input for processing and analysing the data to determine the hydraulic performance of the well (Figure 6).

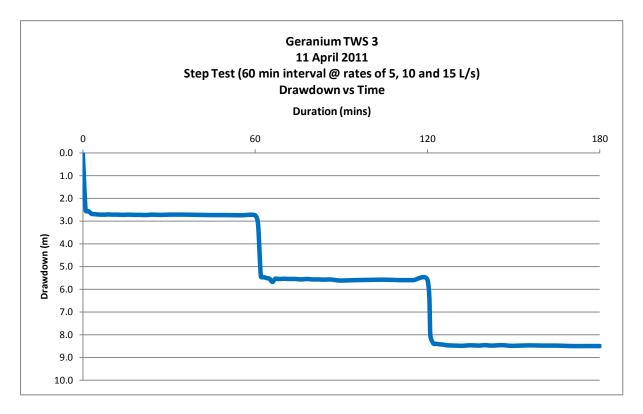
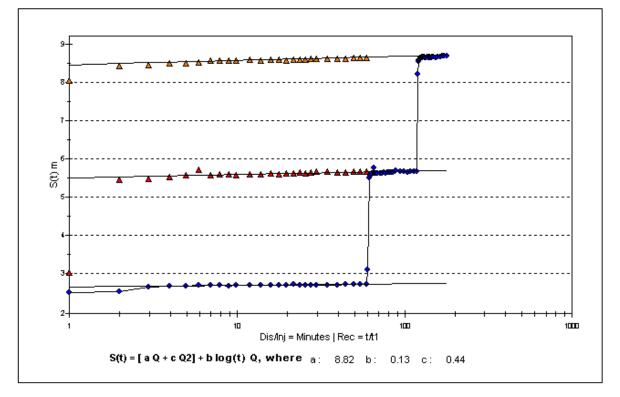
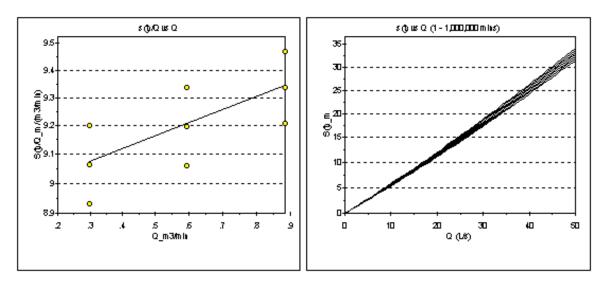


Figure 5. Step drawdown test data for Geranium TWS 3

#### **TEST RESULTS**



TieStep	Q_L/8	Q_m3/m11	D ( ratio) _m i)	St1	St1/Q	St10	St10/Q	St100	St100/Q	dS	dS/Q	T_m2/daγ
1	5.00	0.30	60	2.68	893	2.72	907	2.76	920	1004	0.13	1976
2	10.00	0.60	ഖ	5.44	9.06	5 <i>.</i> 52	920	5.60	9.33	80.0	0.13	1976
З	15.00	0.90	ഒ	829	9.21	8.40	9,33	8.51	9.45	0.11	0.12	2156





Analysis of the step drawdown results leads to the well equation (Equation (1)).

#### s(t) = 8.82 Q + 0.44 Q<sup>2</sup> + 0.13 log (t) Q

#### Equation (1)

The well equation can be used as a predictive tool. Table 6 tabulates well equation predictions for the drawdown in Geranium TWS 3 after 1,000,000 minutes (~2 years) of continuous pumping. The results show that pumping at a rate of 15 L/s generates a drawdown of 9.0 m. Other useful parameters that

#### TEST RESULTS

relate to well performance can be calculated using the well equation. For a discharge rate of 15 L/s and a time of 300 minutes (5 hours):

- The well loss component of the water level drawdown (aQ + cQ2) is 7.62 m (89%)
- The aquifer loss component of the water level drawdown (b log(t) Q) is ~0.94 m. This implies the well efficiency (aquifer loss as a percentage of total drawdown) is ~11%.
- Whilst the well is open hole completion, in an unconfined aquifer the high well loss could be attributed to the locally confined nature of the aquifer at the well. In this case the well loss is reporting the reduction in the confined component of water level. This is confirmed by drilling records, that report the water cut occurring between 50-77 m, and depth to water of 42.35 m.

For a discharge rate of 15 L/s and time of 1,000,000 minutes:

• The specific capacity is 1.75 L/s/m of drawdown. This implies that for every metre of drawdown, the well yields 1.75 L/s.

Analysis of the data using the Hazel method indicates a transmissivity  $1976 \text{ m}^2/\text{d}$ .

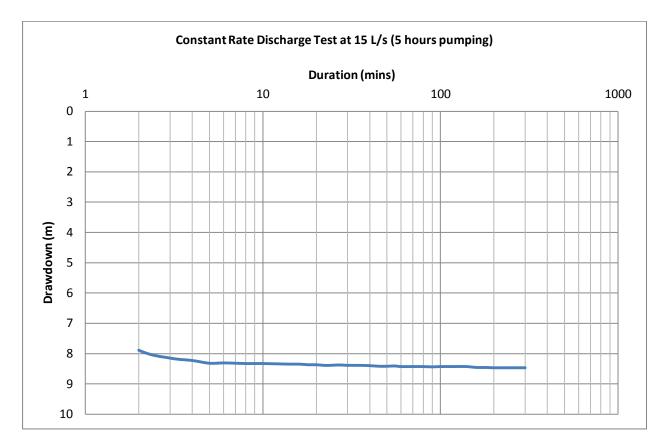
Discharge rate (L/s)	Duration (min)	Predicted Drawdown (m)
5	1,000,000	2.9
10	1,000,000	5.9
15	1,000,000	9.0

 Table 6.
 Drawdown predictions for Geranium TWS 3 using the well equation.

For operational pumping at 5 L/s, the recommended minimum pump intake should be at least 50 m, which will ensure there is available drawdown for the long term. The recommended pump intake setting also allows for a 1 m decline in regional groundwater level due to seasonal variation and pumping.

### 4.1.2. CONSTANT RATE DISCHARGE TEST

Groundwater level measurements were recorded throughout the constant rate discharge test conducted on Geranium TWS 3. A plot of the time series of water level drawdown (log linear plot) is shown in Figure 7.



#### Figure 7. Log-linear plot of constant rate discharge test data for Geranium TWS 3

The following general comments can be made in relation to the constant rate discharge test:

- Pumping at 15 L/s for 300 minutes shows a relatively stable slope, with no evidence of hydraulic boundaries.
- The well equation (Equation 1), slightly over-predicted the observed drawdown at the test rate of 15 L/s, predicting a value of 8.56 m after 300 min compared to the actual measurement of 8.47 m.
- Analysis of the test data using the Cooper-Jacob method indicates a transmissivity of 2650 m<sup>2</sup>/d, which is similar to the analysis obtained from step testing (1976 m<sup>2</sup>/d).
- An observation well was not used for the duration of the test, and recovery data was not recorded.

Groundwater salinity collected during the constant rate discharge test indicates an electrical conductivity (EC) of 2640  $\mu$ s/cm, which equates to ~1500 mg/L total dissolved solids (TDS).

Groundwater samples were sent to the Australian Water Quality Centre for analysis (see Appendix F). Results of the analysis indicate that TDS,  $CaCO_3$  and Na are above Australian Drinking Water Quality Guidelines (ADWQG) in the aesthetic category (taste), but no elements were above ADWQG in the category for health.

### 4.2. BORDERTOWN TWS 10

The following reports on step drawdown and constant rate discharge tests conducted on Bordertown TWS 10 **after** well rehabilitation and insertion of the slotted liner (see Section 2.2 for details).

#### 4.2.1. STEP DRAWDOWN TEST

The following parameters were measured and recorded prior to the commencement of the step drawdown test conducted on Bordertown TWS 10:

- initial (non-pumping) depth to water (DTW) = 16.68 m
- pump intake setting = 34.3 m
- available drawdown (DD) = 17.62 m.

Groundwater level measurements were recorded throughout the step drawdown test. A plot of the time series of water level drawdown is shown in Figure 8.

The data from the step drawdown test and the parameters specified above were used as input for processing and analysing the data to determine the hydraulic performance of the well (Figure 9).

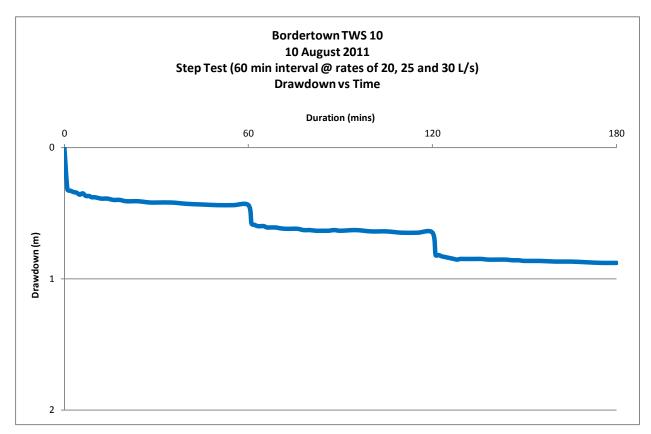
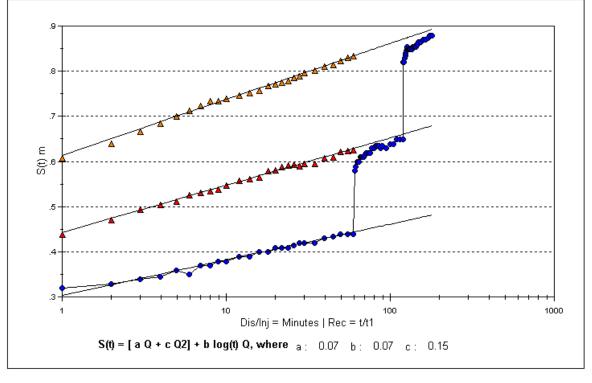
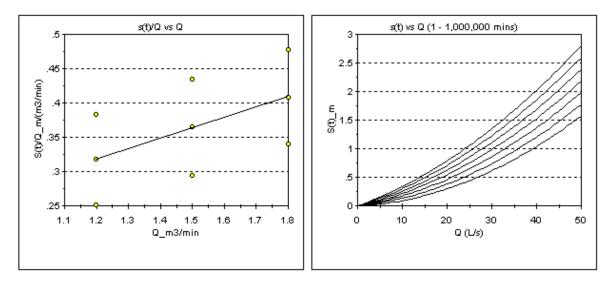


Figure 8. Step drawdown test data for Bordertown TWS 10

### **TEST RESULTS**



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	20.00	1.20	60	0.30	0.25	0.38	0.32	0.46	0.38	0.08	0.07	4003
2	25.00	1.50	60	0.44	0.30	0.55	0.37	0.65	0.44	0.11	0.07	3765
3	30.00	1.80	60	0.61	0.34	0.74	0.41	0.86	0.48	0.12	0.07	3825



#### Figure 9. Step drawdown test analysis using Hazel Method for Bordertown TWS 10

Analysis of the step drawdown results leads to the well equation (Equation (2)).

#### s(t) = 0.07 Q + 0.15 Q<sup>2</sup> + 0.07 log (t) Q

#### Equation (2)

The well equation can be used as a predictive tool. Table 10 presents predictions for the drawdown using the well equation for Bordertown TWS 10 after 1,000,000 minutes ( $^2$  years) of continuous pumping. Other useful parameters that relate to well performance can be calculated using the well equation. For a discharge rate of 30 L/s and a time of 300 minutes (5 hours):

• The well loss component of the water level drawdown (aQ +  $cQ^2$ ) is 0.61 m (66%).

- The aquifer loss component of the water level drawdown (b log(t) Q) is 0.31 m. This implies the well efficiency (aquifer loss as a percentage of total drawdown) is 34%.
- Whilst the well is open hole completion, in an unconfined aquifer the high well loss could be attributed to the locally confined nature of the aquifer at the well. In this case the well loss is reporting the reduction in the confined component of water level. This is confirmed by drilling records, that report the water cut occurring between 18-40 m, and depth to water of 16.68 m.
- Although not included as part of the analysis, pumping tests conducted prior to insertion of the slotted liner (i.e. open hole completion) report a well loss of 59 %, and aquifer loss of 41 %, which is comparable with the above findings.

For a discharge rate of 30 L/s and time of 1,000,000 minutes:

• the specific capacity is 22.2 L/s/m of drawdown. This implies that for every metre of drawdown, the well yields 22.2 L/s.

Analysis of the data using the Hazel method indicates a transmissivity  $\sim$ 3,900 m<sup>2</sup>/d.

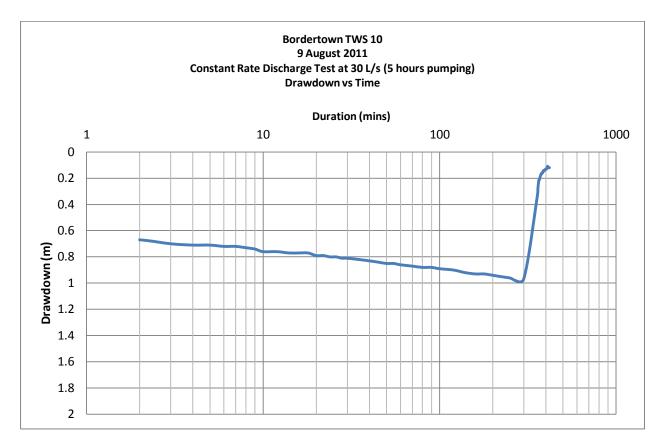
Discharge rate (L/s)	Duration (min)	Predicted Drawdown (m)
20	1,000,000	0.79
25	1,000,000	1.06
30	1,000,000	1.35

 Table 7.
 Drawdown predictions for Bordertown TWS 10 using the well equation.

For operational pumping at 30 L/s, it is recommended that the minimum pump intake depth should be 27 m, which will ensure there is available drawdown for the long term. The recommended pump intake also allows for a 1 m decline in regional groundwater level due to seasonal variation and pumping.

### 4.2.2. CONSTANT RATE DISCHARGE TEST

Groundwater level measurements were recorded throughout the constant rate discharge test conducted on Bordertown TWS 10. A plot of the time series of water level drawdown (log linear plot) is shown in Figure 10.



#### Figure 10. Log linear plot of constant rate discharge and recovery test data for Bordertown TWS 10

The following general comments can be made in relation to the constant rate discharge test:

- Pumping at 30 L/s for 300 minutes shows a gentle increase in drawdown.
- The well equation (Equation 2), slightly under-predicted the observed drawdown at the test rate of 30 L/s, predicting a value of 0.92 m after 300 min compared to the actual measurement of 0.97 m.
- There is no evidence of hydraulic boundaries.
- Analysis of the test data using the Cooper-Jacob method indicates a transmissivity of 3200 m<sup>2</sup>/d, compared to 3900 m<sup>2</sup>/d from step testing.
- An observation well was not used for the duration of the test.
- Recovery was measured for 60 min post pump testing. Full recovery was not achieved, with water level recovering to 16.78 m (0.1 m) from the initial standing water level.

Groundwater salinity collected during the constant rate discharge test indicates an electrical conductivity (EC) of 1056  $\mu$ s/cm, which equates to ~581 mg/L total dissolved solids (TDS).

Groundwater samples were collected and sent to the Australian Water Quality Centre for analysis (see Appendix F). Results of the analysis indicate that turbidity, colour and total iron are above ADWQG in the aesthetic category, but no elements were above ADWQG in the category for health.

Groundwater sampling at Bordertown TWS 10 was repeated on 10 August 2011, after backfilling of Bordertown TWS 2. Total iron concentration was recorded at 0.3517 mg/L which is lower than initial readings, but still slightly above ADWQG of 0.3 mg/L. Total iron concentration may decrease with continued use/development of the well, however it is recommended that SA Water undertake periodic sampling during well operation. Iron concentration from Bordertown TWS 2 should be reviewed to determine background level (i.e. ambient iron concentration).

## 4.3. BORDERTOWN TWS 11

#### 4.3.1. STEP DRAWDOWN TEST

The following parameters were measured and recorded prior to the commencement of the step drawdown test conducted on Bordertown TWS 11:

- initial (non-pumping) depth to water (DTW) = 15.52 m
- pump intake depth =28.00 m
- available drawdown (DD) = 12.48 m.

Groundwater level measurements were recorded throughout the step drawdown test. A plot of the time series of the water level drawdown is shown in Figure 11.

The data from the step drawdown test and the parameters specified above were used as input for processing and analysing the data to determine the hydraulic performance of the well (Figure 12).

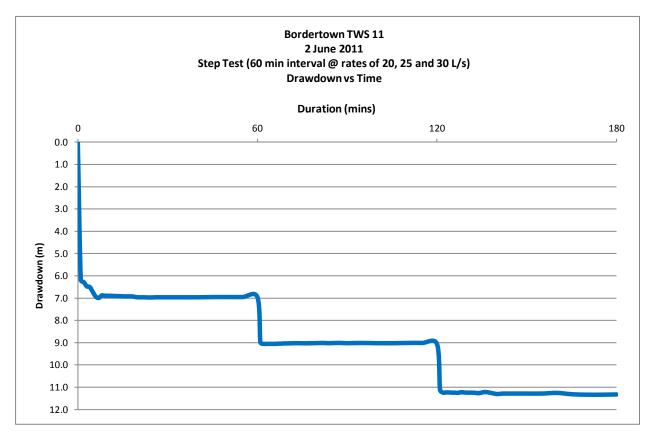
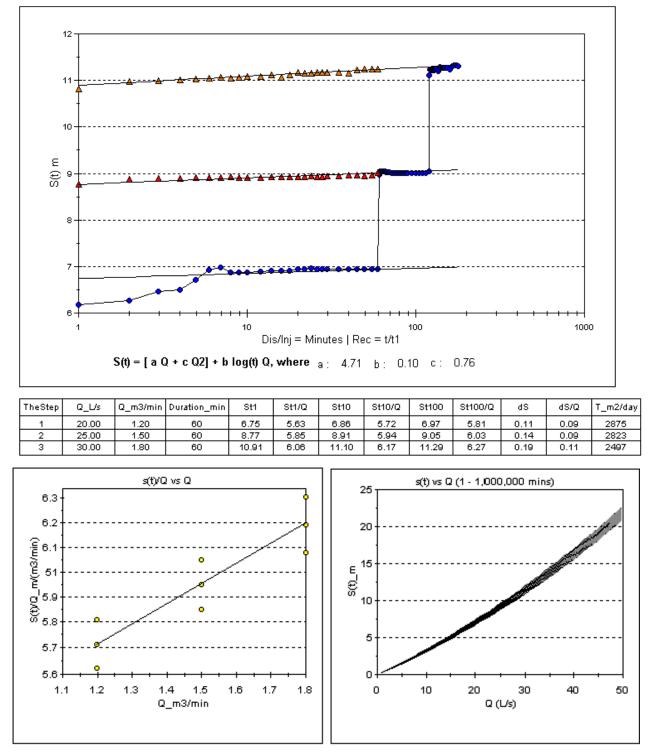


Figure 11. Step drawdown test data for Bordertown TWS 11





Analysis of the step drawdown results leads to the well equation (Equation (3))

#### $s(t) = (4.71 Q + 0.76 Q^2) + 0.10 \log (t) Q$

#### Equation (3)

The well equation can be used as a predictive tool. Table 11 presents predictions for the drawdown using the well equation for Bordertown TWS 11 after 1,000,000 minutes (~2 years) of continuous pumping. The well equation indicates that pumping at 30 L/s for 1000,000 minutes (~2 years) will induce

a drawdown of 11.97 m. Other useful parameters that relate to well performance can be calculated using the well equation. For a discharge rate of 30 L/s and time of 300 minutes (5 hours):

- The well loss  $(aQ + cQ^2)$  is 10.94 m (~96 %).
- The aquifer loss (b log(t) Q) is 0.45 m. This implies the well efficiency (aquifer loss as a percentage of total drawdown) is 4 %.
- Whilst the well is open hole completion, in an unconfined aquifer the high well loss could be attributed to the locally confined nature of the aquifer at the well. In this case the well loss is reporting the reduction in the confined component of water level. This is confirmed by drilling records, that report the water cut occurring between 25-37 m, and depth to water of 15.52 m.

For a discharge rate of 30 L/s and time of 1,000,000 minutes:

• the specific capacity is 2.9 L/s/m of drawdown. This implies that for every metre of drawdown, the well yields 2.9 L/s.

Analysis of the data using the Hazel method indicates a transmissivity of  $\sim$ 2800 m<sup>2</sup>/d.

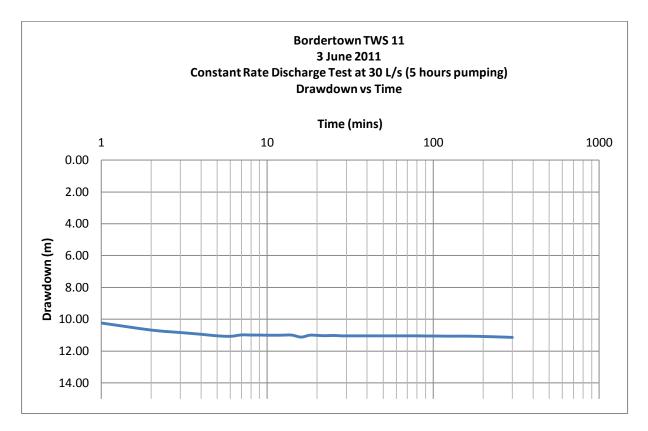
Discharge rate (L/s)	Duration (mins)	Predicted Drawdown (m)
20	1,000,000	7.43
25	1,000,000	9.63
30	1,000,000	11.97

 Table 8.
 Drawdown predictions for Bordertown TWS 11 using the well equation.

For the required operational pumping rate of 20 L/s, it is recommended that the minimum pump intake be at least 28 m, which will ensure there is available drawdown for the long term. The recommended pump intake allows for a 1 m decline in regional groundwater level due to seasonal variation and pumping, and a 1 m decline from interference from neighbouring well Bordertown TWS 12.

### 4.3.2. CONSTANT RATE DISCHARGE TEST

Groundwater level measurements were recorded throughout the constant rate discharge test conducted on Bordertown TWS 11. A plot of the time series of the water level drawdown is shown in Figure 13 (log linear plot).



#### Figure 13. Log linear plot of constant rate discharge test data for Bordertown TWS 11

The following general comments can be made in relation to the constant rate discharge test:

- Pumping at 30 L/s for 300 minutes shows a relatively stable slope, with no evidence of hydraulic boundaries.
- The well equation (Equation 3), over-predicted the observed drawdown at the test rate of 30 L/s, predicting a value of 11.39 m after 300 min compared to the actual measurement of 11.15 m.
- Analysis of the test data using the Cooper-Jacob method indicates a transmissivity of 7970 m<sup>2</sup>/d, compared to 2800 m<sup>2</sup>/d from step testing. The analysis of the constant rate test favours the mid to late time data. The actual transmissivity is likely between 2800 and 7970 m<sup>2</sup>/d.
- An observation well was not used for the duration of the test, and recovery data was not recorded.

Groundwater salinity collected during the constant rate discharge test indicates an electrical conductivity (EC) of 1041  $\mu$ s/cm, which equates to ~573 mg/L total dissolved solids (TDS). Groundwater samples were sent to the Australian Water Quality Centre for analysis (see Appendix F). Results indicate that TDS is slightly above the ADWQG value in the aesthetic category. Unlike Bordertown TWS 10, total iron concentration is low, reported at 0.0152 mg/L.

## 4.4. BORDERTOWN TWS 12

### 4.4.1. STEP DRAWDOWN TEST

The following parameters were measured and recorded prior to the commencement of the step drawdown test conducted on Bordertown TWS 12:

### **TEST RESULTS**

- initial (non-pumping) depth to water (DTW) = 15.41 m
- pump intake depth = 28.00 m
- available drawdown (DD) = 12.59 m.

Groundwater level measurements were recorded throughout the step drawdown test. A plot of the time series of water level drawdown is shown in Figure 14.

The data from the step drawdown test and the parameters specified above were used as input for processing and analysing the data which determines the hydraulic performance of the well (Figure 15).

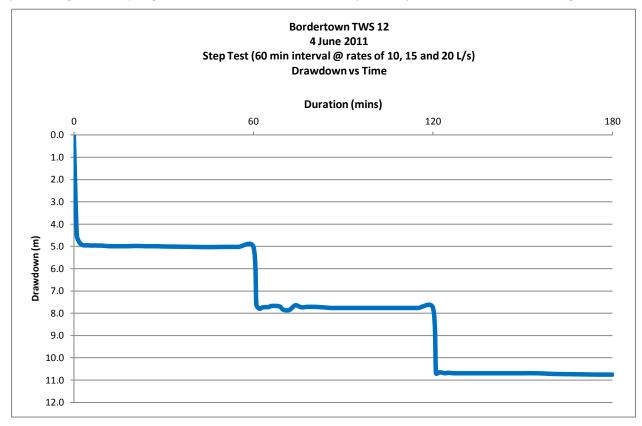
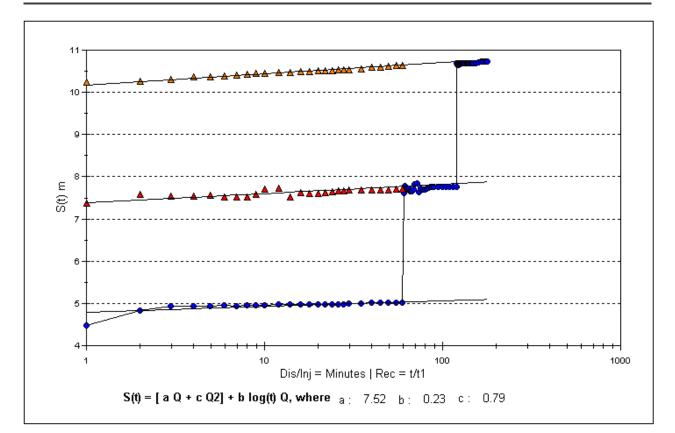


Figure 14. Step drawdown test data for Bordertown TWS 12

#### **TEST RESULTS**



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	10.00	0.60	60	4.81	8.02	4.94	8.23	5.07	8.45	0.13	0.22	1216
2	15.00	0.90	60	7.39	8.21	7.61	8.46	7.83	8.70	0.22	0.24	1078
3	20.00	1.20	60	10.18	8.48	10.45	8.71	10.72	8.93	0.27	0.22	1171

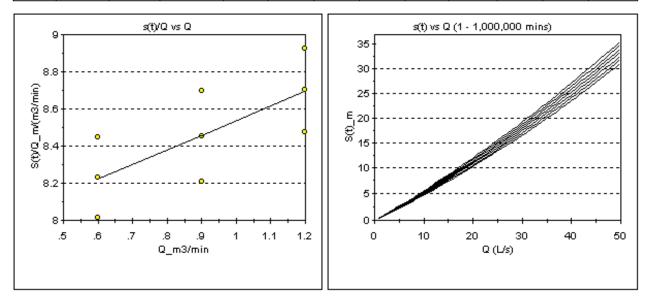


Figure 15. Step drawdown test analysis using Hazel Method for Bordertown TWS 12

Analysis of the step drawdown results leads to the well equation (Equation (4)

#### $s(t) = (7.52 Q + 0.79 Q^2) + 0.23 \log (t) Q$

#### Equation (4)

The well equation can be used as a predictive tool. Table 12 presents predictions for the drawdown using the well equation for Bordertown TWS 12 after 1,000,000 minutes (~2 years) of continuous pumping at 20 L/s. The well equation indicates that pumping at 20 L/s for 1000,000 minutes (~2 years)

will induce a drawdown of 11.81 m. Other useful parameters that relate to well performance can be calculated using the well equation. For a discharge rate of 20 L/s and time of 300 minutes (5 hours):

- The well loss (aQ + cQ2) is 10.16 m (93.7%).
- The aquifer loss (b log(t) Q) is ~0.68 m. This implies the well efficiency (aquifer loss as a percentage of total drawdown) is 6.3 %.
- Whilst the well is open hole completion, in an unconfined aquifer the high well loss could be attributed to the locally confined nature of the aquifer at the well. In this case the well loss is reporting the reduction in the confined component of water level. This is confirmed by drilling records, that report the water cut occurring between 25-37 m, and depth to water of 15.41 m.

For a discharge rate of 20 L/s and time of 1,000,000 minutes:

• the specific capacity is 1.8 L/s/m of drawdown. This implies that for every metre of drawdown, the well yields 1.8 L/s.

Analysis of the data using the Hazel method indicates a transmissivity of  $\sim$ 1200 m<sup>2</sup>/d.

Discharge rate (L/s)	Duration (mins)	Predicted DD (m)
10	1,000,000	5.62
15	1,000,000	8.64
20	1,000,000	11.81

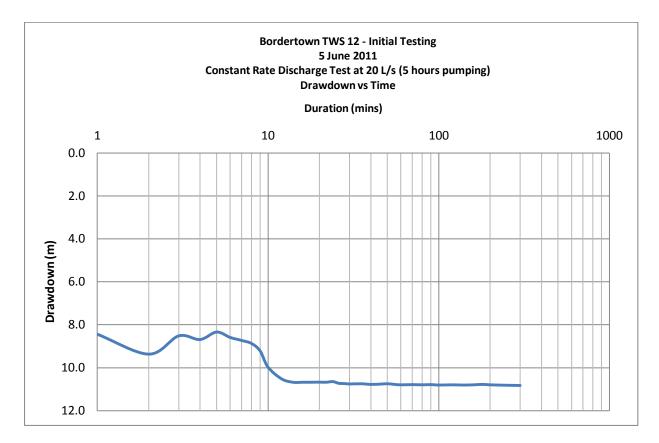
 Table 9.
 Drawdown predictions for Bordertown TWS 11 using the well equation.

For operational pumping at 20 L/s, it is recommended that the minimum pump intake be at least 31 m, which will ensure there is available drawdown for long term use. The recommended pump intake allows for a 1 m decline in regional groundwater level due to seasonal variation and pumping, and a 1 m decline from interference from neighbouring well Bordertown TWS 11.

### 4.4.2. CONSTANT RATE DISCHARGE TEST

Groundwater level measurements were recorded throughout the constant rate discharge test conducted on Bordertown TWS 12. A plot of the time series of water level drawdown is shown in Figure 16 (log-linear plot).

### **TEST RESULTS**



#### Figure 16. Log linear plot of constant rate discharge test data for Bordertown TWS 12

Drawdown versus time is given in the log-linear plot (Figure 20).

The following general comments can be made in relation to the constant rate discharge test:

- The early time data was influenced by variations in pumping rate.
- After initial fluctuations, pumping at 20 L/s for 300 min shows a relatively stable slope, with no evidence of hydraulic boundaries.
- The well equation (Equation 4), marginally over-predicted the observed drawdown at the test rate of 20 L/s, predicting a value of 10.84 m after 300 min compared to the actual measurement of 10.83 m.
- Analysis of the test data using the Cooper-Jacob method indicates a transmissivity of 4980 m<sup>2</sup>/d, compared to 1200 m<sup>2</sup>/d from step testing. The analysis of the constant rate test favours the mid to late time data. The actual transmissivity is likely between 1200 and 4980 m<sup>2</sup>/d.
- An observation well was not used for the duration of the test, and recovery data was not recorded.

Groundwater salinity collected during the constant rate discharge test indicates an electrical conductivity (EC) of 959  $\mu$ s/cm, which equates to 527 mg/L total dissolved solids (TDS). Groundwater samples were sent to the Australian Water Quality Centre for analysis (see Appendix F). Results indicate that TDS is slightly above the ADWQG value in the aesthetic category. Unlike Bordertown TWS 10, total iron concentration is low, reported at 0.0156 mg/L.

### 4.5. PENOLA TWS 7

#### 4.5.1. STEP DRAWDOWN TEST

The following parameters were measured and recorded prior to the commencement of the step drawdown test conducted on Penola TWS 7:

- initial (non-pumping) depth to water (DTW) = 22.47 m
- pump intake depth = 60.30 m
- available drawdown (DD) = 37.83 m.

Groundwater level measurements were recorded throughout the step drawdown test. The time series of the drawdown, the difference between the initial groundwater level and the groundwater levels during the test, are shown in Figure 17.

The data from the step drawdown test and the parameters specified above were used as input for processing and analysing the data which determines the hydraulic performance of the well (Figure 18).

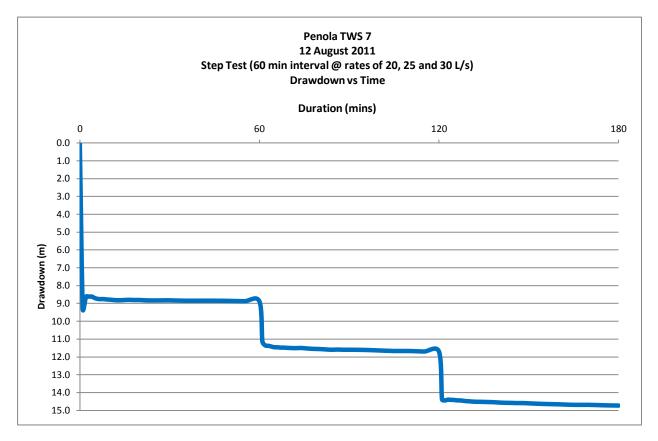
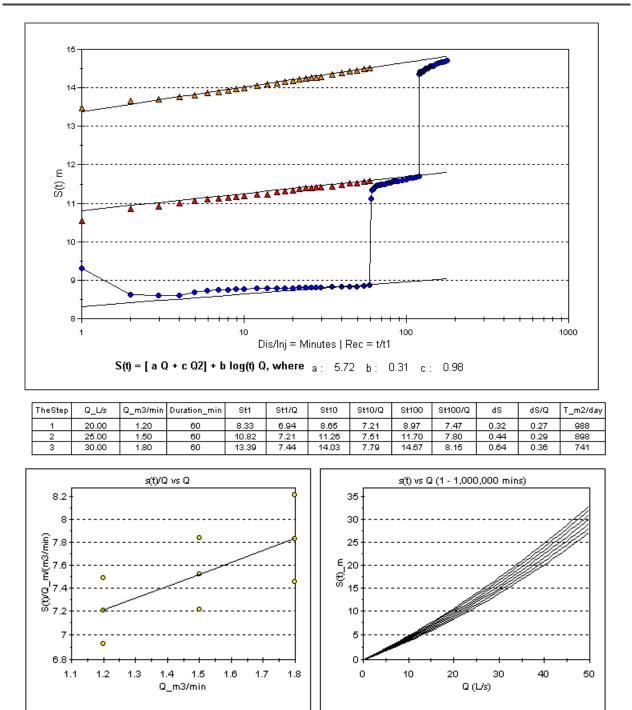


Figure 17. Step drawdown test data for Penola TWS 7



#### Figure 18. Step drawdown test analysis using Hazel Method for Penola TWS 7

Analysis of the step drawdown results leads to the well equation (Equation (5).

#### s(t) = 5.72 Q + 0.98 Q<sup>2</sup> + 0.31 log (t) Q

#### Equation (5)

The well equation can be used as a predictive tool. Table 10 tabulates well equation predictions for the drawdown in Penola TWS 7 after 1,000,000 minutes ( $^2$  years) of continuous pumping. The well equation indicates that pumping at 30 L/s for 1000,000 minutes ( $^2$  years) will induce drawdown of 16.8 m.

Other useful parameters that relate to well performance can be calculated using the well equation. For a discharge rate of 30 L/s and time of 360 minutes (6 hours):

- The well loss (aQ + cQ<sup>2</sup>) is 13.45 m (90.4%). The high well loss is likely related to the screen aperture of 0.6 mm, which was selected and pre-ordered prior to drilling. Given the coarse sands and gravels recorded in drilling returns, the efficiency of the well could be improved by insertion of a larger aperture screen.
- The aquifer loss (b log(t) Q) is ~1.43 m. This implies the well efficiency (aquifer loss as a percentage of total drawdown) is 9.6%.

For a discharge rate of 30 L/s and time of 1,000,000 minutes:

• the specific capacity is 2.02 L/s/m of drawdown. This implies that for every metre of drawdown, the well yields 2.02 L/s.

Analysis of the data using the Hazel method indicates a transmissivity of  $\sim$ 900 m<sup>2</sup>/d.

Table 10. Well equation predictions for Penola TWS 7

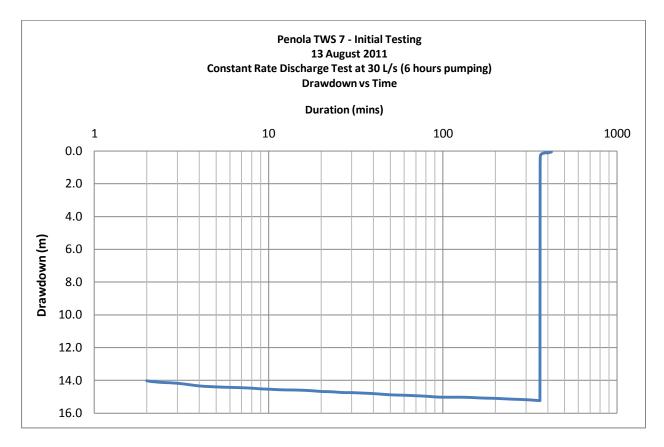
Discharge rate (L/s)	Duration (mins)	Predicted DD (m)
20	1,000,000	10.5
25	1,000,000	13.5
30	1,000,000	16.8

For operational pumping at 30 L/s, it is recommended that the minimum pump intake should be 43 m, which will ensure there is available drawdown in the long term. The recommended pump intake allows for a 1 m decline in regional groundwater level due to seasonal variation and pumping.

### 4.5.2. CONSTANT RATE DISCHARGE TEST

Groundwater level measurements were recorded throughout the constant rate discharge test conducted on Penola TWS 7. A plot of the time series of water level drawdown and recovery is shown in Figure 19 (log linear plot).

### **TEST RESULTS**



#### Figure 19. Log linear plot of constant rate discharge and recovery test data for Penola TWS 7

The following general comments can be made in relation to the constant rate discharge test:

- Pumping at 30 L/s for 360 min shows a relatively stable slope, with no evidence of hydraulic boundaries.
- The well equation (Equation 5), under-predicts the observed drawdown at the test rate of 30 L/s, predicting a value of 14.84 m after 300 min compared to the actual measurement of 15.17 m.
- Analysis of the test data using the Cooper-Jacob method indicates a transmissivity of 1000 m<sup>2</sup>/d which corresponds to the step test analysis of ~900 m<sup>2</sup>/d.
- An observation well was not used for the duration of the test, and recovery data was not recorded.

Groundwater salinity collected during the constant rate discharge test indicates an electrical conductivity (EC) of 1210  $\mu$ s/cm, which equates to 666 mg/L total dissolved solids (TDS).

Groundwater samples were sent to the Australian Water Quality Centre for analysis (see Appendix F). Results of the analysis indicate that turbidity, colour and total hardness are above the AWQDG in the aesthetic category. This probably relates to suspended solids not being completely removed post drilling, however pumping the well long term should rectify this. Total dissolved solids were also above AWQDG in the aesthetic category recording a value of 630 mg/L compared to the guideline value of 500 mg/L.

# 5. **RECOMMENDATIONS**

The following outlines recommendations for the production wells at Geranium, Bordertown and Penola and incorporates results from drilling, pump testing and required pumping rates from SA Water. It should be noted that pumping tests did not utilise an observation well to measure standing water level, hence storativity (storage coefficient) could not be calculated. The tests therefore, do not infer an assessment of the robustness of the resource. It is recommended that future tests utilise observation wells to calculate storativity/specific yield. Existing production wells completed over the same stratigraphic interval should be utilised.

## 5.1. GERANIUM TWS 3

For the newly constructed production well at Geranium, Geranium TWS 3, it is recommended that SA Water consider the following:

- Given the nature of the aquifer system, the hydraulic behaviour of the well is not expected to deviate significantly from that indicated during testing. However, it is still suggested that the well be monitored for 12 months.
- At a demand pumping rate of 5 L/s, the minimum pump intake should be 50 m (in open hole) which allows an available drawdown of approximately 6.5 m.
- For pump security purposes, installation of a slotted liner could be considered if setting in the open hole. This would involve the standover of drilling rig, reaming and installation of a liner.
- Existing wells Geranium TWS 1, Geranium TWS 2 and nearby unnamed well should be decommissioned at the next available opportunity to prevent contamination risk to the groundwater resource. The specific details for the un-named bore should be investigated including total depth and diameter, prior to being backfilled.

# 5.2. BORDERTOWN TWS 10

For the newly constructed production well at Bordertown, Bordertown TWS 10, it is recommended that SA Water consider the following:

- Given the nature of the aquifer system, the hydraulic behaviour of the well is not expected to deviate significantly from that indicated during testing. However, it is still suggested that the well be monitored for standing water level for a full 12 months.
- At a demand pumping rate of 30 L/s, the pump can be set at 27 m (in slotted liner) which allows an available drawdown of approximately 9.0 m.
- SA Water investigate the source of elevated iron, and whether occurrences are widespread, or limited to a local source.

## 5.3. BORDERTOWN TWS 11

For the newly constructed well at Bordertown, Bordertown TWS 11, it is recommended that SA Water consider the following:

• Consider establishing a monitoring network and groundwater management and monitoring plan to assess well-field sustainability. This should be considered given the close proximity to Bordertown TWS 12.

- At a demand pumping rate of 20 L/s, the minimum pump intake should be 28 m (in open hole) which allows an available drawdown of approximately 10.5 m. This accounts for potential interference effects at Bordertown TWS 12.
- For pump security purposes, installation of a liner could be considered. This would involve the standover of drilling rig, reaming and installation of a liner.

## 5.4. BORDERTOWN TWS 12

For the newly constructed well at Bordertown, Bordertown TWS 12, it is recommended that SA Water consider the following:

- Consider establishing a monitoring network and groundwater management and monitoring plan to assess well-field sustainability. This should be considered given the close proximity to Bordertown TWS 11.
- At a demand pumping rate of 20 L/s, the minimum pump intake should be 32 m (in open hole) which allows an available drawdown of approximately 13.5 m. This accounts for potential interference effects at Bordertown TWS 11.
- For pump security purposes, installation of a liner could be considered. This would involve the standover of drilling rig, reaming and installation of a liner.

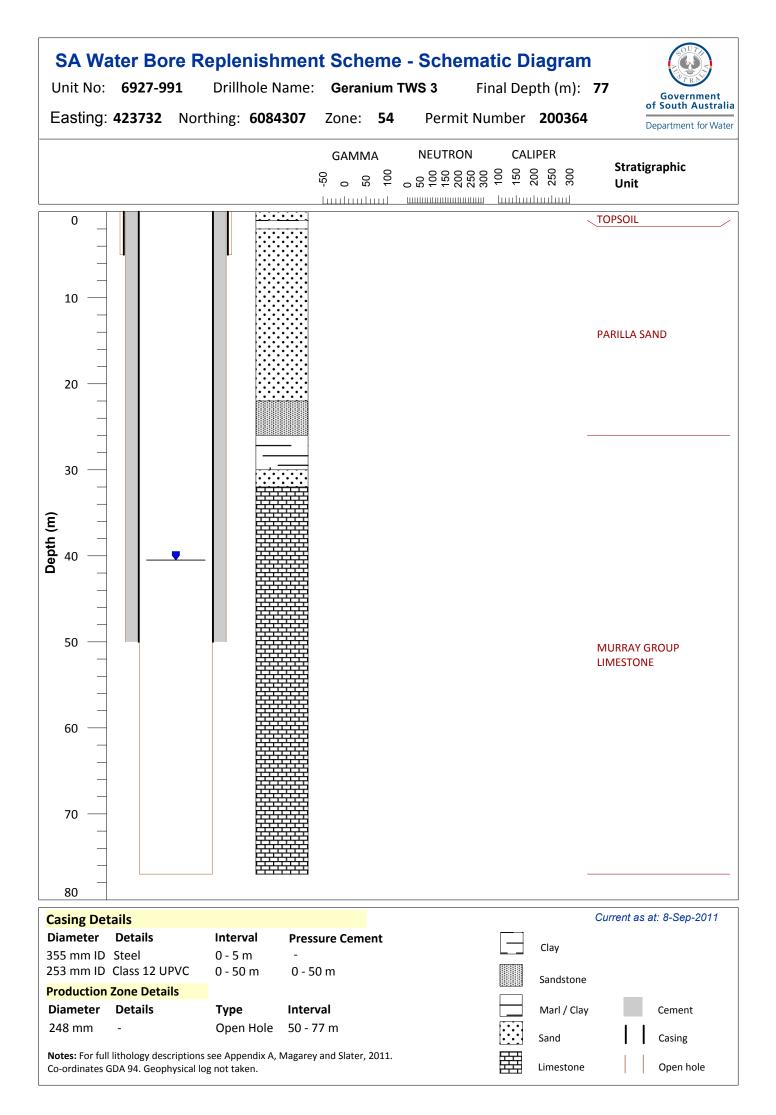
## 5.5. PENOLA TWS 7

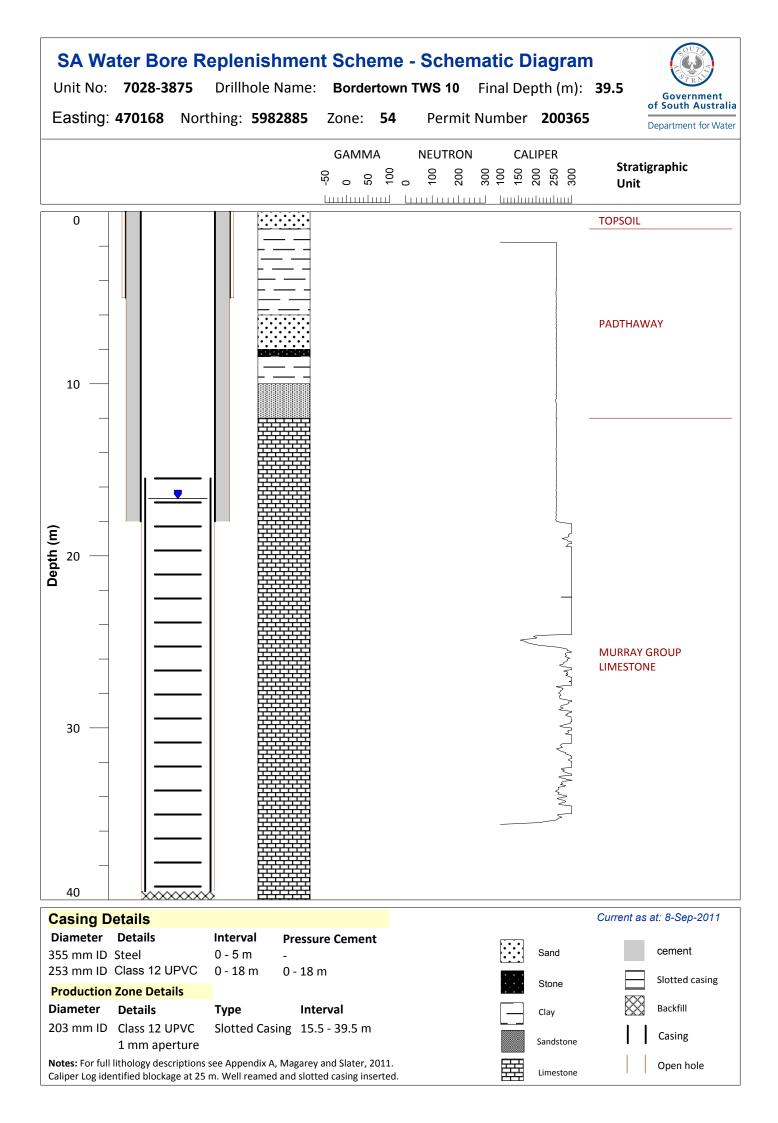
For the newly constructed well at Penola, Penola TWS 7, it is recommended that SA Water consider the following:

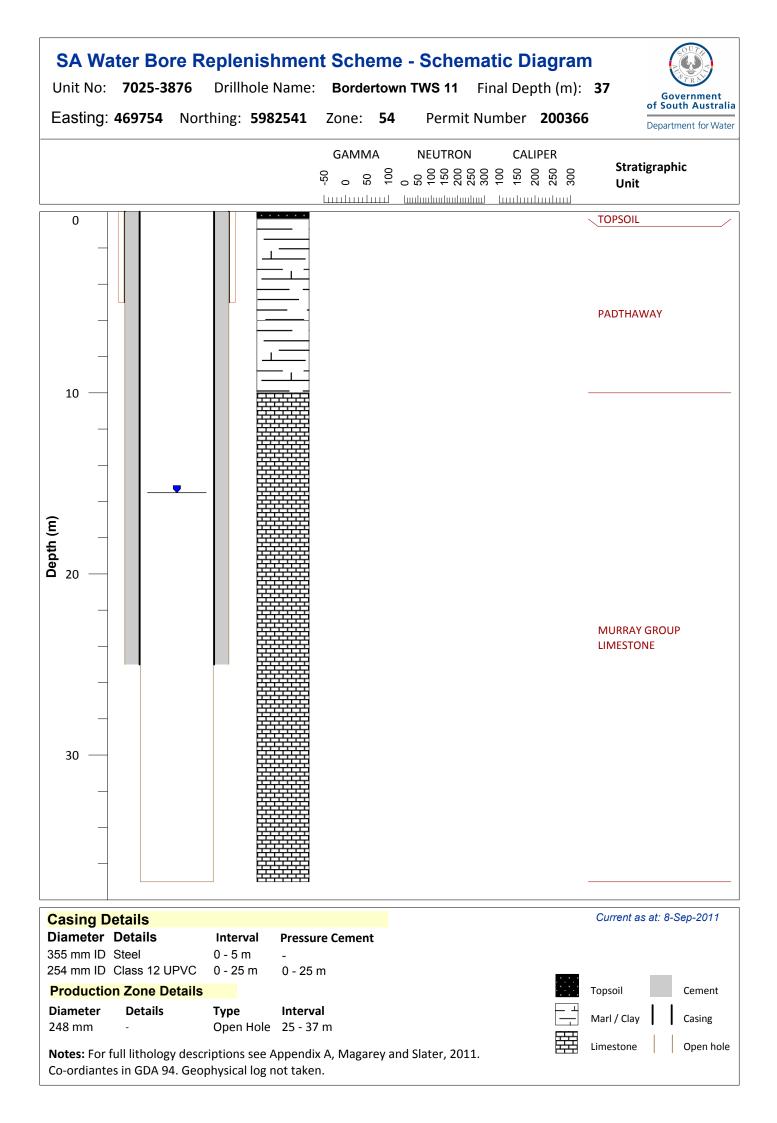
- Given the nature of the aquifer system, the hydraulic behaviour of the well is not expected to deviate significantly from that indicated during testing. However, it is still suggested that the well be monitored for a full 12 months.
- At the demand pumping rate of 30 L/s, the pump can be set at 43 m which allows an available drawdown of approximately 19.5 m.
- Future drilling in the vicinity of Penola TWS 7 should incorporate sampling of unconfined material for arsenic contamination, in lieu of disposal at an EPA (Environment Protection Authority) approved facility.
- Given the very course gravels encountered in the Dilwyn Formation, future drilling adjacent to Penola TWS 7 should incorporate as larger screen size to improve well efficiency.

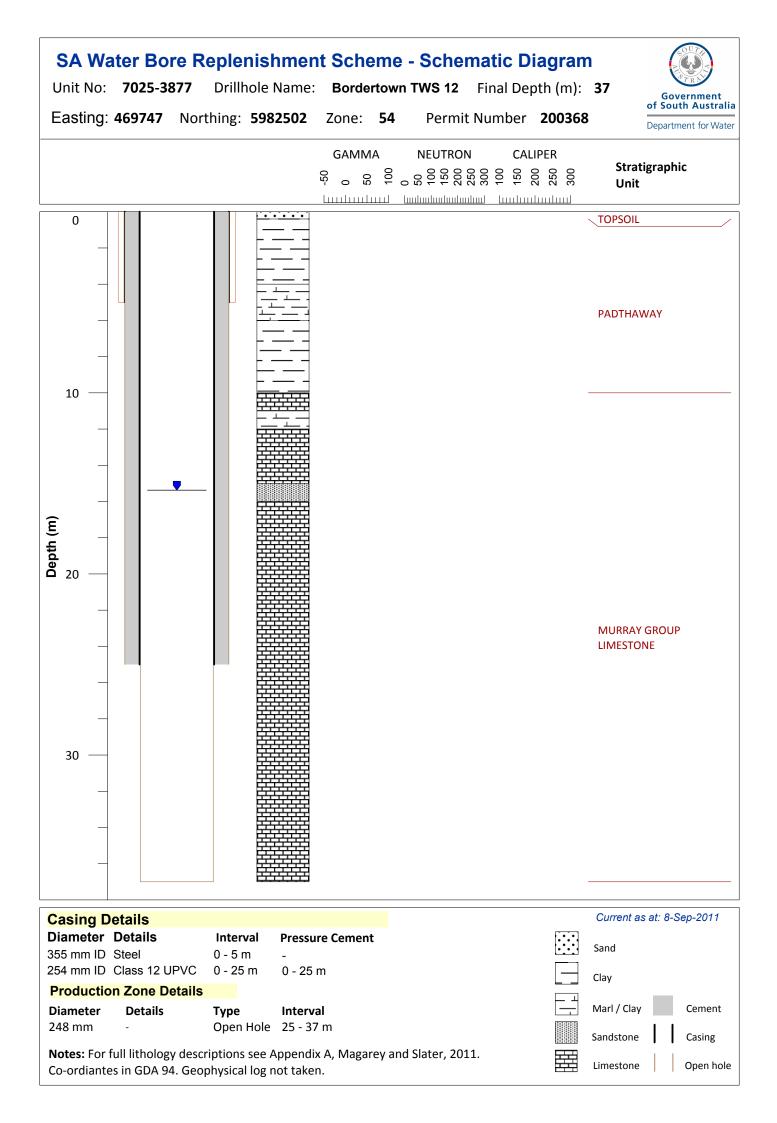
# **APPENDIXES**

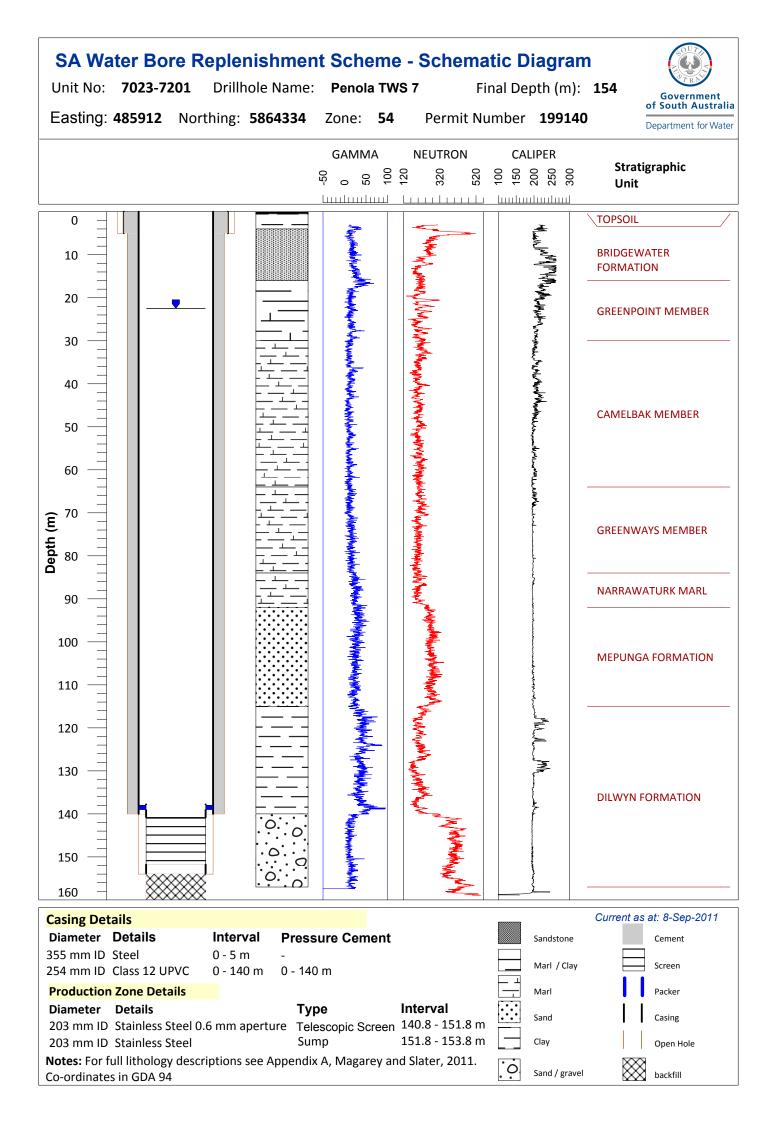
A. WELL CONSTRUCTION DIAGRAMS











# B. WATER WELL LOGS

## Groundwater Program Water Well Log: Unit No. 6927-991



Project:

### SA Water Bore Replenishment Scheme

### Geranium TWS 3

Permit Number:	200364	Backfilled (Y/N):	Ν
Date Completed:	4/3/2011	Total Depth (m):	77 m
Unit No:	6927-991	Drill Method:	Rotary Mud/Air
Drillhole Name:	Geranium TWS 3	Drilling Company:	Kangarilla
Logged By:	Scott Slater / Ian Schneider	Driller:	P. Wagenknecht

### Coordinates

Easting:	423732
Northing:	6084307
Zone:	54
Datum:	GDA94

Ground Elevation (m AHD): TBD Reference Elevation (m AHD): TBD Reference Point Type: TOC

#### **General Comments:**

#### Lithological Description

Dept	h (m)	Major Lith	Lithology	Formation
From	То	Unit(s)		
0	1	SAND	SAND, light tan brown, dry, fine to medium grain	FILL & TOPSOIL
1	2	CLAY	Sandy CLAY, light brown with light olive and grey inclusion, moist, medium plasticity, moderately stiff, sand fine to medium grain	
2	4	SAND	Grades into Clayey SAND, light brown to orange brown with light grey olive inclusions, moist, moderate firmness, and sand fine to coarse grain. Coarser grains are sub-angular	
4	10	SAND	Clayey SAND, light orange brown with minor brown, tan and cream tan inclusions, moist, sand variable fine to medium grain	PARILLA SAND
10	12	SAND	Clayey SAND as above but colour change to very light orange cream, soft,	
12	16	SAND	As above but colour change to dark yellowish orange	
16	22	SAND	As above with inclusions of light grey cream, medium grain sand, slightly less clay	
22	24	SANDSTONE	SANDSTONE, hard with interbedded soft layers, fawn and light tan	
24	26	SANDSTONE	As above but some clay (10-20%)	
26	30	MARL/CLAY	Marly CLAY, light yellowish brown, minor sand, small fragments of hard limestone (positive reaction with Acid test)	MURRAY GROUP LIMESTONE
30	32	SAND	Clayey SAND and SANDSTONE, dark yellowish orange, soft and hard layers, minor MARL	

# Groundwater Program Water Well Log: Unit No. 6927-991



Department for Water

Depth (m) Major Lith		Major Lith	Lithology	Formation
From	То	Unit(s)		
32	58	LIMESTONE	LIMESTONE, white, cream and very light yellow in	
			soft and hard layers.	MURRAY GROUP
58	72	LIMESTONE	LIMESTONE, light yellow cream with some hard	LIMESTONE
			fossiliferous components (coral/shells) and minor	
			fine grain sand	
72	77	LIMESTONE	LIMESTONE, light yellow cream with minor fine	
			grain sand	

#### Water Cut Information

Dept	Depth (m) Depth to		Supply			Water Analysis		
From	То	Water (m)	L/sec	Test Length	Method	Sample No	Salinity	Salinity Unit (EC)
0	77	40.5	4-5	2 h 40 min	Air Lifting	1h 15 min		2.78 mS
						2 hrs 45 mins		2.73 mS

### **Casing and Production Zone Information**

Case or	Depth	า (m)	Diam	Material	Aperture		Cementing	
Prod Zone	From	То	(mm)			Y/N	From (m)	To (m)
Casing	0	50	255	PVC Class 12	n/a	N	0	50
Production Zone	50	77	250	Open Hole	n/a	N	n/a	n/a



Project:

#### SA Water Bore Replenishment Scheme

#### **Bordertown TWS 10**

Permit Number: Date Completed: Unit No: Drillhole Name: Logged By:	200365 4/3/2011 7025-3875 Bordertown TWS 10 S.Slater	Backfilled (Y/N): Total Depth (m): Drill Method: Drilling Company: Driller:	N 40 m Rotary Mud/Air Kangarilla P. Wagenknecht	
Coordinates Easting: 47016		Ground Elevation	, ,	
Northing: 59288 Zone: 54	886	Reference Elevation (m AHD): TB Reference Point Type: TO		

#### **General Comments:**

GDA94

Datum:

Bordertown TWS 10 replaced Bordertown TWS 2. Significant circulation loss during drilling from 18 m to 40 m prevented sample collection from the production zone. Also prevented development of bore when bit was positioned below 18.6 m depth. This was believed to be the result of a large void in the aquifer between approximately 20-25 m. Blockage encountered at 25 m during pump testing that required rehabilitation. Rehabilitation occurred from 27-28 May 2011. Rehabilitation involved:

- down hole camera and calliper investigations followed by cleaning out of bore with air drilling
- repositioning of rig over borehole and drilling out blockage at 25m/cutting in bottom of hole using air only
- installation of 24 m of 8 inch 0.6 mm aperture PVC slotted casing from 15.5-39.5 m (production zone 18-39.5 m and 2.5 m of slotted 8 inch casing inside of 10 inch casing.
- air lifting of remediated bore hole for 2 hours with drill bit set at 38 m. •

Dept	Depth (m) Major Lith		Lithology	Formation
From	То	Unit(s)		
0	0.5	SAND	SAND, Brown grey, slightly moist increasing moisture with depth, minor clay, fine to medium grain sand	TOPSOIL
0.5	1	SAND	Clayey SAND, orange brown and olive grey mottle, slightly firm, moist, sand fine to medium grain	TOPSOIL/DISTURBED NATURAL MATERIAL
1	2	CLAY	CLAY, orange tan with olive grey mottle, moist, firm, medium plasticity, minor sand	
2	6	CLAY	Marly CLAY, pale yellowish brown/grey, moist, moderately firm	
6	8	SAND	SAND, greyish yellow, soft, very moist, fine to medium grain, minor clay	PADTHAWAY
8.2	8.4	STONE	Hard layer, insufficient sample recovered to determine – possibly sand stone or calcrete	
8.4	10	CLAY	Sandy Marly CLAY, pale yellowish grey, sand	

#### Lithological Description

# Groundwater Program Water Well Log: Unit No. 7025-3875



Department for Water

Dept	h (m)	Major Lith	Lithology	Formation
From	То	Unit(s)		
			fine to medium grain	PADTHAWAY
10	12	SANDSTONE	SANDSTONE, dark yellowish orange,	
			moderately hard, sand fine to coarse again,	
			minor clay (most likely cross contamination)	
12	14	LIMESTONE	LIMESTONE, very pale orange/cream, wet,	
			soft, minor sand & clay	
14	16	LIMESTONE	LIMESTONE, pale yellow, wet, hard layers	
16	18	LIMESTONE	LIMESTONE, pale yellow with hard yellowish	MURRAY GROUP
			orange fragments of sandstone	LIMESTONE
18	40	LIMESTONE	LOSS OF CIRCULATION, NO SAMPLES	LIVILSTOINL
			RETREIVED – refer log for TWS 2 and LAS file	
			for lithological information on production	
			zone. Void at 20-25m	

#### Water Cut Information

Depth (m) Depth to		Supply			Water Analysis			
From	То	Water (m)	L/sec	Test Length	Method	Sample No	Salinity	Salinity Unit (EC)
0	40	16	4-5	3 h	Air lifting	180 min	1029	Us/cm

#### **Casing and Production Zone Information**

Case or	Dept	า (m)	Diam	Material	Aperture	Cementing		
Prod Zone	From	То	(mm)			Y/N	From (m)	To (m)
Casing	0	18	250mm	PVC Class	n/a	Y	0	18
				12				
Slotted	15.5	39.5	200mm	PVC	0.6mm	Ν		
Casing								

### Groundwater Program Water Well Log: Unit No. 7025-3876



Project:

### : SA Water Bore Replenishment Scheme

### Bordertown TWS 11

Permit Number:		200366	Backfilled (Y/N):	Ν		
Date Completed:		19/05/2011	Total Depth (m):	37 m		
Unit No:		7025-3876	Drill Method:	Rotary Mud/Air		
Drillhole N	ame:	Bordertown TWS 11	Drilling Company	: Kangarilla		
Logged By:		S.Slater	Driller:	J. Mason		
Coordinate	es					
Easting:	46975	4	Gound Elevation	(m AHD): TBD		
Northing:	59825	41	Reference Elevat	Reference Elevation (m AHD): TBD		
Zone:	e: 54		Reference Point 1	ype: TOC		
Datum:	GDA94	4				

**General Comments:** (Replacement for TWS 7). For comparison see lithological log for Bordertown TWS 7 in SA Geodata

#### **Lithological Description**

Dept	h (m)	Major Lith	Lithology	Formation
From	То	Unit(s)		
0	0.4	SAND	Clayey SAND, grey brown, slightly moist	TOPSOIL
0.4	2	CLAY	Marly CLAY, tan grey, moist, firm	
2	6	CLAY	Marly CLAY, brown grey, some hard calcrete	PADTHAWAY
6	10	CLAY	Sandy Marly CLAY, tan grey with orange brown	
10	26	LIMESTONE	LIMESTONE, grey cream, hard, some marl, lost	
			circulation at 10m	
26	28	LIMESTONE	LIMESTONE, various shades of cream, tan and	
			light grey, some coral and marl, some cement	
			contamination in sample	MURRAY GROUP
28	30	LIMESTONE	LIMESTONE, various shades of cream, tan and	LIMESTONE
			light grey, some coral in inclusions of soft grey	
			silty clay	
30	37	LIMESTONE	LIMESTONE, cream, soft, lots of coral with minor	
			inclusions of light tan brown	

#### Water Cut Information

Depth (m) Depth to		Supply			Water Analysis			
From	То	Water (m)	L/sec	Test Length	Method	Sample No	Salinity	Salinity Unit (EC)
0	37	15	4-5	3 hours	Air lifting	180 min	1067	us/cm



Department for Water

### Casing and Production Zone Information

Case or	Depth	า (m)	Diam	Material	Aperture		Cementing		
Prod Zone	From	То	(mm)			Y/N	From (m)	To (m)	
Casing	0	25	250 mm	PVC Class 12	n/a	Y	0	25	
Open Hole	25	37	225 mm	Open Hole	n/a	Ν			



Project:

### : SA Water Bore Replenishment Scheme

### Bordertown TWS 12

Permit Number:		200368	Backfilled (Y/N):	Rotary Mud/Air
Date Completed:		27/05/2011	Total Depth (m):	
Unit No:		7025-3877	Drill Method:	
Drillhole Name:		Bordertown TWS 12	Drilling Company	
Logged By:		Scott Slater	Driller:	
Coordinate Easting: Northing: Zone: Datum:	es 46974 59825 54 GDA94	02	Ground Elevation Reference Elevat Reference Point	ion (m AHD): TBD

General Comments: Replacement for TWS 5. Compare to lithological log for TWS 5 in SA Geodata.

#### Lithological Description

Dept	h (m)	Major Lith	Lithology	Formation
From	То	Unit(s)		
0	0.4	SAND	Clayey SAND, grey brown, slightly moist	TOPSOIL
0.4	4	CLAY	Marly CLAY, tan grey, moist, firm	
4	6	CLAY/MARL	Marly CLAY/Clayey MARL, mix of light grey cream	
			and orange brown, minor fine grain sand and calcrete	PADTHAWAY
6	10	CLAY	CLAY, Light grey cream/grey tan. Hard layers with minor calcrete/marl	
10	11	LIMESTONE	LIMESTONE, very hard, light grey cream	
11	12	LIMESTONE	Marly Clayey LIMESTONE, grey cream, hard but	
			becoming softer	
12	12.5	LIMESTONE	LIMESTONE, very hard layer	
12.5	15	LIMESTONE	Clayey LIMESTONE, cream and light grey, mixture	
			of hard and soft layers	
15	16	SANDSTONE	SANDSTONE, tan orange, hard, fine to medium	MURRAY GROUP
			grain sand	LIMESTONE
16	18	LIMESTONE	Marly Clayey LIMESTONE, tan grey with	
			cream/white inclusions	
18	22	LIMESTONE	LIMESTONE, cream/white, hard, some light grey	
			clay	
22	28	LIMESTONE	Fossiliferous LIMESTONE, white/cream	
28	37	LIMESTONE	As above but tan yellow inclusions	



Department for Water

Depth (m) Depth to		Supply			Water Analysis			
From	То	Water (m)	L/s	Test Length	Method	Sample No	Salinity	Salinity Unit (EC)
0	37	15	4-5	3 hours	Air lifting	180 min	0.979	ms/cm

### Casing and Production Zone Information

Case or	Depth (m)		Diam	Material	Aperture	Cementing		
Prod Zone	From	То	(mm)			Y/N	From (m)	To (m)
Casing	0	25	250 mm	PVC Class 12	n/a	Y	0	25
Open Hole	25	37	225 mm	Open Hole	n/a	N		

# Groundwater Program Water Well Log: Unit No. 7023-377

GDA94



Project:

Datum:

### SA Water Bore Replenishment Scheme

### Penola TWS No. 7

Permit Number: Date Completed: Unit No: Drillhole Name: Logged By:	199140 22/06/2011 7023-7201 Penola TWS No. 7 Scott Slater	Backfilled (Y/N): Total Depth (m): Drill Method: Drilling Company: Driller:	0	d necht/M. Fosdike	
Coordinates					
Easting: 48590	)7	Ground Elevation	Ground Elevation (mAHD): TBD		
Northing: 5864335		Reference Elevation (mAHD): TBD			
Zone: 54		Reference Point T	ype:	ТОС	

General Comments: Replacement for TWS 4. Refer lithological log for Penola TWS 4 and LAS file for more information on lithology for this well.

Dept	h (m)	Major Lith	Lithology	Formation
From	То	Unit(s)		
0	0.5	SAND	Silty Clayey Gravelly SAND, grey brown and light cream (Fill used to build up compound pad)	FILL
0.5	2	CLAY	CLAY, light cream and tan, minor calcrete	
2	4	CLAY	Marly CLAY Grey olive	BRIDGEWATER
4	10	SANDSTONE	SANDSTONE, tan cream, hard	FORMATION
10	16	SANDSTONE	SANDSTONE, cream, shells	
16	22	MARL	Marly CLAY/Clayey MARL, grey	
22	24	MARL	Marly CLAY/Clayey MARL, grey, hard bands of flint	GREENPOINT MEMBER
24	30	MARL	Marly CLAY/Clayey MARL, grey, minor flint	
30	42	MARL	MARL, grey	CAMELBACK
42	44	MARL	MARL, grey with flint	MEMBER
44	64	MARL	MARL, light greys, olives and greys	IVILIVIDLI
64	80	CLAY/MARL	Marly CLAY, grey yellow	GREENWAYS
80	84	CLAY/MARL	Marly CLAY, grey olive	MEMBER
84	100	MARL	Marly CLAY, brown and olive with glauconitic pellets and minor limestone	NARRAWATURK MARL
100	115	SAND	SAND, light brown, some layers of brown clay. Geothitic grains	MEPUNGA FORMATION
115	140	CLAY	CLAY, Dark Brown, high plasticity and very firm	
140	157	SAND/GRAVEL	SAND grading to GRAVEL with depth. Light greys, opare and Sub-rounded up to 12mm	DILWYN FORMATION
			diameter at 157m.	

# Groundwater Program Water Well Log: Unit No. 7023-377



Department for Water

#### Water Cut Information

Dept	h (m)	Depth to		Supply			Water Anal	ysis
From	То	Water (m)	L/s	Test Length	Method	Sample No	Salinity	Salinity Unit (EC)
140.5	151.5	Na	3-5	1 h	Air lifting	1h	1210	us/cm
140.5	151.5	Na	10-15	2 h	Air lifting	1h	1189	us/cm

### **Casing and Production Zone Information**

Case or	Dept	h (m)	Diam	Material	Aperture		Cementing	
Prod Zone	From	То	(mm)			Y/N	From (m)	To (m)
Casing	0	140	250	PVC Class 12	na	Y	0	140
Screen	140.5	151.5	200	Wire wound	0.6 mm	N		
Riser	137.5	140.5	200	Wire wound	0.0 mm	N		
Sump	151.5	153.5	200	Wire wound	0.0 mm	N		

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Restoration of the local division of the	and the second se	Drilled	No. of Concession, Name	No. of Concession, Name						2, 9, 10, 1					10	(m)	Final Yi	eld	(L/sec)
6.1 Cor	nstruction	Details		g Method	1						20				face	to nearest	0.1 m)	T	
From (m)	To (m)	Diam (mm)	Cable Rotary Down	r Tool, Auger, Hole her, etc.	(Air	id Used , Water, d Type)		Da	te .	Wat From (m)	To (m)	-	tanding Water Level (m)	Estima Yiel (L/se	d	Hole Depth at Test (m)	Casing at Test (m)	Test Method	Salinity (mg/L) or Taste
05	5	343	ROTH	ney ney.	BO	-V.S	5.	1/3	-lu	18	40		6	2		40	18	AIR	400
18	40	248	Kot	ARY	BIO	-1.5	<u>&gt;</u>					-							
7. CAS	ING LEI	T IN WE	LL										and an other speed						
7.1 Din From	To	Inter	nal	Type well loint	, Welded C	ollar			Cemen			Cement	Wa	ater	Ot	her	Cementin	g	
(m)	(m)	Dia (mr	m. n)	Steel, FF	RP, PVC, e		Yes		(m)	32		(bags)	(liti	1000		itives	Method Used		Comments
0	18	35		STE V.C		12			0	15	> <	20	51	10			PEESS	n	
		ASING (n	-								>						12000		
8.1 Met Op Slo	hod ben Hole otted Casi reen(s)	ng details:	8.2 Scree	en or Cas Type	ing (*If v	From (m)	(	To (m)	Apert (m)	m)	ner Diam (mm)		ter Diam (mm)		Mate		Trade Na	me	Completion of Base
A Submer that has a relation	er Seal (Pa	NE DESCRIPTION FOR DESCRIPTION		1	avel Pacl								ATION	and the local data in					
Ma	terial	Depth (m)	Internal Diam		hod of ement	Gravel Mesh	Passing 1 Size		rom m)	To (m)		om n)	To (m)				Description of	of Material	
			(mm)							1	6		1	D	XAe	ic B	ROWN	LOAN	Λ
													2	N	No	TLOY	CLA	Ft.	() m
9. IF NO	2.1.2	Depth	Length	Width	Diam (m)		ining aterial		From	To		Re	-		No.	and the	C.		
10 DE	VELOBA	(m) IENT (Sta	(m)	(m)		IVIC	ateriai		(m)	(m)	2	5	7.5		10	TEP 20 L	ANDR	el c	JAY.
Au	-		hod				Hours		Mir	nutes	1	3.5	11	S			7 Ge		CIAY.
	1		1	2	. '							4	19	L		esto:	JE	WITH	SANID
	ITested	Water	surements f	rom natura Pump	al surface i Discha		t 0.1m) Method	-6		Draw				S	101	JE	LATE	R.	
From (m)	To (m)	Level (m)	Test Method	Depth (m)	Rat (L/se	e N	Measurin Discharg	ng	Hours Pumped	Down (m)		9-	40	- L.	0e	T (	CIRCI	JLAT	100
		-																	
	ural Resou	I Irce Manag st be obtain																	
		onsible I ac					l as des	cribed	above.										
Signatur	e of Licen	sed Driller	P.T	VV	ager	ran	zch	<b>D</b> a	te 2/	4,11						7		12	
and wel	ll location	r this copy 1 map wit Vater Lan	hin 14 day	ys of com	pletion	to any o	ected			(									
Science Water 1 Mount	Monitor Laborato Gambier	ing & Info ry and Ge Regional onal Offic	ormation, ophysical Office, 11	GPO Bo Services Helen S	ox 2834 A 5, 23 Con Street MO	delaide ynghar OUNT (	n Stree GAME	et GL BIER	ENSIE SA 529	DE SA 50	65 or			UNI	TN	<b>70</b>	<b>2</b> 5	38	75

	60	VEDNI	ADVID	OFSOL	TTL ATT		1	BORDER	TOWN	J TU	ss i	0				20 9	SEP 2011
DF	RILLE	RS W	ELL (	OF SOU CONST ce Manag	RUCT	ION I	REPO	ORT		1.	PERM	MIT NO	): 2	0 0	36		ite
								16517	8 P	ERMIT	HOL	DER o	r land oc	cupier	SA V	vater	Corp
				5				)			unt.	C	ambi	er	3 5.A	Post Code	5290
		N OF W		Jei visioii													
Date of	Survey		S	urveyed b	у	M	ethod .			4. LANI	) IDE	NTIFI	CATION	i na se			
	OORD	INATES	[	54h -	0470	168			]]]	Hundred	or Pa	storal L	ease:	W	irvega,		
		WGS84	[	54h - UTM-	598	2885				Parcel II	) or C	T numb	er C. T	5	195%	640	
	GD 66/			ZONE		ZONE	And a local diversion of the local diversion	ZONE		Name of	Prope	erty					
								elevant de		Determent		11					
Work ca	rried out:	New	Well		D	eepen [			Enlarge			]	Rehabilitat	e 🗌		Backfill	Mound
Is this a	Replacen	nent well?	YES/N	O if yes pl	ease quote	replaced	d well r	number		Sam	e	Daca	F				
		Drilled						(m)					el			eld	
		ETAILS	If r	not a drilled	l well, plea	se comp	1	ctions: 6.2,									
6.1 Con	struction	Details		ng Method			6.2 W	Vater Cut D		neasurem er Cut		nding		Hole			
From (m)	To (m)	Diam (mm)	Rota	ole Tool, ry Auger,	Fluid U (Air, W	/ater,	I	Date •			W	ater	Estimated Yield	Depth at Test	Casing at Test	Test Method	Salinity (mg/L) or
		1 A A		wn Hole imer, etc.	Mud T	ype)			From (m)	To (m)		m)	(L/sec)	(m)	(m)		Taste
0	40	248	Kota	xy	A		-		1.1	1		1					
				-													
7. CASI 7.1 Dim		T IN WE		2 Type		7	.3 Casii	ng Cemente	d								
From	То	Inter Dia	nal	Swell Joint,		lar, Y	les No	From	Te		ement	Water		ther	Cementing Method		Comments
(m)	(m)	(mr		Steel, FR	P, PVC, etc.			(m)	(11	1) (t	bags)	(litres)	Add	litives	Used		
8. CON	STRUCT	FION AT	PRODU	CTION L	EVEL	L`											
8.1 Met			1			iable ap From	erture s	screen used		nits) mer Diam	Outo	r Diam	211				C III
	en Hole			Туре		(m)	(m)			(mm)	(n	nm)	Mate P.V	rial	Trade Nar	ne	Completion of Base
10.00	tted Casi reen(s)	ng	La	sing		16	90	0.5		2603	27	25	I°. V.	L 912		C	pen
🗆 Otl	ner, give d	letails:															
8.3 Line	r Seal (Pa		Interna	1	avel Packir							TION I	OG				
Mat	erial	Depth (m)	Diam (mm)	Plac	nod of cement	Gravel Pas Mesh Si		From (m)	To (m)	Fro (m		To (m)			Description o	f Material	
													6	leane	d o	at	
0 IE N		ILLED V			-					┛┝───				11			
9. IF No		Depth (m)	Length (m)	Width (m)	Diam (m)	Linir Mater		From (m)	To (m)	1			68	Ha	psed		-
		(11)	(111)	(111)	(111)	Mutor		(11)	(11)				F	orm	atio	n	From
10. DE	ELOPN			ls and time ta	aken)								-	-	1		
	/	firlif	thod +			Hor	urs	Minu	ites				25	m	d	oWI	1
11. PUN	APING 1	TEST (mea	surement	s from natura	al surface to	nearest 0.	1m)									1	/ n n
Interva From	l Tested To	Water Level	Test	Pump Depth	Discharg Rate		thod of asuring	Hours	Draw Down				Wor	KC	ontinue	d on	Original
(m)	(m)	(m)	Method	1 (m)	(L/sec)		charge	Pumped	(m)				San	10	permit.	-	( - /
													-		1		
	vision of th							s require tha tate reasons:									
				the work h				had -b			_		_				
As the p	erson resp	onsible I a	uvise that	the work h	as been com	ipieted as	s descrit	bed above.									
Signatur	e of Licen	sed Driller	Ŋ	NMAS/	W/			Date 9/0	1/201								
				er with wa lays of com			ted	ow location								i.	
Depart	nent of V	Vater Lan	d and B	iodiversity	Conserva	tion		GLENSIDI		)65 or				71	25	30	75
Mount/	Gambier	Regional	Office,	11 Helen S Cedar Aven	treet MO	UNT GA	AMBIE	ER SA 5290	) or				UNIT N	UMBI		0	

					BC	RDERT	OWN	JT	ws	11					
	G	OVERI	NMENT	OFSC		USTRALL				1.					
• *		ERS V	VELL	CONS	TRUC	CTION RE t Act 2004			1. P	ERMIT	10: 2	Ó	031	665	lite
N	AME OF D			Mas		Licence	145	770					SAW		
			1-		111	Drilli			Postal Addres	13	Box	$\frac{1}{6}$	)3	ard (	or peral li
Na	ame of plant o	perator i	f under su	J			2	· · · · · · · · · · · · · · · · · · ·	Mount	Gambi	er S	<u>.</u> A		Post Code	5290
	LOCATIO	and a straight of	-		756	-	2559		3. WELL	NAME	Town	Supp	14 #1	17 (19	place #5
	ate of Survey					6 05 30 2			4. LAND	DENTIF	ICATION		Borde	rtown	•
	NO DATUM	1 USEE		UTM-	401	7504	48	and the second se	Hundred o Parcel ID					Gled	Plan 211
ā	AGD 66	/84	(	ZONE		<b>ZONE 53</b>		NE 54	Name of P				~~		0.00
	SUMMARY (			S II	boxes ar I	nd complete a	ll relevan	t details)							
Wo	ork carried out	t: Ne	w Well		-1	Deepen		Enlarge	e 🗖		Rehabilitat			Rockfill	
Is th	his an Existin	g well?	YES NO i	f yes plea	ase quote	ote replaced we	or GPS co	ordinates				••••••			
Was	s well Abando ximum Depth	oned? Y	ESNO if	f so pleas	e state rea	ason and metho	d of backfi	ill							
Property and Property of the P	DRILLING D					inal DepthS lease complete		) 6.2, 9, 10,	Final Standi	ng Water Le	vel	(m)	Final Yi	eld	(L/sec)
6.1	Construction	Details		g Method	1	6.	2 Water Cu	ut Details (	measuremen	ts from natu	ral surface	to nearest	t 0.1 m)		1
	rom To m) (m)	. Diam (mm)	Cab Rotar	le Tool, y Auger,	(Ai	id Used r, Water,	Date		ter Cut	Standing Water	Estimated Yield	Hole Depth	Casing at Test	Test	Salinity (mg/L) or
			Ham	mer, etc.	1	d Type)		From (m)	To (m)	Level (m)	(L/sec)	at Test (m)	(m)	Method	Taste
		406			Mud	(Polymer)	7/8 27	\$ 25	37	22	10+	37	25	Air	
			·	<u> </u>		(1 1-)			-						
	CASING LEF	T IN W									an a share ya ay da a share ya share y			1	I
1000	Dimensions rom To		ernal	l Type Swell Joint	, Welded C	Collar	asing Ceme	ented om T	o Ceme	nt Wate			Cementing		
0	m) (m) <b>75</b>	(m	um)		RP, PVC, e	tc. Yes	1) <sup>ON</sup>	m) (n	n) (baga	i) (litres	) Add	her itives	Method Used	C	Comments
	0 6	2		Stee	<u>c) 17</u>			) 2	5 48x7	Okg 648			Pressure	<u>:</u>	
-															
	CONSTRUCT	TION AT													
	Method Open Hole		8.2 Scre	en or Cas Type	sing (*If v		ò Ape			Duter Diam	Mater	ial	Trade Nan		Completion
(1997) - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997	Slotted Casin Screen(s)	ng				(m) (r	n) (r	nm)	(mm)	(mm)					of Base
	Other, give d	etails:	L									1			
ALC: NOT THE OWNER OF THE OWNER OWNER OF THE OWNER	.,	cker)		8.4 Gr	avel Pack	ing				MATION I					
8.3 I	Other, give d		Internal Diam (mm)	8.4 Gr Met			From (m)	To (m)				1	Description of	Material	
8.3 I	Other, give d	cker) Depth	Internal Diam	8.4 Gr Met	avel Pack hod of	ing Gravel Passing	From	То	13. FOR From (m)	To (m)	oc Proy		ands		
8.3 I	Other, give d	cker) Depth (m)	Internal Diam (mm)	8.4 Gr Meti Plac	avel Pack hod of rement	ing Gravel Passing Mesh Size	From	То	13. FOR From (m)	MATION I To	.og Brow Whit	e	ands	Material	limesta
8.3 I	Other, give d	cker) Depth (m)	Internal Diam (mm)	8.4 Gr Met	avel Pack hod of	ing Gravel Passing	From	То	13. FOR From (m)	To (m)	Brow Whit	e i Is	ands		limestar
8.3 I	Other, give d	cker) Depth (m) LLED V Depth	Internal Diam (mm) WELL Length	8.4 Gr Meti Plac	avel Pack hod of rement Diam	ing Gravel Passing Mesh Size Lining	From (m) From	To (m) To	13. FOR From (m) 0 • 5	$\begin{array}{c} \text{MATION I} \\ \text{To} \\ \text{(m)} \\ \hline \cdot \\ \hline \\ 10 \cdot \\ \end{array}$	Brow Whit banc Harc	e Is B	ands ands ands ind li		and
8.3 I	Other, give d	cker) Depth (m) LLED V Depth (m) ENT (Sta	VELL Length (m)	8.4 Gr Meti Plac	avel Pack hod of rement Diam (m)	ing Gravel Passing Mesh Size	From (m) From (m)	To (m) To (m)	13. FOR From (m) 0 • 5 10.8 12.5	MATION I To (m) ·S IO·8 I2·5 22	Brow Whit banc Harc	e Is B W O	ands .		ine line Stone
9. IF	Other, give d Liner Seal (Pa Material PNOT A DRI Method	cker) Depth (m) LLED V Depth (m) ENT (Sta	VELL (m)	8.4 Gr Meti Plac	avel Pack hod of rement Diam (m)	ing Gravel Passing Mesh Size Lining	From (m) From (m)	To (m) To (m) inutes	13. FOR From (m) 0 • 5	MATION I To (m) ·5 10·8 12·5	Brow Whit band Hare ston Yello ston Whi	e B W e te	ands Clay ands ind and line	with of sto white sand stone	and line stone and
8.3 I	Other, give d Liner Seal (Par Material PNOT A DRI Method DEVELOPMI	cker) Depth (m) LLED V Depth (m) ENT (Sta Me	Internal Diam (mm) VELL Length (m) ate methods thod	8.4 Gr Plac - Width (m) and time ta	avel Packet	ing Gravel Passing Mesh Size Lining Material Hours T3	From (m) From (m)	To (m) To (m) inutes	13. FOR From (m) 0 • 5 10.8 12.5	MATION I To (m) ·S IO·8 I2·5 22	Brow White bonce Harce stan Yello stan	e B W e te	ands clay ands ind hi	with of sto white sand	Stone and
8.3 I	Other, give d Liner Seal (Pa Material PNOT A DRI Method DEVELOPMI ALC PUMPING TH rval Tested	cker) Depth (m) LLED V Depth (m) ENT (Sta Me LLED V Depth (m)	Internal Diam (mm) VELL Length (m) ate methods thod	8.4 Gr Meti Plac	avel Pack hod of rement Diam (m) aken) aken)	ing Gravel Passing Mesh Size Lining Material Hours Concernent O.1m) rge Method of	From (m) From (m) Mi 3	To (m) To (m) inutes O	13. FOR From (m) 0 • 5 10.8 12.5	MATION I To (m) ·S IO·8 I2·5 22	Brow Whit band Hare ston Yello ston Whi	e B W e te	ands Clay ands ind and line	with of sto white sand stone	and line stone and
8.3 I	Other, give d Liner Seal (Par Material PNOT A DRI Method DEVELOPMI Air- PUMPING TH rval Tested	cker) Depth (m) LLED V Depth (m) ENT (Sta Me LLED V ENT (Sta Me	VELL Length (m) ate methods thod	Width (m) and time ta	avel Pack hod of rement Diam (m) aken)	ing Gravel Passing Mesh Size Lining Material Hours 	From (m) From (m) Mi 3 Hours	To (m) To (m) inutes	13. FOR From (m) 0 • 5 10.8 12.5	MATION I To (m) ·S IO·8 I2·5 22	Brow Whit band Hare ston Yello ston Whi	e B W e te	ands Clay ands ind and line	with of sto white sand stone	Stone and
8.3 I	Other, give d Liner Seal (Par Material NOT A DRI Method DEVELOPMI Aic	cker) Depth (m) LLED V Depth (m) ENT (Sta EST (mea Water Level	Internal Diam (mm) VELL Length (m) ate methods thod	8.4 Gr Mei Plac 	avel Pack hod of erment Diam (m) aken) ul surface to Dischan Rate	ing Gravel Passing Mesh Size Lining Material Hours 3 D nearest 0.1m) rge Method of Method of	From (m) From (m) Mi 3 Hours	To (m) To (m) inutes O	13. FOR From (m) 0 • 5 10.8 12.5	MATION I To (m) ·S IO·8 I2·5 22	Brow Whit band Hare ston Yello ston Whi	e B W e te	ands Clay ands ind and line	with of sto white sand stone	Stone and
8.3 I	Other, give d Liner Seal (Pa Material NOT A DRI Method DEVELOPMI CUMPING TH rval Tosted To (m)	cker) Depth (m) LLED V Depth (m) ENT (Sta EST (mea Water Level	Internal Diam (mm) VELL Length (m) ate methods thod	8.4 Gr Mei Plac 	avel Pack hod of erment Diam (m) aken) ul surface to Dischan Rate	ing Gravel Passing Mesh Size Lining Material Hours 3 D nearest 0.1m) rge Method of Method of	From (m) From (m) Mi 3 Hours	To (m) To (m) inutes O	13. FOR From (m) 0 • 5 10.8 12.5	MATION I To (m) ·S IO·8 I2·5 22	Brow Whit band Hare ston Yello ston Whi	e B W e te	ands Clay ands ind and line	with of sto white sand stone	Stone and
8.3 I	Other, give d Liner Seal (Par Material NOT A DRI Method DEVELOPMI Air-	cker) Depth (m) LLED V Depth (m) ENT (Sta Me Level (m) Statural I	Internal Diam (mm) VELL Length (m) Ite methods thod surements f Test Method	Width (m) width (m) and time ta pump Depth (m)	avel Pack hod of rement Diam (m) aken) ll surface to Dischar (L/sec	ing Gravel Passing Mesh Size Lining Material Hours Joearest 0.1m) rge Method of Measuring Discharge	From (m)	To (m)	13. FOR From (m) 0 • 5 10.8 12.5	MATION I To (m) ·S IO·8 I2·5 22	Brow Whit band Hare ston Yello ston Whi	e B W e te	ands Clay ands ind and line	with of sto white sand stone	and line stone and
8.3 I	Other, give d Liner Seal (Par Material NOT A DRI Method DEVELOPMI ALC TVMPING TH rval Tested To (m) AMPLES rovision of the ager samples m	cker) Depth (m) LLED V Depth (m) ENT (Sta Me LC-1 EST (mea Water Level (m) Natural I uust be ob	Internal Diam (mm) VELL Length (m) ite methods ithod	Width (m) and time ta Pump Depth (m)	avel Pack hod of rement Diam (m) iken) il surface to Dischan Rate (L/see	ing Gravel Passing Mesh Size Lining Material Hours 3 Denearest 0.1m) rge Method of Measuring Discharge	From (m) From (m) Mi S Hours Pumped	To (m)	13. FOR From (m) 0 • 5 10.8 12.5	MATION I To (m) ·S IO·8 I2·5 22	Brow Whit band Hare ston Yello ston Whi	e B W e te	ands Clay ands ind and line	with of sto white sand stone	Stone and
8.3 I	Other, give d Liner Seal (Par Material NOT A DRI Method DEVELOPMI ALC TVMPING TH rval Tested To (m) AMPLES rovision of the ager samples m	cker) Depth (m) LLED V Depth (m) ENT (Sta Me LC-1 EST (mea Water Level (m) Natural I uust be ob	Internal Diam (mm) VELL Length (m) ite methods ithod	Width (m) and time ta Pump Depth (m)	avel Pack hod of rement Diam (m) iken) il surface to Dischan Rate (L/see	ing Gravel Passing Mesh Size Lining Material Hours Joearest 0.1m) rge Method of Measuring Discharge	From (m) From (m) Mi S Hours Pumped	To (m)	13. FOR From (m) 0 • 5 10.8 12.5	MATION I To (m) ·S IO·8 I2·5 22	Brow Whit band Hare ston Yello ston Whi	e B W e te	ands Clay ands ind and line	with of sto white sand stone	Stone and
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÷	(m) (i	m) Di (m	am. 1111)		Welded Col P, PVC, etc.	IES NO	(11	n) (m)	, .	) (litre		ther litives	Method Used		Comments
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	Screen(s)		L			3m ri		ond		sump	lof	0.00			
	8.3 Liner Seal (	1000 NF 18		1	vel Packin	1g				MATION					
	Material	Depth (m)	Internal Diam (mm)		od of Coment	Gravel Passing Mesh Size	From (m)	To (m)	From (m)	To (m)			Description of	of Material	
									0	1.5	Rub	ble			
	9. IF NOT A D	RILLED	WELL				l		.5	3	Si Ora	ity	white Sand st	lines	tone
	Method	Depth (m)	Length (m)	Width (m)	Diam (III)	Lining Material	From (m)	To (m)			whi	1.1.	limes		6.7
	·								73.5	<b>24</b>	Whit	rt b	ande	then	as above
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	11. PUMPING Interval Tested	Water	Test	Pump	Discharg	e Method of	Hours	Draw	113	139	Bro		s abou	e.	
	From To (m) (m)	Level (m)	Method	Depth (m)	Rate (L/sec)	Measuring Discharge	Pumped	Down (m)	139	160	600	rse	sands	and	biown
						_		<b></b>			silt	yc	lays.		
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	12. SAMPLES The provision of	the Natural	Resource N	lanagemen	at Act 2004	and Regulation	s require t	hat strata							
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	Signature of Lice		11	The foll	·		Date 1	7/11							
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### D. PUMPING TEST THEORY

#### **STEP DRAWDOWN TEST**

The step drawdown test usually consists of three or more steps at increasing discharge rates applied with the rate kept constant throughout each step.

The objective of step drawdown testing is to determine the well equation (Equation (6)) which reflects the efficiency of the wells design, and relates to drawdown, discharge rate and time. This equation (ideally) allows prediction of the hydraulic performance of production wells for a design pumping rate, and generation of yield drawdown curves for any given time (Hazel 1975).

$$s(t) = (aQ + cQ^2) + b \log(t) Q$$

#### Equation (6)

Where,

s(t) = drawdown (m)

- Q = discharge rate (m<sup>3</sup>/min)
- t = time (mins)
- a = constant related to well loss for laminar flow
- c = constant related to well loss for turbulent flow
- b = constant related to aquifer loss for laminar flow

and,

Well loss (m)	=	$aQ + cQ^2$
Aquifer loss (m)	=	b log(t) Q
Well efficiency	=	(aquifer loss / s(t)) x 100

The well equation allows determination of the maximum sustainable pumping rate of the well and consequently the selection of a suitable pumping rate for the constant rate discharge test.

#### CONSTANT RATE DISCHARGE TEST

The constant rate discharge test is conducted at a constant rate for a duration commensurate with the intended use of the well (however, this is often compromised by the cost of running long-term tests).

The water level data collected from the constant rate discharge test allows determination of:

- aquifer and aquitard hydraulic characteristics
- presence of groundwater boundaries which may have an effect on pumping sustainability
- whether there is any de-watering of the aquifer system which may have an effect on the sustainability of the well under long-term operational pumping
- neighbouring well interference.

The pumping phase should be followed by monitoring the recovery in water levels. Ideally, recovery of the groundwater level is monitored until 95% of the drawdown has been recovered. The water level data collected during the recovery period (the residual drawdown) following the constant rate discharge test, allows determination of whether interference effects are present, such as recharge boundaries or alternatively de-watering of the aquifer:

- If no interference effects are present, the extrapolated residual drawdown line should intersect the zero residual drawdown line at t/t1 = 1.
- If a recharge boundary has been encountered, the line will intersect the zero residual drawdown line at a value of t/t1 > 1.
- If de-watering has occurred or an impermeable boundary has been encountered, the line will intersect the zero residual drawdown line at a value of t/t1 < 1.

# E. PUMPING TEST DATA

Step	Rate (L/s)	Duration (min)	Depth to Water (m)	Drawdown (m)
		0	0	0.00
1	5	1	2.54	2.54
1	5	2	2.57	2.57
1	5	3	2.68	2.68
1	5	4	2.7	2.70
1	5	5	2.71	2.71
1	5	6	2.72	2.72
1	5	7	2.72	2.72
1	5	8	2.72	2.72
1	5	9	2.71	2.71
1	5	10	2.72	2.72
1	5	12	2.72	2.72
1	5	14	2.73	2.73
1	5	16	2.72	2.72
1	5	18	2.73	2.73
1	5	20	2.73	2.73
1	5	22	2.738	2.74
1	5	24	2.72	2.72
1	5	26	2.73	2.73
1	5	28	2.73	2.73
1	5	30	2.73	2.72
1	5	35	2.72	2.72
1	5	40	2.72	2.72
1	5	40	2.75	2.75
1	5	43 50		
1	5	55	2.74	2.74
	5		2.75	2.75
1		60	2.75	2.75
2	10	61	3.12	3.12
2	10	62	5.44	5.44
2	10	63	5.47	5.47
2	10	64	5.51	5.51
2	10	65	5.54	5.54
2	10	66	5.68	5.68
2	10	67	5.54	5.54
2	10	68	5.55	5.55
2	10	69	5.55	5.55
2	10	70	5.54	5.54
2	10	72	5.55	5.55
2	10	74	5.55	5.55
2	10	76	5.57	5.57
2	10	78	5.55	5.55
2	10	80	5.57	5.57
2	10	82	5.57	5.57
2	10	84	5.58	5.58
2	10	86	5.57	5.57
2	10	88	5.6	5.60
2	10	90	5.62	5.62

#### Geranium TWS 3 – Step Drawdown Test Data (11 April 2011).

2	10	95	5.6	5.60
2	10	100	5.59	5.59
2	10	105	5.58	5.58
2	10	110	5.6	5.60
2	10	115	5.6	5.60
2	10	120	5.6	5.60
2	15	121	8.04	8.04
2	15	122	8.38	8.38
2	15	123	8.4	8.40
2	15	124	8.42	8.42
2	15	125	8.43	8.43
2	15	126	8.45	8.45
2	15	127	8.47	8.47
3	15	128	8.47	8.47
3	15	129	8.48	8.48
3	15	130	8.48	8.48
3	15	132	8.49	8.49
3	15	134	8.47	8.47
3	15	136	8.47	8.47
3	15	138	8.48	8.48
3	15	140	8.46	8.46
3	15	142	8.48	8.48
3	15	144	8.47	8.47
3	15	146	8.46	8.46
3	15	148	8.48	8.48
3	15	150	8.49	8.49
3	15	155	8.47	8.47
3	15	160	8.48	8.48
3	15	165	8.48	8.48
3	15	170	8.5	8.50
3	15	175	8.5	8.50
3	15	180	8.5	8.50

APPENDIXES

#### Geranium TWS 3 – Constant Rate Discharge Test (12 April 2011)

Rate L/s	Duration (min)	Depth to Water (m)	Drawdown (m)
	0	42.43	0
15	1	49.35	6.92
	2	50.32	7.89
	3	50.58	8.15
	4	50.66	8.23
	5	50.75	8.32
	6	50.74	8.31
	7	50.75	8.32
	8	50.76	8.33
	9	50.76	8.33
15	10	50.76	8.33
	12	50.77	8.34
	14	50.78	8.35
	16	50.78	8.35
	18	50.8	8.37
	20	50.8	8.37
	22	50.82	8.39
	24	50.82	8.39

	26	50.81	8.38
	28	50.81	8.38
15	30	50.82	8.39
	35	50.82	8.39
	40	50.83	8.4
	45	50.85	8.42
15	50	50.85	8.42
	55	50.84	8.41
	60	50.86	8.43
	70	50.86	8.43
15	80	50.86	8.43
	90	50.87	8.44
15	100	50.86	8.43
15	120	50.86	8.43
	140	50.86	8.43
	160	50.89	8.46
15	180	50.89	8.46
	200	50.9	8.47
	250	50.9	8.47
15	300	50.9	8.47

### Bordertown TWS 10 – Step Drawdown Test (1 August 2011)

Step	Rate (L/s)	Duration (min)	Depth to Water (m)	Drawdown (m)
		0	16.68	0.00
1	20	1	17.00	0.32
1	20	2	17.01	0.33
1	20	3	17.02	0.34
1	20	4	17.025	0.34
1	20	5	17.04	0.36
1	20	6	17.03	0.35
1	20	7	17.05	0.37
1	20	8	17.05	0.37
1	20	9	17.06	0.38
1	20	10	17.06	0.38
1	20	12	17.07	0.39
1	20	14	17.07	0.39
1	20	16	17.08	0.40
1	20	18	17.08	0.40
1	20	20	17.09	0.41
1	20	22	17.09	0.41
1	20	24	17.09	0.41
1	20	26	17.095	0.41
1	20	28	17.1	0.42
1	20	30	17.1	0.42
1	20	35	17.1	0.42
1	20	40	17.11	0.43
1	20	45	17.115	0.43
1	20	50	17.12	0.44
1	20	55	17.12	0.44
1	20	60	17.12	0.44

APPENDIX	(ES				
2	25	61	17.26	0.58	
2	25	62	17.27	0.59	
2	25	63	17.28	0.60	
2	25	64	17.28	0.60	
2	25	65	17.28	0.60	
2	25	66	17.29	0.61	
2	25	67	17.29	0.61	
2	25	68	17.29	0.61	
2	25	69	17.29	0.61	
2	25	70	17.295	0.62	
2	25	72	17.3	0.62	
2	25	72	17.3	0.62	
2					
	25	76	17.3	0.62	
2	25	78	17.31	0.63	
2	25	80	17.31	0.63	
2	25	82	17.315	0.64	
2	25	84	17.315	0.64	
2	25	86	17.315	0.64	
2	25	88	17.31	0.63	
2	25	90	17.315	0.64	
2	25	95	17.31	0.63	
2	25	100	17.32	0.64	
2	25	105	17.32	0.64	
2	25	110	17.33	0.65	
2	25	115	17.33	0.65	
2	25	120	17.33	0.65	
3	30	121	17.5	0.82	
3	30	122	17.5	0.82	
3	30	123	17.51	0.83	
3	30	124	17.515	0.84	
3	30	125	17.52	0.84	
3	30	126	17.525	0.84	
3 3	30 30	127 128	17.53 17.535	0.85 0.86	
3	30	128	17.535	0.85	
3	30	130	17.53	0.85	
3	30	132	17.53	0.85	
3	30	134	17.53	0.85	
3	30	136	17.53	0.85	
3	30	138	17.535	0.86	
3	30	140	17.535	0.86	
3	30	142	17.535	0.86	
3	30	144	17.535	0.86	
3	30	146	17.54	0.86	
3	30	148	17.54	0.86	
3	30	150	17.545	0.87	
3	30	155	17.545	0.87	
3	30	160	17.55	0.87	
3	30	165	17.55	0.87	
3	30	170	17.555	0.88	
3	30	175	17.56	0.88	
3	30	180	17.56	0.88	

Rate (L/s)	Duration (min)	Depth to Water (m)	Drawdown (m)
	0	16.66	0.62
30	1	17.28	0.65
	2	17.31	0.67
	3	17.33	0.7
	4	17.36	0.71
	5	17.37	0.71
	6	17.37	0.72
	7	17.38	0.72
	8	17.38	0.73
	9	17.39	0.74
30	10	17.4	0.76
	12	17.42	0.76
	14	17.42	0.77
	16	17.43	0.77
	18	17.43	0.77
	20	17.43	0.79
	22	17.45	0.79
	24	17.45	0.8
	26	17.46	0.8
	28	17.46	0.81
30	30	17.47	0.81
50	35	17.47	0.82
	40	17.48	0.83
	45	17.49	0.84
30	50	17.5	0.85
50	55	17.51	0.85
30	60	17.51	0.86
50	70	17.51	0.80
	80	17.52	0.87
	90	17.55	0.88
30	100		0.88
50	100	17.54 17.55	0.89
	140		
30	140	17.56 17.58	0.92
50			0.93
20	180	17.59	0.93
30	200	17.59	0.94
20	250	17.6	0.96
30	300	17.62	0.97
Start Recovery	360	17.63	0.32
	361	16.98	0.28
	362	16.94	0.27
	363	16.93	0.25
	364	16.91	0.24
	365	16.9	0.22
	366	16.88	0.22
	367	16.88	0.21
	368	16.87	0.21
	369	16.87	0.21
	370	16.87	0.2

## Bordertown TWS 10 – Constant Rate Discharge Test (9 August 2011)

	372	16.86	0.19
	374	16.85	0.18
	376	16.84	0.17
	378	16.83	0.17
	380	16.83	0.16
	382	16.82	0.16
	384	16.82	0.16
	386	16.82	0.15
	388	16.81	0.15
	390	16.81	0.14
	395	16.8	0.14
	400	16.8	0.13
	405	16.79	0.13
	410	16.79	0.11
	415	16.77	0.12
End Recovery	420	16.78	0.12

### Bordertown TWS 11 – Step Drawdown Test (2 June 2011)

		•	Depth to	Drawdown
Step	Rate (L/s)	Duration (min)	Water(m)	(m)
		0	15.52	0.00
1	20	1	21.7	6.18
1		2	21.8	6.28
1		3	21.99	6.47
1		4	22.02	6.50
1	20	5	22.24	6.72
1		6	22.45	6.93
1		7	22.51	6.99
1		8	22.4	6.88
1		9	22.41	6.89
1	20	10	22.41	6.89
1		12	22.42	6.90
1		14	22.43	6.91
1		16	22.44	6.92
1		18	22.44	6.92
1	20	20	22.48	6.96
1		22	22.48	6.96
1		24	22.49	6.97
1		26	22.48	6.96
1		28	22.48	6.96
1	20	30	22.48	6.96
1		35	22.48	6.96
1		40	22.48	6.96
1		45	22.47	6.95
1	20	50	22.47	6.95
1		55	22.47	6.95
1	20	60	22.47	6.95
2	25	61	24.5	8.98
2		62	24.57	9.05
2		63	24.57	9.05
2		64	24.57	9.05
2		65	24.57	9.05
2		66	24.57	9.05

2       25       67       24.56       9.04         2       69       24.55       9.03         2       25       70       24.55       9.03         2       25       70       24.54       9.02         2       74       24.54       9.02         2       74       24.54       9.02         2       76       24.545       9.03         2       25       78       24.54       9.02         2       80       24.535       9.02         2       84       24.53       9.01         2       25       86       24.53       9.01         2       25       86       24.53       9.01         2       25       90       24.54       9.02         2       100       24.53       9.01         2       100       24.53       9.01         2       100       24.53       9.02         2       110       24.53       9.01         2       120       26.75       11.24         3       30       121       26.66       11.24         3       30       126       26						
2       25       68       24.56       9.04         2       25       70       24.55       9.03         2       25       70       24.54       9.02         2       74       24.54       9.02         2       76       24.545       9.03         2       76       24.545       9.03         2       25       78       24.54       9.02         2       80       24.535       9.01         2       84       24.53       9.01         2       25       86       24.53       9.01         2       25       90       24.54       9.02         2       25       90       24.54       9.02         2       100       24.54       9.02         2       105       24.54       9.02         2       105       24.54       9.02         2       110       24.54       9.02         2       25       120       24.54       9.02         2       25       120       24.54       9.02         2       25       120       24.53       9.01         2       25<						
2       25       68       24.56       9.04         2       25       70       24.55       9.03         2       25       70       24.54       9.02         2       74       24.54       9.02         2       76       24.545       9.03         2       76       24.545       9.03         2       25       78       24.54       9.02         2       80       24.535       9.01         2       84       24.53       9.01         2       25       86       24.53       9.01         2       25       90       24.54       9.02         2       25       90       24.54       9.02         2       100       24.54       9.02         2       105       24.54       9.02         2       105       24.54       9.02         2       110       24.54       9.02         2       25       120       24.54       9.02         2       25       120       24.54       9.02         2       25       120       24.53       9.01         2       25<	2		67	24 56	9 04	
2       25       70       24.55       9.03         2       25       70       24.54       9.02         2       74       24.54       9.02         2       76       24.54       9.02         2       25       78       24.54       9.02         2       25       78       24.54       9.02         2       25       78       24.53       9.01         2       25       86       24.53       9.01         2       25       86       24.53       9.01         2       25       86       24.53       9.01         2       25       90       24.54       9.02         2       25       90       24.54       9.02         2       100       24.54       9.02         2       100       24.54       9.02         2       100       24.54       9.02         2       100       24.54       9.02         2       25       102       24.53       9.01         2       25       120       24.58       9.06         3       30       121       26.63       11.24 <th></th> <th>25</th> <th></th> <th></th> <th></th> <th></th>		25				
2       25       70       24.55       9.03         2       72       24.54       9.02         2       76       24.545       9.03         2       25       78       24.545       9.03         2       25       80       24.535       9.02         2       80       24.535       9.02         2       84       24.53       9.01         2       25       86       24.53       9.01         2       25       86       24.53       9.01         2       25       90       24.54       9.02         2       25       90       24.54       9.02         2       25       90       24.54       9.02         2       25       90       24.54       9.02         2       100       24.54       9.02         2       100       24.54       9.02         2       110       24.53       9.01         2       110       24.53       9.01         2       110       24.54       9.02         3       30       121       26.63       11.21         3       30		25				
2       72       24.54       9.02         2       76       24.54       9.02         2       25       78       24.54       9.02         2       25       78       24.54       9.02         2       25       80       24.535       9.02         2       25       86       24.53       9.01         2       25       86       24.53       9.01         2       25       90       24.54       9.02         2       25       90       24.54       9.02         2       25       90       24.54       9.02         2       25       90       24.54       9.02         2       25       90       24.54       9.02         2       100       24.53       9.01         2       25       100       24.53       9.01         2       25       102       24.54       9.02         2       25       120       24.53       9.01         2       25       120       24.54       9.02         2       25       120       26.63       11.24         3       30		25				
2       74       24.54       9.02         2       25       78       24.545       9.03         2       25       78       24.54       9.02         2       80       24.535       9.02         2       82       24.53       9.01         2       84       24.54       9.02         2       25       86       24.53       9.01         2       25       90       24.54       9.02         2       25       90       24.54       9.02         2       95       24.53       9.01         2       95       24.53       9.01         2       95       24.53       9.01         2       100       24.54       9.02         2       110       24.53       9.01         2       25       120       24.54       9.02         2       25       120       24.54       9.02         2       25       120       24.53       9.01         2       25       120       24.54       9.02         3       30       121       26.63       11.24         3       30<		25				
2       25       76       24.545       9.03         2       25       78       24.544       9.02         2       80       24.535       9.02         2       82       24.533       9.01         2       25       86       24.53       9.01         2       25       86       24.53       9.01         2       25       90       24.54       9.02         2       25       90       24.54       9.02         2       25       90       24.54       9.02         2       25       90       24.54       9.02         2       25       90       24.54       9.02         2       100       24.54       9.02         2       25       105       24.53       9.01         2       25       120       24.54       9.02         2       25       120       24.54       9.02         2       25       120       24.54       9.02         3       30       121       26.63       11.24         3       30       122       26.75       11.24         3       30 <th></th> <th></th> <th></th> <th></th> <th></th> <th></th>						
2       25       78       24.54       9.02         2       80       24.535       9.02         2       82       24.53       9.01         2       25       86       24.53       9.01         2       25       86       24.53       9.01         2       25       90       24.54       9.02         2       25       90       24.54       9.02         2       95       24.53       9.01         2       95       24.53       9.01         2       100       24.54       9.02         2       100       24.53       9.01         2       110       24.53       9.01         2       25       120       24.58       9.02         2       25       120       24.58       9.01         2       25       120       24.58       9.01         3       30       121       26.63       11.24         3       30       122       26.76       11.24         3       30       126       26.76       11.24         3       30       130       26.76       11.24 <th></th> <th></th> <th></th> <th></th> <th></th> <th></th>						
2       80       24.535       9.02         2       82       24.53       9.01         2       25       86       24.53       9.01         2       25       90       24.54       9.02         2       25       90       24.54       9.02         2       25       90       24.54       9.02         2       95       24.53       9.01         2       95       24.54       9.02         2       95       24.54       9.02         2       100       24.54       9.02         2       100       24.54       9.02         2       100       24.53       9.01         2       25       120       24.53       9.01         2       25       120       24.53       9.01         3       30       121       26.63       11.11         3       122       26.75       11.23         3       30       126       26.76       11.24         3       30       130       26.76       11.24         3       30       136       26.76       11.24          3 <th></th> <th>25</th> <th></th> <th></th> <th></th> <th></th>		25				
2       82       24.53       9.01         2       25       86       24.53       9.01         2       25       88       24.53       9.01         2       25       90       24.54       9.02         2       25       95       24.53       9.01         2       95       24.53       9.01         2       100       24.54       9.02         2       100       24.54       9.02         2       105       24.53       9.01         2       105       24.53       9.01         2       110       24.53       9.01         2       25       120       24.58       9.06         3       30       121       26.63       11.11         3       30       122       26.76       11.24         3       30       126       26.76       11.24         3       30       126       26.76       11.24         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       136       26.76       11.24		25				
2258624.539.022258624.539.012259024.549.02210024.549.02210024.549.02210024.539.01210024.539.01210524.539.0122512024.539.0122512024.589.0633012126.6311.1133012126.7511.2333012126.7511.2333012626.7611.2433013026.7611.2433013026.7611.2433013026.7811.2333013026.7611.2433013026.7611.2433013026.7611.2433013826.7711.2533013826.7711.2533014626.811.2833014626.811.2833014626.811.2833014626.811.2833014626.811.2833014626.811.2833014626.811.2833014626.811.283						
2258624.539.012259024.549.0229524.539.01210024.549.02210524.539.01210524.539.01210024.549.02211024.539.0122512024.589.0633012126.6311.11312226.7511.2333012426.7511.2333012626.7611.2433012626.7611.2433012626.7611.2433012626.7611.2433012826.7611.2433013826.7611.2433013826.7611.2433013826.7611.2433013826.7611.2433013826.7711.2533013826.7711.2533014626.8311.2833014626.8111.2833015526.8311.2833015526.8311.3133015526.8311.3133015526.8311.3333015526.8311.33330 <t< th=""><th></th><th></th><th></th><th></th><th></th><th></th></t<>						
2       25       90       24.53       9.01         2       95       24.53       9.01         2       95       24.53       9.01         2       100       24.54       9.02         2       105       24.54       9.02         2       105       24.53       9.01         2       25       120       24.53       9.01         2       25       120       24.53       9.01         3       30       121       26.63       11.11         3       30       122       26.76       11.24         3       30       124       26.75       11.23         3       30       126       26.76       11.24         3       30       126       26.76       11.24         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       130       26.77       11.25         3       30       136       26.77       11.26         3       30       146		25				
2       25       90       24.54       9.02         2       95       24.53       9.01         2       100       24.54       9.02         2       105       24.54       9.02         2       105       24.54       9.02         2       110       24.53       9.01         2       25       120       24.58       9.06         3       30       121       26.63       11.11         3       30       121       26.63       11.24         3       30       122       26.76       11.24         3       30       126       26.75       11.23         3       30       126       26.76       11.24         3       30       126       26.76       11.24         3       30       126       26.76       11.24         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       138       26.71       11.25         3       30       138       26.76       11.24         3       30       138		25				
2       95       24.53       9.01         2       100       24.54       9.02         2       105       24.54       9.02         2       110       24.53       9.01         2       110       24.53       9.01         2       25       120       24.58       9.06         3       30       121       26.63       11.11         3       30       122       26.75       11.23         3       30       123       26.75       11.23         3       30       126       26.75       11.24         3       30       126       26.76       11.24         3       30       126       26.76       11.24         3       30       126       26.75       11.23         3       30       128       26.74       11.22         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       138       26.77       11.25         3       30       138       26.77       11.25         3       30       138 <th></th> <th>25</th> <th></th> <th></th> <th></th> <th></th>		25				
2       100       24.54       9.02         2       105       24.54       9.02         2       110       24.53       9.01         2       25       120       24.58       9.06         3       30       121       26.63       11.11         3       30       121       26.63       11.23         3       30       122       26.75       11.23         3       123       26.75       11.23         3       30       126       26.76       11.24         3       30       126       26.76       11.24         3       30       126       26.76       11.24         3       30       126       26.76       11.24         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       136       26.73       11.26         3       30       136       26.73       11.21         3       30       138       26.77       11.25         3       30       138       26.77       11.26         3       30 </th <th></th> <th>25</th> <th></th> <th></th> <th></th> <th></th>		25				
2       105       24.54       9.02         2       110       24.53       9.01         2       25       120       24.58       9.06         3       30       121       26.63       11.11         3       30       122       26.76       11.24         3       123       26.75       11.23         3       124       26.75       11.24         3       124       26.75       11.24         3       30       126       26.76       11.24         3       30       126       26.76       11.24         3       30       126       26.76       11.24         3       30       126       26.76       11.24         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       136       26.77       11.24         3       30       138       26.77       11.24         3       30       138       26.77       11.25         3       30       146						
2       110       24.53       9.01         2       25       120       24.53       9.01         2       25       120       24.53       9.06         3       30       121       26.63       11.11         3       122       26.76       11.24         3       123       26.75       11.23         3       123       26.75       11.24         3       30       126       26.76       11.24         3       30       126       26.76       11.24         3       30       126       26.76       11.24         3       30       126       26.76       11.24         3       30       128       26.76       11.24         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       138       26.77       11.25         3       30       138       26.77       11.25         3       30       146       26.81       11.38         3       30<						
2       25       115       24.53       9.01         2       25       120       24.58       9.06         3       30       121       26.63       11.11         3       122       26.76       11.24         3       123       26.75       11.23         3       124       26.75       11.23         3       125       26.76       11.24         3       30       126       26.76       11.24         3       30       126       26.76       11.24         3       30       126       26.76       11.24         3       30       128       26.76       11.24         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       138       26.77       11.25         3       30       138       26.77       11.28         3       30       142       26.8       11.28         3       30<						
2       25       120       24.58       9.06         3       30       121       26.63       11.11         3       122       26.76       11.24         3       123       26.75       11.23         3       123       26.75       11.23         3       124       26.75       11.24         3       30       126       26.76       11.24         3       30       126       26.76       11.24         3       30       126       26.76       11.24         3       30       128       26.76       11.24         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       138       26.77       11.25         3       30       138       26.77       11.25         3       30       138       26.81       11.28         3       30       146       26.8       11.28         3       30						
3       30       121       26.63       11.11         3       122       26.76       11.24         3       123       26.75       11.23         3       124       26.75       11.24         3       124       26.76       11.24         3       30       126       26.76       11.24         3       30       126       26.76       11.24         3       30       126       26.76       11.24         3       30       126       26.76       11.24         3       30       127       26.77       11.25         3       129       26.75       11.24         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       138       26.77       11.25         3       30       138       26.77       11.25         3       30       138       26.77       11.28         3       30       146       26.8       11.28         3       30       146       26.8       11.28         3       30       15		25				
3       122       26.76       11.24         3       123       26.75       11.23         3       124       26.75       11.23         3       125       26.76       11.24         3       30       126       26.76       11.24         3       30       126       26.76       11.24         3       30       126       26.77       11.25         3       30       127       26.77       11.25         3       128       26.76       11.24         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       138       26.77       11.25         3       30       138       26.77       11.25         3       30       146       26.8       11.28         3       30       146       26.8       11.28         3       30       146       26.8       11.28         3       30       155						
3       123       26.75       11.23         3       124       26.75       11.24         3       30       125       26.76       11.24         3       30       126       26.77       11.25         3       30       127       26.77       11.25         3       128       26.76       11.24         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       132       26.76       11.24         3       30       136       26.73       11.21         3       30       138       26.77       11.25         3       140       26.82       11.30         3       30       146       26.8       11.28         3       30       146       26.8       11.28         3       30       155       26.8       11.28         3       30<						
3       124       26.75       11.23         3       30       125       26.76       11.24         3       30       126       26.76       11.24         3       127       26.77       11.25         3       128       26.76       11.23         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       132       26.76       11.24         3       30       136       26.73       11.26         3       30       138       26.77       11.25         3       30       138       26.77       11.28         3       30       1442       26.8       11.28         3       30       144       26.8       11.28         3       30       146       26.8       11.28         3       30       155       26.8       11.28         3       30       155       26.83       11.31         3<						
3       30       125       26.76       11.24         3       30       126       26.76       11.24         3       127       26.77       11.25         3       128       26.74       11.22         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       132       26.76       11.24         3       30       138       26.73       11.26         3       30       138       26.77       11.25         3       30       138       26.82       11.30         3       30       146       26.8       11.28         3       30       146       26.8       11.28         3       30       155       26.8       11.28         3       30       155       26.8       11.28         3       30       155       26.83       11.31						
3       30       126       26.76       11.24         3       127       26.77       11.25         3       128       26.74       11.22         3       129       26.75       11.24         3       30       130       26.76       11.24         3       30       130       26.76       11.24         3       30       132       26.76       11.24         3       30       134       26.78       11.26         3       30       136       26.73       11.21         3       30       138       26.77       11.25         3       30       138       26.77       11.25         3       30       138       26.77       11.25         3       30       140       26.82       11.30         3       30       146       26.8       11.28         3       30       146       26.8       11.28         3       30       155       26.8       11.28         3       30       155       26.8       11.28         3       30       155       26.83       11.31         3 </th <th></th> <th></th> <th></th> <th></th> <th></th> <th></th>						
3       127       26.77       11.25         3       128       26.74       11.22         3       30       130       26.75       11.23         3       30       130       26.76       11.24         3       30       132       26.76       11.24         3       30       132       26.76       11.24         3       30       134       26.78       11.26         3       30       138       26.77       11.25         3       30       138       26.77       11.25         3       30       140       26.82       11.30         3       30       144       26.8       11.28         3       30       146       26.8       11.28         3       30       146       26.8       11.28         3       30       155       26.8       11.28         3       30       155       26.8       11.28         3       30       155       26.83       11.28         3       30       155       26.83       11.31         3       160       26.77       11.25       1.33		30				
312826.7411.2233012926.7511.2333013026.7611.24313226.7611.24313426.7811.2633013826.7711.2533013826.7711.2533014026.8211.3033014626.811.2833014626.811.2833015526.811.2833015526.811.2833015526.811.2833015526.811.2833015526.811.2833015526.811.2833015526.811.2833015526.811.31317026.8511.33317526.8511.33						
312926.7511.2333013026.7611.24313226.7611.24313426.7811.2633013826.7711.2533013826.7711.2533014026.8211.30344426.811.2833014626.811.2833014626.811.2833015526.811.2833015526.811.2833015526.811.2833015526.811.2833015526.811.2833015526.811.2833015526.811.31316026.7711.25317026.8511.33317526.8511.33						
313226.7611.24313426.7811.2633013626.7311.2133013826.7711.2533014026.8211.30314226.811.2833014626.811.2833014626.811.2833014626.811.2833015526.811.2833015526.811.2833015526.811.28316026.7711.25316526.8311.31317526.8511.33	3				11.23	
313426.7811.26313626.7311.2133013826.7711.25314026.8211.30314226.811.2833014626.811.2833014626.811.2833015526.811.2833015526.811.2833015526.811.2833015526.811.28316026.7711.25316526.8311.31317526.8511.33	3	30	130	26.76	11.24	
313626.7311.2133013826.7711.25314026.8211.30314226.811.2833014626.811.2833014626.811.2833014626.811.2833015026.811.2833015526.811.2833015526.811.2833015526.811.2833015526.8311.31316026.7711.25317026.8511.33317526.8511.33	3		132	26.76	11.24	
33013826.7711.25314026.8211.30314226.811.2833014626.811.2833014626.811.2833014626.811.2833015526.811.2833015526.811.2833015526.811.28316026.7711.25316526.8311.31317026.8511.33317526.8511.33	3		134	26.78	11.26	
314026.8211.30314226.811.28314426.811.2833014626.811.2833014626.811.2833015026.811.2833015526.811.2833015526.811.2833015526.8311.28316026.7711.25317026.8511.33317526.8511.33	3		136	26.73	11.21	
314226.811.28314426.811.2833014626.811.28314826.811.28315026.811.2833015526.811.28316026.7711.25316526.8311.31317026.8511.33317526.8511.33	3	30	138	26.77	11.25	
314426.811.2833014626.811.28314826.811.28315026.811.2833015526.811.28316026.7711.25316526.8311.31317026.8511.33317526.8511.33	3		140	26.82	11.30	
33014626.811.28314826.811.28315026.811.2833015526.811.28316026.7711.25316526.8311.31317026.8511.33317526.8511.33	3		142	26.8	11.28	
314826.811.28315026.811.2833015526.811.28316026.7711.25316526.8311.31317026.8511.33317526.8511.33			144	26.8	11.28	
315026.811.2833015526.811.28316026.7711.25316526.8311.31317026.8511.33317526.8511.33		30	146	26.8	11.28	
33015526.811.28316026.7711.25316526.8311.31317026.8511.33317526.8511.33			148	26.8	11.28	
316026.7711.25316526.8311.31317026.8511.33317526.8511.33			150			
316526.8311.31317026.8511.33317526.8511.33		30				
317026.8511.33317526.8511.33				26.77	11.25	
3 175 26.85 11.33						
3 30 180 26.84 11.32						
	3	30	180	26.84	11.32	

		Depth to	
Rate (L/s)	Duration (min)	Water (m)	Drawdown (m)
	0	15.52	0.00
30	1	25.75	10.23
	2	26.2	10.68
	3	26.36	10.84
	4	26.47	10.95
	5	26.57	11.05
	6	26.6	11.08
	7	26.51	10.99
30	8	26.52	11.00
	9	26.52	11.00
	10	26.53	11.01
	12	26.53	11.01
	14	26.52	11.00
	16	26.65	11.13
	18	26.53	11.01
	20	26.54	11.02
30	22	26.56	11.04
	24	26.55	11.03
	26	26.55	11.03
	28	26.57	11.05
	30	26.57	11.05
	35	26.57	11.05
	40	26.57	11.05
30	45	26.57	11.05
	50	26.57	11.05
	55	26.57	11.05
	60	26.57	11.05
	70	26.57	11.05
	80	26.57	11.05
30	90	26.58	11.06
	100	26.58	11.06
	120	26.59	11.07
	140	26.59	11.07
	160	26.59	11.07
	180	26.6	11.08
30	200	26.61	11.09
	250	26.64	11.12
30	300	26.67	11.15

### Bordertown TWS 11 – Constant Rate Discharge Test (3 June 2011)

ordertowi	n TWS 12 – Si	rdertown TWS 12 – Step Drawdown Test (4 June 2011)			
Step	Rate (L/s)	Duration (min)	Depth to Water (m)	Drawdowr (m)	
		0	15.41	0.00	
1	10	1	19.9	4.49	
1		2	20.25	4.84	
1		3	20.35	4.94	
1		4	20.36	4.95	
1	10	5	20.36	4.95	
	10	6			
1			20.37	4.96	
1		7	20.365	4.96	
1		8	20.37	4.96	
1		9	20.37	4.96	
1		10	20.38	4.97	
1	10	12	20.4	4.99	
1		14	20.4	4.99	
1		16	20.4	4.99	
1		18	20.4	4.99	
1	10	20	20.39	4.98	
1		22	20.39	4.98	
1		24	20.4	4.99	
1		26	20.4	4.99	
1		28	20.4	4.99	
1	10	30	20.41	5.00	
1		35	20.42	5.01	
1		40	20.43	5.02	
1		45	20.44	5.03	
1	10	50	20.43	5.02	
1	10	55	20.43	5.02	
1	10	60	20.43	5.02	
2	15	61	23.03	7.62	
2 2		62	23.2	7.79	
		63	23.15	7.74	
2 2		64 65	23.13	7.72	
2		66	23.13	7.72	
2		67	23.08 23.08	7.67 7.67	
2	15	68	23.08	7.67	
2	15	69	23.12	7.71	
2	15	70	23.25	7.84	
2	15	72	23.26	7.85	
2		74	23.05	7.64	
2		76	23.14	7.73	
2	15	78	23.12	7.71	
2		80	23.12	7.71	
2		82	23.13	7.72	
2		84	23.15	7.74	
2	15	86	23.17	7.76	
2		88	23.17	7.76	
2	15	90	23.17	7.76	
2		95	23.17	7.76	
2		100	23.17	7.76	
2		105	23.17	7.76	
2		110	23.17	7.76	
2		115	23.17	7.76	
2	15	120	23.17	7.76	
3	20	121	26.1	10.69	

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3		122	26.06	10.65
3		123	26.07	10.66
3		124	26.1	10.69
3		125	26.08	10.67
3	20	126	26.09	10.68
3		127	26.1	10.69
3		128	26.1	10.69
3		129	26.1	10.69
3	20	130	26.1	10.69
3		132	26.1	10.69
3		134	26.1	10.69
3		136	26.1	10.69
3	20	138	26.1	10.69
3		140	26.1	10.69
3		142	26.1	10.69
3		144	26.1	10.69
3	20	146	26.1	10.69
3		148	26.1	10.69
3		150	26.1	10.69
3	20	155	26.1	10.69
3		160	26.13	10.72
3		165	26.14	10.73
3		170	26.15	10.74
3		175	26.16	10.75
3	20	180	26.16	10.75

#### Bordertown TWS 12 – Constant Rate Discharge Test (5 June 2011)

Rate (L/s)	Duration (min)	DTW (m)	Drawdown (m)
20	0	15.38	0.00
	1	23.82	8.44
	2	24.75	9.37
18-20*	3	23.9	8.52
18-20*	4	24.07	8.69
18-20*	5	23.72	8.34
18-20*	6	23.97	8.59
	7	24.11	8.73
20	8	24.25	8.87
	9	24.6	9.22
	10	25.35	9.97
	12	25.9	10.52
	14	26.06	10.68
	16	26.06	10.68
	18	26.06	10.68
	20	26.055	10.68
20	22	26.06	10.68
	24	26.03	10.65
	26	26.11	10.73
	28	26.12	10.74
	30	26.14	10.76
	35	26.13	10.75
	40	26.16	10.78
20	45	26.15	10.77
	50	26.13	10.75

	55	26.16	10.78
	60	26.18	10.80
	70	26.17	10.79
	80	26.18	10.80
20	90	26.17	10.79
	100	26.19	10.81
	120	26.18	10.80
	140	26.19	10.81
	160	26.18	10.80
	180	26.16	10.78
20	200	26.18	10.80
	250	26.2	10.82
20	300	26.21	10.83

\*Variation in flow rate between 18-20 L/s

#### Penola TWS 7 – Step Drawdown Test (12 August 2011)

		Depth to	Drawdown
Rate (L/s)	Duration (min)	Water (m)	(m)
	0	22.47	0.00
20	1	31.78	9.31
	2	31.1	8.63
	3	31.08	8.61
	4	31.08	8.61
20	5	31.16	8.69
	6	31.21	8.74
	7	31.22	8.75
	8	31.22	8.75
	9	31.24	8.77
	10	31.25	8.78
20	12	31.28	8.81
	14	31.28	8.81
	16	31.26	8.79
	18	31.27	8.80
20	20	31.27	8.80
	22	31.29	8.82
	24	31.295	8.83
	26	31.295	8.83
	28	31.29	8.82
20	30	31.29	8.82
	35	31.31	8.84
	40	31.31	8.84
	45	31.31	8.84
20	50	31.32	8.85
	55	31.34	8.87
20	60	31.35	8.88
25	61	33.6	11.13
	62	33.82	11.35
	63	33.84	11.37
	64	33.88	11.41
	65	33.92	11.45
	66	33.92	11.45
	20 20 20 20 20 20 20 20 20	$egin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$

APPENDIX	ES				
2		67	33.94	11.47	
2	25	68	33.94	11.47	
2		69	33.95	11.48	
2	25	70	33.96	11.49	
2		72	33.97	11.50	
2		74	33.96	11.49	
2		76	33.99	11.52	
2	25	78	34.01	11.54	
2		80	34.02	11.55	
2		82	34.04	11.57	
2		84	34.06	11.59	
2	25	86	34.05	11.58	
2		88	34.06	11.59	
2	25	90	34.06	11.59	
2		95	34.07	11.60	
2		100	34.1	11.63	
2		105	34.13	11.66	
2		110	34.13	11.66	
2		115	34.16	11.69	
2	25	120	34.17	11.70	
3	30	121	36.84	14.37	
3		122	36.9	14.43	
3		123	36.86	14.39	
3		124	36.87	14.40	
3		125	36.875	14.41	
3		126	36.9	14.43	
3		127	36.9	14.43	
3		128	36.92	14.45	
3		129	36.94	14.47	
3	30	130	36.95	14.48	
3		132	36.975	14.51	
3		134	36.98	14.51	
3		136	36.99	14.52	
3		138	37	14.53	
3	30	140	37.02	14.55	
3		142	37.035	14.57	
3		144	37.04	14.57	
3		146	37.05	14.58	
3		148	37.05	14.58	
3	30	150	37.065	14.60	
3		155	37.1	14.63	
3		160	37.12	14.65	
3		165	37.15	14.68	
3		170	37.15	14.68	
3		175	37.175	14.71	
3	30	180	37.19	14.72	

Rate (L/s)	Duration (min)	Depth to Water (m)	Drawdown (m)
30	0	22.47	0.00
	1	35.84	13.37
	2	36.49	14.02
	3	36.64	14.17
	4	36.8	14.33
	5	36.86	14.39
	6	36.89	14.42
	7	36.91	14.44
	8	36.94	14.47
	9	36.98	14.51
30	10	37	14.53
30	10		
		37.04	14.57
	14	37.05	14.58
	16	37.07	14.60
	18	37.1	14.63
	20	37.14	14.67
	22	37.15	14.68
	24	37.17	14.70
	26	37.2	14.73
	28	37.21	14.74
30	30	37.21	14.74
	35	37.24	14.77
	40	37.27	14.80
	45	37.31	14.84
	50	37.343	14.87
	55	37.36	14.89
30	60	37.37	14.90
30	70	37.4	14.93
	80	37.43	14.96
30	90		
50		37.47	15.00
	100	37.49	15.02
	120	37.49	15.02
	140	37.5	15.03
30	160	37.53	15.06
	180	37.55	15.08
30	200	37.56	15.09
	250	37.61	15.14
	300	37.64	15.17
End of Test	360	37.7	15.23
Start of Recovery	361	37.7	15.23
	362	23.18	0.71
	363	22.76	0.29
	364 365	22.72 22.7	0.25 0.23
	365	22.7	0.23
	367	22.68	0.20
	368	22.67	0.19
	369	22.64	0.13
	370	22.63	0.16
	370	22.63	0.16

Penola TWS 7 – Constant Rate Discharge Test (13 August 201	11
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	376	22.61	0.14
	378	22.6	0.13
	380	22.6	0.13
	382	22.59	0.12
	384	22.59	0.12
	386	22.58	0.11
	388	22.58	0.11
	390	22.58	0.11
	395	22.58	0.11
	400	22.58	0.11
	405	22.58	0.11
	410	22.54	0.07
	415	22.54	0.07
End of Recovery	420	22.53	0.06

# F. GROUNDWATER CHEMISTRY DATA



Parameter	Australian D	rinking Water	Borehole	
	Quality Guideline Values		Geranium	Limits of
	Health	Aesthetic	TWS 3	Reporting
pH*	i	6.5-8.5	7.0	n/a
Conductivity**			2640	1
Turbidity***	i	5	0.61	0.1
Colour - Apparent (456nm)****	n	15	2	1
TDS Total Hardness as CaC03	n	500 200	1500	1 2
Alkalinity as CaC03	n	200	621 496	∠ n/a
Bicarbonate			606	n/a
Carbonate			0	n/a
Hydroxide			0	n/a
Calcium			103	0.04
Ammonia (N)	i	0.5	<lor< td=""><td>0.005</td></lor<>	0.005
Nitrate + Nitrite (N)			0.16	0.003
Nitrate + Nitrite (N0 <sub>3</sub> )	50		0.71	0.02
Nitrite (N)	3		<lor< td=""><td>0.003</td></lor<>	0.003
Dissolved Organic Carbon			0.7	0.3
Bromide	15		2.02	0.1
Fluoride Iodide	1.5		0.98	0.1
Chlorine Demand - 24 hrs	0.1		<lor 1.55</lor 	0.05 n/a
Chlorine Demand - 30 minutes	1		2.63	n/a n/a
Chlorine Demand - 8 hrs			1.09	n/a
Total Cyanide	0.08		<lor< td=""><td>0.05</td></lor<>	0.05
Sodium	n	180	370	0.04
Sulphur (Sulphate)	500	250	125	1.5
Gross Alpha Activity*****			0.022	0.005
Gross Beta Activity*****			<lor< td=""><td>0.01</td></lor<>	0.01
Langelier Index			0.11	
Metals/Metalloids				
Aluminium - Acid Soluble	i	0.2	<lor< td=""><td>0.001</td></lor<>	0.001
Aluminium - Soluble Aluminium - Total			<lor< td=""><td>0.001</td></lor<>	0.001
Antimony - Soluble and Total	0.003		0.001 <lor< td=""><td>0.001 0.0005</td></lor<>	0.001 0.0005
Arsenic - Soluble	0.003		0.0005	0.0003
Arsenic - Total	0.007		0.0006	0.0003
Barium - Soluble			0.0050	0.0005
Barium - Total	0.7		0.0048	0.0005
Beryllium - Soluble and Total	i		<lor< td=""><td>0.0003</td></lor<>	0.0003
Boron - Soluble			0.298	0.02
Cadmium - Soluble and Total	0.002		<lor< td=""><td>0.001</td></lor<>	0.001
Chromium - Soluble			0.0020	0.0001
Chromium - Total	0.05		0.0024	0.0001
Copper - Soluble and Total	2	1	<lor< td=""><td>0.0001</td></lor<>	0.0001
Iron - Soluble Iron - Total		0.2	0.0033	0.0005
Lead - Soluble	i	0.3	0.0160 <lor< td=""><td>0.0005 0.0001</td></lor<>	0.0005 0.0001
Lead - Total	0.01		0.0001	0.0001
Magnesium - Total	0.01		88.4	0.04
Manganese - Soluble			0.0072	0.0001
Manganese - Total	0.5	0.1	0.0070	0.0001
Mercury - Soluble and Total	0.001		<lor< td=""><td>0.00003</td></lor<>	0.00003
Molybdenum - Soluble and Total	0.05		0.0003	0.0001
Nickel - Soluble			0.0004	0.0001
Nickel - Total	0.02		0.0005	0.0001
Potassium - Total	1		12.5	0.04
Selenium - Soluble	0.01		0.0036	0.0001
Selenium - Total Silver - Soluble and Total	0.01		0.0037	0.0001
Tin - Soluble and Total	0.1 i		<lor< td=""><td>0.00003</td></lor<>	0.00003
Uranium - Soluble and Total	0.02		<lor 0.0013</lor 	0.0005 0.0001
Zinc - Soluble	0.02		0.00750	0.0001
Zinc - Total	i	5	0.00810	0.0003
Acidic Based Herbicides	Various	Various	<lor< td=""><td>Various</td></lor<>	Various
OrganoChlorine Pesticides	Various	Various	<lor< td=""><td>Various</td></lor<>	Various
Organophosphorous and Triazine Pesticides	Various	Various	<lor< td=""><td>Various</td></lor<>	Various

i - Insufficient data to set a guideline value based on health considerations.

n - listed as not necessary in ADWG

All results reported as mg/L unless stated otherwise <LOR - indicated all analytes in category were below limits of detection, and so not shown



Parameter		rinking Water	Borehole	Borehole	
	Quality Guideline Values		Bordertown TWS 10	Bordertown TWS 10	Limits of Reporting
	Health	Aesthetic	(28 Apr 2011)	(10 Aug 2011)^	Reporting
pH*	i	6.5-8.5	7.1		n/a
Conductivity**			911		1
Turbidity***	i	5	7.8		0.1
Colour - Apparent (456nm)****	n	15	87		1
TDS	n	500	500		1
Total Hardness as CaC03	n	200			2
Alkalinity as CaC0 <sub>3</sub>			315		n/a
Bicarbonate Carbonate			384		n/a
Hydroxide			0		n/a n/a
Calcium			79.6		0.04
Ammonia (N)	i	0.5	0.062		0.004
Nitrate + Nitrite (N)		0.0	0.024		0.003
Nitrate + Nitrite (N03)	50		0.110		0.02
Nitrite (N)	3		0.110		0.003
Dissolved Organic Carbon	-		1.100		0.3
Bromide			0.240		0.1
Fluoride	1.5		0.190		0.1
Iodide	0.1		<0.05		0.05
Chlorine Demand - 24 hrs			11.020	1.090	n/a
Chlorine Demand - 30 minutes			3.070	0.620	n/a
Chlorine Demand - 8 hrs			10.430	1.760	n/a
Total Cyanide	0.08		<0.05		0.05
Sodium	n	180	70.7		0.04
Sulphur (Sulphate)	500	250	?		1.5
Gross Alpha Activity****			<0.005		0.005
Gross Beta Activity****			<0.010		0.01
Langelier Index			0.000		
Metals/Metalloids Aluminium - Acid Soluble		0.2	0.00200		0.001
Aluminium - Acid Soluble Aluminium - Soluble	i	0.2	0.00200 <0.001		0.001 0.001
Aluminium - Total			0.025		0.001
Antimony - Soluble and Total	0.003		<0.0005		0.0005
Arsenic - Soluble	0.000		0.0022	0.0011	0.0003
Arsenic - Total	0.007		0.0039	0.0019	0.0003
Barium - Soluble			0.0358		0.0005
Barium - Total	0.7		0.0387		0.0005
Beryllium - Soluble and Total	i		<0.0003		0.0003
Boron - Soluble			0.120		0.02
Cadmium - Soluble and Total	0.002		<0.0001		0.001
Chromium - Soluble			<0.0001		0.0001
Chromium - Total	0.05		0.0001		0.0001
Copper - Soluble and Total	2	1	0.0128		0.0001
Iron - Soluble			0.0017	0.0010	0.0005
Iron - Total	i	0.3	0.7996	0.3517	0.0005
Lead - Soluble			<0.0001		0.0001
Lead - Total	0.01		0.0006		0.0001
Magnesium - Total			15.8		0.04
Manganese - Soluble	0.5	0.1	0.0130		0.0001
Manganese - Total Marguny - Soluble and Total	0.5	0.1	0.0167		0.0001
Mercury - Soluble and Total Molybdenum - Soluble and Total	0.001 0.05		<0.00003 0.0002		0.00003 0.0001
Nickel - Soluble	0.05		0.0002		0.0001
Nickel - Total	0.02		0.0001		0.0001
Potassium - Total	0.02		4.77		0.0001
Selenium - Soluble			0.00100		0.0001
Selenium - Total	0.01		0.00090		0.0001
Silver - Soluble and Total	0.1		<0.00003		0.00003
Tin - Soluble and Total	i		<0.00003		0.0005
Uranium - Soluble and Total	0.02		0.00040		0.0001
Zinc - Soluble			0.03080		0.0003
1	i	5	0.02910		0.0003
Zinc - Total			1		1
Zinc - Total Acidic Based Herbicides	Various	Various	<lor< td=""><td></td><td>Various</td></lor<>		Various
	Various Various	Various Various	<lor <lor< td=""><td></td><td>Various Various</td></lor<></lor 		Various Various

n - listed as not necessary in ADWG ^Only select analytes tested for repeat sampling

 \* - unitless

 \* - μS/cm

 \*\*\* - NTU (nephelometric turbidity units)

 \*\*\*\* - HU (Hazen Units)

- Use Control of the control of t



Parameter	Australian D	rinking Water	Borehole	
	Quality Guideline Values		Bordertown	Limits of
	Health	Aesthetic	TWS 11	Reporting
pH*	i	6.5-8.5	7	n/a
Conductivity**			994	1
Turbidity***	i	5	0.47	0.1
Colour - Apparent (456nm)****	n	15		1
TDS	n	500	550	1
Total Hardness as CaC03	n	200		2
Alkalinity as CaC0 <sub>3</sub>			290	n/a
Bicarbonate Carbonate			354	n/a
			0.00	n/a
Hydroxide Calcium			0.00 56.50	n/a 0.04
Ammonia (N)	i	0.5	0.01	0.04
Nitrate + Nitrite (N)	1	0.5	0.01	0.003
Nitrate + Nitrite (N03)	50		0.16	0.003
Nitrite (N)	3		0.10	0.002
Dissolved Organic Carbon	Ű		0.60	0.3
Bromide			0.45	0.1
Fluoride	1.5		0.47	0.1
Iodide	0.1		<0.05	0.05
Chlorine Demand - 24 hrs			0.60	n/a
Chlorine Demand - 30 minutes			0.82	n/a
Chlorine Demand - 8 hrs			0.56	n/a
Total Cyanide	0.08		<0.05	0.05
Sodium	n	180	93.70	0.04
Sulphur (Sulphate)	500	250	20.40	1.5
Gross Alpha Activity*****			<0.005	0.005
Gross Beta Activity*****			<0.01	0.01
Langelier Index	L		0.00	
Metals/Metalloids				
Aluminium - Acid Soluble	i	0.2	0.00100	0.001
Aluminium - Soluble			<0.001	0.001
Aluminium - Total			<0.001	0.001
Antimony - Soluble and Total	0.003		< 0.0005	0.0005
Arsenic - Soluble Arsenic - Total	0.007		< 0.0003	0.0003
Barium - Soluble	0.007		<0.0003 0.0120	0.0003 0.0005
Barium - Total	0.7		0.0120	0.0005
Beryllium - Soluble and Total	i		< 0.0003	0.0003
Boron - Soluble	•		0.122	0.02
Cadmium - Soluble and Total	0.002		< 0.0001	0.001
Chromium - Soluble			< 0.0001	0.0001
Chromium - Total	0.05		< 0.0001	0.0001
Copper - Soluble and Total	2	1	0.0008	0.0001
Iron - Soluble			0.0033	0.0005
Iron - Total	i	0.3	0.0152	0.0005
Lead - Soluble			<0.0001	0.0001
Lead - Total	0.01		<0.0001	0.0001
Magnesium - Total			26.3	0.04
Manganese - Soluble			0.0004	0.0001
Manganese - Total	0.5	0.1	0.0003	0.0001
Mercury - Soluble and Total	0.001		<0.00003	0.00003
Molybdenum - Soluble and Total	0.05		0.0003	0.0001
Nickel - Soluble			0.0012	0.0001
Nickel - Total	0.02		0.0014	0.0001
Potassium - Total			5.27	0.04
Selenium - Soluble	0.01		0.0004	0.0001
Selenium - Total	0.01		0.0004	0.0001
Silver - Soluble and Total	0.1		< 0.00003	0.00003
Tin - Soluble and Total Uranium - Soluble and Total	i 0.02		0.0005	0.0005
Zinc - Soluble	0.02		0.0031	0.0001
Zinc - Soluble Zinc - Total	i	5	0.00810 0.00870	0.0003 0.0003
Acidic Based Herbicides	Various	5 Various	<lor< td=""><td>Various</td></lor<>	Various
OrganoChlorine Pesticides	Various	Various	<lor <lor< td=""><td>Various</td></lor<></lor 	Various
Organophosphorous and Triazine Pesticides	Various	Various	<lor <lor< td=""><td>Various</td></lor<></lor 	Various
i - Insufficient data to set a guideline value based on health considerations	vailuus	vailuus	LON	various

i - Insufficient data to set a guideline value based on health considerations.

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Parameter	Australian Drinking Water Boreh		Borehole	
	Quality Guideline Values		Bordertown	Limits of
	Health	Aesthetic	<b>TWS 12</b>	Reporting
pH*	i	6.5-8.5	7.3	n/a
Conductivity**			903	1
Turbidity***	i	5	0.40	0.1
Colour - Apparent (456nm)****	n	15	2	1
TDS	n	500	500	1
Total Hardness as CaC03	n	200		2
Alkalinity as CaC0 <sub>3</sub>			292	n/a
Bicarbonate Carbonate			357	n/a
			0	n/a
Hydroxide Calcium			0 58.50	n/a 0.04
Ammonia (N)	i	0.5	0.007	0.04
Nitrate + Nitrite (N)		0.5	0.034	0.003
Nitrate + Nitrite (N03)	50		0.150	0.003
Nitrite (N)	3		0.150	0.002
Dissolved Organic Carbon	5		0.7	0.000
Bromide			0.350	0.0
Fluoride	1.5		0.37	0.1
lodide	0.1		< 0.05	0.05
Chlorine Demand - 24 hrs			1.30	n/a
Chlorine Demand - 30 minutes			1.45	n/a
Chlorine Demand - 8 hrs			1.69	n/a
Total Cyanide	0.08		<0.05	0.05
Sodium	n	180	87	0.04
Sulphur (Sulphate)	500	250	16.50	1.5
Gross Alpha Activity*****			<0.005	0.005
Gross Beta Activity*****			0.04	0.01
Langelier Index			0.00	
Metals/Metalloids				
Aluminium - Acid Soluble	i	0.2	0.001	0.001
Aluminium - Soluble			<0.001	0.001
Aluminium - Total			0.002	0.001
Antimony - Soluble and Total	0.003		< 0.0005	0.0005
Arsenic - Soluble Arsenic - Total	0.007		< 0.0003	0.0003
Barium - Soluble	0.007		< 0.0003	0.0003
Barium - Total	0.7		0.0204 0.0209	0.0005 0.0005
Beryllium - Soluble and Total	0.7 i		<0.0209	0.0003
Boron - Soluble	1		0.117	0.0003
Cadmium - Soluble and Total	0.002		<0.0001	0.001
Chromium - Soluble	01002		< 0.0001	0.0001
Chromium - Total	0.05		< 0.0001	0.0001
Copper - Soluble and Total	2	1	0.0005	0.0001
Iron - Soluble			0.0016	0.0005
Iron - Total	i	0.3	0.0156	0.0005
Lead - Soluble			<0.0001	0.0001
Lead - Total	0.01		<0.0001	0.0001
Magnesium - Total			23.3	0.04
Manganese - Soluble			0.0004	0.0001
Manganese - Total	0.5	0.1	0.0004	0.0001
Mercury - Soluble and Total	0.001		<0.00003	0.00003
Molybdenum - Soluble and Total	0.05		0.0003	0.0001
Nickel - Soluble			0.0005	0.0001
Nickel - Total	0.02		0.0005	0.0001
Potassium - Total			4.84	0.04
Selenium - Soluble	0.01		0.0007	0.0001
Selenium - Total	0.01		0.0007	0.0001
Silver - Soluble and Total	0.1		< 0.00003	0.00003
Tin - Soluble and Total Uranium - Soluble and Total	i 0.02		< 0.0005	0.0005
Zinc - Soluble	0.02		0.0019	0.0001
Zinc - Total	i	5	0.0072 0.01	0.0003 0.00
Acidic Based Herbicides	Various	Various	<lor< td=""><td>Various</td></lor<>	Various
OrganoChlorine Pesticides	Various	Various	<lor <lor< td=""><td>Various</td></lor<></lor 	Various
Organophosphorous and Triazine Pesticides	Various	Various	<lor <lor< td=""><td>Various</td></lor<></lor 	Various
organophosphorous and mazine resultides	vailuus	v ai iUUS	<b>NLON</b>	vailuus

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Quality Guideline Values         Penota TWS         R           pH*         Health         Aesthetic         7.10           Conductivity**         i         5         9.30           Turbidity**         i         5         9.30           Tots         n         150         90         336           Atkainity as CaC0.         n         200         336           Bicarbonate         0.00         4414         444           Carbonate         0.00         69.10         300           Calcium         6.30         0.01         6.30         0.01           Ammonia (N)         i         0.5         0.064         0.00           Nitrate + Nitrite (NO.)         50         0.16         0.16         0.16           Nitrate + Nitrite (NO.)         50         0.1         -0.05         1.131           Total Cyanide         0.08         -0.05         -1.31         -0.05           Fluoride         1.5         0.20         -0.05         -1.31         -0.05           Fluoride         1.5         0.20         -0.05         -1.31         -0.05           Sodium         n         180         -0.05         -0.05         <	Parameter	Australian D	rinking Water	Borehole	Linte C
Preatm         Attract         7.           Conductivity**         i         6.5.8.5         7.100           Colour Apparent (456nm)****         n         15         89           TOS         n         500         630           Atkainity as CaC0.         n         200         336           Bicarbonate         0.000         340           Bicarbonate         0.000         340           Catbonate         0.000         340           Hydroxide         0.000         99.10           Armonia (N)         i         0.5         0.076           Nitrate + Nitrite (NO)         50         0.16         0.16           Nitrate + Nitrite (NO)         50         0.16         0.35           Fluoride         1.5         0.20         1.31           Total Cyanide         0.1         -0.05         1.31           Total Cyanide         0.08         -0.05         1.32           Choirine Demand - 24 hrs         1.32         1.36         -0.05           Choirine Demand - 30 minutes         1.32         -0.06         1.35         -0.006           Sodium         n         180         1.360         -0.05         -0.006		Ű			Limits of
Conductivity**         i         5         9.30           Colour - Apparent (456nm)****         n         15         89           TDS         n         500         680           TDS         n         200         336           Alkalinity as CaC0s         n         200         336           Bicarbonate         414         200         336           Mittate + Nitrite (NO         0.00         99.10         300           Sicarbonate         0.00         99.10         300           Mittate + Nitrite (NOs)         50         0.04         99.10           Nitrate + Nitrite (NOs)         50         0.16         Nitrite (NOs)           Storide         0.5         0.04         0.06           Elocitide         1.5         0.20         106           Bromide         0.1         <0.05				7.	Reporting
Turbidity***         i         5         9.30           Colour - Apparent (456m)****         n         500         680           TDS         n         500         680           Total Hardness as CaC03         n         200         336           Makalinity as CaCo.         340         340           Bicarbonate         0.00         340           Carbonate         0.00         340           Hydroxide         0.00         0.00           Calcium         99.10         340           Mirrate + Nitrite (N)         i         0.5         0.076           Nitrate + Nitrite (NOs)         50         0.16         0.16           Nitrate + Nitrite (NOs)         3         0.20         0.35           Flouride         1.5         0.20         0.36           Flouride         0.1         <0.05		i	6.5-8.5	7.10	n/a
Colour - Apparent (456nm)****         n         15         83           TDS         n         500         680           Total Hardness as CaC03         n         200         336           Alkalinity as CaC0.         340         340           Bicarbonate         414         680         340           Carbonate         99.10         340         99.10           Ammonia (N)         i         0.5         0.076         0.01           Nitrate + Nitrite (N0)         50         0.16         0.16         0.16           Nitrate + Nitrite (N0)         3         0.25         0.20         103           Dissolved Organic Carbon         1.5         0.20         103         0.20           Bromide         0.1         -0.05         1.13         1.22         Choirne Demand - 24 hrs         1.22         1.35.0         0.05         300         1.35.0         1.35.0         0.05         300         1.35.0         1.35.0         1.35.0         1.35.0         1.35.0         1.35.0         1.35.0         1.35.0         1.35.0         1.35.0         1.35.0         1.35.0         1.35.0         1.35.0         1.35.0         1.35.0         1.35.0         1.35.0         1.35.0					1
TDS         n         500         630           Totk Hardness as CaC03         n         200         336           Makinity as CaC0.         n         200         336           Bicarbonate         0.00         340           Carbonate         0.00         0.00           Hydroxide         0.00         0.00           Carbonate         0.00         0.00           Mirrate Nirrite (NO)         50         0.16           Nitrate Nirrite (NO)         50         0.16           Dissolved Organic Carbon         1.5         0.20           Bromide         0.1         <0.05			-		0.1
Total Hardness as CaC03         n         200         336           Alkalinity as CaC0.         340         340           Bicarbonate         0.00         340           Carbonate         0.00         340           Mitrate Nitrite (N)         i         0.5         0.076           Nitrate + Nitrite (N0:)         50         0.16         0.11           Dissolved Organic Carbon         50         0.16         1.5           Bromide         0.1         -0.05         1.74           Chorine Demand - 24 hrs         1.5         0.20         1.51           Chorine Demand - 30 minutes         1.51         0.20         1.51           Chorine Demand - 4 hrs         1.52         Chorine Demand - 8 hrs         1.52           Chorine Demand - 4 hrs         1.50         0.005         3.00           Sodium         n         180         108.00         50           Sulphur (Sulphate)         500         250         13.50         Gross Alpha Activity*****         -0.001           Alurninum - Soluble         1         0.2         -0.001         Alurninum - Soluble         -0.001           Alurninum - Soluble         0.007         0.0007         0.0007         Barson - 0.0001			-		1
Alkalinity as CaC0.       340         Bicarbonate       414         Carbonate       414         Carbonate       0.00         Hydroxide       0.00         Calcium       1       0.5         Armonia (N)       i       0.5         Nitrate + Nitrite (No)       50       0.16         Nitrate + Nitrite (No)       3       1         Dissolved Organic Carbon       0.35       1.5       0.20         Bromide       1.5       0.20       1.5       0.20         Iodide       1.5       0.20       1.5       0.20         Iodide       0.1       -0.05       5       5         Choirne Demand - 24 hrs       1.5       1.52       1.52         Choirne Demand - 30 minutes       1.52       -0.05       5         Sodium       n       180       108.00       5         Sulphur (Sulphate)       500       250       13.50       -0.05         Gross Alpha Activity*****       -0.01       -0.001       -0.001       -0.001         Aluminium - Soluble       0.003       -0.001       -0.001       -0.001         Aluminium - Soluble       0.007       0.0007       -0.001	-				1
Bicarbonate         414           Carbonate         0.00           Calcum         0.00           Calcum         99.10           Ammonia (N)         i         0.5           Nitrate + Nitrite (No)         50         0.44           Nitrate + Nitrite (No)         50         0.44           Nitrate + Nitrite (No)         50         0.44           Nitrate + Nitrite (No)         50         0.41           Nitrate + Nitrite (No)         50         0.41           Sisolved Organic Carbon         5         0.20           Bromide         0.1         <0.05		n	200		2
Carbonate         0.00         0.00           Hydroxide         0.00         0.00           Calcium         i         0.5         0.076           Armonia (N)         i         0.5         0.076           Nitrate + Nitrite (No)         50         0.16           Nitrate + Nitrite (No)         3         0.35           Fluoride         1.5         0.20           Iodide         0.1         -0.05           Chlorine Demand - 24 hrs         1.51         0.20           Chlorine Demand - 30 minutes         1.52         1.81           Chorine Demand - 8 hrs         1.81         1.52           Chorine Demand - 30 minutes         0.08         -0.05           Sodium         n         180         108.00           Sulphur (Sulphate)         500         250         13.50           Gross Apha Activity*****         -0.001         -0.001         -0.001           Alurinium - Soluble Activity*****         -0.003         -0.003         -0.003           Arsenic - Total         0.007         0.0007         Barium - Total         -0.001           Alurinium - Soluble and Total         0.05         -0.001         -0.003           Barium - Soluble and Total <td></td> <td></td> <td></td> <td></td> <td>n/a</td>					n/a
hydroxide         0.00         99.10           Calcium         i         0.5         0.076           Nitrate + Nitrite (N0)         50         0.16         0.16           Nitrate + Nitrite (N0)         50         0.16         0.16           Nitrate + Nitrite (N0)         3         0.55         0.24           Dissolved Organic Carbon         0.1         <0.05					n/a
Calcium         99.10           Armmonia (N)         i         0.5         0.076           Nitrate + Nitrite (N)         50         0.16           Nitrate + Nitrite (N)         3					n/a
Ammonia (N)         i         0.5         0.076           Nitrate + Nitrite (N)         50         0.04           Nitrate + Nitrite (NOs)         50         0.16           Nitrate + Nitrite (NOs)         3         0.35           Bromide         0.35         0.20           Iodide         1.5         0.20           Iodide         0.1         <0.05					n/a 0.04
Nitrate + Nitrite (N)         50         0.4           Nitrate + Nitrite (No)         3         50         0.16           Dissolved Organic Carbon         3         50         0.35           Fluoride         1.5         0.20         0.35           Fluoride         0.1         <0.05		i	0.5		0.04
Nitrate (N0:3)         50         0.16           Nitrite (N)         3         0.35           Bromide         0.35           Fluoride         1.5         0.20           Iodide         0.1         <0.05		1	0.5		0.003
Nittrie (N)         3		50			0.003
Dissolved Organic Carbon         0.35           Bromide         1.5         0.20           Iodide         0.1         <.0.05				0.10	0.02
Bromide         0.35           Fluoride         1.5         0.20           Iodide         0.1         -0.05           Chlorine Demand - 24 hrs         1.52         -0.05           Chlorine Demand - 30 minutes         1.52         -0.05           Chlorine Demand - 8 hrs         1.81         -0.05           Sodium         n         180         108.00           Sulphur (Sulphate)         500         250         13.50           Gross Beta Activity****         -0.005         -0.005         -0.005           Gross Beta Activity*****         -0.01         -0.001         -0.001           Langelier Index         -0.007         -0.001         -0.001           Alurninum - Soluble         -0.007         0.0006         -0.006           Arsenic - Total         0.007         0.0007         0.0007           Barium - Total         0.07         0.0007         0.0007           Barium - Soluble         0.022         -0.001         -0.001           Chromium - Soluble and Total         0.002         -0.001         -0.002           Boron - Total         0.005         -0.0001         -0.0001         -0.0001           Chromium - Soluble and Total         0.05 <t< td=""><td></td><td>Ū</td><td></td><td></td><td>0.3</td></t<>		Ū			0.3
Fluoride         1.5         0.20           Iodide         0.1         -0.05           Chlorine Demand - 24 hrs         1.74           Chlorine Demand - 30 minutes         1.81           Chlorine Demand - 8 hrs         0.08           Total Cyanide         0.08           Sodium         n           Sulphur (Sulphate)         500           Gross Alpha Activity*****         -0.005           Langelier Index         -0.01           Aurminium - Acid Soluble         i         0.2           Alurninium - Soluble         -0.001           Alurninium - Soluble         -0.007         -0.001           Alurninium - Soluble         0.003         -0.0004           Arsenic - Soluble         0.007         0.0007           Arsenic - Soluble         0.7         0.0303           Barium - Soluble and Total         0.002         -0.001           Arsenic - Soluble         0.022         -0.001           Chromium - Soluble and Total         0.07         0.0303           Beryllium - Soluble and Total         0.05         -0.0001           Chromium - Soluble         0.01         -0.0001           Chromium - Soluble and Total         0.05         -0.0001      <	0			0.35	0.0
lodide         0.1         -0.05           Chlorine Demand - 24 hrs         1.74           Chlorine Demand - 30 minutes         1.52           Chlorine Demand - 8 hrs         1.81           Total Cyanide         0.08         -0.05           Sodium         n         180         108.00           Sulphur (Sulphate)         500         250         13.50           Gross Beta Activity*****         -0.01         -0.005         -0.01           Langelier Index         0.07         Metals/Metalloids         -0.01           Aluminium - Acid Soluble         i         0.2         -0.001           Aluminium - Soluble         0.007         0.0007         -0.001           Aluminium - Soluble and Total         0.007         0.0007         -0.001           Arsenic - Soluble         0.02         -0.001         -0.003           Barium - Soluble and Total         0.07         0.0007         Barium - Soluble         0.122           Chromium - Total         0.002         -0.001         -0.0001           Chromium - Soluble and Total         0.05         -0.0001           Chromium - Soluble and Total         0.05         -0.0001           Chromium - Soluble         0.01         -0.0001		1.5			0.1
Chlorine Demand - 24 hrs         1.74           Chlorine Demand - 30 minutes         1.52           Chlorine Demand - 30 minutes         1.81           Total Cyanide         0.08         -0.05           Sodium         n         180         108.00           Sulphur (Sulphate)         500         250         13.50           Gross Alpha Activity*****         -0.005         -0.005           Langelier Index         -0.01         -0.001           Aluminium - Acid Soluble         i         0.2         -0.001           Aluminium - Soluble         -0.001         -0.001         -0.001           Aluminium - Soluble         0.007         -0.001         -0.001           Aluminium - Soluble         0.007         -0.001         -0.006           Arsenic - Soluble         0.007         -0.003         -0.0005           Barium - Soluble         0.007         0.0303         -0.0003           Boron - Soluble         0.007         -0.0303         -0.0001           Chromium - Total         0.05         -0.001         -0.001           Chromium - Soluble and Total         0.05         -0.001         -0.0001           Chromium - Soluble and Total         0.05         -0.001         -		-			0.05
Chlorine Demand - 30 minutes         1.52           Chlorine Demand - 8 hrs         1.81           Total Cyanide         0.08           Sodium         n           Sodium (Sulphate)         500           Gross Alpha Activity****         -0.005           Gross Beta Activity*****         -0.007           Langelier Index         -0.07           Metals/Metalloids         -0.07           Aluminium - Acid Soluble         i         0.2           Aluminium - Total         -0.001           Aluminium - Soluble and Total         0.003         -0.006           Arsenic - Total         0.007         0.0007           Barium - Soluble         0.77         0.0303           Beryllium - Soluble and Total         0.02         -0.001           Arsenic - Total         0.07         0.0003           Born - Soluble         -0.02         -0.0001           Chromium - Soluble and Total         0.02         -0.0001           Chromium - Soluble         -0.02         -0.0001					n/a
Chlorine Demand - 8 hrs         1.81           Total Cyanide         0.08           Sodium         n           Sulphur (Sulphate)         500           Sulphat Activity*****         -0.05           Gross Sela Activity*****         -0.01           Langelier Index         0.07           Metals/Metalloids         -0.01           Aluminium - Acid Soluble         i         0.2           Aluminium - Soluble         -0.003           Arsenic - Total         0.003         -0.0005           Arsenic - Soluble         0.003         -0.0005           Arsenic - Total         0.007         0.0303           Barium - Soluble and Total         0.7         0.0303           Bernium - Soluble         0.122         -0.001           Cadmium - Soluble and Total         0.002         -0.0001           Chromium - Soluble         0.122         -0.0001           Chromium - Soluble and Total         0.002         -0.0001           Chromium - Soluble         0.025         -0.0001           Chromium - Soluble and Total         0.01         -0.0001           Iron - Total         1         0.3         0.8842           Lead - Soluble and Total         0.01         -0.0					n/a
Sodium         n         180         108.00           Sulphur (Sulphate)         500         250         13.50           Gross Alpha Activity*****         -         -         -           Gross Alpha Activity*****         -         -         -           Langelier Index         -         -         0.07         -           Metals/Metalloids         -         -         -         0.07           Aluminium - Soluble         i         0.2         -         0.001           Aluminium - Soluble and Total         0.003         -         -         0.006           Arsenic - Soluble         0.007         0.0007         0.0007           Barium - Soluble and Total         0.7         0.0303         -           Beryllium - Soluble and Total         0.002         -         -           Barium - Soluble and Total         0.05         -         -           Chromium - Soluble and Total         0.05         -         -           Chromium - Soluble and Total         2         1         0.001           Chromium - Soluble and Total         2         1         0.001           Chromium - Soluble and Total         0.01         -         -           Ir	Chlorine Demand - 8 hrs			1.81	n/a
Sodium         n         180         108.00           Sulphur (Sulphate)         500         250         13.50           Gross Alpha Activity****         -         -         -           Langelier Index         -         0.07         -           Metals/Metalloids         -         -         -           Aluminium - Acid Soluble         i         0.2         -         -           Aluminium - Soluble and Total         0.003         -         -         -           Aluminium - Soluble and Total         0.007         0.0006         -         -           Arsenic - Soluble         0.007         0.0007         Barium - Total         0.0296         -           Barium - Soluble and Total         i         -         -         -         -           Boron - Soluble and Total         0.002         -         -         -         -           Chromium - Total         0.05         -         -         -         -         -           Iron - Soluble and Total         2         1         0.0001         -         -         -         -         -         -         -         -         -         -         -         -         -         - </td <td></td> <td>0.08</td> <td></td> <td></td> <td>0.05</td>		0.08			0.05
Gross Alpha Activity*****          <0.005		n	180	108.00	0.04
Gross Beta Activity*****          <0.01	Sulphur (Sulphate)	500	250	13.50	1.5
Langelier Index         0.07           MetalS/Metalloids         i         0.2         <0.001				< 0.005	0.005
Metals/Metalloids         i         0.2         <0.001           Aluminium - Acid Soluble         i         0.2         <0.001	Gross Beta Activity*****			<0.01	0.01
Aluminium - Acid Soluble         i         0.2         <0.001           Aluminium - Soluble         -0.001         <0.001	Langelier Index			0.07	
Aluminium - Soluble       -0.001         Aluminium - Total       0.003         Arsenic - Soluble and Total       0.007         Arsenic - Soluble       0.007         Arsenic - Soluble       0.007         Barium - Total       0.007         Barium - Total       0.7         Beryllium - Soluble and Total       0.7         Boron - Soluble and Total       0.002         Cadmium - Soluble and Total       0.002         Cromium - Soluble and Total       0.002         Chromium - Soluble and Total       0.002         Chromium - Total       0.005         Copper - Soluble       -0.0001         Chromium - Total       0.01         Iron - Soluble       -0.0001         Chromium - Total       0.05         Iron - Total       0.01         Iron - Total       -0.001         Vanganese - Soluble       -0.001         Lead - Soluble       -0.001         Manganese - Total       0.05         Manganese - Total       0.05         Molybdenum - Soluble and Total       0.05         Nickel - Soluble       0.001         Nickel - Soluble       0.001         Nickel - Soluble and Total       0.02 <tr< td=""><td></td><td></td><td></td><td></td><td></td></tr<>					
Aluminium - Total       -0.003       -0.005         Antimony - Soluble and Total       0.003       -0.0005         Arsenic - Total       0.007       0.0007         Barium - Soluble       0.7       0.0303         Beryllium - Soluble and Total       0.7       0.0303         Beryllium - Soluble and Total       0.7       0.0303         Boron - Soluble       0.122       -0.0001         Cadmium - Soluble and Total       0.002       -0.0001         Chromium - Soluble and Total       0.002       -0.0001         Chromium - Soluble and Total       0.005       -0.0001         Copper - Soluble and Total       0.05       -0.0001         Iron - Soluble       i       0.3       0.8842         Lead - Soluble       i       0.3       0.8842         Lead - Soluble       0.01       -0.0001       -0.0001         Magnese - Soluble       0.5       0.1       -0.0001         Magnapaese - Soluble and Total       0.05       0.0002       0.0012         Marganese - Soluble and Total       0.05       0.0002       0.0012         Molybdenum - Soluble and Total       0.05       0.0002       0.0012         Nickel - Soluble       0.02       0.0014       <		i	0.2		0.001
Antimony - Soluble and Total       0.003       -0.0005         Arsenic - Soluble       0.0007       0.0006         Arsenic - Total       0.007       0.0007         Barium - Soluble       0.7       0.0303         Beryllium - Soluble and Total       i       -0.0003         Born - Soluble       0.002       -0.0001         Chromium - Soluble and Total       0.002       -0.0001         Chromium - Soluble       0.005       -0.0001         Chromium - Soluble and Total       0.05       -0.0001         Chromium - Total       0.05       -0.0001         Chromium - Total       0.05       -0.0001         Iron - Soluble       0.05       -0.0001         Iron - Total       0.01       -0.0953         Iron - Total       0.01       -0.0001         Lead - Soluble       -0.011       -0.0001         Manganese - Total       0.5       0.1       0.0112         Manganese - Total       0.05       0.0002       0.0012         Nickel - Soluble and Total       0.05       0.0002       0.0012         Nickel - Total       0.05       0.0002       0.0012         Nickel - Total       0.02       0.0014       0.0004       0.0004				<0.001	0.001
Arsenic - Soluble       0.007       0.0006         Arsenic - Total       0.007       0.0007         Barium - Soluble       0.7       0.0303         Beryllium - Soluble and Total       0.7       0.0303         Boron - Soluble       0.122       0.0001         Chromium - Soluble and Total       0.002       -0.0001         Chromium - Soluble       0.002       -0.0001         Chromium - Soluble and Total       0.05       -0.0001         Corper - Soluble and Total       2       1       0.0001         Copper - Soluble       0.0953       -0.0001       -0.0001         Iron - Total       i       0.3       0.8842       -0.0001         Lead - Soluble       0.01       -0.0001       -0.0001         Magnesium - Total       0.01       -0.0001       -0.0001         Magnese - Soluble       0.01       -0.0003       0.001         Magnese - Soluble and Total       0.05       0.0002       0.012         Nickel - Soluble and Total       0.05       0.0002       0.0012         Nickel - Soluble and Total       0.02       0.0014       -0.0003         Nickel - Soluble       0.02       0.0014       -0.0004       -0.0004       -0.0004					0.001
Arsenic - Total       0.007       0.0007         Barium - Soluble       0.7       0.0333         Beryllium - Soluble and Total       i          Boron - Soluble       0.122          Cadmium - Soluble and Total       0.002       <0.0001		0.003			0.0005
Barium - Soluble         0.0296           Barium - Total         0.7         0.0303           Beryllium - Soluble and Total         i             Boron - Soluble         0.002         <0.0001					0.0003
Barium - Total         0.7         0.0303           Beryllium - Soluble and Total         i		0.007			0.0003
Beryllium - Soluble and Total         i         - <th-< td=""><td></td><td></td><td></td><td></td><td>0.0005</td></th-<>					0.0005
Boron - Soluble         0.122           Cadmium - Soluble and Total         0.002         <0.0001		-			0.0005
Cadmium - Soluble and Total         0.002         <0.0001	5	I			0.0003
Chromium - Soluble       -0.001         Chromium - Total       0.05       <0.001		0.002			0.02 0.0001
Chromium - Total         0.05         <0.0001           Copper - Soluble and Total         2         1         0.0001           Iron - Soluble         i         0.3         0.8842           Lead - Soluble         i         0.3         0.8842           Lead - Soluble         0.01         <0.0001		0.002			0.0001
Copper - Soluble and Total         2         1         0.0001           Iron - Soluble         i         0.3         0.8842           Lead - Soluble         i         0.3         0.8842           Lead - Soluble         0.01         <0.0001		0.05			0.0001
Iron - Soluble         0.0953           Iron - Total         i         0.3         0.8842           Lead - Soluble         -         -         -         -         -         -         -         0.0001           Lead - Total         0.01         <0.0001			1		0.0001
Iron - Total         i         0.3         0.8842           Lead - Soluble	••	2	'		0.0001
Lead - Soluble         -0.0001           Lead - Total         0.01         <0.0001		i	0.3		0.0005
Lead - Total       0.01       <0.0001			0.0		0.0003
Magnesium - Total       21.4         Manganese - Soluble       0.0172         Manganese - Total       0.5       0.1       0.0181         Mercury - Soluble and Total       0.001       <0.0003		0.01			0.0001
Manganese - Soluble         0.0172           Manganese - Total         0.5         0.1         0.0181           Mercury - Soluble and Total         0.001         <0.00003					0.04
Manganese - Total         0.5         0.1         0.0181           Mercury - Soluble and Total         0.001         <0.0003					0.0001
Mercury - Soluble and Total         0.001         <0.0003         0           Molybdenum - Soluble and Total         0.05         0.0002         0.0012           Nickel - Soluble         0.02         0.0014         0.0014           Nickel - Total         0.02         0.0014         3.36           Selenium - Soluble         0.01         0.0004         0.0004           Selenium - Total         0.01         0.0004         0.0004           Silver - Soluble and Total         0.1         <0.00003	5	0.5	0.1		0.0001
Molybdenum - Soluble and Total         0.05         0.0002           Nickel - Soluble         0.0012         0.0012           Nickel - Total         0.02         0.0014           Potassium - Total         3.36         3.36           Selenium - Soluble         0.01         0.0004           Selenium - Total         0.01         0.0004           Selenium - Total         0.1         0.0004           Silver - Soluble and Total         0.1         <0.00003	•				0.00003
Nickel - Total         0.02         0.0014           Potassium - Total         3.36         3.36           Selenium - Soluble         0.0004         0.0004           Selenium - Total         0.01         0.0004           Selenium - Total         0.01         0.0004           Silver - Soluble and Total         0.1         <0.0003					0.0001
Potassium - Total         3.36           Selenium - Soluble         0.0004           Selenium - Total         0.01         0.0004           Selenium - Total         0.01         0.0004           Silver - Soluble and Total         0.1         <0.0003	Nickel - Soluble			0.0012	0.0001
Selenium - Soluble         0.0004           Selenium - Total         0.01         0.0004           Silver - Soluble and Total         0.1         <0.0003	Nickel - Total	0.02		0.0014	0.0001
Selenium - Total         0.01         0.0004           Silver - Soluble and Total         0.1         <0.0003				3.36	0.04
Silver - Soluble and Total         0.1         <0.0003				0.0004	0.0001
Strontium         0.72520           Tin - Soluble and Total         i         0.0005           Uranium - Soluble and Total         0.02         <0.0001		0.01		0.0004	0.0001
Tin - Soluble and Total         i         0.0005           Uranium - Soluble and Total         0.02         <0.0011		0.1		<0.00003	0.00003
Uranium - Soluble and Total         0.02         <0.0001				0.72520	0.0001
Zinc - Soluble         0.0029           Zinc - Total         i         5         0.0035           Acidic Based Herbicides         Various         Various         <         I		i		0.0005	0.0005
Zinc - Total     i     5     0.0035       Acidic Based Herbicides     Various     Various <lor< td=""></lor<>		0.02		<0.0001	0.0001
Acidic Based Herbicides Various Various <lor< td=""><td></td><td></td><td></td><td></td><td>0.0003</td></lor<>					0.0003
					0.0003
OrganoChlorine Pesticides Various Various <lor< td=""><td></td><td></td><td></td><td></td><td>Various</td></lor<>					Various
	OrganoChlorine Pesticides	Various	Various	<lor< td=""><td>Various</td></lor<>	Various
Organophosphorous and Triazine Pesticides Various Various <lor< td=""><td></td><td>Various</td><td>Various</td><td><lor< td=""><td>Various</td></lor<></td></lor<>		Various	Various	<lor< td=""><td>Various</td></lor<>	Various

I - Insufficient data to set a guideline value based on health considerations. n - listed as not necessary in ADWG \* - unitless \*\* - μS/cm \*\*\* - NTU (nephelometric turbidity units) \*\*\*\* - HU (Hazen Units) \*\*\*\*\* - Bq/L All results reported as moll unless stated otherwise

All results reported as mg/L unless stated otherwise
<LOR - indicated all analytes in category were below limits of detection, and so not shown</p>

# **UNITS OF MEASUREMENT**

### Units of measurement commonly used (SI and non-SI Australian legal)

Name of unit	Symbol	Definition in terms of other metric units	Quantity
day	d	24 h	time interval
gigalitre	GL	10 <sup>6</sup> m <sup>3</sup>	volume
gram	g	10 <sup>-3</sup> kg	mass
hectare	ha	$10^4 m^2$	area
hour	h	60 min	time interval
kilogram	kg	base unit	mass
kilolitre	kL	1 m <sup>3</sup>	volume
kilometre	km	10 <sup>3</sup> m	length
litre	L	10 <sup>-3</sup> m <sup>3</sup>	volume
megalitre	ML	10 <sup>3</sup> m <sup>3</sup>	volume
metre	m	base unit	length
microgram	μg	10 <sup>-6</sup> g	mass
microlitre	μL	10 <sup>-9</sup> m <sup>3</sup>	volume
milligram	mg	10 <sup>-3</sup> g	mass
millilitre	mL	10 <sup>-6</sup> m <sup>3</sup>	volume
millimetre	mm	10 <sup>-3</sup> m	length
minute	min	60 s	time interval
second	S	base unit	time interval
tonne	t	1000 kg	mass
year	У	365 or 366 days	time interval

#### **Shortened forms**

- ~ approximately equal to
- bgs below ground surface
- BNS below natural surface
- EC electrical conductivity (µS/cm)
- K hydraulic conductivity (m/d)
- pH acidity

# GLOSSARY

Ambient — The background level of an environmental parameter (eg. a measure of water quality such as salinity)

Aquifer — An underground layer of rock or sediment that holds water and allows water to percolate through

**Aquifer, confined** — Aquifer in which the upper surface is impervious (see 'confining layer') and the water is held at greater than atmospheric pressure; water in a penetrating well will rise above the surface of the aquifer

Aquifer test — A hydrological test performed on a well, aimed to increase the understanding of the aquifer properties, including any interference between wells, and to more accurately estimate the sustainable use of the water resources available for development from the well

**Aquifer, unconfined** — Aquifer in which the upper surface has free connection to the ground surface and the water surface is at atmospheric pressure

AWQC — Australian Water Quality Centre

Bore — See 'well'

**Cone of depression** — An inverted cone-shaped space within an aquifer caused by a rate of groundwater extraction that exceeds the rate of recharge; continuing extraction of water can extend the area and may affect the viability of adjacent wells, due to declining water levels or water quality

**Depth to Water** - The distance from a reference point (such as top of well casing) to the top of the water table (unconfined aquifer) or potentiometric surface (confined aquifer). See also standing water level.

DFW — Department for Water (Government of South Australia)

**DOC** — Dissolved Organic Carbon

**Drawdown** — the difference between the initial groundwater level and the groundwater level recorded during a pumping test

**EC** — Electrical conductivity; 1 EC unit = 1 micro-Siemen per centimetre ( $\mu$ S/cm) measured at 25°C; commonly used as a measure of water salinity as it is quicker and easier than measurement by TDS

**Groundwater** — Water occurring naturally below ground level or water pumped, diverted and released into a well for storage underground; see also 'underground water'

**Heavy metal** — Any metal with a high atomic weight (usually, although not exclusively, greater than 100), for example mercury, lead and chromium. Heavy metals have widespread industrial uses, and many are released into the biosphere via air, water and solids pollution. Usually these metals are toxic at low concentrations to most plant and animal life.

**Hydraulic conductivity (K)** — A measure of the ease of flow through aquifer material: high K indicates low resistance, or high flow conditions; measured in metres per day

**Hydrogeology** — The study of groundwater, which includes its occurrence, recharge and discharge processes, and the properties of aquifers; see also 'hydrology'

**Hydrology** — The study of the characteristics, occurrence, movement and utilisation of water on and below the Earth's surface and within its atmosphere; see also 'hydrogeology'

**m AHD** — Defines elevation in metres (m) according to the Australian Height Datum (AHD)

**Observation well** — A narrow well or piezometer whose sole function is to permit water level measurements

Potable water — Water suitable for human consumption such as drinking or cooking water

**Potentiometric head** — The potentiometric head or surface is the level to which water rises in a well due to water pressure in the aquifer, measured in metres (m); also known as piezometric surface

**Production well** — The pumped well in an aquifer test, as opposed to observation wells; a wide-hole well, fully developed and screened for water supply, drilled on the basis of previous exploration wells

#### GLOSSARY

**Reduced standing water level (RSWL)** – the standing water level referenced to the Australian Height Datum (m AHD)

SA Water — South Australian Water Corporation (Government of South Australia)

**Specific storage (S**<sub>s</sub>) — Specific storativity; the amount of stored water realised from a unit volume of aquifer per unit decline in head; it is dimensionless

**Specific yield (S<sub>y</sub>)** — The volume ratio of water that drains by gravity, to that of total volume of the porous medium. It is dimensionless

**Standing Water Level (SWL)** – The distance from the ground level to the top of the water table (unconfined aquifer) or potentiometric surface (confined aquifer).

T — Transmissivity; a parameter indicating the ease of groundwater flow through a metre width of aquifer section (taken perpendicular to the direction of flow), measured in m<sup>2</sup>/d

TDS — Total dissolved solids, measured in milligrams per litre (mg/L); a measure of water salinity

**Tertiary aquifer** — A term used to describe a water-bearing rock formation deposited in the Tertiary geological period (1–65 million years ago)

**TKN** — Total Kjeldahl Nitrogen; the sum of aqueous ammonia and organic nitrogen; used as a measure of probable sewage pollution

**TN** — Total nitrogen

**TOC** — Total organic carbon

**TP** — Total phosphorus

**Transmissivity (T)** — A parameter indicating the ease of groundwater flow through a metre width of aquifer section

**Turbidity** — The cloudiness or haziness of water (or other fluid) caused by individual particles that are too small to be seen without magnification, thus being much like smoke in air; measured in Nephelometric Turbidity Units (NTU)

**Underground water (groundwater)** — Water occurring naturally below ground level or water pumped, diverted or released into a well for storage underground

**Water quality data** — Chemical, biological, and physical measurements or observations of the characteristics of surface and groundwaters, atmospheric deposition, potable water, treated effluents, and wastewater, and of the immediate environment in which the water exists

**Well** — (1) An opening in the ground excavated for the purpose of obtaining access to underground water. (2) An opening in the ground excavated for some other purpose but that gives access to underground water. (3) A natural opening in the ground that gives access to underground water

# REFERENCES

Hazel CP, 1975, 'Groundwater Hydraulics', Lectures material, The Irrigation and Water Supply Commission, Queensland.