TECHNICAL REPORT

SOUTH EAST TOWN WATER SUPPLIES – GERANIUM, BORDERTOWN AND PENOLA

2011/24

Government of South Australia
Department for Water

SOUTH EAST TOWN WATER SUPPLIES—GERANIUM, BORDERTOWN AND PENOLA

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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.

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

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	50 m	18 m	25 m	25 m	140 m
Casing type	Class 12 PVC	Class 12 PVC	Class 12 PVC	Class 12 PVC	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

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.
[#]Includes interference of ~1m from Bordertown TWS 12; [##]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.

Table 2. Geranium town water supply well details

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

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.

Table 3. Bordertown town water supply well details

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

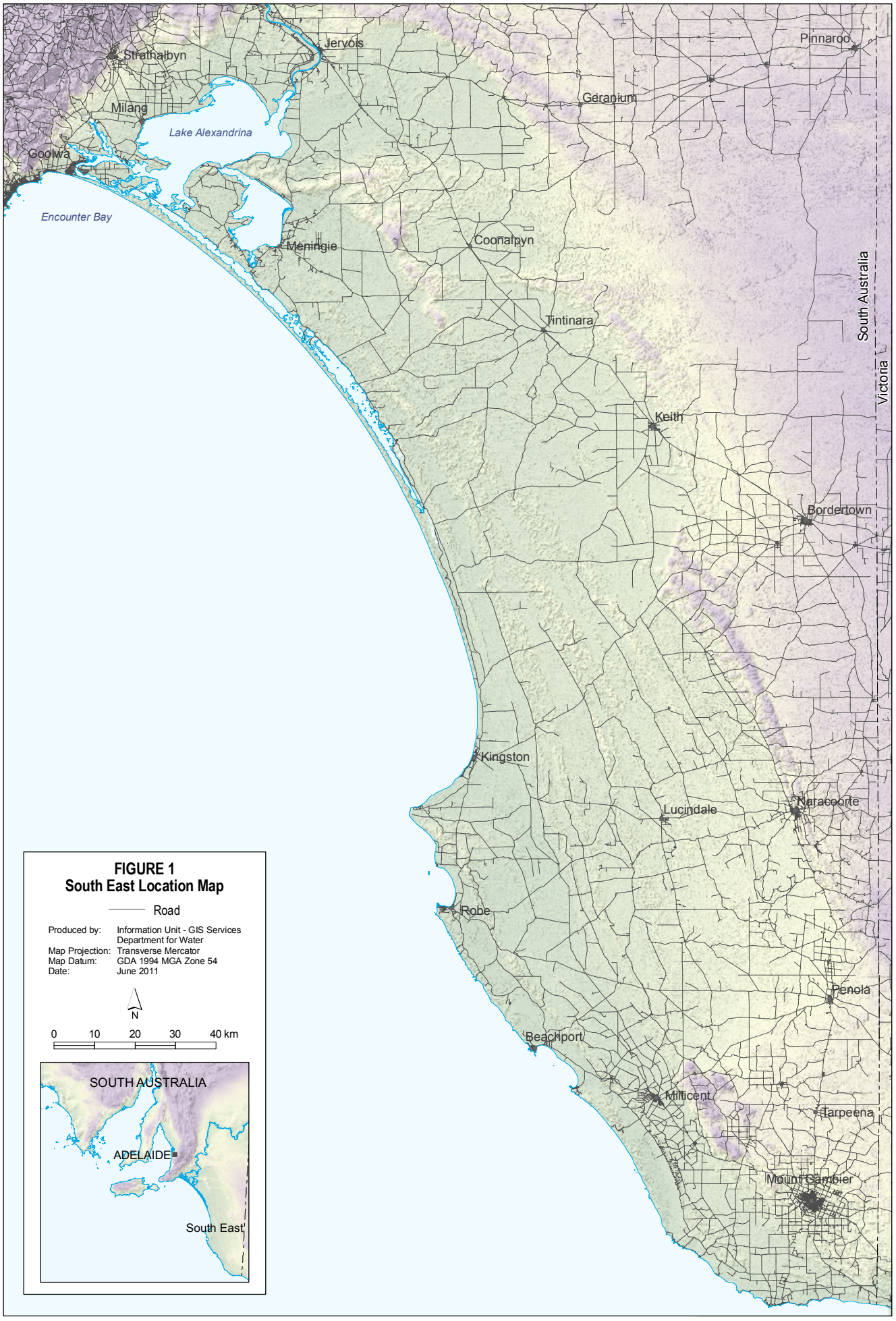
*Well deepened from 22.5 m to 40.0 m in Oct-1980
^Well deepened from 22.86 to 40.0 m in Sep-1980
**Well rehabilitated on 28 May 2011
Note: Bordertown 2, 5 and 7 were backfilled on 28 June 2011.

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


Jervois
Strathalbyn
Milang
Lake Alexandrina
Goolwa
Encounter Bay
Meningie
Coonalpyn
Tintinara
Keith
Bordertown
Pinnaroo
Geranium
South Australia
Victoria
Kingston
Lucindale
Naracoorte
Robe
Penola
Beachport
Millicent
Tarpeena
Mount Gambier
FIGURE 1
South East Location Map
Road
Produced by: Information Unit - GIS Services
Department for Water
Map Projection: Transverse Mercator
Map Datum: GDA 1994 MGA Zone 54
Date: June 2011
N
0 10 20 30 40 km
SOUTH AUSTRALIA
ADELAIDE
South East
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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.

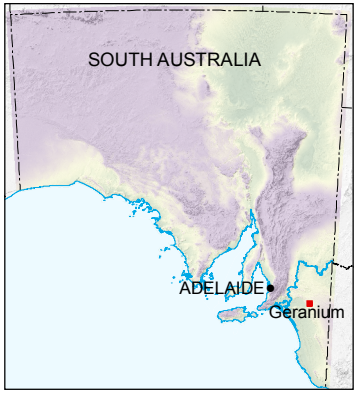
FIGURE 2
Geranium Groundwater Well Infrastructure

- **New TWS Well**
- **Existing TWS Well**

N

0 150 300 450 600 750
Metres

Produced by:	Department for Water Information Unit - GIS Services
Map Projection:	Transverse Mercator
Map Datum:	GDA 1994 South Australian Lamberts
Date:	September 2011
Map Sheet:	1:50,000 Topographic



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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.

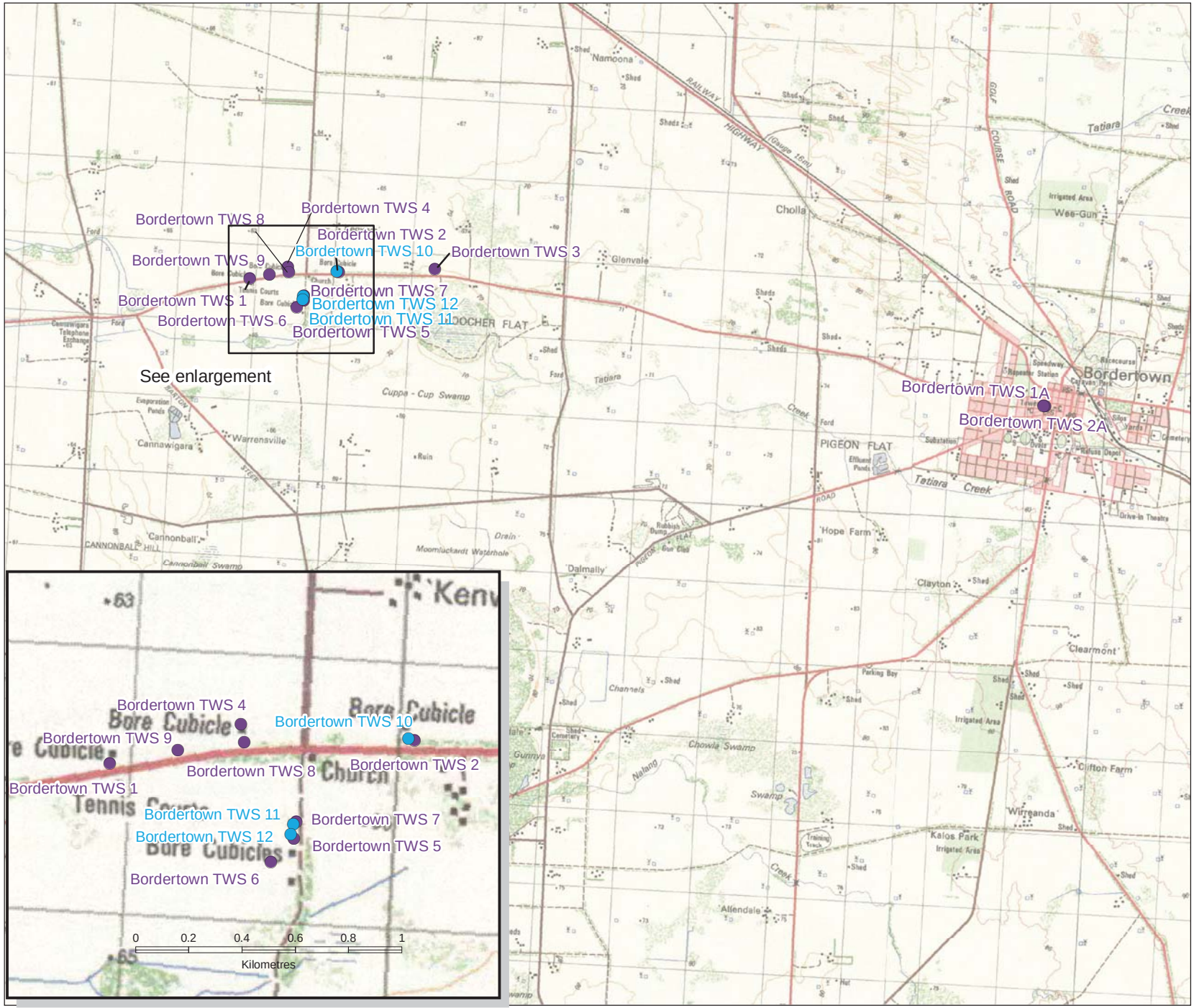

FIGURE 3
Bordertown Groundwater Well Infrastructure

- New TWS Well
- Existing TWS Well

Produced by: Department for Water
Information Unit - GIS Services
Map Projection: Transverse Mercator
Map Datum: GDA 1994 South Australian Lamberts
Date: September 2011
Map Sheet: 1:50,000 Topographic

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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 pre-ordered, 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.

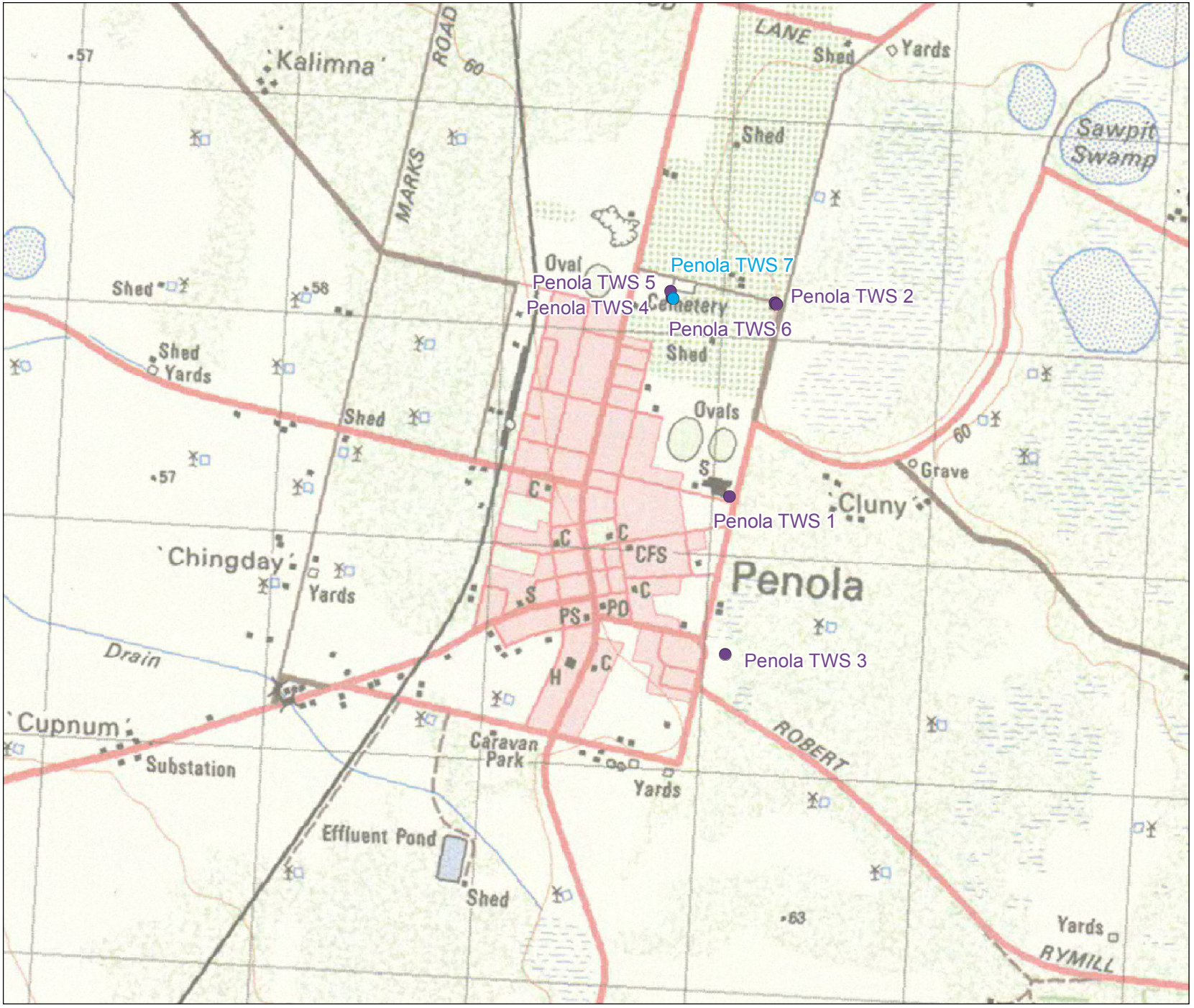

FIGURE 4
Penola Groundwater
Well Infrastructure

- New TWS Well
- Existing TWS Well

N

0 0.2 0.4 0.6 0.8 1

Kilometres

Produced by:	Department for Water Information Unit - GIS Services
Map Projection:	Transverse Mercator
Map Datum:	GDA 1994 South Australian Lamberts
Date:	September 2011
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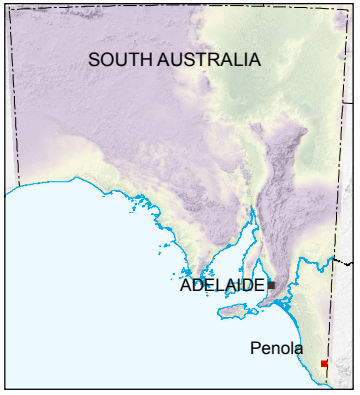

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3. PUMPING TESTS

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.

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

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

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_3, Cl, F, SO_4, hardness and alkalinity
- pH, colour and turbidity
- nutrients: NH_4, NO_3, NO_2, 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).

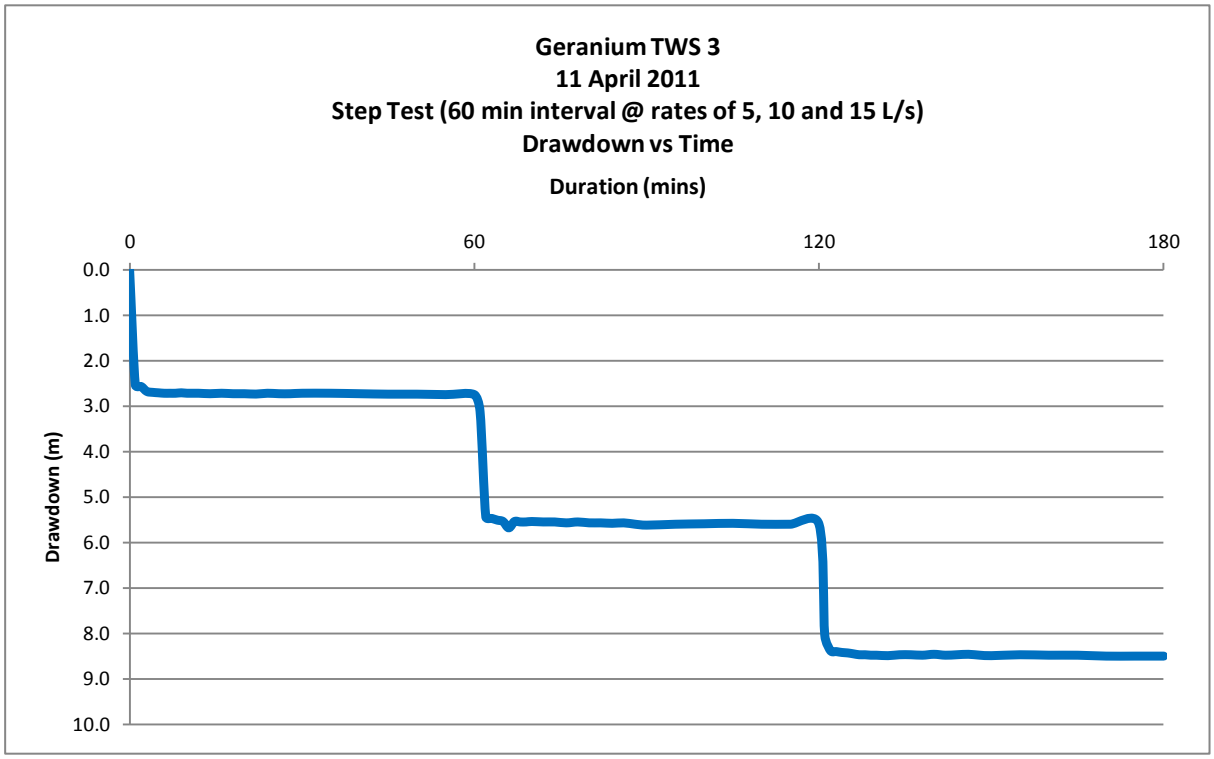
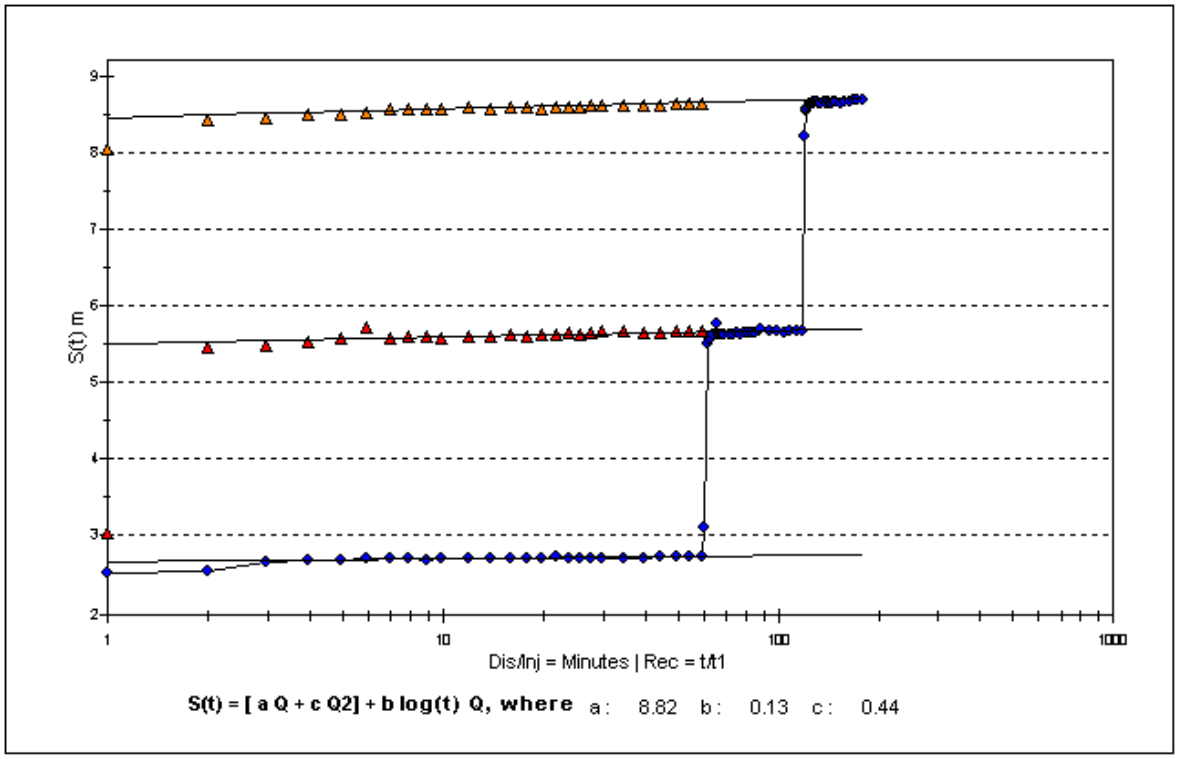


Figure 5. Step drawdown test data for Geranium TWS 3



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	5.00	0.30	60	2.68	8.93	2.72	9.07	2.76	9.20	0.04	0.13	1976
2	10.00	0.60	60	5.44	9.06	5.52	9.20	5.60	9.33	0.08	0.13	1976
3	15.00	0.90	60	8.29	9.21	8.40	9.33	8.51	9.45	0.11	0.12	2156

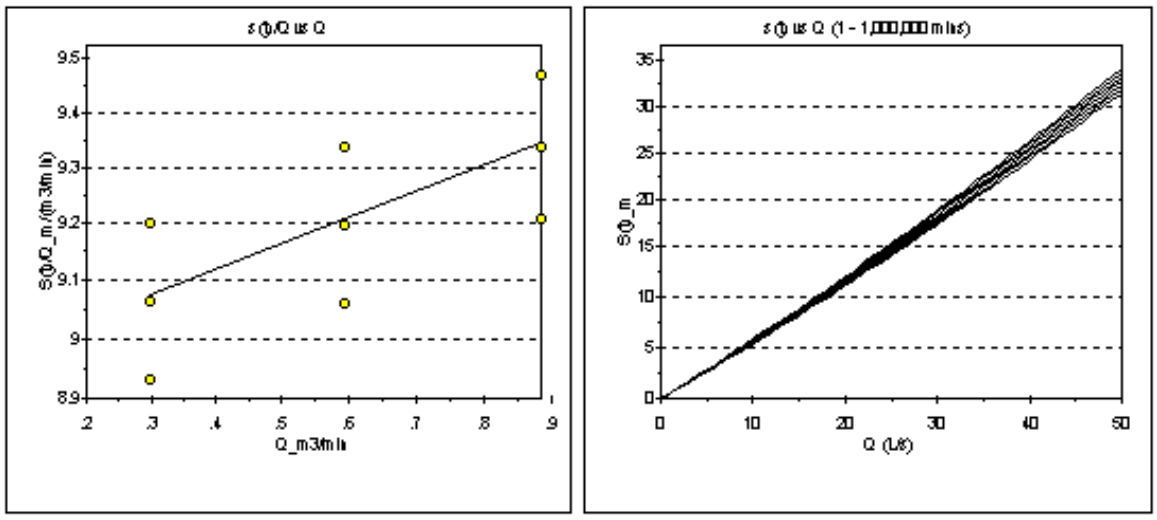


Figure 6. Step drawdown test analysis using Hazel Method for Geranium TWS 3

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

$$s(t) = 8.82\,Q + 0.44\,Q^2 + 0.13 \log (t)\,Q \qquad \textbf{Equation (1)}$$

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

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 m^2/d.

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

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

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.

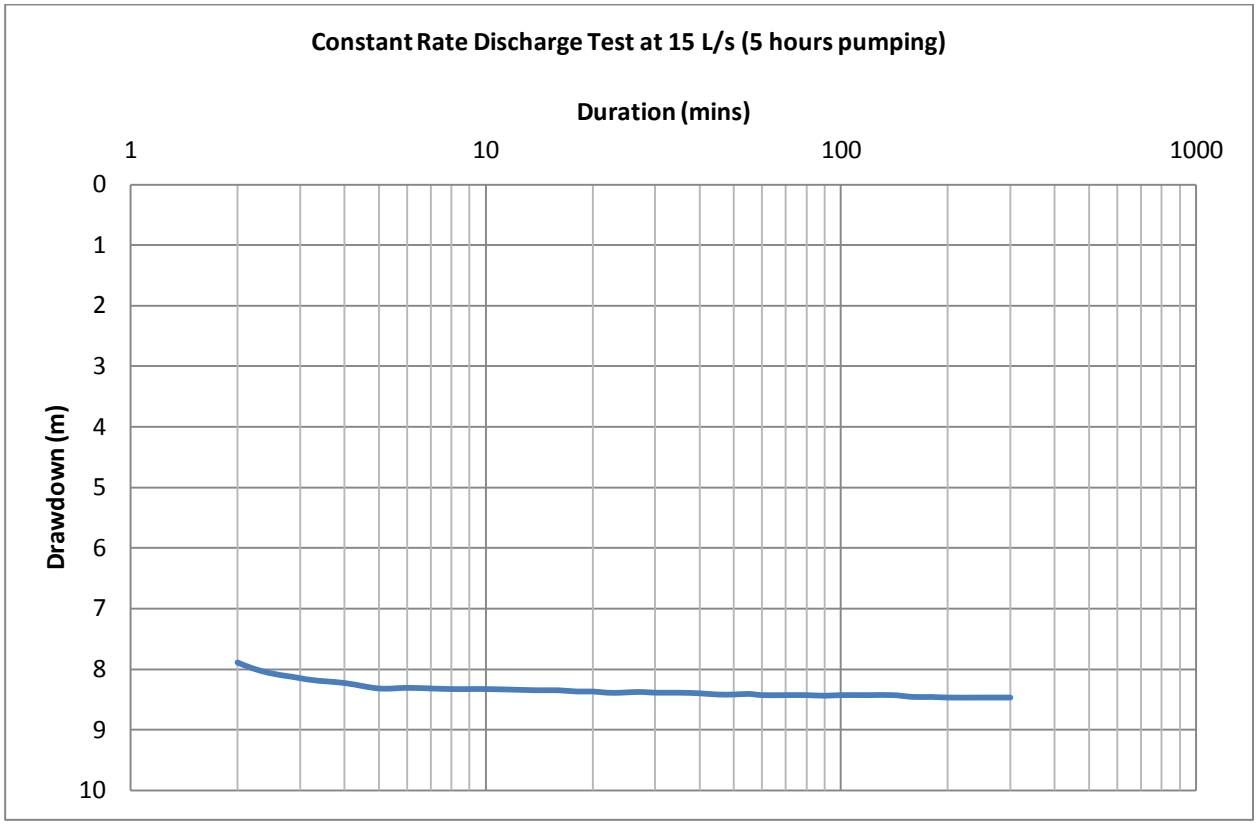


Figure 7. Log-linear plot of constant rate discharge test data for Geranium TWS 3

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^2/d, which is similar to the analysis obtained from step testing (1976 m^2/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 µs/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).

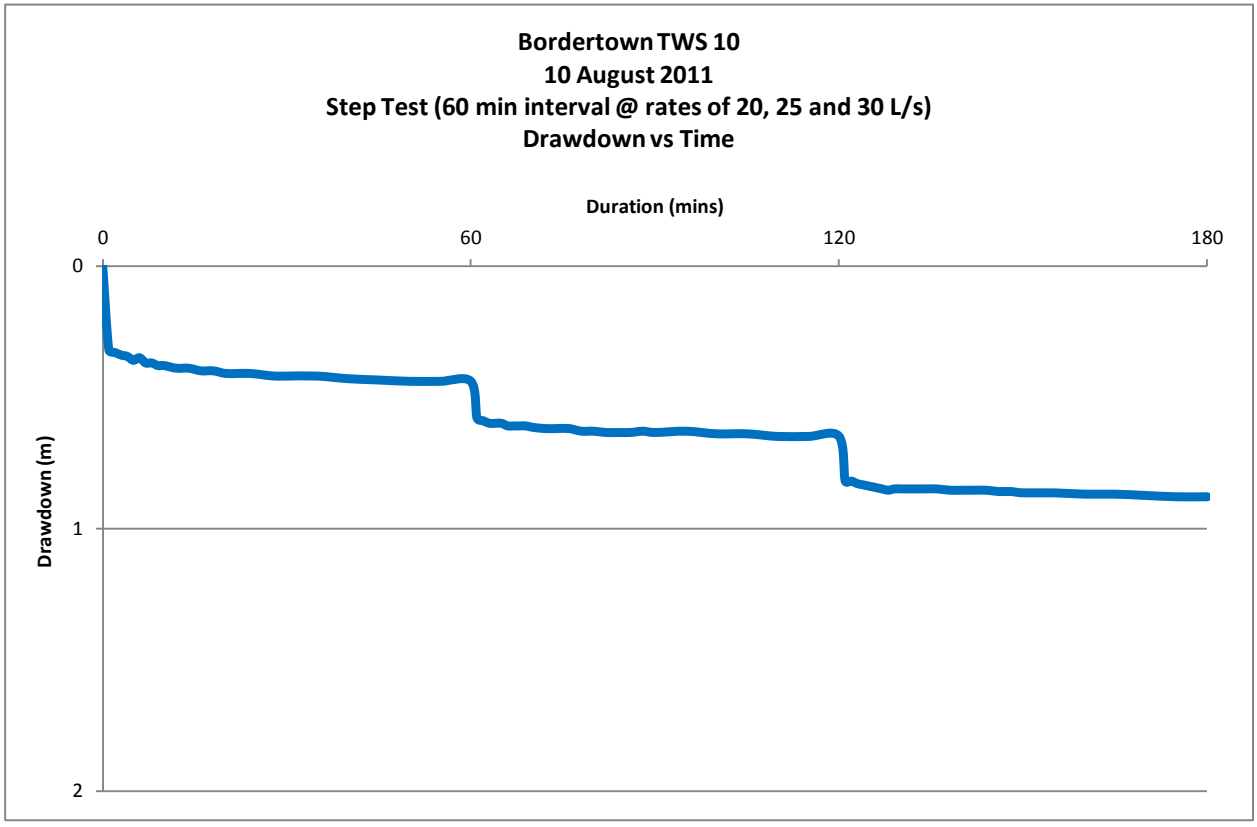
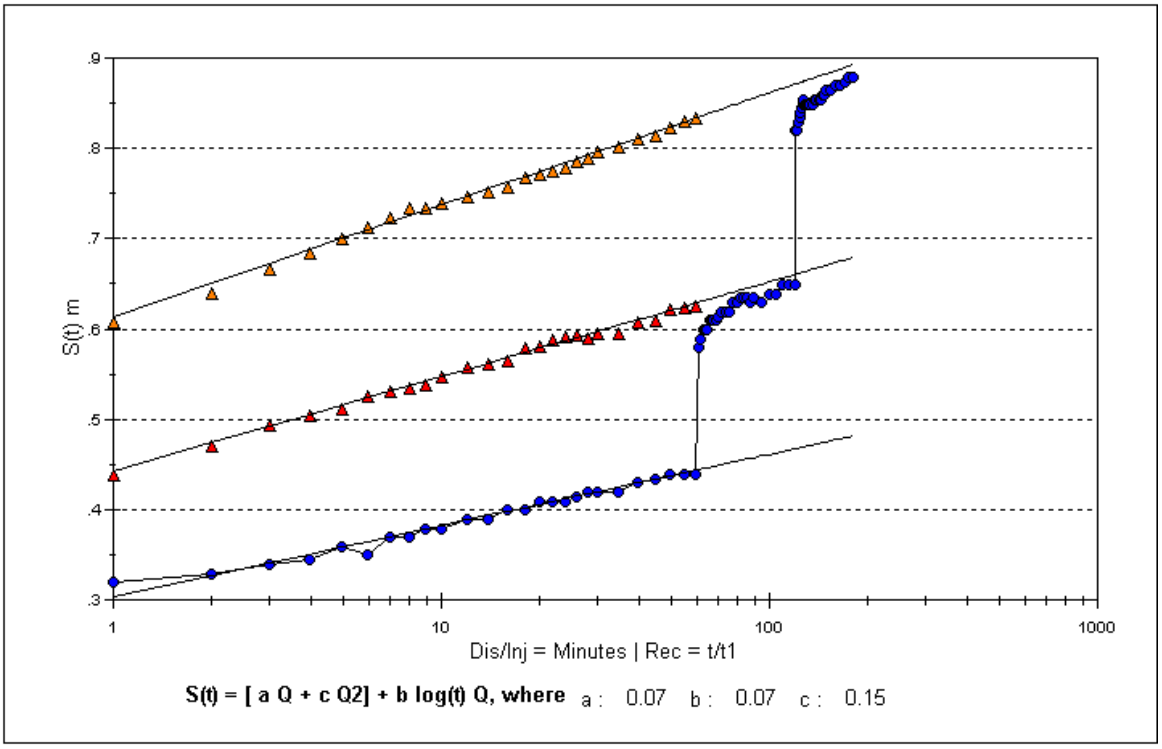


Figure 8. Step drawdown test data for Bordertown TWS 10



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

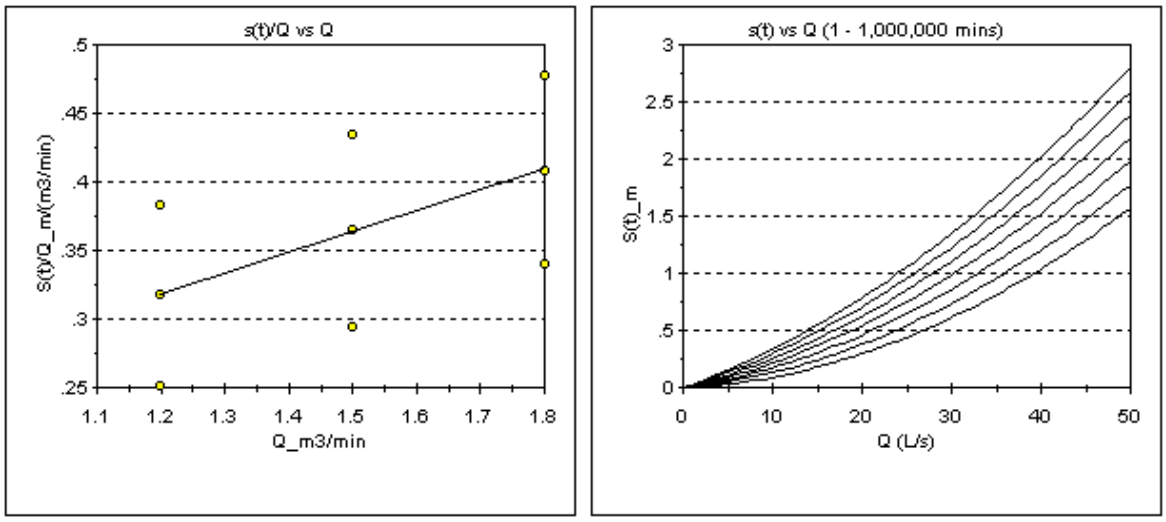


Figure 9. Step drawdown test analysis using Hazel Method for Bordertown TWS 10

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

$s(t) = 0.07\ Q + 0.15\ Q^2 + 0.07 \log (t)\ Q$ **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 ~3,900 m^2/d.

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

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

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.

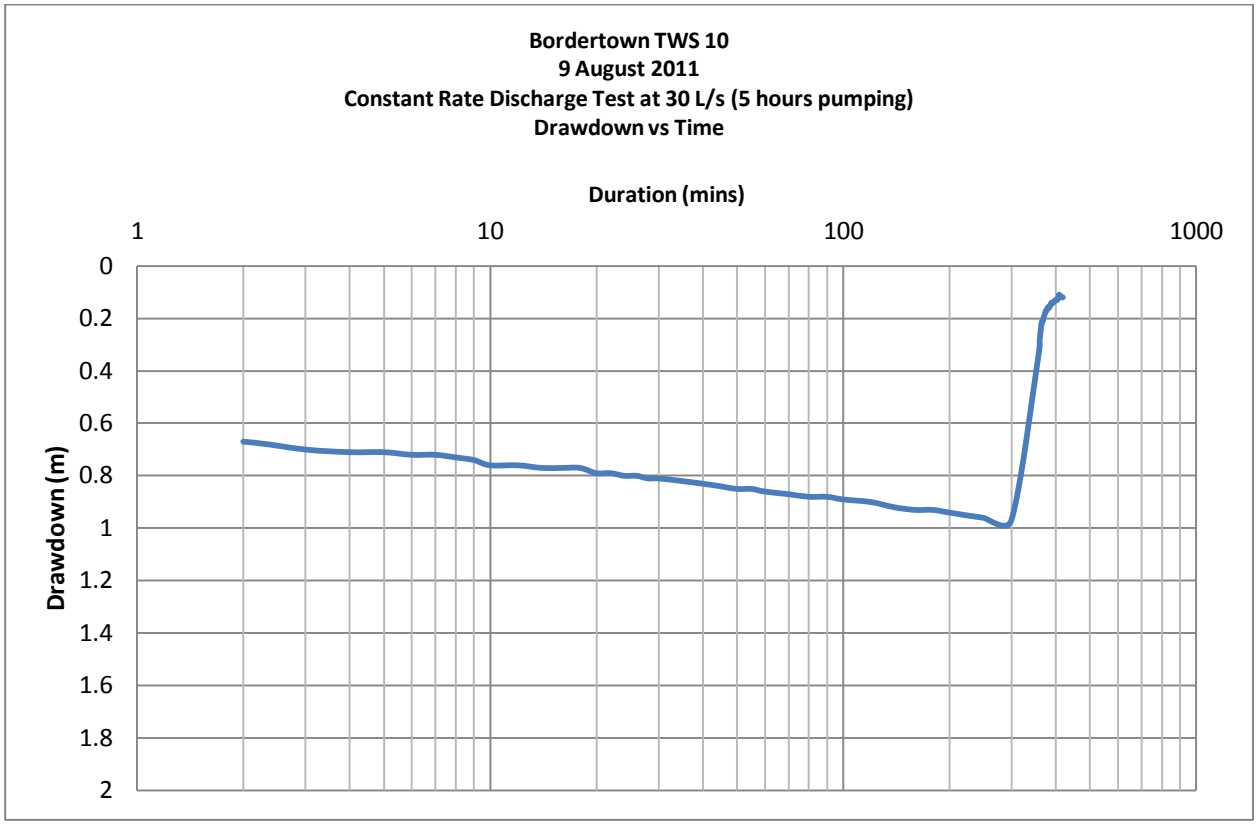


Figure 10. Log linear plot of constant rate discharge and recovery test data for Bordertown TWS 10

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^2/d, compared to 3900 m^2/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 µs/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).

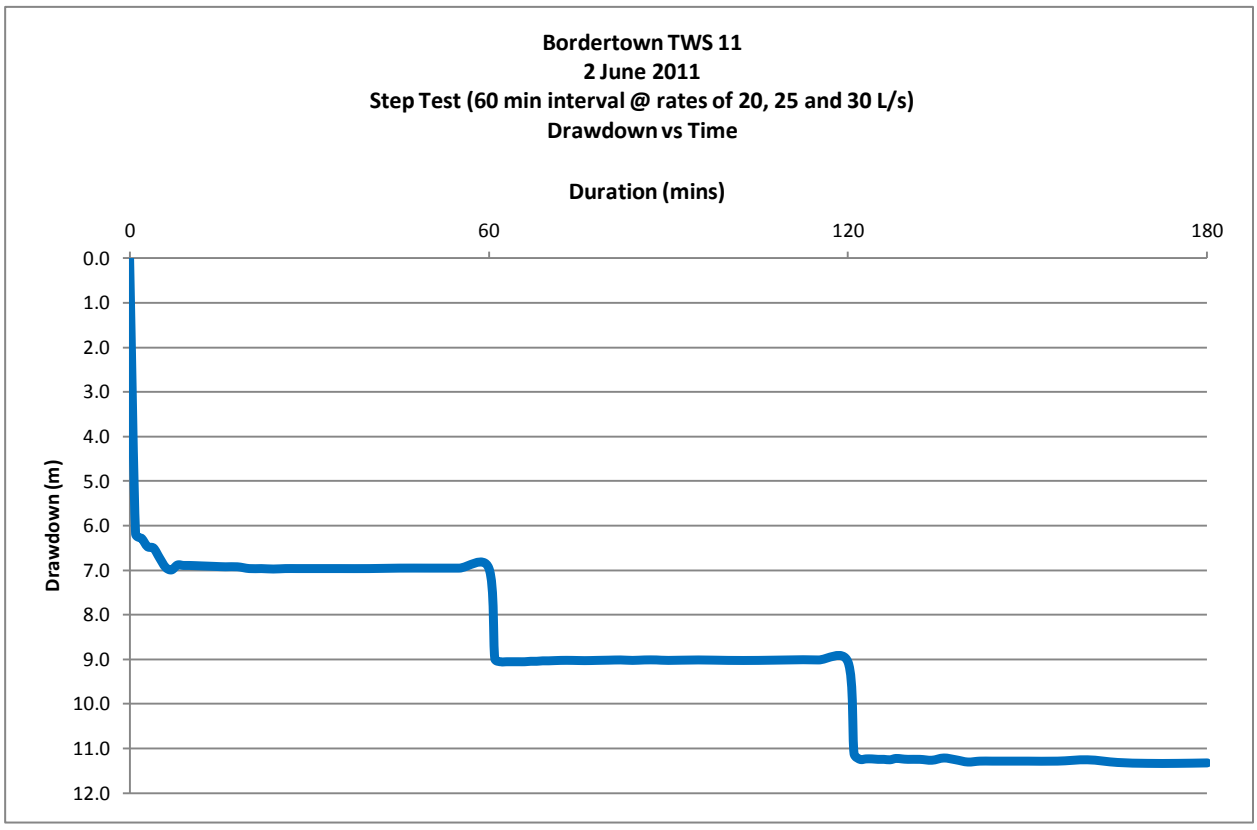
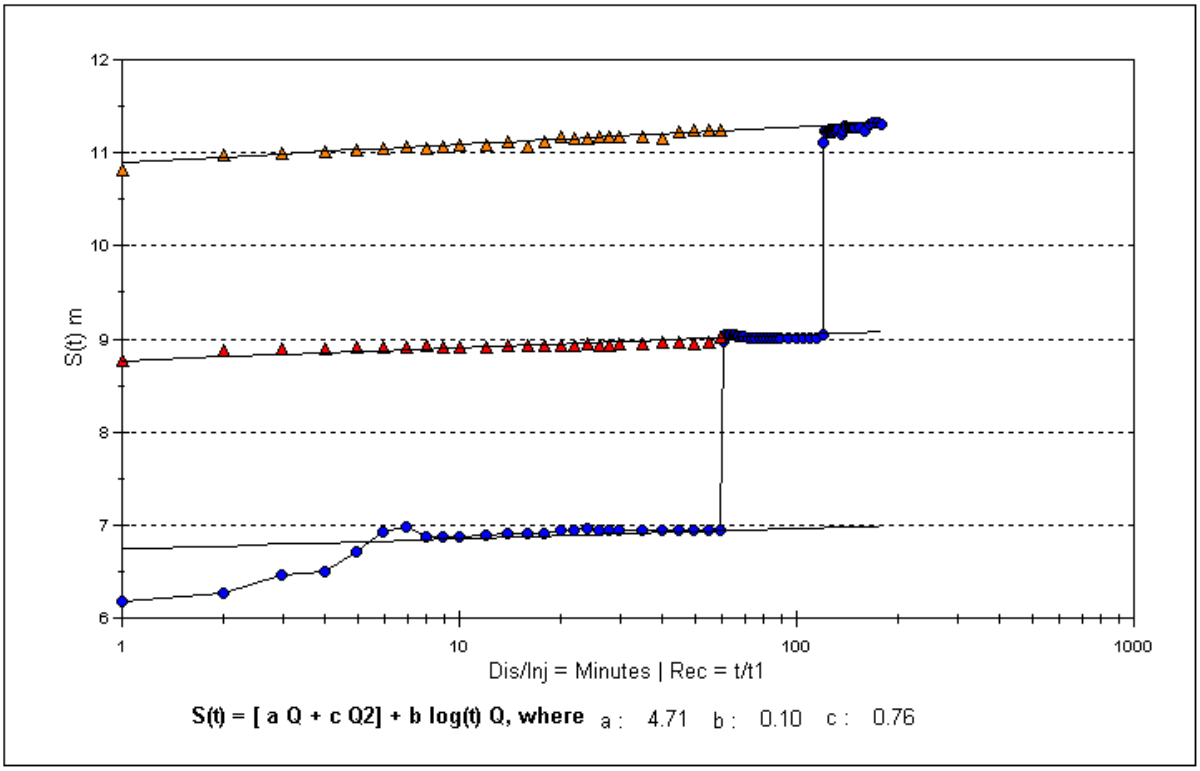


Figure 11. Step drawdown test data for Bordertown TWS 11



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	6.75	5.63	6.86	5.72	6.97	5.81	0.11	0.09	2875
2	25.00	1.50	60	8.77	5.85	8.91	5.94	9.05	6.03	0.14	0.09	2823
3	30.00	1.80	60	10.91	6.06	11.10	6.17	11.29	6.27	0.19	0.11	2497

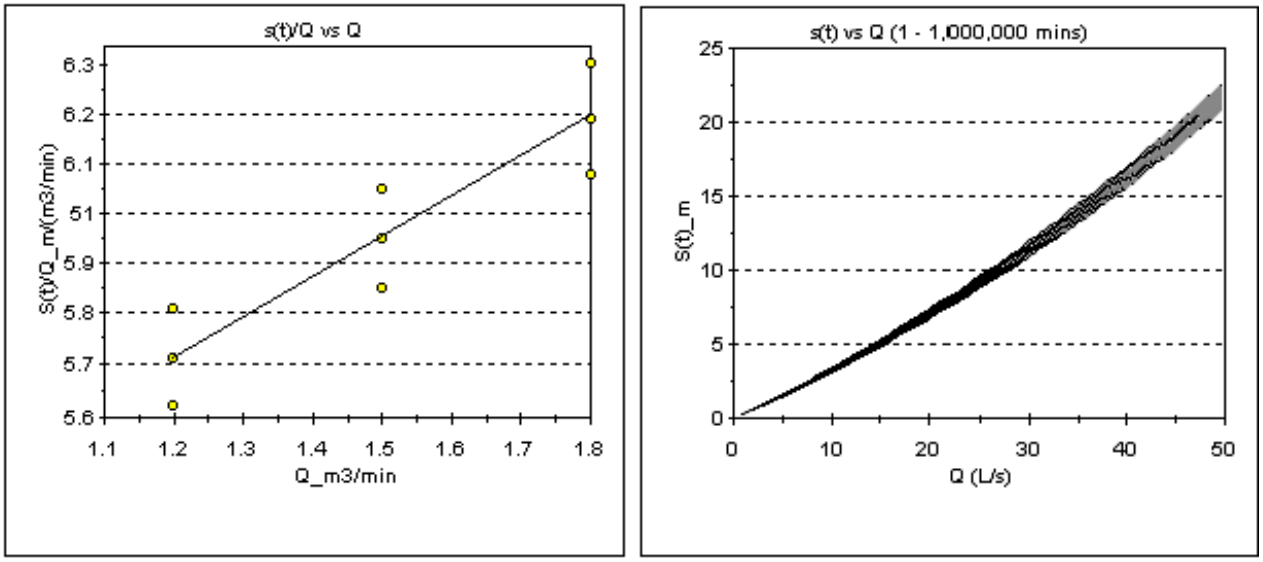


Figure 12. Step drawdown test analysis using Hazel Method for Bordertown TWS 11

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

$$s(t) = (4.71\ Q + 0.76\ Q^2) + 0.10 \log (t)\ Q \qquad \textbf{Equation (3)}$$

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 ~2800 m^2/d.

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

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

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).

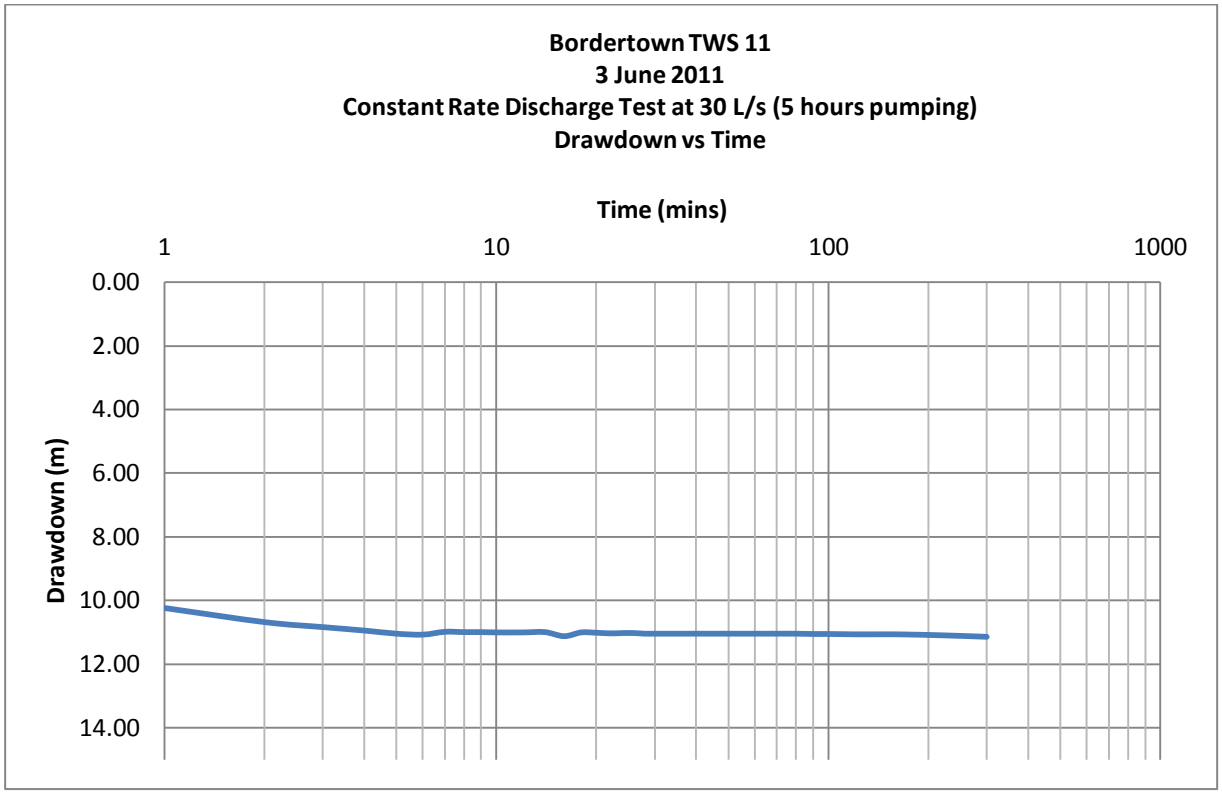


Figure 13. Log linear plot of constant rate discharge test data for Bordertown TWS 11

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^2/d, compared to 2800 m^2/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^2/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 µs/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:

- 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).

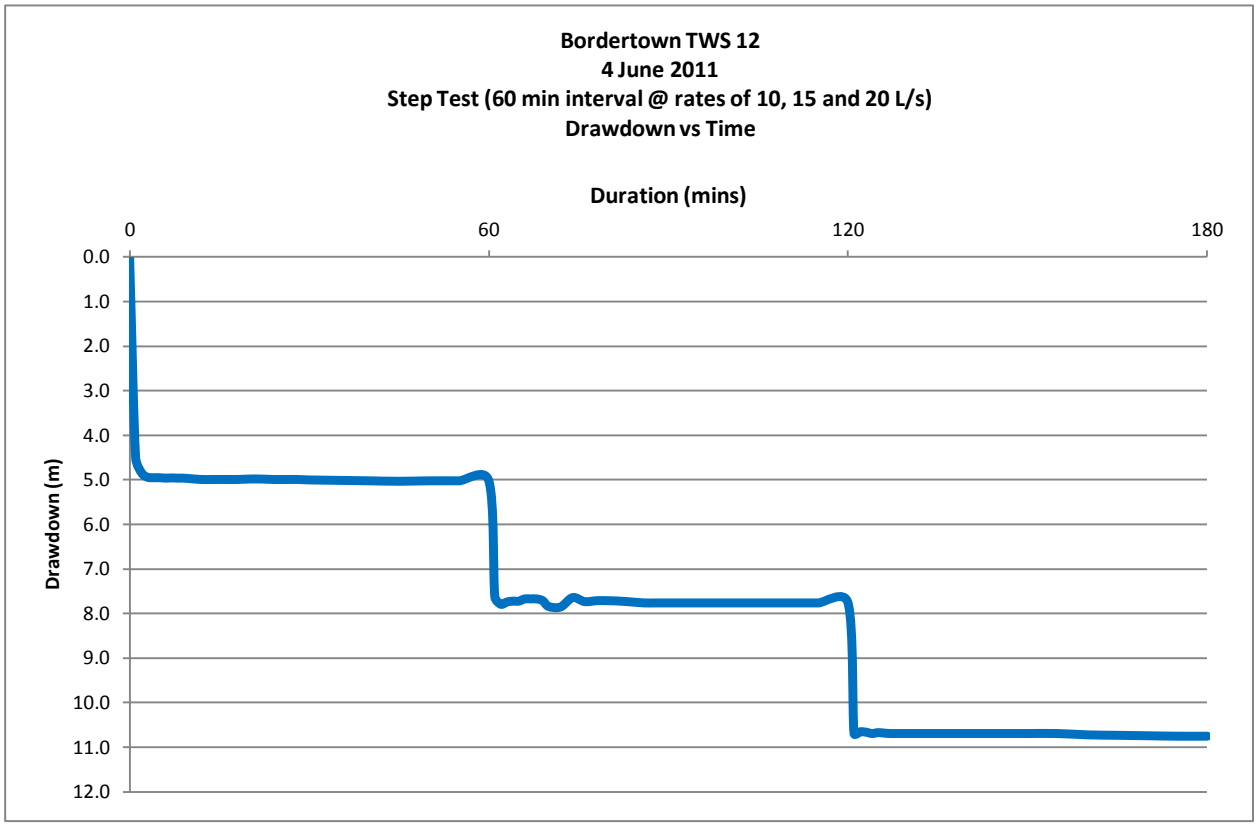
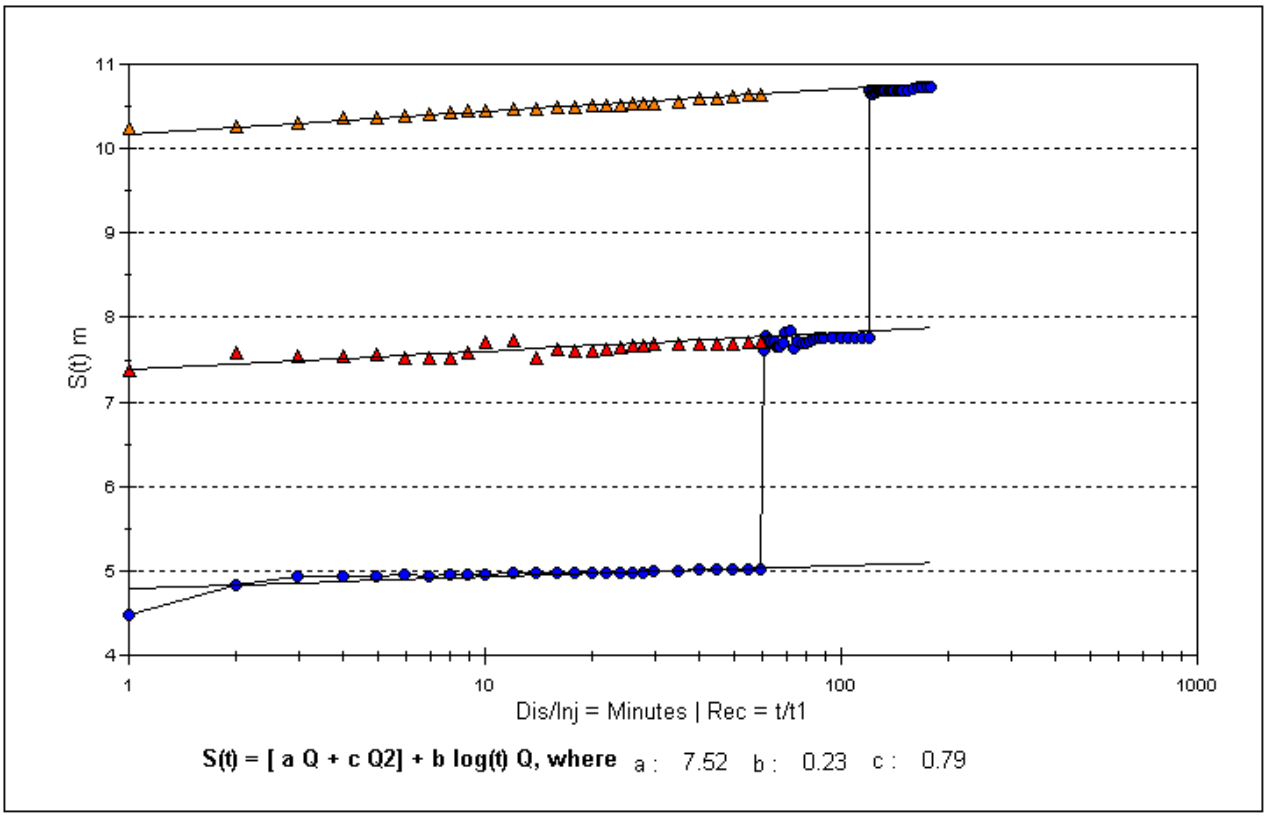


Figure 14. Step drawdown test data for Bordertown TWS 12



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

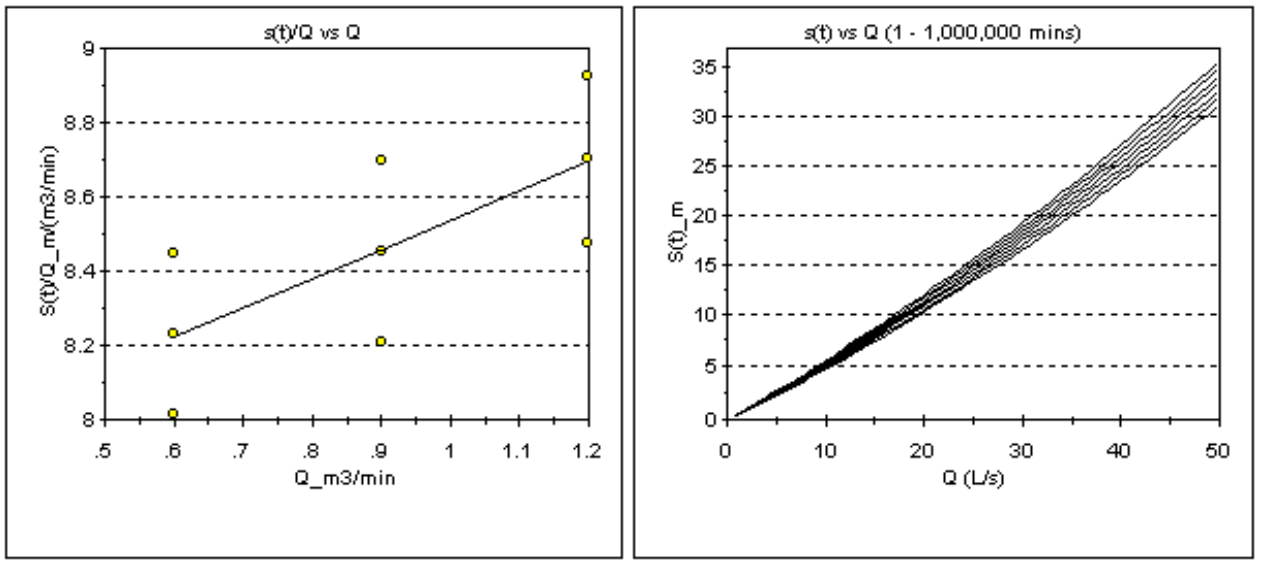


Figure 15. Step drawdown test analysis using Hazel Method for Bordertown TWS 12

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 ~1200 m^2/d.

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

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

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).

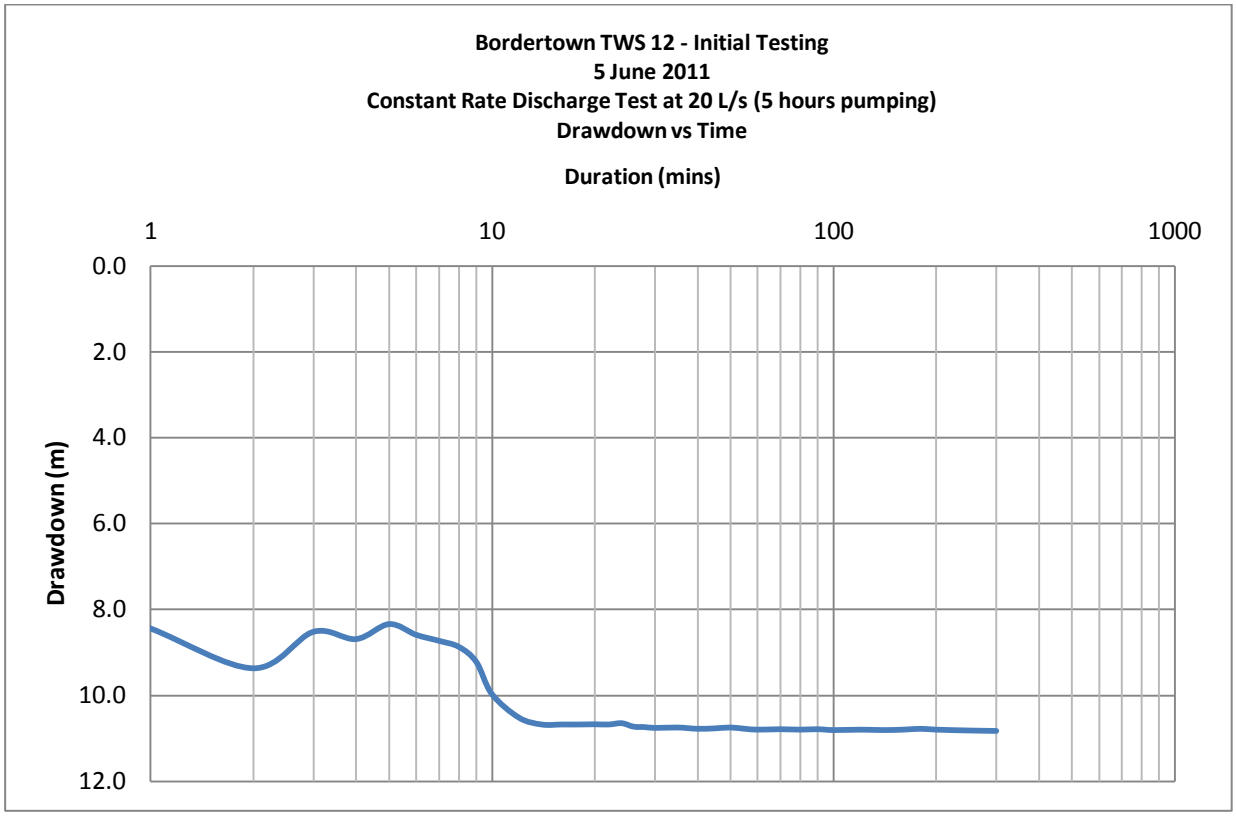


Figure 16. Log linear plot of constant rate discharge test data for Bordertown TWS 12

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^2/d, compared to 1200 m^2/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^2/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 µs/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).

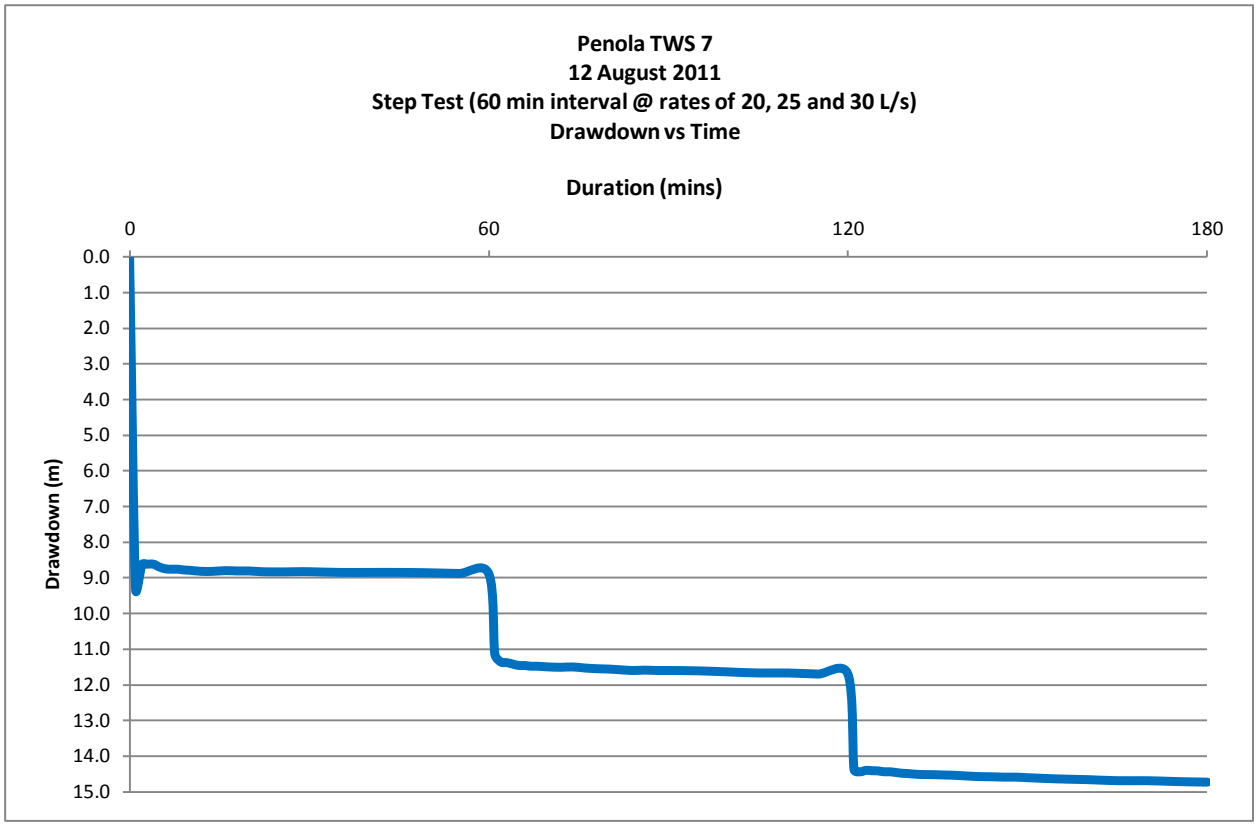
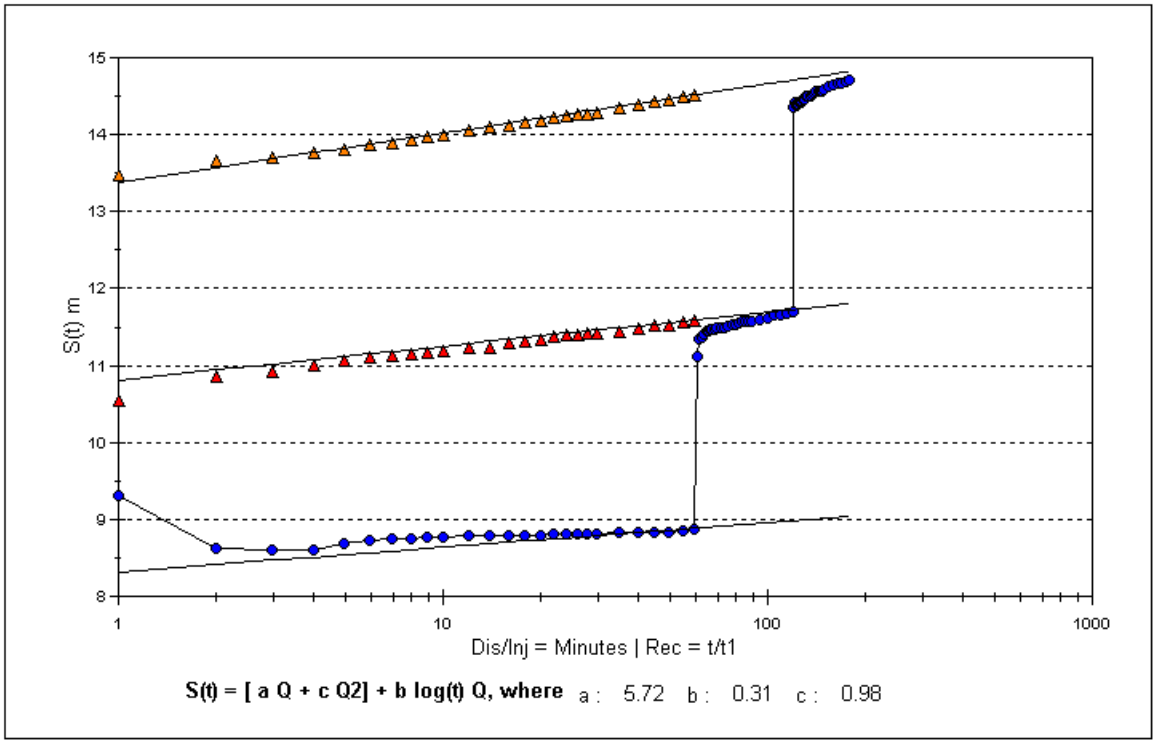


Figure 17. Step drawdown test data for Penola TWS 7



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	8.33	6.94	8.65	7.21	8.97	7.47	0.32	0.27	988
2	25.00	1.50	60	10.82	7.21	11.26	7.51	11.70	7.80	0.44	0.29	898
3	30.00	1.80	60	13.39	7.44	14.03	7.79	14.67	8.15	0.64	0.36	741

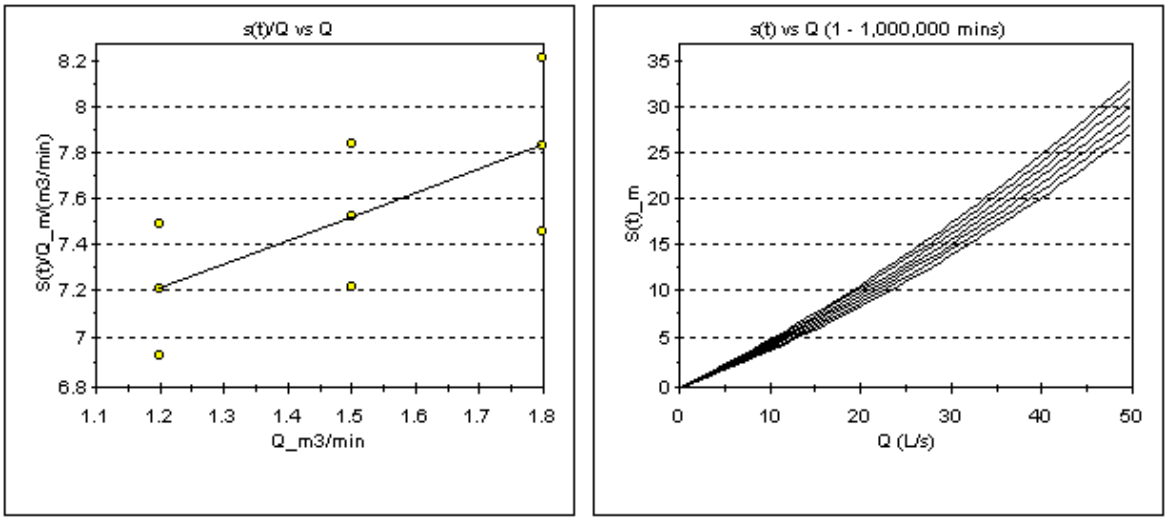


Figure 18. Step drawdown test analysis using Hazel Method for Penola TWS 7

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

$s(t) = 5.72\ Q + 0.98\ Q^2 + 0.31 \log (t)\ Q$ **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 ($aQ + cQ^2$) 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 ~900 m^2/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).

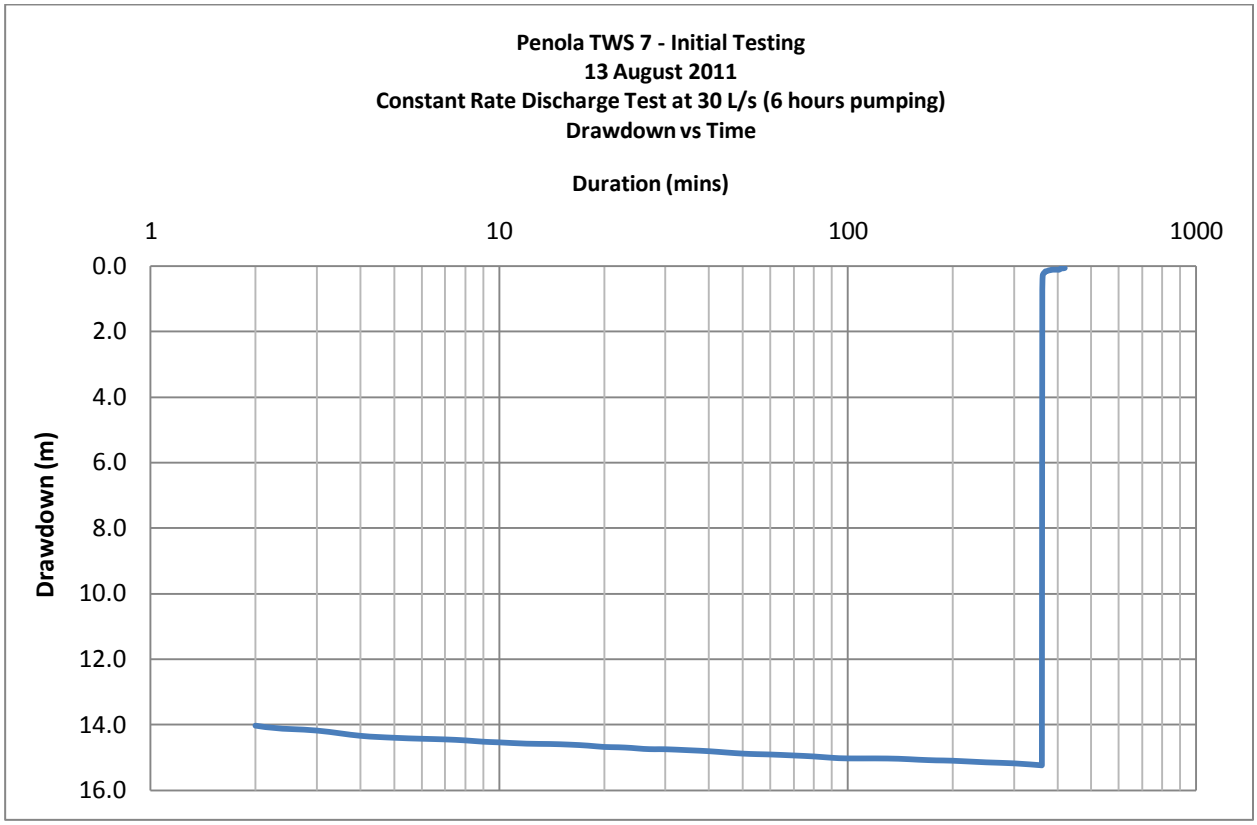


Figure 19. Log linear plot of constant rate discharge and recovery test data for Penola TWS 7

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^2/d which corresponds to the step test analysis of ~900 m^2/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 µs/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

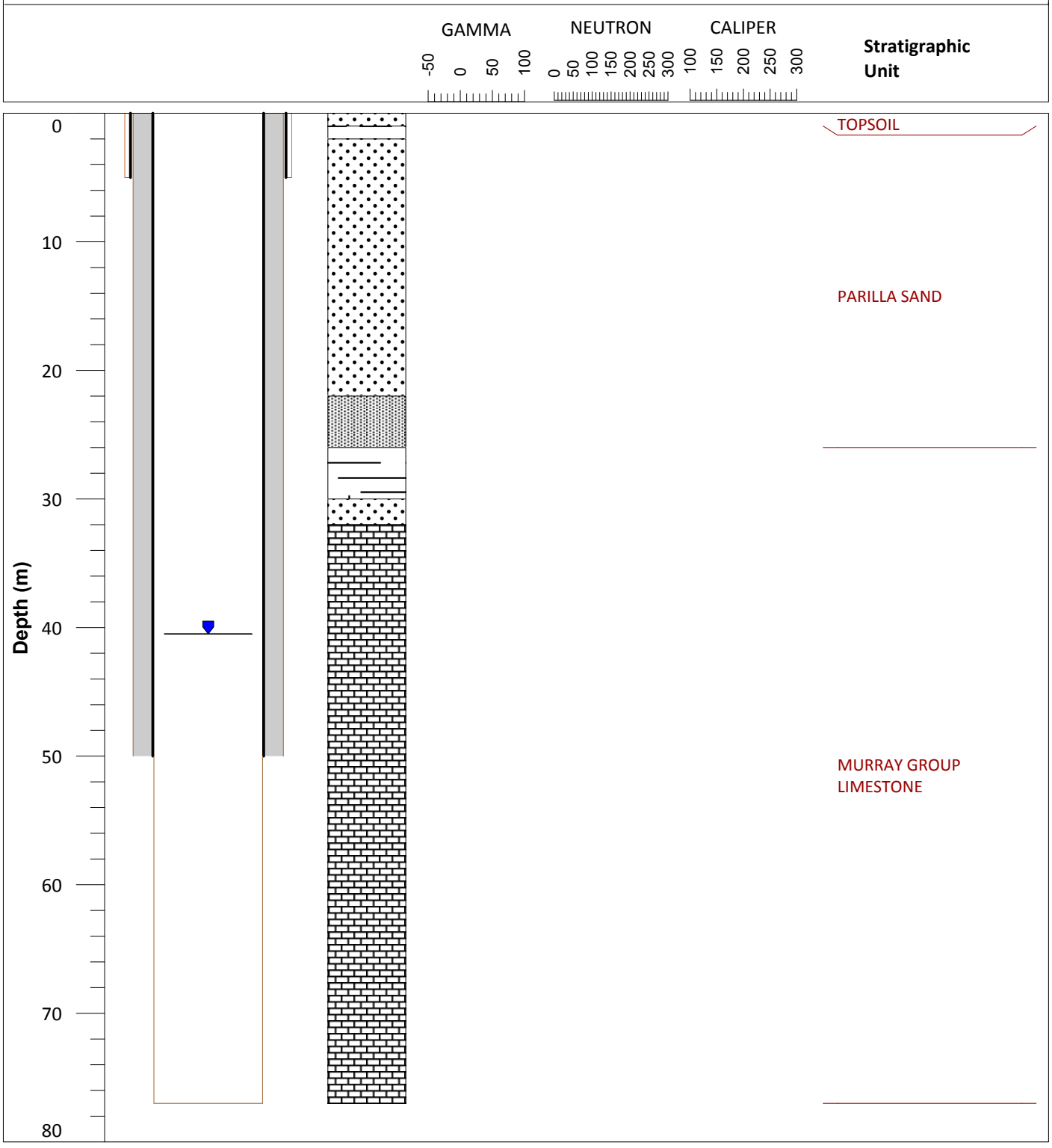
A. WELL CONSTRUCTION DIAGRAMS

SA Water Bore Replenishment Scheme - Schematic Diagram

Unit No: **6927-991** Drillhole Name: **Geranium TWS 3** Final Depth (m): **77**

Easting: **423732** Northing: **6084307** Zone: **54** Permit Number **200364**

Government of South Australia
Department for Water



Casing Details

Diameter	Details	Interval	Pressure Cement
355 mm ID	Steel	0 - 5 m	-
253 mm ID	Class 12 UPVC	0 - 50 m	0 - 50 m

Production Zone Details

Diameter	Details	Type	Interval
248 mm	-	Open Hole	50 - 77 m

Notes: For full lithology descriptions see Appendix A, Magarey and Slater, 2011.
Co-ordinates GDA 94. Geophysical log not taken.

Current as at: 8-Sep-2011

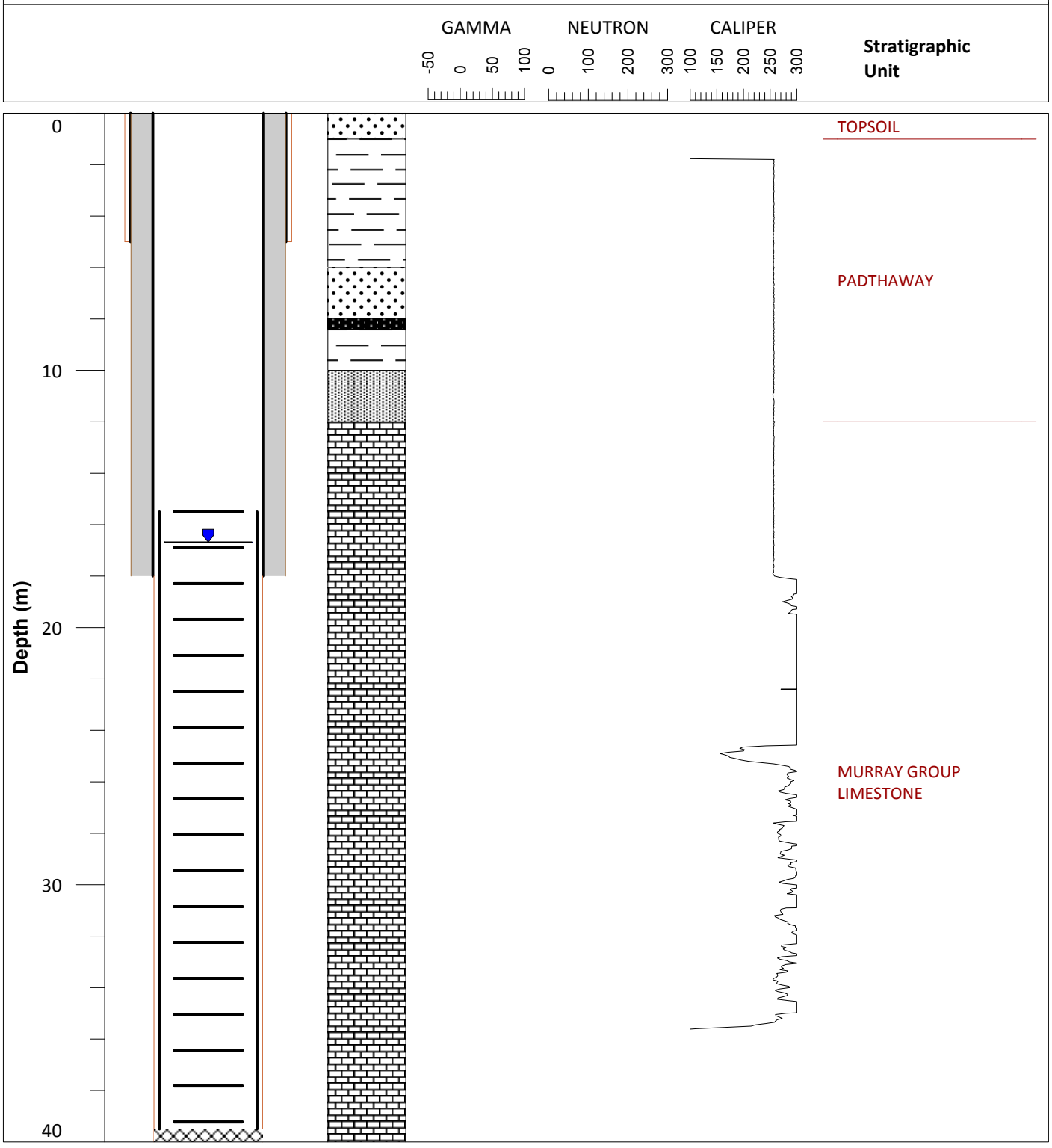
Clay
Sandstone
Marl / Clay
Sand
Limestone
Cement
Casing
Open hole

SA Water Bore Replenishment Scheme - Schematic Diagram

Unit No: **7028-3875** Drillhole Name: **Bordertown TWS 10** Final Depth (m): **39.5**

Easting: **470168** Northing: **5982885** Zone: **54** Permit Number **200365**

Government of South Australia
Department for Water



Casing Details

Diameter	Details	Interval	Pressure Cement
355 mm ID	Steel	0 - 5 m	-
253 mm ID	Class 12 UPVC	0 - 18 m	0 - 18 m

Production Zone Details

Diameter	Details	Type	Interval
203 mm ID	Class 12 UPVC 1 mm aperture	Slotted Casing	15.5 - 39.5 m

Notes: For full lithology descriptions see Appendix A, Magarey and Slater, 2011.
Caliper Log identified blockage at 25 m. Well reamed and slotted casing inserted.

Current as at: 8-Sep-2011

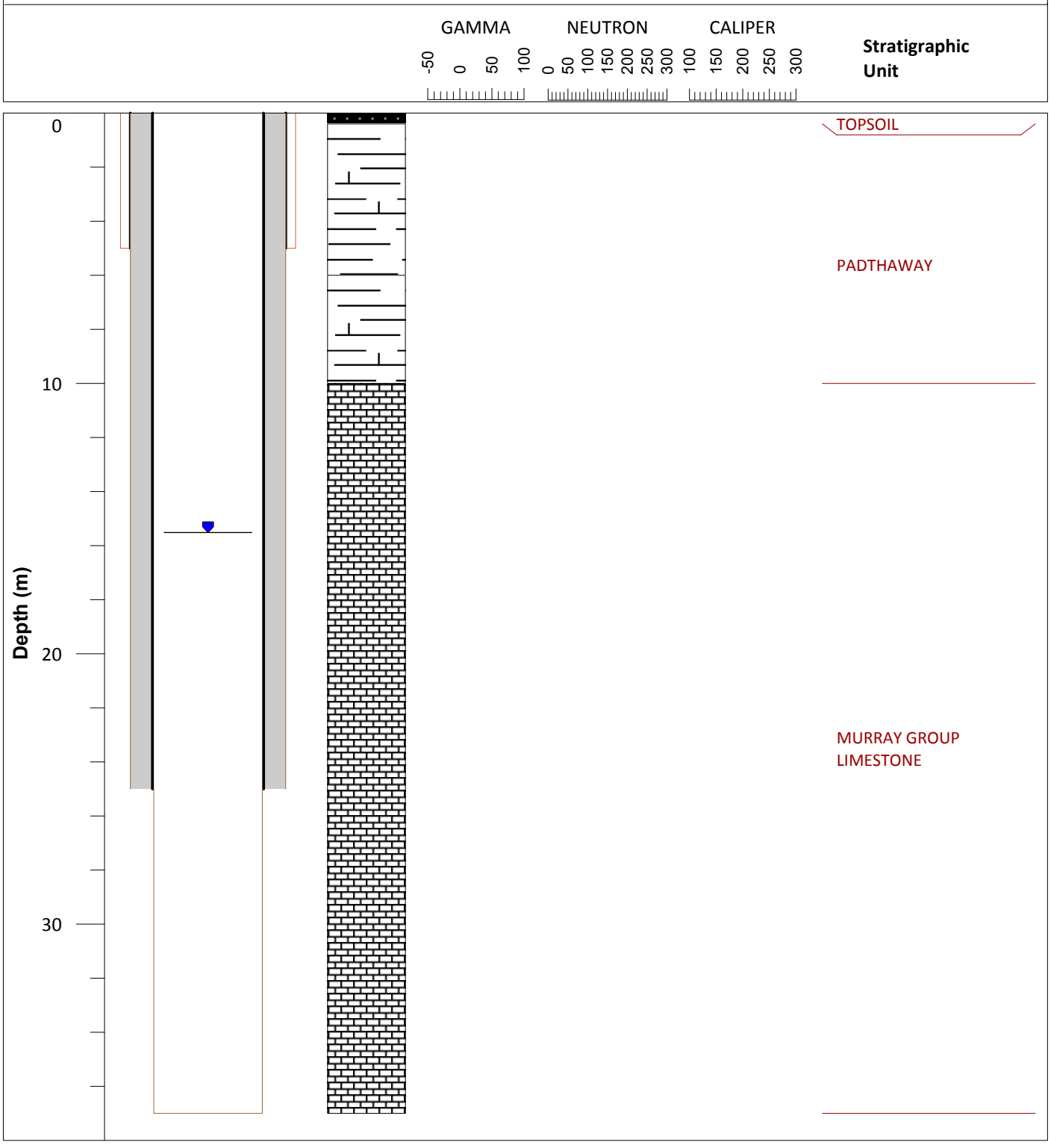
Sand
Stone
Clay
Sandstone
Limestone
cement
Slotted casing
Backfill
Casing
Open hole

SA Water Bore Replenishment Scheme - Schematic Diagram

Unit No: **7025-3876** Drillhole Name: **Bordertown TWS 11** Final Depth (m): **37**

Easting: **469754** Northing: **5982541** Zone: **54** Permit Number **200366**

Government of South Australia
Department for Water



Casing Details

Diameter	Details	Interval	Pressure Cement
355 mm ID	Steel	0 - 5 m	-
254 mm ID	Class 12 UPVC	0 - 25 m	0 - 25 m

Production Zone Details

Diameter	Details	Type	Interval
248 mm	-	Open Hole	25 - 37 m

Current as at: 8-Sep-2011

Topsoil
Marl / Clay
Limestone
Cement
Casing
Open hole

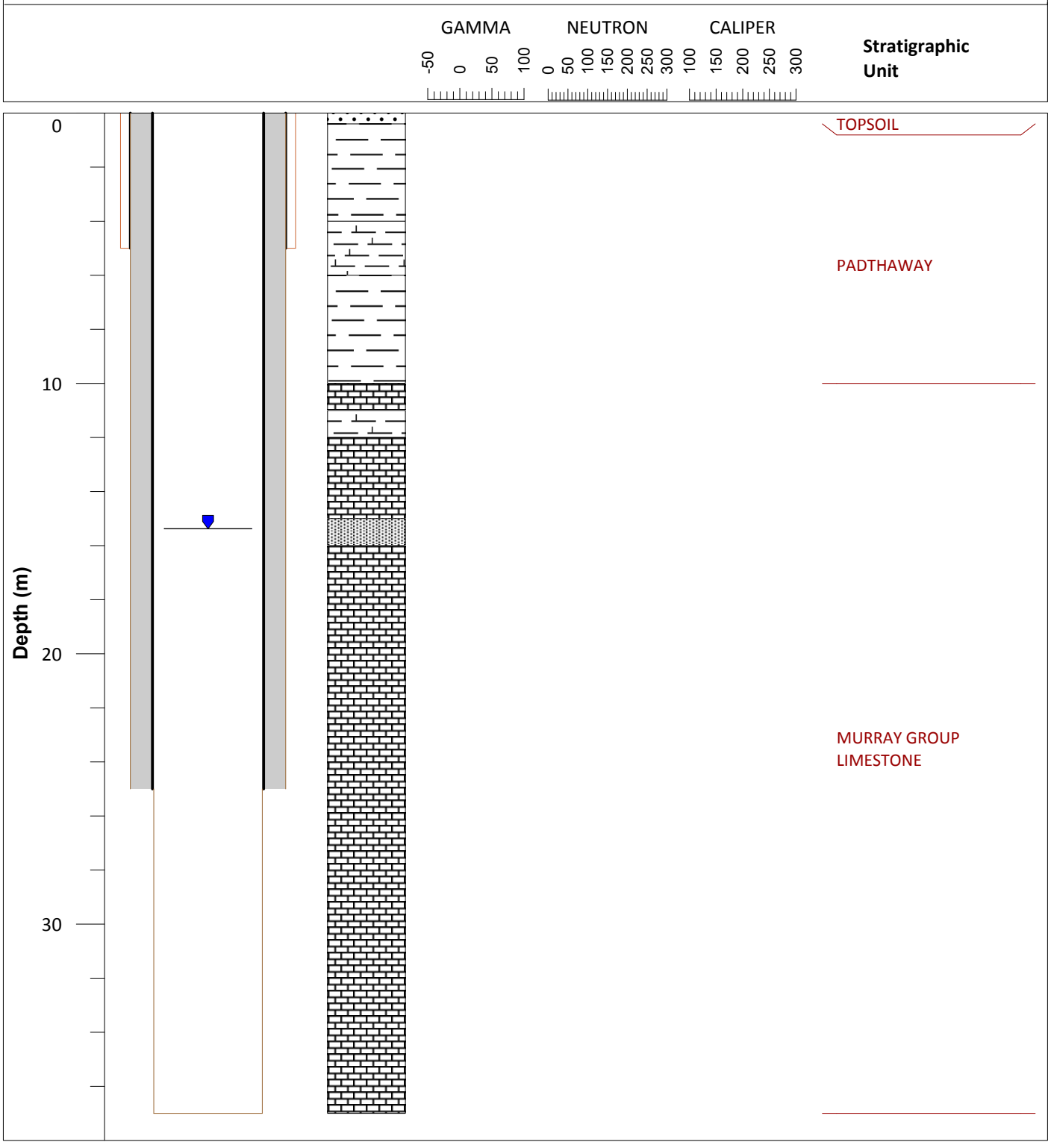
Notes: For full lithology descriptions see Appendix A, Magarey and Slater, 2011.
Co-ordiantes in GDA 94. Geophysical log not taken.

SA Water Bore Replenishment Scheme - Schematic Diagram

Unit No: **7025-3877** Drillhole Name: **Bordertown TWS 12** Final Depth (m): **37**

Easting: **469747** Northing: **5982502** Zone: **54** Permit Number **200368**

Government of South Australia
Department for Water



Casing Details

Diameter	Details	Interval	Pressure Cement
355 mm ID	Steel	0 - 5 m	-
254 mm ID	Class 12 UPVC	0 - 25 m	0 - 25 m

Production Zone Details

Diameter	Details	Type	Interval
248 mm	-	Open Hole	25 - 37 m

Notes: For full lithology descriptions see Appendix A, Magarey and Slater, 2011.
Co-ordiantes in GDA 94. Geophysical log not taken.

Current as at: 8-Sep-2011

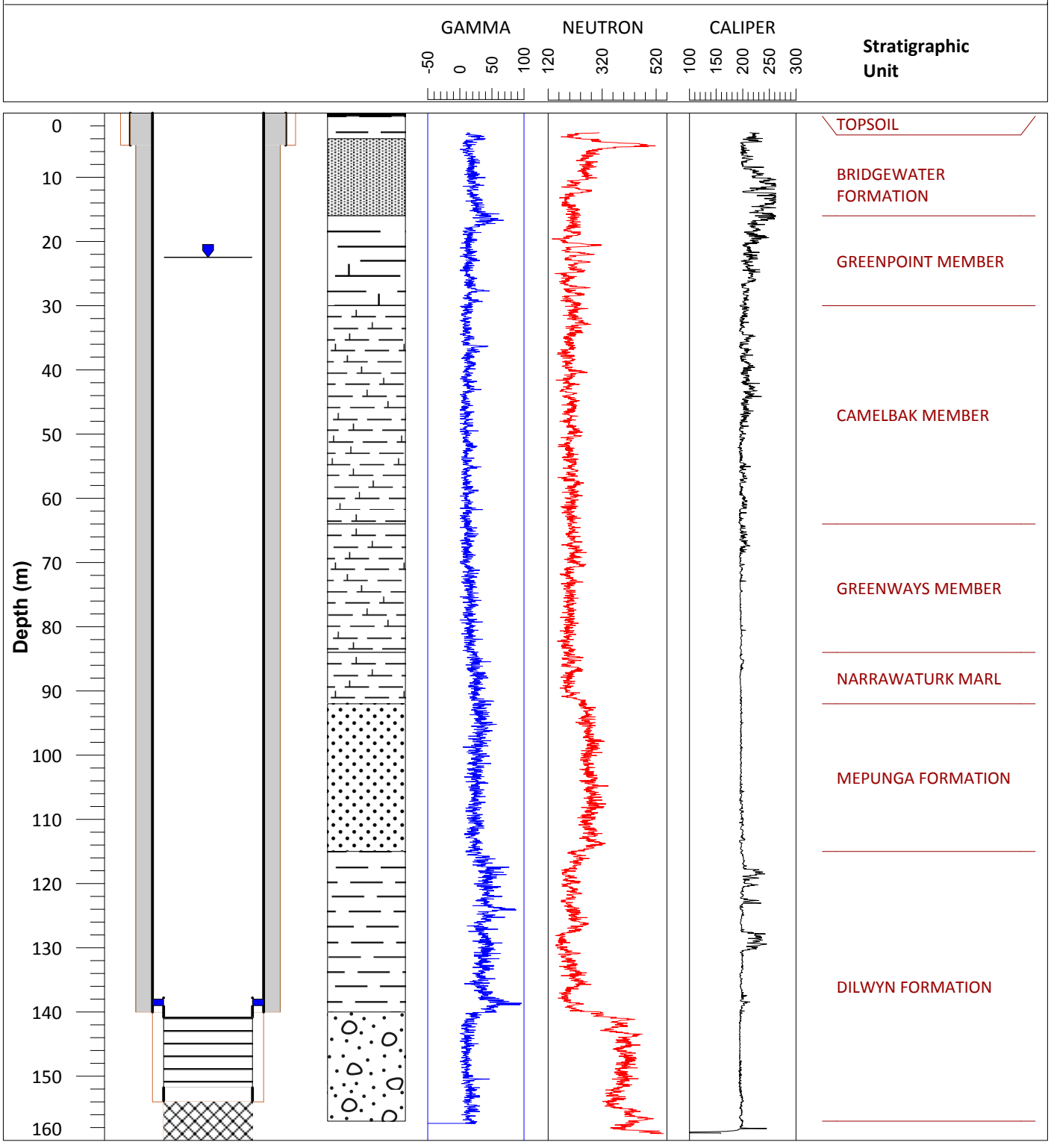
Sand
Clay
Marl / Clay
Cement
Sandstone
Casing
Limestone
Open hole

SA Water Bore Replenishment Scheme - Schematic Diagram

Unit No: **7023-7201** Drillhole Name: **Penola TWS 7** Final Depth (m): **154**

Easting: **485912** Northing: **5864334** Zone: **54** Permit Number **199140**

Government of South Australia
Department for Water



Casing Details

Diameter	Details	Interval	Pressure Cement
355 mm ID	Steel	0 - 5 m	-
254 mm ID	Class 12 UPVC	0 - 140 m	0 - 140 m

Production Zone Details

Diameter	Details	Type	Interval
203 mm ID	Stainless Steel 0.6 mm aperture	Telescopic Screen	140.8 - 151.8 m
203 mm ID	Stainless Steel	Sump	151.8 - 153.8 m

Notes: For full lithology descriptions see Appendix A, Magarey and Slater, 2011.
Co-ordinates in GDA 94

Current as at: 8-Sep-2011

Sandstone
Marl / Clay
Marl
Sand
Clay
Sand / gravel
Cement
Screen
Packer
Casing
Open Hole
backfill

B. WATER WELL LOGS

Project: **SA Water Bore Replenishment Scheme**

Geranium TWS 3

Permit Number:	200364	Backfilled (Y/N):	N
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	Ground Elevation (m AHD):	TBD
Northing:	6084307	Reference Elevation (m AHD):	TBD
Zone:	54	Reference Point Type:	TOC
Datum:	GDA94		

General Comments:

Lithological Description

Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
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	PARILLA SAND
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	
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	

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

Water Cut Information

Depth (m)		Depth to Water (m)	Supply			Water Analysis		
From	To		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 Prod Zone	Depth (m)		Diam (mm)	Material	Aperture	Cementing		
	From	To				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:	200365	Backfilled (Y/N):	N
Date Completed:	4/3/2011	Total Depth (m):	40 m
Unit No:	7025-3875	Drill Method:	Rotary Mud/Air
Drillhole Name:	Bordertown TWS 10	Drilling Company:	Kangarilla
Logged By:	S.Slater	Driller:	P. Wagenknecht

Coordinates

Easting:	470167	Ground Elevation (m AHD):	TBD
Northing:	5928886	Reference Elevation (m AHD):	TBD
Zone:	54	Reference Point Type:	TOC
Datum:	GDA94		

General Comments:

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.

Lithological Description

Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
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	PADTHAWAY
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	
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	

Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
			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	MURRAY GROUP LIMESTONE
14	16	LIMESTONE	LIMESTONE, pale yellow, wet, hard layers	
16	18	LIMESTONE	LIMESTONE, pale yellow with hard yellowish orange fragments of sandstone	
18	40	LIMESTONE	LOSS OF CIRCULATION, NO SAMPLES 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 Water (m)	Supply			Water Analysis		
From	To		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 Prod Zone	Depth (m)		Diam (mm)	Material	Aperture	Cementing		
	From	To				Y/N	From (m)	To (m)
Casing	0	18	250mm	PVC Class 12	n/a	Y	0	18
Slotted Casing	15.5	39.5	200mm	PVC	0.6mm	N		

Project: **SA Water Bore Replenishment Scheme**

Bordertown TWS 11

Permit Number:	200366	Backfilled (Y/N):	N
Date Completed:	19/05/2011	Total Depth (m):	37 m
Unit No:	7025-3876	Drill Method:	Rotary Mud/Air
Drillhole Name:	Bordertown TWS 11	Drilling Company:	Kangarilla
Logged By:	S.Slater	Driller:	J. Mason

Coordinates

Easting:	469754	Gound Elevation (m AHD):	TBD
Northing:	5982541	Reference Elevation (m AHD):	TBD
Zone:	54	Reference Point Type:	TOC
Datum:	GDA94		

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

Lithological Description

Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
0	0.4	SAND	Clayey SAND, grey brown, slightly moist	TOPSOIL
0.4	2	CLAY	Marly CLAY, tan grey, moist, firm	PADTHAWAY
2	6	CLAY	Marly CLAY, brown grey, some hard calcrete	
6	10	CLAY	Sandy Marly CLAY, tan grey with orange brown	
10	26	LIMESTONE	LIMESTONE, grey cream, hard, some marl, lost circulation at 10m	MURRAY GROUP LIMESTONE
26	28	LIMESTONE	LIMESTONE, various shades of cream, tan and light grey, some coral and marl, some cement contamination in sample	
28	30	LIMESTONE	LIMESTONE, various shades of cream, tan and 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 Water (m)	Supply			Water Analysis		
From	To		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

Casing and Production Zone Information

Case or Prod Zone	Depth (m)		Diam (mm)	Material	Aperture	Cementing		
	From	To				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		

Project: **SA Water Bore Replenishment Scheme**

Bordertown TWS 12

Permit Number:	200368	Backfilled (Y/N):	N
Date Completed:	27/05/2011	Total Depth (m):	37 m
Unit No:	7025-3877	Drill Method:	Rotary Mud/Air
Drillhole Name:	Bordertown TWS 12	Drilling Company:	Kangarilla
Logged By:	Scott Slater	Driller:	J. Mason

Coordinates

Easting:	469747	Ground Elevation (m AHD):	TBD
Northing:	5982502	Reference Elevation (m AHD):	TBD
Zone:	54	Reference Point Type:	TOC
Datum:	GDA94		

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

Lithological Description

Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
0	0.4	SAND	Clayey SAND, grey brown, slightly moist	TOPSOIL
0.4	4	CLAY	Marly CLAY, tan grey, moist, firm	PADTHAWAY
4	6	CLAY/MARL	Marly CLAY/Clayey MARL, mix of light grey cream and orange brown, minor fine grain sand and calcrete	
6	10	CLAY	CLAY, Light grey cream/grey tan. Hard layers with minor calcrete/marl	
10	11	LIMESTONE	LIMESTONE, very hard, light grey cream	MURRAY GROUP LIMESTONE
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 grain sand	
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	

Water Cut Information

Depth (m)		Depth to Water (m)	Supply			Water Analysis		
From	To		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 Prod Zone	Depth (m)		Diam (mm)	Material	Aperture	Cementing		
	From	To				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		

Project: **SA Water Bore Replenishment Scheme**

Penola TWS No. 7

Permit Number:	199140	Backfilled (Y/N):	N
Date Completed:	22/06/2011	Total Depth (m):	160
Unit No:	7023-7201	Drill Method:	Rotary Mud
Drillhole Name:	Penola TWS No. 7	Drilling Company:	Kangarilla
Logged By:	Scott Slater	Driller:	P. Wagenknecht/M. Fosdike

Coordinates

Easting:	485907	Ground Elevation (mAHD):	TBD
Northing:	5864335	Reference Elevation (mAHD):	TBD
Zone:	54	Reference Point Type:	TOC
Datum:	GDA94		

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

Depth (m)		Major Lith Unit(s)	Lithology	Formation
From	To			
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	BRIDGEWATER FORMATION
2	4	CLAY	Marly CLAY Grey olive	
4	10	SANDSTONE	SANDSTONE, tan cream, hard	
10	16	SANDSTONE	SANDSTONE, cream, shells	
16	22	MARL	Marly CLAY/Clayey MARL, grey	GREENPOINT MEMBER
22	24	MARL	Marly CLAY/Clayey MARL, grey, hard bands of flint	
24	30	MARL	Marly CLAY/Clayey MARL, grey, minor flint	
30	42	MARL	MARL, grey	CAMELBACK MEMBER
42	44	MARL	MARL, grey with flint	
44	64	MARL	MARL, light greys, olives and greys	
64	80	CLAY/MARL	Marly CLAY, grey yellow	GREENWAYS MEMBER
80	84	CLAY/MARL	Marly CLAY, grey olive	
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	DILWYN FORMATION
140	157	SAND/GRAVEL	SAND grading to GRAVEL with depth. Light greys, opare and Sub-rounded up to 12mm diameter at 157m.	

Water Cut Information

Depth (m)		Depth to Water (m)	Supply			Water Analysis		
From	To		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 Prod Zone	Depth (m)		Diam (mm)	Material	Aperture	Cementing		
	From	To				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		

C. WELL CONSTRUCTION REPORTS

GERANIUM TWS 3

GOVERNMENT OF SOUTH AUSTRALIA

DRILLERS WELL CONSTRUCTION REPORT

Natural Resource Management Act 2004

DETAILS OF ALL WORK UNDERTAKEN MUST BE REFLECTED IN THIS REPORT

1. PERMIT NO: 200364 Site: 08 JUN 2011

NAME OF DRILLER PAUL WAGENKNECHT Licence No: 165177

Contact Phone/Mobile No.:

Name of plant operator if under supervision

PERMIT HOLDER or land occupier SOUTH AUSTRALIAN WATER CORP

Postal Address P.O BOX 603

MOUNT GAMBIER Post Code 5290

2. LOCATION OF WELL

Date of Survey ..... Surveyed by ..... Method .....

GPS COORDINATES AND DATUM USED

☑ GDA 94/WGS84

☐ AGD 66/84

S4H 0423732

UTM 6084307

☐ ZONE 52 ☐ ZONE 53 ☑ ZONE 54

3. WELL NAME

4. LAND IDENTIFICATION

Pastoral Lease or Hundred: PRICE

Title or Plan and Parcel: CT 5758/522

Name of Property

5. SUMMARY *(Please tick appropriate boxes and complete all relevant details)*

Date work Commenced 1/3/2011 Date work Completed 3/3/2011

Work carried out: New Well ☑ Deepen ☐ Enlarge ☐ Rehabilitate ☐ Backfill ☐

Is this a Replacement well? ~~YES~~/NO if yes please quote replaced well number

Is this an Existing well? ~~YES~~/NO **if yes please quote well number or GPS coordinates**

Was well Abandoned? ~~YES~~/NO if so please state reason and method of backfill

Maximum Depth Drilled 77 (m) Final Depth 77 (m) Final Standing Water Level 40.5 (m) Final Yield 6 (L/sec)

6. DRILLING DETAILS If not a drilled well, please complete Sections: 6.2, 9, 10, 11, 12 and 13 as necessary

6.1 Construction Details

From (m)	To (m)	Diam (mm)	Drilling Method Cable Tool, Rotary Auger, Down Hole Hammer, etc.	Fluid Used (Air, Water, Mud Type)
0	5	381	ROTARY	BIO-V.S
5	50	343	ROTARY	BIO-V.S.
50	77	248	ROTARY	BIO-V.S.

6.2 Water Cut Details (measurements from natural surface to nearest 0.1 m)

Date	Water Cut From (m)	Water Cut To (m)	Standing Water Level (m)	Estimated Yield (L/sec)	Hole Depth at Test (m)	Casing at Test (m)	Test Method	Salinity (mg/L) or Taste
3/3/11	50	77	40.5	6	77	50	AIR	950

7. CASING LEFT IN WELL

7.1 Dimensions / 7.2 Type / 7.3 Casing Cemented

From (m)	To (m)	Internal Diam. (mm)	Swell Joint, Welded Collar, Steel, FRP, PVC, etc.	Yes	No	From (m)	To (m)	Cement (bags)	Water (litres)	Other Additives	Cementing Method Used	Comments
0	5	355	STEEL.	☐	☑							
1.05	500	258	P.V.C CL 12	☑	☐	0	50	48	1296		PRESSURE	

7.4 **COLLAR CASING** (must be cemented to surface)

				☐	☐							

8. CONSTRUCTION AT PRODUCTION LEVEL

8.1 Method

☑ Open Hole

☐ Slotted Casing

☐ Screen(s)

☐ Other, give details:

8.2 Screen or Casing (*If variable aperture screen used give limits)

Type	From (m)	To (m)	Aperture* (mm)	Inner Diam (mm)	Outer Diam (mm)	Material	Trade Name	Completion of Base

8.3 Liner Seal (Packer)

Material	Depth (m)	Internal Diam (mm)

8.4 Gravel Packing

Method of Placement	Gravel Passing Mesh Size	From (m)	To (m)

9. IF NOT A DRILLED WELL

Method	Depth (m)	Length (m)	Width (m)	Diam (m)	Lining Material	From (m)	To (m)

10. DEVELOPMENT (State methods and time taken)

Method	Hours	Minutes
AIR.	2	30

11. PUMPING TEST (measurements from natural surface to nearest 0.1m)

Interval Tested From (m)	Interval Tested To (m)	Water Level (m)	Test Method	Pump Depth (m)	Discharge Rate (L/sec)	Method of Measuring Discharge	Hours Pumped	Draw Down (m)

12. SAMPLES

The Natural Resource Management Act 2004 and Regulations require that strata and water samples must be obtained. If any samples have not been obtained state reasons:

As the person responsible I advise that the work has been completed as described above.

Signature of Licensed Driller P. Wagenknecht Date 2/4/11

Driller to deliver this copy together with water samples collected and well location map within 14 days of completion to any of the locations below:

Department of Water Land and Biodiversity Conservation

Science Monitoring & Information, GPO Box 2834 Adelaide SA 5001 (reports only)

Water Laboratory and Geophysical Services, 23 Conyngham Street GLENSIDE SA 5065 or Mount Gambier Regional Office, 11 Helen Street MOUNT GAMBIER SA 5290 or Naracoorte Regional Office, 101 Cedar Avenue, NARACOORTE SA 5271

13. FORMATION LOG

From (m)	To (m)	Description of Material
0	.2	SAND
.2	3	STICKY BROWN CLAY
3	14	BROWN WHITE SANDY CLAY
14	17	BROWN SILTY CLAY
17	22.5	BROWN & WHITE SANDY CLAY
22.5	27	SAND STONE HARD & SOFT LAYERS
27	38.	BROWN MARL WITH GREY CLAY LAYERS
38	77	WHITE LIMESTONE

UNIT NUMBER 6927 991

REGISTERED

GOVERNMENT OF SOUTH AUSTRALIA BORDERTOWN TWS 10

DRILLERS WELL CONSTRUCTION REPORT

Natural Resource Management Act 2004

DETAILS OF ALL WORK UNDERTAKEN MUST BE REFLECTED IN THIS REPORT

1. PERMIT NO: 200365 Site 08 JUN 2011

NAME OF DRILLER Paul Wagenknecht Licence No: 165177

Contact Phone/Mobile No.:

Name of plant operator if under supervision

PERMIT HOLDER or land occupier South Australian Water Corp

Postal Address P.O Box 603

Mount Gambier S.A Post Code 5290

2. LOCATION OF WELL

Date of Survey ..... Surveyed by ..... Method .....

GPS COORDINATES AND DATUM USED

- ☑ GDA 94/WGS84
- ☐ AGD 66/84

S4H 0470168
UTM 5982885

☐ ZONE 52 ☐ ZONE 53 ☑ ZONE 54

3. WELL NAME

4. LAND IDENTIFICATION

Pastoral Lease or Hundred: Wirrega

Title or Plan and Parcel CT 5195/640

Name of Property

5. SUMMARY *(Please tick appropriate boxes and complete all relevant details)*

Date work Commenced 7/3/2011 Date work Completed 9/3/2011

Work carried out: New Well ☑ Deepen ☐ Enlarge ☐ Rehabilitate ☐ Backfill ☐

Is this a Replacement well? ~~YES~~/NO if yes please quote replaced well number

Is this an Existing well? ~~YES~~/NO **if yes please quote well number or GPS coordinates**

Was well Abandoned? ~~YES~~/NO if so please state reason and method of backfill

Maximum Depth Drilled 40 (m) Final Depth 40 (m) Final Standing Water Level 16 (m) Final Yield 2 (L/sec)

6. DRILLING DETAILS

If not a drilled well, please complete Sections: 6.2, 9, 10, 11, 12 and 13 as necessary

6.1 Construction Details

From (m)	To (m)	Diam (mm)	Drilling Method Cable Tool, Rotary Auger, Down Hole Hammer, etc.	Fluid Used (Air, Water, Mud Type)
0	5	381	Rotary	Bio-V.S.
5	18	343	Rotary.	Bo-Vis.
18	40	248	Rotary	Bio-V.S.

6.2 Water Cut Details (measurements from natural surface to nearest 0.1 m)

Date	Water Cut From (m)	Water Cut To (m)	Standing Water Level (m)	Estimated Yield (L/sec)	Hole Depth at Test (m)	Casing at Test (m)	Test Method	Salinity (mg/L) or Taste
9/3/11	18	40	16	2	40	18	Air	400

7. CASING LEFT IN WELL

7.1 Dimensions / 7.2 Type / 7.3 Casing Cemented

From (m)	To (m)	Internal Diam. (mm)	Swell Joint, Welded Collar, Steel, FRP, PVC, etc.	Yes	No	From (m)	To (m)	Cement (bags)	Water (litres)	Other Additives	Cementing Method Used	Comments
0	5	355	Steel	☐	☑							
+05	18	258	P.V.C Cl 12	☑	☐	0	18	20	540		Pressure	

7.4 **COLLAR CASING** (must be cemented to surface)

				☐	☐							

8. CONSTRUCTION AT PRODUCTION LEVEL

8.1 Method

- ☑ Open Hole
- ☐ Slotted Casing
- ☐ Screen(s)
- ☐ Other, give details:

8.2 Screen or Casing (*If variable aperture screen used give limits)

Type	From (m)	To (m)	Aperture* (mm)	Inner Diam (mm)	Outer Diam (mm)	Material	Trade Name	Completion of Base

8.3 Liner Seal (Packer)

Material	Depth (m)	Internal Diam (mm)

8.4 Gravel Packing

Method of Placement	Gravel Passing Mesh Size	From (m)	To (m)

9. IF NOT A DRILLED WELL

Method	Depth (m)	Length (m)	Width (m)	Diam (m)	Lining Material	From (m)	To (m)

10. DEVELOPMENT (State methods and time taken)

Method	Hours	Minutes
Air	3	

11. PUMPING TEST (measurements from natural surface to nearest 0.1m)

Interval Tested From (m)	Interval Tested To (m)	Water Level (m)	Test Method	Pump Depth (m)	Discharge Rate (L/sec)	Method of Measuring Discharge	Hours Pumped	Draw Down (m)

12. SAMPLES

The Natural Resource Management Act 2004 and Regulations require that strata and water samples must be obtained. If any samples have not been obtained state reasons:

As the person responsible I advise that the work has been completed as described above.

Signature of Licensed Driller P.T. Wagenknecht Date 2/4/11

Driller to deliver this copy together with water samples collected and well location map within 14 days of completion to any of the locations below:

Department of Water Land and Biodiversity Conservation

Science Monitoring & Information, GPO Box 2834 Adelaide SA 5001 (reports only)

Water Laboratory and Geophysical Services, 23 Conyngham Street GLENSIDE SA 5065 or

Mount Gambier Regional Office, 11 Helen Street MOUNT GAMBIER SA 5290 or

Naracoorte Regional Office, 101 Cedar Avenue, NARACOORTE SA 5271

13. FORMATION LOG

From (m)	To (m)	Description of Material
0	1	Dark Brown Loam
1	2	Motley Clay.
~~2~~	~~35~~	~~Brown Clay Sandy~~
~~35~~	~~85~~	
2	7.5	Motley Grey Clay.
7.5	8.5	Hard Layer.
8.5	11	Motley Grey Clay.
11	14	Soft Sandstone and Limestone
14	19.	Limestone with Sand Stone Layer.
19 - 40		Lost Circulation

UNIT NUMBER 7025 3875

BORDERTOWN TWS 10

20 SEP 2011

GOVERNMENT OF SOUTH AUSTRALIA

DRILLERS WELL CONSTRUCTION REPORT

Natural Resource Management Act 2004

1. PERMIT NO: 2 0 0 3 6 5 Site

NAME OF DRILLER J. Mason Licence No: 165178

Contact Phone/Mobile No.: Kangarilla Drilling

Name of plant operator if under supervision

PERMIT HOLDER or land occupier SA Water Corp

Postal Address P.O Box 603

Mount Gambier SA Post Code 5290

2. LOCATION OF WELL

Date of Survey ..... Surveyed by ..... Method .....

GPS COORDINATES AND DATUM USED

☑ GDA 94/WGS84

☐ AGD 66/84

54h – 0470168

UTM – 5982885

☐ ZONE 52 ☐ ZONE 53 ☑ ZONE 54

3. WELL NAME

4. LAND IDENTIFICATION

Hundred or Pastoral Lease: Wirrega

Parcel ID or CT number CT 5195/640

Name of Property

5. SUMMARY *(Please tick appropriate boxes and complete all relevant details)*

Date work Commenced ..... Date work Completed .....

Work carried out: New Well ☑ Deepen ☐ Enlarge ☐ Rehabilitate ☐ Backfill ☑

Is this a Replacement well? YES/NO if yes please quote replaced well number .....

Is this an Existing well? YES/NO **if yes please quote well number or GPS coordinates** Same permit

Was well Abandoned? YES/NO if so please state reason and method of backfill .....

Maximum Depth Drilled.....(m) Final Depth.....(m) Final Standing Water Level.....(m) Final Yield.....(L/sec)

6. DRILLING DETAILS If not a drilled well, please complete Sections: 6.2, 9, 10, 11, 12 and 13 as necessary

6.1 Construction Details

From (m)	To (m)	Diam (mm)	Drilling Method Cable Tool, Rotary Auger, Down Hole Hammer, etc.	Fluid Used (Air, Water, Mud Type)
0	40	248	Rotary	Air

6.2 Water Cut Details (measurements from natural surface to nearest 0.1 m)

Date	Water Cut From (m)	Water Cut To (m)	Standing Water Level (m)	Estimated Yield (L/sec)	Hole Depth at Test (m)	Casing at Test (m)	Test Method	Salinity (mg/L) or Taste

7. CASING LEFT IN WELL

7.1 Dimensions / 7.2 Type / 7.3 Casing Cemented

From (m)	To (m)	Internal Diam. (mm)	Swell Joint, Welded Collar, Steel, FRP, PVC, etc.	Yes	No	From (m)	To (m)	Cement (bags)	Water (litres)	Other Additives	Cementing Method Used	Comments
				☐	☐							
				☐	☐							
				☐	☐							
				☐	☐							

8. CONSTRUCTION AT PRODUCTION LEVEL

8.1 Method

☐ Open Hole

☑ Slotted Casing

☐ Screen(s)

☐ Other, give details:

8.2 Screen or Casing (*If variable aperture screen used give limits)

Type	From (m)	To (m)	Aperture* (mm)	Inner Diam (mm)	Outer Diam (mm)	Material	Trade Name	Completion of Base
Casing	16	40	0.5	208.3	225	P.V.C 412		Open

8.3 Liner Seal (Packer)

Material	Depth (m)	Internal Diam (mm)

8.4 Gravel Packing

Method of Placement	Gravel Passing Mesh Size	From (m)	To (m)

9. IF NOT A DRILLED WELL

Method	Depth (m)	Length (m)	Width (m)	Diam (m)	Lining Material	From (m)	To (m)

10. DEVELOPMENT (State methods and time taken)

Method	Hours	Minutes
Airlift	1	

11. PUMPING TEST (measurements from natural surface to nearest 0.1m)

Interval Tested From (m)	Interval Tested To (m)	Water Level (m)	Test Method	Pump Depth (m)	Discharge Rate (L/sec)	Method of Measuring Discharge	Hours Pumped	Draw Down (m)

12. SAMPLES

The provision of the Natural Resource Management Act 2004 and Regulations require that strata and water samples must be obtained. If any samples have not been obtained state reasons:

.....

As the person responsible I advise that the work has been completed as described above.

Signature of Licensed Driller J.L.Mason Date 19/9/2011

Driller to deliver this copy together with water samples collected and well location map within 14 days of completion to any of the below locations:
Department of Water Land and Biodiversity Conservation
Water Laboratory and Geophysical Services, 23 Conyngham Street GLENSIDE SA 5065 or
Mount Gambier Regional Office, 11 Helen Street MOUNT GAMBIER SA 5290 or
Naracoorte Regional Office, 101 Cedar Avenue, NARACOORTE SA 5271

ENTERED IN RECORDS DATE ... BY ...

13. FORMATION LOG

From (m)	To (m)	Description of Material
		Cleaned out collapsed formation from 25m down
		Work continued on (original) same permit.

7025 3875

UNIT NUMBER

BORDERTOWN TWS 11

GOVERNMENT OF SOUTH AUSTRALIA

DRILLERS WELL CONSTRUCTION REPORT

Natural Resource Management Act 2004

1. PERMIT NO: 20366 Site

NAME OF DRILLER J. Mason Licence No: 165178

Contact Phone/Mobile No.: Kangarilla Drilling

Name of plant operator if under supervision

PERMIT HOLDER or land occupier SA Water Corporation

Postal Address P.O Box 603

Mount Gambier S.A Post Code 5290

2. LOCATION OF WELL 469756 5982559

Date of Survey 26/5 Surveyed by Method

GPS COORDINATES AND DATUM USED

☑ GDA 94/WGS84 ☐ AGD 66/84

54 - 0530248

MTM - 4017504

☐ ZONE 52 ☐ ZONE 53 ☑ ZONE 54

3. WELL NAME Town Supply #17 (replace #5)

4. LAND IDENTIFICATION Bordertown

Hundred or Pastoral Lease: Wirrega

Parcel ID or CT number CT 5623/949 Filed Plan 216910

Name of Property

5. SUMMARY *(Please tick appropriate boxes and complete all relevant details)*

Date work Commenced 26/5/11 Date work Completed 27/5/11

Work carried out: New Well ☑ Deepen ☐ Enlarge ☐ Rehabilitate ☐ Backfill ☐

Is this a Replacement well? YES/NO if yes please quote replaced well number

Is this an Existing well? YES/NO **if yes please quote well number or GPS coordinates**

Was well Abandoned? YES/NO if so please state reason and method of backfill

Maximum Depth Drilled 37 (m) Final Depth 37 (m) Final Standing Water Level 22 (m) Final Yield 10+ (L/sec)

6. DRILLING DETAILS If not a drilled well, please complete Sections: 6.2, 9, 10, 11, 12 and 13 as necessary

6.1 Construction Details

From (m)	To (m)	Diam (mm)	Drilling Method Cable Tool, Rotary Auger, Down Hole Hammer, etc.	Fluid Used (Air, Water, Mud Type)
0	5	406	Rotary	Mud (Polymer)
5	25	330	Rotary	Mud (polymer)

6.2 Water Cut Details (measurements from natural surface to nearest 0.1 m)

Date	Water Cut From (m)	Water Cut To (m)	Standing Water Level (m)	Estimated Yield (L/sec)	Hole Depth at Test (m)	Casing at Test (m)	Test Method	Salinity (mg/L) or Taste
27/5	25	37	22	10+	37	25	Air	

7. CASING LEFT IN WELL

7.1 Dimensions / 7.2 Type / 7.3 Casing Cemented

From (m)	To (m)	Internal Diam. (mm)	Swell Joint, Welded Collar, Steel, FRP, PVC, etc.	Yes	No	From (m)	To (m)	Cement (bags)	Water (litres)	Other Additives	Cementing Method Used	Comments
0	25	354	P.V.C Cl 12	☑	☐	0	25	46x20kg	648	~	Pressure	~
0	6	355	Steel	☐	☐							
				☐	☐							
				☐	☐							

8. CONSTRUCTION AT PRODUCTION LEVEL

8.1 Method

☑ Open Hole

☐ Slotted Casing

☐ Screen(s)

☐ Other, give details:

8.2 Screen or Casing (*If variable aperture screen used give limits)

Type	From (m)	To (m)	Aperture* (mm)	Inner Diam (mm)	Outer Diam (mm)	Material	Trade Name	Completion of Base

8.3 Liner Seal (Packer)

Material	Depth (m)	Internal Diam (mm)

8.4 Gravel Packing

Method of Placement	Gravel Passing Mesh Size	From (m)	To (m)

9. IF NOT A DRILLED WELL

Method	Depth (m)	Length (m)	Width (m)	Diam (m)	Lining Material	From (m)	To (m)

10. DEVELOPMENT (State methods and time taken)

Method	Hours	Minutes
Air lift	3	30

11. PUMPING TEST (measurements from natural surface to nearest 0.1m)

Interval Tested From (m)	Interval Tested To (m)	Water Level (m)	Test Method	Pump Depth (m)	Discharge Rate (L/sec)	Method of Measuring Discharge	Hours Pumped	Draw Down (m)

12. SAMPLES

The provision of the Natural Resource Management Act 2004 and Regulations require that strata and water samples must be obtained. If any samples have not been obtained state reasons:

Refer to Scott Slater or D.F.W

As the person responsible I advise that the work has been completed as described above.

Signature of Licensed Driller [signature] Date 11/7/11

Driller to deliver this copy together with water samples collected and well location map within 14 days of completion to any of the below locations:

Department of Water Land and Biodiversity Conservation

Water Laboratory and Geophysical Services, 23 Conyngham Street GLENSIDE SA 5065 or

Mount Gambier Regional Office, 11 Helen Street MOUNT GAMBIER SA 5290 or

Naracoorte Regional Office, 101 Cedar Avenue, NARACOORTE SA 5271

13. FORMATION LOG

From (m)	To (m)	Description of Material
0	.5	Brown Sands
.5	10.8	White Clay with limestone bands
10.8	12.5	Hard Bands of Sand stone and lime stone
12.5	22	Yellow and white lime stone and sand stone
22	37	White lime stone and sand stone layers

7025 3876 UNIT NUMBER

E 469624 N 5982340

DATE BY

BORDERTOWN TWS 12

GOVERNMENT OF SOUTH AUSTRALIA

DRILLERS WELL CONSTRUCTION REPORT

Natural Resource Management Act 2004

1. PERMIT NO: 20638 Site

NAME OF DRILLER J. Mason Licence No: 16578

Contact Phone/Mobile No.: Kangarilla Drilling

Name of plant operator if under supervision

PERMIT HOLDER or land occupier SA Water Corporation

Postal Address P.O Box 603

Mount Gambier S.A Post Code 5290

2. LOCATION OF WELL

Date of Survey 17/5 Surveyed by ..... Method .....

GPS COORDINATES AND DATUM USED

☑ GDA 94/WGS84 ☐ AGD 66/84

54h - 0530248

4TM - 4017460

☐ ZONE 52 ☐ ZONE 53 ☑ ZONE 54

3. WELL NAME Town supply #12 (replace #7) Bordertown

4. LAND IDENTIFICATION

Hundred or Pastoral Lease: Wirrega

Parcel ID or CT number CT 5623/949 Filed Plan 216

Name of Property

5. SUMMARY *(Please tick appropriate boxes and complete all relevant details)*

Date work Commenced 17/5/11 Date work Completed 19/5/11

Work carried out: New Well ☑ Deepen ☐ Enlarge ☐ Rehabilitate ☐ Backfill ☐

Is this a Replacement well? YES/(NO) if yes please quote replaced well number

Is this an Existing well? YES/(NO) **if yes please quote well number or GPS coordinates**

Was well Abandoned? YES/(NO) if so please state reason and method of backfill

Maximum Depth Drilled 37 (m) Final Depth 37 (m) Final Standing Water Level 22 (m) Final Yield 10+ (L/sec)

6. DRILLING DETAILS If not a drilled well, please complete Sections: 6.2, 9, 10, 11, 12 and 13 as necessary

6.1 Construction Details

From (m)	To (m)	Diam (mm)	Drilling Method Cable Tool, Rotary Auger, Down Hole Hammer, etc.	Fluid Used (Air, Water, Mud Type)
0	5	406	Rotary	Mud (polymer)
5	25	330	Rotary	Mud (polymer)

6.2 Water Cut Details (measurements from natural surface to nearest 0.1 m)

Date	Water Cut From (m)	Water Cut To (m)	Standing Water Level (m)	Estimated Yield (L/sec)	Hole Depth at Test (m)	Casing at Test (m)	Test Method	Salinity (mg/L) or Taste
18/5/11	25	37	22	10+	37	25	Air	

7. CASING LEFT IN WELL

7.1 Dimensions / 7.2 Type

From (m)	To (m)	Internal Diam. (mm)	Swell Joint, Welded Collar, Steel, FRP, PVC, etc.
+0.5	25	254	P.V.C C112
0	6	355	Steel

7.3 Casing Cemented

Yes	No	From (m)	To (m)	Cement (bags)	Water (litres)	Other Additives	Cementing Method Used	Comments
☑	☐	0	25	55 x 20kg	648	–	Pressure	–

8. CONSTRUCTION AT PRODUCTION LEVEL

8.1 Method

☑ Open Hole

☐ Slotted Casing

☐ Screen(s)

☐ Other, give details:

8.2 Screen or Casing (*If variable aperture screen used give limits)

Type	From (m)	To (m)	Aperture* (mm)	Inner Diam (mm)	Outer Diam (mm)	Material	Trade Name	Completion of Base

8.3 Liner Seal (Packer)

Material	Depth (m)	Internal Diam (mm)

8.4 Gravel Packing

Method of Placement	Gravel Passing Mesh Size	From (m)	To (m)

9. IF NOT A DRILLED WELL

Method	Depth (m)	Length (m)	Width (m)	Diam (m)	Lining Material	From (m)	To (m)

10. DEVELOPMENT (State methods and time taken)

Method	Hours	Minutes
Air lift	3	30

11. PUMPING TEST (measurements from natural surface to nearest 0.1m)

Interval Tested From (m)	Interval Tested To (m)	Water Level (m)	Test Method	Pump Depth (m)	Discharge Rate (L/sec)	Method of Measuring Discharge	Hours Pumped	Draw Down (m)

12. SAMPLES

The provision of the Natural Resource Management Act 2004 and Regulations require that strata and water samples must be obtained. If any samples have not been obtained state reasons:

Refer to Scott Slater or DFW.

As the person responsible I advise that the work has been completed as described above.

Signature of Licensed Driller J. Mason Date 14/7/11

Driller to deliver this copy together with water samples collected and well location map within 14 days of completion to any of the below locations:

Department of Water Land and Biodiversity Conservation

Water Laboratory and Geophysical Services, 23 Conyngham Street GLENSIDE SA 5065 or

Mount Gambier Regional Office, 11 Helen Street MOUNT GAMBIER SA 5290 or

Naracoorte Regional Office, 101 Cedar Avenue, NARACOORTE SA 5271

DATE RECEIVED BY

13. FORMATION LOG

From (m)	To (m)	Description of Material
0	.2	Brown Sand
.2	1	White marly Limestone
1	7.8	White Clay with small amount of Limestone
7.8	9.5	Hard bands and Soft bands and orange Sandstone
9.5		LOST CIRCULATION (Cased to 25m regained circulation
25	37	White limestone
	9.5	Cavernous Limestone

7025 3877

UNIT NUMBER

E 469624 N 5982301

PENOLA TWS 7

GOVERNMENT OF SOUTH AUSTRALIA

DRILLERS WELL CONSTRUCTION REPORT

Natural Resource Management Act 2004

1. PERMIT NO: 1 9 9 1 4 0 Site

NAME OF DRILLER S. Mason Licence No: 165178

Contact Phone/Mobile No.: Kangarilla Drilling

Name of plant operator if under supervision:

PERMIT HOLDER or land occupier S.A Water Corporation

Postal Address P.O Box 603 Mount Gambier S.A Post Code:

2. LOCATION OF WELL

Date of Survey 7/6/10 Surveyed by: Method:

GPS COORDINATES AND DATUM USED

☑ GDA 94/WGS84 ☐ AGD 66/84

54h- 0485912

UTM- 5864334

☐ ZONE 52 ☐ ZONE 53 ☑ ZONE 54

3. WELL NAME Penola T.W.S 2011

4. LAND IDENTIFICATION

Hundred or Pastoral Lease: Penola

Parcel ID or CT number CT 6044/597 Cle Plan 16266

Name of Property:

5. SUMMARY *(Please tick appropriate boxes and complete all relevant details)*

Date work Commenced 7/6/10 Date work Completed 22/6/11

Work carried out: New Well ☑ Deepen ☐ Enlarge ☐ Rehabilitate ☐ Backfill ☑ ???

Is this a Replacement well? YES/NO if yes please quote replaced well number:

Is this an Existing well? YES/NO **if yes please quote well number or GPS coordinates:**

Was well Abandoned? YES/NO if so please state reason and method of backfill ????

Maximum Depth Drilled 160 (m) Final Depth 154 (m) Final Standing Water Level: (m) Final Yield 5+ (L/sec)

6. DRILLING DETAILS If not a drilled well, please complete Sections: 6.2, 9, 10, 11, 12 and 13 as necessary

6.1 Construction Details

From (m)	To (m)	Diam (mm)	Drilling Method Cable Tool, Rotary Auger, Down Hole Hammer, etc.	Fluid Used (Air, Water, Mud Type)
0	5	406	Rotary	Mud (polymer)
5	140	330	Rotary	Mud (polymer)
140	154	254	Rotary	Mud (polymer)
154	160	203	Rotary	Mud (polymer)

6.2 Water Cut Details (measurements from natural surface to nearest 0.1 m)

Date	Water Cut From (m)	Water Cut To (m)	Standing Water Level (m)	Estimated Yield (L/sec)	Hole Depth at Test (m)	Casing at Test (m)	Test Method	Salinity (mg/L) or Taste
21/6/11	140	154		5+	154	140	Air	

7. CASING LEFT IN WELL

7.1 From (m)	7.1 To (m)	7.1 Internal Diam. (mm)	7.2 Type: Swell Joint, Welded Collar, Steel, FRP, PVC, etc.	7.3 Yes	7.3 No	7.3 From (m)	7.3 To (m)	Cement (bags)	Water (litres)	Other Additives	Cementing Method Used	Comments
+0.5	140	254	P.V.C C117	☑	☐	0	140	93x40kg	3511	–	Drill Pipe	
				☐	☐							
				☐	☐			+38x20kg	top up			
				☐	☐			x 432L	water			

8. CONSTRUCTION AT PRODUCTION LEVEL

8.1 Method

☐ Open Hole ☐ Slotted Casing ☑ Screen(s) ☐ Other, give details:

8.2 Screen or Casing (*If variable aperture screen used give limits)

Type	From (m)	To (m)	Aperture* (mm)	Inner Diam (mm)	Outer Diam (mm)	Material	Trade Name	Completion of Base
Screen	137.8	153.8	0-.6	203	223	Stainless Steel	Johnsons	Sump
	3m	riser	and	2m	sump	of	0.00mm	

8.3 Liner Seal (Packer)

Material	Depth (m)	Internal Diam (mm)

8.4 Gravel Packing

Method of Placement	Gravel Passing Mesh Size	From (m)	To (m)

9. IF NOT A DRILLED WELL

Method	Depth (m)	Length (m)	Width (m)	Diam (m)	Lining Material	From (m)	To (m)

10. DEVELOPMENT (State methods and time taken)

Method	Hours	Minutes
Air lift	3	

11. PUMPING TEST (measurements from natural surface to nearest 0.1m)

Interval Tested From (m)	Interval Tested To (m)	Water Level (m)	Test Method	Pump Depth (m)	Discharge Rate (L/sec)	Method of Measuring Discharge	Hours Pumped	Draw Down (m)

12. SAMPLES

The provision of the Natural Resource Management Act 2004 and Regulations require that strata and water samples must be obtained. If any samples have not been obtained state reasons:

Refer to Scott Slater after D.E.W

As the person responsible I advise that the work has been completed as described above.

Signature of Licensed Driller: Date 11/7/11

Driller to deliver this copy together with water samples collected and well location map within 14 days of completion to any of the below locations:
Department of Water Land and Biodiversity Conservation
Water Laboratory and Geophysical Services, 23 Conyngham Street GLENSIDE SA 5065 or
Mount Gambier Regional Office, 11 Helen Street MOUNT GAMBIER SA 5290 or
Naracoorte Regional Office, 101 Cedar Avenue, NARACOORTE SA 5271

13. FORMATION LOG

From (m)	To (m)	Description of Material
0	.5	Rubble
.5	3	Silty white limestone
3	21	Orange Sandstone and white limestone
23.5	38	Chert bands then as above
38	84	White, green, yellow silty marly limestone
84	106	Brown silty Clay, layers with fine sand layers
106		Hard Band of Sandstone then as above
113	139	Brown Clay
139	160	Coarse sands and brown silty clays.

7023 7201 UNIT NUMBER

RECEIVED DATE BY

E 485907 N 5864 335

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).

$$\mathbf{s(t) = (aQ + cQ^2) + b \log(t) Q} \qquad \textbf{Equation (6)}$$

Where,

s(t) = drawdown (m)
Q = discharge rate (m^3/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

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

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	2.72	2.72
1	5	35	2.72	2.72
1	5	40	2.73	2.73
1	5	45	2.74	2.74
1	5	50	2.74	2.74
1	5	55	2.75	2.75
1	5	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

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

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

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	74	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	30	127	17.53	0.85
3	30	128	17.535	0.86
3	30	129	17.53	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

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

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
	35	17.47	0.82
	40	17.48	0.83
	45	17.49	0.84
30	50	17.5	0.85
	55	17.51	0.85
30	60	17.51	0.86
	70	17.52	0.87
	80	17.53	0.88
	90	17.54	0.88
30	100	17.54	0.89
	120	17.55	0.9
	140	17.56	0.92
30	160	17.58	0.93
	180	17.59	0.93
30	200	17.59	0.94
	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

	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)

Step	Rate (L/s)	Duration (min)	Depth to Water(m)	Drawdown (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		67	24.56	9.04
2	25	68	24.56	9.04
2		69	24.55	9.03
2	25	70	24.55	9.03
2		72	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		82	24.53	9.01
2		84	24.54	9.02
2	25	86	24.53	9.01
2		88	24.53	9.01
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		110	24.53	9.01
2		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		127	26.77	11.25
3		128	26.74	11.22
3		129	26.75	11.23
3	30	130	26.76	11.24
3		132	26.76	11.24
3		134	26.78	11.26
3		136	26.73	11.21
3	30	138	26.77	11.25
3		140	26.82	11.30
3		142	26.8	11.28
3		144	26.8	11.28
3	30	146	26.8	11.28
3		148	26.8	11.28
3		150	26.8	11.28
3	30	155	26.8	11.28
3		160	26.77	11.25
3		165	26.83	11.31
3		170	26.85	11.33
3		175	26.85	11.33
3	30	180	26.84	11.32

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

Rate (L/s)	Duration (min)	Depth to 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 12 – Step Drawdown Test (4 June 2011)

Step	Rate (L/s)	Duration (min)	Depth to Water (m)	Drawdown (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
1		6	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		55	20.43	5.02
1	10	60	20.43	5.02
2	15	61	23.03	7.62
2		62	23.2	7.79
2		63	23.15	7.74
2		64	23.13	7.72
2		65	23.13	7.72
2		66	23.08	7.67
2		67	23.08	7.67
2	15	68	23.08	7.67
2		69	23.12	7.71
2	15	70	23.25	7.84
2		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

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)

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

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

Penola TWS 7 – Constant Rate Discharge Test (13 August 2011)

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
	12	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
	70	37.4	14.93
	80	37.43	14.96
30	90	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	22.72	0.25
	365	22.7	0.23
	366	22.68	0.21
	367	22.67	0.20
	368	22.66	0.19
	369	22.64	0.17
	370	22.63	0.16
	372	22.63	0.16
	374	22.62	0.15

	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

SA Water
Bore Replenishment Program
Geranium TWS 3
Unit No: 6927-991

Groundwater Analytical Results

Government of South Australia
Department for Water

Parameter	Australian Drinking Water Quality Guideline Values		Borehole Geranium TWS 3	Limits of Reporting
	Health	Aesthetic		
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	n	500	1500	1
Total Hardness as CaC03	n	200	621	2
Alkalinity as $CaC0_3$			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	0.005
Nitrate + Nitrite (N)			0.16	0.003
Nitrate + Nitrite ($N0_3$)	50		0.71	0.02
Nitrite (N)	3		<LOR	0.003
Dissolved Organic Carbon			0.7	0.3
Bromide			2.02	0.1
Fluoride	1.5		0.98	0.1
Iodide	0.1		<LOR	0.05
Chlorine Demand - 24 hrs			1.55	n/a
Chlorine Demand - 30 minutes			2.63	n/a
Chlorine Demand - 8 hrs			1.09	n/a
Total Cyanide	0.08		<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	0.01
Langelier Index			0.11	
Metals/Metalloids				
Aluminium - Acid Soluble	i	0.2	<LOR	0.001
Aluminium - Soluble			<LOR	0.001
Aluminium - Total			0.001	0.001
Antimony - Soluble and Total	0.003		<LOR	0.0005
Arsenic - Soluble			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	0.0003
Boron - Soluble			0.298	0.02
Cadmium - Soluble and Total	0.002		<LOR	0.001
Chromium - Soluble			0.0020	0.0001
Chromium - Total	0.05		0.0024	0.0001
Copper - Soluble and Total	2	1	<LOR	0.0001
Iron - Soluble			0.0033	0.0005
Iron - Total	i	0.3	0.0160	0.0005
Lead - Soluble			<LOR	0.0001
Lead - Total	0.01		0.0001	0.0001
Magnesium - Total			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	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			12.5	0.04
Selenium - Soluble			0.0036	0.0001
Selenium - Total	0.01		0.0037	0.0001
Silver - Soluble and Total	0.1		<LOR	0.00003
Tin - Soluble and Total	i		<LOR	0.0005
Uranium - Soluble and Total	0.02		0.0013	0.0001
Zinc - Soluble			0.00750	0.0003
Zinc - Total	i	5	0.00810	0.0003
Acidic Based Herbicides	Various	Various	<LOR	Various
OrganoChlorine Pesticides	Various	Various	<LOR	Various
Organophosphorous and Triazine Pesticides	Various	Various	<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 mg/L unless stated otherwise
<LOR - indicated all analytes in category were below limits of detection, and so not shown
<LOR - indicated some analytes in category were below limits of detection, and so not shown

SA Water
Bore Replenishment Program
Bordertown TWS 10
Unit No: 7025-3875

Groundwater Analytical Results

Government of South Australia
Department for Water

Parameter	Australian Drinking Water Quality Guideline Values		Borehole Bordertown TWS 10 (28 Apr 2011)	Borehole Bordertown TWS 10 (10 Aug 2011)^	Limits of Reporting
	Health	Aesthetic			
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 $CaC0_3$			315		n/a
Bicarbonate			384		n/a
Carbonate			0		n/a
Hydroxide			0		n/a
Calcium			79.6		0.04
Ammonia (N)	i	0.5	0.062		0.005
Nitrate + Nitrite (N)			0.024		0.003
Nitrate + Nitrite ($N0_3$)	50		0.110		0.02
Nitrite (N)	3				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	i	0.2	0.00200		0.001
Aluminium - Soluble			<0.001		0.001
Aluminium - Total			0.025		0.001
Antimony - Soluble and Total	0.003		<0.0005		0.0005
Arsenic - Soluble			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			0.0130		0.0001
Manganese - Total	0.5	0.1	0.0167		0.0001
Mercury - Soluble and Total	0.001		<0.00003		0.00003
Molybdenum - Soluble and Total	0.05		0.0002		0.0001
Nickel - Soluble			0.0077		0.0001
Nickel - Total	0.02		0.0001		0.0001
Potassium - Total			4.77		0.04
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
Zinc - Total	i	5	0.02910		0.0003
Acidic Based Herbicides	Various	Various	<LOR		Various
OrganoChlorine Pesticides	Various	Various	<LOR		Various
Organophosphorous and Triazine Pesticides	Various	Various	<LOR		Various

i - Insufficient data to set a guideline value based on health considerations.
n - listed as not necessary in ADWG
^Only select analytes tested for repeat sampling
* - unitless
** - µS/cm
*** - NTU (nephelometric turbidity units)
**** - HU (Hazen Units)
***** - Bq/L
All results reported as mg/L unless stated otherwise
<LOR - indicated all analytes in category were below limits of detection, and so not shown
<LOR - indicated some analytes in category were below limits of detection, and so not shown

SA Water
Bore Replenishment Program
Bordertown TWS 11
Unit No: 7025-3876

Groundwater Analytical Results

Government of South Australia
Department for Water

Parameter	Australian Drinking Water Quality Guideline Values		Borehole Bordertown TWS 11	Limits of Reporting
	Health	Aesthetic		
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 $CaC0_3$			290	n/a
Bicarbonate			354	n/a
Carbonate			0.00	n/a
Hydroxide			0.00	n/a
Calcium			56.50	0.04
Ammonia (N)	i	0.5	0.01	0.005
Nitrate + Nitrite (N)			0.04	0.003
Nitrate + Nitrite ($N0_3$)	50		0.16	0.02
Nitrite (N)	3			0.003
Dissolved Organic Carbon			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			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			<0.0003	0.0003
Arsenic - Total	0.007		<0.0003	0.0003
Barium - Soluble			0.0120	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			0.0004	0.0001
Selenium - Total	0.01		0.0004	0.0001
Silver - Soluble and Total	0.1		<0.00003	0.00003
Tin - Soluble and Total	i		0.0005	0.0005
Uranium - Soluble and Total	0.02		0.0031	0.0001
Zinc - Soluble			0.00810	0.0003
Zinc - Total	i	5	0.00870	0.0003
Acidic Based Herbicides	Various	Various	<LOR	Various
OrganoChlorine Pesticides	Various	Various	<LOR	Various
Organophosphorous and Triazine Pesticides	Various	Various	<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 mg/L unless stated otherwise
<LOR - indicated all analytes in category were below limits of detection, and so not shown
<LOR - indicated some analytes in category were below limits of detection, and so not shown

SA Water
Bore Replenishment Program
Bordertown TWS 12
Unit No: 7025-3877

Groundwater Analytical Results

Government of South Australia
Department for Water

Parameter	Australian Drinking Water Quality Guideline Values		Borehole Bordertown TWS 12	Limits of Reporting
	Health	Aesthetic		
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 $CaC0_3$			292	n/a
Bicarbonate			357	n/a
Carbonate			0	n/a
Hydroxide			0	n/a
Calcium			58.50	0.04
Ammonia (N)	i	0.5	0.007	0.005
Nitrate + Nitrite (N)			0.034	0.003
Nitrate + Nitrite ($N0_3$)	50		0.150	0.02
Nitrite (N)	3			0.003
Dissolved Organic Carbon			0.7	0.3
Bromide			0.350	0.1
Fluoride	1.5		0.37	0.1
Iodide	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			<0.0003	0.0003
Arsenic - Total	0.007		<0.0003	0.0003
Barium - Soluble			0.0204	0.0005
Barium - Total	0.7		0.0209	0.0005
Beryllium - Soluble and Total	i		<0.0003	0.0003
Boron - Soluble			0.117	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	0.0005	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			0.0007	0.0001
Selenium - Total	0.01		0.0007	0.0001
Silver - Soluble and Total	0.1		<0.00003	0.00003
Tin - Soluble and Total	i		<0.0005	0.0005
Uranium - Soluble and Total	0.02		0.0019	0.0001
Zinc - Soluble			0.0072	0.0003
Zinc - Total	i	5	0.01	0.00
Acidic Based Herbicides	Various	Various	<LOR	Various
OrganoChlorine Pesticides	Various	Various	<LOR	Various
Organophosphorous and Triazine Pesticides	Various	Various	<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 mg/L unless stated otherwise
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SA Water
Bore Replenishment Program
Penola TWS 7
Unit No: 7023-7201

Groundwater Analytical Results

Government of South Australia
Department for Water

Parameter	Australian Drinking Water Quality Guideline Values		Borehole Penola TWS 7.	Limits of Reporting
	Health	Aesthetic		
pH*	i	6.5-8.5	7.10	n/a
Conductivity**			1150	1
Turbidity***	i	5	9.30	0.1
Colour - Apparent (456nm)****	n	15	89	1
TDS	n	500	630	1
Total Hardness as CaC03	n	200	336	2
Alkalinity as $CaC0_3$			340	n/a
Bicarbonate			414	n/a
Carbonate			0.00	n/a
Hydroxide			0.00	n/a
Calcium			99.10	0.04
Ammonia (N)	i	0.5	0.076	0.005
Nitrate + Nitrite (N)			0.04	0.003
Nitrate + Nitrite ($N0_3$)	50		0.16	0.02
Nitrite (N)	3			0.003
Dissolved Organic Carbon				0.3
Bromide			0.35	0.1
Fluoride	1.5		0.20	0.1
Iodide	0.1		<0.05	0.05
Chlorine Demand - 24 hrs			1.74	n/a
Chlorine Demand - 30 minutes			1.52	n/a
Chlorine Demand - 8 hrs			1.81	n/a
Total Cyanide	0.08		<0.05	0.05
Sodium	n	180	108.00	0.04
Sulphur (Sulphate)	500	250	13.50	1.5
Gross Alpha Activity*****			<0.005	0.005
Gross Beta Activity*****			<0.01	0.01
Langelier Index			0.07	
Metals/Metalloids				
Aluminium - Acid Soluble	i	0.2	<0.001	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			0.0006	0.0003
Arsenic - Total	0.007		0.0007	0.0003
Barium - Soluble			0.0296	0.0005
Barium - Total	0.7		0.0303	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	0.0001
Chromium - Soluble			<0.0001	0.0001
Chromium - Total	0.05		<0.0001	0.0001
Copper - Soluble and Total	2	1	0.0001	0.0001
Iron - Soluble			0.0953	0.0005
Iron - Total	i	0.3	0.8842	0.0005
Lead - Soluble			<0.0001	0.0001
Lead - Total	0.01		<0.0001	0.0001
Magnesium - Total			21.4	0.04
Manganese - Soluble			0.0172	0.0001
Manganese - Total	0.5	0.1	0.0181	0.0001
Mercury - Soluble and Total	0.001		<0.00003	0.00003
Molybdenum - Soluble and Total	0.05		0.0002	0.0001
Nickel - Soluble			0.0012	0.0001
Nickel - Total	0.02		0.0014	0.0001
Potassium - Total			3.36	0.04
Selenium - Soluble			0.0004	0.0001
Selenium - Total	0.01		0.0004	0.0001
Silver - Soluble and Total	0.1		<0.00003	0.00003
Strontium			0.72520	0.0001
Tin - Soluble and Total	i		0.0005	0.0005
Uranium - Soluble and Total	0.02		<0.0001	0.0001
Zinc - Soluble			0.0029	0.0003
Zinc - Total	i	5	0.0035	0.0003
Acidic Based Herbicides	Various	Various	<LOR	Various
OrganoChlorine Pesticides	Various	Various	<LOR	Various
Organophosphorous and Triazine Pesticides	Various	Various	<LOR	Various

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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	10^6 m^3	volume
gram	g	10^{-3} kg	mass
hectare	ha	10^4 m^2	area
hour	h	60 min	time interval
kilogram	kg	base unit	mass
kilolitre	kL	1 m^3	volume
kilometre	km	10^3 m	length
litre	L	10^{-3} m^3	volume
megalitre	ML	10^3 m^3	volume
metre	m	base unit	length
microgram	µg	10^{-6} g	mass
microlitre	µL	10^{-9} m^3	volume
milligram	mg	10^{-3} g	mass
millilitre	mL	10^{-6} m^3	volume
millimetre	mm	10^{-3} m	length
minute	min	60 s	time interval
second	s	base unit	time interval
tonne	t	1000 kg	mass
year	y	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 (µS/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_s) — 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_y) — 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^2/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.