DWLBC Technical Report

Far North Town Water Supplies—Quorn and Wilmington, South Australia

Government of South Australia
Department of Water, Land and Biodiversity Conservation

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Far North Town Water Supplies—Quorn and Wilmington, South Australia

Adrian Costar, Nicholas Kruger and Stephen Howles

Science, Monitoring and Information Division
Department of Water, Land and Biodiversity Conservation

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Government of South Australia
Department of Water, Land and Biodiversity Conservation

Science, Monitoring and Information Division
Department of Water, Land and Biodiversity Conservation
25 Grenfell Street, Adelaide
GPO Box 2834, Adelaide SA 5001

Telephone	National	(08) 8463 6946
	International	+61 8 8463 6946
Fax	National	(08) 8463 6999
	International	+61 8 8463 6999
Website	www.dwlbc.sa.gov.au	

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FOREWORD

South Australia's unique and precious natural resources are fundamental to the economic and social wellbeing of the state. It is critical that these resources are managed in a sustainable manner to safeguard them for both current users and future generations.

The Department of Water, Land and Biodiversity Conservation (DWLBC) strives to ensure that our natural resources are managed so that they are available for all users, including the environment.

In order for us to best manage these natural resources it is imperative that we have a sound knowledge of their condition and how they are likely to respond to management changes. DWLBC scientific and technical staff continue to improve this knowledge through undertaking investigations, technical reviews and resource modelling.

Scott Ashby
CHIEF EXECUTIVE
DEPARTMENT OF WATER, LAND AND BIODIVERSITY CONSERVATION

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1. INTRODUCTION

In early 2009, the Department of Water, Land and Biodiversity Conservation (DWLBC) was approached by the South Australian Water Corporation (SA Water) to drill and complete two production wells for the townships of Quorn and Wilmington in the Flinders Ranges (Fig. 1).

These new wells were to be used to supplement the existing town water supplies for both townships. At Quorn, the new well was required primarily as a standby well, while the new well at Wilmington would supply a further 4 L/s, since the main production well was currently operating at full capacity.

Gorey and Cole Drillers, based in Alice Springs, were contracted to drill and construct the two new wells. Drilling commenced in mid July 2009 and was completed two weeks later. DWLBC Groundwater Technical Services (Walkley Heights) conducted pumping tests that commenced in early September 2009.

1.1 QUORN TOWN WATER SUPPLY

Quorn is located approximately 250 km north of Adelaide and is reliant on groundwater from fractured rock aquifers for its town water supply. Prior to the commencement of this project, there were three production wells in use: Quorn TWS 2, Quorn TWS 3 and Quorn TWS 5. Quorn TWS 5 was the most recently constructed well and is located within 20 m of the disused well, Quorn TWS 1.

The groundwater salinity in the vicinity of Quorn TWS 5 is approximately 1200 mg/L which is lower than that found near Quorn TWS 2, 3 and 4 (Quorn TWS 4 is not in use).

Current pumping rates from Quorn TWS 5 are approximately 8 L/s. While the well is capable of producing larger supplies, the pumping rate is limited by the capacity of the power supply available at the site.

SA Water required a standby well to be drilled adjacent to Quorn TWS 5.

Well details are given in Table 1.

Table 1. Quorn town water supply well details

Well name	Unit number	Depth (m)	Completion date	DTW (m)	DTW date
Quorn TWS 1	6533-174	80.5	Aug-1948	50.3	5-Aug-1948
Quorn TWS 2	6533-177	56.4	Jun-1969	40.3	6-Dec-1978
Quorn TWS 3	6533-179	69.0	Mar-1978	42.0	9-Jul-1997
Quorn TWS 4	6533-626	76.5	Jul-1985	53.9	10-Sep-2009
Quorn TWS 5	6533-863	122.0	Sep-2002	58.0	7-Sep-2002
Quorn TWS 6	6533-910	148.0	Jul-2009	58.9	17-Jul-2009

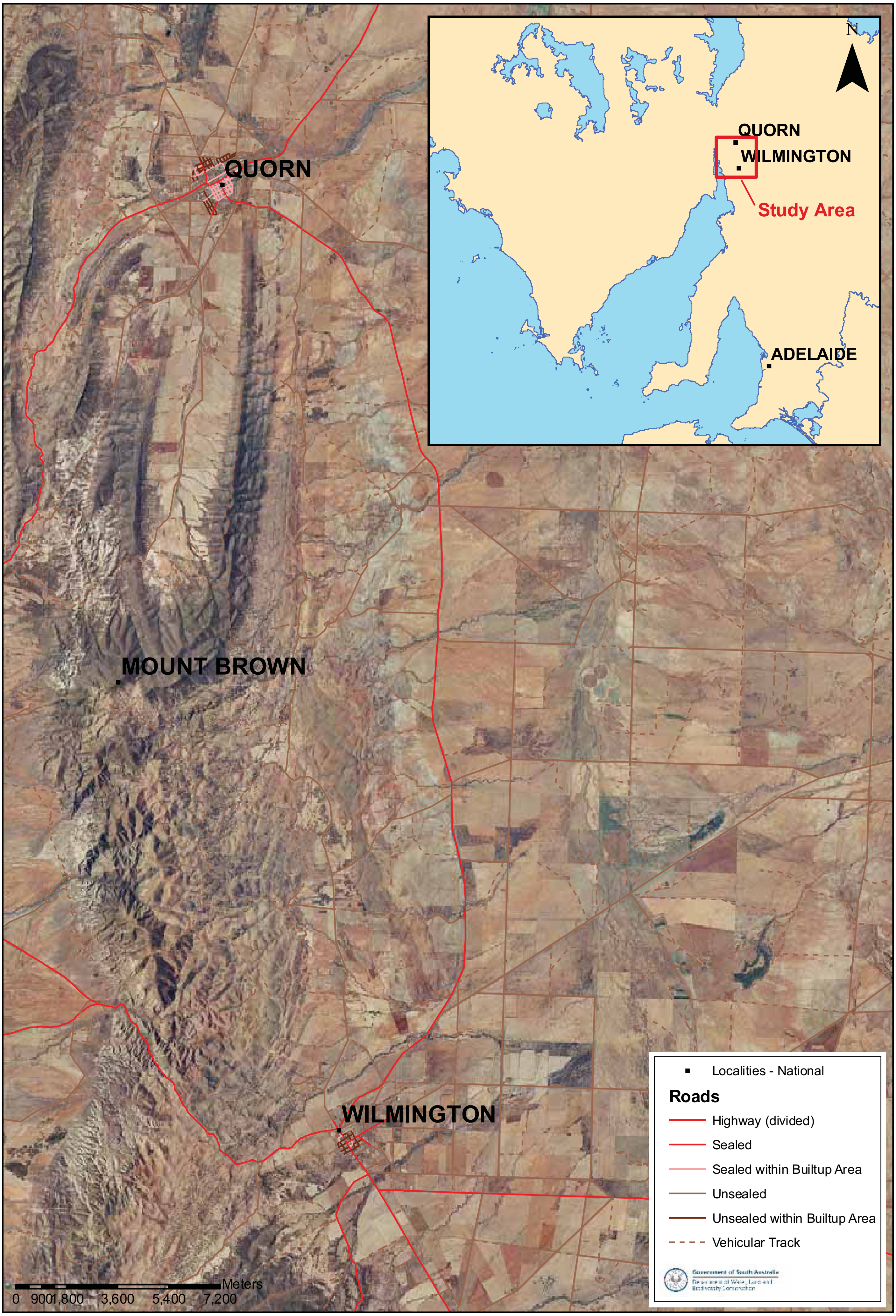

Figure 1. Location of the Quorn and Wilmington townships

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1.2 WILMINGTON TOWN WATER SUPPLY

Wilmington is located approximately 200 km north of Adelaide and is also reliant on groundwater from fractured rock aquifers for its town water supply. The primary source of water is an old mine shaft (known as the Wilmington TWS Mine Shaft), which has provided approximately 95% of the demand since the 1900s with a salinity of approximately 300 mg/L. Another well, Wilmington TWS 2, is used to intermittently supplement the supply from a different geological unit. The chemistry of this groundwater is not as suitable for potable use as that from the Wilmington TWS Mine Shaft.

The current pumping rate from the Wilmington TWS Mine Shaft is approximately 8 L/s, which is limited by the available drawdown in the well with the pump positioned approximately 31 m below the ground surface. During summer, the water level has been observed to drop to just 3 m above the pump.

SA Water decided that a new well (Wilmington TWS 3) should be drilled near the Wilmington TWS Mine Shaft to supplement the supply, preferably with groundwater of better quality than that available from Wilmington TWS 2.

Well details are given in Table 2.

Table 2. Wilmington town water supply well details

Well name	Unit number	Depth (m)	Completion date	DTW (m)	DTW date
Wilmington TWS Mine Shaft	6532-1005	32.0	1874	11.5	21-Dec-1994
Wilmington TWS 2	6532-1499	81.0	4-Dec-1999	5.0	4-Dec-1999
Wilmington TWS 3	6532-1642	115.0	22-Jul-2009	18.7	22-Jul-2009
Monitoring Well	6532-1332	134.0	10-Mar-1986	6.5	11-Mar-1986

2. WELL DESIGN AND CONSTRUCTION

2.1 QUORN TWS 6

Quorn TWS 6 was drilled as a production well under permit number 161383 (well unit number 6533-910) and was completed on 17 July 2009. The site location is given in Figure 2, with the well construction details shown in Figure 3.

The site of Quorn TWS 6 was chosen by SA Water hydrogeologists, taking into consideration the following factors:

- A site within 20–30 m of the existing production well (Quorn TWS 5), to intercept the same geological unit and obtain a similar groundwater supply with an acceptable salinity and yield (Osei-Bonsu & Evans 2002).
- Rig access, and proximity to power and the existing pipeline infrastructure.

On instructions from SA Water to reduce construction costs, the well design for Quorn TWS 6 was based on that of Quorn TWS 5, with savings made in areas such as materials, geophysics and standby time.

Quorn TWS 6 was air drilled to a depth of 56 m, at which strata samples indicated competent fractured rock. PVC casing (203 mm ID) was set to 56 m, with the shoe grouted in place. The well was then air drilled to a total depth of 148 m, resulting in an open-hole interval within a yellow quartz sandstone unit from 56–148 m. A number of fractures were intersected during drilling (Fig. 3). The driller indicated the first water cut was intersected at 74 m. The groundwater salinity measured on-site was reasonably constant at ~1400 mg/L to the total depth.

A final depth to water of 59.4 m, an airlift yield of ~8 L/s, and salinity of 1200 mg/L were recorded.

Figure 3 indicates the lithology encountered during drilling. Strata samples were taken every rod change (6 m) due to poor sample return. On-site groundwater salinity and yield were also recorded after every rod change where possible.

The well construction report (Schedule 8) for Quorn 6 is provided in Appendix A.

Figure 2. Site location for Quorn TWS 6

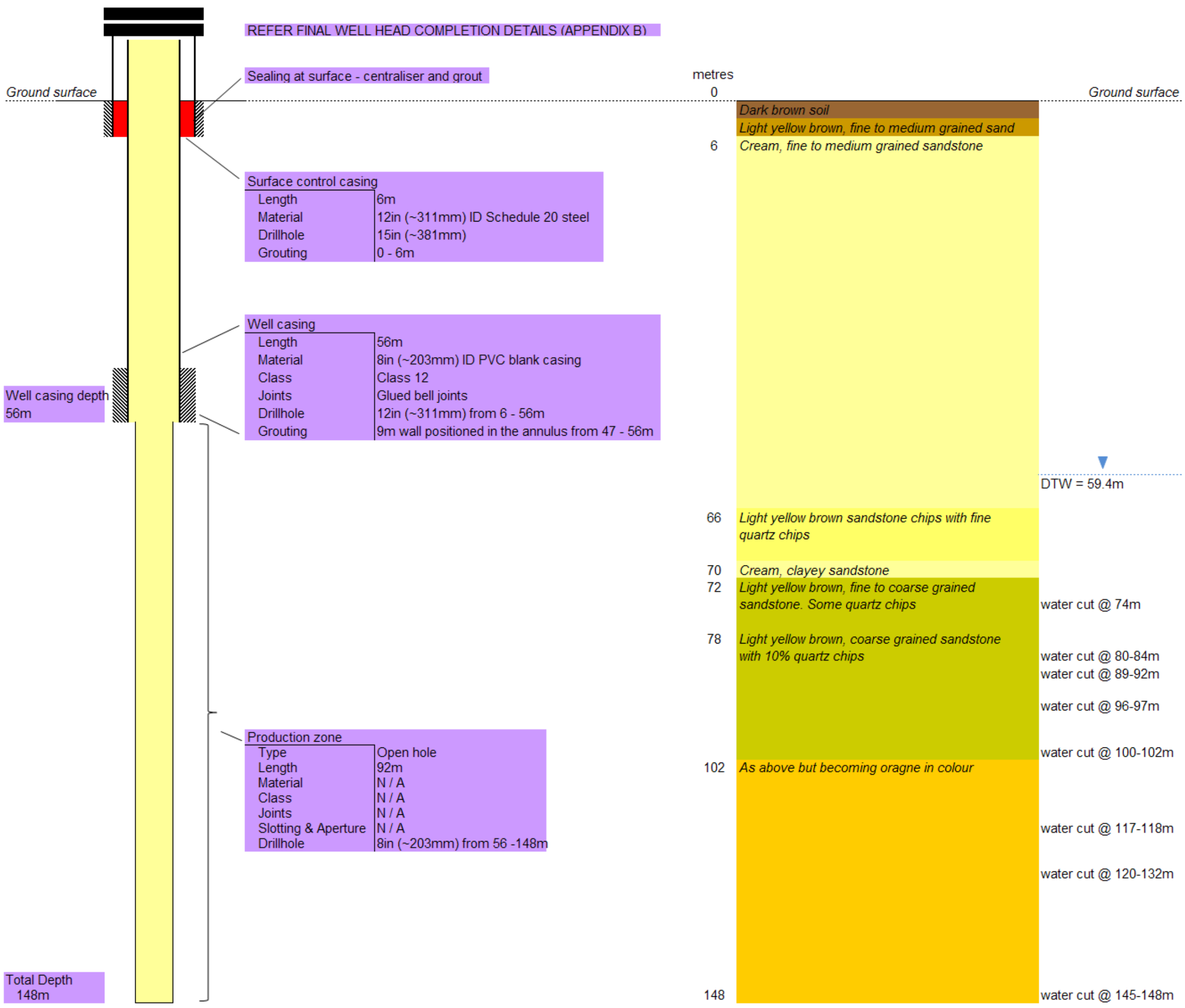


Figure 3. Well construction diagram for Quorn TWS 6

The wellhead for Quorn 6 was completed as detailed in Appendix B.

2.2 WILMINGTON TWS 3

Wilmington TWS 3 was drilled as a production well under permit number 164133 (well unit number 6532-1642) and was completed on 22 July 2009. The site location is given in Figure 4, with the well construction details shown in Figure 5.

As with the Quorn well, the site of Wilmington TWS 3 was chosen by SA Water hydrogeologists taking into consideration the following factors:

- A site within the same lithology as the existing Wilmington TWS Mine Shaft, to obtain a similar groundwater supply with an acceptable salinity and yield (see SA Water report provided in Appendix C).
- Rig access, and proximity to power and the existing pipeline infrastructure.

This well was air drilled to a total depth of 115 m, at which drilling was terminated due to an unstable formation, with concern being expressed by the driller that the drilling rods would become locked in the formation. A depthing tool was then employed, which indicated a total depth of 107.5 m. A casing string comprising 53.5 m of blank PVC casing (203 mm ID) and 54 m of slotted PVC casing (203 mm ID) was then run into the hole to a depth of 107.5 m. A seal was set at 48 m and grouted in place. A number of fractures were intersected during drilling (Fig. 4). The driller indicated the first water cut was intersected at 53 m. The groundwater salinity measured on-site was reasonably constant at ~350 mg/L to total depth.

During the grouting process some grout was lost down the hole, resulting in a final depth of 97.5 m.

A final depth to water of 18.7 m, an airlift yield of ~20 L/s, and a groundwater salinity of 350 mg/L were recorded.

Figure 4 indicates the lithology encountered during drilling. Strata samples were taken every rod change (6 m) due to difficulties in collecting samples. In-field groundwater salinity and yield were also recorded after every rod change where possible.

The well construction report (Schedule 8) for Wilmington TWS 3 is provided in Appendix A.

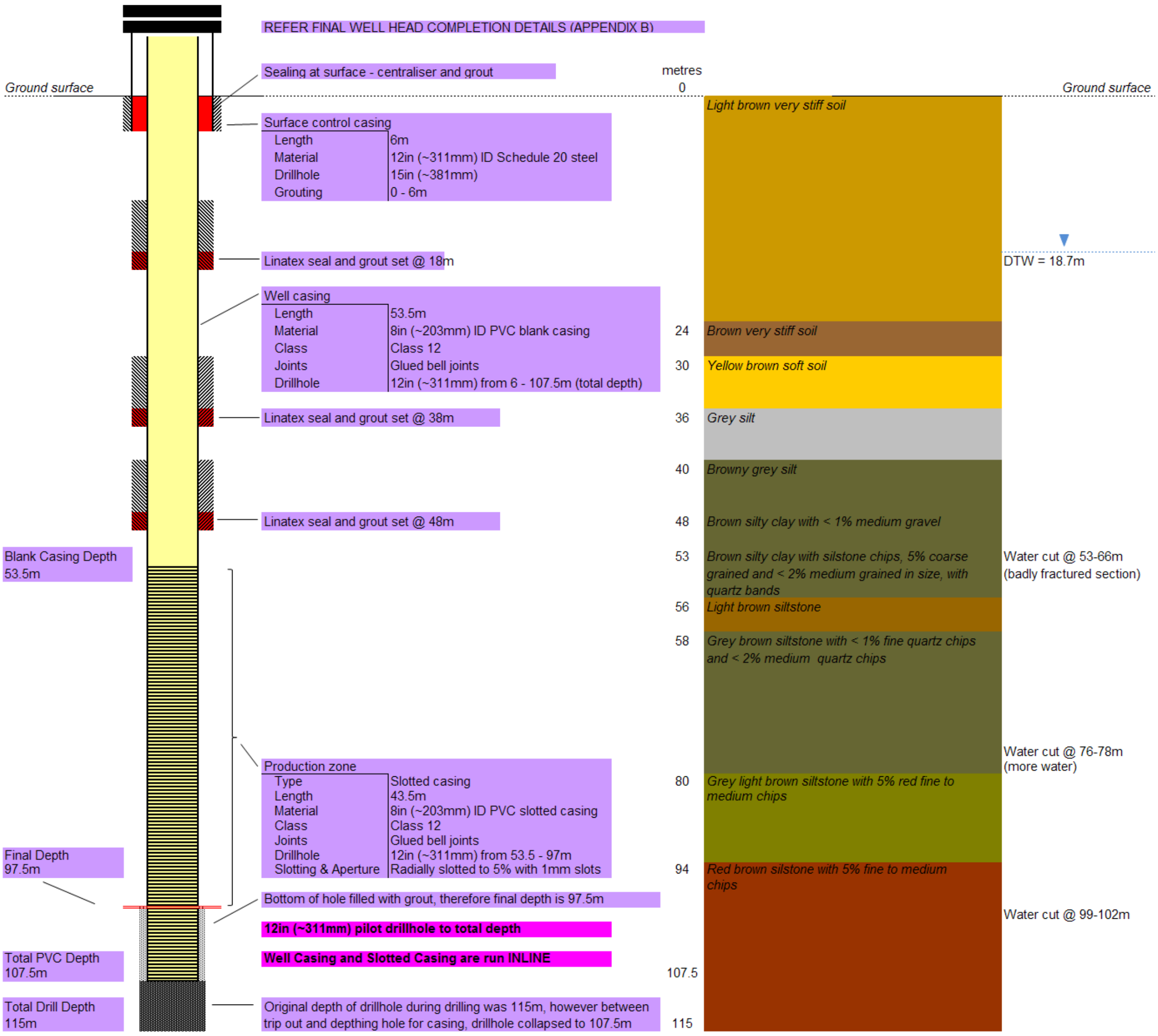


Figure 4. Well construction diagram for Wilmington TWS 3

The wellhead for Wilmington TWS 3 was completed as detailed in Appendix B.

Figure 5. Site location for Wilmington TWS 3

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.

In this case, SA Water required a pumping test on the new supply wells 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 pumping tests conducted on both Quorn TWS 6 and Wilmington TWS 3 consisted of a step drawdown test and a constant rate discharge test.

3.1.1 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 (1)) which relates drawdown, discharge rate and time. This equation (ideally) allows prediction of the hydraulic performance of production wells for a design pumping rate, and generation of yield drawdown curves for any given time (Hazel 1975).

$$s(t) = (aQ + cQ^2) + b \log(t)\, Q \qquad \textbf{Equation (1)}$$

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.

3.1.2 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.

3.1.3 GROUNDWATER QUALITY TEST

Groundwater for use in non-potable domestic application should be tested for the following suite of chemical parameters:

- 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.

3.2 QUORN TWS 6

The pumping tests conducted on Quorn TWS 6 consisted of a step drawdown test and a constant rate discharge test conducted from 2–6 September 2009. In order to allow sufficient recovery of groundwater levels at the Quorn site, SA Water switched off the current production well (Quorn TWS 5) 24 hours prior to commencement of testing.

DWLBC Groundwater Technical Services (Walkley Heights) carried out the testing. The pump was placed approximately 90 m below the ground surface. Development of the well was carried out while discharge rates and groundwater levels were monitored. From this data, and the current pumping rate of neighbouring well (Quorn TWS 5), rates were selected for the step drawdown test (Table 3).

The constant rate discharge test commenced on 4 September 2009 at a discharge rate of 12 L/s for a duration of 24 hours (1440 minutes). Extending the pumping duration to 48 hours was considered, however SA Water required that Quorn TWS 5 be brought back online as soon as possible.

Once a 99% recovery was achieved (after a duration of 450 minutes), the neighbouring production well (Quorn 5) was brought online.

Groundwater levels and groundwater salinity were monitored throughout the test, and groundwater samples were collected for laboratory analysis. Groundwater levels in the neighbouring wells Quorn TWS 1 and Quorn TWS 5 were also monitored throughout the test.

The manually recorded hydraulic data for both the step drawdown test and the constant rate discharge test are provided in Appendix D.

Table 3. Pumping test details for Quorn TWS 6

Test type	Test date	Step no.	Duration (mins)	Discharge rate (L/s)
Step drawdown	3 Sep 09	1	100	8
		2	100	12
		3	100	16
Constant rate discharge	4–6 Sep 09	-	1440	12
		(Recovery)	450	0

3.3 WILMINGTON TWS 3

The pumping tests conducted on Wilmington TWS 3 consisted of a step drawdown test and a constant rate discharge test conducted over two separate periods from 7–11 September 2009 and 22–25 September 2009 due to logistical issues.

DWLBC Groundwater Technical Services (Walkley Heights) carried out the testing. The pump was placed approximately 50 m below the ground surface. DWLBC then proceeded with development of the well while monitoring discharge rates and groundwater levels. Based on this data and the current pumping rate of neighbouring Wilmington TWS Mine Shaft, rates were selected for the step drawdown test (Table 4).

The constant rate discharge test was initially started on 9 September 2009 at a discharge rate of 15 L/s. During the test it was discovered that the neighbouring production well, Wilmington TWS 2, was not offline and was pumping intermittently while the test was being conducted.

For this reason, the constant rate discharge test was repeated during the period 22–25 September 2009. In order to allow sufficient recovery of water levels at the Wilmington site, SA Water switched off the current production well (Wilmington TWS Mine Shaft) and the secondary well (Wilmington TWS 2) 24 hours prior to commencement of testing. The pumping duration was extended from 24 hours to 48 hours (2880 minutes). It should also be noted that Spring Creek began flowing during the test. Once 24 hours of recovery was complete, the neighbouring Wilmington TWS Mine Shaft and Wilmington TWS 2 were brought online.

Groundwater levels and groundwater salinity were monitored throughout the test and groundwater samples were collected for laboratory analysis. Groundwater levels in the neighbouring Wilmington TWS Mine Shaft and Wilmington TWS 2 were monitored throughout the constant rate discharge test.

The manually recorded hydraulic data for both the step drawdown test and the constant rate discharge test for Wilmington TWS 3 are provided in Appendix D.

Table 4. Pumping test details for Wilmington TWS 3

Test type	Test date	Step no.	Duration (mins)	Discharge rate (L/s)
Step drawdown	8 Sep 09	1	100	10
		2	100	15
		3	100	20
Constant rate discharge	22–25 Sep 09	-	2880	15
		(Recovery)	1440	0

4. TEST RESULTS

4.1 QUORN TWS 6

4.1.1 STEP DRAWDOWN TEST

The following parameters were measured and recorded prior to the commencement of the step drawdown test conducted on Quorn 6:

- initial (non-pumping) depth to water (DTW) = 59.4 m
- pump setting = 90 m
- actual available drawdown (DD) = ~30 m
- allowing a buffer of 10 m in the available drawdown as a safety factor, available drawdown (DD) = ~20 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 6.

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 (Fig. 7).

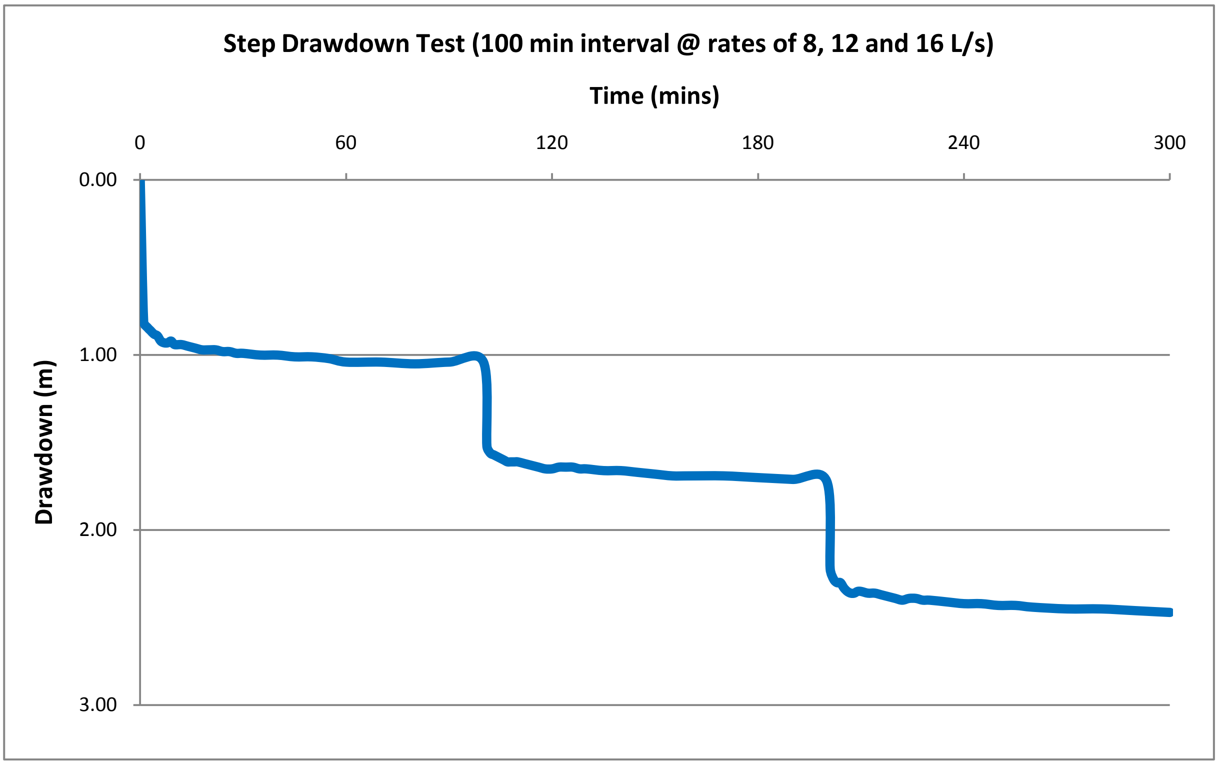
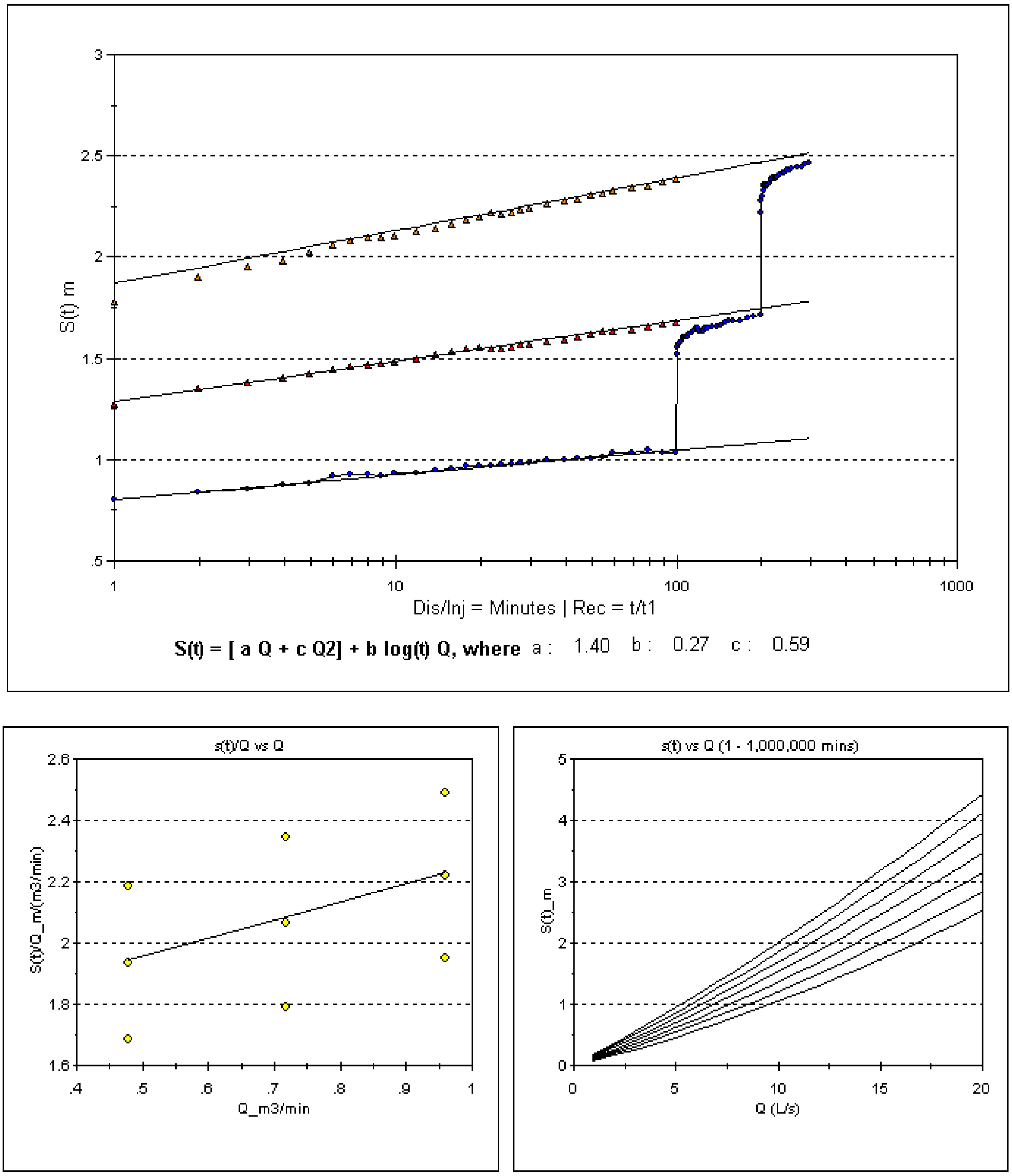


Figure 6. Step drawdown test data for Quorn TWS 6



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	8.00	0.48	100	0.81	1.69	0.93	1.94	1.05	2.19	0.12	0.25	1054
2	12.00	0.72	100	1.29	1.79	1.49	2.07	1.69	2.35	0.20	0.28	949
3	16.00	0.96	100	1.87	1.95	2.13	2.22	2.39	2.49	0.26	0.27	973

Figure 7. Step drawdown test analysis using Hazel Method for Quorn TWS 6

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

$s(t) = 1.40\ Q + 0.59\ Q^2 + 0.27 \log(t)\ Q$ **Equation (2)**

The well equation can be used as a predictive tool. Table 5 tabulates well equation predictions for the drawdown in Quorn 6 after 1,000,000 minutes (~2 years) of continuous pumping.

Table 5. Well equation predictions for Quorn TWS 6

Discharge rate (L/s)	Available DD (m)	Duration (mins)	Predicted DD (m)
5	20	1,000,000	~1.0
10	20	1,000,000	~2.0
15	20	1,000,000	~3.0

It should be noted that the step drawdown test analysis conducted here may not be fully applicable to a fractured rock aquifer, but provides an indication of the hydraulic behaviour of the well. This is because the hydraulics of fractured rock aquifers are very complex and not well understood.

The numbers given in Table 5 should be used with caution. These are winter pumping conditions and do not account for seasonal groundwater fluctuations, which may result in the available drawdown being significantly reduced during summer, when rainfall (and therefore recharge to the aquifer) is at a minimum and groundwater extractions are at a maximum.

4.1.2 CONSTANT RATE DISCHARGE TEST

Groundwater level measurements were recorded throughout the constant rate discharge test (and the recovery period) conducted on Quorn TWS 6. The time series of drawdown, the difference between the initial groundwater level and the groundwater levels during the test and recovery period, are shown in Figure 8.

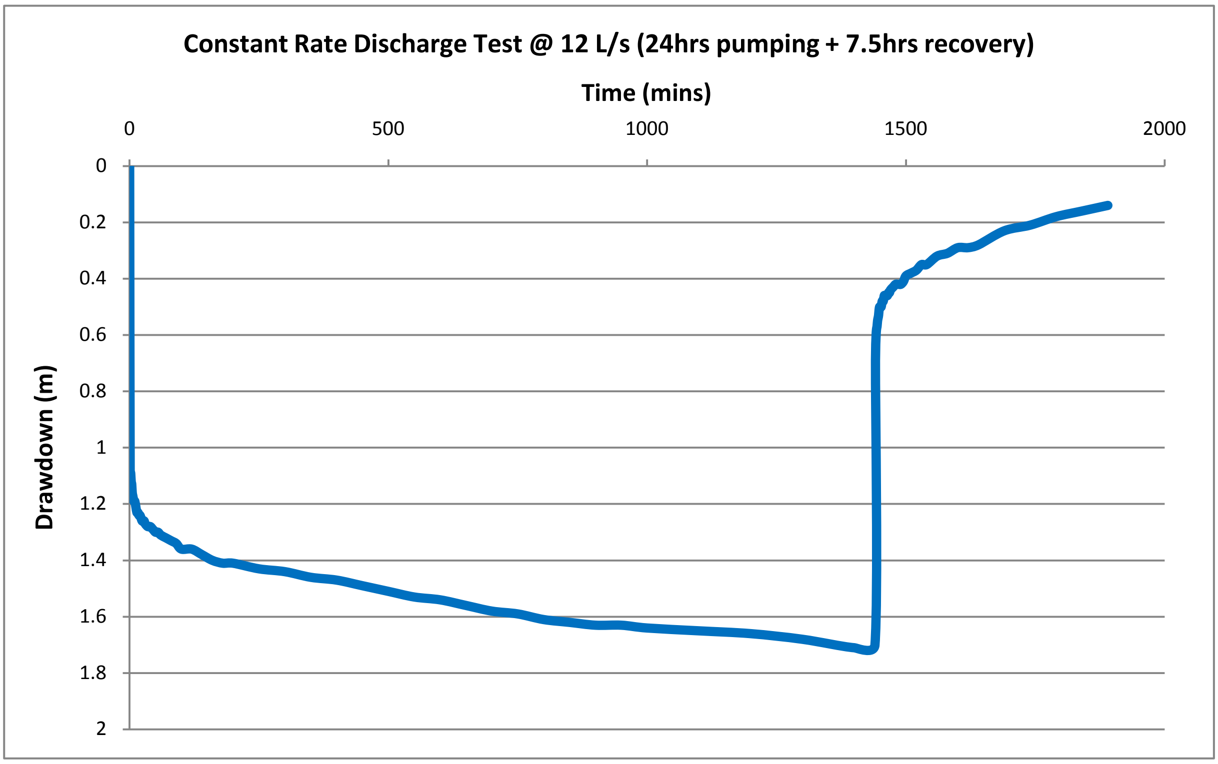


Figure 8. Constant rate discharge test data for Quorn TWS 6

Drawdown versus time and residual drawdown verses t/t_1 (where t is the time since pumping began and t_1 is the time since pumping stopped) are both given in the log-linear plot (Fig. 9).

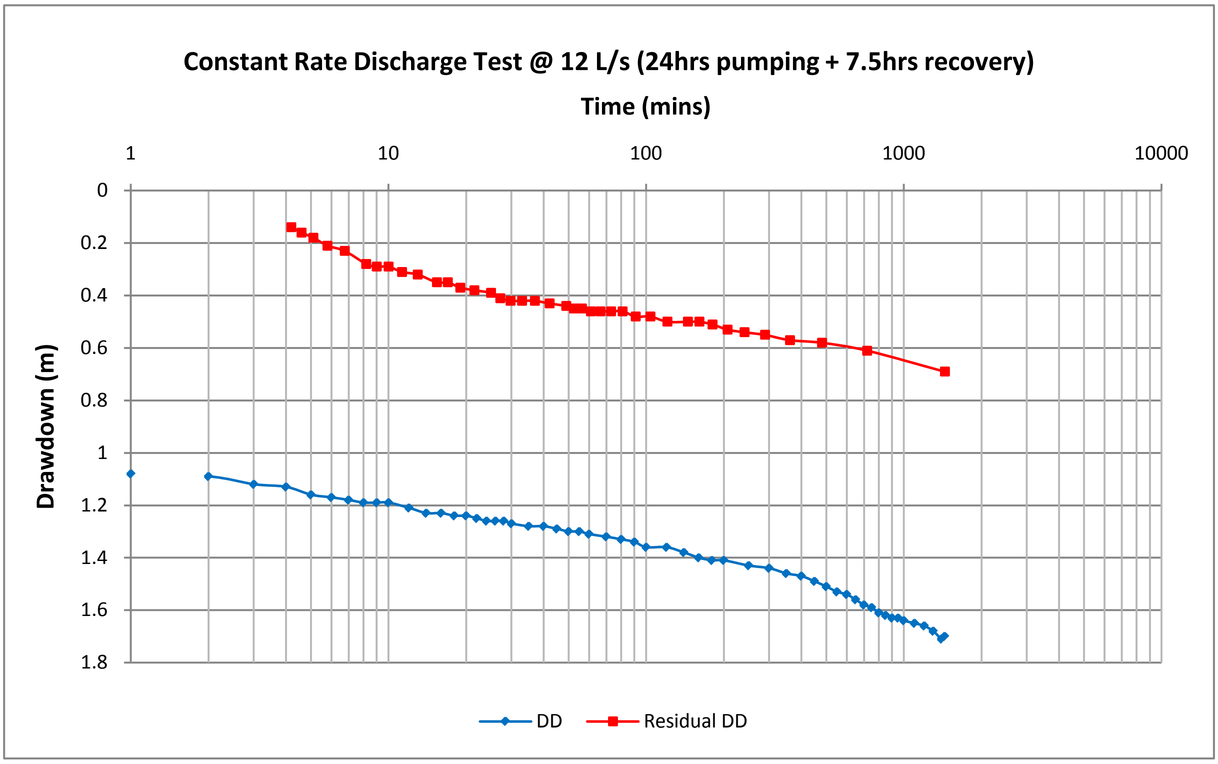


Figure 9. Log-linear plot of constant rate discharge test data and residual drawdown data for Quorn TWS 6

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

The drawdown data provides evidence of a possible low permeability boundary, which is indicated by the increasing drawdown towards the end of the test. This may have implications for the actual drawdown when the well is pumped continuously, or intermittently pumped for long periods. It would have been advantageous to continue the pumping test for a duration of 48 hours.

The extrapolation of the residual drawdown data indicates that intersection with zero residual drawdown at $t/t_1 > 1$, suggesting the well has encountered a recharge boundary, or at least the aquifer is not undergoing de-watering. The existence of a recharge boundary may be expected due to the close proximity of the reservoir (100 m distant), however it is interesting to note that this boundary is not apparent in the drawdown data.

A transmissivity of ~1,000 m^2/day was calculated.

The well equation (Equation 2), slightly over-predicts the observed drawdown at the test rate of 12 L/s, predicting a value of 1.93 m after 1440 minutes compared to the actual measurement of 1.72 m.

Other useful parameters that relate to well performance can be calculated using the well equation. For a discharge rate of 12 L/s and a time of 1440 minutes (24 hours):

- The specific capacity is ~6.22 L/s/m of drawdown. This implies that for every metre of drawdown, the well yields 6.22 L/s.
- The well loss ($aQ + cQ^2$) is ~1.31 m.

- The aquifer loss (b log(t) Q) is ~0.61 m. This implies the well efficiency (aquifer loss as a percentage of total drawdown) is ~32%.

Data collected in the pumping test indicates the development of minor drawdown in both Quorn TWS 1 and 5 (Table 6).

Table 6. Drawdown at nearby wells during Quorn TWS 6 constant rate discharge test

Well name	Distance from Quorn TWS 6 (m)	Initial WL (m)	Final WL (m)	DD (m)
Quorn TWS 1	40.0	60.20*	60.37*	0.17
Quorn TWS 5	20.0	33.32**	33.16**	0.16

Note: Initial WL was taken prior to pumping and final WL was taken before the pump was switched off
* refers to DTW (depth to water from a reference point, usually top of casing)
** refers to measurements taken from a digital logger which measures water height above the pump (i.e. not DTW)

Groundwater salinities were recorded in the field during the constant rate discharge test. Results are given in Figure 10 for both electrical conductivity (EC in units of uS/cm) and total dissolved solids (TDS in units of mg/L). Groundwater salinity decreased to ~2000 EC at a time of 500 minutes, and remained relatively stable through the remainder of the test.

Groundwater samples were sent to the Australian Water Quality Centre for analyses (see Appendix E for results).

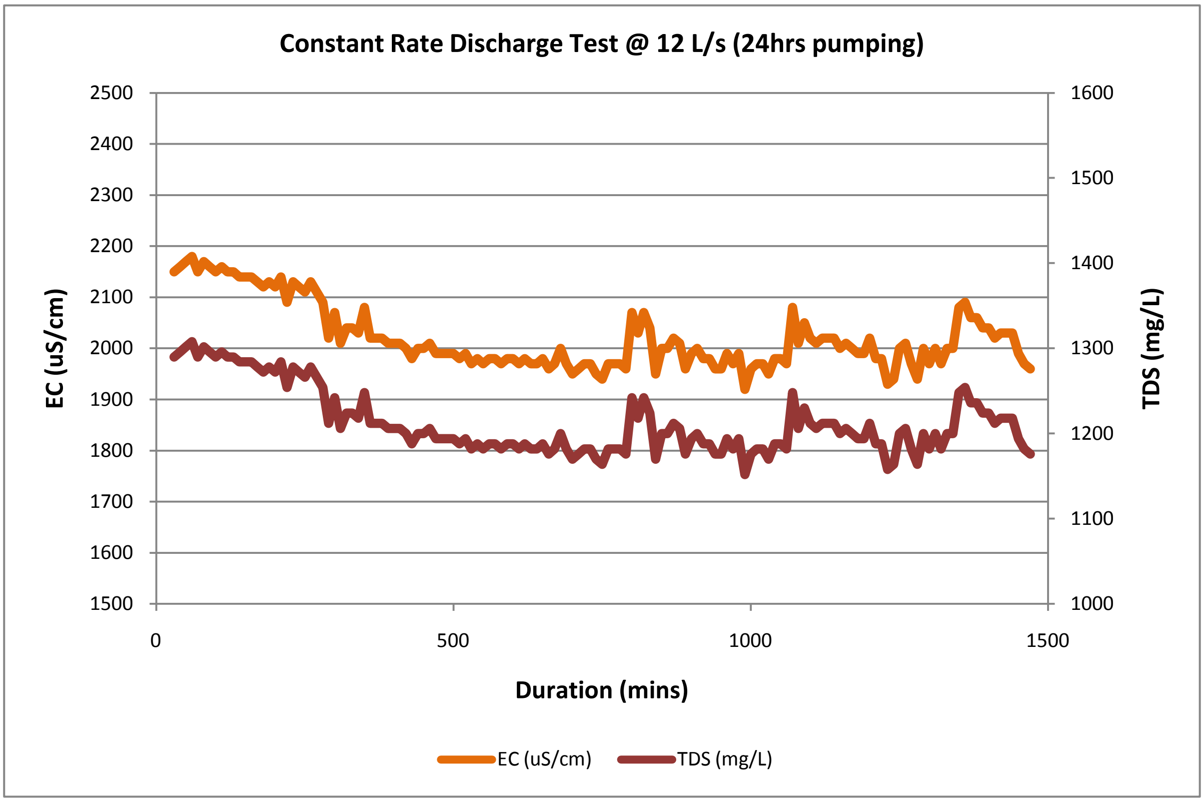


Figure 10. Groundwater salinity during constant rate discharge test data for Quorn TWS 6

4.2 WILMINGTON TWS 3

4.2.1 STEP DRAWDOWN TEST

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

- initial (non-pumping) depth to water (DTW) = 19.4 m
- pump setting = ~50 m
- actual available drawdown (DD) = ~30 m
- allowing a buffer of 10 m in the available drawdown as a safety factor, available drawdown (DD) = ~20 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 11.

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 (Fig. 12).

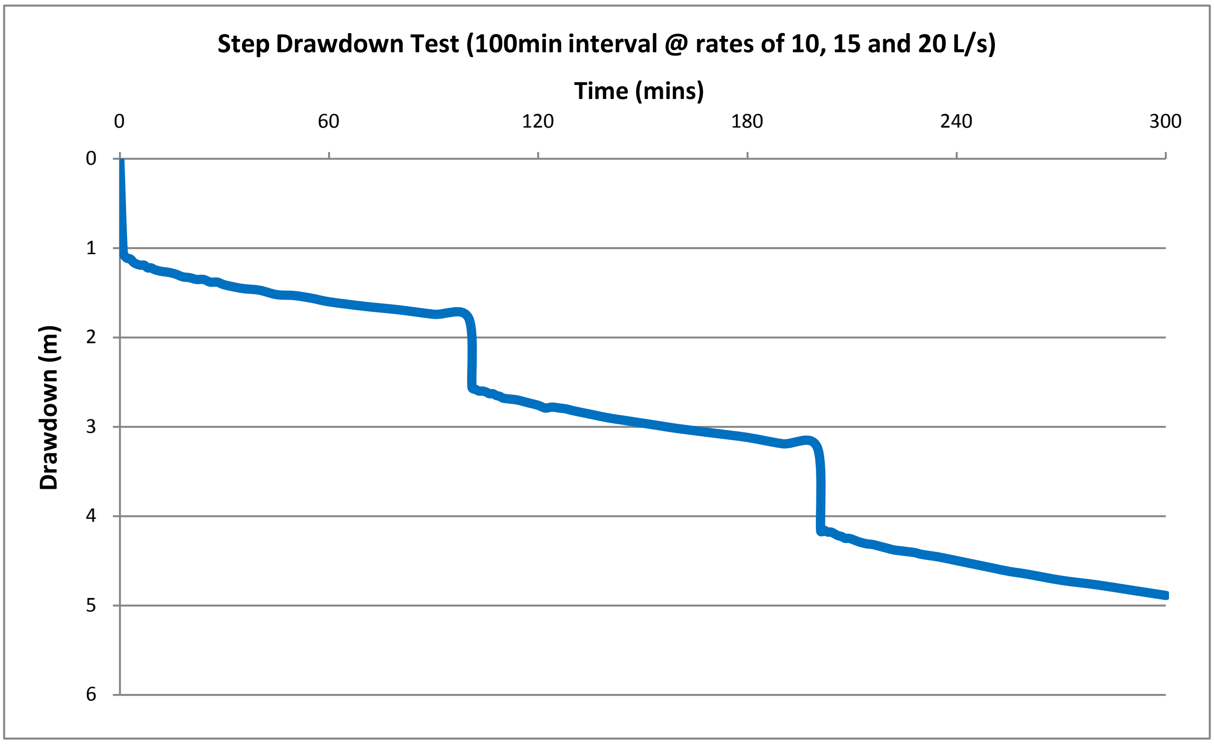
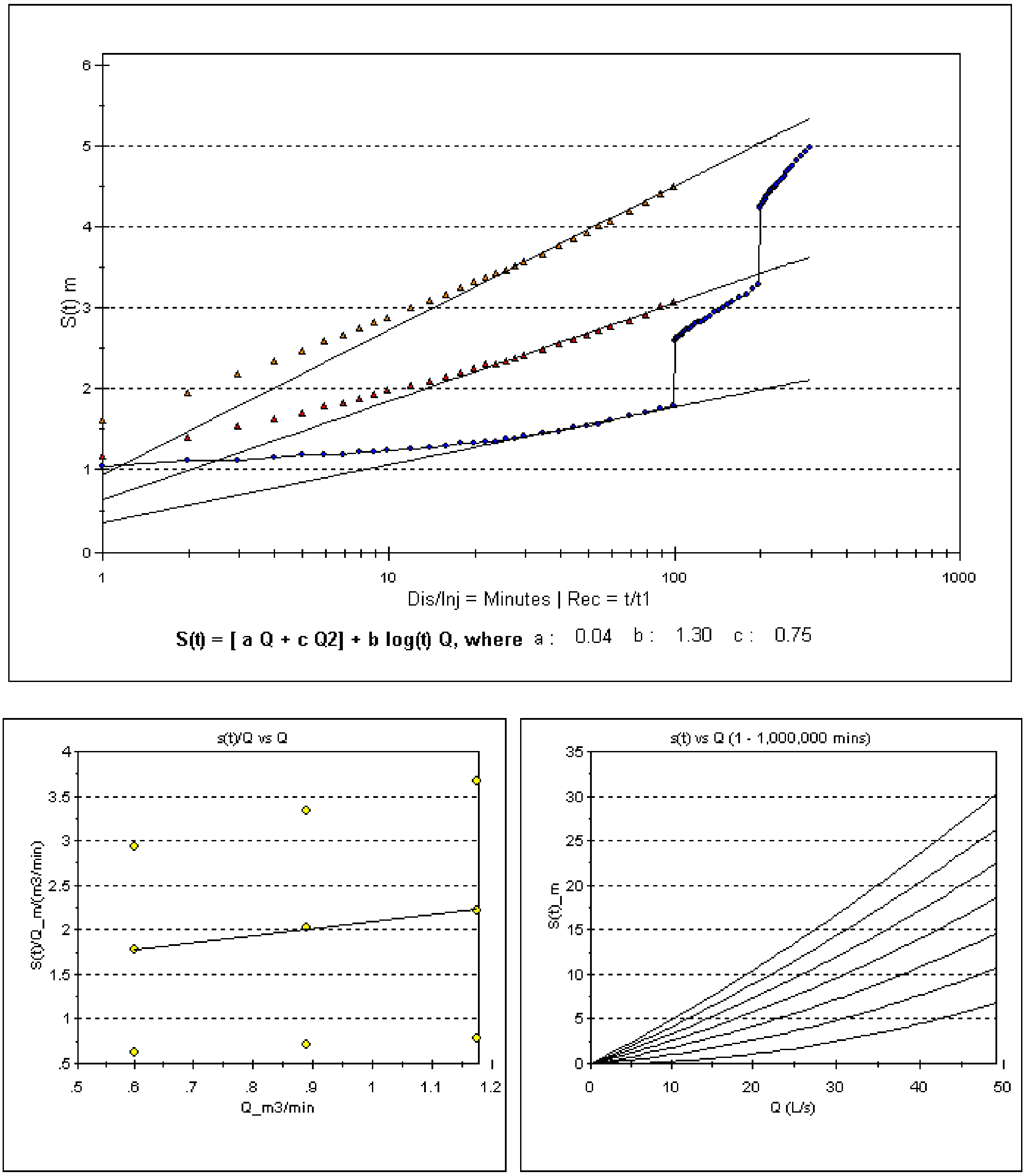


Figure 11. Step drawdown test data for Wilmington TWS 3



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	10.00	0.60	100	0.38	0.63	1.07	1.78	1.76	2.93	0.69	1.15	229
2	15.00	0.90	100	0.65	0.72	1.83	2.03	3.01	3.34	1.18	1.31	201
3	20.00	1.20	100	0.95	0.79	2.68	2.23	4.41	3.67	1.73	1.44	183

Figure 12. Step drawdown test analysis using Hazel Method for Wilmington TWS 3

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

$s(t) = 0.04\ Q + 0.75\ Q^2 + 1.30\ \log(t)$ **Equation (3)**

The well equation can be used as a predictive tool. Table 7 tabulates well equation predictions for the drawdown in Wilmington TWS 3 after 1,000,000 minutes (~2 years) of continuous pumping.

Table 7. Well equation predictions for Wilmington TWS 3

Discharge rate (L/s)	Available DD (m)	Duration (mins)	Estimated DD (m)
10	20	1,000,000	~5.0
15	20	1,000,000	~7.5
20	20	1,000,000	~10.5
25	20	1,000,000	~13.5

It should be noted that the step drawdown test analysis conducted here may not be fully applicable to a fractured rock aquifer, but provides an indication of the hydraulic behaviour of the well. This is because the hydraulics of fractured rock aquifers are very complex and not well understood.

The numbers given in Table 7 should be used with caution. These are winter pumping conditions and do not account for seasonal groundwater fluctuations, which may result in the available drawdown being significantly reduced during summer, when rainfall (and therefore recharge to the aquifer) is at a minimum and groundwater extractions are at a maximum.

4.2.2 CONSTANT RATE DISCHARGE TEST

Groundwater level measurements were recorded throughout the constant rate discharge test (and the recovery period) conduced on Wilmington TWS 3. The time series of drawdown, the difference between the initial groundwater level and the groundwater levels during the test and recovery period, are shown in Figure 13.

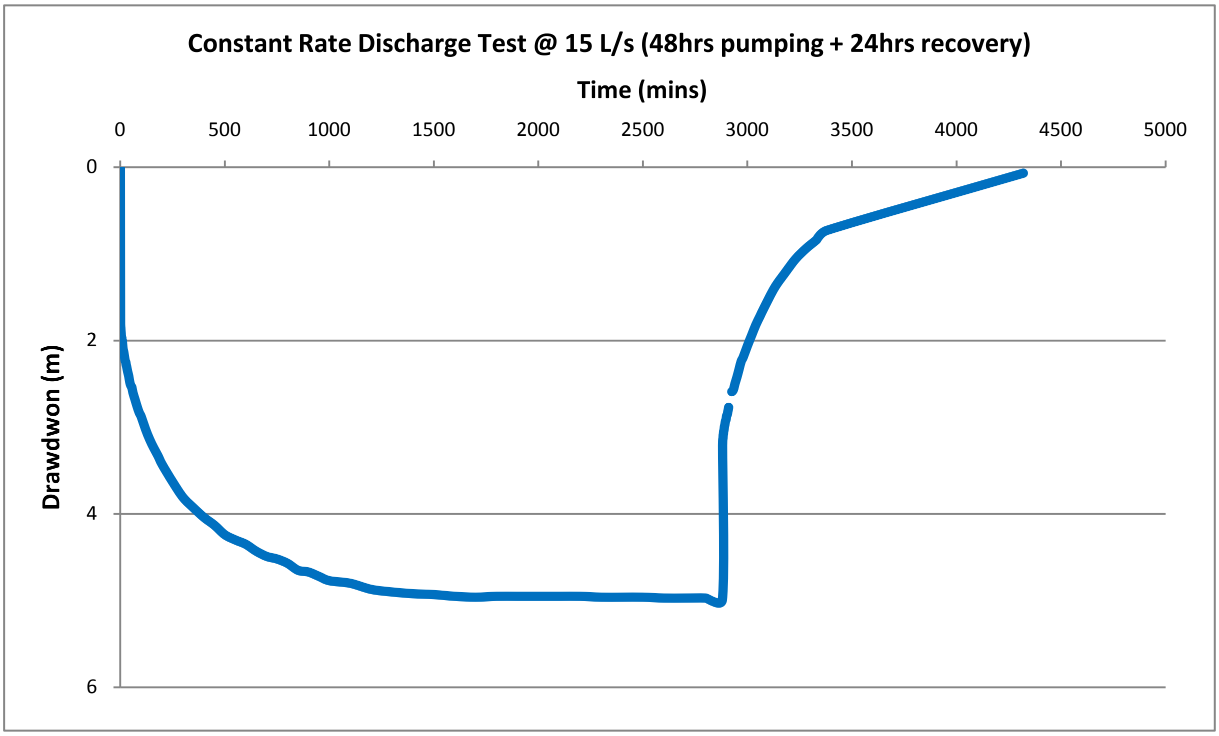


Figure 13. Constant rate discharge test data for Wilmington TWS 3

Drawdown versus time and residual drawdown verses t/t_1 (where t is the time since pumping began and t_1 is the time since pumping stopped) are both given in Figure 14.

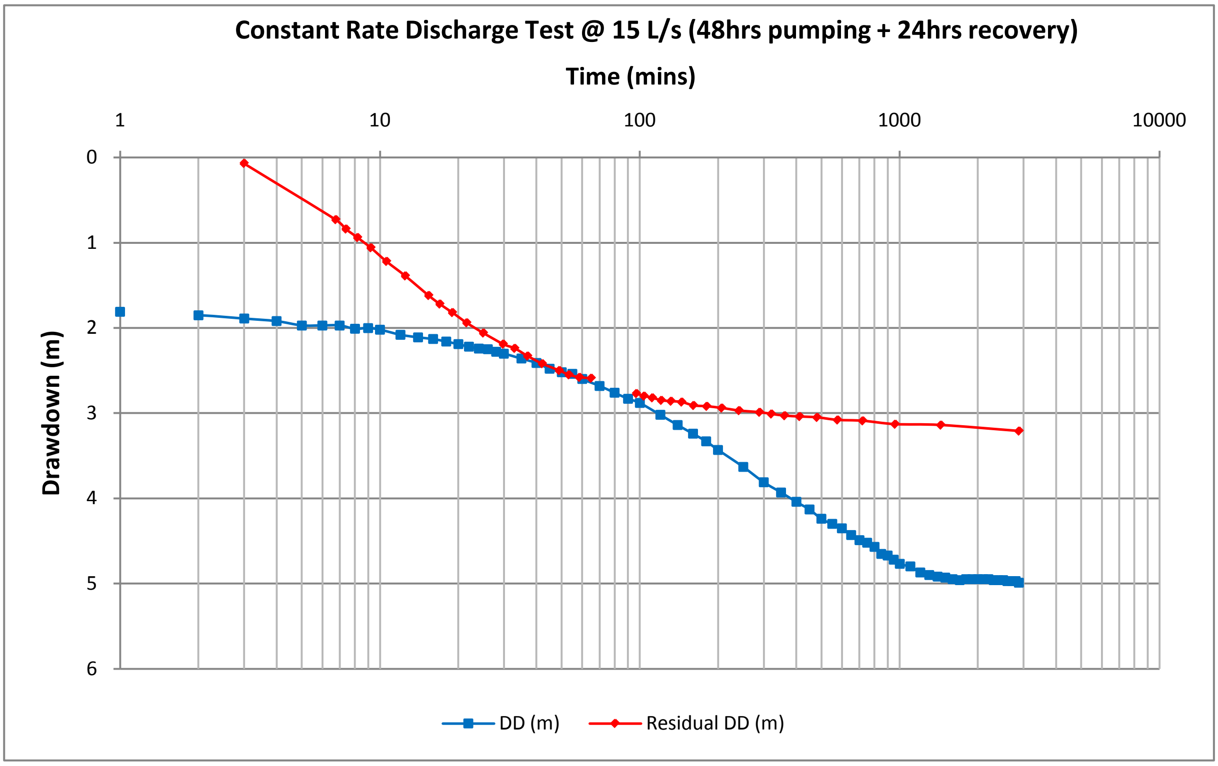


Figure 14. Log-linear plot of constant rate discharge test data and residual drawdown data for Wilmington TWS 3

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

The drawdown data provides evidence of a possible low permeability boundary, which is indicated by the increasing drawdown. A recharge boundary, Spring Creek, is clearly indicated after 1000 minutes. This low permeability boundary may have implications for the actual drawdown when the well is pumped continuously or intermittently for long periods during summer when there is no recharge from Spring Creek.

The extrapolation of the residual drawdown data indicates that intersection with zero residual drawdown at $t/t_1 > 1$, indicating the well has encountered a recharge boundary (Spring Creek).

A transmissivity of ~200 m^2/day was calculated.

The well equation (Equation 3), slightly under-predicts the observed drawdown at the test rate of 15 L/s, predicting a value of 4.69 m after 2880 minutes compared to the actual measurement of 4.99 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 2880 minutes (48 hours):

- The specific capacity is ~3.20 L/s/m of drawdown. This implies that for every metre of drawdown, the well yields 3.20 L/s.
- The well loss ($aQ + cQ^2$) is ~0.64 m.
- The aquifer loss (b log(t) Q) is ~4.05 m. This implies the well efficiency (aquifer loss as a percentage of total drawdown) is ~86%.

It should be noted that these predictions should be used with caution as Spring Creek (which is approximately 100 m from Wilmington TWS 3) started running in the second 24 hours of the test, and the well responds quickly to this influence.

Data collected in the pumping test indicates the development of minor drawdown in both Wilmington TWS Mine Shaft and the Monitoring Well (Table 8).

The final groundwater level given in Table 8 was measured after 5 hours and 40 minutes of recovery, as Spring Creek started flowing after 24 hours of pumping and eventually became impassable.

Table 8. Drawdown at neighbouring wells during the constant rate discharge test conducted on Wilmington TWS 3

Well name	Radial distance from Wilmington TWS 3 (m)	Initial WL (m)	Final WL (m)	DD (m)
Wilmington TWS Mine Shaft	150.0	16.0**	15.5**	0.5
Monitoring Well (adj. to Wilmington TWS 2)	220.0	4.0*	2.7*	1.3

Note: Initial WL was taken prior to pumping and final WL was taken before the pump was switched off

* refers to DTW (depth to water from a reference point, usually top of casing)

** refers to measurements taken from a digital logger which measures water height above the pump (i.e. not DTW)

Groundwater salinities were recorded in the field during the constant rate discharge test. Results are given in Figure 15 for both electrical conductivity (EC in units of uS/cm) and total dissolved solids (TDS in units of mg/L). Groundwater salinity steadily decreased throughout the test to a minimum value of 500 EC.

It should be noted that the data given in Figure 15 is from the first constant rate discharge test conducted between 9–11 September 2009. This test was of 24 hours duration. As previously noted, the test was repeated 11 days later with 48 hours of pumping. Groundwater samples were collected for laboratory analysis in this second test, but groundwater salinity was not recorded with a data logger.

The close proximity of Wilmington TWS 3 to Spring Creek indicates the potential for direct recharge from the creek to the aquifer. This means that even though groundwater salinity may increase through summer, recharge may result during winter, thus resulting in a repeated cycle of increasing groundwater salinity during annual pumping reaching a maximum towards the end of summer.

Groundwater samples were sent to the Australian Water Quality Centre for analyses (see Appendix E for results).

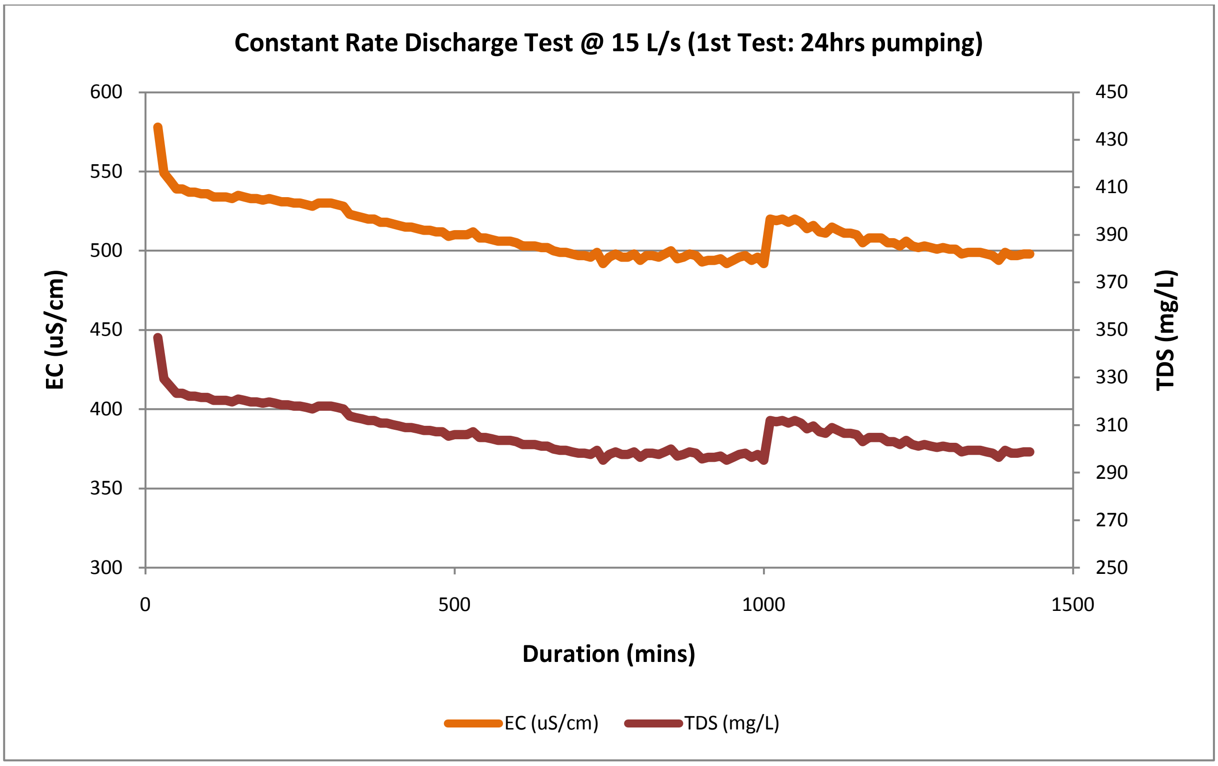


Figure 15. Groundwater salinity during constant rate discharge test data for Wilmington TWS 3

5. RECOMMENDATIONS

Downhole tools such as calliper and geophysics were not run on Quorn TWS 6 or Wilmington TWS 3 due to SA Water budgetary constraints. It is, however, a recommendation of DWLBC that downhole logging be made a mandatory requirement of a new drillhole prior to the final design and construction of (in particular) town water supply production wells, especially where the well is essentially an exploration well.

There are several downhole tools/instrumentation that could be run on a drillhole prior to completion. Costs for conducting such work are not limited to the logging itself, but also include inherent costs such as drilling company standby time, and the acquisition of additional materials (which may become redundant) pending final on-site decision making regarding the design of the well.

As a minimum for well design it is recommended that the following instrumentation should be run:

- caliper
- gamma and neutron probes (geophysical logging).

Downhole tools provide important information regarding the drillhole and formation, including the depth of fracturing, lithological changes and the formation stability. This critical information allows key decisions regarding well design and construction to be made which will ensure a well's ultimate performance and integrity over time.

While not critical for production wells completed in unconfined aquifers, it would be desirable for the well's annulus to be fully grouted above the production zone to the ground surface. This provides further stability for the well casing. Again due to budget constraints and logistically difficult site locations, full grouting of each well above the production zone to the ground surface was not implemented. Instead, fabricated rubber seals (grouted in place) were set at strategic positions in the well annulus.

5.1 QUORN

For the newly constructed well at Quorn, Quorn TWS 6, it is recommended that SA Water consider the following:

- The well must be pumped operationally and monitored for a full 12 months to accurately determine the long-term hydraulic behaviour of the well.
- The pump should be set at 90 m below the ground surface to ensure the maximum available drawdown.

A well completion and pumping test summary is given in Table 9.

5.2 WILMINGTON

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

- The well must be pumped operationally and monitored for a full 12 months, as for Quorn TWS 6, to accurately determine the long-term hydraulic behaviour of the well.

- The pump should be set at 50 m below the ground surface. At this level the pump remains protected by the casing, but results in a satisfactory pumping rate.

A well completion and summary is provided in Table 9.

Table 9. Well construction details and constant rate discharge test summary

Specifications	Quorn TWS 6	Wilmington TWS 3
Unit number	6533-910	6532-1642
Easting	219501	230765
Northing	6422360	6375015
GDA 94 Zone	54	54
Well completion date	17 Jul 2009	22 Jul 2009
Well completion depth	148 mBNS	97.5 mBNS
Casing length	56 m	53.5 m
Casing type	Class 12 PVC	Class 12 PVC
Casing inner diameter	203 mm	203 mm
Production zone	56-148 mBNS (open hole)	53.5-97 mBNS (inline PVC screen)
Depth to water	58.87 mBNS	18.67 mBNS
CRD test date	4-6 Sep 2009	22-25 Sep 2009
Discharge rate (CRD test)	12 L/s	15 L/s
Duration (CRD test)	1440 mins	2880 mins
Well efficiency	32%	86%
Recommended pump depth	90 mBNS	50 mBNS

Note: CRD (constant rate discharge)

APPENDICES

A. WELL CONSTRUCTION REPORTS

DMC-17

QUORN TWS 6

Water Resources Act, 1976

DRILLERS WELL CONSTRUCTION REPORT

- Quorn (Quorn_6)

E: 219501
N: 6422630

As the person responsible for the work carried c as described below:

Official Well No.

1. PERMIT No. 161383.

2. LOCATION OF WELL:

Hundred or Pastoral Lease No. Pichi Richi
Section CT 5602/731 Lot No. 128 Site No. 185540
Name of Property Quorn Creek

Name of Driller M Tomlin Licence No. ....
Name of plant operator if under supervision ....

Permit holder or land occupier DWLBC
Postal Address Lvl 11 25 Grenfell St
Adelaide SA Postcode 5000

5. SUMMARY

Date work commenced 13.7.09 Date completed 17.7.09
Work carried out: New well ☒, Existing well, deepen ☐, enlarge ☐, rehabilitate ☐, backfill ☐(tick appropriate boxes)
Final Depth 148 m Final standing water level 58.87 m Final yield 8 l/sec.
Was well abandoned? NO If yes, state method ....

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

6.1 CONSTRUCTION DETAILS — 6.2 WATERS CUT (measurements from natural surface to nearest 0.1 m)

From (m)	To (m)	Diam. (mm)	Drilling Method Cable Tool, Rotary Auger, Etc.	Fluid Used (Air, Water, Mud Type)	Date	Water Cut From (m)	Water Cut To (m)	Standing Level (m)	Estimated Yield l/sec.	Hole Depth at Test (m)	Casing at Test (m)	Test Method	Salinity mg/l or Taste
0	5.6	380	Rot Hammer	Air	16.7.09	74	92		3				
5.6	56	310	Rot Hammer	Air	17.7.09	96	102		13.				
56	150	200	Rot Hammer	Air	17.7.09	117	150		1.5+				

7. CASING LEFT IN WELL

7.1 Dimensions From (m)	To (m)	Internal Diam.	7.2 Type Swell Joint, Welded Collar, Steel, Plastic, Etc.	7.3 Casing Shoe Yes	No	Diam. (mm)	Cemented Yes	Cemented No	7.4 Casing Pressure Cemented Yes	No	From (m)	To (m)	Cement (bags)	Water (litres)	Other Additives
+0.5	5.6	311	Steel	☐	☐		☐	☐	☐	☒	0	5.6	8	200	
+0.3	56	203	PVC Socket	☐	☐		☐	☐	☐	☐	47	56	10	270	
				☐	☐		☐	☐	☐	☐					
				☐	☐		☐	☐	☐	☐					

8. CONSTRUCTION AT PRODUCTION LEVEL

8.1 METHOD

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

8.2 SCREEN OR SLOTTED 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)	Diam. (mm)

8.4 GRAVEL PACKING

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

9. IF NOT A DRILLED WELL (i.e. hand dug, etc.)

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

10. DEVELOPMENT State methods and times taken

Airlift 2 hrs @ 90 m 8 l/s.

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

Interval Tested From (m)	To (m)	Water Level Stablised at End?	Test Method	Depth of Pump (m)	Discharge Rate l/sec.	Method of Measuring Discharge	No. of Hours Pumped	Draw Down (m)

13. FORMATION LOG

From (m)	To (m)	Description of Material
0	2	Clay & boulders.
2	150	Sandstone.
		fracturing from
		50 through to 150m
		open hole may not
		stay open

12. SAMPLES
The provisions of the Water Resources Act and Regulations thereto require that strata and water samples must be obtained. If any samples have not been obtained state reasons:—

....

Signature of Licensed Driller MD Tomlin Date 18/7/09.

ENTERED
DATE BY

6533 910

WILMINGTON TWS 3

DMC-17

SCHEDULE EIGHT—FORM FOUR
GOVERNMENT OF SOUTH AUSTRALIA
Water Resources Act, 1976

Official Well No.

DRILLERS WELL CONSTRUCTION REPORT

1. PERMIT No. 164133

As the person responsible for the work carried as described below:

- Wilmington ~~(Spring Creek 3)~~ (Well No. 3)
E: 230765
N: 6375015

2. LOCATION OF WELL:

Hundred or Pastoral Lease No. ...... Section 445 ...... Lot No. ...... Site No. ......
Name of Property ......

Name of Driller M Tomba ...... Licence No. ......
Name of plant operator if under supervision ......

Permit holder or land occupier DWLBC
Postal Address Lvl 11 25 Grenfell St
Adelaide SA Postcode 5000

5. SUMMARY

Date work commenced 18.7.09 Date completed 22.7.09

Work carried out: New well ☐, Existing well, deepen ☐, enlarge ☐, rehabilitate ☐, backfill ☐(tick appropriate boxes)

Final Depth 97.5 m Final standing water level 18.67 m Final yield 20 l/sec.

Was well abandoned? No If yes, state method ......

6. DRILLING DETAILS If not a drilled well please complete paragraphs 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, Etc.	Fluid Used (Air, Water, Mud Type)
0	56	360	Rot Hammer	Air
56	115	310	Rot Hammer	Air

6.2 WATERS CUT (measurements from natural surface to nearest 0.1 m)

Date	Water Cut From (m)	Water Cut To (m)	Standing Level (m)	Estimated Yield l/sec.	Hole Depth at Test (m)	Casing at Test (m)	Test Method	Salinity mg/l or Taste
21.7.09	53	66		10+				
"	76	78		20+				
"	99	108		30+				

7. CASING LEFT IN WELL

7.1 From (m)	To (m)	Internal Diam.	7.2 Type: Swell Joint, Welded Collar, Steel, Plastic, Etc.	7.3 Casing Shoe Yes	No	Diam. (mm)	Cemented Yes	Cemented No	7.4 Casing Pressure Cemented Yes	No	From (m)	To (m)	Cement (bags)	Water (litres)	Other Additives
+0.5	56	311	Steel	☐	☐		☐	☐	☐	☒	0	56	4	100	
+0.3	58.7	203	PVC Socket	☐	☐		☐	☐	☒	☐	?	48	50	350	
				☐	☐		☐	☐	☒	☐	97.5	107			
				☐	☐		☐	☐	☐	☐					

8. CONSTRUCTION AT PRODUCTION LEVEL

8.1 METHOD

☐ Open Hole

☐ Screen(s) ☐ Slotted Casing

☐ Other, give details ......

8.2 SCREEN OR SLOTTED 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
Mach Slot	58.7	107.7	0.5	203	225	C12 PVC	Hydromaster	Open

8.3 LINER SEAL (packer)

Material	Depth (m)	Diam. (mm)

8.4 GRAVEL PACKING

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

9. IF NOT A DRILLED WELL (i.e. hand dug, etc.)

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

10. DEVELOPMENT State methods and times taken

Airlift 2½ hrs @ 45 m 20 l/s

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

Interval Tested From (m)	To (m)	Water Level Stablised at End?	Test Method	Depth of Pump (m)	Discharge Rate l/sec.	Method of Measuring Discharge	No. of Hours Pumped	Draw Down (m)

12. SAMPLES
The provisions of the Water Resources Act and Regulations thereto require that strata and water samples must be obtained. If any samples have not been obtained state reasons:—

13. FORMATION LOG

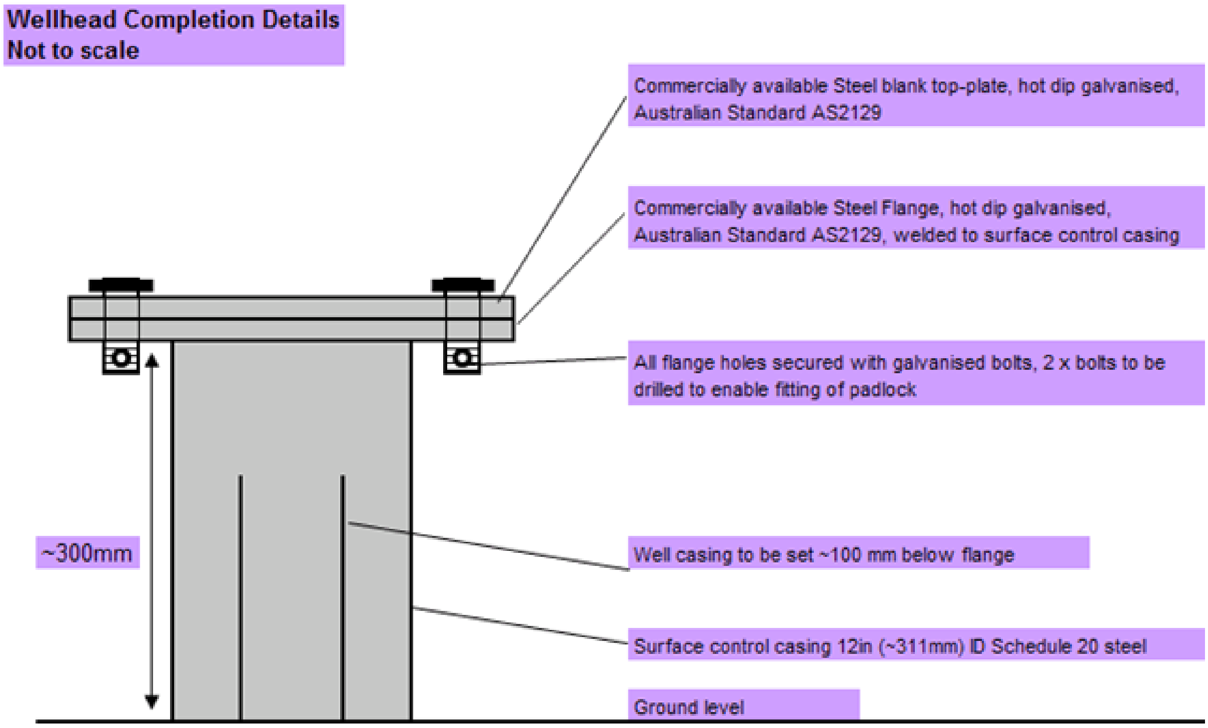
From (m)	To (m)	Description of Material
0	53	Clay & weathered Siltstone
53	115	Siltstone with quartz bands

Signature of Licensed Driller MD Tomba Date 22/07/09

ENTERED
DATE BY

6532 1642

B. WELLHEAD SPECIFICATIONS



C. WILMINGTON WATER SUPPLY PROPOSED AUGMENTATION (NEW WELLS SITE SELECTION) SA WATER REPORT (HAJRUDIN ZULFIC)

WILMINGTON WATER SUPPLY PROPOSED AUGMENTATION (NEW WELLS SITE SELECTION)

INTRODUCTION

The groundwater group has been asked to select two locations for two new investigation / production wells to supplement the Wilmington town water supply. Reasons why new wells are needed have not been clearly stated in the request. It was not clear whether the occasionally elevated arsenic in well no 2 or inadequate available quantity was the primary issue. However, the minutes dated 15/08/2000 (Regional Manager Northern Regions) stated that the Wilmington town water supply has a number of issues:

- Quantity –additional supply of 4L/s is required,
- Quality – the new well at the proposed location (investigation well 6532-1349) would supply groundwater of ~1200 mg/L, whilst the current supply has salinity of ~400 mg/L
- Issues with the reticulation network and power supply.

The proposed site, as recommended in the minutes, was in the township of Wilmington and has a groundwater salinity of ~1200 mg/L which is much higher than the salinity of the current supply. Consequently, it would require shandying with the good quality water from the existing sources.

With this in view, the groundwater group has reviewed previous investigations and investigated new options.

From the perspective of good water quality and reasonable quantity it is understood that the area of the mine shaft and well no 2 might provide both. It is recommended that one well be drilled 150 m north of the mine shaft, and a second well 70 m south of well no 2. The logic for this selection is elaborated in the text below.

The production well in the vicinity of the investigation well 6532-1349, recommended in the minutes, would be an option only if the management of the Northern Region prefer this option to the Spring Creek area due to infrastructure and power supply constraints.

LITERATURE REVIEW OF WILMINGTON TWS

Spring Creek Mine Shaft (6532-1005)

Since 1916 the Wilmington township has, during summer months, depended on water pumped from the mine shaft of the Spring Creek Mine.

Geology and hydrogeology

The region of the mine is composed of slates overlain by feldspatic sandstone and tillites (probably Sturtian Tillite). The geological formations have been considerably disturbed by geological faulting, particularly in the vicinity of the old mine.

The mine shaft has been sunk on the eastern lower slope of Spring Creek in slates of the Tapley's Hill Formation, just above the Rhynie Sandstone which forms prominent ridge to the east. Under normal conditions these slates would be considered as being practically impervious to water, but owing to the intensive faulting which has occurred in the immediate vicinity, the slates have been so fractured as to permit water to percolate down through fractured zone.

Well Details

- The well unit no. 6532-1005 is rectangular shaft 2.1 m by 3.5 m and 32 m deep.
- Access to the pump controls is by means of an adit about 9 m above the level of the Spring Creek.
- Standing water level was 10.12 m below the safety-grille at the adit level.
- The shaft bottom is 32 m below the adit level and the pump is set at 31 m.

Discharge Test

In 1980 a 26 hour pump test was conducted on the Spring Creek Mine Shaft well (Read 1980), and a water level recorder was operated on the well between 15/04/1980 and 23/11/1982.

Pumping test details:

- Continuous discharge for 26 hours
- Pump was a submersible turbine (pumping rate declines with increasing head)
- Volume discharge was measured from a water meter on the discharge line
- The average discharge for the first 30 minutes was 11.8 L/sec (1020 KL/day),
- This discharge steadily declined to 10 L/sec (870 KL/day) at 900 minutes after which it remained constant,
- Water was pumped into Wilmington supply system (no possibility of water returning to the aquifer)

The discharge test has shown that:

- The discharge of the existing pump (June 1980) is very close to the safe yield of the well
- **Analyses of the drawdown curve shows that the second production well sited about 150 m from the well 6532-1005 in the same fissure system would produce only minor interference with the existing well**
- An investigation drilling program on the opposite side of Spring Creek to explore the potential for an additional supply was recommended.

Investigation Drilling 1986/87

In 1986 and 1987 six and four investigation wells were drilled respectively (R Read 1988). **The aim of the investigation was to locate water supplies close to the existing pipeline to minimise cost of development.** The investigation was hampered by difficult drilling conditions. The Adelaidean rocks beneath the sediments of the Willochra Basin are generally so weathered that they are too unstable to air-drill in the upper part, while interbedded sandstones are often too hard to be drilled satisfactorily with roller bits.

Drilling Program Outcomes:

Hydrogeology: The drilling program has provided new information on the hydrogeology of the Willochra Basin as summarised:

- O'Driscoll (1995) believed that the basin was recharged from Spring Creek and other creeks. Since about 90 meters of clay overlies the aquifers at the margin of the basin this is clearly not the case.
- The potentiometric surface shows a steep hydraulic gradient in the Adelaidean rocks near the western margin of the basin.
- The Tertiary sand aquifer does not extend to the western margin of the basin. Recharge to the sand is presumably by flow through the fractured rocks on the basin margin and the weathered and fractured rocks beneath the basin sediments.
- The lowest salinities occur in the topographically steep south western part of the area where Adelaidean rocks outcrop.
- Salinities increase rapidly to the north; the reasons for this are not clear, but the following factors may contribute:
    - The gentler topography leads to gentler hydraulic gradients and less effective flushing of aquifers,
    - Soil cover is thicker, reducing the amount of recharge.

  These two factors do not seem to be sufficient to explain the increase in salinity.

Potential Drilling Sites – Recommendations:

- The well 6532-1349 tapped the Wilmington (or Willochra) Formation. This aquifer has the potential to yield at least 7.6 L/sec. A deeper well may yield more. However, salinity of 1185 mg/L is an issue.
- The Spring Creek Mine should remain the main source of water supply
    - Water level records (15/04/1980 and 13/08/1982) show that the Spring Creek mine shaft is capable of increased annual pumping, without any significant reduction in maximum discharge rate. There is no reason to expect any change in water quality.
    - Water level records also suggest that there are nearby aquifers.
    - Further development of this area is difficult because of the steep hillsides and the steep narrow access road which proved impossible for the drilling rig in the winter of 1987.
    - **If any further drilling is done in this area in dry weather at least one well should be drilled near the Spring Creek mine shaft.**

Summary of drilling results is presented in the table 1.

Table 1. Summary of town water supply and investigation wells as per Read 1988

Author	Well Unit No	TWS Well No	Reasons for site selection	Results	Depth (m)	Yield (L/sec)	Water Salinity (mg/L)	Comments
SADME 1916	6532-1005	Spring Creek mine shaft			32	7.5	~ 300	Tapley Hill Formation – slates Underlined by Rhynie Sandstone
R. E Read (1986)	6532-1326		To test Willochra Basin sediments and underlying Adelaidean	No Aquifers found	182	Dry to 150m		**Wilmington Formation** Air drilled to 150m, than mud drilled. 150-182 Clay???? 82-133??
	6532-1327		To test Adelidean sandstones on edge of Willochra Basin	Small supply	133	2	1000	**In Wilmington Formation.** [Could be Angepena Formation – HZ from geological Map] Salinity decreases with depth.
	6532-1328		In creek bed close to Spring Creek Mine	Unreliable	6	-	-	Boulders - Abandoned
	6532-1329		To test Willochra Basin sediments and underlying Adelaidean	No Aquifers found	201	Dry		**Weathered Wilmington Formation?** [More likely Angepena Formation – HZ from geological Map] Mud drilled. Geophysical logs do not indicate presence of aquifers: 0-165? Cz 165-201 P
	6532-1331		On fault line in ABC Quartzite	Very saline, small supply	91	1.2	7700	On fault line in **ABC Quartzite**

	6532-1332		In spring Creek Mine area	Moderate success	134	3.7	465	**Adelaidean** [Appila Tillite Formation - Tillite; quartzite; siltstone – HZ from geological Map] Near fault in Spring Creek Mine Area
R. E Read (1987)	6532-1348		To test Willochra Basin in an area of Sandstone catchment	No aquifers in basin, but indicated potential of Wilmington Formation	65	1	2300	**In Wilmington Formation** [Also could be ABC Range Quartzite – pink colour and hard for drilling???] Difficult drilling.
	6532-1349		Sited to search for Wilmington Formation and possible lower salinity close to Wilmington.	Success	99	12.5	1180	**Completed in Wilmington Formation** [Could be Wilmington ? or ABC Range Quartzite]
	6532-1350		Sited to look for better quality water in the Wilmington Formation close to Wilmington	Failure	163	0.3	1480	**Wilmington Formation** [Could be Brachina Formation – siltstone; shale.. – HZ form geological map] Thick weathered zone overlying tight siltstones
	6532-1351		To test Adelaidean sediments under the Willochra Basin	Failed to penetrate sediments	120	Nil	-	Air-drilled in Cainozoic to 120m. Attempt to mud-drill on was unsuccessful.
DWLBC 1999	6532-1499	Wilmington TWS 2			81	4	~ 500	Yudnamutana Subgroup - Appila Tillite – Tillite, quartzite, Massive grey

* Pump test data

Wilmington TWS Well No 2

In December 1999 production well 6532-1499 - Wilmington TWS 2 was constructed in the vicinity of the well 6532-1332 (13 m away). Well details are presented in the table 1. Reasons for drilling the production well on this site could be as follows:

- The investigation well 6532-1332 was moderately successful – producing ~4 L/sec of groundwater with salinity of ~500 mg/L
- Favourable site accessibility.

The new water supply well is producing a similar quantity of groundwater of the same salinity as the investigation well 6532-1332. However, this water contains H_2S and frequently arsenic above AWQDG. The source of the arsenic is most likely the fractured rock formation in which the well was completed. From the lithological log of 6532-1332 and drillers log 6532-1449 it is noted that siltstone and sandstone on this site contains pyrite, which might be responsible for the elevated arsenic in the extracted groundwater. (Note: Full groundwater analyses for drinking water should have been conducted on the well 6532-1332 prior to drilling production well 6532-1449).

The well 6532-1332 could not be utilised as a production well since it was found to be too bent to allow the installation of a pump (D Clarke, 1999).

Discharge Test
A discharge test on the well 6532-1499 was completed and analysed by PIRSA in December 1999.

Pumping test details:

- The well was pumped at a rate of 5L/sec for 15 hours,
- The water level in the well was monitored for a total of 3.5 days from the beginning of the pumping,
- A maximum drawdown of 44.25 m was recorded,
- The data indicates that one aquifer was dewatered at 15 m and probably a second aquifer at around 26 m,
- Well 6532-1332 was monitored during the test and recovery period.

Conclusions and recommendations:

- The several water cuts make the selection of an appropriate available drawdown problematic,
- The recommended maximum extraction rates given in table below are based on the well equation and an available drawdown of 25 m.

Duration of Discharge	Calculated maximum discharge rate (m^3/day)	Recommended maximum (30% safety margin)	
1 day	233	160 m^3/day	1.9 L/sec
10 days	200	140 m^3/day	1.6 L/sec
100 days	175	120 m^3/day	1.4 L/sec

LETTERS AND MINUTES

Following documents were reviewed:

- Letter Department of Mines and Energy South Australia; April 1986,
- Minutes forming Enclosure EWS 5937/68; February 1987,
- Minutes forming Enclosure – Wilmington Water Supply – Proposed Augmentation; August 2000.

FIELD VISIT

In February 2009 field work was undertaken in order to assess accessibility of the potential sites recommended during previous investigations and to check condition of the investigation well 6532-1332.

Three out of four MESA recommended sites (MESA 1, 2 and 3) along Spring Creek (figure 1) were visited and it was found that access to these sites is very difficult.

Investigation well 6532-1332 was found to be blocked at 56.8 m, however water level was responding to pumping of the production well Wilmington TWS well no. 2, (figures 2 and 3).

One potential drilling site for the new investigation/production well was selected 70 m south of the production well no. 2 (Easting 230658 Northing 6374756) as shown in figures 1 – 3.

Another potential drilling site for the new investigation/production well was selected 150 m north of the Spring Creek mine shaft (turn around area). This well would be completed in the same formation as the existing Spring Creek mine shaft. This turn around area needs to be enlarged to accommodate a well, figure 3.

RECOMMENDATIONS

After reviewing available reports and other available relevant information, as well as completion of the field work it is recommended that two investigation / production wells are drilled. Rational behind site selection is presented in the Table 2.

Table 2. Site selection - rational

Site Name	Location	Points For	Points against
1 - 2009	Eastern side of the Spring Creek, 150 m north of the mine shaft	HYDROGEOLOGY Previous investigations suggested that one well should be drilled in the mine shaft vicinity, but access was a major problem until now. According to the current knowledge Spring Creek mine shaft does not have arsenic and H_2S issues. Analysis of the discharge test on Spring Creek mine shaft, conducted in 1980 concluded that a second production well sited about 150 m from the mine shaft in the same aquifer (fissure system) would produce only minor interference with the existing well. New well should be drilled to 150 m, which will allow larger drawdown during pumping, especially if recharge and consequently water level declines. INFRASTRUCTURE Existing infrastructure, pipeline and power supply (electricity) is in the vicinity (mine shaft). <u>Note</u>: Sufficiency of the power supply should be checked.	Some earth work will be required to enlarge turnaround area.
2 - 2009	Western side of the Spring Creek, 70 m south of Wilmington well no. 2	HYDROGEOLOGY Existing investigation well 6532-1332 and production well no 2 show that the aquifer is capable of yielding reasonable quantity of	Arsenic content could be elevated from time to time Power supply might remain as for Well no

		low salinity groundwater, however content of arsenic might be a problem from time to time. More water cuts could be encountered if the new well is completed at 150 m. Well completed at this might provide larger quantity and will allow larger drawdown during pumping. Arsenic level might be different to Wilmington Well no, 2. This is going to be initialy tested on the investigation well 6532-1332, which is completed at 134m. INFRASTRUCTURE Existing pipeline infrastructure is in the vicinity (Well no 2) No earth work is required.	2 – diesel.
MES 1, 2, 3 and 4	All sites located in the close vicinity of the Spring Creek, downstream from the existing well-field	HYDROGEOLOGY Previous investigations (after drilling 10 investigation well) and information from the existing private wells suggest that apart from the mine shaft and well no 2 area; good quality and reasonable quantity might be obtained from some of these sites. Drilling on some of these sites could be undertaken if the proposed wells on sites 1 – 2009 and 2 – 2009 are not productive as expected. INFRASTRUCTURE Existing pipeline is in the vicinity.	Access to these sites to construct investigation/production well is difficult. Power supply would be an issue
Site selected by	North-eastern side of the main road.	INFRASTRUCTURE Existing infrastructure, pipeline and power supply (electricity) is in	HYDROGEOLOGY There are no previous investigations that

Franz Lintl		the close vicinity.	tapped deeper fractured rock aquifer. The closest deep well is 6532-1329 (see details in table 1). This well was dry at 201 m.

Figure 1. Investigation area - Location map

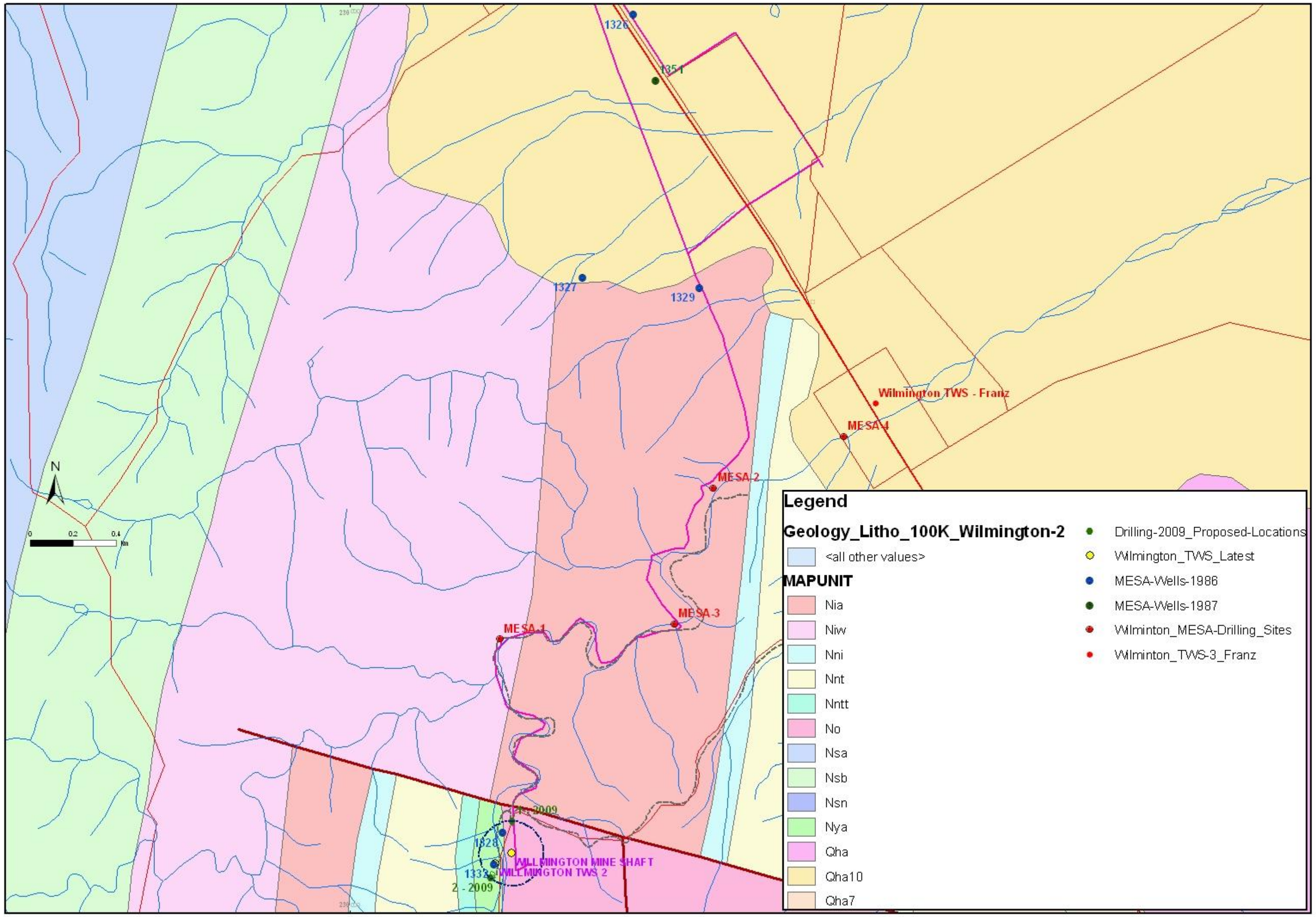


Figure 2.Well field site location map

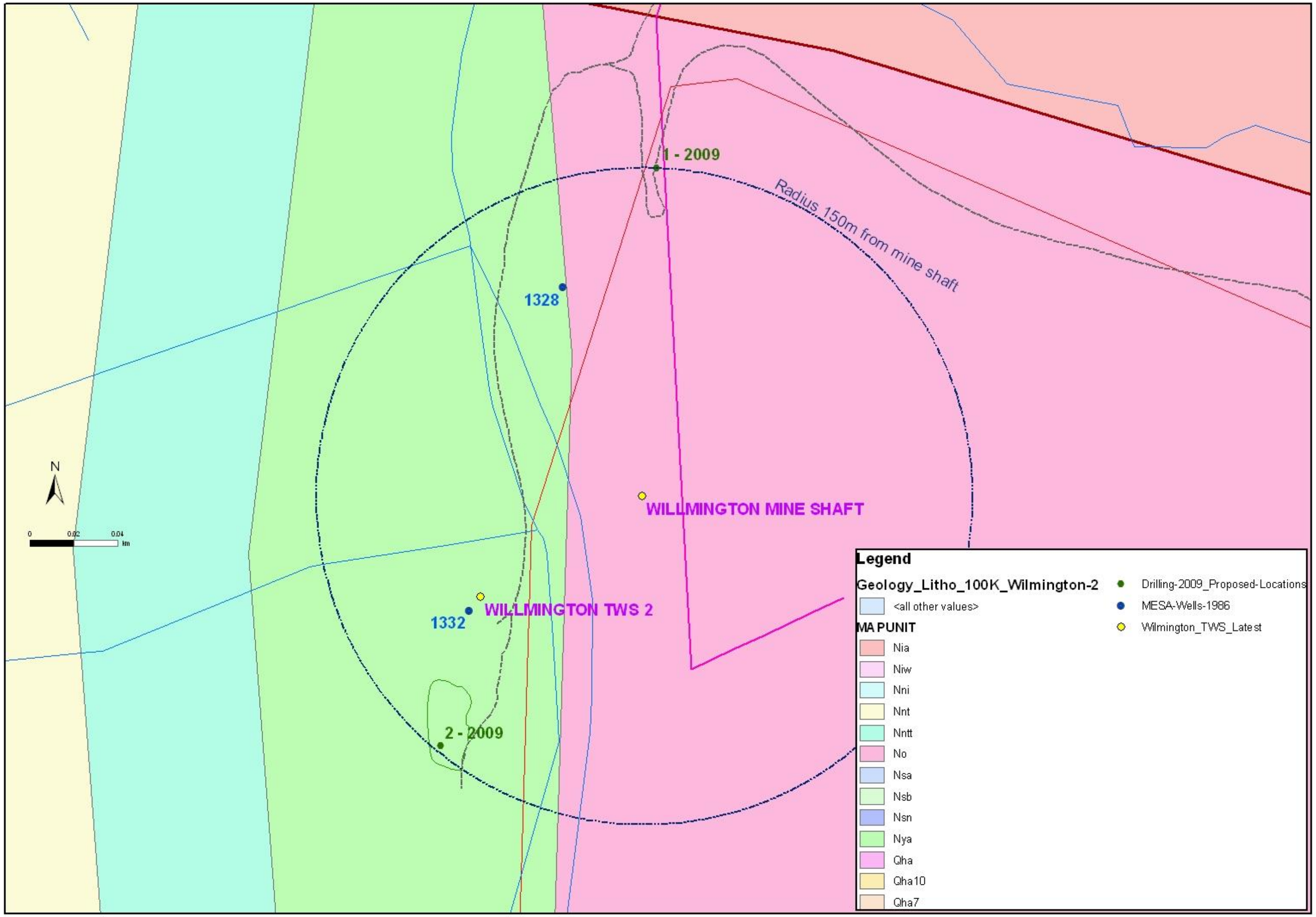


Figure 3. Satellite image of the well-field supply area

D. PUMPING TEST DATA

Quorn TWS 6—Step drawdown test

Step No.	Rate (L/s)	Duration (mins)	DTW (m)	DD (m)
-	-	0	59.34	0.00
1	8	1	60.15	0.81
1	8	2	60.18	0.84
1	8	3	60.20	0.86
1	8	4	60.22	0.88
1	8	5	60.23	0.89
1	8	6	60.26	0.92
1	8	7	60.27	0.93
1	8	8	60.27	0.93
1	8	9	60.26	0.92
1	8	10	60.28	0.94
1	8	12	60.28	0.94
1	8	14	60.29	0.95
1	8	16	60.30	0.96
1	8	18	60.31	0.97
1	8	20	60.31	0.97
1	8	22	60.31	0.97
1	8	24	60.32	0.98
1	8	26	60.32	0.98
1	8	28	60.33	0.99
1	8	30	60.33	0.99
1	8	35	60.34	1.00
1	8	40	60.34	1.00
1	8	45	60.35	1.01
1	8	50	60.35	1.01
1	8	55	60.36	1.02
1	8	60	60.38	1.04
1	8	70	60.38	1.04
1	8	80	60.39	1.05
1	8	90	60.38	1.04
1	8	100	60.38	1.04
2	12	101	60.86	1.52
2	12	102	60.90	1.56
2	12	103	60.91	1.57
2	12	104	60.92	1.58
2	12	105	60.93	1.59
2	12	106	60.94	1.60
2	12	107	60.95	1.61

Step No.	Rate (L/s)	Duration (mins)	DTW (m)	DD (m)
2	12	108	60.95	1.61
2	12	109	60.95	1.61
2	12	110	60.95	1.61
2	12	112	60.96	1.62
2	12	114	60.97	1.63
2	12	116	60.98	1.64
2	12	118	60.99	1.65
2	12	120	60.99	1.65
2	12	122	60.98	1.64
2	12	124	60.98	1.64
2	12	126	60.98	1.64
2	12	128	60.99	1.65
2	12	130	60.99	1.65
2	12	135	61.00	1.66
2	12	140	61.00	1.66
2	12	145	61.01	1.67
2	12	150	61.02	1.68
2	12	155	61.03	1.69
2	12	160	61.03	1.69
2	12	170	61.03	1.69
2	12	180	61.04	1.70
2	12	190	61.05	1.71
2	12	200	61.06	1.72
3	16	201	61.56	2.22
3	16	202	61.62	2.28
3	16	203	61.64	2.30
3	16	204	61.64	2.30
3	16	205	61.67	2.33
3	16	206	61.69	2.35
3	16	207	61.70	2.36
3	16	208	61.70	2.36
3	16	209	61.69	2.35
3	16	210	61.69	2.35
3	16	212	61.70	2.36
3	16	214	61.70	2.36
3	16	216	61.71	2.37
3	16	218	61.72	2.38
3	16	220	61.73	2.39
3	16	222	61.74	2.40
3	16	224	61.73	2.39
3	16	226	61.73	2.39

Step No.	Rate (L/s)	Duration (mins)	DTW (m)	DD (m)
3	16	228	61.74	2.40
3	16	230	61.74	2.40
3	16	235	61.75	2.41
3	16	240	61.76	2.42
3	16	245	61.76	2.42
3	16	250	61.77	2.43
3	16	255	61.77	2.43
3	16	260	61.78	2.44
3	16	270	61.79	2.45
3	16	280	61.79	2.45
3	16	290	61.80	2.46
3	16	300	61.81	2.47

Quorn TWS 6—Constant rate discharge test

Rate (L/s)	Duration (mins)	DTW (m)	DD (m)
12	0	59.37	0.00
12	1	60.45	1.08
12	2	60.46	1.09
12	3	60.49	1.12
12	4	60.50	1.13
12	5	60.53	1.16
12	6	60.54	1.17
12	7	60.55	1.18
12	8	60.56	1.19
12	9	60.56	1.19
12	10	60.56	1.19
12	12	60.58	1.21
12	14	60.60	1.23
12	16	60.60	1.23
12	18	60.61	1.24
12	20	60.61	1.24
12	22	60.62	1.25
12	24	60.63	1.26
12	26	60.63	1.26
12	28	60.63	1.26
12	30	60.64	1.27
12	35	60.65	1.28
12	40	60.65	1.28
12	45	60.66	1.29
12	50	60.67	1.30

Rate (L/s)	Duration (mins)	DTW (m)	DD (m)
12	55	60.67	1.30
12	60	60.68	1.31
12	70	60.69	1.32
12	80	60.70	1.33
12	90	60.71	1.34
12	100	60.73	1.36
12	120	60.73	1.36
12	140	60.75	1.38
12	160	60.77	1.40
12	180	60.78	1.41
12	200	60.78	1.41
12	250	60.80	1.43
12	300	60.81	1.44
12	350	60.83	1.46
12	400	60.84	1.47
12	450	60.86	1.49
12	500	60.88	1.51
12	550	60.90	1.53
12	600	60.91	1.54
12	650	60.93	1.56
12	700	60.95	1.58
12	750	60.96	1.59
12	800	60.98	1.61
12	850	60.99	1.62
12	900	61.00	1.63
12	950	61.00	1.63
12	1000	61.01	1.64
12	1100	61.02	1.65
12	1200	61.03	1.66
12	1300	61.05	1.68
12	1400	61.08	1.71
12	1440	61.07	1.70
0	1441	60.06	0.69
0	1442	59.98	0.61
0	1443	59.95	0.58
0	1444	59.94	0.57
0	1445	59.92	0.55
0	1446	59.91	0.54
0	1447	59.90	0.53
0	1448	59.88	0.51
0	1449	59.87	0.50

Rate (L/s)	Duration (mins)	DTW (m)	DD (m)
0	1450	59.87	0.50
0	1452	59.87	0.50
0	1454	59.85	0.48
0	1456	59.85	0.48
0	1458	59.83	0.46
0	1460	59.83	0.46
0	1462	59.83	0.46
0	1464	59.83	0.46
0	1466	59.82	0.45
0	1468	59.82	0.45
0	1470	59.81	0.44
0	1475	59.80	0.43
0	1480	59.79	0.42
0	1485	59.79	0.42
0	1490	59.79	0.42
0	1495	59.78	0.41
0	1500	59.76	0.39
0	1510	59.75	0.38
0	1520	59.74	0.37
0	1530	59.72	0.35
0	1540	59.72	0.35
0	1560	59.69	0.32
0	1580	59.68	0.31
0	1600	59.66	0.29
0	1620	59.66	0.29
0	1640	59.65	0.28
0	1690	59.6	0.23
0	1740	59.58	0.21
0	1790	59.55	0.18
0	1840	59.53	0.16
0	1890	59.51	0.14

Wilmington TWS 3—Step drawdown test

Step No.	Rate (L/s)	Duration (mins)	DTW (m)	DD (m)
-	-	0	19.38	0.00
1	10	1	20.43	1.05
1	10	2	20.49	1.11
1	10	3	20.50	1.12
1	10	4	20.54	1.16
1	10	5	20.56	1.18

Step No.	Rate (L/s)	Duration (mins)	DTW (m)	DD (m)
1	10	6	20.57	1.19
1	10	7	20.57	1.19
1	10	8	20.60	1.22
1	10	9	20.60	1.22
1	10	10	20.62	1.24
1	10	12	20.64	1.26
1	10	14	20.65	1.27
1	10	16	20.67	1.29
1	10	18	20.70	1.32
1	10	20	20.71	1.33
1	10	22	20.73	1.35
1	10	24	20.73	1.35
1	10	26	20.76	1.38
1	10	28	20.76	1.38
1	10	30	20.79	1.41
1	10	35	20.83	1.45
1	10	40	20.85	1.47
1	10	45	20.90	1.52
1	10	50	20.91	1.53
1	10	55	20.94	1.56
1	10	60	20.98	1.60
1	10	70	21.03	1.65
1	10	80	21.07	1.69
1	10	90	21.12	1.74
1	10	100	21.16	1.78
2	15	101	21.94	2.56
2	15	102	21.96	2.58
2	15	103	21.98	2.60
2	15	104	21.98	2.60
2	15	105	21.99	2.61
2	15	106	22.01	2.63
2	15	107	22.01	2.63
2	15	108	22.03	2.65
2	15	109	22.04	2.66
2	15	110	22.06	2.68
2	15	112	22.07	2.69
2	15	114	22.08	2.70
2	15	116	22.10	2.72
2	15	118	22.12	2.74
2	15	120	22.14	2.76
2	15	122	22.17	2.79

Step No.	Rate (L/s)	Duration (mins)	DTW (m)	DD (m)
2	15	124	22.16	2.78
2	15	126	22.17	2.79
2	15	128	22.18	2.80
2	15	130	22.20	2.82
2	15	135	22.24	2.86
2	15	140	22.28	2.90
2	15	145	22.31	2.93
2	15	150	22.34	2.96
2	15	155	22.37	2.99
2	15	160	22.40	3.02
2	15	170	22.45	3.07
2	15	180	22.50	3.12
2	15	190	22.57	3.19
2	15	200	22.61	3.23
3	20	201	23.55	4.17
3	20	202	23.54	4.16
3	20	203	23.56	4.18
3	20	204	23.56	4.18
3	20	205	23.58	4.20
3	20	206	23.60	4.22
3	20	207	23.61	4.23
3	20	208	23.63	4.25
3	20	209	23.63	4.25
3	20	210	23.64	4.26
3	20	212	23.67	4.29
3	20	214	23.69	4.31
3	20	216	23.70	4.32
3	20	218	23.72	4.34
3	20	220	23.74	4.36
3	20	222	23.76	4.38
3	20	224	23.77	4.39
3	20	226	23.78	4.4
3	20	228	23.79	4.41
3	20	230	23.81	4.43
3	20	235	23.84	4.46
3	20	240	23.88	4.50
3	20	245	23.92	4.54
3	20	250	23.96	4.58
3	20	255	24.00	4.62
3	20	260	24.03	4.65
3	20	270	24.10	4.72

Step No.	Rate (L/s)	Duration (mins)	DTW (m)	DD (m)
3	20	280	24.15	4.77
3	20	290	24.21	4.83
3	20	300	24.27	4.89

Wilmington TWS 3—Constant rate discharge test

Rate (L/s)	Duration (mins)	DTW (m)	DD (m)
15	0	18.28	0.00
15	1	20.09	1.81
15	2	20.13	1.85
15	3	20.17	1.89
15	4	20.20	1.92
15	5	20.25	1.97
15	6	20.25	1.97
15	7	20.25	1.97
15	8	20.29	2.01
15	9	20.28	2.00
15	10	20.30	2.02
15	12	20.36	2.08
15	14	20.39	2.11
15	16	20.41	2.13
15	18	20.44	2.16
15	20	20.47	2.19
15	22	20.50	2.22
15	24	20.52	2.24
15	26	20.53	2.25
15	28	20.56	2.28
15	30	20.58	2.30
15	35	20.64	2.36
15	40	20.69	2.41
15	45	20.76	2.48
15	50	20.80	2.52
15	55	20.82	2.54
15	60	20.88	2.60
15	70	20.96	2.68
15	80	21.04	2.76
15	90	21.11	2.83
15	100	21.16	2.88
15	120	21.30	3.02
15	140	21.42	3.14
15	160	21.52	3.24

Rate (L/s)	Duration (mins)	DTW (m)	DD (m)
15	180	21.61	3.33
15	200	21.71	3.43
15	250	21.91	3.63
15	300	22.09	3.81
15	350	22.21	3.93
15	400	22.32	4.04
15	450	22.41	4.13
15	500	22.52	4.24
15	550	22.58	4.30
15	600	22.63	4.35
15	650	22.71	4.43
15	700	22.77	4.49
15	750	22.80	4.52
15	800	22.85	4.57
15	850	22.93	4.65
15	900	22.95	4.67
15	950	23.00	4.72
15	1000	23.05	4.77
15	1100	23.08	4.80
15	1200	23.15	4.87
15	1300	23.18	4.90
15	1400	23.20	4.92
15	1500	23.21	4.93
15	1600	23.23	4.95
15	1700	23.24	4.96
15	1800	23.23	4.95
15	1900	23.23	4.95
15	2000	23.23	4.95
15	2100	23.23	4.95
15	2200	23.23	4.95
15	2300	23.24	4.96
15	2400	23.24	4.96
15	2500	23.24	4.96
15	2600	23.25	4.97
15	2700	23.25	4.97
15	2800	23.25	4.97
15	2880	23.27	4.99
0	2881	21.49	3.21
0	2882	21.42	3.14
0	2883	21.41	3.13
0	2884	21.37	3.09

Rate (L/s)	Duration (mins)	DTW (m)	DD (m)
0	2885	21.36	3.08
0	2886	21.33	3.05
0	2887	21.32	3.04
0	2888	21.31	3.03
0	2889	21.29	3.01
0	2890	21.27	2.99
0	2892	21.25	2.97
0	2894	21.22	2.94
0	2896	21.20	2.92
0	2898	21.19	2.91
0	2900	21.15	2.87
0	2902	21.14	2.86
0	2904	21.13	2.85
0	2906	21.10	2.82
0	2908	21.08	2.80
0	2910	21.05	2.77
0	2915	-	-
0	2920	-	-
0	2925	20.87	2.59
0	2930	20.86	2.58
0	2935	20.83	2.55
0	2940	20.78	2.50
0	2950	20.70	2.42
0	2960	20.61	2.33
0	2970	20.52	2.24
0	2980	20.47	2.19
0	3000	20.34	2.06
0	3020	20.22	1.94
0	3040	20.1	1.82
0	3060	20.00	1.72
0	3080	19.90	1.62
0	3130	19.67	1.39
0	3180	19.50	1.22
0	3230	19.34	1.06
0	3280	19.22	0.94
0	3330	19.12	0.84
0	3380	19.01	0.73
0	4320	18.35	0.07

E. WATER CHEMISTRY

PO Box 1751
Adelaide SA 5001

250 Victoria Square
Adelaide SA 5000

Tel: 1300 653 366
Fax: 1300 883 171

Internet: www.awqc.com.au
Email: awqc@sawater.com.au

Australian Water Quality Centre

DWLBC
ATTN: Nico Kruger
DWLBC Level11 25 Grenfell Street
ADELAIDE
SA 5001 AUSTRALIA

23/09/2009

Dear Nico

Please find attached the Preliminary Analytical Report for

Customer Service Request:	108874-2009-CSR-11
Account:	108874
Project:	AWQC-32434 DWLBC - Nicholas Kruger- Water Testing - 08/09

Sample Date Range: 01-May-2009 to 31-May-2009

Please note AWQC Sample Receipt hours are Monday to Friday 8.30am - 4.30pm.
AWQC has moved for more details visit www.awqc.com.au/awqc

Yours sincerely,

Borjana Stazic-Mandic
Team Leader Account Management
Borjana.Stazic-Mandic@sawater.com.au
1300653366

NATA
WORLD RECOGNISED ACCREDITATION

PO Box 1751
Adelaide SA 5001

250 Victoria Square
Adelaide SA 5000

Tel: 1300 653 366
Fax: 1300 883 171

Internet: www.awqc.com.au
Email: awqc@sawater.com.au

Australian Water Quality Centre

PRELIMINARY REPORT: 57676

Report Information

Project Name	AWQC-32434
Customer	DWLBC
CSR_ID	108874-2009-CSR-11

Analytical Results

Customer Sample Description	Quorn TWS Q6
Sampling Point	11438-DWLBC - GENERAL
Sampled Date	8/09/2009 12:00:00AM
Sample Received Date	8/09/2009 2:52:27PM
Sample ID	2009-003-6126
Status	Inprogress
Collection Type	Customer Collected

Inorganic Chemistry - Metals	LOR	Result
Cadmium - Total	0.0005	<0.0005 mg/L
Aluminium - Soluble TIC-003 W09-023		
Aluminium - Soluble	0.001	<0.001 mg/L
Aluminium - Total TIC-003 W09-023		
Aluminium - Total	0.001	0.017 mg/L
Antimony - Soluble TIC-003 W09-023		
Antimony - Soluble	0.0005	<0.0005 mg/L
Antimony - Total TIC-003 W09-023		
Antimony - Total	0.0005	<0.0005 mg/L
Arsenic - Soluble TIC-003 W09-023		
Arsenic - Soluble	0.0003	0.0004 mg/L
Arsenic - Total TIC-003 W09-023		
Arsenic - Total	0.001	<0.001 mg/L
Barium - Soluble TIC-003 W09-023		
Barium - Soluble	0.0005	0.0950 mg/L
Barium - Total TIC-003 W09-023		
Barium - Total	0.0005	0.0973 mg/L
Beryllium - Soluble TIC-003 W09-023		
Beryllium - Soluble	0.0003	<0.0003 mg/L
Beryllium - Total TIC-003 W09-023		
Beryllium - Total	0.0003	<0.0003 mg/L
Boron - Soluble TIC-003 W09-023		
Boron - Soluble	0.020	0.221 mg/L
Cadmium - Soluble TIC-003 W09-023		
Cadmium - Soluble	0.0001	<0.0001 mg/L
Calcium TIC-003 W09-023		
Calcium	0.04	93.0 mg/L
Chromium - Soluble TIC-003 W09-023		
Chromium - Soluble	0.0001	<0.0001 mg/L
Chromium - Total TIC-003 W09-023		
Chromium - Total	0.003	<0.003 mg/L

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Adelaide SA 5001
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Adelaide SA 5000
Tel: 1300 653 366
Fax: 1300 883 171
Internet: www.awqc.com.au
Email: awqc@sawater.com.au

Australian Water Quality Centre

PRELIMINARY REPORT: 57676

Analytical Results

Customer Sample Description	Quorn TWS Q6
Sampling Point	11438-DWLBC - GENERAL
Sampled Date	8/09/2009 12:00:00AM
Sample Received Date	8/09/2009 2:52:27PM
Sample ID	2009-003-6126
Status	Inprogress
Collection Type	Customer Collected

Copper - Soluble TIC-003 W09-023		
Copper - Soluble	0.0001	0.0014 mg/L
Copper - Total TIC-004 W09-023		
Copper - Total	0.005	<0.005 mg/L
Iron - Soluble TIC-003 W09-023		
Iron - Soluble	0.0005	0.0146 mg/L
Iron - Total TIC-003 W09-023		
Iron - Total	0.0005	0.1367 mg/L
Lead - Soluble TIC-003 W09-023		
Lead - Soluble	0.0001	<0.0001 mg/L
Lead - Total TIC-003 W09-023		
Lead - Total	0.0005	<0.0005 mg/L
Magnesium TIC-003 W09-023		
Magnesium	0.04	76.6 mg/L
Manganese - Soluble TIC-003 W09-023		
Manganese - Soluble	0.0001	0.0013 mg/L
Manganese - Total TIC-003 W09-023		
Manganese - Total	0.0001	0.0016 mg/L
Mercury - Soluble TIC-003 W09-023		
Mercury - Soluble	0.00003	<0.00003 mg/L
Mercury - Total TIC-003 W09-023		
Mercury - Total	0.0003	<0.0003 mg/L
Molybdenum - Soluble TIC-003 W09-023		
Molybdenum - Soluble	0.0001	0.0008 mg/L
Molybdenum - Total TIC-003 W09-023		
Molybdenum - Total	0.0005	0.0008 mg/L
Nickel - Soluble TIC-003 W09-023		
Nickel - Soluble	0.0001	0.0005 mg/L
Nickel - Total TIC-003 W09-023		
Nickel - Total	0.0001	0.0005 mg/L
Potassium TIC-003 W09-023		
Potassium	0.040	7.72 mg/L
Selenium - Soluble TIC-003 W09-023		
Selenium - Soluble	0.0001	0.0008 mg/L
Selenium - Total TIC-003 W09-023		
Selenium - Total	0.003	<0.003 mg/L
Silver - Soluble TIC-003 W09-023		
Silver - Soluble	0.00003	<0.00003 mg/L

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	LOR	Result
Silver - Total TIC-003 W09-023		
Silver - Total	0.00003	<0.00003 mg/L
Sodium TIC-003 W09-023		
Sodium	0.04	233 mg/L
Sulphur TIC-004 W09-023		
Sulphate	1.5	93.0 mg/L
Tin - Soluble TIC-003 W09-023		
Tin - Soluble	0.0005	<0.0005 mg/L
Tin - Total TIC-003 W09-023		
Tin - Total	0.0005	<0.0005 mg/L
Total Hardness as CaCO3 W09-023		
Total Hardness as CaCO3	2.0	548 mg/L
Uranium - Soluble TIC-003 W09-023		
Uranium - Soluble	0.0001	0.0045 mg/L
Uranium - Total TIC-003 W09-023		
Uranium - Total	0.0005	0.0047 mg/L
Vanadium - Total TIC-003 W09-023		
Vanadium - Total	0.003	0.005 mg/L
Zinc - soluble TIC-003 W09-023		
Zinc - Soluble	0.0003	0.0054 mg/L
Zinc - Total TIC-003 W09-023		
Zinc - Total	0.0003	0.0055 mg/L

Inorganic Chemistry - Nutrients	LOR	Result
Ammonia as N T0100-01 W09-023		
Ammonia as N	0.005	<0.005 mg/L
Bromide W09-023		
Bromide	0.10	1.33 mg/L
Chloride T0104-02 W09-023		
Chloride	4.0	421 mg/L
Fluoride W09-023		
Fluoride	0.10	0.54 mg/L
Iodide T0117-01 W09-023		
Iodide	0.05	<0.05 mg/L
Nitrate + Nitrite as N T0161-01 W09-023		
Nitrate + Nitrite as N	0.005	0.107 mg/L
Nitrate as N W09-023		

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Sampled Date	8/09/2009 12:00:00AM
Sample Received Date	8/09/2009 2:52:27PM
Sample ID	2009-003-6126
Status	Inprogress
Collection Type	Customer Collected

	LOR	Result
Nitrate as N W09-023		
Nitrate as Nitrogen	0	0.102 mg/L
Nitrite as N T0107-01 W09-023		
Nitrite as Nitrogen	0.005	<0.005 mg/L
Phosphorus - Filterable Reactive as P T0108-01 W09-023		
Phosphorus - Filterable Reactive as P	0.005	0.012 mg/L

Organic Chemistry	LOR	Result
Dissolved Organic Carbon W09-023		
Dissolved Organic Carbon	0.3	1.0 mg/L

Inorganic Chemistry - Physical	LOR	Result
Alkalinity Carbonate Bicarbonate and Hydroxide T0101-01 W09-023		
Alkalinity as Calcium Carbonate		428 mg/L
Bicarbonate		522 mg/L
Carbonate		0 mg/L
Hydroxide		0 mg/L
Colour - True (456nm) Filtered T0029-01 W09-023		
Colour - True (456nm)	1	<1 HU
Conductivity & Total Dissolved Solids T0016-01 W09-023		
Conductivity	1	2180 µScm
Total Dissolved Solids (by EC)	1.0	1200 mg/L
pH T0010-01 W09-023		
pH		7.0 pH units
Turbidity T0018-01 W09-023		
Turbidity	0.1	1.9 NTU

Inorganic Chemistry - Waste Water	LOR	Result
Cyanide - Total W09-023		
Cyanide as CN - Total	0.05	- mg/L

Western Radiation Services	LOR	Result
Gross Alpha Activity W09-023		
Gross Alpha Activity		- mBq/L
Gross Beta Activity (K-40 corrected) W09-023		
Gross Beta Activity (K-40 corrected)		- mBq/L

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ABN 69336525019
A business unit of the South Australian Water Corporation

PO Box 1751
Adelaide SA 5001
250 Victoria Square
Adelaide SA 5000
Tel: 1300 653 366
Fax: 1300 883 171
Internet: www.awqc.com.au
Email: awqc@sawater.com.au

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PRELIMINARY REPORT: 57676

Analytical Results

Customer Sample Description	Wilmington TWS Well No.3
Sampling Point	11438-DWLBC - GENERAL
Sampled Date	11/09/2009 12:00:00AM
Sample Received Date	11/09/2009 2:58:17PM
Sample ID	2009-003-6127
Status	Inprogress
Collection Type	Customer Collected

Inorganic Chemistry - Metals	LOR	Result
Cadmium - Total	0.0001	<0.0001 mg/L
Aluminium - Soluble TIC-003 W09-023		
Aluminium - Soluble	0.001	<0.001 mg/L
Aluminium - Total TIC-003 W09-023		
Aluminium - Total	0.001	0.002 mg/L
Antimony - Soluble TIC-003 W09-023		
Antimony - Soluble	0.0005	<0.0005 mg/L
Antimony - Total TIC-003 W09-023		
Antimony - Total	0.0005	<0.0005 mg/L
Arsenic - Soluble TIC-003 W09-023		
Arsenic - Soluble	0.0003	0.0006 mg/L
Arsenic - Total TIC-003 W09-023		
Arsenic - Total	0.0003	0.0006 mg/L
Barium - Soluble TIC-003 W09-023		
Barium - Soluble	0.0005	0.2094 mg/L
Barium - Total TIC-003 W09-023		
Barium - Total	0.0005	0.2153 mg/L
Beryllium - Soluble TIC-003 W09-023		
Beryllium - Soluble	0.0003	<0.0003 mg/L
Beryllium - Total TIC-003 W09-023		
Beryllium - Total	0.0003	<0.0003 mg/L
Boron - Soluble TIC-003 W09-023		
Boron - Soluble	0.020	0.021 mg/L
Cadmium - Soluble TIC-003 W09-023		
Cadmium - Soluble	0.0001	<0.0001 mg/L
Calcium TIC-003 W09-023		
Calcium	0.04	18.4 mg/L
Chromium - Soluble TIC-003 W09-023		
Chromium - Soluble	0.0001	<0.0001 mg/L
Chromium - Total TIC-003 W09-023		
Chromium - Total	0.0001	0.0002 mg/L
Chromium - Total	0.0001	0.0002 mg/L
Copper - Soluble TIC-003 W09-023		
Copper - Soluble	0.0001	0.0135 mg/L
Copper - Total TIC-004 W09-023		

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Sample Received Date	11/09/2009 2:58:17PM
Sample ID	2009-003-6127
Status	Inprogress
Collection Type	Customer Collected

Copper - Total TIC-004 W09-023		
Copper - Total	0.005	0.015 mg/L
Iron - Soluble TIC-003 W09-023		
Iron - Soluble	0.0005	0.0083 mg/L
Iron - Total TIC-003 W09-023		
Iron - Total	0.0005	0.0685 mg/L
Lead - Soluble TIC-003 W09-023		
Lead - Soluble	0.0001	<0.0001 mg/L
Lead - Total TIC-003 W09-023		
Lead - Total	0.0001	0.0001 mg/L
Magnesium TIC-003 W09-023		
Magnesium	0.04	20.6 mg/L
Manganese - Soluble TIC-003 W09-023		
Manganese - Soluble	0.0001	0.0006 mg/L
Manganese - Total TIC-003 W09-023		
Manganese - Total	0.0001	0.0006 mg/L
Mercury - Soluble TIC-003 W09-023		
Mercury - Soluble	0.00003	<0.00003 mg/L
Mercury - Total TIC-003 W09-023		
Mercury - Total	0.0003	<0.0003 mg/L
Molybdenum - Soluble TIC-003 W09-023		
Molybdenum - Soluble	0.0001	0.0004 mg/L
Molybdenum - Total TIC-003 W09-023		
Molybdenum - Total	0.0001	0.0004 mg/L
Nickel - Soluble TIC-003 W09-023		
Nickel - Soluble	0.0001	0.0022 mg/L
Nickel - Total TIC-003 W09-023		
Nickel - Total	0.0001	0.0027 mg/L
Potassium TIC-003 W09-023		
Potassium	0.040	14.9 mg/L
Selenium - Soluble TIC-003 W09-023		
Selenium - Soluble	0.0001	0.0003 mg/L
Selenium - Total TIC-003 W09-023		
Selenium - Total	0.0001	0.0003 mg/L
Silver - Soluble TIC-003 W09-023		
Silver - Soluble	0.00003	<0.00003 mg/L
Silver - Total TIC-003 W09-023		
Silver - Total	0.00003	<0.00003 mg/L

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Sample ID	2009-003-6127
Status	Inprogress
Collection Type	Customer Collected

Sodium TIC-003 W09-023		
Sodium	0.04	54.8 mg/L
Sulphur TIC-004 W09-023		
Sulphate	1.5	33.9 mg/L
Tin - Soluble TIC-003 W09-023		
Tin - Soluble	0.0005	<0.0005 mg/L
Tin - Total TIC-003 W09-023		
Tin - Total	0.0005	<0.0005 mg/L
Total Hardness as CaCO3 W09-023		
Total Hardness as CaCO3	2.0	131 mg/L
Uranium - Soluble TIC-003 W09-023		
Uranium - Soluble	0.0001	<0.0001 mg/L
Uranium - Total TIC-003 W09-023		
Uranium - Total	0.0001	<0.0001 mg/L
Vanadium - Total TIC-003 W09-023		
Vanadium - Total	0.0001	0.0002 mg/L
Zinc - soluble TIC-003 W09-023		
Zinc - Soluble	0.0003	0.0045 mg/L
Zinc - Total TIC-003 W09-023		
Zinc - Total	0.0003	0.0072 mg/L

Inorganic Chemistry - Nutrients	LOR	Result
Ammonia as N T0100-01 W09-023		
Ammonia as N	0.005	<0.005 mg/L
Bromide W09-023		
Bromide	0.10	- mg/L
Chloride T0104-02 W09-023		
Chloride	4.0	94 mg/L
Fluoride W09-023		
Fluoride	0.10	0.16 mg/L
Iodide T0117-01 W09-023		
Iodide	0.05	<0.05 mg/L
Nitrate + Nitrite as N T0161-01 W09-023		
Nitrate + Nitrite as N	0.005	0.157 mg/L
Nitrate as N W09-023		
Nitrate as Nitrogen	0	0.152 mg/L
Nitrite as N T0107-01 W09-023		

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Sample ID	2009-003-6127
Status	Inprogress
Collection Type	Customer Collected

Nitrite as N T0107-01 W09-023		
Nitrite as Nitrogen	0.005	<0.005 mg/L
Phosphorus - Filterable Reactive as P T0108-01 W09-023		
Phosphorus - Filterable Reactive as P	0.005	0.077 mg/L

Organic Chemistry	LOR	Result
Dissolved Organic Carbon W09-023		
Dissolved Organic Carbon	0.3	1.7 mg/L

Inorganic Chemistry - Physical	LOR	Result
Alkalinity Carbonate Bicarbonate and Hydroxide T0101-01 W09-023		
Alkalinity as Calcium Carbonate		96 mg/L
Bicarbonate		117 mg/L
Carbonate		0 mg/L
Hydroxide		0 mg/L
Colour - True (456nm) Filtered T0029-01 W09-023		
Colour - True (456nm)	1	<1 HU
Conductivity & Total Dissolved Solids T0016-01 W09-023		
Conductivity	1	554 µScm
Total Dissolved Solids (by EC)	1.0	300 mg/L
pH T0010-01 W09-023		
pH		6.7 pH units
Turbidity T0018-01 W09-023		
Turbidity	0.1	0.58 NTU

Inorganic Chemistry - Waste Water	LOR	Result
Cyanide - Total W09-023		
Cyanide as CN - Total	0.05	- mg/L

Western Radiation Services	LOR	Result
Gross Alpha Activity W09-023		
Gross Alpha Activity		- mBq/L
Gross Beta Activity (K-40 corrected) W09-023		
Gross Beta Activity (K-40 corrected)		- mBq/L

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Incidents

Sample ID	S.Point	Description	Sampled Date	Analysis (where Applicable)	Incident Description
2009-003-6124	11438	Nepabunna TWS N-329	2/09/2009	Iodide	Test results outside of specification limits have been checked and the results verified

Samples Not Collected

Sample ID	S.Point	Description	Sampled Date	Non Collect Reason
2009-003-6124	11438	Nepabunna TWS N-329	2/09/2009	Not required
2009-003-6125	11438	XXX Nepabunna TWS (Site 2)	25/05/2009	Scheduling error
2009-003-6128	11438	XXX Wilmington TWS (Secondary)	25/05/2009	Scheduling error

Bottles Not Collected

Sample ID	S.Point	Description	Sampled Date	Laboratory	Non Collect Reason
2009-003-6124	11438	Nepabunna TWS N-329	2/09/2009	Bacteriology	Not required
2009-003-6124	11438	Nepabunna TWS N-329	2/09/2009	Organic Chemistry	Not required
2009-003-6127	11438	Wilmington TWS Well No.3	11/09/2009	Bacteriology	Reason for non collection not known
2009-003-6127	11438	Wilmington TWS Well No.3	11/09/2009	Organic Chemistry	Reason for non collection not known

Analytical Method

Analytical Method Code	Description
T0010-01	Determination of pH
T0016-01	Determination of Conductivity
T0018-01	Turbidity - Nephelometric Measurement
T0029-01	Colour, True - Spectrophotometric Measurement
T0100-01	Ammonia/Ammonium - Automated Flow Colorimetry
T0101-01	Alkalinity - Automated Acidimetric Titration
T0104-02	Chloride - Automated Flow Colorimetry
T0107-01	Nitrite - Automated Flow Colorimetry
T0108-01	Filterable Reactive Phosphorus - Automated Flow Colorimetry
T0117-01	Iodide
T0161-01	Nitrate + Nitrate (NOx) - Automated Flow Colorimetry
TIC-003	Elemental Analysis - ICP Mass Spectrometry
TIC-004	Determination of Metals - ICP Spectrometry by ICP2
W-052	Preparation of Samples for Metal Analysis

Sampling Method

Sampling Method Code	Description
W09-023	Sampling Method for Chemical Analyses

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Laboratory Information

Laboratory	NATA accreditation ID
Inorganic Chemistry - Metals	1115
Inorganic Chemistry - Nutrients	1115
Organic Chemistry	1115
Inorganic Chemistry - Physical	1115
Inorganic Chemistry - Waste Water	1115
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Notes
1. The last figure of the result value is a significant figure.
2. Samples are analysed as received.
3. # determination of the component is not covered by NATA Accreditation.
4. ^ indicates result is out of specification according to the reference Guideline. Refer to Report footer.
5. * indicates incident have been recorded against the sample. Refer to Report footer.
6. & Indicates the results have changed since the last issued report.
7. The Limit of Reporting (LOR) is the lowest concentration of analyte which is reported at the AWQC and is based on the LOQ rounded up to a more readily used value. The Limit of Quantitation (LOQ) is the lowest concentration of analyte for which quantitative results may be obtained within a specified degree of confidence.

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

Chemical elements and compounds

Element/compound	Symbol	Element/compound	Symbol
Aluminium	Al	Iron	Fe
Antimony	Sb	Lead	Pb
Arsenic	As	Magnesium	Mg
Ammonium	NH_4	Manganese	Mn
Barium	Ba	Mercury	Hg
Beryllium	Be	Molybdenum	Mo
Bicarbonate	HCO_3	Nickel	Ni
Boron	B	Nitrate	NO_3
Bromide	Br	Nitrite	NO_2
Cadmium	Cd	Phosphorus	P
Calcium	Ca	Potassium	K
Carbonate	CO_3	Selenium	Se
Chloride	Cl	Silver	Ag
Chromium	Cr	Sodium	Na
Copper	Cu	Sulfate	SO_4
Cyanide	CN	Tin	Sn
Dissolved Organic Carbon	DOC	Uranium	U
Fluoride	F	Zinc	Zn
Iodide	I		

Shortened forms

~	approximately equal to
CRD	constant rate discharge
DD	drawdown
DTW	depth to water (measured from a reference point usually top of casing)
EC	electrical conductivity (µS/cm)
ID	inner diameter
K	hydraulic conductivity (m/d)
mBNS	metres below natural surface
PVC	polyvinyl chloride
TDS	total dissolved solids (mg/L)
WL	water level

GLOSSARY

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

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

Aquitard — A layer in the geological profile that separates two aquifers and restricts the flow between them

DWLBC — Department of Water, Land and Biodiversity Conservation (Government of South Australia)

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

Fracture — General term applied to any break in a material, but commonly applied to more or less clean breaks in rocks or minerals

Geophysics — The science concerned with all aspects of the physical properties and processes of the Earth and planetary bodies and their interpretation

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

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

Infrastructure — Artificial lakes; dams or reservoirs; embankments, walls, channels or other works; buildings or structures; or pipes, machinery or other equipment

Lithology — The description of the microscopic features of a rock

Monitoring — (1) The repeated measurement of parameters to assess the current status and changes over time of the parameters measured (2) Periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements and/or pollutant levels in various media or in humans, animals, and other living things

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

Permeability — A measure of the ease with which water flows through an aquifer or aquitard, measured in m^2/d

Piezometer — A narrow tube, pipe or well; used for measuring moisture in soil, water levels in an aquifer, or pressure head in a tank, pipeline, etc

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

Recharge area — The area of land from which water from the surface (rainfall, streamflow, irrigation, etc.) infiltrates into an aquifer. See also artificial recharge, natural recharge

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

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 (1–70 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

Transmissivity (T) — 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

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

Unit number — A unique identifier given to all registered wells within South Australia

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

Osei-Bonsu K & Evans S, 2002, *Groundwater Exploration—Quorn Township Water Supply Wellfield,* DWLBC Report 2002/28, Department of Water, Land and Biodiversity Conservation, Adelaide