DWLBC REPORT

Regional Disposal Strategy – Renmark Group Deep Aquifer Injection Phase IIb Preliminary Pumping and Injection Trials

2009/01 - part 1

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

Regional Disposal Strategy – Renmark Group Deep Aquifer Injection

Phase IIb Preliminary Pumping and Injection Trials

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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

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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 both for current users and for 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 continues 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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EXECUTIVE SUMMARY

The potential for the disposal of saline groundwater pumped from a shallow water table aquifer (Monoman Formation) into a deep regionally confined aquifer (Renmark Group) has been investigated over the past 3 years in the Chowilla region, South Australia. Phase I included a desktop study to identify a target aquifer (the Warina Sands) while Phase II involved the construction of a 450 m deep investigation well which was completed as an observation well. Due to the small diameter of this well, traditional pumping tests could not be conducted to determine well hydraulic behaviour and estimate aquifer transmissivity. Phase IIb was commissioned in an attempt to obtain this information.

Phase IIb pumping and injection trials involved airlift pump testing and preliminary injection testing. Transmissivity was estimated at ~70 m^2/day using Logan's approximation, which utilises corrected drawdown data. The testing procedure recognised the limitation of the results due to the 100 mm diameter well in which considerable friction losses occurred. Minor anomalies in the airlifting and injection data were also encountered due to temperature changes in the water column in the well brought about by the airlifting of warm (35°C) native Warina Sands groundwater and injection of relatively cooler (21°C) Monoman Formation groundwater.

Groundwater sampling of a nearby Monoman Formation production well and sampling of Warina Sands observation well 7030-809 was undertaken to gain further understanding of the physiochemical attributes of the injectant and of the native groundwater. The results indicate that the injectant requires filtration with an appropriately sized filter prior to injection.

The results of the Phase IIb trial indicate that deep aquifer disposal of saline groundwater in the Chowilla region is technically feasible. Given the limitations resulting from the casing diameter of the existing well, it is recommended that a Phase III injection trial utilising a large diameter injection well be undertaken.

For a Phase III injection trial to proceed, due consideration must be given to the design of the injection well, location of Monoman Formation production wells, and disposal of groundwater produced during development and pumping tests. Filtration and backflushing capabilities must be incorporated into the design to allow for routine backflushing of the injection well.

1. INTRODUCTION

The Science, Monitoring and Information Division has undertaken work on the Chowilla Floodplain in relation to the potential for deep aquifer disposal of saline groundwater pumped from water table aquifers (Monomon Formation) since 2005. Work to date has included a Desktop Study (Phase 1) which was completed in November 2005 (Rammers *et al*, 2005), and a Feasibility Study (Phase II) which was completed in December 2007 (Magarey and Osei-Bonsu, 2008). Work has focussed on the deep confined Warina Sands at the base of the Renmark Group.

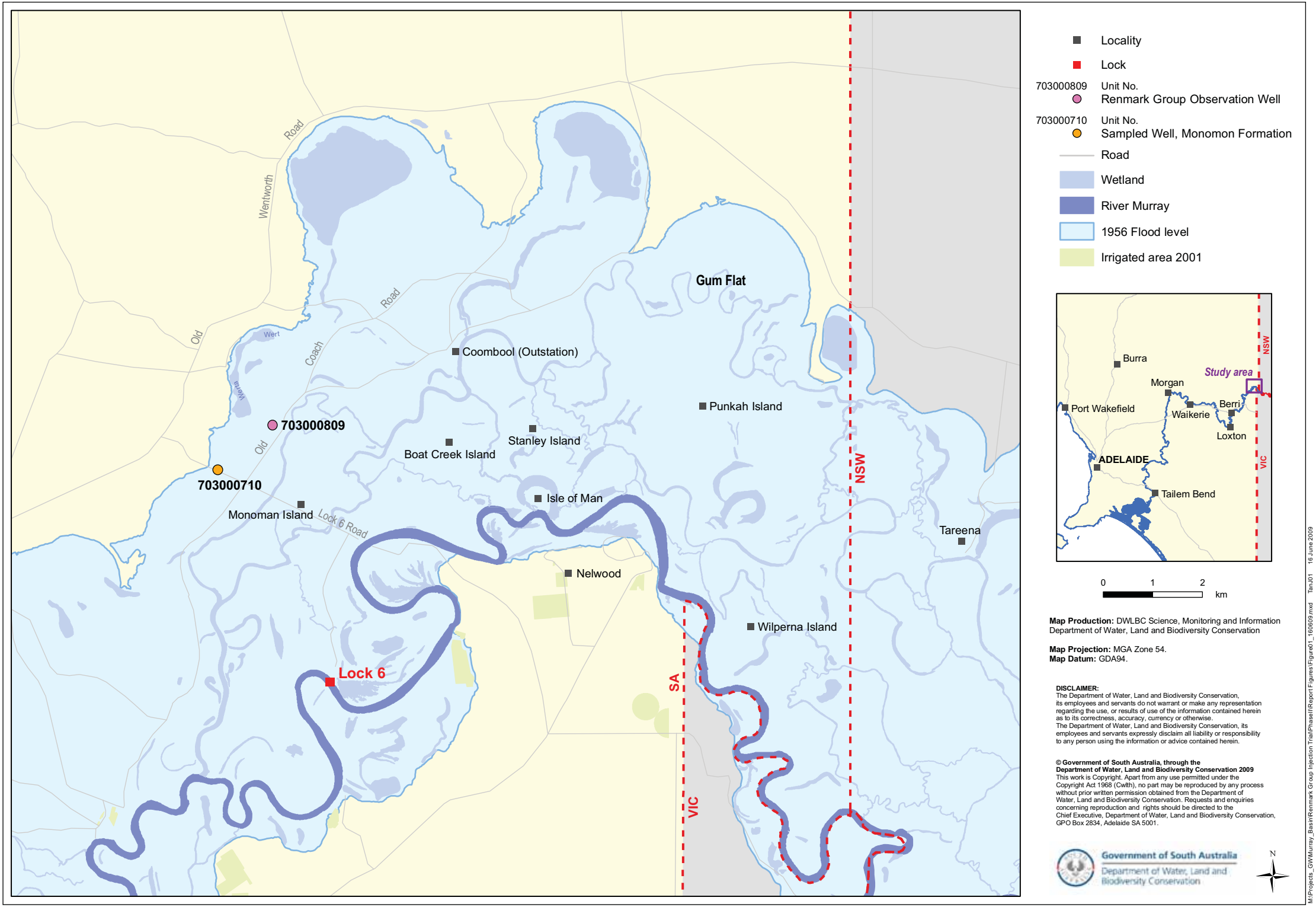
The Phase II Feasibility Study involved the construction of a 450 m deep artesian observation well (Unit Number 7030-809) completed in the Warina Sands, a geochemical modelling/clogging study, and a seismic hazard risk assessment. Results from Phase II indicate the Warina Sands was of sufficient thickness and permeability to receive saline groundwater (injectant), however this was not quantified to the level of detail required to commit to the proposed Phase III injection trial.

The current phase of work was implemented in order to obtain preliminary information on well hydraulic behaviour and aquifer transmissivity using an approach not considered during Phase II. This approach was required due to the limitations imposed by the original decision to complete well 7030-809 with 100 mm ID casing (note that during the planning of this well no testing had been considered). The investigation involved conducting airlift–recovery tests and injection tests. The airlift–recovery testing used a methodology similar to that outlined by Smith (1982). This method, which was used successfully for water supply investigations in the southeast of South Australia, involves airlift pumping of relatively small diameter wells and analysing the recovery curve. This method was applied to well 7030-809 located near Werta Wert wetland on the Chowilla Floodplain.

In total, three airlift–recovery tests, four short–term injection tests (up to eight hours), and one longer–term injection test (ten days) were conducted between March and June 2008. The initial short–term injection tests were conducted using groundwater collected and stored from the Warina Sands, and the longer–term test was conducted using groundwater pumped from Monoman Formation production well 7030-710 located 1.5 km to the south. Groundwater sampling was also undertaken on Warina Sands observation well 7030-809 and Monoman Formation production well 7030-710. The location of the investigation site is given in Figure 1.

The key objectives of this investigation, as outlined in the Project Brief, were to:

1. Characterise the hydraulics of observation well 7030-809 and the Warina Sands at the investigation site.
2. Characterise the clogging potential of the Monoman Formation groundwater.
3. Gain a preliminary understanding of hydraulic behaviour of well 7030-809 under injection using Warina Sands groundwater and Monoman Formation groundwater.


Locality
Lock
703000809 Unit No.
Renmark Group Observation Well
703000710 Unit No.
Sampled Well, Monomon Formation
Road
Wetland
River Murray
1956 Flood level
Irrigated area 2001
Gum Flat
Coombool (Outstation)
Punkah Island
Stanley Island
Boat Creek Island
Isle of Man
Monoman Island
Lock 6 Road
Nelwood
Wilperna Island
Tareena
Lock 6
703000809
703000710
Wentworth Road
Old Coach Road
Old Wert
Old Wert
NSW
SA
VIC
Burra
Morgan
Study area
Port Wakefield
Waikerie
Berri
Loxton
ADELAIDE
Tailem Bend
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Map Production: DWLBC Science, Monitoring and Information Department of Water, Land and Biodiversity Conservation
Map Projection: MGA Zone 54.
Map Datum: GDA94.
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M:\Projects_GW\Murray_Basin\Renmark Group Injection Trial\Phase II\Report Figures\Figure01_160609.mxd TanJ01 16 June 2009

2. AIRLIFT–RECOVERY TESTING

The following sections outline the objectives, methodology and results of the airlift–recovery testing conducted on observation well 7030-809. DWLBC Groundwater Technical Services conducted all on site works.

Three separate constant rate airlift–recovery tests (summarised in Table 1) were conducted on observation well 7030-809 at pumping rates of 9.5, 11.8 and 13.0 L/s. Testing commenced on 27 March 2008. Results from the airlift–recovery tests are plotted as residual drawdown in metres vs. time in seconds. Two graphs are presented for each of the tests, with the latter showing potentiometric head in the well during the initial minutes of recovery. Data for the recovery testing is provided in Appendix 1. Residual drawdown is signed positive, and therefore a head developing above the initial potentiometric head in the well must be signed negative (as is injection head which develops during injection testing).

In pumping and injecting into the Warina Sands, considerable pipe friction losses occur due to the great length of small diameter casing (398 m of 100 mm ID fibreglass reinforced plastic (FRP)). At a pumping rate of 12 L/s these pipe friction losses are ~1.96 m per 100 m of casing. This effect results in water levels observed at the surface (under pumping conditions) being less than the potentiometric pressures, which would be observed at the well/aquifer interface (under injecting conditions the reverse applies). In this report the uncorrected data has been reported and graphed. However, when data has been used for calculating aquifer transmissivity it is important to apply the correction, and this has been done where relevant. Temperature and density also affects the observed water levels, but to a lesser degree.

Table 1: Airlift-recovery test details

Test	Date	Depth of air injection line below TOC (m)	Airlift pressure (kPa)	Pumping rate (L/s)	Test duration (mins)	Maximum drawdown (m)	Time until recovery following cessation of airlifting (s)
1	27/3/2008	21	~689	9.5	240	13.0	~ 90
2	28/3/2008	51	~689	11.8	240	24.3	120
3	29/3/2008	81	~689	13.0	480	27.7	240

2.1 OBJECTIVES

The objectives of the airlift–recovery testing were to:

1. Gain a preliminary understanding of well hydraulic behaviour of observation well 7030-809 under pumping (including well loss and aquifer loss).
2. Characterise the Warina Sands by quantifying (as far as practical) the transmissivity.

2.2 PREPARATION FOR AIRLIFT–RECOVERY TESTING

2.2.1 CONSTRUCTION OF HOLDING DAMS

Two new dams were constructed to accommodate groundwater produced during airlifting. The smaller dam had dimensions 7 x 7 x 1.5 m while the larger dam had dimensions 35 x 35 x 2 m. The capacity of the large dam was based on the expected volume of water produced during airlifting, which was estimated at ~2.5 ML if airlift–recovery pumping rates of 10, 15 and 20 L/s were obtained for a duration of eight hours each. The smaller dam was lined with plastic to prevent seepage, and discharge occurred initially to this dam with subsequent storage of the groundwater in the larger dam.

The two dams were connected by a 150 mm ID PVC pipe fitted with a flow meter to record the pumping rates. This method was adopted due to the pulsating nature of the airlift driven pumping which did not lend itself well to the traditional method of measuring flow rate directly from the well.

The holding dams are shown in Figures 2 through 4.

Figure 2. Small dam

Figure 3. Large dam

Figure 4. 150 mm PVC pipe connecting the dams with attached flow meter

2.2.2 WELL HEADWORKS - INJECTION PIPEWORK

The artesian well headworks were modified to include a T-piece, a 50 mm steel air injection line connected to an air compressor, and an outlet pipe diverting water into the small dam. The depth of the air injection line was increased for each of the three stages, which allowed the increased pumping rates.

2.2.3 DATA RECORDING

Potentiometric pressure in the observation well was recorded using an automated downhole logging device attached ~1.5 m below the bottom of the air injection line (Figure 5). The logger recorded baseline potentiometric pressure prior to airlifting and during recovery following the cessation of airlifting. Due to the turbulence that occurred during airlifting, the logger was only turned on several minutes before cessation of airlifting. The downhole logger recorded pressure in the well at intervals of ten seconds. Figure 6 is a photo taken during airlifting.

Figure 5. Downhole logger attached to the air-exit pipe

Figure 6. Airlifting looking east

2.3 AIRLIFT–RECOVERY TEST 1

Airlift–recovery Test 1 residual drawdown data following the cessation of airlifting is plotted in Figures 7 and 8. The following general comments can be made:

1. During the airlifting an average pumping rate of 9.5 L/s was achieved.
2. Prior to turning off the air compressor a drawdown of ~13.0 m developed.
3. Once the compressor was switched off, recovery occurred within ~30 seconds, the head rebounded above the initial potentiometric head. This effect may be the result of a column of air being trapped in the well on shutting of the air injection line and discharge line simultaneously.
4. The head stabilised in 90 seconds.
5. During the 60 minutes of recovery observation, the head in the well remained slightly above the initial head (~0.65 m). The reason for this discrepancy is likely to be density and viscosity changes brought about by the change in the temperature of the water column. Prior to airlifting the water column in the well was in equilibrium with the surrounding formation with a temperature gradient reducing from 35°C (native groundwater temperature) at the well screen to ~20°C at the well-head. During airlifting the water in the well column was displaced with warmer water from the aquifer. At the conclusion of the test, the temperature of the water column in the well was consistent with that of the ambient groundwater. It should be noted that the hydraulic conductivity is a function of density and viscosity that are affected by temperature (and gravity).

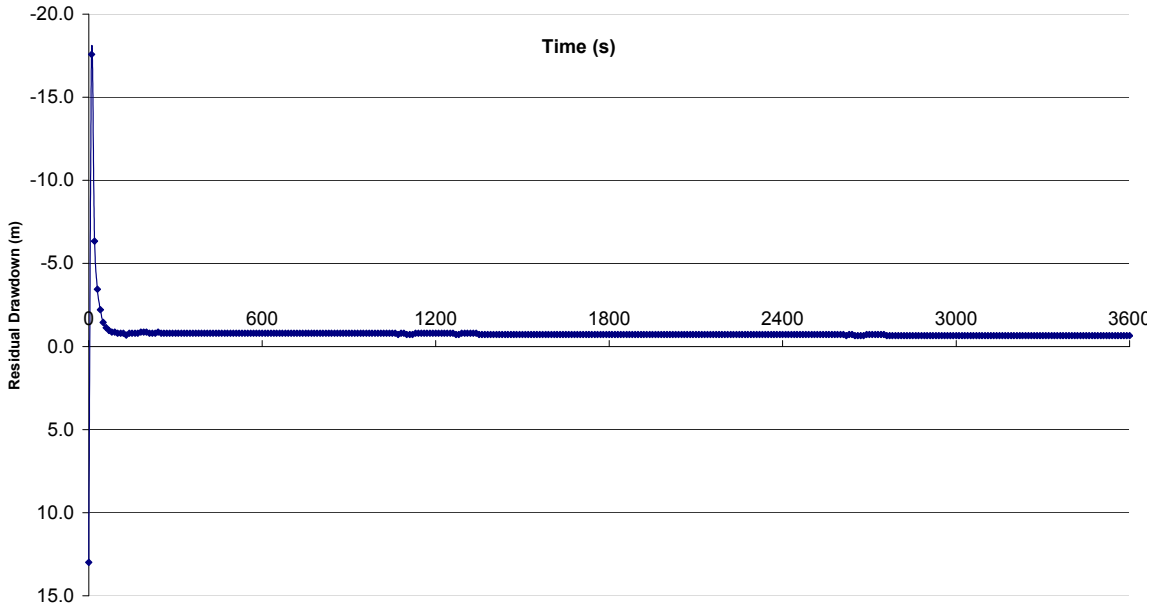

Figure 7. Residual drawdown during Test 1 (airlifting at 9.5 L/s)

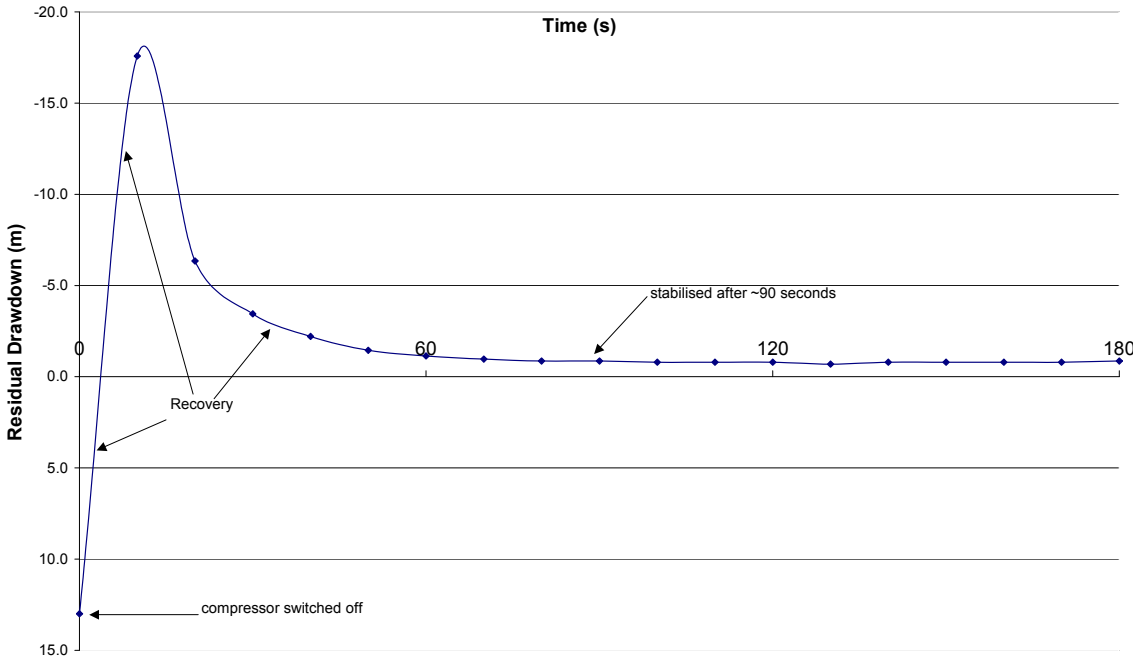

Figure 8. Residual drawdown during first 180 seconds of Test 1

2.4 AIRLIFT–RECOVERY TEST 2

Airlift–recovery Test 2 residual drawdown data following the cessation of airlifting is plotted in Figures 9 and 10. The following general comments can be made:

1. During the airlifting an average pumping rate of 11.8 L/s was achieved.
2. Prior to turning off the air compressor a drawdown of 24.5 m developed.
3. Once the air compressor was switched off, recovery occurred in ~15 seconds with the head rebounding above the initial potentiometric head, but to a lesser degree than in Test 1, possibly due to the greater submergence of the air injection line.
4. The head stabilised in 120 seconds.
5. During the 50 minutes of recovery observation, the head in the well remained slightly above the initial head (~0.5 m). As for Test 1, this is attributed to the temperature change in the water column in the well.

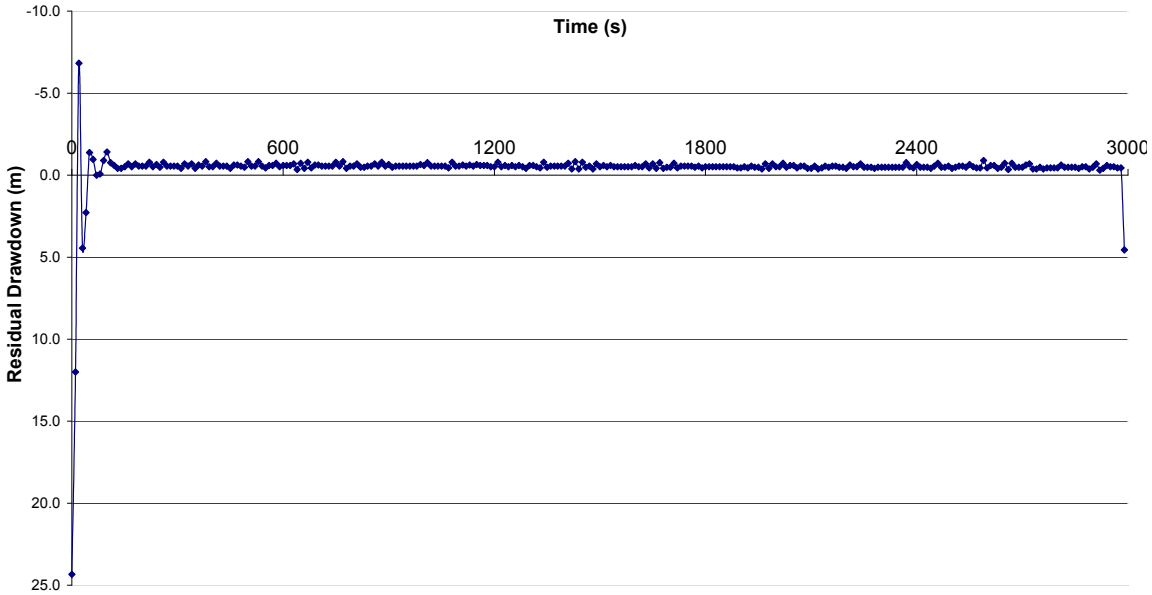

Figure 9. Residual drawdown during Test 2 (airlifting at 11.8 L/s)

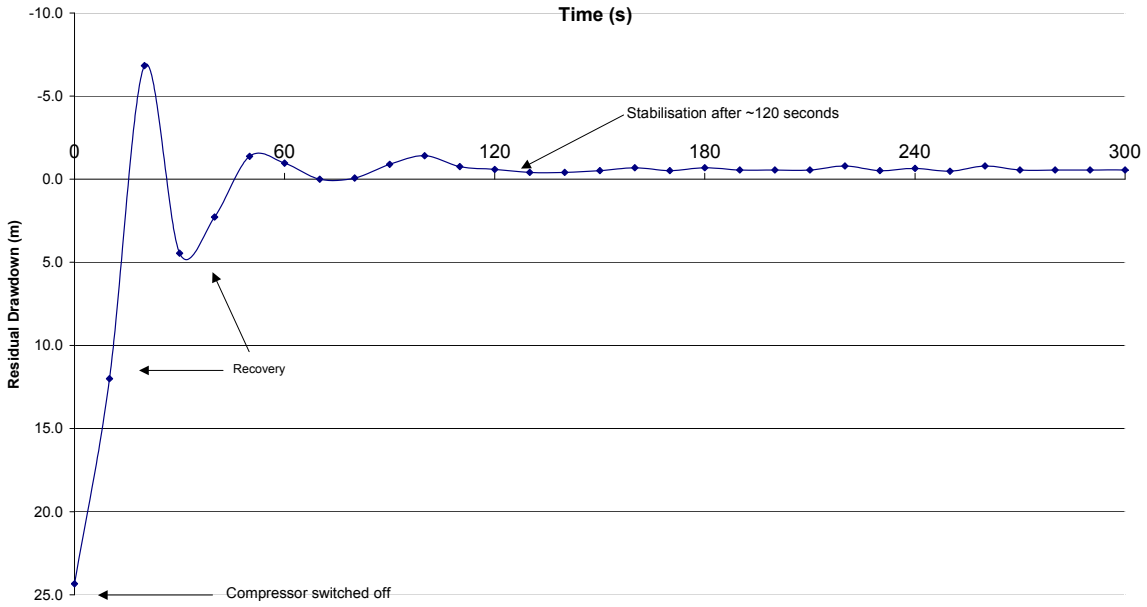

Figure 10. Residual drawdown during the first 300 seconds of Test 2

2.5 AIRLIFT–RECOVERY TEST 3

Airlift–recovery Test 3 residual drawdown data, following the cessation of airlifting is plotted in Figures 11 and 12. The following general comments can be made:

1. During the airlifting an average pumping rate of 13.0 L/s was achieved.
2. Prior to turning off the compressor a drawdown of 27.7 m developed.
3. Once the air compressor was switched off, recovery occurred within 70 seconds, with the head rebounding above the initial potentiometric head, but to a lesser degree than in Test 2. Similar to Test 2, this response is possibly due to the greater submergence of the air injection line.
4. The head stabilised in 240 seconds.
5. During the 60 minutes of recovery observation, the head in the well remained slightly above the initial head (0.01 m).

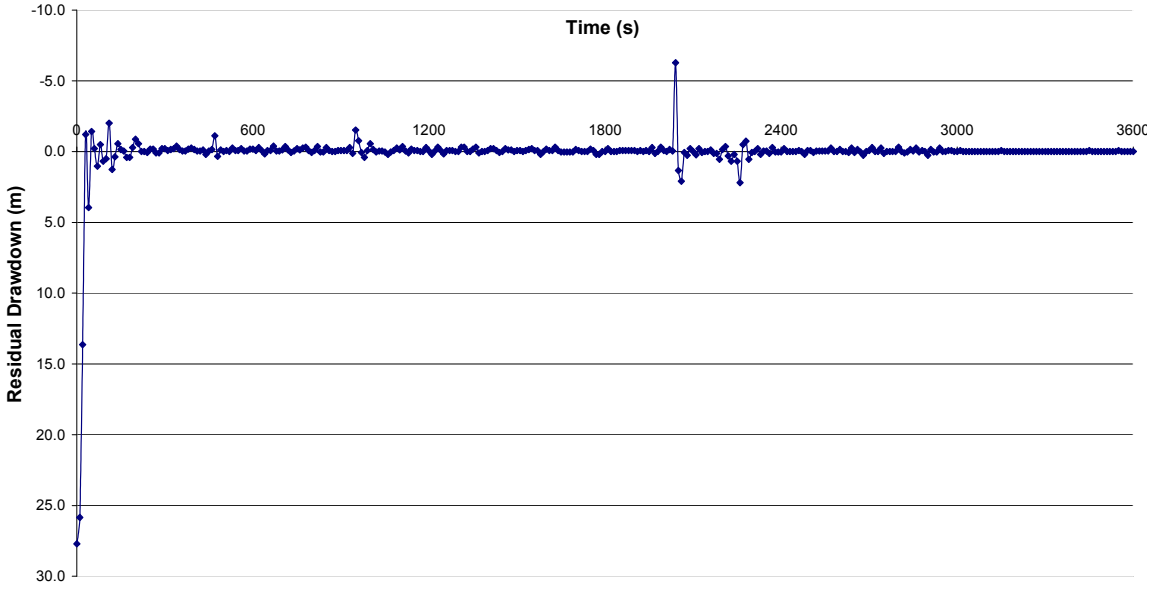

Figure 11. Residual drawdown during airlifting Test 3 (airlifting at 13.0 L/s)

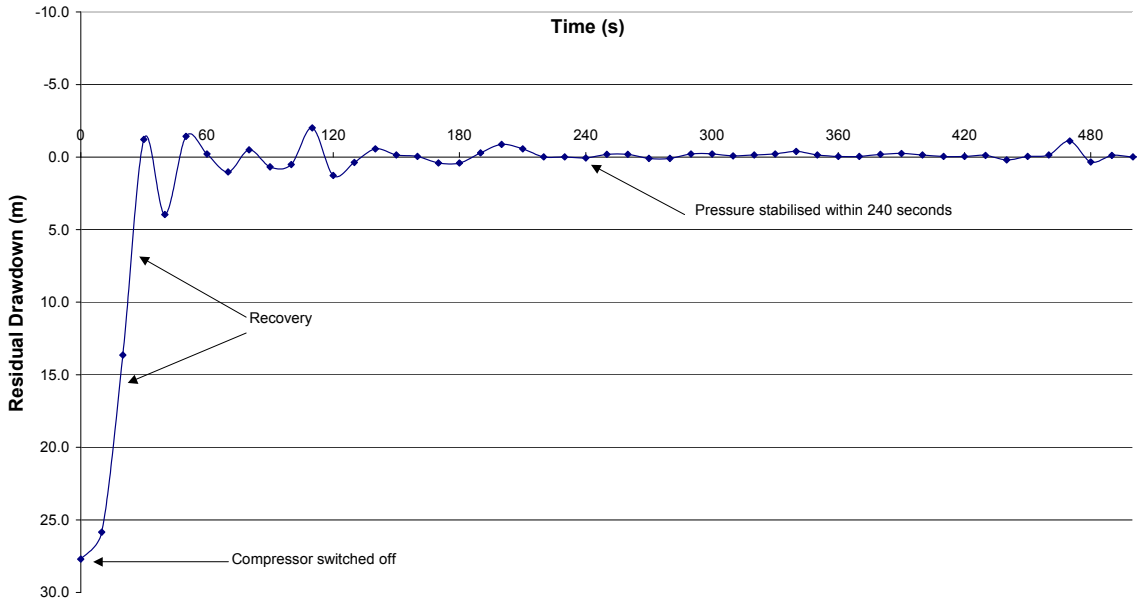

Figure 12. Residual drawdown during the first 480 seconds of Test 3

2.6 WELL AND AQUIFER HYDRAULICS

2.6.1 HYDRAULIC BEHAVIOUR OF OBSERVATION WELL UNDER PUMPING STRESS

The preliminary constant–rate airlift–recovery tests conducted on observation well 7030-809 indicate the hydraulic behaviour of the well under pumping stress. The following general comments can be made:

1. A maximum pumping rate of 13 L/s was achieved which resulted in the development of ~27 m of drawdown.
2. A specific capacity of 0.48 L/s per metre of drawdown is indicated at a pumping rate of 13 L/s.
3. Assuming a (conservative) specific capacity of 0.4 L/s per metre of drawdown, it is possible the well could be pumped at 50 L/s with the (indicative) development of ~125 m of drawdown.
4. A well equation could not be determined from the test data.

2.6.2 HYDRAULIC BEHAVIOUR OF AQUIFER UNDER PUMPING STRESS

The preliminary constant–rate airlift–recovery tests conducted on the observation well 7030-809 indicate the hydraulic behaviour of the aquifer system under pumping stress. The following general comments can be made:

1. Drawdown was not observed during testing and transmissivity cannot be calculated from drawdown data.
2. An estimation of the transmissivity can be obtained from the residual drawdown data using Logan's approximation for confined aquifers (an approximation derived from the Thiem equation):

   $T = 1.22\ Q / s$

   Where:

   T = transmissivity (m^2/d)

   Q = pumping rate (m^3/day)

   s = residual drawdown (m)

   Using the data from airlift–recovery Test 3, i.e. the pumping rate of 13 L/s (1,123 m^3/day) and a residual drawdown of 19.86 m (drawdown at the time the pumping ended, 27.7 m, corrected for pipe friction losses of 1.96 m per 100 m of FRP casing), a transmissivity of ~70 m^2/d can be calculated. Note that Test 3 was selected as it was conducted at the highest pumping rate and for the longest duration.

3. The transmissivity estimated here (~70 m^2/d) is considerably less than that reported in Magarey and Osei-Bonsu (2008) of 800 – 25,000 m^2/d based on hydraulic conductivity values determined from particle size analysis. It is believed that this range is grossly in error due to the sample collection method being biased towards the coarser grain size fraction.
4. No hydraulic boundaries presented during the tests.

3. INJECTION TESTING - WARINA SANDS TO WARINA SANDS

The following sections outline the objectives, methodology and results of the injection testing conducted on observation well 7030-809 using Warina Sands groundwater. Groundwater Technical Services (DWLBC) conducted all on site works.

Four separate constant rate injection tests (summarised in Table 2) were conducted on observation well 7030-809 at injection rates of 3, 6, 9 and 12 L/s. Testing commencing on 31 March 2008 using groundwater sourced from the Warina Sands to ensure chemical compatibility and minimise the potential for any clogging. The duration of each test was dictated by the time it took for the holding tanks to be emptied at the prescribed injection rate. Sufficient time was allowed for full recovery before the commencement of each test. Results from the injection tests are plotted as injection head vs. time in minutes. Data for the injection testing and associated recovery is provided in Appendix 2. Injection head is signed negative.

Table 2: Injection test details

Test	Date	Injection rate (L/s)	Test duration (mins)	Time until recovery following cessation of injection (mins)
1	31/3/2008	3	500	< 1
2	2/4/2008	6	299	< 1
3	4/4/2008	9	200	< 1
4	5/4/2008	12	158	< 1

3.1 OBJECTIVES

The objectives of the injection testing were to:

1. Gain a preliminary understanding of well hydraulic behaviour of observation well 7030-809 under injection using Warina Sands groundwater.
2. If practical, through the development of a well equation, determine the long–term injection capacity of the well and aquifer, and the well and aquifer loss.

3.2 PREPARATION FOR INJECTION TESTING

3.2.1 SITE INFRASTRUCTURE

Four 30,000 L holding tanks were transported to the work site. The four tanks were linked together by connecting to a central 100 mm PVC pipe which was connected to the headworks of observation well 7030-809 (Figures 13 and 14). Prior to each test the tanks were filled to capacity using the artesian flow of the Warina Sands. This water was then re-injected back into the aquifer. Air was bled from the injection line prior to injection.

3.2.2 DATA RECORDING

Potentiometric pressure in the observation well was recorded using an automated downhole logging device installed at a depth of 10 m. A separate pressure transducer was installed at the top of the headworks thus providing independent validation for the downhole logging device. These devices recorded baseline potentiometric pressure prior to, during, and post injection. The downhole logger recorded at one minute intervals, and the surface transducer was read every one minute for the first ten minutes, every two minutes for the next 20 minutes, and between five and ten minutes for the remainder of the tests.

Field parameters of the injectant including temperature and electrical conductivity (EC) were measured using an FL-90 multi-parameter instrument fitted to a flow-through cell.

Figure 13. Network of pipes connecting the holding tanks to the pump

Figure 14. Well headworks

3.3 INJECTION TEST 1

Injection Test 1 was conducted at an injection rate of 3 L/s and lasted a total of 500 minutes. Injection head data is plotted in Figure 15. The following general comments can be made:

1. At the commencement of injection, the injection head increased to -9.5 m, before rebounding and reducing to -1.8 m at ten minutes. This response may be due to a mechanical effect within the aquifer surrounding the screen.
2. Continued injection resulted in an injection head of ~-2.6 m developing at ~400 minutes which remained stable until the end of the test.
3. At the end of the test, recovery occurred within one minute resulting in a head 0.55 m below the initial potentiometric level. Similar to airlifting, these anomalies are attributed to density and viscosity variations brought about by the change in the temperature of the water column resulting from the temperature difference between the injectant and the native groundwater. The stored groundwater (~21°C) is 14°C cooler than that of the Warina Sands (35°C).

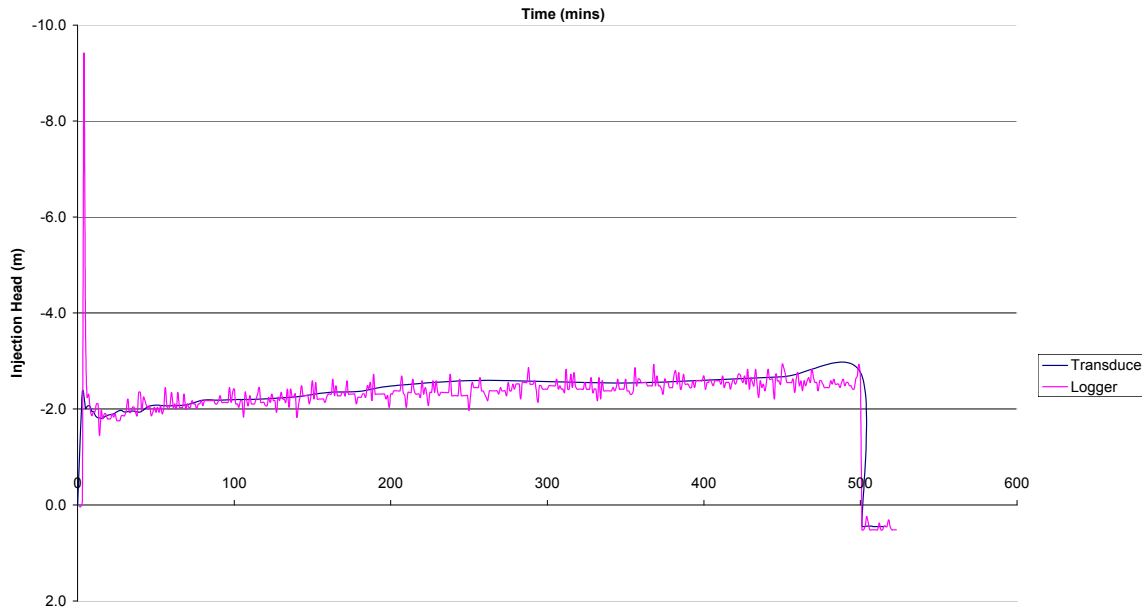

Figure 15. Injection head during Test 1 (injecting at 3 L/s)

3.4 INJECTION TEST 2

Injection Test 2 was conducted at a rate of 6 L/s and lasted a total of 299 minutes. Injection head data is plotted in Figure 16. The following general comments can be made:

1. The injection head increased to –5.76 m at ten minutes, and then increased to –5.79 m by the end of the test.
2. The temperature range of the injectant was recorded 28.8 - 31.1°C.
3. At the end of the test recovery occurred within one minute. After 60 minutes the potentiometric level was 0.03 m below the initial level.

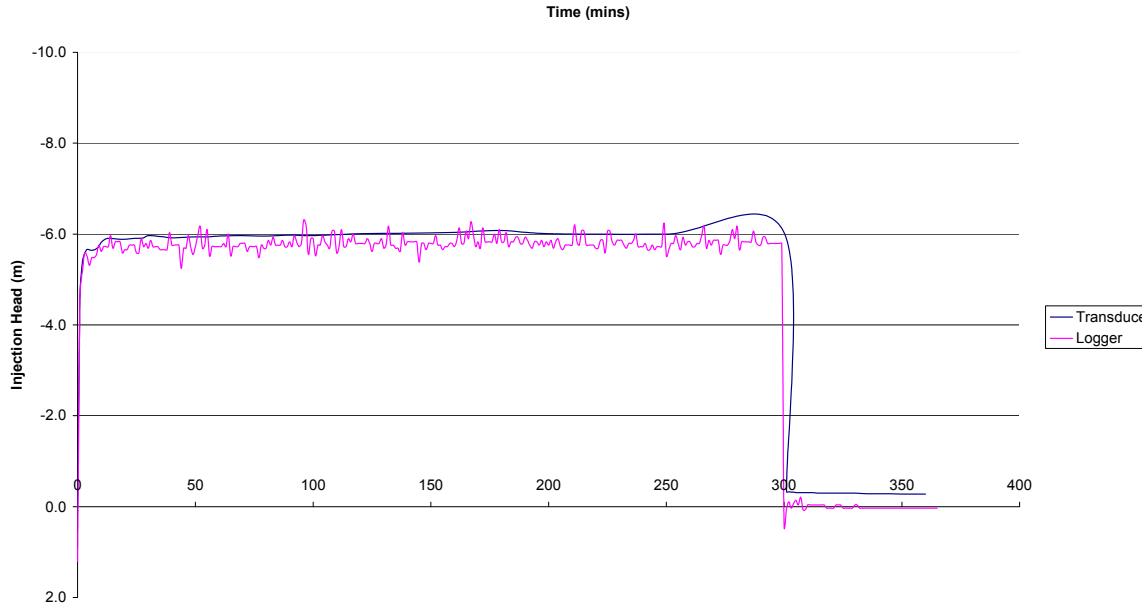

Figure 16. Injection head during Test 2 (injecting at 6 L/s)

3.5 INJECTION TEST 3

Injection Test 3 was conducted at a rate of 9 L/s and lasted for 200 minutes. Injection head data is plotted in Figure 17. The following general comments can be made:

1. The injection head increased to -10.03 m at ten minutes and then increased to -10.34 m by the end of the test.
2. The temperature of the injectant was recorded 29.3 - 31.1°C.
3. At the end of the test recovery occurred within one minute. After 60 minutes the potentiometric level was 0.03 m above the initial level.

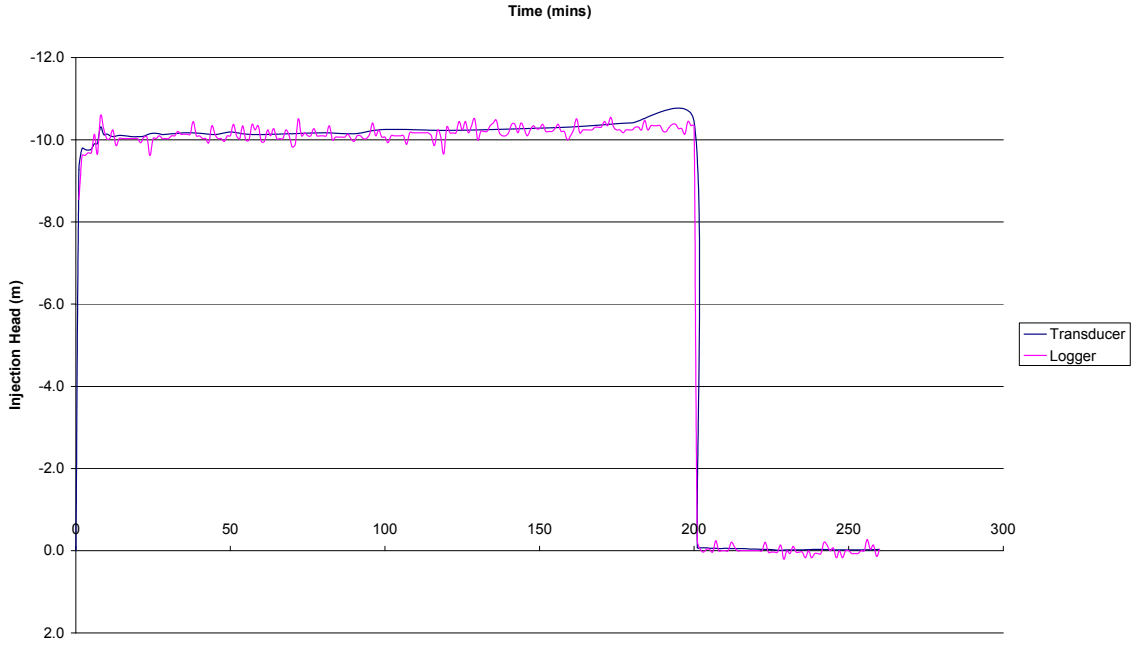

Figure 17. Injection head during Test 3 (injecting at 9 L/s)

3.6 INJECTION TEST 4

Injection Test 4 was conducted at a rate of 12 L/s and lasted a total of 154 minutes. Injection head data is plotted in Figure 18. The following general comments can be made:

1. The injection head increased to -15.55 m at ten minutes and then increased to -15.62 m at 64 minutes. The injection head fluctuated for the remainder of the test, and after 154 minutes was observed at -15.41 m.
2. The temperature of the injectant was not recorded due to a malfunction in the water quality instrument.
3. At the end of the test recovery occurred within one minute. After 28 minutes of recovery the potentiometric level was 0.21 m below the pre injection level.

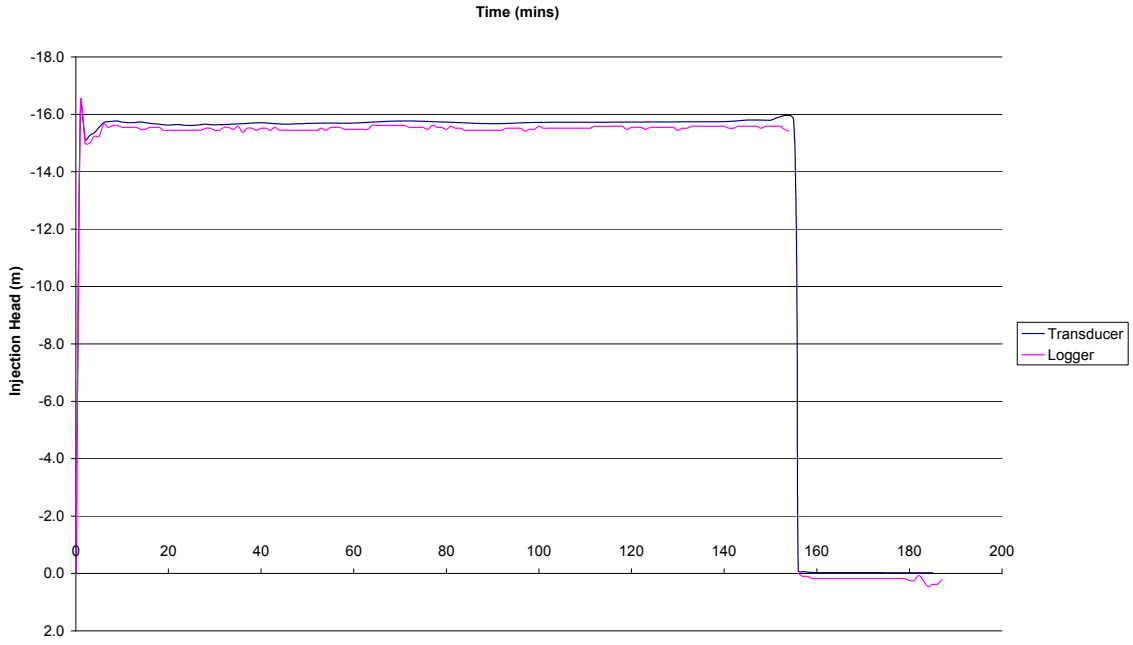

Figure 18. Injection head during Test 4 (injecting at 12 L/s)

3.7 WELL AND AQUIFER HYDRAULICS

3.7.1 HYDRAULIC BEHAVIOUR OF OBSERVATION WELL UNDER INJECTION STRESS

The preliminary constant–rate injection tests conducted on the observation well 7030-809 indicate the hydraulic behaviour of the well under injection stress. The following general comments can be made:

1. A maximum injection rate of 12 L/s was achieved which resulted in the development of ~-15.5 m of injection head.
2. A well equation for injection cannot be determined from the test data.
3. A specific capacity of 0.77 L/s per metre of injection head is indicated at an injection rate of 12 L/s. This is greater than the figure of 0.48 L/s per metre of drawdown that was indicated from airlift pumping Test 3, which was conducted at 13 L/s. This anomaly is due to density and temperature effects.
4. Assuming a specific capacity of 0.77 L/s per metre of injection head, in theory the well could be injected at 70 L/s with the (indicative) development of ~-100 m. However, reference to Figure 19, which is based on very limited data, indicates potential exponential growth in injection head with increasing injection rate. The figure indicates that an injection rate of 30 L/s may result in the development of up to -100 m of injection head. This apparent exponential growth is believed to be a result of the increasing pipe friction losses caused by the restrictive diameter of the casing (100 mm). This effect will be considerably less with a production well constructed with a 200 mm ID casing. Calculations by Mr Don Armstrong indicate that for a 200 mm ID casing, and injection rate of 50 L/s, an injection head of –50 m would develop.
5. While there is a slow development of injection head during the tests, there is no evidence of an increasing rate of injection head development in any individual test, thus indicating that no clogging occurred during the period of the tests.

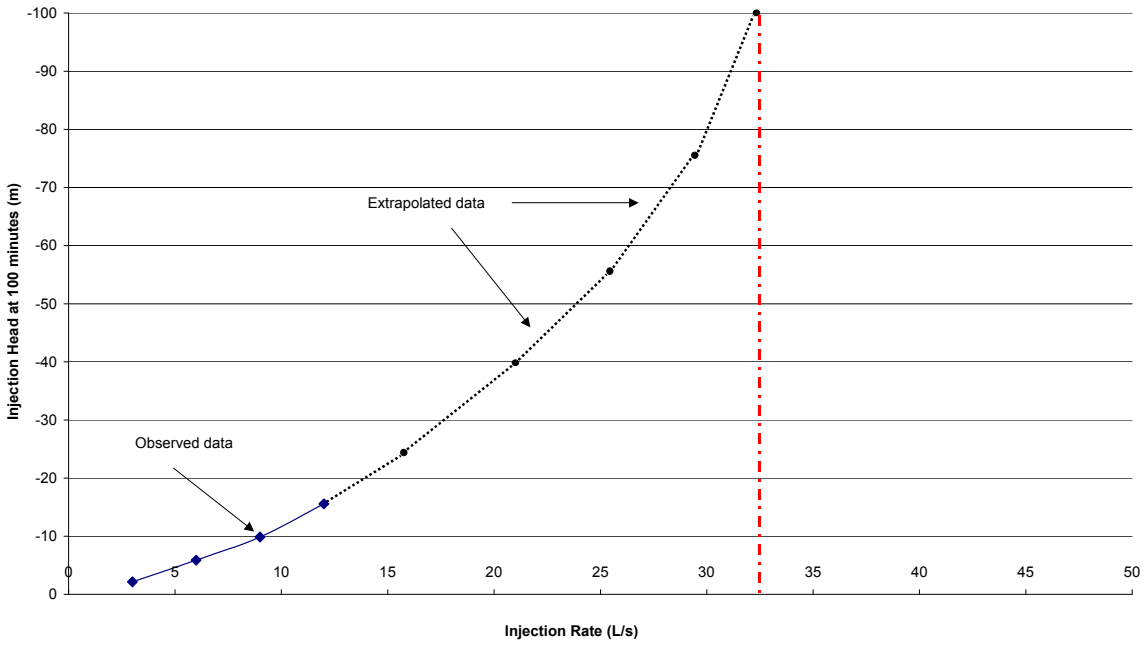

Figure 19. Injection head at 100 minutes vs. injection rate at 3, 6, 9 and 12 L/s. Extrapolation of the data gives an indication of possible head build up at higher injection rates

3.7.2 HYDRAULIC BEHAVIOUR OF AQUIFER UNDER INJECTION STRESS

The preliminary constant–rate injection tests conducted on the observation well 7030-809 indicate the hydraulic behaviour of the aquifer system under injection stress. The following general comments can be made:

1. While a transmissivity value can be determined from the injection head data, by applying Logan's approximation in a similar manner to the airlift–recovery testing, the results indicate values ~1.4 times higher than that observed under pumping conditions. This is due to the 'resistive' effects of injection resulting from the temperature difference between the injectant and the native groundwater. Theoretically, the most reliable results will be obtained when flow is out of the aquifer at the ambient aquifer temperature in which case the density and viscosity effects are not operating. Forcing cooler water into a warm aquifer is the least favourable scenario.
2. A well equation could not be developed for injection.
3. No hydraulic boundaries presented during the period of the tests.
4. Recovery occurred within one minute. This behaviour is commensurate with that of a very leaky aquifer system in which almost instantaneous injection head build–up develops, which is then followed by very little change. This is likely to be reflective of the ~50 m thick section of aquifer (in which the 30 m long well screen is set) being in hydraulic communication with the very much thicker Renmark Group (~200 m).

4. GROUNDWATER SAMPLING

4.1 OBJECTIVES

Sampling was undertaken to determine the level of suspended solids and turbidity of the Monoman Formation groundwater to aid in filter selection for the Monoman Sands to Warina Sands Injection Test, and to gain a greater understanding of the physical attributes of the injectant. Previous sampling indicates that suspended solids and turbidity in Monoman Formation groundwater is variable across the Floodplain with ranges 6 – 76 mg/L, and 2.3 – 140 NTU respectively. The results from previous sampling are given in Table 3.

Table 3: Suspended solids and turbidity results from wells completed in the Monoman Formation across the Chowilla floodplain

Location	Unit Number	Date	Screen Interval (m)	Total suspended solids (mg/L)	Turbidity (NTU)
Werta Wert	7030-759	11/04/2007	10-12	30	41
Werta Wert	7030-765	11/04/2007	8.5-10.5	15	27
Werta Wert	7030-756	11/04/2007	4.5-6.5	36	140
Werta Wert	7030-712	11/04/2007	15.07-17.07	16	10
Gum Flat	7030-577	03/05/2005	10-14	73	na
Coppermine	7030-695	03/05/2005	5.76-8.76	55	na
Tareena	7130-56	03/05/2005	3.10-6.10	56	na
Tareena	7130-33	06/06/2003	12-18	25	12
Tareena	7130-33	18/12/2002	12-18	16	16
Tareena	7130-33	12/12/2002	12-18	13	16
Gum Flat	7030-577	06/12/2002	10-14	6	7.2
Gum Flat	7030-577	28/11/2002	10-14	24	26
Gum Flat	7030-577	21/11/2002	10-14	33	19
Gum Flat	7030-577	14/11/2002	10-14	76	21
Gum Flat	7030-577	08/11/2002	10-14	10	2.3

It was recognised that some previous samples were collected from observation wells. Subsequently, questions were raised as to the reliability of these samples to give a true indication of the suspended solids of the groundwater. Current sampling was undertaken to determine whether lower values could be obtained from a screened (wirewound) production well (7030-710) completed in the Monoman Formation, and pumped over a 48-hour period. Sampling of the Warina Sands observation well 7030-809 was also undertaken.

4.2 SAMPLING METHODOLOGY

Sampling of observation well 7030-809 occurred on 23/4/2008 from 10:00 until 20:30 (total pumping time 10.5 hours). Prior to sampling, field parameters were measured using a YSI (Yellow Springs Instruments) multi-parameter instrument calibrated to known standards. The flow rate was held constant at 8 L/s, and four sets of samples were collected at 14:30, 16:30, 18:30 and 20:30. Samples were submitted to Australian Water Quality Centre (AWQC) for analysis of total suspended solids, turbidity, major ions and nutrients. A further three 15 L samples were collected at 15:20, 17:00 and 19:30 and submitted to CSIRO for particle size distribution (PSD) and membrane filtration index (MFI).

Sampling of production well 7030-710 occurred from 11:00 24/4/2008 to 08:00 26/4/2008 (total pumping time 45 hours). Field parameters including temperature, specific conductance, pH, dissolved oxygen (DO) and oxidation-reduction potential (ORP) were measured with a YSI-multi parameter instrument and a FL-90 flow through cell. Pumping was held constant at rate of ~10 L/s. Ten sets of samples were collected at 1, 3, 6, 10, 15, 20, 30, 35, 40 and 45 hrs. Samples were submitted to AWQC for major ions, suspended solids, volatile suspended solids, turbidity, iron bacteria, nutrients, phosphorus, soluble iron, soluble manganese, and dissolved organic carbon. A further six 15 L samples were collected at 1, 3, 10, 20, 35 and 45 hours and submitted to CSIRO for PSD and MFI.

NB: MFI is another index of physical clogging potential that better accounts for the effect of particle size and composition. MFI is a laboratory-based measure of the potential for physical clogging of a 0.45 μm membrane filter (Dillon et al., 2001). The greater the retention of particles on the filter, the greater the MFI value (reported in units of s/L^2) and hence also the rate of physical clogging. Note that chemically and biologically derived forms of clogging are not accounted for due to the nature and brevity of the test procedure (Pavelic et al, 2007).

4.3 RESULTS

Groundwater quality data from the sampling is given in Table 4 while the raw data provided by AWQC is given in Appendix 3. The following general comments can be made:

1. Monoman Formation groundwater
    a. Total suspended solids ranges 8 - 18 mg/L (average of 10.6 mg/L).
    b. Temperature 20.70 - 21.35 °C.
2. Warina Sands groundwater
    a. Total suspended solids ranges 5 - 13 mg/L (average of 8.6 mg/L).
    b. Temperature 34.44 - 34.60 °C.

PSD and MFI results are given in Table 5. Graphs showing the PSD are also given in Appendix 4.

The following general comments can be made:

1. MFI from the Monoman Formation groundwater ranged 1.2 - 2.3 s/L^2.

2. The PSD of the Monoman Formation groundwater was variable. Samples collected within the first ten hours of pumping show a medium to high proportion of particles in the range of 1–10 microns (27 – 71% of total load). However, samples collected in the latter part of pumping (the final 25 hours) recorded a PSD with a particle size generally in the range 100 – 800 microns (82.84%, 71.11% and 71.55% of total load at 20, 35 and 45 hours respectively).
3. MFI for the Warina Sands groundwater was ranged 1.8 – 3.4 s/L^2.
4. The PSD_{50} (the median) of for the Warina Sands groundwater was recorded between 284 and 395 microns.

Aquifer	WS	WS	WS	WS	MF	MF	MF	MF	MF	MF	MF	MF	MF	MF
Sample # /Description	Sample 1	Sample 2	Sample 3	Sample 4	1 hr	3 hrs	6 hrs	10 hrs	15 hrs	20 hrs	30 hrs	35 hrs	40 hrs	45 hrs
Unit number	7030-809	7030-809	7030-809	7030-809	7030-710	7030-710	7030-710	7030-710	7030-710	7030-710	7030-710	7030-710	7030-710	7030-710
Date sampled	23/04/2008	23/04/2008	23/04/2008	23/04/2008	24/04/2008	24/04/2008	24/04/2008	24/04/2008	25/04/2008	25/04/2008	25/04/2008	26/04/2008	26/04/2008	26/04/2008
Field Parameters														
Time	14:30	16:30	18:30	20:30	12:10	14:30	17:20	21:20	2:20	7:20	17:20	22:20	3:20	8:20
Temp (deg C)	35.60	35.44	35.43	35.44	21.35	20.76								
pH	6.82	6.85	6.87	6.88		6.28								
DO (mg/L)	0.05	0.02	0.03	0.03	0.11	0.11								
ORP (mV)	-241	-277.8	-284.6	-288.6	-9.9	-37								
TDS (g/L)	21.84	21.8	21.81	21.79	33.81	33.81								
Specific conductance (uSiemens/cm)	33,590	33,507	33,589	33,510	52,009	52,017								
Laboratory Analysis														
Turbidity (NTU)	0.84	0.61	0.77	0.66	6.6	6.3	7.6	9.1	5.5	6	6.7	7.1	5.4	5.3
Suspended Solids (mg/L)	5	13	12	5	10	9	17	9	7	9	9	18	8	10
Volatile suspended solids (mg/L)					2	2	3	2	2	2	2	2	2	3
Iron bacteria (microscopic)	not detected	not detected	not detected	not detected	not detected	not detected	not detected	not detected	not detected	not detected	not detected	not detected	not detected	not detected
Iron bacteria (heterotrophic /mL)	300	200	80	120	< 10	< 10	< 10	< 10	< 10	< 10	<10	<10	<10	< 10
Alkalinity as CaCO3 (mg/L)	353	356	352	354	246	246	246	246	246	246	246	246	246	246
Bicarbonate (mg/L)	431	434	430	432	300	300	300	300	300	300	300	301	300	300
Carbonate (mg/L)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydroxide (mg/L)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium (mg/L)	558	542	536	532	589	594	589	590	581	589	578	585	575	586
Magnesium (mg/L)	611	593	588	584	1380	1390	1380	1380	1370	1390	1360	1370	1350	1370
Potassium (mg/L)	83.4	83	76.3	75.8	161	162	161	161	159	161	159	161	158	160
Sodium (mg/L)	6830	6800	6690	6770	11400	11300	11500	11200	11400	11400	11300	11200	11300	11100
Chloride (mg/L)	11,300	11300	11400	11300	18900	17700	17200	17400	18100	18100	17000	18400	17700	18400
Fluoride (mg/L)	0	0.18	0.18	0.18	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Sulphate (mg/L)	2,220	2150	2130	2110	6270	6330	6240	6300	6210	6270	6180	6210	6090	6240
Iron (mg/L)	0.067	0.079	0.042	0.044	1.727	1.756	1.79	1.811	1.853	1.849	1.859	1.812	1.875	1.9
Iron (soluble)	0.064	0.076	0.042	0.041	1.688	1.719	1.734	1.73	1.816	1.777	1.776	1.789	1.851	1.862
Manganese (mg/L)	0.695	0.701	0.711	0.707	0.026	0.027	0.028	0.029	0.03	0.031	0.032	0.032	0.034	0.034
Manganese - soluble (mg/L)	0.686	0.674	0.709	0.674	0.026	0.028	0.028	0.029	0.03	0.031	0.032	0.033	0.033	0.034
Phosphorus (mg/L)					0.059	0.062	0.059	0.064	0.062	0.067	0.058	0.062	0.055	0.066
Phosphorus - Filterable reactive as P					0.05	0.05	0.042	0.045	0.053	0.054	0.044	0.048	0.066	0.053
Nitrogen - Total					0.22	0.24	0.22	0.3	0.22	0.22	0.22	0.22	0.22	0.22
TKN as N (mg/L)					0.18	0.24	0.2	0.29	0.19	0.16	0.22	0.19	0.16	0.15
Ammonia as N (mg/L)					0.224	0.217	0.222	0.229	0.219	0.218	0.222	0.221	0.218	
Nitrate + Nitrite as N (mg/L)	< 0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
DOC (mg/L)	2	2	1.9	1.9	0.9	0.8	0.8	0.8	0.8	0.7	0.8	0.8	0.9	0.8

Table 4: Groundwater quality results from the Warina Sands and Monoman Formation

Table 5: Groundwater MFI and PSD results from the Warina Sands and Monoman Formation

Identifier	Test Date	Test No.	MFI (s/L^2)	Turbidity (NTU)	PSD_{10} (um)	PSD_{50} (um)	PSD_{90} (um)
Mon 1	16/06/08	Test 1	2.3[a]	12.3	1.29	8.57	175.28
Mon 2	16/06/08	Test 1	1.4[a]	10.2	1.15	112.53	181.25
Mon 3	16/06/08	Test 1	N/A	15.2	0.79	4.5	11.07
Mon 4	16/06/08	Test 1	N/A	15	9.18	280.34	433.63
Mon 5	13/06/2008	Test 1	1.2[a]	15.2	3.09	235.45	441.22
Mon 6	13/06/2008	Test 1	2.1[a]	10.0	3.84	329.58	536.03
War 1	12/06/2008	Test 1	1.8[a]	0.78	189.35	290.45	501.5
War 2	12/06/2008	Test 1	N/A	1.1	163.20	284.64	565.45
War 3	12/06/2008	Test 1	3.4	1.43	123.70	395.1	674.58
	12/06/2008	Test 2	3.3[b]	1.25			

Mon refers to Monoman Formation groundwater samples

War refers to Warina Sands groundwater samples

4.4 DISCUSSION

The MFI and PSD results clearly indicate there is a small amount of suspended material present in groundwater pumped from the Monoman Formation production well. The level of suspended solids is close to or below an acceptable limit of 10 mg/L for aquifer storage and recovery (ASR) related activity (Pavelic et al, 2007).

MFI values of 66.1 – 208.9 s/L^2 were observed in wells completed in the Monoman Formation at Gum Flat in 2005. These values far exceeded the 5 s/L^2 considered acceptable for injection into fine textured sand dunes (Pavelic et al, 2007). The current results of 1.2 – 2.3 s/L^2 are more conducive for injection into the Warina Sands.

The PSD of the Monoman Formation groundwater is generally in the range 100 – 800 microns at longer pumping times. Strata samples collected from the Warina Sands resulted in sieve analysis range of 0.08 (800 microns) – 3 mm. Some caution should be applied to this interpretation as the strata samples were collected post shale shaker and may be low in the fine component.

Regardless of filtration techniques very fine material (<50 micron) will enter the aquifer through the screen, which may lead to physical clogging, and this will need to be removed by backflushing.

Other potential clogging mechanisms include physical clogging from iron precipitation if the injectant is exposed to air (although this can be removed by filtration), and biological clogging by iron bacteria have not been considered as part of this study. These forms of clogging were considered as part of the clogging assessment conducted in 2007, which forms part of the Phase II Feasibility Study undertaken by DWLBC (Magarey and Osei-Bonsu, 2008).

5. INJECTION TESTING – MONOMAN FORMATION TO WARINA SANDS

The following sections outline the objectives, methodology and results of the injection test conducted on observation well 7030-809 using Monoman Formation groundwater. Groundwater Technical Services (DWLBC) conducted all on site works.

A single constant rate injection test was conducted on observation well 7030-809 at an injection rate of 6 L/s for a duration of ten days. Testing commenced on 20 June 2008 (concluded 30 June 2008) using groundwater pumped from Monoman Formation production well 7030-710 located at a distance of 1.4 km. For the first seven days the injection rate was held constant at 6 L/s, before increasing to 12 L/s for the final three days. This testing was conducted to determine the hydraulic response of the well and aquifer to the physical and chemical properties of the operational water (which represents a simulation of a Phase III injection trial). Results from the injection test are plotted as injection head vs. time in minutes. Data for the injection test and associated recovery is provided in Appendix 5. Injection head is signed negative.

5.1 OBJECTIVES

The objectives of the injection testing were to:

1. Gain a preliminary understanding of well hydraulic behaviour of observation well 7030-809 under injection using Monoman Formation groundwater.

5.2 PREPARATION FOR INJECTION TESTING

5.2.1 FILTRATION

Prior to the test, an inline filter was purchased to assist in the removal of remnant suspended solids pumped from the Monoman Formation. The filter included interchangeable cartridges with apertures of 50, 100 and 200 microns. The filter was installed at the southern (pumping) end of the line, and was programmed to backflush every eight hours or to flush automatically if excessive pressure built up by blocking with particulate matter. Air was bled from the injection line prior to injection.

5.2.2 DATA RECORDING

Potentiometric pressure in the observation well was recorded using an automated downhole logging device installed at a depth of 6.4 m. A separate pressure transducer was installed at the top of the headworks thus providing independent validation for the downhole logging device. These devices recorded baseline potentiometric pressure prior to, during, and post injection. The downhole logger recorded at one minute intervals, and the surface transducer was read every one minute for the first ten minutes, every two minutes for the next 20 minutes, and between 5 and 30 minutes for the remainder of the test.

5.3 INJECTION TEST

The long–term injection test was conducted at an injection rate of 6 L/s for the first seven days, then increased to 12 L/s for the final three days – total duration 14,402 minutes. Injection head data is plotted in Figure 20. The following general comments can be made:

1. The initial injection head spiked during the first ten minutes before falling below the pre–injection potentiometric level and stabilising at ~1,000 minutes. These anomalies are attributed to density and viscosity variations brought about by the change in the temperature of the water column resulting from the temperature difference between the injectant and the native groundwater. The Monoman Formation groundwater (~21°C) is 14°C cooler than that of the Warina Sands (35°C).
2. The temperature of the injectant was not recorded during the testing, however temperature recorded during chemistry sampling was 20.6 – 21.35°C. These temperatures are considered equivalent with those encountered during the testing.
3. At 1,400 minutes the injection head reduced, coinciding with the blocking of the 50 micron filter cartridge, which was then replaced with a 100 micron cartridge. Inspection of the cartridge revealed the fine particles had been wedged in the openings, as the automatic backflushing device did not produce sufficient pressure to remove the particulates.
4. The injection head continued to remain below the pre–injection potentiometric levels until ~4,000 minutes. It appears that temperature of the injectant had a greater influence on injection head during the first 3,500 minutes than the injection process itself.
5. From 4,000 to 10,096 minutes the injection head fluctuated around 0 m.
6. At 10,096 minutes the injection rate was increased (incrementally) from 6 L/s to 12 L/s. For each 1 L/s increase, the injection head increased by ~-1.8 m, increasing rapidly to ~-10.5 m. This is 5 m less than the 15.5 m of injection head that developed during the Warina Sands to Warina Sands Injection Test at the same injection rate. The reason for the discrepancy is due to temperature effects caused by the injection of cooler Monoman Formation groundwater.
7. At 10,440 minutes the injection head reduced, coinciding with the blocking of the 100 micron filter cartridge, and a reduced injection rate. The 100 micron cartridge was then replaced with a 200 micron cartridge.
8. During the final 4,000 minutes of the test the injection head continued to develop, increasing to -11.44 m at 14,402 minutes. The injection head increased by -1.03 m during this period and maintained a constant rate of increase over the final 3,000 minutes of ~-0.21 m/d.
9. Steady state was not reached.
10. Recovery in the well was not recorded at test completion.

5.4 WELL AND AQUIFER HYDRAULICS

The long–term constant–rate injection test conducted on the observation well 7030-809 indicates the hydraulic behaviour of the well under injection stress. The following comment can be made in addition to those from the Warina Sands to Warina Sands Injection Test:

1. Once the injection rate is increased to 12 L/s there is a slow development of injection head. When the data is plotted on log–linear commencing at time zero there is evidence of increasing rate, however, this cannot be attributed to well clogging and may simply be an aquifer response. The test did not continue for a sufficiently long duration at the higher rate for any clear departure from the simple leaky aquifer system response to become evident. The small head rise could also be analogous to the delayed yield response, which can occur when coarse and fine sands are interbedded or when water stored in the aquitards begins to be released into the aquifer in a pumped–well situation. In the case of injection, the response could be to increasing resistance to flow into the aquitards located above, below (and within) the target aquifer. There is also the possibility that the increase in head is another temperature driven response, as the aquifer in the vicinity of the injection well is filling with cooler water.

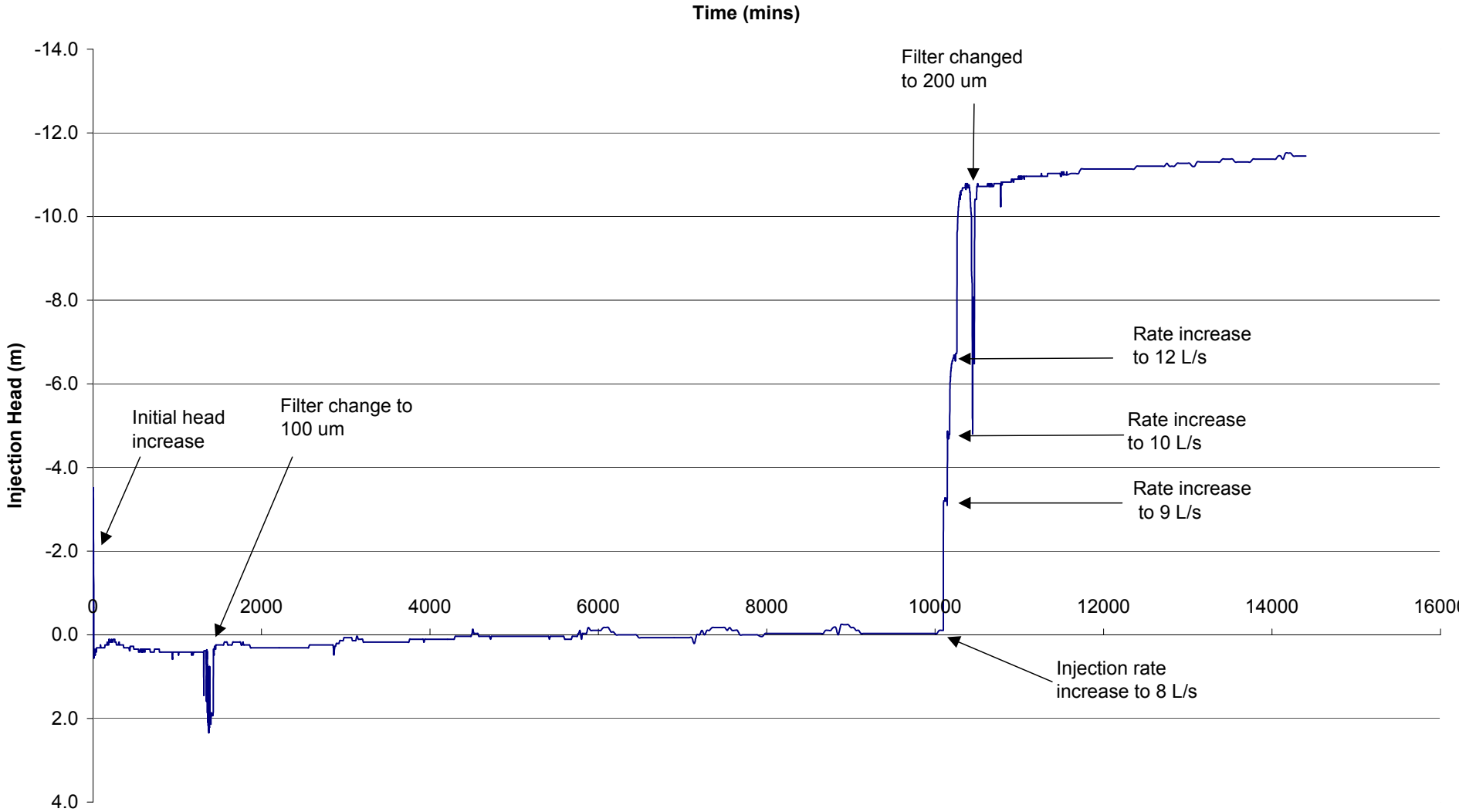

Figure 20. Injection head during Monoman Sands to Warina Sands Injection Test

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

The results from the various stages of airlift–recovery testing, injection testing and groundwater sampling have resulted in a greater understanding of the potential for deep aquifer disposal of Monoman Formation groundwater into the Warina Sands, within the limitations placed on the project by the diameter of the observation well and the testing methods applied. The results indicate that deep aquifer disposal of saline groundwater in the Chowilla region is technically feasible. Conclusions that can be drawn from the current investigations include:

1. The Warina Sands has the potential to receive Monoman Formation groundwater at favourable rates.
2. The injection head that will develop in a large diameter 200 mm ID injection well will be considerably less than was developed in the 100 mm ID observation well for a given injection rate.
3. In order to maintain any particular injection rate, a steady state situation must ideally be reached. Assuming a leaky aquifer system, the testing conducted did not extend for a sufficiently long duration for steady state conditions to develop in the Monoman Formation to Warina Sands injection test. If the aquifer system is confined, then there will be a small (and reducing) additional increment of additional injection head developed with each log cycle of time according to the Theis curve solution.
4. The physical and chemical characteristics of the Monoman Formation groundwater are suitable for injection, provided filtration is used. A 50 micron filter will be consistent with the particle size distribution of the Monoman Formation groundwater.

6.2 RECOMMENDATIONS

Given the limitations resulting from the casing diameter of the existing well, it is recommended that a Phase III injection trial utilising a large diameter injection well be undertaken. The following recommendations highlight the major issues that should be considered as part of a Stage III injection trial:

1. Drill and construct a Warina Sands injection (production) well at the study site and adequately develop it.
    a. The specifications for this well must be carefully considered prior to construction but should include a minimum casing diameter of 200 mm ID, which will have a significant effect on reducing pipe friction losses.
    b. Careful selection of the drilling method and construction materials may assist with reducing the potential for clogging (Segalen et al., 2005). Remediation methods need to be determined prior to drilling and may include backflush pumping, jetting and surging with a drilling rig in the event of severe clogging. A pumping chamber will need to be incorporated into the design to a depth of ~100 m to accommodate a high capacity pump to be used during backflushing.

c. The production well should be drilled to the casing point, set the casing and grout it, and then drill and core the production zone with reverse circulation drilling or cable tool drilling to allow accurate strata sample collection and particle size determination of the Warina Sands. Ideally the production zone should be drilled without the use of drilling fluids, the practicality of this would need to be further considered in view of the artesian nature of the aquifer, which would flow in excess of 10 L/s.
d. The disposal of groundwater will need to be considered during the drilling, development and pumping tests. It is possible that the excess from the holding dam could be redirected to Monoman Formation disposal well(s) or perhaps the Warina Sands observation well if it were filtered, although the rate required for disposal may be a problem.

2. Conduct a pumping test on the Warina Sands injection well, using observation well 7030-809 as an observation well, to quantify well hydraulics and aquifer and aquitard hydraulic parameters.

    a. The positioning of the injection well in relation to the existing observation well must be carefully considered to ensure the maximum amount of useful data can be collected. From the hydraulic perspective the observation well should be located at a distance of 1.5 times the aquifer thickness in order to overcome complications resulting from partial penetration of the aquifer (resulting in a separation of 75 m – based on an aquifer thickness of 50 m).
    b. Consideration should also be given to the position of the injection well with regards to monitoring of physio–chemical parameters as a result of breakthrough of injectant in the Warina Sands. This will give an indication of any chemical changes that may be occurring as a result of mixing Monoman Formation and Warina Sands groundwater.

3. Drill and construct multiple feeder production wells completed in the Monoman Formation.
    a. The feeder production wells will be used to pump Monoman Formation groundwater into the Warina Sands injection well. The feeder wells will lower the water table around Werta Wert wetland with the aim of returning positive ecological outcomes and reduce salt accumulation in the soils.
    b. The well construction method and development of these production wells will play an important role in the determining the concentration of suspended solids in the source injectant. It is recommended that production wells include wirewound screens (to minimise the entrance velocity) and gravel packs, and be developed at the rate at which they will be pumped for an injection trial.
    c. The amount of suspended material produced from production wells will be critical for the overall management of a Phase III injection trial, and will reduce the amount of remediation work required during an operational phase. In addition to the production wells, observation wells should be drilled adjacent to the Monoman Formation production wells to determine groundwater lowering.

4. Obtain filtration equipment and implement infrastructure for direct injection of Monoman Formation groundwater into the Warina Sands.

    a. This is viewed as a more favourable option than relying solely on the potential to rectify clogging once it has occurred. Further discussions with Groundwater Technical Services and AMIAD Filtration Systems should occur prior to design and purchase.

b. A series of in line filters should be considered with a 50 micron filter providing the final filtration. Problems encountered during the Monoman Sands to Warina Sands Injection Test (blocking, excessive flushing and inadequate cleaning of the 50 micron filter cartridge) can be overcome by ensuring sufficient backpressure is maintained (Holliday (AMIAD) pers comm., 2008).
c. Consideration should also be given to the potential for clogging with iron bacteria, and precipitation of iron, and how these may be controlled.
d. Backflushing rules must be developed prior to any injection. One simple measure is the injection head development at both the injection and observation well. This should be consistent with the observed aquifer hydraulics and should not change with time if no clogging is occurring.

5. Sample Monoman Formation production wells for a range of physio–chemical parameters including suspended solids, turbidity, membrane filtration index, particle size distribution, major ions and nutrients.

6. Implement seismic monitoring stations with adequate monitoring prior to commencing a Phase III injection trial (refer to Magarey and Osei-Bonsu 2008).

7. Undertake trial injection testing for 6 – 12 months duration.
   a. Injection testing should commence at lower rates increasing with time, provided backflushing proves successful.
   b. The maximum (safe) injection head that can be developed needs to be considered further. A nominal value of 100 m has been discussed in this report. The safe injection head should be less than the fracture pressure, which is related to the depth and strength of overburden materials. A conservative estimate of the fracture pressure can be made by assuming the overburden has zero strength and that gravity is the only force keeping it in place. Assuming a density of 2 t/m^3 for the dry material, and allowing 1 t/m^3 for the buoyancy effect of the artesian conditions, the resultant downward force is equivalent to 1 t/m depth. This is equivalent to column of water equal in height to the depth to the aquifer, and thus an injection head of up to 350 m would be theoretically considered to be safe. An even more conservative value of safe injection head is derived by taking 85% of the fracture pressure at aquifer level, resulting in 250 m.

8. The Warina Sands is a regional confined aquifer and deep aquifer disposal may have application elsewhere in the Riverland for the disposal of saline groundwater or brines generated from desalination.

GLOSSARY

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

Ambient water monitoring — All forms of monitoring conducted beyond the immediate influence of a discharge pipe or injection well, and may include sampling of sediments and living resources

Ambient water quality — The overall quality of water when all the effects that may impact upon the water quality are taken into consideration

Aquiclude — In hydrologic terms, a formation that contains water but cannot transmit it rapidly enough to furnish a significant supply to a well or spring

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

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

ASR — Aquifer Storage and Recovery; involves the process of recharging water into an aquifer for the purpose of storage and subsequent withdrawal; also known as aquifer storage and retrieval

Artesian — An aquifer in which the water surface is bounded by an impervious rock formation; the water surface is at greater than atmospheric pressure, and hence rises in any well which penetrates the overlying confining aquifer

Artificial recharge — The process of artificially diverting water from the surface to an aquifer; artificial recharge can reduce evaporation losses and increase aquifer yield; see also 'natural recharge', 'aquifer'

Baseflow — The water in a stream that results from groundwater discharge to the stream; often maintains flows during seasonal dry periods and has important ecological functions

Basin — The area drained by a major river and its tributaries

Bgs — below ground surface

Biodiversity — (1) The number and variety of organisms found within a specified geographic region. (2) The variability among living organisms on the earth, including the variability within and between species and within and between ecosystems

Bore — See 'well'

Catchment — That area of land determined by topographic features within which rainfall will contribute to run-off at a particular point

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

Confining layer — A rock unit impervious to water, which forms the upper bound of a confined aquifer; a body of impermeable material adjacent to an aquifer; see also 'aquifer, confined'

Contaminant — A material added by humans or natural activities that may, in sufficient concentrations, render the environment unacceptable for biota; the presence of these materials is not necessarily harmful

CSIRO — Commonwealth Scientific and Industrial Research Organisation

DEH — Department for Environment and Heritage (Government of South Australia)

Diversity — The distribution and abundance of different kinds of plant and animal species and communities in a specified area

DO — Dissolved Oxygen

DOC — Dissolved Organic Carbon

Domestic purpose — The taking of water for ordinary household purposes; includes the watering of land in conjunction with a dwelling not exceeding 0.4 hectares

Dryland salinity — The process whereby salts stored below the surface of the ground are brought close to the surface by the rising watertable. The accumulation of salt degrades the upper soil profile, with impacts on agriculture, infrastructure and the environment.

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

Ecology — The study of the relationships between living organisms and their environment

Ecosystem — Any system in which there is an interdependence upon, and interaction between, living organisms and their immediate physical, chemical and biological environment

Ephemeral streams or wetlands — Those streams or wetlands that usually contain water only on an occasional basis after rainfall events. Many arid zone streams and wetlands are ephemeral.

Evapotranspiration — The total loss of water as a result of transpiration from plants and evaporation from land, and surface water bodies

EWS — Engineering and Water Supply Department (Government of South Australia); now 'SA Water'

Floodplain — Of a watercourse means: (1) floodplain (if any) of the watercourse identified in a catchment water management plan or a local water management plan; adopted under the Act; or (2) where (1) does not apply — the floodplain (if any) of the watercourse identified in a development plan under the *Development (SA) Act 1993*; or (3) where neither (1) nor (2) applies — the land adjoining the watercourse that is periodically subject to flooding from the watercourse

Fully-penetrating well — In theory this is a wellhole that is screened throughout the full thickness of the target aquifer; in practice, any screen that is open to at least the mid 80% of a confined aquifer is regarded as fully-penetrating

Geological features — Include geological monuments, landscape amenity and the substrate of land systems and ecosystems

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

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'

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

Injection well — An artificial recharge well through which water is pumped or gravity-fed into the ground

Lake — A natural lake, pond, lagoon, wetland or spring (whether modified or not) that includes part of a lake and a body of water declared by regulation to be a lake. A reference to a lake is a reference to either the bed, banks and shores of the lake or the water for the time being held by the bed, banks and shores of the lake, or both, depending on the context.

Land — Whether under water or not, and includes an interest in land and any building or structure fixed to the land

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

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

Native species — Any animal and plant species originally in Australia; see also 'indigenous species'

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

Obswell — Observation Well Network

Penetrating well — See 'fully-penetrating well'

Perennial streams — Permanently inundated surface stream courses. Surface water flows throughout the year except in years of infrequent drought.

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

pH – acidity

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

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

Ramsar Convention — This is an international treaty on wetlands titled *The Convention on Wetlands of International Importance Especially as Waterfowl Habitat*. It is administered by the International Union for Conservation of Nature and Natural Resources. It was signed in the town of Ramsar, Iran in 1971, hence its common name. The convention includes a list of wetlands of international importance and protocols regarding the management of these wetlands. Australia became a signatory in 1974.

SA Geodata — A collection of linked databases storing geological and hydrogeological data, which the public can access through the offices of PIRSA. Custodianship of data related to minerals and petroleum, and groundwater, is vested in PIRSA and DWLBC, respectively. DWLBC should be contacted for database extracts related to groundwater

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

(S) — Storativity; storage coefficient; the volume of groundwater released or taken into storage per unit plan area of aquifer per unit change of head; it is dimensionless

Surface water — (a) water flowing over land (except in a watercourse), (i) after having fallen as rain or hail or having precipitated in any another manner, (ii) or after rising to the surface naturally from underground; (b) water of the kind referred to in paragraph (a) that has been collected in a dam or reservoir

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 (1–70 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 — Top of casing

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

TSS — Dissolved suspended solids

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

Watercourse — A river, creek or other natural watercourse (whether modified or not) and includes: a dam or reservoir that collects water flowing in a watercourse; a lake through which water flows; a channel (but not a channel declared by regulation to be excluded from the this definition) into which the water of a watercourse has been diverted; and part of a watercourse

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

Wetlands — Defined by the Act as a swamp or marsh and includes any land that is seasonally inundated with water. This definition encompasses a number of concepts that are more specifically described in the definition used in the Ramsar Convention on Wetlands of International Importance. This describes wetlands as areas of permanent or periodic to intermittent inundation, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tides does not exceed six metres.

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DWLBC REPORT

Regional Disposal Strategy – Renmark Group Deep Aquifer Injection Phase IIb Preliminary Pumping and Injection Trials

2009/01 - part 2

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

APPENDICES

APPENDIX 1: AIRLIFT-RECOVERY TEST DATA

Test	Date	Depth of air injection line below TOC (m)	Airlift pressure (kPa)	Pumping rate (L/s)	Test duration (mins)	Maximum drawdown (m)	Time until recovery following cessation of airlifting (s)
1	27/3/2008	21	~689	9.5	240	13.0	~ 90
2	28/3/2008	51	~689	11.8	240	24.3	120
3	29/3/2008	81	~689	13.0	480	27.7	240

Test 1 Residual drawdown logger data following cessation of pumping
Head prior to airlifting: 31.912 m above logger

Time (s)	Head above logger (m)	Resid – S(t) (m)
0	18.915	12.997
10	49.490	-17.578
20	38.253	-6.341
30	35.358	-3.446
40	34.117	-2.205
50	33.359	-1.447
60	33.049	-1.137
70	32.877	-0.965
80	32.773	-0.861
90	32.773	-0.861
100	32.704	-0.792
110	32.704	-0.792
120	32.704	-0.792
130	32.601	-0.689
140	32.704	-0.792
150	32.704	-0.792
160	32.704	-0.792
170	32.704	-0.792
180	32.773	-0.861
190	32.773	-0.861
200	32.773	-0.861
210	32.704	-0.792
220	32.704	-0.792
230	32.704	-0.792
240	32.773	-0.861
250	32.704	-0.792
260	32.704	-0.792
270	32.704	-0.792

Time (s)	Head above logger (m)	Resid – S(t) (m)
280	32.704	-0.792
290	32.704	-0.792
300	32.704	-0.792
310	32.704	-0.792
320	32.704	-0.792
330	32.704	-0.792
340	32.704	-0.792
350	32.704	-0.792
360	32.704	-0.792
370	32.704	-0.792
380	32.704	-0.792
390	32.704	-0.792
400	32.704	-0.792
410	32.704	-0.792
420	32.704	-0.792
430	32.704	-0.792
440	32.704	-0.792
450	32.704	-0.792
460	32.704	-0.792
470	32.704	-0.792
480	32.704	-0.792
490	32.704	-0.792
500	32.704	-0.792
510	32.704	-0.792
520	32.704	-0.792
530	32.704	-0.792
540	32.704	-0.792
550	32.704	-0.792
560	32.704	-0.792
570	32.704	-0.792
580	32.704	-0.792
590	32.704	-0.792
600	32.704	-0.792
610	32.704	-0.792
670	32.704	-0.792
730	32.704	-0.792
790	32.704	-0.792
850	32.704	-0.792
910	32.704	-0.792
970	32.704	-0.792
1030	32.704	-0.792
1090	32.704	-0.792
1150	32.704	-0.792
1210	32.704	-0.792

Time (s)	Head above logger (m)	Resid – S(t) (m)
1270	32.635	-0.723
1330	32.704	-0.792
1390	32.635	-0.723
1450	32.635	-0.723
1510	32.635	-0.723
1570	32.635	-0.723
1630	32.635	-0.723
1690	32.635	-0.723
1750	32.635	-0.723
1810	32.635	-0.723
1870	32.635	-0.723
1930	32.635	-0.723
1990	32.635	-0.723
2050	32.635	-0.723
2110	32.635	-0.723
2170	32.635	-0.723
2230	32.635	-0.723
2290	32.635	-0.723
2350	32.635	-0.723
2410	32.635	-0.723
2470	32.635	-0.723
2530	32.635	-0.723
2590	32.635	-0.723
2650	32.566	-0.654
2710	32.635	-0.723
2770	32.566	-0.654
2830	32.566	-0.654
2890	32.566	-0.654
2950	32.566	-0.654
3010	32.566	-0.654
3070	32.566	-0.654
3130	32.566	-0.654
3190	32.566	-0.654
3250	32.566	-0.654
3310	32.566	-0.654
3370	32.566	-0.654
3430	32.566	-0.654
3490	32.566	-0.654
3550	32.566	-0.654
3610	32.566	-0.654
3670	32.566	-0.654
3730	32.566	-0.654

Test 2 Residual drawdown logger data following cessation of pumping
Head prior to airlifting: 62.452 m above logger

Time (s)	Head above probe (m)	Resid – S(t) (m)
0	38.115	24.337
10	50.457	11.995
20	69.278	-6.826
30	58.005	4.447
40	60.178	2.274
50	63.831	-1.379
60	63.417	-0.965
70	62.452	0.000
80	62.521	-0.069
90	63.349	-0.897
100	63.865	-1.413
110	63.211	-0.759
120	63.038	-0.586
130	62.866	-0.414
140	62.866	-0.414
150	62.969	-0.517
160	63.142	-0.690
170	62.969	-0.517
180	63.142	-0.690
190	63.004	-0.552
200	63.004	-0.552
210	63.004	-0.552
220	63.245	-0.793
230	62.969	-0.517
240	63.107	-0.655
250	62.935	-0.483
260	63.245	-0.793
270	63.004	-0.552
280	63.004	-0.552
290	63.004	-0.552
300	63.004	-0.552
310	62.866	-0.414
320	63.142	-0.690
330	63.004	-0.552
340	63.142	-0.690
350	62.866	-0.414
360	63.073	-0.621
370	63.004	-0.552
380	63.280	-0.828
390	62.969	-0.517
400	62.969	-0.517
410	63.176	-0.724

Time (s)	Head above probe (m)	Resid – S(t) (m)
420	63.004	-0.552
430	63.004	-0.552
440	63.004	-0.552
450	62.866	-0.414
460	63.073	-0.621
470	63.073	-0.621
480	63.004	-0.552
490	62.935	-0.483
500	63.280	-0.828
510	63.004	-0.552
520	63.004	-0.552
530	63.280	-0.828
540	63.004	-0.552
550	62.901	-0.449
560	63.038	-0.586
570	63.038	-0.586
580	63.176	-0.724
590	62.969	-0.517
650	63.176	-0.724
710	63.004	-0.552
770	63.280	-0.828
830	62.935	-0.483
890	63.004	-0.552
950	63.004	-0.552
1010	63.211	-0.759
1070	62.901	-0.449
1130	63.073	-0.621
1190	62.969	-0.517
1250	63.038	-0.586
1310	63.038	-0.586
1370	63.004	-0.552
1430	63.280	-0.828
1490	63.142	-0.690
1550	62.969	-0.517
1610	62.969	-0.517
1670	63.211	-0.759
1730	63.004	-0.552
1790	62.901	-0.449
1850	62.969	-0.517
1910	62.969	-0.517
1970	63.142	-0.690
2030	62.935	-0.483
2090	62.866	-0.414
2150	62.935	-0.483
2210	63.073	-0.621

Time (s)	Head above probe (m)	Resid – S(t) (m)
2270	62.935	-0.483
2330	62.935	-0.483
2390	62.901	-0.449
2450	63.004	-0.552
2510	62.935	-0.483
2570	62.901	-0.449
2630	62.866	-0.414
2690	62.935	-0.483
2750	62.935	-0.483
2810	63.073	-0.621
2870	62.969	-0.517
2930	62.866	-0.414
2990	57.901	4.551

Test 3 Residual drawdown logger data following cessation of pumping
Head prior to airlifting: 93.399 m above logger

Time (s)	Head above logger (m)	Resid – S(t) (m)0
0	65.692	27.707
10	67.553	25.846
20	79.757	13.642
30	94.613	-1.214
40	89.444	3.955
50	94.820	-1.421
60	93.614	-0.215
70	92.373	1.026
80	93.889	-0.49
90	92.718	0.681
100	92.890	0.509
110	95.406	-2.007
120	92.132	1.267
130	93.028	0.371
140	93.958	-0.559
150	93.545	-0.146
160	93.441	-0.042
170	92.993	0.406
180	92.993	0.406
190	93.683	-0.284
200	94.268	-0.869
210	93.958	-0.559
220	93.407	-0.008
230	93.407	-0.008
240	93.338	0.061
250	93.579	-0.18
260	93.579	-0.18
270	93.304	0.095
280	93.304	0.095
290	93.614	-0.215
300	93.614	-0.215
310	93.476	-0.077
320	93.545	-0.146
330	93.614	-0.215
340	93.786	-0.387
350	93.545	-0.146
360	93.441	-0.042
370	93.441	-0.042
380	93.579	-0.18
390	93.648	-0.249
400	93.545	-0.146

Time (s)	Head above logger (m)	Resid – S(t) (m)0
410	93.441	-0.042
420	93.441	-0.042
430	93.510	-0.111
440	93.200	0.199
450	93.441	-0.042
460	93.545	-0.146
470	94.510	-1.111
480	93.062	0.337
490	93.510	-0.111
500	93.407	-0.008
510	93.476	-0.077
520	93.407	-0.008
530	93.648	-0.249
540	93.476	-0.077
550	93.476	-0.077
560	93.614	-0.215
570	93.441	-0.042
580	93.441	-0.042
590	93.579	-0.18
600	93.579	-0.18
660	93.476	-0.077
720	93.510	-0.111
780	93.717	-0.318
840	93.372	0.027
900	93.476	-0.077
960	94.165	-0.766
1020	93.372	0.027
1080	93.476	-0.077
1140	93.579	-0.18
1200	93.441	-0.042
1260	93.476	-0.077
1320	93.717	-0.318
1380	93.407	-0.008
1440	93.338	0.061
1500	93.476	-0.077
1560	93.476	-0.077
1620	93.476	-0.077
1680	93.372	0.027
1740	93.407	-0.008
1800	93.407	-0.008
1860	93.476	-0.077
1920	93.476	-0.077
1980	93.407	-0.008
2040	99.681	-6.282
2100	93.407	-0.008

Time (s)	Head above logger (m)	Resid – S(t) (m)0
2160	93.510	-0.111
2220	93.097	0.302
2280	94.131	-0.732
2340	93.441	-0.042
2400	93.372	0.027
2460	93.476	-0.077
2520	93.441	-0.042
2580	93.407	-0.008
2640	93.648	-0.249
2700	93.476	-0.077
2760	93.407	-0.008
2820	93.304	0.095
2880	93.476	-0.077
2940	93.648	-0.249
3000	93.407	-0.008
3060	93.407	-0.008
3120	93.407	-0.008
3180	93.407	-0.008
3240	93.407	-0.008
3300	93.407	-0.008
3360	93.407	-0.008
3420	93.407	-0.008
3480	93.407	-0.008
3540	93.407	-0.008
3600	93.407	-0.008

APPENDIX 2: WARINA SANDS TO WARINA SANDS INJECTION DATA

Test	Date	Injection rate (L/s)	Test duration (mins)	Time until recovery following cessation of injection (mins)
1	31/3/2008	3	500	< 1
2	2/4/2008	6	299	< 1
3	4/4/2008	9	200	< 1
4	5/4/2008	12	158	< 1

Test 1 injection head data

Time (mins)	Head above logger (m)	Injection Head (m)	Comment
	Initial head 20.741		
1	20.707	0.034	
2	20.707	-0.069	
3	20.81	-9.376	
4	30.117	-3.621	
5	24.362	-2.243	
6	22.984	-2.311	
7	23.052	-2.001	
8	22.742	-1.863	
9	22.604	-1.932	
10	22.673	-1.932	
11	22.673	-2.105	
12	22.846	-2.105	
13	22.846	-1.45	
14	22.191	-1.967	
15	22.708	-1.795	
16	22.536	-1.898	
17	22.639	-1.898	
18	22.639	-1.795	
19	22.536	-1.795	
20	22.536	-1.795	
21	22.536	-1.898	
22	22.639	-1.829	
23	22.57	-1.898	
24	22.639	-1.76	
25	22.501	-1.76	
26	22.501	-1.76	
27	22.501	-1.863	
28	22.604	-1.863	
29	22.604	-1.863	
30	22.604	-1.967	
31	22.708	-2.208	

Time (mins)	Head above logger (m)	Injection Head (m)	Comment
32	22.949	-1.932	
33	22.673	-1.932	
34	22.673	-2.036	
35	22.777	-2.036	
36	22.777	-1.932	
37	22.673	-1.863	
38	23.604	-2.346	
39	23.087	-2.346	
40	22.087	-1.967	
41	22.708	-2.243	
42	22.984	-2.174	
43	22.915	-2.07	
44	22.811	-2.001	
45	22.742	-2.07	
46	22.811	-1.863	
47	22.604	-1.932	
48	22.673	-2.036	
49	22.777	-1.932	
50	22.673	-2.036	
51	22.777	-1.932	
52	22.673	-2.07	
53	22.811	-1.898	
54	22.639	-2.001	
55	23.742	-2.449	
56	23.19	-2.07	
57	22.811	-2.001	
58	22.742	-2.07	
59	22.811	-2.346	
60	23.087	-2.036	
65	22.777	-2.036	
70	22.777	-2.036	
80	22.915	-2.174	
90	23.018	-2.277	
95	22.880	-2.139	
100	22.846	-2.105	
105	22.570	-1.829	
110	22.846	-2.105	
115	23.190	-2.449	
120	22.811	-2.07	
125	22.915	-2.174	
130	22.949	-2.208	
135	23.156	-2.415	
140	22.811	-2.07	
145	23.018	-2.277	
150	22.949	-2.208	

Time (mins)	Head above logger (m)	Injection Head (m)	Comment
155	22.949	-2.208	
160	23.052	-2.311	
165	23.018	-2.277	
170	23.018	-2.277	
175	23.052	-2.311	
180	22.984	-2.243	
185	23.156	-2.415	
190	23.052	-2.311	
195	23.052	-2.311	
200	23.052	-2.311	
205	23.121	-2.38	
210	23.087	-2.346	
215	23.052	-2.311	
220	23.052	-2.311	
225	23.087	-2.346	
230	23.018	-2.277	
235	23.087	-2.346	
240	23.018	-2.277	
245	23.018	-2.277	
250	23.052	-2.311	
255	23.190	-2.449	
260	22.984	-2.243	
265	23.121	-2.38	
270	23.121	-2.38	
275	23.121	-2.38	
280	23.259	-2.518	
285	23.294	-2.553	
290	23.259	-2.518	
295	23.225	-2.484	
300	23.225	-2.484	
305	23.363	-2.622	
310	23.087	-2.346	
315	23.190	-2.449	
320	23.156	-2.415	
325	23.156	-2.415	
330	23.156	-2.415	
335	23.121	-2.38	
340	23.121	-2.38	
345	23.156	-2.415	
350	23.121	-2.38	
355	23.604	-2.863	
360	23.294	-2.553	
365	23.225	-2.484	
370	23.225	-2.484	
375	23.294	-2.553	

Time (mins)	Head above logger (m)	Injection Head (m)	Comment
380	23.466	-2.725	
385	23.225	-2.484	
390	23.190	-2.449	
395	23.328	-2.587	
400	23.156	-2.415	
405	23.225	-2.484	
410	23.259	-2.518	
415	23.294	-2.553	
420	23.328	-2.587	
425	23.432	-2.691	
430	23.294	-2.553	
435	23.328	-2.587	
440	23.569	-2.828	
445	23.466	-2.725	
450	23.604	-2.863	
455	23.294	-2.553	
460	23.225	-2.484	
465	23.328	-2.587	
470	23.294	-2.553	
475	23.259	-2.518	
480	23.328	-2.587	
485	23.259	-2.518	
490	23.294	-2.553	
495	23.156	-2.415	
500	23.432	0.517	Injection Stopped
505	20.362	0.517	
510	20.224	0.517	
515	20.293	0.448	
520	20.224	0.517	

Test 2 injection head data

Time (mins)	Head above logger (m)	Injection Head (m)	Comment
0	Initial head 20.74	1.205	
1	25.40	-4.656	
2	25.91	-5.173	
3	26.33	-5.586	
4	26.26	-5.518	
5	26.05	-5.311	
6	26.22	-5.483	
7	26.22	-5.483	
8	26.29	-5.552	
9	26.50	-5.759	
10	26.36	-5.621	
11	26.46	-5.724	
12	26.46	-5.724	
13	26.46	-5.724	
14	26.71	-5.966	
15	26.43	-5.69	
16	26.57	-5.828	
17	26.57	-5.828	
18	26.57	-5.828	
19	26.33	-5.586	
20	26.40	-5.655	
21	26.40	-5.655	
22	26.50	-5.759	
23	26.50	-5.759	
24	26.50	-5.759	
25	26.33	-5.586	
26	26.33	-5.586	
27	26.64	-5.897	
28	26.46	-5.724	
29	26.53	-5.793	
30	26.43	-5.69	
31	26.60	-5.862	
32	26.46	-5.724	
33	26.46	-5.724	
34	26.46	-5.724	
35	26.40	-5.655	
36	26.40	-5.655	
37	26.40	-5.655	
38	26.40	-5.655	
39	26.77	-6.034	
40	26.50	-5.759	
41	26.50	-5.759	

Time (mins)	Head above logger (m)	Injection Head (m)	Comment
42	26.50	-5.759	
43	26.50	-5.759	
44	25.98	-5.242	
45	26.43	-5.69	
46	26.43	-5.69	
47	26.71	-5.966	
48	26.46	-5.724	
49	26.29	-5.552	
50	26.46	-5.724	
51	26.71	-5.966	
52	26.91	-6.172	
53	26.43	-5.69	
54	26.50	-5.759	
55	26.84	-6.103	
56	26.26	-5.518	
57	26.46	-5.724	
58	26.46	-5.724	
59	26.46	-5.724	
60	26.46	5.724	
65	26.258	-6.00	
70	26.53	-5.793	
75	26.46	-5.724	
80	26.43	-5.69	
85	26.50	-5.759	
90	26.57	-5.72	
95	26.53	-5.724	
100	26.64	-5.897	
105	26.57	-5.966	
110	26.33	-6.069	
115	26.64	-5.724	
120	26.53	-5.793	
125	26.36	-5.793	
130	26.43	-5.897	
135	26.43	-5.759	
140	26.57	-5.759	
145	26.12	-5.828	
150	26.53	-5.793	
155	26.40	-5.759	
160	26.46	-5.793	
165	26.81	-5.793	
170	26.57	-5.724	
175	26.57	-5.828	
180	26.57	-6.103	
185	26.57	-5.828	

Time (mins)	Head above logger (m)	Injection Head (m)	Comment
190	26.67	-5.793	
195	26.57	-5.828	
200	26.50	-5.828	
205	26.46	-5.897	
210	26.50	-5.759	
215	26.81	-6.069	
220	26.43	-5.759	
225	26.81	-5.586	
230	26.60	-5.862	
235	26.53	-5.793	
240	26.46	-5.724	
245	26.40	-5.759	
250	26.26	-6.241	
255	26.53	-5.97	
260	26.57	-5.828	
265	26.71	-5.79	
270	26.50	-5.759	
275	26.50	-5.759	
280	26.91	-5.90	
285	26.57	-5.828	
290	26.50	-5.759	
295	26.53	-5.793	
300	26.53	-5.793	Injection stopped
305	20.81	-0.07	
310	20.67	0.068	
315	20.78	-0.036	
320	20.71	0.033	
325	20.78	-0.036	
330	20.71	0.033	
335	20.71	0.033	
340	20.71	0.033	
345	20.71	0.033	
350	20.71	0.033	
355	20.71	0.033	
360	20.71	0.033	
365	20.71	0.033	

Test 3 injection head data

Time (mins)	Head above logger (m)	Injection Head (m)	Comment
	Initial head 20.879		
1	29.221	-8.342	
2	30.290	-9.411	
3	30.290	-9.411	
4	30.359	-9.480	
5	30.359	-9.480	
6	30.807	-9.928	
7	30.324	-9.445	
8	31.255	-10.376	
9	30.945	-10.066	
10	30.703	-9.824	
11	30.703	-9.824	
12	30.910	-10.031	
13	30.531	-9.652	
14	30.703	-9.824	
15	30.703	-9.824	
16	30.703	-9.824	
17	30.703	-9.824	
18	30.703	-9.824	
19	30.703	-9.824	
20	30.703	-9.824	
21	30.600	-9.721	
22	30.738	-9.859	
23	30.738	-9.859	
24	30.290	-9.411	
25	30.703	-9.824	
26	30.703	-9.824	
27	30.772	-9.893	
28	30.703	-9.824	
29	30.703	-9.824	
30	30.703	-9.824	
31	30.772	-9.893	
32	30.772	-9.893	
33	30.876	-9.997	
34	30.807	-9.928	
35	30.807	-9.928	
36	30.807	-9.928	
37	30.807	-9.928	
38	31.117	-10.238	
39	30.772	-9.893	
40	30.772	-9.893	
41	30.703	-9.824	
42	30.703	-9.824	

Time (mins)	Head above logger (m)	Injection Head (m)	Comment
43	30.600	-9.721	
44	31.013	-10.134	
45	30.807	-9.928	
46	30.703	-9.824	
47	30.703	-9.824	
48	30.634	-9.755	
49	30.772	-9.893	
50	30.772	-9.893	
51	31.048	-10.169	
52	30.772	-9.893	
53	30.703	-9.824	
54	31.013	-10.134	
55	30.669	-9.790	
56	30.669	-9.790	
57	31.048	-10.169	
58	30.910	-10.031	
59	31.013	-10.134	
60	30.634	-9.755	
65	30.703	-9.824	
70	30.496	-9.617	
75	30.772	-9.893	
80	30.772	-9.893	
85	30.738	-9.859	
90	30.634	-9.755	
95	30.807	-9.928	
100	30.738	-9.859	
105	30.772	-9.893	
110	30.841	-9.962	
115	30.772	-9.893	
120	30.979	-10.100	
125	30.910	-10.031	
130	30.669	-9.790	
135	31.082	-10.203	
140	30.841	-9.962	
145	30.945	-10.066	
150	30.945	-10.066	
155	30.945	-10.066	
160	30.772	-9.893	
165	30.910	-10.031	
170	30.979	-10.100	
175	30.910	-10.031	
180	30.910	-10.031	
185	30.910	-10.031	
190	30.876	-9.997	
195	30.945	-10.066	

Time (mins)	Head above logger (m)	Injection Head (m)	Comment
200	31.013	-10.134	Injection Stopped
205	20.707	0.172	
210	20.672	0.207	
215	20.672	0.207	
220	20.672	0.207	
225	20.638	0.241	
230	20.672	0.207	
235	20.638	0.241	
240	20.603	0.276	
245	20.741	0.138	
250	20.672	0.207	
255	20.672	0.207	
260	20.707	0.172	

Test 4 injection head data

Time (mins)	Head above logger (m)	Injection Head (m)	Comment
	Initial head 20.672		
1	37.081	-16.409	
2	35.668	-14.996	
3	35.668	-14.996	
4	35.909	-15.237	
5	35.909	-15.237	
6	36.323	-15.651	
7	36.22	-15.548	
8	36.288	-15.616	
9	36.288	-15.616	
10	36.22	-15.548	
11	36.22	-15.548	
12	36.22	-15.548	
13	36.22	-15.548	
14	36.151	-15.479	
15	36.151	-15.479	
16	36.22	-15.548	
17	36.22	-15.548	
18	36.22	-15.548	
19	36.116	-15.444	
20	36.116	-15.444	
21	36.116	-15.444	
22	36.116	-15.444	
23	36.116	-15.444	
24	36.116	-15.444	
25	36.116	-15.444	
26	36.116	-15.444	
27	36.116	-15.444	
28	36.185	-15.513	
29	36.185	-15.513	
30	36.116	-15.444	
31	36.116	-15.444	
32	36.22	-15.548	
33	36.22	-15.548	
34	36.151	-15.479	
35	36.254	-15.582	
36	36.047	-15.375	
37	36.185	-15.513	
38	36.185	-15.513	
39	36.116	-15.444	
40	36.185	-15.513	
41	36.185	-15.513	

Time (mins)	Head above logger (m)	Injection Head (m)	Comment
42	36.116	-15.444	
43	36.22	-15.548	
44	36.116	-15.444	
45	36.116	-15.444	
46	36.116	-15.444	
47	36.116	-15.444	
48	36.116	-15.444	
49	36.116	-15.444	
50	36.116	-15.444	
51	36.116	-15.444	
52	36.116	-15.444	
53	36.185	-15.513	
54	36.116	-15.444	
55	36.22	-15.548	
56	36.22	-15.548	
57	36.22	-15.548	
58	36.151	-15.479	
59	36.151	-15.479	
60	36.151	-15.479	
61	36.151	-15.479	
62	36.151	-15.479	
63	36.151	-15.479	
64	36.288	-15.616	
65	36.288	-15.616	
66	36.288	-15.616	
67	36.288	-15.616	
68	36.288	-15.616	
69	36.288	-15.616	
70	36.288	-15.616	
71	36.288	-15.616	
72	36.22	-15.548	
73	36.22	-15.548	
74	36.22	-15.548	
75	36.22	-15.548	
76	36.151	-15.479	
77	36.288	-15.616	
78	36.22	-15.548	
79	36.22	-15.548	
80	36.151	-15.479	
81	36.254	-15.582	
82	36.185	-15.513	
83	36.185	-15.513	
84	36.116	-15.444	
85	36.116	-15.444	

Time (mins)	Head above logger (m)	Injection Head (m)	Comment
86	36.116	-15.444	
87	36.116	-15.444	
88	36.116	-15.444	
89	36.116	-15.444	
90	36.116	-15.444	
91	36.116	-15.444	
92	36.116	-15.444	
93	36.185	-15.513	
94	36.185	-15.513	
95	36.185	-15.513	
96	36.185	-15.513	
97	36.082	-15.41	
98	36.151	-15.479	
99	36.151	-15.479	
100	36.254	-15.582	
101	36.185	-15.513	
102	36.185	-15.513	
103	36.185	-15.513	
104	36.185	-15.513	
105	36.185	-15.513	
106	36.185	-15.513	
107	36.185	-15.513	
108	36.185	-15.513	
109	36.185	-15.513	
110	36.185	-15.513	
111	36.185	-15.513	
112	36.254	-15.582	
113	36.254	-15.582	
114	36.254	-15.582	
115	36.254	-15.582	
116	36.254	-15.582	
117	36.254	-15.582	
118	36.254	-15.582	
119	36.151	-15.479	
120	36.22	-15.548	
121	36.22	-15.548	
122	36.22	-15.548	
123	36.151	-15.479	
124	36.22	-15.548	
125	36.22	-15.548	
126	36.22	-15.548	
127	36.22	-15.548	
128	36.22	-15.548	
129	36.22	-15.548	

Time (mins)	Head above logger (m)	Injection Head (m)	Comment
130	36.116	-15.444	
131	36.185	-15.513	
132	36.185	-15.513	
133	36.254	-15.582	
134	36.254	-15.582	
135	36.254	-15.582	
136	36.254	-15.582	
137	36.254	-15.582	
138	36.254	-15.582	
139	36.254	-15.582	
140	36.254	-15.582	
141	36.185	-15.513	
142	36.185	-15.513	
143	36.254	-15.582	
144	36.254	-15.582	
145	36.254	-15.582	
146	36.254	-15.582	
147	36.254	-15.582	
148	36.185	-15.513	
149	36.254	-15.582	
150	36.254	-15.582	
151	36.254	-15.582	
152	36.254	-15.582	
153	36.151	-15.479	
154	36.082	-15.41	Injection Stopped
155	14.883	5.789	
156	20.672	0	
157	20.569	0.103	
158	20.569	0.103	
159	20.5	0.172	
160	20.5	0.172	
161	20.5	0.172	
162	20.5	0.172	
163	20.5	0.172	
164	20.5	0.172	
165	20.5	0.172	
166	20.5	0.172	
167	20.5	0.172	
168	20.5	0.172	
169	20.5	0.172	
170	20.5	0.172	
171	20.5	0.172	
172	20.5	0.172	
173	20.5	0.172	

Time (mins)	Head above logger (m)	Injection Head (m)	Comment
174	20.5	0.172	
175	20.5	0.172	
176	20.5	0.172	
177	20.5	0.172	
178	20.5	0.172	
179	20.5	0.172	
180	20.431	0.241	
181	20.431	0.241	
182	20.603	0.069	
183	20.431	0.241	
184	20.224	0.448	
185	20.293	0.379	
186	20.293	0.379	
187	20.466	0.206	

APPENDIX 3: GROUNDWATER CHEMISTRY RESULTS (AWQC)

From: 84180100 To: 84636999 Page: 1/50 Date: 16/05/2008 11:49:31 AM

n Australian Water Corporation

84180100

FACSIMILE TRANSMISSION

:	84636999	Company:	
om:	Borjana Stazic Mandic	Date:	16/05/2008
bject:	AWQC Final Report for Project 'AWQC-20543' (12/03/2008 - 18/03/2008)		

lessage:

ear Paul,

ttached is the FINAL report for review.

SR: '108874-2008-CSR-8' - DWLBC - Paul Magarey - 07/08
roject: 'AWQC-20543' - DWLBC - Paul Magarey - 07/08
roject Range: 12/03/2008 - 18/03/2008

egards,
ohn Winter

lease note AWQC Sample Receipt hours are Monday to Friday 8.30am - 4.30pm.

Hodgson Road, Bolivar, 5110, South Australia

Phone: +61 1300 653 366

84180100

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Australian Water Quality Centre

DWLBC
ATTN: Paul Magarey
Leve 11 25 Grenfell St
Adelaide
SA 5000 AUSTRALIA

16/05/2008

Dear Paul

Please find attached the Final Analytical Report for

Customer Service Request: 108874-2008-CSR-8
Account: 108874
Project: AWQC-20543 DWLBC - Paul Magarey - 07/08

Sample Date Range: 12-March-2008 to 18-March-2008

Yours sincerely,

John Winter
Account Manager
John.Winter@sawater.com.au
(08) 8259 0257

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FINAL REPORT: 36182

Analytical Results

Customer Sample Description	Sample 1
Sampling Point	93308-DWLBC - Warina 1 Observation Well Unit Number 7030-809
Sampled Date	23/04/2008 12:00:00AM
Sample Received Date	24/04/2008 4:13:04PM
Sample ID	2008 001 2665
Status	Endorsed
Collection Type	Customer Collected

Bacteriology	LOR	Result
Iron Bacteria - Heterotrophic T460-01 WMZ-500		
Iron Bacteria - Heterotrophic	10	300 /mL
Iron Bacteria - Heterotrophic T460-05 WMZ-500		
Iron Bacteria - Microscopic examination		Microscopical examination of the sample did not detect iron associated microorganisms

Inorganic Chemistry - Metals	LOR	Result
Calcium TIC-001 W09-023		
Calcium	0.1	558 mg/L
Iron - Soluble TIC-004 W09-023		
Iron - Soluble	0.005	0.064 mg/L
Iron - Total TIC-004 W09-023		
Iron - Total	0.005	0.067 mg/L
Magnesium TIC-001 W09-023		
Magnesium	0.3	611 mg/L
Manganese - Soluble TIC-004 W09-023		
Manganese - Soluble	0.001	0.686 mg/L
Manganese - Total TIC-004 W09-023		
Manganese - Total	0.001	0.695 mg/L
Potassium TIC-001 W09-023		
Potassium	1.0	83.4 mg/L
Sodium Adsorption Ratio W09-023		
Sodium Adsorption Ratio - Calculation		47.5
Sodium TIC-001 W09-023		
Sodium	0.5	6830 mg/L
Sulphur TIC-001 W09-023		
Sulphate	1.5	2220 mg/L
Total Hardness as CaCO3 W09-023		
Total Hardness as CaCO3	2.0	3910 mg/L

Inorganic Chemistry - Nutrients	LOR	Result
Chloride T0104-02 W09-023		
Chloride	4.0	11300 mg/L
Fluoride W09-023		
Fluoride	0.10	0.18 mg/L

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FINAL REPORT: 36182

Analytical Results

Customer Sample Description	Sample 1
Sampling Point	93308-DWLBC - Warina 1 Observation Well Unit Number 7030-809
Sampled Date	23/04/2008 12:00:00AM
Sample Received Date	24/04/2008 4:13:04PM
Sample ID	2008-001-2655
Status	Endorsed
Collection Type	Customer Collected

Nitrate + Nitrite as N T0161-01 W09-023

Nitrate + Nitrite as N	0.005	<0.005 mg/L

Organic Chemistry	LOR	Result
Dissolved Organic Carbon T0158-09 W09-023		
Dissolved Organic Carbon	0.3	2.0 mg/L

Inorganic Chemistry - Physical	LOR	Result
Alkalinity Carbonate Bicarbonate and Hydroxide T0101-01 W09-023		
Alkalinity as Calcium Carbonate		353 mg/L
Bicarbonate		431 mg/L
Carbonate		0 mg/L
Hydroxide		0 mg/L
Turbidity T0018-01 W09-023		
Turbidity	0.1	0.84 NTU

Inorganic Chemistry - Waste Water	LOR	Result
Suspended Solids T0160-01 W09-023		
Suspended Solids	1.0	5 mg/L

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Report Information

Project Name	AWQC-20543
Customer	DWLBC
CSR_ID	108874-2008-CSR-8

Analytical Results

Customer Sample Description	Sample 2
Sampling Point	93308-DWLBC - Warina 1 Observation Well Unit Number 7030-809
Sampled Date	23/04/2008 12:00:00AM
Sample Received Date	24/04/2008 4:13:00PM
Sample ID	2008-001-2644
Status	Endorsed
Collection Type	Customer Collected

Bacteriology	**LOR**	**Result**
Iron Bacteria - Heterotrophic T460-01 WMZ-500		
Iron Bacteria - Heterotrophic	10	200 /mL
Iron Bacteria - Heterotrophic T460-05 WMZ-500		
Iron Bacteria - Microscopic examination		Microscopical examination of the sample did not detect iron associated microorganisms

Inorganic Chemistry - Metals	**LOR**	**Result**
Calcium TIC-001 W09-023		
Calcium	0.1	542 mg/L
Iron - Soluble TIC-004 W09-023		
Iron - Soluble	0.005	0.075 mg/L
Iron - Total TIC-004 W09-023		
Iron - Total	0.005	0.079 mg/L
Magnesium TIC-001 W09-023		
Magnesium	0.3	593 mg/L
Manganese - Soluble TIC-004 W09-023		
Manganese - Soluble	0.001	0.674 mg/L
Manganese - Total TIC-004 W09-023		
Manganese - Total	0.001	0.701 mg/L
Potassium TIC-001 W09-023		
Potassium	1.0	83.0 mg/L
Sodium Adsorption Ratio W09-023		
Sodium Adsorption Ratio - Calculation		48.0
Sodium TIC-001 W09-023		
Sodium	0.5	6800 mg/L
Sulphur TIC-001 W09-023		
Sulphate	1.5	2150 mg/L
Total Hardness as CaCO3 W09-023		
Total Hardness as CaCO3	2.0	3800 mg/L

Inorganic Chemistry - Nutrients	**LOR**	**Result**

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Analytical Results

Customer Sample Description	Sample 2
Sampling Point	93308-DWLBC - Warina 1 Observation Well Unit Number 7030-809
Sampled Date	23/04/2008 12:00:00AM
Sample Received Date	24/04/2008 4:13:00PM
Sample ID	2008-001-2644
Status	Endorsed
Collection Type	Customer Collected

	LOR	Result
Chloride T0104-02 W09-023		
Chloride	4.0	11300 mg/L
Fluoride W09-023		
Fluoride	0.10	0.18 mg/L
Nitrate + Nitrite as N T0161-01 W09-023		
Nitrate + Nitrite as N	0.005	<0.005 mg/L

Organic Chemistry	LOR	Result
Dissolved Organic Carbon T0158-09 W09-023		
Dissolved Organic Carbon	0.3	2.0 mg/L

Inorganic Chemistry - Physical	LOR	Result
Alkalinity Carbonate Bicarbonate and Hydroxide T0101-01 W09-023		
Alkalinity as Calcium Carbonate		356 mg/L
Bicarbonate		434 mg/L
Carbonate		0 mg/L
Hydroxide		0 mg/L
Turbidity T0018-01 W09-023		
Turbidity	0.1	0.61 NTU

Inorganic Chemistry - Waste Water	LOR	Result
Suspended Solids T0160-01 W09-023		
Suspended Solids	1.0	13 mg/L

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Analytical Results

Customer Sample Description	Sample 3
Sampling Point	93308-DWLBC - Warina 1 Observation Well Unit Number 7030-809
Sampled Date	23/04/2008 12:00:00AM
Sample Received Date	24/04/2008 4:12:58PM
Sample ID	*2008 001 2645
Status	Endorsed
Collection Type	Customer Collected

Bacteriology	LOR	Result
Iron Bacteria - Heterotrophic T460-01 WMZ-500		
Iron Bacteria - Heterotrophic	10	80 /mL
Iron Bacteria - Heterotrophic T460-05 WMZ-500		
Iron Bacteria - Microscopic examination		Microscopical examination of the sample did not detect iron associated microorganisms

Inorganic Chemistry - Metals	LOR	Result
Calcium TIC-001 W09-023		
Calcium	0.1	536 mg/L
Iron - Soluble TIC-004 W09-023		
Iron - Soluble	0.005	0.042 mg/L
Iron - Total TIC-004 W09-023		
Iron - Total	0.005	0.042 mg/L
Magnesium TIC-001 W09-023		
Magnesium	0.3	588 mg/L
Manganese - Soluble TIC-004 W09-023		
Manganese - Soluble	0.001	0.711 mg/L
Manganese - Total TIC-004 W09-023		
Manganese - Total	0.001	0.709 mg/L
Potassium TIC-001 W09-023		
Potassium	1.0	76.3 mg/L
Sodium Adsorption Ratio W09-023		
Sodium Adsorption Ratio - Calculation		47.5
Sodium TIC-001 W09-023		
Sodium	0.5	6690 mg/L
Sulphur TIC-001 W09-023		
Sulphate	1.5	2130 mg/L
Total Hardness as CaCO3 W09-023		
Total Hardness as CaCO3	2.0	3760 mg/L

Inorganic Chemistry - Nutrients	LOR	Result
Chloride T0104-02 W09-023		
Chloride	4.0	11400 mg/L
Fluoride W09-023		
Fluoride	0.10	0.18 mg/L

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Analytical Results

Customer Sample Description	Sample 3
Sampling Point	93308-DWLBC - Warina 1 Observation Well Unit Number 7030-809
Sampled Date	23/04/2008 12:00:00AM
Sample Received Date	24/04/2008 4:12:58PM
Sample ID	*2008-001-2645
Status	Endorsed
Collection Type	Customer Collected

Nitrate + Nitrite as N T0161-01 W09-023		
Nitrate + Nitrite as N	0.005	<0.005 mg/L
Organic Chemistry	**LOR**	**Result**
Dissolved Organic Carbon T0158-09 W09-023		
Dissolved Organic Carbon	0.3	1.9 mg/L
Inorganic Chemistry - Physical	**LOR**	**Result**
Alkalinity Carbonate Bicarbonate and Hydroxide T0101-01 W09-023		
Alkalinity as Calcium Carbonate		352 mg/L
Bicarbonate		430 mg/L
Carbonate		0 mg/L
Hydroxide		0 mg/L
Turbidity T0018-01 W09-023		
Turbidity	0.1	0.77 NTU
Inorganic Chemistry - Waste Water	**LOR**	**Result**
Suspended Solids T0160-01 W09-023		
Suspended Solids	1.0	12 mg/L

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Analytical Results

Customer Sample Description	Sample 4
Sampling Point	93308-DWLBC - Warina 1 Observation Well Unit Number 7030-809
Sampled Date	23/04/2008 8:30:00PM
Sample Received Date	24/04/2008 4:13:02PM
Sample ID	2008-001-2646
Status	Endorsed
Collection Type	Customer Collected

Bacteriology	LOR	Result
Iron Bacteria - Heterotrophic T460-01 WMZ-500		
Iron Bacteria - Heterotrophic	10	120 /mL
Iron Bacteria - Heterotrophic T460-05 WMZ-500		
Iron Bacteria - Microscopic examination		Microscopical examination of the sample did not detect iron associated microorganisms

Inorganic Chemistry - Metals	LOR	Result
Calcium TIC-001 W09-023		
Calcium	0.1	532 mg/L
Iron - Soluble TIC-004 W09-023		
Iron - Soluble	0.005	0.041 mg/L
Iron - Total TIC-004 W09-023		
Iron - Total	0.005	0.044 mg/L
Magnesium TIC-001 W09-023		
Magnesium	0.3	584 mg/L
Manganese - Soluble TIC-004 W09-023		
Manganese - Soluble	0.001	0.674 mg/L
Manganese - Total TIC-004 W09-023		
Manganese - Total	0.001	0.707 mg/L
Potassium TIC-001 W09-023		
Potassium	1.0	75.8 mg/L
Sodium Adsorption Ratio W09-023		
Sodium Adsorption Ratio - Calculation		48.2
Sodium TIC-001 W09-023		
Sodium	0.5	6770 mg/L
Sulphur TIC-001 W09-023		
Sulphate	1.5	2110 mg/L
Total Hardness as CaCO3 W09-023		
Total Hardness as CaCO3	2.0	3730 mg/L

Inorganic Chemistry - Nutrients	LOR	Result
Chloride T0104-02 W09-023		
Chloride	4.0	11300 mg/L
Fluoride W09-023		
Fluoride	0.10	0.18 mg/L

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Analytical Results

Customer Sample Description	Sample 4
Sampling Point	93308-DWLBC - Warina 1 Observation Well Unit Number 7030-809
Sampled Date	23/04/2008 8:30:00PM
Sample Received Date	24/04/2008 4:13:02PM
Sample ID	2008-001-2646
Status	Endorsed
Collection Type	Customer Collected

Nitrate + Nitrite as N T0161-01 W09-023		
Nitrate + Nitrite as N	0.005	<0.005 mg/L
Organic Chemistry	**LOR**	**Result**
Dissolved Organic Carbon T0158-09 W09-023		
Dissolved Organic Carbon	0.3	1.9 mg/L
Inorganic Chemistry - Physical	**LOR**	**Result**
Alkalinity Carbonate Bicarbonate and Hydroxide T0101-01 W09-023		
Alkalinity as Calcium Carbonate		354 mg/L
Bicarbonate		432 mg/L
Carbonate		0 mg/L
Hydroxide		0 mg/L
Turbidity T0018-01 W09-023		
Turbidity	0.1	0.66 NTU
Inorganic Chemistry - Waste Water	**LOR**	**Result**
Suspended Solids T0160-01 W09-023		
Suspended Solids	1.0	5 mg/L

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Analytical Results

Customer Sample Description	1 hour
Sampling Point	93309-DWLBC - Lock 6 Production Bore Unit Number 7030-710
Sampled Date	26/04/2008 12:00:00AM
Sample Received Date	28/04/2008 11:03:06AM
Sample ID	*2008-001-2641
Status	Endorsed
Collection Type	Customer Collected

Bacteriology	LOR	Result
Iron Bacteria - Heterotrophic T460-01 WMZ-500		
Iron Bacteria - Heterotrophic	10	<10 /mL
Iron Bacteria - Heterotrophic T460-05 WMZ-500		
Iron Bacteria - Microscopic examination		Microscopical examination of the sample did not detect iron associated microorganisms

Inorganic Chemistry - Metals	LOR	Result
Calcium TIC-001 W09-023		
Calcium	0.1	589 mg/L
Iron - Soluble TIC-004 W09-023		
Iron - Soluble	0.005	1.688 mg/L
Iron - Total TIC-004 W09-023		
Iron - Total	0.005	1.727 mg/L
Magnesium TIC-001 W09-023		
Magnesium	0.3	1380 mg/L
Manganese - Soluble TIC-004 W09-023		
Manganese - Soluble	0.001	0.026 mg/L
Manganese - Total TIC-004 W09-023		
Manganese - Total	0.001	0.026 mg/L
Potassium TIC-001 W09-023		
Potassium	1.0	161 mg/L
Sodium Adsorption Ratio W09-023		
Sodium Adsorption Ratio - Calculation		58.7
Sodium TIC-001 W09-023		
Sodium	0.5	11400 mg/L
Sulphur TIC-001 W09-023		
Sulphate	1.5	6270 mg/L
Total Hardness as CaCO3 W09-023		
Total Hardness as CaCO3	2.0	7150 mg/L

Inorganic Chemistry - Nutrients	LOR	Result
Ammonia as N T0100-01 W09-023		
Ammonia as N	0.005	0.224 mg/L
Chloride T0104-02 W09-023		
Chloride	4.0	18900 mg/L

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Analytical Results

Customer Sample Description	1
Sampling Point	93309-DWLBC - Lock 6 Production Bore Unit Number 7030-710
Sampled Date	26/04/2008 12:00:00AM
Sample Received Date	28/04/2008 11:03:06AM
Sample ID	*2008-001-2641
Status	Endorsed
Collection Type	Customer Collected

Fluoride W09-023		
Fluoride	0.10	1.9 mg/L
Nitrate + Nitrite as N T0161-01 W09-023		
Nitrate + Nitrite as N	0.005	<0.005 mg/L
Nitrogen - Total W09-023		
Nitrogen - Total	0.05	0.22 mg/L
Phosphorus - Filterable Reactive as P T0108-01 W09-023		
Phosphorus - Filterable Reactive as P	0.005	0.050 mg/L
Phosphorus - Total T0109-01 W09-023		
Phosphorus - Total	0.005	0.059 mg/L
TKN as N T0112-01 W09-023		
TKN as Nitrogen	0.05	0.18 mg/L

Organic Chemistry	**LOR**	**Result**
Dissolved Organic Carbon T0158-09 W09-023		
Dissolved Organic Carbon	0.3	0.9 mg/L

Inorganic Chemistry - Physical	**LOR**	**Result**
Alkalinity Carbonate Bicarbonate and Hydroxide T0101-01 W09-023		
Alkalinity as Calcium Carbonate		246 mg/L
Bicarbonate		300 mg/L
Carbonate		0 mg/L
Hydroxide		0 mg/L
Turbidity T0018-01 W09-023		
Turbidity	0.1	6.6 NTU

Inorganic Chemistry - Waste Water	**LOR**	**Result**
Suspended Solids T0160-01 W09-023		
Suspended Solids	1.0	10 mg/L
Volatile Suspended Solids W09-023		
Volatile Suspended Solids	1	2 mg/L

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Analytical Results

Customer Sample Description	3 hours
Sampling Point	93309-DWLBC - Lock 6 Production Bore Unit Number 7030-710
Sampled Date	26/04/2008 12:00:00AM
Sample Received Date	28/04/2008 11:02:57AM
Sample ID	*2008-001-2642
Status	Endorsed
Collection Type	Customer Collected

Bacteriology	LOR	Result
Iron Bacteria - Heterotrophic T460-01 WMZ-500		
Iron Bacteria - Heterotrophic	10	<10 /mL
Iron Bacteria - Heterotrophic T460-05 WMZ-500		
Iron Bacteria - Microscopic examination		Microscopical examination of the sample did not detect iron associated microorganisms

Inorganic Chemistry - Metals	LOR	Result
Calcium TIC-001 W09-023		
Calcium	0.1	594 mg/L
Iron - Soluble TIC-004 W09-023		
Iron - Soluble	0.005	1.719 mg/L
Iron - Total TIC-004 W09-023		
Iron - Total	0.005	1.756 mg/L
Magnesium TIC-001 W09-023		
Magnesium	0.3	1390 mg/L
Manganese - Soluble TIC-004 W09-023		
Manganese - Soluble	0.001	0.028 mg/L
Manganese - Total TIC-004 W09-023		
Manganese - Total	0.001	0.027 mg/L
Potassium TIC-001 W09-023		
Potassium	1.0	162 mg/L
Sodium Adsorption Ratio W09-023		
Sodium Adsorption Ratio - Calculation		57.9
Sodium TIC-001 W09-023		
Sodium	0.5	11300 mg/L
Sulphur TIC-001 W09-023		
Sulphate	1.5	6330 mg/L
Total Hardness as CaCO3 W09-023		
Total Hardness as CaCO3	2.0	7210 mg/L

Inorganic Chemistry - Nutrients	LOR	Result
Ammonia as N T0100-01 W09-023		
Ammonia as N	0.005	0.217 mg/L
Chloride T0104-02 W09-023		
Chloride	4.0	17700 mg/L

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Analytical Results

Customer Sample Description	3
Sampling Point	93309-DWLBC - Lock 6 Production Bore Unit Number 7030-710
Sampled Date	26/04/2008 12:00:00AM
Sample Received Date	28/04/2008 11:02:57AM
Sample ID	*2008-001-2642
Status	Endorsed
Collection Type	Customer Collected

Fluoride W09-023		
Fluoride	0.10	1.9 mg/L
Nitrate + Nitrite as N T0161-01 W09-023		
Nitrate + Nitrite as N	0.005	<0.005 mg/L
Nitrogen - Total W09-023		
Nitrogen - Total	0.05	0.24 mg/L
Phosphorus - Filterable Reactive as P T0108-01 W09-023		
Phosphorus - Filterable Reactive as P	0.005	0.050 mg/L
Phosphorus - Total T0109-01 W09-023		
Phosphorus - Total	0.005	0.062 mg/L
TKN as N T0112-01 W09-023		
TKN as Nitrogen	0.05	0.24 mg/L

Organic Chemistry	LOR	Result
Dissolved Organic Carbon T0158-09 W09-023		
Dissolved Organic Carbon	0.3	0.8 mg/L

Inorganic Chemistry - Physical	LOR	Result
Alkalinity Carbonate Bicarbonate and Hydroxide T0101-01 W09-023		
Alkalinity as Calcium Carbonate		246 mg/L
Bicarbonate		300 mg/L
Carbonate		0 mg/L
Hydroxide		0 mg/L
Turbidity T0018-01 W09-023		
Turbidity	0.1	6.3 NTU

Inorganic Chemistry - Waste Water	LOR	Result
Suspended Solids T0160-01 W09-023		
Suspended Solids	1.0	9 mg/L
Volatile Suspended Solids W09-023		
Volatile Suspended Solids	1	2 mg/L

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Analytical Results

Customer Sample Description	6 hours
Sampling Point	93309-DWLBC - Lock 6 Production Bore Unit Number 7030-710
Sampled Date	26/04/2008 12:00:00AM
Sample Received Date	28/04/2008 11:02:43AM
Sample ID	*2008-001-2643
Status	Endorsed
Collection Type	Customer Collected

Bacteriology	LOR	Result
Iron Bacteria - Heterotrophic T460-01 WMZ-500		
Iron Bacteria - Heterotrophic	10	<10 /mL
Iron Bacteria - Heterotrophic T460-05 WMZ-500		
Iron Bacteria - Microscopic examination		Microscopical examination of the sample did not detect iron associated microorganisms

Inorganic Chemistry - Metals	LOR	Result
Calcium TIC-001 W09-023		
Calcium	0.1	589 mg/L
Iron - Soluble TIC-004 W09-023		
Iron - Soluble	0.005	1.734 mg/L
Iron - Total TIC-004 W09-023		
Iron - Total	0.005	1.790 mg/L
Magnesium TIC-001 W09-023		
Magnesium	0.3	1380 mg/L
Manganese - Soluble TIC-004 W09-023		
Manganese - Soluble	0.001	0.028 mg/L
Manganese - Total TIC-004 W09-023		
Manganese - Total	0.001	0.028 mg/L
Potassium TIC-001 W09-023		
Potassium	1.0	161 mg/L
Sodium Adsorption Ratio W09-023		
Sodium Adsorption Ratio - Calculation		59.2
Sodium TIC-001 W09-023		
Sodium	0.5	11500 mg/L
Sulphur TIC-001 W09-023		
Sulphate	1.5	6240 mg/L
Total Hardness as CaCO3 W09-023		
Total Hardness as CaCO3	2.0	7150 mg/L

Inorganic Chemistry - Nutrients	LOR	Result
Ammonia as N T0100-01 W09-023		
Ammonia as N	0.005	0.222 mg/L
Chloride T0104-02 W09-023		
Chloride	4.0	17200 mg/L

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Analytical Results

Customer Sample Description	6
Sampling Point	93309-DWLBC - Lock 6 Production Bore Unit Number 7030-710
Sampled Date	26/04/2008 12:00:00AM
Sample Received Date	28/04/2008 11:02:43AM
Sample ID	*2008-001-2643
Status	Endorsed
Collection Type	Customer Collected

Fluoride W09-023		
Fluoride	0.10	1.9 mg/L
Nitrate + Nitrite as N T0161-01 W09-023		
Nitrate + Nitrite as N	0.005	<0.005 mg/L
Nitrogen - Total W09-023		
Nitrogen - Total	0.05	0.22 mg/L
Phosphorus - Filterable Reactive as P T0108-01 W09-023		
Phosphorus - Filterable Reactive as P	0.005	0.042 mg/L
Phosphorus - Total T0109-01 W09-023		
Phosphorus - Total	0.005	0.059 mg/L
TKN as N T0112-01 W09-023		
TKN as Nitrogen	0.05	0.20 mg/L

Organic Chemistry	LOR	Result
Dissolved Organic Carbon T0158-09 W09-023		
Dissolved Organic Carbon	0.3	0.8 mg/L

Inorganic Chemistry - Physical	LOR	Result
Alkalinity Carbonate Bicarbonate and Hydroxide T0101-01 W09-023		
Alkalinity as Calcium Carbonate		246 mg/L
Bicarbonate		300 mg/L
Carbonate		0 mg/L
Hydroxide		0 mg/L
Turbidity T0018-01 W09-023		
Turbidity	0.1	7.6 NTU

Inorganic Chemistry - Waste Water	LOR	Result
Suspended Solids T0160-01 W09-023		
Suspended Solids	1.0	17 mg/L
Volatile Suspended Solids W09-023		
Volatile Suspended Solids	1	3 mg/L

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Analytical Results

Customer Sample Description	10 hours
Sampling Point	93309-DWLBC - Lock 6 Production Bore Unit Number 7030-710
Sampled Date	26/04/2008 12:00:00AM
Sample Received Date	28/04/2008 11:02:45AM
Sample ID	*2008-001-2648
Status	Endorsed
Collection Type	Customer Collected

Bacteriology	LOR	Result
Iron Bacteria - Heterotrophic T460-01 WMZ-500		
Iron Bacteria - Heterotrophic	10	<10 /mL
Iron Bacteria - Heterotrophic T460-05 WMZ-500		
Iron Bacteria - Microscopic examination		Microscopical examination of the sample did not detect iron associated microorganisms

Inorganic Chemistry - Metals	LOR	Result
Calcium TIC-001 W09-023		
Calcium	0.1	590 mg/L
Iron - Soluble TIC-004 W09-023		
Iron - Soluble	0.005	1.730 mg/L
Iron - Total TIC-004 W09-023		
Iron - Total	0.005	1.811 mg/L
Magnesium TIC-001 W09-023		
Magnesium	0.3	1380 mg/L
Manganese - Soluble TIC-004 W09-023		
Manganese - Soluble	0.001	0.029 mg/L
Manganese - Total TIC-004 W09-023		
Manganese - Total	0.001	0.029 mg/L
Potassium TIC-001 W09-023		
Potassium	1.0	161 mg/L
Sodium Adsorption Ratio W09-023		
Sodium Adsorption Ratio - Calculation		57.6
Sodium TIC-001 W09-023		
Sodium	0.5	11200 mg/L
Sulphur TIC-001 W09-023		
Sulphate	1.5	6300 mg/L
Total Hardness as CaCO3 W09-023		
Total Hardness as CaCO3	2.0	7160 mg/L

Inorganic Chemistry - Nutrients	LOR	Result
Ammonia as N T0100-01 W09-023		
Ammonia as N	0.005	0.229 mg/L
Chloride T0104-02 W09-023		
Chloride	4.0	17400 mg/L

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Analytical Results

Customer Sample Description	10
Sampling Point	93309-DWLBC - Lock 6 Production Bore Unit Number 7030-710
Sampled Date	26/04/2008 12:00:00AM
Sample Received Date	28/04/2008 11:02:45AM
Sample ID	*2008-001-2648
Status	Endorsed
Collection Type	Customer Collected

Fluoride W09-023		
Fluoride	0.10	1.9 mg/L
Nitrate + Nitrite as N T0161-01 W09-023		
Nitrate + Nitrite as N	0.005	<0.005 mg/L
Nitrogen - Total W09-023		
Nitrogen - Total	0.05	0.30 mg/L
Phosphorus - Filterable Reactive as P T0108-01 W09-023		
Phosphorus - Filterable Reactive as P	0.005	0.045 mg/L
Phosphorus - Total T0109-01 W09-023		
Phosphorus - Total	0.005	0.064 mg/L
TKN as N T0112-01 W09-023		
TKN as Nitrogen	0.05	0.29 mg/L

Organic Chemistry	**LOR**	**Result**
Dissolved Organic Carbon T0158-09 W09-023		
Dissolved Organic Carbon	0.3	0.8 mg/L

Inorganic Chemistry - Physical	**LOR**	**Result**
Alkalinity Carbonate Bicarbonate and Hydroxide T0101-01 W09-023		
Alkalinity as Calcium Carbonate		246 mg/L
Bicarbonate		300 mg/L
Carbonate		0 mg/L
Hydroxide		0 mg/L
Turbidity T0018-01 W09-023		
Turbidity	0.1	9.1 NTU

Inorganic Chemistry - Waste Water	**LOR**	**Result**
Suspended Solids T0160-01 W09-023		
Suspended Solids	1.0	9 mg/L
Volatile Suspended Solids W09-023		
Volatile Suspended Solids	1	2 mg/L

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Analytical Results

Customer Sample Description	15 hours
Sampling Point	93309-DWLBC - Lock 6 Production Bore Unit Number 7030-710
Sampled Date	26/04/2008 12:00:00AM
Sample Received Date	28/04/2008 11:02:33AM
Sample ID	*2008-001-2640
Status	Endorsed
Collection Type	Customer Collected

Bacteriology	LOR	Result
Iron Bacteria - Heterotrophic T460-01 WMZ-500		
Iron Bacteria - Heterotrophic	10	<10 /mL
Iron Bacteria - Heterotrophic T460-05 WMZ-500		
Iron Bacteria - Microscopic examination		Microscopical examination of the sample did not detect iron associated microorganisms

Inorganic Chemistry - Metals	LOR	Result
Calcium TIC-001 W09-023		
Calcium	0.1	581 mg/L
Iron - Soluble TIC-004 W09-023		
Iron - Soluble	0.005	1.816 mg/L
Iron - Total TIC-004 W09-023		
Iron - Total	0.005	1.853 mg/L
Magnesium TIC-001 W09-023		
Magnesium	0.3	1370 mg/L
Manganese - Soluble TIC-004 W09-023		
Manganese - Soluble	0.001	0.030 mg/L
Manganese - Total TIC-004 W09-023		
Manganese - Total	0.001	0.030 mg/L
Potassium TIC-001 W09-023		
Potassium	1.0	159 mg/L
Sodium Adsorption Ratio W09-023		
Sodium Adsorption Ratio - Calculation		58.9
Sodium TIC-001 W09-023		
Sodium	0.5	11400 mg/L
Sulphur TIC-001 W09-023		
Sulphate	1.5	6210 mg/L
Total Hardness as CaCO3 W09-023		
Total Hardness as CaCO3	2.0	7090 mg/L

Inorganic Chemistry - Nutrients	LOR	Result
Ammonia as N T0100-01 W09-023		
Ammonia as N	0.005	0.219 mg/L
Chloride T0104-02 W09-023		
Chloride	4.0	18100 mg/L

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Analytical Results

Customer Sample Description	15
Sampling Point	93309-DWLBC - Lock 6 Production Bore Unit Number 7030-710
Sampled Date	26/04/2008 12:00:00AM
Sample Received Date	28/04/2008 11:02:33AM
Sample ID	*2008-001-2649
Status	Endorsed
Collection Type	Customer Collected

	LOR	Result
Fluoride W09-023		
Fluoride	0.10	1.9 mg/L
Nitrate + Nitrite as N T0161-01 W09-023		
Nitrate + Nitrite as N	0.005	<0.005 mg/L
Nitrogen - Total W09-023		
Nitrogen - Total	0.05	0.22 mg/L
Phosphorus - Filterable Reactive as P T0108-01 W09-023		
Phosphorus - Filterable Reactive as P	0.005	0.053 mg/L
Phosphorus - Total T0109-01 W09-023		
Phosphorus - Total	0.005	0.062 mg/L
TKN as N T0112-01 W09-023		
TKN as Nitrogen	0.05	0.19 mg/L

Organic Chemistry	LOR	Result
Dissolved Organic Carbon T0158-09 W09-023		
Dissolved Organic Carbon	0.3	0.8 mg/L

Inorganic Chemistry - Physical	LOR	Result
Alkalinity Carbonate Bicarbonate and Hydroxide T0101-01 W09-023		
Alkalinity as Calcium Carbonate		246 mg/L
Bicarbonate		300 mg/L
Carbonate		0 mg/L
Hydroxide		0 mg/L
Turbidity T0018-01 W09-023		
Turbidity	0.1	5.5 NTU

Inorganic Chemistry - Waste Water	LOR	Result
Suspended Solids T0160-01 W09-023		
Suspended Solids	1.0	7 mg/L
Volatile Suspended Solids W09-023		
Volatile Suspended Solids	1	2 mg/L

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FINAL REPORT: 36182

Analytical Results

Customer Sample Description	20 hours
Sampling Point	93309-DWLBC - Lock 6 Production Bore Unit Number 7030-710
Sampled Date	26/04/2008 12:00:00AM
Sample Received Date	28/04/2008 11:02:59AM
Sample ID	*2008-001-2650
Status	Endorsed
Collection Type	Customer Collected

Bacteriology	LOR	Result
Iron Bacteria - Heterotrophic T460-01 WMZ-500		
Iron Bacteria - Heterotrophic	10	<10 /mL
Iron Bacteria - Heterotrophic T460-05 WMZ-500		
Iron Bacteria - Microscopic examination		Microscopical examination of the sample did not detect iron associated microorganisms

Inorganic Chemistry - Metals	LOR	Result
Calcium TIC-001 W09-023		
Calcium	0.1	589 mg/L
Iron - Soluble TIC-004 W09-023		
Iron - Soluble	0.005	1.777 mg/L
Iron - Total TIC-004 W09-023		
Iron - Total	0.005	1.849 mg/L
Magnesium TIC-001 W09-023		
Magnesium	0.3	1390 mg/L
Manganese - Soluble TIC-004 W09-023		
Manganese - Soluble	0.001	0.031 mg/L
Manganese - Total TIC-004 W09-023		
Manganese - Total	0.001	0.031 mg/L
Potassium TIC-001 W09-023		
Potassium	1.0	161 mg/L
Sodium Adsorption Ratio W09-023		
Sodium Adsorption Ratio - Calculation		58.5
Sodium TIC-001 W09-023		
Sodium	0.5	11400 mg/L
Sulphur TIC-001 W09-023		
Sulphate	1.5	6270 mg/L
Total Hardness as CaCO3 W09-023		
Total Hardness as CaCO3	2.0	7190 mg/L

Inorganic Chemistry - Nutrients	LOR	Result
Ammonia as N T0100-01 W09-023		
Ammonia as N	0.005	0.218 mg/L
Chloride T0104-02 W09-023		
Chloride	4.0	18100 mg/L

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Analytical Results

Customer Sample Description	20
Sampling Point	93309-DWLBC - Lock 6 Production Bore Unit Number 7030-710
Sampled Date	26/04/2008 12:00:00AM
Sample Received Date	28/04/2008 11:02:59AM
Sample ID	*2008-001-2650
Status	Endorsed
Collection Type	Customer Collected

	LOR	Result
Fluoride W09-023		
Fluoride	0.10	1.9 mg/L
Nitrate + Nitrite as N T0161-01 W09-023		
Nitrate + Nitrite as N	0.005	<0.005 mg/L
Nitrogen - Total W09-023		
Nitrogen - Total	0.05	0.22 mg/L
Phosphorus - Filterable Reactive as P T0108-01 W09-023		
Phosphorus - Filterable Reactive as P	0.005	0.054 mg/L
Phosphorus - Total T0109-01 W09-023		
Phosphorus - Total	0.005	0.067 mg/L
TKN as N T0112-01 W09-023		
TKN as Nitrogen	0.05	0.16 mg/L

Organic Chemistry	**LOR**	**Result**
Dissolved Organic Carbon T0158-09 W09-023		
Dissolved Organic Carbon	0.3	0.7 mg/L

Inorganic Chemistry - Physical	**LOR**	**Result**
Alkalinity Carbonate Bicarbonate and Hydroxide T0101-01 W09-023		
Alkalinity as Calcium Carbonate		246 mg/L
Bicarbonate		300 mg/L
Carbonate		0 mg/L
Hydroxide		0 mg/L
Turbidity T0018-01 W09-023		
Turbidity	0.1	6.0 NTU

Inorganic Chemistry - Waste Water	**LOR**	**Result**
Suspended Solids T0160-01 W09-023		
Suspended Solids	1.0	9 mg/L
Volatile Suspended Solids W09-023		
Volatile Suspended Solids	1	2 mg/L

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Analytical Results

Customer Sample Description	30 hours
Sampling Point	93309-DWLBC - Lock 6 Production Bore Unit Number 7030-710
Sampled Date	26/04/2008 12:00:00AM
Sample Received Date	28/04/2008 11:02:48AM
Sample ID	*2008-001-2651
Status	Endorsed
Collection Type	Customer Collected

Bacteriology	LOR	Result
Iron Bacteria - Heterotrophic T460-01 WMZ-500		
Iron Bacteria - Heterotrophic	10	<10 /mL
Iron Bacteria - Heterotrophic T460-05 WMZ-500		
Iron Bacteria - Microscopic examination		Microscopical examination of the sample did not detect iron associated microorganisms

Inorganic Chemistry - Metals	LOR	Result
Calcium TIC-001 W09-023		
Calcium	0.1	578 mg/L
Iron - Soluble TIC-004 W09-023		
Iron - Soluble	0.005	1.776 mg/L
Iron - Total TIC-004 W09-023		
Iron - Total	0.005	1.859 mg/L
Magnesium TIC-001 W09-023		
Magnesium	0.3	1360 mg/L
Manganese - Soluble TIC-004 W09-023		
Manganese - Soluble	0.001	0.032 mg/L
Manganese - Total TIC-004 W09-023		
Manganese - Total	0.001	0.032 mg/L
Potassium TIC-001 W09-023		
Potassium	1.0	159 mg/L
Sodium Adsorption Ratio W09-023		
Sodium Adsorption Ratio - Calculation		58.6
Sodium TIC-001 W09-023		
Sodium	0.5	11300 mg/L
Sulphur TIC-001 W09-023		
Sulphate	1.5	6180 mg/L
Total Hardness as CaCO3 W09-023		
Total Hardness as CaCO3	2.0	7040 mg/L

Inorganic Chemistry - Nutrients	LOR	Result
Ammonia as N T0100-01 W09-023		
Ammonia as N	0.005	0.222 mg/L
Chloride T0104-02 W09-023		
Chloride	4.0	17000 mg/L

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Analytical Results

Customer Sample Description	30
Sampling Point	93309-DWLBC - Lock 6 Production Bore Unit Number 7030-710
Sampled Date	26/04/2008 12:00:00AM
Sample Received Date	28/04/2008 11:02:48AM
Sample ID	*2008-001-2651
Status	Endorsed
Collection Type	Customer Collected

	LOR	Result
Fluoride W09-023		
Fluoride	0.10	1.9 mg/L
Nitrate + Nitrite as N T0161-01 W09-023		
Nitrate + Nitrite as N	0.005	<0.005 mg/L
Nitrogen - Total W09-023		
Nitrogen - Total	0.05	0.22 mg/L
Phosphorus - Filterable Reactive as P T0108-01 W09-023		
Phosphorus - Filterable Reactive as P	0.005	0.044 mg/L
Phosphorus Total T0109-01 W09-023		
Phosphorus - Total	0.005	0.058 mg/L
TKN as N T0112-01 W09-023		
TKN as Nitrogen	0.05	0.22 mg/L

Organic Chemistry	LOR	Result
Dissolved Organic Carbon T0158-09 W09-023		
Dissolved Organic Carbon	0.3	0.8 mg/L

Inorganic Chemistry - Physical	LOR	Result
Alkalinity Carbonate Bicarbonate and Hydroxide T0101-01 W09-023		
Alkalinity as Calcium Carbonate		246 mg/L
Bicarbonate		300 mg/L
Carbonate		0 mg/L
Hydroxide		0 mg/L
Turbidity T0018-01 W09-023		
Turbidity	0.1	6.7 NTU

Inorganic Chemistry - Waste Water	LOR	Result
Suspended Solids T0160-01 W09-023		
Suspended Solids	1.0	9 mg/L
Volatile Suspended Solids W09-023		
Volatile Suspended Solids	1	2 mg/L

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Analytical Results

Customer Sample Description	35 hours
Sampling Point	93309-DWLBC - Lock 6 Production Bore Unit Number 7030-710
Sampled Date	26/04/2008 12:00:00AM
Sample Received Date	28/04/2008 11:03:03AM
Sample ID	*2008-001-2652
Status	Endorsed
Collection Type	Customer Collected

Bacteriology	**LOR**	**Result**
Iron Bacteria - Heterotrophic T460-01 WMZ-500		
Iron Bacteria - Heterotrophic	10	<10 /mL
Iron Bacteria - Heterotrophic T460-05 WMZ-500		
Iron Bacteria - Microscopic examination		Microscopical examination of the sample did not detect iron associated microorganisms

Inorganic Chemistry - Metals	**LOR**	**Result**
Calcium TIC-001 W09-023		
Calcium	0.1	585 mg/L
Iron - Soluble TIC-004 W09-023		
Iron - Soluble	0.005	1.789 mg/L
Iron - Total TIC-004 W09-023		
Iron - Total	0.005	1.812 mg/L
Magnesium TIC-001 W09-023		
Magnesium	0.3	1370 mg/L
Manganese - Soluble TIC-004 W09-023		
Manganese - Soluble	0.001	0.033 mg/L
Manganese - Total TIC-004 W09-023		
Manganese - Total	0.001	0.032 mg/L
Potassium TIC-001 W09-023		
Potassium	1.0	161 mg/L
Sodium Adsorption Ratio W09-023		
Sodium Adsorption Ratio - Calculation		57.8
Sodium TIC-001 W09-023		
Sodium	0.5	11200 mg/L
Sulphur TIC-001 W09-023		
Sulphate	1.5	6210 mg/L
Total Hardness as CaCO3 W09-023		
Total Hardness as CaCO3	2.0	7100 mg/L

Inorganic Chemistry - Nutrients	**LOR**	**Result**
Ammonia as N T0100-01 W09-023		
Ammonia as N	0.005	0.221 mg/L
Chloride T0104-02 W09-023		
Chloride	4.0	18400 mg/L

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Analytical Results

Customer Sample Description	35
Sampling Point	93309-DWLBC - Lock 6 Production Bore Unit Number 7030-710
Sampled Date	26/04/2008 12:00:00AM
Sample Received Date	28/04/2008 11:03:03AM
Sample ID	*2008-001-2652
Status	Endorsed
Collection Type	Customer Collected

Fluoride W09-023		
Fluoride	0.10	1.9 mg/L
Nitrate + Nitrite as N T0161-01 W09-023		
Nitrate + Nitrite as N	0.005	<0.005 mg/L
Nitrogen - Total W09-023		
Nitrogen - Total	0.05	0.22 mg/L
Phosphorus - Filterable Reactive as P T0108-01 W09-023		
Phosphorus - Filterable Reactive as P	0.005	0.048 mg/L
Phosphorus - Total T0109-01 W09-023		
Phosphorus - Total	0.005	0.062 mg/L
TKN as N T0112-01 W09-023		
TKN as Nitrogen	0.05	0.19 mg/L

Organic Chemistry	LOR	Result
Dissolved Organic Carbon T0158-09 W09-023		
Dissolved Organic Carbon	0.3	0.8 mg/L

Inorganic Chemistry - Physical	LOR	Result
Alkalinity Carbonate Bicarbonate and Hydroxide T0101-01 W09-023		
Alkalinity as Calcium Carbonate		246 mg/L
Bicarbonate		301 mg/L
Carbonate		0 mg/L
Hydroxide		0 mg/L
Turbidity T0018-01 W09-023		
Turbidity	0.1	7.1 NTU

Inorganic Chemistry - Waste Water	LOR	Result
Suspended Solids T0160-01 W09-023		
Suspended Solids	1.0	18 mg/L
Volatile Suspended Solids W09-023		
Volatile Suspended Solids	1	2 mg/L

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Analytical Results

Customer Sample Description	40 hours
Sampling Point	93309-DWLBC - Lock 6 Production Bore Unit Number 7030-710
Sampled Date	26/04/2008 12:00:00AM
Sample Received Date	28/04/2008 11:02:35AM
Sample ID	*2008-001-2653
Status	Endorsed
Collection Type	Customer Collected

Bacteriology	LOR	Result
Iron Bacteria - Heterotrophic T460-01 WMZ-500		
Iron Bacteria - Heterotrophic	10	30 /mL
Iron Bacteria - Heterotrophic T460-05 WMZ-500		
Iron Bacteria - Microscopic examination		Microscopical examination of the sample did not detect iron associated microorganisms

Inorganic Chemistry - Metals	LOR	Result
Calcium TIC-001 W09-023		
Calcium	0.1	575 mg/L
Iron - Soluble TIC-004 W09-023		
Iron - Soluble	0.005	1.851 mg/L
Iron - Total TIC-004 W09-023		
Iron - Total	0.005	1.875 mg/L
Magnesium TIC-001 W09-023		
Magnesium	0.3	1350 mg/L
Manganese - Soluble TIC-004 W09-023		
Manganese - Soluble	0.001	0.033 mg/L
Manganese - Total TIC-004 W09-023		
Manganese - Total	0.001	0.034 mg/L
Potassium TIC-001 W09-023		
Potassium	1.0	158 mg/L
Sodium Adsorption Ratio W09-023		
Sodium Adsorption Ratio - Calculation		58.8
Sodium TIC-001 W09-023		
Sodium	0.5	11300 mg/L
Sulphur TIC-001 W09-023		
Sulphate	1.5	6090 mg/L
Total Hardness as CaCO3 W09-023		
Total Hardness as CaCO3	2.0	7000 mg/L

Inorganic Chemistry - Nutrients	LOR	Result
Ammonia as N T0100-01 W09-023		
Ammonia as N	0.005	0.218 mg/L
Chloride T0104-02 W09-023		
Chloride	4.0	17700 mg/L

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Analytical Results

Customer Sample Description	40
Sampling Point	93309-DWLBC - Lock 6 Production Bore Unit Number 7030-710
Sampled Date	26/04/2008 12:00:00AM
Sample Received Date	28/04/2008 11:02:35AM
Sample ID	*2008-001-2853
Status	Endorsed
Collection Type	Customer Collected

Fluoride W09-023		
Fluoride	0.10	1.9 mg/L
Nitrate + Nitrite as N T0161-01 W09-023		
Nitrate + Nitrite as N	0.005	<0.005 mg/L
Nitrogen - Total W09-023		
Nitrogen - Total	0.05	0.22 mg/L
Phosphorus - Filterable Reactive as P T0108-01 W09-023		
Phosphorus - Filterable Reactive as P	0.005	0.055 mg/L
Phosphorus - Total T0109-01 W09-023		
Phosphorus - Total	0.005	0.066 mg/L
TKN as N T0112-01 W09-023		
TKN as Nitrogen	0.05	0.16 mg/L

Organic Chemistry	LOR	Result
Dissolved Organic Carbon T0158-09 W09-023		
Dissolved Organic Carbon	0.3	0.9 mg/L

Inorganic Chemistry - Physical	LOR	Result
Alkalinity Carbonate Bicarbonate and Hydroxide T0101-01 W09-023		
Alkalinity as Calcium Carbonate		246 mg/L
Bicarbonate		300 mg/L
Carbonate		0 mg/L
Hydroxide		0 mg/L
Turbidity T0018-01 W09-023		
Turbidity	0.1	5.4 NTU

Inorganic Chemistry - Waste Water	LOR	Result
Suspended Solids T0160-01 W09-023		
Suspended Solids	1.0	8 mg/L
Volatile Suspended Solids W09-023		
Volatile Suspended Solids	1	2 mg/L

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Analytical Results

Customer Sample Description	45 hours
Sampling Point	93309-DWLBC - Lock 6 Production Bore Unit Number /030-/10
Sampled Date	26/04/2008 12:00:00AM
Sample Received Date	28/04/2008 11:02:46AM
Sample ID	*2008-001-2654
Status	Endorsed
Collection Type	Customer Collected

Bacteriology	LOR	Result
Iron Bacteria - Heterotrophic T460-01 WMZ-500		
Iron Bacteria - Heterotrophic	10	<10 /mL
Iron Bacteria - Heterotrophic T460-05 WMZ-500		
Iron Bacteria - Microscopic examination		Microscopical examination of the sample did not detect iron associated microorganisms

Inorganic Chemistry - Metals	LOR	Result
Calcium TIC-001 W09-023		
Calcium	0.1	586 mg/L
Iron - Soluble TIC-004 W09-023		
Iron - Soluble	0.005	1.862 mg/L
Iron - Total TIC-004 W09-023		
Iron - Total	0.005	1.900 mg/L
Magnesium TIC-001 W09-023		
Magnesium	0.3	1370 mg/L
Manganese - Soluble TIC-004 W09-023		
Manganese - Soluble	0.001	0.034 mg/L
Manganese - Total TIC-004 W09-023		
Manganese - Total	0.001	0.034 mg/L
Potassium TIC-001 W09-023		
Potassium	1.0	160 mg/L
Sodium Adsorption Ratio W09-023		
Sodium Adsorption Ratio - Calculation		57.3
Sodium TIC-001 W09-023		
Sodium	0.5	11100 mg/L
Sulphur TIC-001 W09-023		
Sulphate	1.5	6240 mg/L
Total Hardness as CaCO3 W09-023		
Total Hardness as CaCO3	2.0	7100 mg/L

Inorganic Chemistry - Nutrients	LOR	Result
Ammonia as N T0100-01 W09-023		
Ammonia as N	0.005	0.225 mg/L
Chloride T0104-02 W09-023		
Chloride	4.0	18400 mg/L

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Corporate Accreditation No.1115
Chemical and Biological Testing
This document is issued in accordance with NATA's accreditation requirements.

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.

84180100

Private Mail Bag 3 Salisbury SA 5108 | Hodgson Road Bolivar SA 5110 | Tel: 1300 653 366 Fax: 61 8 8259 0228 | Internet: www.awqc.com.au Email: awqc@sawater.com.au

Australian Water Quality Centre

FINAL REPORT: 36182

Analytical Results

Customer Sample Description	45
Sampling Point	93309-DWLBC - Lock 6 Production Bore Unit Number 7030-710
Sampled Date	26/04/2008 12:00:00AM
Sample Received Date	28/04/2008 11:02:46AM
Sample ID	*2008-001-2654
Status	Endorsed
Collection Type	Customer Collected

	LOR	Result
Fluoride W09-023		
Fluoride	0.10	1.9 mg/L
Nitrate + Nitrite as N T0161-01 W09-023		
Nitrate + Nitrite as N	0.005	<0.005 mg/L
Nitrogen - Total W09-023		
Nitrogen - Total	0.05	0.22 mg/L
Phosphorus - Filterable Reactive as P T0108-01 W09-023		
Phosphorus - Filterable Reactive as P	0.005	0.053 mg/L
Phosphorus - Total T0109-01 W09-023		
Phosphorus - Total	0.005	0.066 mg/L
TKN as N T0112-01 W09-023		
TKN as Nitrogen	0.05	0.15 mg/L

Organic Chemistry	LOR	Result
Dissolved Organic Carbon T0158-09 W09-023		
Dissolved Organic Carbon	0.3	0.8 mg/L

Inorganic Chemistry - Physical	LOR	Result
Alkalinity Carbonate Bicarbonate and Hydroxide T0101-01 W09-023		
Alkalinity as Calcium Carbonate		246 mg/L
Bicarbonate		300 mg/L
Carbonate		0 mg/L
Hydroxide		0 mg/L
Turbidity T0018-01 W09-023		
Turbidity	0.1	5.3 NTU

Inorganic Chemistry - Waste Water	LOR	Result
Suspended Solids T0160-01 W09-023		
Suspended Solids	1.0	10 mg/L
Volatile Suspended Solids W09-023		
Volatile Suspended Solids	1	3 mg/L

NATA WORLD RECOGNISED ACCREDITATION

Corporate Accreditation No.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.

APPENDIX 4: PSD AND MFI RESULTS

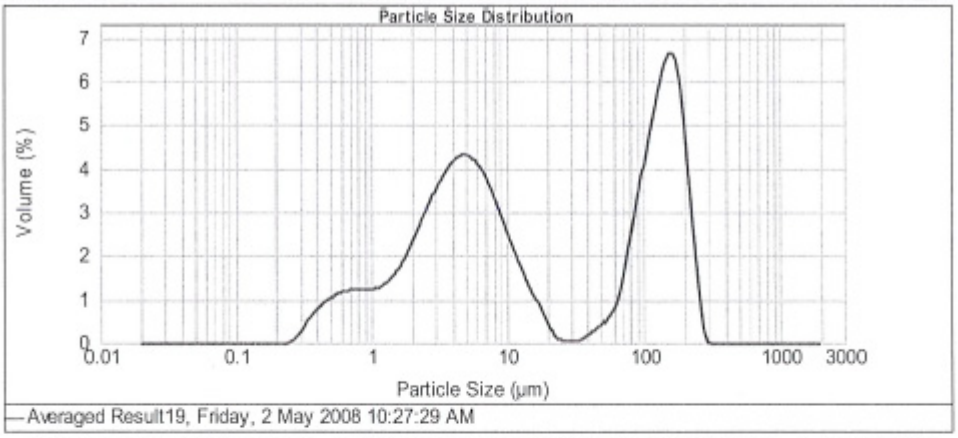
N.B: The name at the bottom of the graph represents the time and aquifer from which sampling was undertaken.

MASTERSIZER 2000

Result Analysis Report

Sample Name: Averaged Result19	**SOP Name:**	**Measured:** Friday, 2 May 2008 10:27:29 AM	
Sample Source & type: Supplier	**Measured by:** bar539	**Analysed:** Friday, 2 May 2008 10:27:31 AM	
Sample bulk lot ref:	**Result Source:** Averaged		
Particle Name: Kaolinite high	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Normal
Particle RI: 1.570	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 0.81 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 8.896 %	**Result Emulation:** Off
Concentration: 0.0005 %Vol	**Span :** 20.292	**Uniformity:** 6.55	**Result units:** Volume
Specific Surface Area: 1.73 m²/g	**Surface Weighted Mean D[3,2]:** 3.459 um	**Vol. Weighted Mean D[4,3]:** 59.727 um	

d(0.1): 1.294 um **d(0.5):** 8.574 um **d(0.9):** 175.282 um



Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	1.17	11.482	1.69	120.226	5.34	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.29	13.183	1.30	138.038	5.93	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	1.49	15.136	0.95	158.489	5.87	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	1.77	17.378	0.60	181.970	4.75	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	2.12	19.953	0.26	208.930	2.75	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	2.51	22.909	0.07	239.883	0.95	2511.886	0.00
0.023	0.00	0.240	0.03	2.512	2.80	26.303	0.04	275.423	0.02	2884.032	0.00
0.026	0.00	0.275	0.19	2.884	3.27	30.200	0.04	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.46	3.311	3.58	34.674	0.10	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.65	3.802	3.80	39.811	0.22	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.83	4.365	3.90	45.709	0.36	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.96	5.012	3.86	52.481	0.56	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	1.05	5.754	3.69	60.256	0.89	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	1.09	6.607	3.39	69.183	1.64	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	1.10	7.586	3.00	79.433	2.61	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	1.10	8.710	2.57	91.201	3.57	954.993	0.00	10000.000	
0.091	0.00	0.955	1.12	10.000	2.11	104.713	4.50	1096.478	0.00		
0.105		1.096		11.482		120.226		1258.925	0.00		

Operator notes: *Average of 19 measurements from dwlbc mon1.mea*

Malvern Instruments Ltd.
Malvern, UK

Mastersizer 2000 Ver. 5.22
Serial Number : MAL101764

File name: dwlbc mon1.mea
Record Number: 24

MASTERSIZER 2000

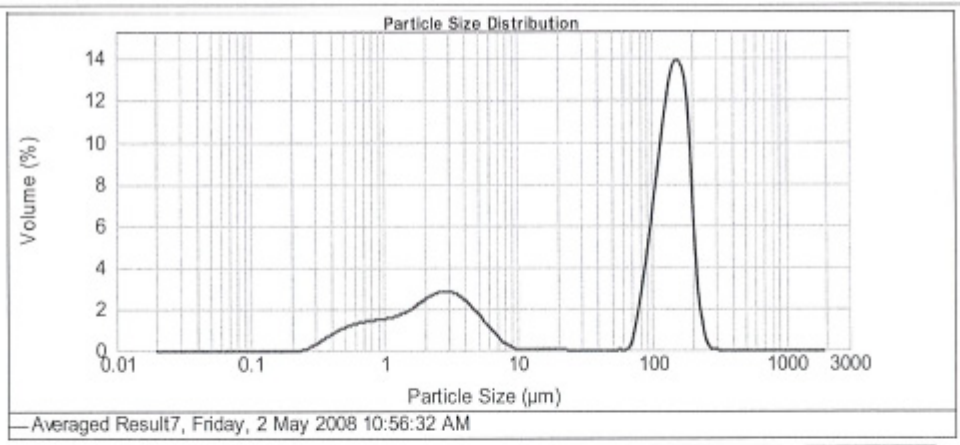
Result Analysis Report

Sample Name: Averaged Result7	**SOP Name:**	**Measured:** Friday, 2 May 2008 10:56:32 AM
Sample Source & type: Supplier	**Measured by:** bar539	**Analysed:** Friday, 2 May 2008 10:56:33 AM
Sample bulk lot ref:	**Result Source:** Averaged	

Particle Name: Kaolinite high	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Normal
Particle RI: 1.570	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 0.84 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 13.098 %	**Result Emulation:** Off

Concentration: 0.0005 %Vol	**Span :** 1.601	**Uniformity:** 0.564	**Result units:** Volume
Specific Surface Area: 1.61 m²/g	**Surface Weighted Mean D[3,2]:** 3.733 um	**Vol. Weighted Mean D[4,3]:** 92.979 um	

d(0.1): 1.158 um **d(0.5):** 112.513 um **d(0.9):** 181.240 um



Size (µm)	Volume In %
0.010	0.00
0.011	0.00
0.013	0.00
0.015	0.00
0.017	0.00
0.020	0.00
0.023	0.00
0.026	0.00
0.030	0.00
0.035	0.00
0.040	0.00
0.046	0.00
0.052	0.00
0.060	0.00
0.069	0.00
0.079	0.00
0.091	0.00
0.105	0.00

Size (µm)	Volume In %
0.105	0.00
0.120	0.00
0.138	0.00
0.158	0.00
0.182	0.00
0.209	0.00
0.240	0.03
0.275	0.19
0.316	0.43
0.363	0.63
0.417	0.83
0.479	0.99
0.550	1.13
0.631	1.22
0.724	1.28
0.832	1.32
0.955	1.37
1.096	1.37

Size (µm)	Volume In %
1.096	1.45
1.259	1.58
1.445	1.76
1.660	1.99
1.905	2.22
2.188	2.42
2.512	2.53
2.884	2.53
3.311	2.39
3.802	2.13
4.365	1.77
5.012	1.36
5.754	0.93
6.607	0.55
7.586	0.26
8.710	0.06
10.000	0.01
11.482	0.01

Size (µm)	Volume In %
11.482	0.01
13.183	0.03
15.136	0.03
17.378	0.03
19.953	0.01
22.909	0.00
26.303	0.00
30.200	0.00
34.674	0.00
39.811	0.00
45.709	0.00
52.481	0.00
60.256	0.02
69.183	1.20
79.433	3.30
91.201	5.83
104.713	8.65
120.226	

Size (µm)	Volume In %
120.226	11.22
138.038	12.58
158.489	12.03
181.970	7.58
208.930	1.93
239.883	0.15
275.423	0.00
316.228	0.00
363.078	0.00
416.869	0.00
478.630	0.00
549.541	0.00
630.957	0.00
724.436	0.00
831.764	0.00
954.993	0.00
1096.478	0.00
1258.925	

Size (µm)	Volume In %
1258.925	0.00
1445.440	0.00
1659.587	0.00
1905.461	0.00
2187.762	0.00
2511.886	0.00
2884.032	0.00
3311.311	0.00
3801.894	0.00
4365.158	0.00
5011.872	0.00
5754.399	0.00
6606.934	0.00
7585.776	0.00
8709.636	0.00
10000.000	

Operator notes: *Average of 7 measurements from dwlbc mon2.mea*

Malvern Instruments Ltd.
Malvern, UK

Mastersizer 2000 Ver. 5.22
Serial Number : MAL101764

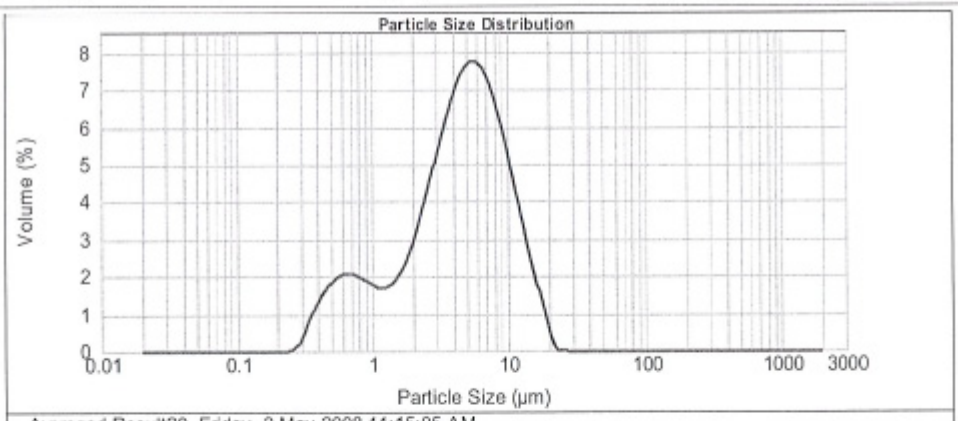
File name: dwlbc mon2.mea
Record Number: 23

MASTERSIZER 2000

Result Analysis Report

Sample Name: Averaged Result20	**SOP Name:**	**Measured:** Friday, 2 May 2008 11:15:05 AM	
Sample Source & type: Supplier	**Measured by:** bar539	**Analysed:** Friday, 2 May 2008 11:15:06 AM	
Sample bulk lot ref:	**Result Source:** Averaged		
Particle Name: Kaolinite high	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Normal
Particle RI: 1.570	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 1.68 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 4.294 %	**Result Emulation:** Off
Concentration: 0.0006 %Vol	**Span :** 2.263	**Uniformity:** 0.684	**Result units:** Volume
Specific Surface Area: 2.69 m²/g	**Surface Weighted Mean D[3,2]:** 2.231 um	**Vol. Weighted Mean D[4,3]:** 5.380 um	

d(0.1): 0.791 um **d(0.5):** 4.541 um **d(0.9):** 11.065 um



Size (µm)	Volume In %
0.010	0.00
0.011	0.00
0.013	0.00
0.015	0.00
0.017	0.00
0.020	0.00
0.023	0.00
0.026	0.00
0.030	0.00
0.035	0.00
0.040	0.00
0.046	0.00
0.052	0.00
0.060	0.00
0.069	0.00
0.079	0.00
0.091	0.00
0.105	0.00

Size (µm)	Volume In %
0.105	0.00
0.120	0.00
0.138	0.00
0.158	0.00
0.182	0.00
0.209	0.00
0.240	0.03
0.275	0.20
0.316	0.69
0.363	1.08
0.417	1.43
0.479	1.69
0.550	1.84
0.631	1.88
0.724	1.82
0.832	1.70
0.955	1.59
1.096	1.53

Size (µm)	Volume In %
1.096	1.53
1.259	1.56
1.445	1.76
1.660	2.15
1.905	2.69
2.188	3.37
2.512	4.13
2.884	4.93
3.311	5.68
3.802	6.32
4.365	6.78
5.012	7.00
5.754	6.94
6.607	6.61
7.586	6.02
8.710	5.26
10.000	4.36
11.482	3.46

Size (µm)	Volume In %
11.482	3.46
13.183	2.56
15.136	1.72
17.378	0.94
19.953	0.20
22.909	0.01
26.303	0.00
30.200	0.00
34.674	0.00
39.811	0.00
45.709	0.00
52.481	0.00
60.256	0.00
69.183	0.00
79.433	0.00
91.201	0.00
104.713	0.00
120.226	0.00

Size (µm)	Volume In %
120.226	0.00
138.038	0.00
158.489	0.00
181.970	0.00
208.930	0.00
239.883	0.00
275.423	0.00
316.228	0.00
363.078	0.00
416.869	0.00
478.630	0.00
549.541	0.00
630.957	0.00
724.436	0.00
831.764	0.00
954.993	0.00
1096.478	0.00
1258.925	0.00

Size (µm)	Volume In %
1258.925	0.00
1445.440	0.00
1659.587	0.00
1905.461	0.00
2187.762	0.00
2511.886	0.00
2884.032	0.00
3311.311	0.00
3801.894	0.00
4365.158	0.00
5011.872	0.00
5754.399	0.00
6606.934	0.00
7585.776	0.00
8709.636	0.00
10000.000	

Operator notes: *Average of 20 measurements from dwlbc mon3.mea*

Malvern Instruments Ltd.
Malvern, UK

Mastersizer 2000 Ver. 5.22
Serial Number : MAL101764

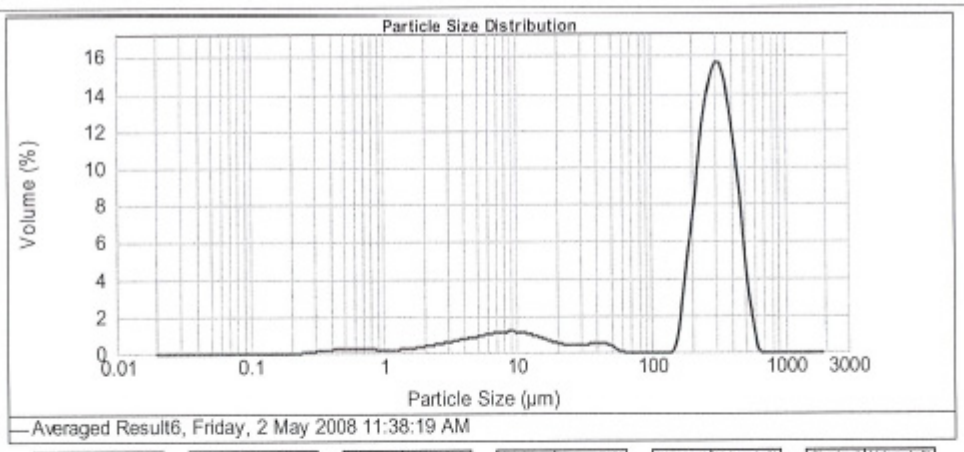
File name: dwlbc mon3.mea
Record Number: 21

MASTERSIZER 2000

Result Analysis Report

Sample Name: Averaged Result6	**SOP Name:**	**Measured:** Friday, 2 May 2008 11:38:19 AM	
Sample Source & type: Supplier	**Measured by:** bar539	**Analysed:** Friday, 2 May 2008 11:38:20 AM	
Sample bulk lot ref:	**Result Source:** Averaged		
Particle Name: Kaolinite high	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Normal
Particle RI: 1.570	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 1.54 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 16.427 %	**Result Emulation:** Off
Concentration: 0.0015 %Vol	**Span :** 1.514	**Uniformity:** 0.393	**Result units:** Volume
Specific Surface Area: 0.341 m²/g	**Surface Weighted Mean D[3,2]:** 17.598 um	**Vol. Weighted Mean D[4,3]:** 264.439 um	

d(0.1): 9.180 um **d(0.5):** 280.343 um **d(0.9):** 433.630 um



Size (µm)	Volume In %
0.010	0.00
0.011	0.00
0.013	0.00
0.015	0.00
0.017	0.00
0.020	0.00
0.023	0.00
0.026	0.00
0.030	0.00
0.035	0.00
0.040	0.00
0.046	0.00
0.052	0.00
0.060	0.00
0.069	0.00
0.079	0.00
0.091	0.00
0.105	0.00

Size (µm)	Volume In %
0.105	0.00
0.120	0.00
0.138	0.00
0.158	0.00
0.182	0.00
0.209	0.00
0.240	0.00
0.275	0.05
0.316	0.11
0.363	0.14
0.417	0.17
0.479	0.18
0.550	0.19
0.631	0.18
0.724	0.17
0.832	0.15
0.955	0.14
1.096	

Size (µm)	Volume In %
1.096	0.14
1.259	0.16
1.445	0.20
1.660	0.25
1.905	0.31
2.188	0.38
2.512	0.45
2.884	0.52
3.311	0.60
3.802	0.67
4.365	0.75
5.012	0.83
5.754	0.90
6.607	0.96
7.586	1.01
8.710	1.01
10.000	0.98
11.482	

Size (µm)	Volume In %
11.482	0.91
13.183	0.79
15.136	0.66
17.378	0.52
19.953	0.41
22.909	0.34
26.303	0.32
30.200	0.36
34.674	0.41
39.811	0.43
45.709	0.33
52.481	0.07
60.256	-0.00
69.183	-0.00
79.433	-0.00
91.201	-0.00
104.713	0.00
120.226	

Size (µm)	Volume In %
120.226	0.00
138.038	0.25
158.489	2.76
181.970	5.96
208.930	9.60
239.883	12.51
275.423	14.03
316.228	13.70
363.078	11.34
416.869	8.17
478.630	3.60
549.541	0.90
630.957	0.00
724.436	0.00
831.764	0.00
954.993	0.00
1096.478	0.00
1258.925	

Size (µm)	Volume In %
1258.925	0.00
1445.440	0.00
1659.587	0.00
1905.461	0.00
2187.762	0.00
2511.886	0.00
2884.032	0.00
3311.311	0.00
3801.894	0.00
4365.158	0.00
5011.872	0.00
5754.399	0.00
6606.934	0.00
7585.776	0.00
8709.636	0.00
10000.000	

Operator notes: *Average of 6 measurements from dwlbc mon4.mea*

Malvern Instruments Ltd.
Malvern, UK

Mastersizer 2000 Ver. 5.22
Serial Number : MAL101764

File name: dwlbc mon4.mea
Record Number: 22

MASTERSIZER 2000

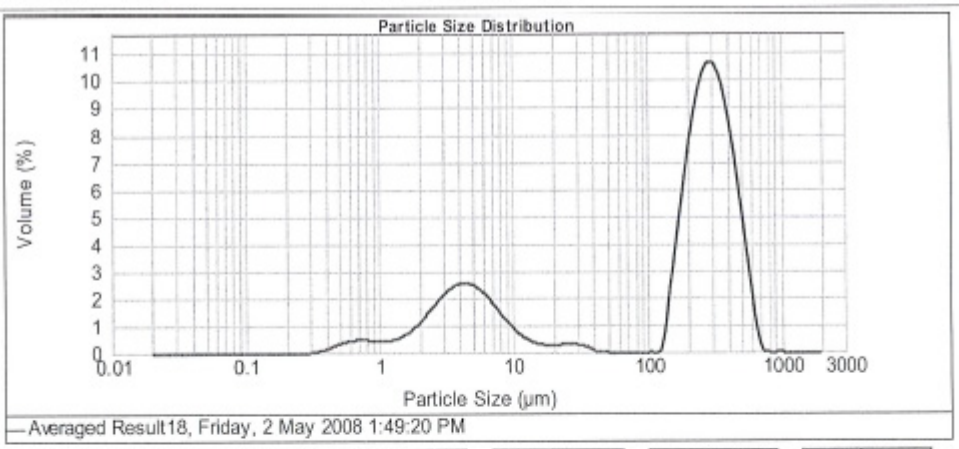
Result Analysis Report

Sample Name: Averaged Result18	**SOP Name:**	**Measured:** Friday, 2 May 2008 1:49:20 PM
Sample Source & type: Supplier	**Measured by:** bar539	**Analysed:** Friday, 2 May 2008 1:49:21 PM
Sample bulk lot ref:	**Result Source:** Averaged	

Particle Name: Kaolinite high	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Normal
Particle RI: 1.570	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 1.35 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 17.187 %	**Result Emulation:** Off

Concentration: 0.0017 %Vol	**Span :** 1.861	**Uniformity:** 0.589	**Result units:** Volume
Specific Surface Area: 0.679 m²/g	**Surface Weighted Mean D[3,2]:** 8.831 um	**Vol. Weighted Mean D[4,3]:** 222.764 um	

d(0.1): 3.090 um **d(0.5):** 235.446 um **d(0.9):** 441.215 um



Size (µm)	Volume In %
0.010	0.00
0.011	0.00
0.013	0.00
0.015	0.00
0.017	0.00
0.020	0.00
0.023	0.00
0.026	0.00
0.030	0.00
0.035	0.00
0.040	0.00
0.046	0.00
0.052	0.00
0.060	0.00
0.069	0.00
0.079	0.00
0.091	0.00
0.105	0.00

Size (µm)	Volume In %
0.105	0.00
0.120	0.00
0.138	0.00
0.158	0.00
0.182	0.00
0.209	0.00
0.240	0.00
0.275	0.00
0.316	0.02
0.363	0.11
0.417	0.21
0.479	0.32
0.550	0.39
0.631	0.42
0.724	0.43
0.832	0.41
0.955	0.40
1.096	0.41

Size (µm)	Volume In %
1.096	0.41
1.259	0.47
1.445	0.59
1.660	0.79
1.905	1.05
2.188	1.36
2.512	1.68
2.884	1.96
3.311	2.18
3.802	2.29
4.365	2.28
5.012	2.15
5.754	1.92
6.607	1.61
7.586	1.27
8.710	0.95
10.000	0.68
11.482	0.48

Size (µm)	Volume In %
11.482	0.48
13.183	0.34
15.136	0.27
17.378	0.25
19.953	0.25
22.909	0.27
26.303	0.28
30.200	0.24
34.674	0.14
39.811	0.02
45.709	0.00
52.481	0.00
60.256	0.00
69.183	0.00
79.433	0.00
91.201	0.00
104.713	0.00
120.226	0.00

Size (µm)	Volume In %
120.226	0.42
138.038	2.53
158.489	4.54
181.970	6.58
208.930	8.23
239.883	9.30
275.423	9.62
316.228	9.14
363.078	7.96
416.869	6.21
478.630	4.18
549.541	2.03
630.957	0.37
724.436	0.00
831.764	0.00
954.993	0.00
1096.478	0.00
1258.925	0.00

Size (µm)	Volume In %
1258.925	0.00
1445.440	0.00
1659.587	0.00
1905.461	0.00
2187.762	0.00
2511.886	0.00
2884.032	0.00
3311.311	0.00
3801.894	0.00
4365.158	0.00
5011.872	0.00
5754.399	0.00
6606.934	0.00
7585.776	0.00
8709.636	0.00
10000.000	0.00

Operator notes: *Average of 18 measurements from dwlbc mon5.msa*

Malvern Instruments Ltd.
Malvern, UK

Mastersizer 2000 Ver. 5.22
Serial Number : MAL101764

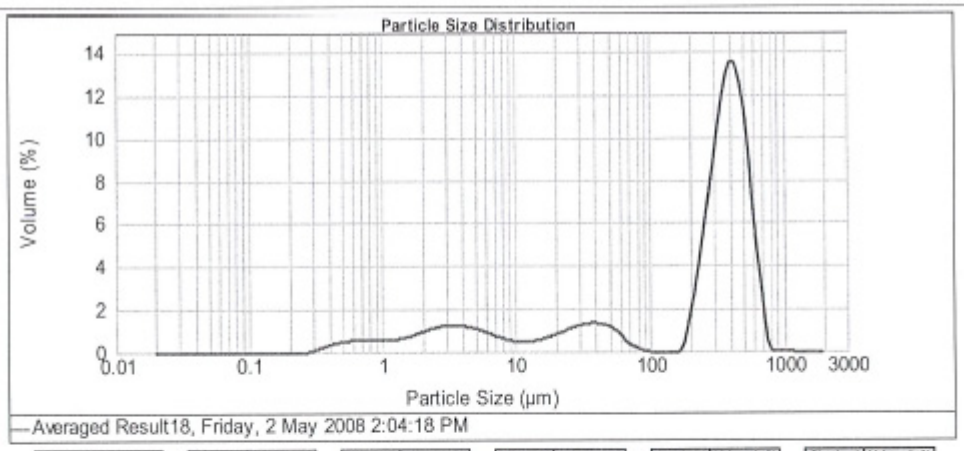
File name: dwlbc mon5.mea
Record Number: 21

MASTERSIZER 2000

Result Analysis Report

Sample Name: Averaged Result18	**SOP Name:**	**Measured:** Friday, 2 May 2008 2:04:18 PM	
Sample Source & type: Supplier	**Measured by:** bar539	**Analysed:** Friday, 2 May 2008 2:04:20 PM	
Sample bulk lot ref:	**Result Source:** Averaged		
Particle Name: Kaolinite high	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Normal
Particle RI: 1.570	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 0.93 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 15.776 %	**Result Emulation:** Off
Concentration: 0.0013 %Vol	**Span :** 1.621	**Uniformity:** 0.507	**Result units:** Volume
Specific Surface Area: 0.673 m²/g	**Surface Weighted Mean D[3,2]:** 8.920 um	**Vol. Weighted Mean D[4,3]:** 292.395 um	

d(0.1): 3.270 um **d(0.5):** 328.578 um **d(0.9):** 536.031 um



Size (µm)	Volume In %
0.010	0.00
0.011	0.00
0.013	0.00
0.015	0.00
0.017	0.00
0.020	0.00
0.023	0.00
0.026	0.00
0.030	0.00
0.035	0.00
0.040	0.00
0.046	0.00
0.052	0.00
0.060	0.00
0.069	0.00
0.079	0.00
0.091	0.00
0.105	0.00

Size (µm)	Volume In %
0.105	0.00
0.120	0.00
0.136	0.00
0.156	0.00
0.182	0.00
0.209	0.00
0.240	0.00
0.275	0.02
0.316	0.14
0.363	0.27
0.417	0.38
0.479	0.43
0.550	0.48
0.631	0.50
0.724	0.50
0.832	0.49
0.955	0.48
1.096	0.50

Size (µm)	Volume In %
1.096	0.50
1.259	0.55
1.445	0.63
1.660	0.74
1.905	0.86
2.188	0.98
2.512	1.07
2.884	1.12
3.311	1.13
3.802	1.09
4.365	1.02
5.012	0.91
5.754	0.79
6.607	0.67
7.586	0.55
8.710	0.47
10.000	0.43
11.482	0.43

Size (µm)	Volume In %
11.482	0.43
13.183	0.47
15.136	0.56
17.378	0.67
19.953	0.80
22.909	0.93
26.303	1.06
30.200	1.16
34.674	1.21
39.811	1.20
45.709	1.08
52.481	0.86
60.256	0.47
69.183	0.24
79.433	0.07
91.201	0.00
104.713	0.00
120.226	0.00

Size (µm)	Volume In %
120.226	0.00
138.038	0.00
158.489	0.09
181.970	1.44
208.930	3.37
239.883	5.71
275.423	8.27
316.228	10.68
363.078	12.13
416.869	11.74
478.630	9.73
549.541	5.61
630.957	2.68
724.436	0.16
831.764	0.03
954.993	0.00
1096.478	0.00
1258.925	0.00

Size (µm)	Volume In %
1258.925	0.00
1445.440	0.00
1659.587	0.00
1905.461	0.00
2187.762	0.00
2511.886	0.00
2884.032	0.00
3311.311	0.00
3801.894	0.00
4365.158	0.00
5011.872	0.00
5754.399	0.00
6606.934	0.00
7585.776	0.00
8709.636	0.00
10000.000	0.00

Operator notes: *Average of 18 measurements from dwlbc mon6.mea*

MASTERSIZER 2000

Result Analysis Report

Sample Name: Averaged Result19
Sample Source & type: Supplier
Sample bulk lot ref:

SOP Name:
Measured by: bar539
Result Source: Averaged

Measured: Friday, 2 May 2008 2:44:19 PM
Analysed: Friday, 2 May 2008 2:44:20 PM

Particle Name: Kaolinite high
Particle RI: 1.570
Dispersant Name: Water

Accessory Name: Hydro 2000G (A)
Absorption: 0.1
Dispersant RI: 1.330

Analysis model: General purpose
Size range: 0.020 to 2000.000 um
Weighted Residual: 6.872 %

Sensitivity: Normal
Obscuration: 0.21 %
Result Emulation: Off

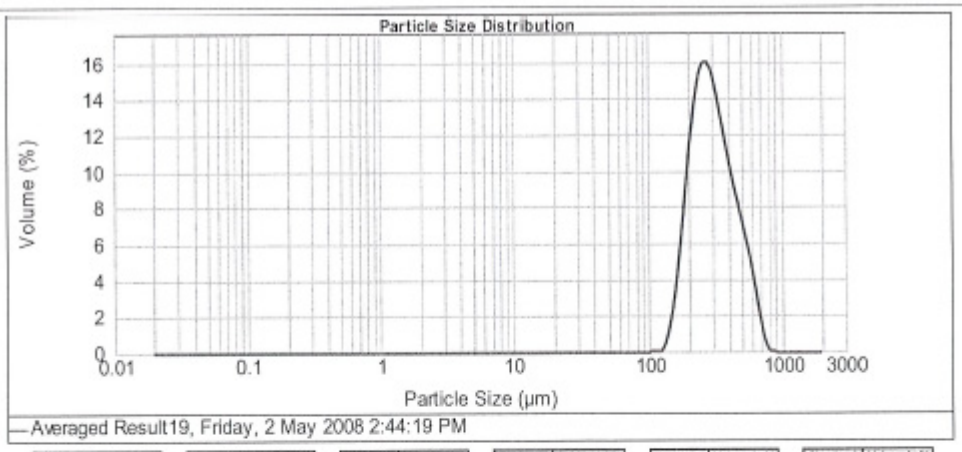
Concentration: 0.0086 %Vol
Specific Surface Area: 0.0214 m²/g

Span : 1.075
Surface Weighted Mean D[3,2]: 280.641 um

Uniformity: 0.327
Vol. Weighted Mean D[4,3]: 320.281 um

Result units: Volume

d(0.1): 189.351 um **d(0.5):** 290.448 um **d(0.9):** 501.497 um



Size (µm)	Volume In %
0.010	0.00
0.011	0.00
0.013	0.00
0.015	0.00
0.017	0.00
0.020	0.00
0.023	0.00
0.026	0.00
0.030	0.00
0.035	0.00
0.040	0.00
0.046	0.00
0.052	0.00
0.060	0.00
0.069	0.00
0.079	0.00
0.091	0.00
0.105	0.00

Size (µm)	Volume In %
0.105	0.00
0.120	0.00
0.138	0.00
0.158	0.00
0.182	0.00
0.209	0.00
0.240	0.00
0.275	0.00
0.316	0.00
0.363	0.00
0.417	0.00
0.479	0.00
0.550	0.00
0.631	0.00
0.724	0.00
0.832	0.00
0.955	0.00
1.096	0.00

Size (µm)	Volume In %
1.096	0.00
1.259	0.00
1.445	0.00
1.660	0.00
1.905	0.00
2.188	0.00
2.512	0.00
2.884	0.00
3.311	0.00
3.802	0.00
4.365	0.00
5.012	0.00
5.754	0.00
6.607	0.00
7.586	0.00
8.710	0.00
10.000	0.00
11.482	0.00

Size (µm)	Volume In %
11.482	0.00
13.183	0.00
15.136	0.00
17.378	0.00
19.953	0.00
22.909	0.00
26.303	0.00
30.200	0.00
34.674	0.00
39.811	0.00
45.709	0.00
52.481	0.00
60.256	0.00
69.183	0.00
79.433	0.00
91.201	0.00
104.713	0.00
120.226	0.01

Size (µm)	Volume In %
120.226	0.28
138.038	2.09
158.489	5.31
181.970	9.46
208.930	12.91
239.883	14.46
275.423	13.83
316.228	11.86
363.078	9.71
416.869	7.81
478.630	6.09
549.541	4.12
630.957	1.84
724.436	0.21
831.764	0.00
954.993	0.00
1096.478	0.00
1258.925	0.00

Size (µm)	Volume In %
1258.925	0.00
1445.440	0.00
1659.587	0.00
1905.461	0.00
2187.762	0.00
2511.886	0.00
2884.032	0.00
3311.311	0.00
3801.894	0.00
4365.158	0.00
5011.872	0.00
5754.399	0.00
6606.934	0.00
7585.776	0.00
8709.636	0.00
10000.000	

Operator notes: *Average of 19 measurements from dwlbc war1R.mea*

Malvern Instruments Ltd.
Malvern, UK

Mastersizer 2000 Ver. 5.22
Serial Number : MAL101764

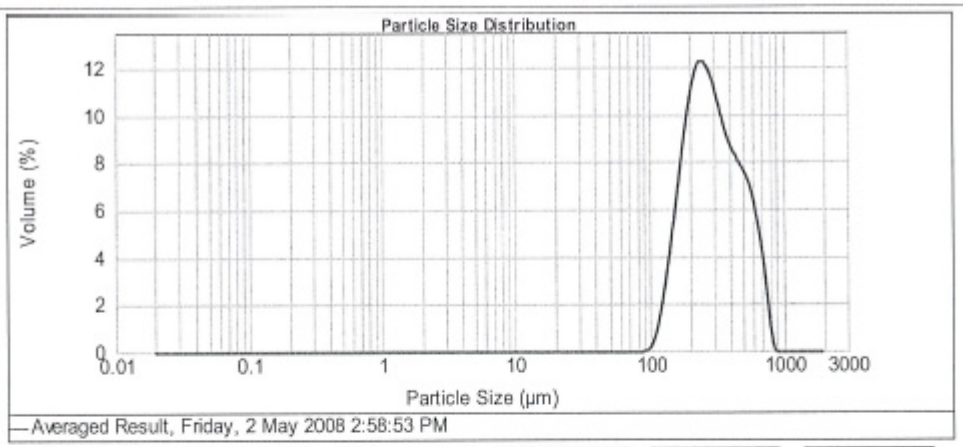
File name: dwlbc war1R.mea
Record Number: 21

MASTERSIZER 2000

Result Analysis Report

Sample Name: Averaged Result	**SOP Name:**	**Measured:** Friday, 2 May 2008 2:58:53 PM	
Sample Source & type: Supplier	**Measured by:** har539	**Analysed:** Friday, 2 May 2008 2:58:54 PM	
Sample bulk lot ref:	**Result Source:** Averaged		
Particle Name: Kaolinite high	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Normal
Particle RI: 1.570	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 0.22 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 7.352 %	**Result Emulation:** Off
Concentration: 0.0082 %Vol	**Span :** 1.413	**Uniformity:** 0.428	**Result units:** Volume
Specific Surface Area: 0.0226 m²/g	**Surface Weighted Mean D[3,2]:** 265.746 um	**Vol. Weighted Mean D[4,3]:** 327.396 um	

d(0.1): 163.204 um **d(0.5):** 284.638 um **d(0.9):** 565.452 um



Size (µm)	Volume In %
0.010	0.00
0.011	0.00
0.013	0.00
0.015	0.00
0.017	0.00
0.020	0.00
0.023	0.00
0.026	0.00
0.030	0.00
0.035	0.00
0.040	0.00
0.046	0.00
0.052	0.00
0.060	0.00
0.069	0.00
0.079	0.00
0.091	0.00
0.105	0.00

Size (µm)	Volume In %
0.105	0.00
0.120	0.00
0.138	0.00
0.158	0.00
0.182	0.00
0.209	0.00
0.240	0.00
0.275	0.00
0.316	0.00
0.363	0.00
0.417	0.00
0.479	0.00
0.550	0.00
0.631	0.00
0.724	0.00
0.832	0.00
0.955	0.00
1.096	0.00

Size (µm)	Volume In %
1.096	0.00
1.259	0.00
1.445	0.00
1.660	0.00
1.905	0.00
2.188	0.00
2.512	0.00
2.884	0.00
3.311	0.00
3.802	0.00
4.365	0.00
5.012	0.00
5.754	0.00
6.607	0.00
7.586	0.00
8.710	0.00
10.000	0.00
11.482	0.00

Size (µm)	Volume In %
11.482	0.00
13.183	0.00
15.136	0.00
17.378	0.00
19.953	0.00
22.909	0.00
26.303	0.00
30.200	0.00
34.674	0.00
39.811	0.00
45.709	0.00
52.481	0.00
60.256	0.00
69.183	0.00
79.433	0.00
91.201	0.10
104.713	0.96
120.226	

Size (µm)	Volume In %
120.226	2.65
138.038	4.92
158.489	7.40
181.970	9.60
208.930	10.87
239.883	10.98
275.423	10.15
316.228	8.96
363.078	7.97
416.869	7.33
478.630	6.80
549.541	5.80
630.957	4.14
724.436	1.37
831.764	0.00
954.993	0.00
1096.478	0.00
1258.925	

Size (µm)	Volume In %
1258.925	0.00
1445.440	0.00
1659.587	0.00
1905.461	0.00
2187.762	0.00
2511.886	0.00
2884.032	0.00
3311.311	0.00
3801.894	0.00
4365.158	0.00
5011.872	0.00
5754.399	0.00
6606.934	0.00
7585.776	0.00
8709.636	0.00
10000.000	

Operator notes: *Average of 20 measurements from dwlbc war2R.mea*

Malvern Instruments Ltd.
Malvern, UK

Mastersizer 2000 Ver. 5.22
Serial Number : MAL101764

File name: dwlbc war2R.mea
Record Number: 21

MASTERSIZER 2000

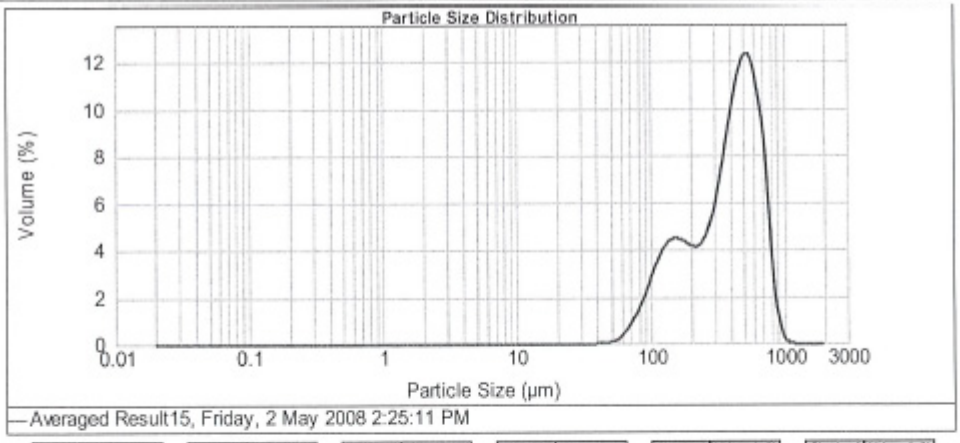
Result Analysis Report

Sample Name: Averaged Result15	**SOP Name:**	**Measured:** Friday, 2 May 2008 2:25:11 PM
Sample Source & type: Supplier	**Measured by:** bar539	**Analysed:** Friday, 2 May 2008 2:25:12 PM
Sample bulk lot ref:	**Result Source:** Averaged	

Particle Name: Kaolinite high	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Normal
Particle RI: 1.570	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 0.16 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 8.340 %	**Result Emulation:** Off

Concentration: 0.0062 %Vol	**Span :** 1.394	**Uniformity:** 0.439	**Result units:** Volume
Specific Surface Area: 0.0226 m²/g	**Surface Weighted Mean D[3,2]:** 265.174 um	**Vol. Weighted Mean D[4,3]:** 395.584 um	

d(0.1): 123.704 um **d(0.5):** 395.100 um **d(0.9):** 674.578 um



Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	0.00	11.482	0.00	120.226	3.82	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	0.00	13.183	0.00	138.038	4.05	1445.440	0.00
0.013	0.00	0.136	0.00	1.445	0.00	15.136	0.00	158.489	3.96	1659.587	0.00
0.015	0.00	0.156	0.00	1.660	0.00	17.378	0.00	181.970	3.79	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	0.00	19.953	0.00	208.930	3.75	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	0.00	22.909	0.00	239.883	4.17	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	0.00	26.303	0.00	275.423	5.22	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	0.00	30.200	0.00	316.228	6.85	3311.311	0.00
0.030	0.00	0.316	0.00	3.311	0.00	34.674	0.00	363.078	8.73	3801.894	0.00
0.035	0.00	0.363	0.00	3.802	0.00	39.811	0.01	416.869	10.36	4365.158	0.00
0.040	0.00	0.417	0.00	4.365	0.00	45.709	0.07	478.630	11.14	5011.872	0.00
0.046	0.00	0.479	0.00	5.012	0.00	52.481	0.19	549.541	10.48	5754.399	0.00
0.052	0.00	0.550	0.00	5.754	0.00	60.256	0.52	630.957	8.58	6606.934	0.00
0.060	0.00	0.631	0.00	6.607	0.00	69.183	1.03	724.436	4.47	7585.776	0.00
0.069	0.00	0.724	0.00	7.586	0.00	79.433	1.67	831.764	1.25	8709.636	0.00
0.079	0.00	0.832	0.00	8.710	0.00	91.201	2.48	954.993	0.13	10000.000	0.00
0.091	0.00	0.955	0.00	10.000	0.00	104.713	3.28	1096.478	0.00		
0.105	0.00	1.096	0.00	11.482	0.00	120.226		1258.925			

Operator notes: *Average of 15 measurements from dwlbc war3.mea*

Malvern Instruments Ltd.
Malvern, UK

Mastersizer 2000 Ver. 5.22
Serial Number : MAL101764

File name: dwlbc war3.mea
Record Number: 19

APPENDIX 5: MONOMAN SANDS TO WARINA SANDS INJECTION DATA

Test	Date	Start time	Injection Rate (L/s)	Test Duration (mins)
1a	20/6/2008	09:30 AM	6 L/s (first 7 days)	10,098
1b	27/6/2008	09:30 AM	12 L/s (final 3 days)	4,304
				(Total 14,402)

Time (mins)	Head above logger (m)	Injection Head (m)	Injection Rate (L/s)	Comment
	Initial head 16.985			
0	16.916	0.069		
2	20.431	-3.446	6.0	
4	19.811	-2.826		
6	18.708	-1.723		
8	17.640	-0.655		
10	16.537	0.448		
12	16.433	0.552		
14	16.502	0.483		
16	16.502	0.483		
18	16.502	0.483		
20	16.571	0.414		
22	16.571	0.414		
24	16.502	0.483		
26	16.640	0.345		
28	16.640	0.345		
30	16.640	0.345	6.0	
32	16.640	0.345		
34	16.640	0.345		
36	16.571	0.414		
38	16.571	0.414		
40	16.675	0.310		
42	16.675	0.310		
44	16.675	0.310		
46	16.675	0.310		
48	16.675	0.310		
50	16.675	0.310		
52	16.675	0.310		
54	16.675	0.310		
56	16.675	0.310		
58	16.675	0.310		
60	16.675	0.310	6.0	
62	16.675	0.310		

Time (mins)	Head above logger (m)	Injection Head (m)	Injection Rate (L/s)	Comment
64	16.675	0.310		
66	16.675	0.310		
68	16.675	0.310		
70	16.675	0.310		
72	16.675	0.310		
74	16.675	0.310		
76	16.675	0.310		
78	16.675	0.310		
80	16.675	0.310		
82	16.675	0.310		
84	16.675	0.310		
86	16.675	0.310		
88	16.744	0.241		
90	16.675	0.310		
92	16.675	0.310		
94	16.675	0.310		
96	16.675	0.310		
98	16.675	0.310		
100	16.675	0.310		
110	16.675	0.310		
120	16.675	0.310	6.0	
130	16.675	0.310		
140	16.744	0.241		
150	16.744	0.241		
160	16.744	0.241		
170	16.812	0.173		
180	16.744	0.241	6.0	
190	16.812	0.173		
200	16.812	0.173		
210	16.812	0.173		
220	16.881	0.104		
230	16.812	0.173		
240	16.881	0.104	6.0	
250	16.881	0.104		
260	16.812	0.173		
270	16.812	0.173		
280	16.744	0.241		
290	16.744	0.241		
300	16.744	0.241	6.0	
310	16.812	0.173		
320	16.744	0.241		
330	16.744	0.241		
340	16.744	0.241		
350	16.744	0.241		
352	16.744	0.241		

Time (mins)	Head above logger (m)	Injection Head (m)	Injection Rate (L/s)	Comment
354	16.744	0.241		
356	16.744	0.241		
358	16.744	0.241		
360	16.744	0.241	6.0	
370	16.675	0.310		
380	16.675	0.310		
390	16.675	0.310		
400	16.675	0.310		
410	16.675	0.310		
420	16.675	0.310	6.0	
430	16.675	0.310		
440	16.709	0.276		
450	16.709	0.276		
460	16.709	0.276		
470	16.709	0.276		
480	16.709	0.276	6.0	
490	16.640	0.345		
500	16.640	0.345		
510	16.640	0.345		
520	16.640	0.345		
530	16.640	0.345		
540	16.571	0.414		
550	16.571	0.414		
560	16.640	0.345		
570	16.640	0.345		
580	16.640	0.345		
590	16.640	0.345		
600	16.640	0.345	6.0	
610	16.640	0.345		
620	16.640	0.345		
630	16.640	0.345		
640	16.640	0.345		
650	16.640	0.345		
660	16.640	0.345		
670	16.640	0.345		
680	16.571	0.414		
690	16.571	0.414		
700	16.571	0.414		
710	16.571	0.414		
720	16.571	0.414	6.0	
730	16.640	0.345		
740	16.640	0.345		
750	16.640	0.345		
760	16.640	0.345		
770	16.640	0.345		

Time (mins)	Head above logger (m)	Injection Head (m)	Injection Rate (L/s)	Comment
780	16.640	0.345		
790	16.571	0.414		
800	16.571	0.414		
810	16.571	0.414		
820	16.571	0.414		
830	16.571	0.414		
840	16.571	0.414		
850	16.571	0.414		
860	16.571	0.414		
870	16.571	0.414		
880	16.571	0.414		
890	16.571	0.414		
900	16.571	0.414		
910	16.571	0.414		
920	16.571	0.414		
930	16.571	0.414		
940	16.571	0.414		
950	16.571	0.414		
960	16.571	0.414	6.0	
970	16.571	0.414		
980	16.571	0.414		
990	16.571	0.414		
1000	16.571	0.414		
1030	16.571	0.414		
1060	16.571	0.414		
1090	16.571	0.414		
1120	16.571	0.414		
1150	16.571	0.414		
1180	16.571	0.414	6.0	
1210	16.571	0.414		
1240	16.571	0.414		
1270	16.571	0.414		
1300	16.571	0.414		
1330	16.606	0.379		
1360	15.124	1.861		
1390	14.917	2.068		
1420	15.055	1.930		
1430	16.640	0.345		Replaced filter to 100 micron
1450	16.640	0.345		
1480	16.744	0.241		
1510	16.744	0.241		
1540	16.744	0.241		
1570	16.812	0.173		
1600	16.744	0.241		

Time (mins)	Head above logger (m)	Injection Head (m)	Injection Rate (L/s)	Comment
1630	16.744	0.241		
1660	16.812	0.173		
1690	16.812	0.173	6.0	
1720	16.812	0.173		
1750	16.812	0.173		
1780	16.812	0.173		
1810	16.744	0.241		
1840	16.744	0.241		
1870	16.675	0.310		
1900	16.675	0.310		
1930	16.675	0.310	6.0	
1960	16.675	0.310		
1990	16.675	0.310		
2020	16.675	0.310		
2050	16.675	0.310		
2080	16.675	0.310		
2110	16.675	0.310		
2140	16.675	0.310	6.0	
2170	16.675	0.310		
2200	16.675	0.310		
2230	16.675	0.310		
2260	16.675	0.310		
2290	16.675	0.310		
2320	16.675	0.310		
2350	16.675	0.310		
2380	16.675	0.310	6.0	
2410	16.675	0.310		
2440	16.675	0.310		
2470	16.675	0.310		
2500	16.675	0.310		
2530	16.675	0.310		
2560	16.675	0.310		
2590	16.744	0.241		
2620	16.744	0.241		
2650	16.744	0.241	6.0	
2680	16.744	0.241		
2710	16.744	0.241		
2740	16.744	0.241		
2770	16.744	0.241		
2800	16.744	0.241		
2830	16.744	0.241		
2860	16.502	0.483	6.0	
2890	16.778	0.207		
2920	16.778	0.207		
2950	16.847	0.138		

Time (mins)	Head above logger (m)	Injection Head (m)	Injection Rate (L/s)	Comment
2980	16.916	0.069		
3010	16.916	0.069	6.0	
3040	16.916	0.069		
3070	16.916	0.069		
3100	16.847	0.138		
3130	16.950	0.035	6.0	
3160	16.881	0.104		
3190	16.881	0.104		
3220	16.812	0.173		
3250	16.812	0.173		
3280	16.812	0.173		
3310	16.812	0.173		
3340	16.812	0.173	6.0	
3370	16.812	0.173		
3400	16.812	0.173		
3430	16.812	0.173		
3460	16.812	0.173		
3490	16.812	0.173		
3520	16.812	0.173		
3550	16.812	0.173		
3580	16.812	0.173		
3610	16.812	0.173		
3640	16.812	0.173		
3670	16.812	0.173		
3700	16.812	0.173		
3730	16.812	0.173	6.0	
3760	16.881	0.104		
3790	16.881	0.104		
3820	16.881	0.104		
3850	16.881	0.104		
3880	16.881	0.104		
3910	16.881	0.104		
3940	16.881	0.104	6.0	
3970	16.881	0.104		
4000	16.881	0.104		
4030	16.881	0.104		
4060	16.881	0.104		
4090	16.881	0.104		
4120	16.881	0.104		
4150	16.881	0.104		
4180	16.881	0.104		
4210	16.881	0.104	6.0	
4240	16.881	0.104		
4270	16.881	0.104		
4300	16.950	0.035		

Time (mins)	Head above logger (m)	Injection Head (m)	Injection Rate (L/s)	Comment
4330	16.950	0.035		
4360	16.950	0.035		
4390	16.950	0.035		
4420	16.950	0.035		
4450	16.950	0.035	6.0	
4480	16.950	0.035		
4510	17.123	-0.138		
4540	17.019	-0.034		
4570	17.019	-0.034	6.0	
4600	16.950	0.035		
4630	16.950	0.035		
4660	16.950	0.035		
4690	16.950	0.035		
4720	16.881	0.104		
4750	16.950	0.035		
4780	16.950	0.035	6.0	
4810	16.950	0.035		
4840	16.950	0.035		
4870	16.950	0.035		
4900	16.950	0.035		
4930	16.950	0.035		
4960	16.950	0.035		
4990	16.950	0.035		
5020	16.950	0.035		
5050	16.950	0.035		
5080	16.950	0.035		
5110	16.950	0.035		
5140	16.950	0.035		
5170	16.950	0.035	6.0	
5200	16.950	0.035		
5230	16.950	0.035		
5260	16.950	0.035		
5290	16.950	0.035		
5320	16.950	0.035		
5350	16.950	0.035		
5380	16.950	0.035		
5410	16.950	0.035	6.0	
5440	16.950	0.035		
5470	16.950	0.035		
5500	16.950	0.035		
5530	16.950	0.035		
5560	16.950	0.035		
5590	16.950	0.035		
5620	16.881	0.104		
5650	16.881	0.104	6.0	

Time (mins)	Head above logger (m)	Injection Head (m)	Injection Rate (L/s)	Comment
5680	16.881	0.104		
5710	16.950	0.035		
5740	16.950	0.035		
5770	17.019	-0.034		
5800	16.881	0.104		
5830	17.019	-0.034		
5860	17.019	-0.034		
5880	17.157	-0.172	6.0	
5910	17.088	-0.103		
5940	17.088	-0.103		
5970	17.088	-0.103		
6000	17.088	-0.103		
6030	17.088	-0.103		
6060	17.157	-0.172		
6090	17.157	-0.172		
6120	17.157	-0.172	6.0	
6150	17.054	-0.069		
6180	17.054	-0.069		
6210	16.985	0.000		
6240	16.985	0.000		
6270	16.985	0.000		
6300	16.985	0.000		
6330	16.985	0.000		
6360	16.985	0.000		
6390	16.985	0.000		
6420	16.985	0.000		
6450	16.985	0.000		
6480	16.916	0.069		
6510	16.916	0.069		
6540	16.916	0.069		
6570	16.916	0.069		
6600	16.916	0.069	6.0	
6630	16.916	0.069		
6660	16.916	0.069		
6690	16.916	0.069		
6720	16.916	0.069		
6750	16.916	0.069		
6780	16.916	0.069		
6810	16.916	0.069		
6840	16.916	0.069	6.0	
6870	16.916	0.069		
6900	16.916	0.069		
6930	16.916	0.069		
6960	16.916	0.069		
6990	16.916	0.069		

Time (mins)	Head above logger (m)	Injection Head (m)	Injection Rate (L/s)	Comment
7020	16.916	0.069		
7050	16.916	0.069		
7080	16.916	0.069	6.0	
7110	16.916	0.069		
7140	16.778	0.207		
7170	16.985	0.000		
7200	16.985	0.000		
7230	17.088	-0.103		
7260	16.985	0.000		
7290	17.088	-0.103		
7320	17.088	-0.103	6.0	
7350	17.157	-0.172		
7380	17.157	-0.172		
7410	17.157	-0.172		
7440	17.157	-0.172		
7470	17.157	-0.172		
7500	17.157	-0.172		
7530	17.088	-0.103		
7560	17.157	-0.172	6.0	
7590	17.088	-0.103		
7620	17.088	-0.103		
7650	17.088	-0.103		
7680	16.985	0.000		
7710	16.985	0.000		
7740	16.985	0.000		
7770	16.985	0.000		
7800	16.985	0.000	6.0	
7830	16.985	0.000		
7860	16.985	0.000		
7890	16.985	0.000		
7920	16.950	0.035		
7950	16.950	0.035		
7980	17.019	-0.034		
8010	17.019	-0.034		
8040	17.019	-0.034	6.0	
8070	17.019	-0.034		
8100	17.019	-0.034		
8130	17.019	-0.034		
8160	17.019	-0.034		
8190	17.019	-0.034		
8220	17.019	-0.034		
8250	17.019	-0.034		
8280	17.019	-0.034	6.0	
8310	17.019	-0.034		
8340	17.019	-0.034		

Time (mins)	Head above logger (m)	Injection Head (m)	Injection Rate (L/s)	Comment
8370	17.019	-0.034		
8400	17.019	-0.034		
8430	17.019	-0.034		
8460	17.019	-0.034		
8490	17.019	-0.034		
8520	17.019	-0.034	6.0	
8550	17.019	-0.034		
8580	17.019	-0.034		
8610	17.019	-0.034		
8640	17.019	-0.034		
8670	17.019	-0.034		
8700	17.088	-0.103		
8730	17.088	-0.103		
8760	17.088	-0.103	6.0	
8790	17.157	-0.172		
8820	17.157	-0.172		
8850	16.985	0.000		
8880	17.226	-0.241		
8910	17.226	-0.241		
8940	17.226	-0.241		
8970	17.226	-0.241		
9000	17.157	-0.172	6.0	
9030	17.157	-0.172		
9060	17.088	-0.103		
9090	17.088	-0.103		
9120	17.019	-0.034		
9150	17.019	-0.034		
9180	17.019	-0.034		
9210	17.019	-0.034		
9240	17.019	-0.034	6.0	
9270	17.019	-0.034		
9300	17.019	-0.034		
9330	17.019	-0.034		
9360	17.019	-0.034		
9390	17.019	-0.034		
9420	17.019	-0.034		
9450	17.019	-0.034		
9480	17.019	-0.034	6.0	
9510	17.019	-0.034		
9540	17.019	-0.034		
9570	17.019	-0.034		
9600	17.019	-0.034		
9630	17.019	-0.034		
9660	17.019	-0.034		
9690	17.019	-0.034		

Time (mins)	Head above logger (m)	Injection Head (m)	Injection Rate (L/s)	Comment
9720	17.019	-0.034	6.0	
9750	17.019	-0.034		
9780	17.019	-0.034		
9810	17.019	-0.034		
9840	17.019	-0.034		
9870	17.019	-0.034		
9900	17.019	-0.034		
9930	17.019	-0.034		
9960	17.019	-0.034	6.0	
9990	17.019	-0.034		
10020	17.019	-0.034		
10050	17.088	-0.103		
10080	17.088	-0.103		
10098	18.605	-1.620	8.0	Injection rate increased
10100	20.052	-3.067		
10102	20.190	-3.205		
10104	20.190	-3.205		
10106	20.190	-3.205		
10108	20.190	-3.205		
10110	20.190	-3.205	8.0	
10112	20.190	-3.205		
10114	20.190	-3.205		
10116	20.190	-3.205		
10118	20.259	-3.274		
10120	20.190	-3.205		
10122	20.190	-3.205		
10124	20.190	-3.205		
10126	20.190	-3.205		
10128	20.190	-3.205		
10130	20.190	-3.205		
10132	20.190	-3.205		
10134	20.190	-3.205		
10136	20.259	-3.274		
10138	20.259	-3.274		
10140	20.259	-3.274	8.0	
10142	20.086	-3.101		
10144	20.431	-3.446		
10146	21.844	-4.859		
10148	21.741	-4.756		
10150	21.672	-4.687		
10152	21.672	-4.687		
10154	21.672	-4.687		
10156	21.672	-4.687	9.0	
10158	21.672	-4.687		

Time (mins)	Head above logger (m)	Injection Head (m)	Injection Rate (L/s)	Comment
10160	21.672	-4.687		
10162	21.672	-4.687		
10164	21.775	-4.790		
10166	21.775	-4.790		
10168	21.775	-4.790		
10170	21.775	-4.790	9.0	
10172	21.775	-4.790		
10174	22.673	-5.688		
10176	22.949	-5.964		
10178	23.052	-6.067		
10180	23.052	-6.067		
10182	23.156	-6.171		
10184	23.156	-6.171		
10186	23.294	-6.309	10.0	
10188	23.294	-6.309		
10190	23.363	-6.378		
10192	23.363	-6.378		
10194	23.466	-6.481		
10196	23.466	-6.481		
10198	23.466	-6.481		
10200	23.466	-6.481	10.0	
10202	23.535	-6.550		
10204	23.535	-6.550		
10206	23.535	-6.550		
10208	23.535	-6.550		
10210	23.535	-6.550		
10212	23.604	-6.619		
10214	23.604	-6.619		
10216	23.604	-6.619		
10218	23.604	-6.619		
10220	23.604	-6.619		
10222	23.673	-6.688		
10224	23.673	-6.688		
10226	23.673	-6.688		
10228	23.673	-6.688		
10230	23.673	-6.688	10.0	
10232	23.673	-6.688		
10234	23.673	-6.688		
10236	23.673	-6.688		
10238	23.673	-6.688		
10240	23.535	-6.550		
10242	23.707	-6.722		
10244	23.707	-6.722		
10246	23.707	-6.722		
10248	23.707	-6.722		

Time (mins)	Head above logger (m)	Injection Head (m)	Injection Rate (L/s)	Comment
10250	23.707	-6.722		
10252	23.707	-6.722		
10254	23.707	-6.722		
10256	23.707	-6.722		
10258	23.776	-6.791		
10260	26.533	-9.548	12.0	
10262	26.637	-9.652		
10264	26.706	-9.721		
10266	26.706	-9.721		
10268	26.878	-9.893		
10270	26.981	-9.996		
10272	27.050	-10.065		
10274	27.154	-10.169		
10276	27.222	-10.237		
10278	27.222	-10.237		
10280	27.326	-10.341		
10282	27.326	-10.341		
10284	27.326	-10.341		
10286	27.429	-10.444		
10288	27.429	-10.444		
10290	27.429	-10.444	12.0	
10292	27.498	-10.513		
10294	27.395	-10.410		
10296	27.567	-10.582		
10298	27.567	-10.582		
10300	27.567	-10.582		
10302	27.567	-10.582		
10304	27.498	-10.513		
10306	27.602	-10.617		
10308	27.602	-10.617		
10310	27.602	-10.617		
10312	27.602	-10.617		
10314	27.602	-10.617		
10316	27.602	-10.617		
10318	27.602	-10.617		
10320	27.602	-10.617		
10322	27.602	-10.617		
10324	27.671	-10.686		
10326	27.671	-10.686		
10328	27.671	-10.686		
10330	27.671	-10.686		
10332	27.671	-10.686		
10334	27.671	-10.686		
10336	27.671	-10.686		
10338	27.671	-10.686		

Time (mins)	Head above logger (m)	Injection Head (m)	Injection Rate (L/s)	Comment
10340	27.671	-10.686		
10342	27.671	-10.686		
10344	27.671	-10.686		
10346	27.671	-10.686		
10348	27.671	-10.686		
10350	27.671	-10.686	12.0	
10352	27.671	-10.686		
10354	27.671	-10.686		
10356	27.671	-10.686		
10358	27.671	-10.686		
10360	27.774	-10.789		
10362	27.671	-10.686		
10364	27.739	-10.754		
10366	27.636	-10.651		
10368	27.774	-10.789		
10370	27.774	-10.789		
10372	27.774	-10.789		
10374	27.774	-10.789		
10376	27.774	-10.789		
10378	27.705	-10.720		
10380	27.774	-10.789		
10382	27.774	-10.789		
10384	27.774	-10.789		
10386	27.671	-10.686		
10388	27.739	-10.754		
10390	27.739	-10.754		
10392	27.739	-10.754		
10394	27.739	-10.754		
10396	27.671	-10.686		
10398	27.671	-10.686		
10400	27.671	-10.686		
10402	27.739	-10.754		
10404	27.739	-10.754		
10406	27.671	-10.686		
10408	27.671	-10.686		
10410	27.567	-10.582	12.0	
10412	27.567	-10.582		
10414	27.567	-10.582		
10416	27.395	-10.410		
10418	27.395	-10.410		
10420	27.291	-10.306		
10422	27.188	-10.203		
10424	27.188	-10.203		
10426	27.050	-10.065		
10428	27.050	-10.065		

Time (mins)	Head above logger (m)	Injection Head (m)	Injection Rate (L/s)	Comment
10430	26.981	-9.996		
10432	25.775	-8.790		
10434	25.637	-8.652		
10436	25.534	-8.549		
10438	25.465	-8.480		
10440	25.327	-8.342	10.0	Changed filter to 200 micron
10442	22.846	-5.861		dropped rate back to 10 L/s
10444	21.810	-4.825		for 15 minutes then back to
10446	22.122	-5.137		12 L/s
10448	23.328	-6.343		
10450	25.051	-8.066		
10452	24.017	-7.032		
10454	23.569	-6.584		
10456	23.776	-6.791		
10458	23.776	-6.791		
10460	23.776	-6.791		
10462	23.466	-6.481		
10464	23.466	-6.481		
10466	23.466	-6.481		
10468	25.327	-8.342		
10470	27.222	-10.237		
10472	27.395	-10.410		
10474	27.395	-10.410		
10476	27.395	-10.410		
10478	27.395	-10.410		
10480	27.395	-10.410		
10482	27.395	-10.410		
10484	27.395	-10.410		
10486	27.395	-10.410		
10488	27.395	-10.410		
10490	27.395	-10.410		
10492	27.395	-10.410		
10494	27.705	-10.720		
10496	27.705	-10.720		
10498	27.705	-10.720		
10500	27.705	-10.720		
10502	27.705	-10.720		
10504	27.774	-10.789		
10506	27.774	-10.789		
10508	27.774	-10.789		
10510	27.705	-10.720		
10512	27.705	-10.720		

Time (mins)	Head above logger (m)	Injection Head (m)	Injection Rate (L/s)	Comment
10514	27.705	-10.720		
10516	27.705	-10.720		
10518	27.705	-10.720		
10520	27.705	-10.720		
10530	27.705	-10.720		
10540	27.705	-10.720		
10550	27.705	-10.720		
10560	27.705	-10.720		
10570	27.705	-10.720		
10580	27.705	-10.720		
10590	27.705	-10.720		
10600	27.705	-10.720		
10610	27.705	-10.720		
10620	27.705	-10.720		
10630	27.774	-10.789		
10640	27.705	-10.720		
10650	27.774	-10.789		
10660	27.705	-10.720		
10670	27.774	-10.789		
10680	27.705	-10.720		
10690	27.705	-10.720		
10700	27.774	-10.789		
10710	27.774	-10.789		
10720	27.774	-10.789		
10730	27.774	-10.789		
10740	27.774	-10.789		
10750	27.774	-10.789		
10760	27.774	-10.789		
10770	27.774	-10.789		
10780	27.739	-10.754		
10790	27.739	-10.754		
10800	27.808	-10.823		
10810	27.808	-10.823		
10820	27.808	-10.823		
10830	27.808	-10.823		
10840	27.808	-10.823		
10850	27.808	-10.823		
10860	27.808	-10.823		
10870	27.808	-10.823		
10880	27.808	-10.823		
10890	27.808	-10.823		
10900	27.808	-10.823		
10910	27.877	-10.892		
10920	27.877	-10.892	12.0	
10930	27.808	-10.823		

Time (mins)	Head above logger (m)	Injection Head (m)	Injection Rate (L/s)	Comment
10940	27.877	-10.892		
10950	27.877	-10.892		
10960	27.877	-10.892		
10970	27.877	-10.892		
10980	27.877	-10.892		
10990	27.946	-10.961		
11000	27.877	-10.892		
11010	27.946	-10.961		
11020	27.946	-10.961		
11030	27.946	-10.961		
11040	27.946	-10.961		
11050	27.946	-10.961		
11060	27.946	-10.961		
11070	27.946	-10.961		
11080	27.946	-10.961		
11090	27.946	-10.961		
11100	27.946	-10.961		
11110	27.946	-10.961		
11120	27.946	-10.961		
11130	27.946	-10.961		
11140	27.946	-10.961		
11150	27.946	-10.961		
11160	27.946	-10.961	12.0	
11170	27.946	-10.961		
11180	27.946	-10.961		
11190	27.946	-10.961		
11200	27.946	-10.961		
11210	27.946	-10.961		
11220	27.946	-10.961		
11230	27.946	-10.961		
11240	27.946	-10.961		
11250	27.946	-10.961		
11260	28.015	-11.030		
11270	27.946	-10.961		
11280	27.946	-10.961		
11290	27.946	-10.961		
11300	27.946	-10.961		
11310	27.946	-10.961		
11320	27.946	-10.961		
11330	27.946	-10.961		
11340	28.015	-11.030		
11350	28.015	-11.030		
11360	28.015	-11.030		
11370	28.015	-11.030		
11380	28.015	-11.030		

Time (mins)	Head above logger (m)	Injection Head (m)	Injection Rate (L/s)	Comment
11390	28.015	-11.030		
11400	28.015	-11.030	12.0	
11410	28.015	-11.030		
11420	28.015	-11.030		
11450	28.015	-11.030		
11480	28.015	-11.030		
11510	28.050	-11.065		
11540	27.981	-10.996		
11570	27.981	-10.996		
11572	27.981	-10.996		
11574	27.981	-10.996		
11612	28.015	-11.030		
11642	28.015	-11.030	12.0	
11672	28.015	-11.030		
11702	28.015	-11.030		
11732	28.119	-11.134		
11762	28.119	-11.134		
11792	28.119	-11.134		
11822	28.119	-11.134		
11852	28.119	-11.134		
11882	28.119	-11.134	12.0	
11912	28.119	-11.134		
11942	28.119	-11.134		
11972	28.119	-11.134		
12002	28.119	-11.134		
12032	28.119	-11.134		
12062	28.119	-11.134		
12092	28.119	-11.134		
12122	28.119	-11.134	12.0	
12152	28.119	-11.134		
12182	28.119	-11.134		
12212	28.119	-11.134		
12242	28.119	-11.134		
12272	28.119	-11.134		
12302	28.119	-11.134		
12332	28.119	-11.134		
12362	28.119	-11.134	12.0	
12392	28.187	-11.202		
12422	28.187	-11.202		
12452	28.187	-11.202		
12482	28.187	-11.202		
12512	28.187	-11.202		
12542	28.187	-11.202		
12572	28.187	-11.202		
12602	28.187	-11.202	12.0	

Time (mins)	Head above logger (m)	Injection Head (m)	Injection Rate (L/s)	Comment
12632	28.187	-11.202		
12662	28.187	-11.202		
12692	28.187	-11.202		
12722	28.187	-11.202		
12752	28.256	-11.271		
12782	28.187	-11.202		
12812	28.187	-11.202		
12842	28.187	-11.202	12.0	
12872	28.256	-11.271		
12902	28.256	-11.271		
12932	28.256	-11.271		
12962	28.256	-11.271		
12992	28.256	-11.271		
13022	28.256	-11.271		
13052	28.187	-11.202		
13082	28.187	-11.202	12.0	
13112	28.291	-11.306		
13142	28.291	-11.306		
13172	28.291	-11.306		
13202	28.291	-11.306		
13232	28.291	-11.306		
13262	28.291	-11.306		
13292	28.291	-11.306		
13322	28.291	-11.306	12.0	
13352	28.291	-11.306		
13382	28.291	-11.306		
13412	28.360	-11.375		
13442	28.360	-11.375		
13472	28.360	-11.375		
13502	28.360	-11.375		
13532	28.360	-11.375		
13562	28.291	-11.306	12.0	
13592	28.291	-11.306		
13622	28.291	-11.306		
13652	28.291	-11.306		
13682	28.291	-11.306		
13712	28.291	-11.306		
13742	28.291	-11.306		
13772	28.360	-11.375		
13802	28.360	-11.375	12.0	
13832	28.360	-11.375		
13862	28.360	-11.375		
13892	28.360	-11.375		
13922	28.360	-11.375		
13952	28.360	-11.375		

Time (mins)	Head above logger (m)	Injection Head (m)	Injection Rate (L/s)	Comment
13982	28.360	-11.375		
14012	28.360	-11.375		
14042	28.360	-11.375	12.0	
14072	28.429	-11.444		
14102	28.429	-11.444		
14132	28.360	-11.375		
14162	28.498	-11.513		
14192	28.498	-11.513		
14222	28.498	-11.513		
14252	28.429	-11.444		
14282	28.429	-11.444	12.0	
14312	28.429	-11.444		
14342	28.429	-11.444		
14372	28.429	-11.444		
14402	28.429	-11.444		Pump stopped
				6736.13 KL pumped

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	pH	acidity
agl	above ground level	ppb	parts per billion
bgs	below ground surface	ppm	parts per million
bgl	below ground level	PSD	particle size distribution
DO	Dissolved oxygen	PVC	polyvinyl chloride
EC	electrical conductivity (μS/cm)	TDS	total dissolved solids
FRP	fibreglass reinforced plastic		
ID	Internal diameter		
K	hydraulic conductivity (m/d)		
ORP	oxidation-reduction potential		

GLOSSARY

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

Ambient water monitoring — All forms of monitoring conducted beyond the immediate influence of a discharge pipe or injection well, and may include sampling of sediments and living resources

Ambient water quality — The overall quality of water when all the effects that may impact upon the water quality are taken into consideration

Aquiclude — In hydrologic terms, a formation that contains water but cannot transmit it rapidly enough to furnish a significant supply to a well or spring

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

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

ASR — Aquifer Storage and Recovery; involves the process of recharging water into an aquifer for the purpose of storage and subsequent withdrawal; also known as aquifer storage and retrieval

Artesian — An aquifer in which the water surface is bounded by an impervious rock formation; the water surface is at greater than atmospheric pressure, and hence rises in any well which penetrates the overlying confining aquifer

Artificial recharge — The process of artificially diverting water from the surface to an aquifer; artificial recharge can reduce evaporation losses and increase aquifer yield; see also 'natural recharge', 'aquifer'

Baseflow — The water in a stream that results from groundwater discharge to the stream; often maintains flows during seasonal dry periods and has important ecological functions

Basin — The area drained by a major river and its tributaries

Bgs — below ground surface

Biodiversity — (1) The number and variety of organisms found within a specified geographic region. (2) The variability among living organisms on the earth, including the variability within and between species and within and between ecosystems

Bore — See 'well'

Catchment — That area of land determined by topographic features within which rainfall will contribute to run-off at a particular point

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

Confining layer — A rock unit impervious to water, which forms the upper bound of a confined aquifer; a body of impermeable material adjacent to an aquifer; see also 'aquifer, confined'

Contaminant — A material added by humans or natural activities that may, in sufficient concentrations, render the environment unacceptable for biota; the presence of these materials is not necessarily harmful

CSIRO — Commonwealth Scientific and Industrial Research Organisation

DEH — Department for Environment and Heritage (Government of South Australia)

Diversity — The distribution and abundance of different kinds of plant and animal species and communities in a specified area

DO — Dissolved Oxygen

DOC — Dissolved Organic Carbon

Domestic purpose — The taking of water for ordinary household purposes; includes the watering of land in conjunction with a dwelling not exceeding 0.4 hectares

Dryland salinity — The process whereby salts stored below the surface of the ground are brought close to the surface by the rising watertable. The accumulation of salt degrades the upper soil profile, with impacts on agriculture, infrastructure and the environment.

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

Ecology — The study of the relationships between living organisms and their environment

Ecosystem — Any system in which there is an interdependence upon, and interaction between, living organisms and their immediate physical, chemical and biological environment

Ephemeral streams or wetlands — Those streams or wetlands that usually contain water only on an occasional basis after rainfall events. Many arid zone streams and wetlands are ephemeral.

Evapotranspiration — The total loss of water as a result of transpiration from plants and evaporation from land, and surface water bodies

EWS — Engineering and Water Supply Department (Government of South Australia); now 'SA Water'

Floodplain — Of a watercourse means: (1) floodplain (if any) of the watercourse identified in a catchment water management plan or a local water management plan; adopted under the Act; or (2) where (1) does not apply — the floodplain (if any) of the watercourse identified in a development plan under the *Development (SA) Act 1993*; or (3) where neither (1) nor (2) applies — the land adjoining the watercourse that is periodically subject to flooding from the watercourse

Fully-penetrating well — In theory this is a wellhole that is screened throughout the full thickness of the target aquifer; in practice, any screen that is open to at least the mid 80% of a confined aquifer is regarded as fully-penetrating

Geological features — Include geological monuments, landscape amenity and the substrate of land systems and ecosystems

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

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'

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

Injection well — An artificial recharge well through which water is pumped or gravity-fed into the ground

Lake — A natural lake, pond, lagoon, wetland or spring (whether modified or not) that includes part of a lake and a body of water declared by regulation to be a lake. A reference to a lake is a reference to either the bed, banks and shores of the lake or the water for the time being held by the bed, banks and shores of the lake, or both, depending on the context.

Land — Whether under water or not, and includes an interest in land and any building or structure fixed to the land

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

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

Native species — Any animal and plant species originally in Australia; see also 'indigenous species'

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

Obswell — Observation Well Network

Penetrating well — See 'fully-penetrating well'

Perennial streams — Permanently inundated surface stream courses. Surface water flows throughout the year except in years of infrequent drought.

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

pH – acidity

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

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

Ramsar Convention — This is an international treaty on wetlands titled *The Convention on Wetlands of International Importance Especially as Waterfowl Habitat*. It is administered by the International Union for Conservation of Nature and Natural Resources. It was signed in the town of Ramsar, Iran in 1971, hence its common name. The convention includes a list of wetlands of international importance and protocols regarding the management of these wetlands. Australia became a signatory in 1974.

SA Geodata — A collection of linked databases storing geological and hydrogeological data, which the public can access through the offices of PIRSA. Custodianship of data related to minerals and petroleum, and groundwater, is vested in PIRSA and DWLBC, respectively. DWLBC should be contacted for database extracts related to groundwater

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

(S) — Storativity; storage coefficient; the volume of groundwater released or taken into storage per unit plan area of aquifer per unit change of head; it is dimensionless

Surface water — (a) water flowing over land (except in a watercourse), (i) after having fallen as rain or hail or having precipitated in any another manner, (ii) or after rising to the surface naturally from underground; (b) water of the kind referred to in paragraph (a) that has been collected in a dam or reservoir

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 (1–70 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 — Top of casing

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

TSS — Dissolved suspended solids

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

Watercourse — A river, creek or other natural watercourse (whether modified or not) and includes: a dam or reservoir that collects water flowing in a watercourse; a lake through which water flows; a channel (but not a channel declared by regulation to be excluded from the this definition) into which the water of a watercourse has been diverted; and part of a watercourse

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

Wetlands — Defined by the Act as a swamp or marsh and includes any land that is seasonally inundated with water. This definition encompasses a number of concepts that are more specifically described in the definition used in the Ramsar Convention on Wetlands of International Importance. This describes wetlands as areas of permanent or periodic to intermittent inundation, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tides does not exceed six metres.

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