Uley South Observation Well Network Review. Stage 2: Augmentation Project

> DWLBC Report 2005/06









Uley South Observation Well Network Review. Stage 2: Augmentation Project

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Report DWLBC 2005/06





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Foreword

South Australia's natural resources are fundamental to the economic and social well-being of the State. One of the State's most precious natural resources, water is a basic requirement of all living organisms and is one of the essential elements ensuring biological diversity of life at all levels. In pristine or undeveloped situations, the condition of water resources reflects the equilibrium between, rainfall, vegetation and other physical parameters. Development of these resources changes the natural balance and may cause degradation. If degradation is small, and the resource retains its utility, the community may assess these changes as being acceptable. However, significant stress will impact on the ability of the resource to continue to meet the needs of users and the environment. Understanding the cause and effect relationship between the various stresses imposed on the natural resources is paramount to developing effective management strategies. Reports of investigations into the availability and guality of water supplies throughout the State aim to build upon the existing knowledge base enabling the community to make informed decisions concerning the future management of the natural resources thus ensuring conservation of biological diversity.

Bryan Harris

Director, Knowledge and Information Division Department of Water, Land and Biodiversity Conservation

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SI UNITS COMMONLY USED WITHIN TEXT

Name of unit	Symbol	Definition in terms of other metric units	
Millimetre	mm	10 ⁻³ m	length
Metre	m		length
Kilometre	km	10 ³ m	length
Hectare	ha	10 ⁴ m ²	area
Microlitre	μL	10 ⁻⁹ m ³	volume
Millilitre	mL	10 ⁻⁶ m ³	volume
Litre	L	10 ⁻³ m ³	volume
Kilolitre	kL	1 m ³	volume
Megalitre	ML	10 ³ m ³	volume
Gigalitres	GL	10 ⁶ m ³	volume
Microgram	μ g	10 ⁻⁶ g	mass
Milligram	mg	10 ⁻³ g	mass
Gram	g		mass
Kilogram	kg	10 ³ g	Mass
Ohm	Ω	V/A	Electric resistance
Ohm metre	Ωm	Resistance of a metre cube to the flow of current between two faces	Resistivity

Abbreviations Commonly Used Within Text

Abbreviation		Name	Units of measure
DWLBC	=	Department of Water, Land and Biodiversity Conservation	
PWA	=	Prescribed wells area	
ТЕМ	=	Transient electromagnetic	
TDS	=	Total Dissolved Solids (milligrams per litre)	mg/L
EC	=	Electrical Conductivity (micro Siemens per centimetre)	μS/cm
PH	=	Acidity	
δD	=	Hydrogen isotope composition	°/ ₀₀
CFC	=	Chlorofluorocarbon (parts per trillion volume)	pptv
$\delta^{18}O$	=	Oxygen isotope composition	°/ ₀₀
¹⁴ C	=	Carbon-14 isotope (percent modern Carbon)	pmC
Ppm	=	Parts per million	
Ppb	=	Parts per billion	

EXECUTIVE SUMMARY

SA Water and the Department of Water, Land and Biodiversity Conservation (DWLBC) have been working cooperatively on Eyre Peninsula to ensure that extractions of water from groundwater supplies, particularly from the Southern Basin Prescribed Wells Area (PWA), are managed sustainably.

A review of the monitoring networks was undertaken between May and July 2002 (Clarke et al., 2003). As a result further investigations were recommended and subsequently undertaken during Stage 2: Augmentation Project 2004.

The aim of this project was to:

- Augment and rehabilitate the current monitoring network by drilling new wells and rehabilitating old wells at strategic positions in the basin where hydrogeological knowledge gaps have been identified.
- Ground truth the possible saline interface identified during the surface geophysics survey.
- Undertake salinity monitoring by performing salinity profiling in new, rehabilitated and selected observation wells.
- Augment water-level monitoring records by installing two additional transducers in new or rehabilitated wells.
- Build on the information base of the basin by down-hole geophysical logging of new and rehabilitated observation network wells.

The Stage 2 Augmentation Project successfully established three new, five rehabilitated and two replacement observation wells within the Uley South Lens. These wells underwent purging, sampling, chemical analysis, geophysical logging and salinity profiling. Salinity profiling successfully established and benchmarked the position of the saline interface and zone of diffusion for future monitoring. Pressure transducers with data loggers were installed in selected wells.

The following actions are now recommended:

- Establish a monitoring program to profile the saline interface and zone of diffusion.
- Undertake another surface geophysical survey.
- Review the future of abandoned historical observation wells and action as required.
- Investigate the feasibility of an integrated telemetry system to automatically download real-time data for automated monitoring equipment.
- Establish a regime for the regular transfer of extraction data from SA Water to DWLBC.
- SA Water to review their groundwater sampling technique to ensure that samples are representative of the aquifer.
- SA Water to pursue options for investigating the extent of the Coffin Bay Lens.

In addition the Eyre Peninsula Water Management Board has requested the establishment of additional observation wells and pluviometers up-hydraulic gradient of the original wellfield.

1 INTRODUCTION

SA Water and the Department of Water, Land and Biodiversity Conservation (DWLBC) have been working cooperatively on Eyre Peninsula to ensure that extractions of water from groundwater supplies, particularly from the Southern Basin Prescribed Wells Area (PWA), are managed sustainability.

Uley South – Coffin Bay Observation Well Network Review (2002)

A review of the current monitoring networks was undertaken between May and July 2002. The DWLBC Report 2003/04, *Uley South – Coffin Bay Observation Well Network Review* (Clarke et al., 2003) was published in 2003.

Outcomes of this investigation were to strengthen the understanding of the impacts of utilising allocated water from these resources, thereby aiding and supporting the ongoing development of the Eyre Peninsula Catchment Water Management Board (EPCWMB) Southern Basins PWA Water Allocation Plan (WAP) by the:

- Establishment of a more rigorous monitoring framework to facilitate the management of the resource.
- Identification of the scope of further works to be undertaken on the Uley South and Coffin Bay 'A' lenses of the Southern Basins PWA (Fig. 1) to understand the hydrodynamic behaviour of these systems in response to recharge and pumping demands.
- Definition of variability of salinity with depth within the Uley South and Coffin Bay 'A' lenses of the Southern Basins PWA (Fig 1).

To satisfy these outcomes the review:

- Evaluated the condition of the current Uley South and Coffin Bay observation wells by surveying the wells, and purging and sampling groundwater.
- Considered the need for augmentation of the network to fill knowledge gaps.
- Conducted surface geophysical surveys and salinity profiling to establish the existence and position of the saline interface.
- Installed pressure transducers and pluviometers at selected well sites to provide more accurate aquifer storage and recharge information.

Review recommendations for further work

SA Water engaged DWLBC to implement further work as a result of the following recommendations that resulted from the review (Clarke et al., 2003).

- 1. Augmentation and rehabilitation of the monitoring network will provide a more comprehensive knowledge base to effectively observe changes in the basin over time. It was recommended that:
 - Current observation wells ULE 97, ULE 134 and ULE 147 be rehabilitated (Fig. 2).
 - Historical observation wells SLE 10, ULE 133, ULE 98 and ULE 96 be rehabilitated and included in the current monitoring network (Fig. 2).



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- Three new wells be drilled at strategic positions in the basin where hydrogeological knowledge gaps have been identified (Fig. 2).
- SA Water and DWLBC review the future of open hole historical wells.
- Water-level monitoring frequency remains monthly due to the irregularity of timing and magnitude of recharge events.
- 2. The assessment of the ongoing monitoring records of water-level changes and chemical analyses from monitoring sites within the Uley South groundwater monitoring network will give confidence that the current management framework is appropriate for this lens. It was recommended that:
 - The current observation wells (except those wells without casing and completion details), including the new and rehabilitated wells, undergo salinity profiling (App. A). This involves well purging followed by immediate salinity profiling, and a repeat salinity profiling after one month residence time. The information from a second and third profiling, coupled with the first, should give clear indication on salinity stratification within the basin.
 - A second round of water samples be collected during well purging. If conducted during autumn these will assist in determining any trend in lens salinity, will help to establish the extent and thickness of the lens, and assist in defining the saline interface when compared with the July 2002 results.
 - SA Water review the groundwater sampling technique to ensure that samples are representative of the aquifer. A pumped sample not bailed is recommended.
- 3. The strategic placement of two additional transducers in either the new or rehabilitated wells will provide an improved coverage of water-level monitoring, which will provide confidence that the current management framework is appropriate and assist with the determination of the extent and sustainability of the resources (Fig. 3).
- 4. It was recommended that one of the new observation bores is drilled to groundtruth the geophysical results and define the geological, hydrogeological and geochemical profile to identify possible salinity stratification, and a transducer is installed to monitor any water-level changes. It is understood that the saline interface in coastal aquifers can be dynamic with movement caused by natural oscillations, such as tidal fluctuations. Repeated monitoring will be necessary to identify the natural range of movement, setting a benchmark to identify a negative shift due to saline intrusion.
- 5. It is critical that surface geophysical surveys are repeated in future programs. Correlation of geophysical data with the geological borehole logs, and downhole salinity profiles will enable a more precise position of any saline interface to be interpreted and monitored. This knowledge will greatly improve the ability to manage the groundwater resources to protect them from induced migration of saline water into the aquifer due to pumping pressures.
- 6. It was recommended that SA Water and DWLCB review options of investigating the extent of the Coffin Bay Lens. Drilling wells is the only definitive method in identifying the extent of the lens, therefore it is recommended that a series of wells be drilled through the sand dunes into the Bridgewater Formation aquifer. Environmental tracer analysis may be useful to delineate recharge processes. Alternative investigations may include a remote geophysical investigative method such as aerial surveys.



2 AIMS

The aim of Stage 2: Augmentation Project of the Uley South Observation Well Network Review is to:

- 1. Augment and rehabilitate the current monitoring network by:
 - Drilling three new wells at strategic positions in the basin where hydrogeological knowledge gaps have been identified (Fig. 2). One of the new observation bores is positioned to ground truth the possible saline interface identified during the surface geophysics survey. The information from this well will define the geological, hydrogeological and salinity profile, and monitor the possible salinity stratification.
 - Rehabilitation of current observation wells ULE 97, ULE 134 and ULE 147 (Fig 2).
 - Rehabilitation of historical observation wells SLE 10, ULE 133, ULE 98 and ULE 96 and include in the current monitoring network (Fig. 2).
- 2. Augment salinity monitoring by performing salinity profiling on current observation wells not profiled during the initial review, new and rehabilitated wells. This will establish areas of salinity stratification within the basin for ongoing monitoring (App. A).
- 3. Augment water-level monitoring records by the installation of two additional transducers in the new wells (ULE 205 and ULE 208) (Fig. 3).
- 4. Augment the information base of the basin by downhole geophysical logging of new and rehabilitated observation network wells.

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3 METHODOLOGY

Drilling and rehabilitation of wells

Drilling commenced in June 2003. Two drilling companies were contracted to complete the drilling and rehabilitation of wells.

- A local drilling company, EP Water Bores, commenced drilling in June 2003. They were contracted to rehabilitate the shallower wells (< 50 m) using cable drilling.
- Underdale Drillers commenced drilling on 24 June 2004. They were contracted to rehabilitate the deeper wells and drill the new wells using mud/air rotary drilling.

Due to wet and boggy conditions the drilling by Underdale Drillers was postponed on 27 June and resumed on 2 December 2003. The drilling was completed on 16 December 2004.

ULE 133 and SLE 10 were to be rehabilitated, however, the casing separated in the well during removal. The wells were backfilled and new replacement wells were drilled, ULE 206 and SLE 69 respectively (Fig 2).

The ideal drilling method for karstic geology is cable drilling. However, there are few drilling companies that own cable drill rigs capable of drilling the depths required for this project. Therefore for the deeper wells (>50 m) it was necessary to utilise the rotary drilling method. This presented many difficulties and problems.

Rotary drilling requires foam or mud to be introduced to maintain the integrity of the hole during drilling, and assist with returning the drilled product to the surface. Due to the karstic nature of the geology the mud or foam would be lost in voids resulting in the drilling product not returning to the surface for geological logging. Consequently there is missing information in the geological logs over some depth intervals of the deeper wells where rotary drilling method was applied.

All new, replacement and rehabilitated wells were subsequently geophysically logged which has assisted in qualifying the geology.

Installation of automated monitoring equipment

Two Innovonics MD4 transducers with data logger were installed into new wells ULE 205 and ULE 208 (Fig. 3).

Geophysical logging and salinity profiling

All wells were purged and samples were collected for full chemical analysis (with the exemption of ULE 194 and ULE 202) to AS/NZS 5667.11:1998 (Australian Standard for groundwater quality sampling) prior to salinity profiling to remove all the stagnant groundwater in the casing or column. The groundwater is removed by careful placement of the pump within the column, usually just above the production zone or screen, and

pumping at suitable pumping rates for the aquifer type. The EC and pH of the extracted groundwater was monitored during this process. The stabilisation of these parameters indicates that formation water is being pumped and therefore suitable for collection of water samples.

Groundwater samples collected at the completion of purging were sent to the Australian Water Quality Centre for analysis. The results of the full chemical analyses are tabulated in Appendix B.

Geophysical logging and salinity profiling was conducted on all current, new, replacement and rehabilitated wells, including Coffin Bay observation wells LKW 37, LKW 38, LKW 39 and LKW 40, by DWLBC Geophysics Unit (App. A and C).

Geophysical parameters logged include:

- depth (m)
- gamma ray (API)
- neutron (cps)
- spontaneous potential (mV)
- point resistance (Ω)
- caliper (mm)
- bulk density (cps)
- medium induction (Ω/m)
- deep induction (Ω/m)
- temperature (°C)
- pH
- conductivity (µs/cm).

Many wells that were not purged in 2002 during the initial review, due to the pump failing, were purged and reprofiled during this Stage 2: Augmentation Project; these include Coffin Bay 'A' Lens wells LKW 37, LKW 38, LKW 39 and LKW 40. Results are provided in the Observation Well Information Sheets in Appendix A.

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4 RESULTS

Drilling and rehabilitation of wells

Figure 2 and Table 1 provide the location and construction details of completed wells (rehabilitated, new and replacements). For further information on construction, monitoring and salinity profiles refer to the Observation Well Information Sheets in Appendix A.

Table 1. Drilling summary of rehabilitated, new and replacement wells

Rehabilita	ted Wells								
		Co-or GDA 94 M	dinates GA Zone 53			Productio	n Zone (m)		-
Obs Well No.	Unit No.	Easting	Northing	Drill Completion Depth (m)	Completion Date	From	То	RSWL (mAHD)	-
ULE 96	602800657	548678	6153739	13.70	11/06/2003	7.0	13.7	1.58	-
ULE 97 ULE 98	602800755 602800754	548797 547745	6152875 6151752	17.00 18.00	11/06/2003 2/07/2003	2.0 2.2	14.4 15.2	1.05 1.08	
ULE 134 ULE 147	602800744 602800759	550992 552034	6148604 6147706	23.00 78.00	2/07/2003 27/06/2003	17.5 66.0	22.0 78.0	1.25 1.61	-
New Wells	6		<u> </u>						-
		GDA 94 M	dinates GA Zone 53			Productio	n Zone (m)		-
Obs Well No.	Unit No.	Easting	Northing	Drill Completion Depth (m)	Completion Date	From	То	RSWL (mAHD)	
ULE 205	602802319	549935	6147386	99.00	12/12/2003	39.0	99.0	0.66	-
ULE 207	602802316	548078	6150373	65.50	14/12/2003	41.5	65.5	1.29	
ULE 208	602802317	547736	6153092	38.00	15/12/2003	20.0	38.0	1.08	-
Replacem	ent Wells								
		Co-or GDA 94 M	dinates GA Zone 53			Production	n Zone (m)		Well Replaced
Obs Well No.	Unit No.	Easting	Northing	Drill Completion Depth (m)	Completion Date	From	То	RSWL (mAHD)	Obs Well No.
ULE 206	602802318	550117 551460	6147799	64.00 154.00	5/12/2003	46.0 118.0	64.0 154.0	0.7	ULE 133

Installation of automated monitoring equipment

Figure 3 and Table 2 provide the location and details of the automated monitoring equipment. Additional to the equipped sites described in the initial review (Clarke et al., 2003), Innovonics MD4 logger transducers have been installed into two of the three new wells, ULE 205 and ULE 208.

The data loggers, which record data from the pluviometer and the pressure transducers, are downloaded every two months. Although there is only limited automated logged data, hydrographs from these wells have been included in Appendix D. There is not enough logged data at this time to make valid trend assessments or rainfall recharge relationships. It will be necessary to collect at least two years of data before relationships can be estimated.

				Co-ord	linates	
E	quipment	Obs Well No.	Serial No.	Easting	Northing	
	Pluviometer	ULE 202	20219	548779	6154502	
Croup Instrumentation	PS700	ULE 194	20220	547859	6151029	
Group instrumentation	Greenspan SL300 logger	ULE 196	17698	551618	6149131	Share
		ULE 135	17700	551618	6149131	Pluviometer
		LKW 38	17699	544127	6167401	Share
		LKW 39	17701	544122	6167400	Pluviometer
		ULE 205	46692	549935	6147386	
	Innovanias MD4 lagger	ULE 147	48773	552035	6147708	
	Innovonics MD4 logger	ULE 134	48771	550991	6148603	
		ULE 208	45002	547736	6153092	
	Greenspan PS2100 & logger	ULE 139	45001	553492	6151286	

Table 2. Summary of automated monitoring equipment

Automated Monitoring Equipment

Geophysical logging and salinity profiling

Geophysical logging and salinity profiling were performed on wells listed in Table 3. Uley South and Coffin Bay observation wells that were not purged or salinity profiled in 2002 were included in the 2004 profiling, with the addition of all the new, rehabilitated and replacement wells. The salinity profiling results are presented as graphs on Observation Well Information Sheets (App. A) and geophysical logs are presented as composite graphs in Appendix C.

The geophysical logs assisted in the identification of aquifers, particularly where there was missing information due to no drill samples, geology or drillers logs.

Information from salinity profiling can identify the presence of salinity stratification within the aquifer. Salinity stratification within the production zone of the well with a deviation from the constant casing profile can indicate the position of a saline interface or saline intrusion within coastal aquifers.

COFFIN BAY 'A' LENS

The Coffin Bay observation wells LKW 37, LKW 38, LKW 39 and LKW 40 showed very similar salinity profiles to the 2002 sonding (Clarke et al., 2003), and therefore do not indicate any immediate concerns.

As previously presented in Clarke et al. (2003), the bailing method for salinity sampling does not guarantee a representative aguifer sample. The salinity samples collected by SA Water from the Coffin Bay observation wells do not reliably represent the salinity of the formation water as exhibited in the sonding results.

Table 3. Observation wells salinity profiled in 2004

Ohe V	Noll	Salinity Profile	Reason for Salinity Profile	Geenbysically Logged 2004
005 0	Ven	2002	2004	Geophysically Logged 2004
LKW	37	yes	not purged 2002	Depth, Temp, pH, Cond
LKW	38	yes	not purged 2002	Depth, Temp, pH, Cond
LKW	39	yes	not purged 2002	Depth, Temp, pH, Cond
LKW	40	yes	not purged 2002	Depth, Temp, pH, Cond
SLE	69	no	Replacment Well for SLE 10	Depth, Gamm, Neut, SP, PR, Cali, DB, Med, Deep, Temp, pH Cond
ULE	77	no	not purged 2002	Depth, Temp, pH, Cond
ULE	96	no	Rehabilitated Well	Depth, Gamm, Neut, Cali, DB, Med, Deep, Temp, pH Cond
ULE	97	no	Rehabilitated Well	Depth, Gamm, Neut, SP, PR, DB, Temp, pH Cond
ULE	98	no	Rehabilitated Well	Depth, Gamm, Neut, SP, PR, DB, Med, Deep, Temp, pH, Cond
ULE	99	yes	Re-sonded	Depth, Gamm, Neut, SP, PR, DB, Temp, pH Cond
ULE	134	yes	Rehabilitated Well	Depth, Gamm, Neut, SP, PR, Cali, DB, Med, Deep, Temp, pH Cond
ULE	147	yes	Rehabilitated Well	Depth, Gamm, Neut, SP, PR, Cali, DB, Med, Deep, Temp, pH Cond
ULE	188	yes	not purged 2002	Depth, Temp, pH, Cond
ULE	190	yes	not purged 2002	Depth, Temp, pH, Cond
ULE	194	yes	Re-sonded	Depth, Gamm, Neut, SP, PR, DB, Temp, pH Cond
ULE	201	yes	not purged 2002	Depth, Gamm, Neut, Cali, DB, Med, Deep, Temp, pH Cond
ULE	202	yes	Re-sonded	Depth, Temp, pH, Cond
ULE	203	yes	not purged 2002	Depth, Gamm, Neut, Cali, DB, Med, Deep, Temp, pH Cond
ULE	204	no	not located	Depth, Gamm, Neut, SP, PR, DB, Med, Deep, Temp, pH, Cond
ULE	205	no	New Well	Depth, Gamm, Neut, SP, PR, Cali, DB, Med, Deep, Temp, pH Cond
ULE	206	no	Replacment Well for ULE 133	Depth, Gamm, Neut, SP, PR, Cali, DB, Temp, pH Cond
ULE	207	no	New Well	Depth, Gamm, Neut, SP, PR, DB, Med, Deep, Temp, pH, Cond
ULE	208	no	New Well	Depth, Gamm, Neut, SP, PR, Cali, DB, Med, Deep, Temp, pH Cond

Geophysical Logging and Salinity Profiling 2004

The salinity profile of LKW 38 indicates that the salinity in the production zone ranges between 800 and 880 EC. However, the last sample collected on the 7 July 2004 is 1442 EC.

Furthermore, the salinity profile in the production zone of LKW 39 ranges between 1300 and 1850 EC, and for LKW 40 between 1500 and 29 500 EC. However, the last samples collected on 7 July 2004 were 722 and 2610 EC respectively.

It was recommended that if a more representative sample of aquifer salinity is required that SA Water review its sampling techniques. It is suggested that SA Water collect only pumped samples using AS/NZS 56676.11:1998 for groundwater quality sampling.

ULEY SOUTH LENS

The Uley South observation well salinity profiles of those wells profiled during the 2002 sonding (Clarke et al., 2003) showed very similar results, and therefore do not indicate any immediate concerns. The profile of ULE 147 was slightly higher than the 2002 results, however the well was rehabilitated, therefore the original 2002 profile is considered unreliable.

The salinity profiles from the new, rehabilitated and replacement wells do not indicate any immediate concerns, however, two wells provide a distinct salinity stratification indicative of a saline interface (new well ULE 205, and replacement well SLE 69). Both wells are ~500 to 600 m from the coast (Fig. 2). These results will provide a benchmark for further salinity profile monitoring.

ULE 205

Transient electromagnetic (TEM) surface geophysics results from the 2002 review (Clarke et al., 2003) identified a possible saline interface ~700 m from the coast at an approximate depth of 85 m along TEM transect 'Uley 1000N'. A new well, ULE 205 (Fig. 2), was drilled in the approximate position identified by the TEM surface geophysics to groundtruth these results.

The salinity profile results for ULE 205 indicate salinity of ~1000 EC from 1 to -9 m AHD, followed by a gradual increase to 6000 EC from -9 to -23 m AHD, then a rapid increase to 50 000 EC from -23 to -31 m AHD. The salinity of seawater is effectively 50 000 EC, signifying that the saline interface is positioned at approximately -31 m AHD.

The salinity profile for ULE 205 correlates well with the approximate position identified by TEM surface geophysics. The TEM surface geophysics technique has provided a valuable tool to identify zones of differing resistivity, enabling the strategic placement of a well for monitoring the saline interface or diffusion zones.

SLE 69

DWLBC records revealed a salinity profile ranging from 2000 to 26 000 EC recorded during drilling in 1962 for historical Observation Well SLE 10 to a total depth of -163 m. The salinity profile results indicate constant salinity of <2000 EC from -1 to -10 m AHD, followed by a gradual increase to 5000 EC from -10 m to -12 m AHD. The salinity remained stable from -12 m to -20 m AHD, followed by a rapid increase to 26 000 EC from -20 m C (-20 m (-20 m C (-20 m (

The salinity profile results for SLE 69 indicate salinity of ~3000 EC from 1 m to -15 m AHD, than a very rapid increase to 40 000 EC from -15 m to -23 m AHD (App. A). The graphed results on the Observation Well Information Sheet for SLE 69 also includes the results of the 1962 salinity profile for comparison.

It is anticipated that the saline interface in coastal aquifers may be dynamic with movement caused by tidal fluctuations and aquifer water-level changes. No conclusion can be made regarding the dynamic behaviour of the profile from these two data sets. Several years of moderately frequent salinity profile monitoring may be necessary in order to identify the natural range of movement, and to establish and identify any inland shift due to over extraction. he geology shows that the zone of diffusion (see Discussion section) and interface are predominantly located in the less transmissive Wanilla Formation. However, the zone of diffusion is present in the Bridgewater Formation close to the coast.

5 DISCUSSION

Under natural coastal conditions, the pressure from the flow of fresh water discharging to the sea limits the landward encroachment of denser seawater into the aquifer. Within the aquifer the fresh groundwater often grades into saline water (zone of diffusion) with a steady increase in the content of dissolved solids at the interface (Fig. 4). In some situations, the contact may be quite sharp, that is, a very thin zone of diffusion exists. If the aquifer is subject to hydraulic head fluctuations caused by tides, the zone of diffusion would range in location and be enlarged as a result (Fetter, 2001).



Figure 4. Salinity profile illustrating the zone of diffusion and saline interface (ULE 205).

In unconfined coastal aquifers, the depth to which fresh water extends below sea level is ~40 times the height of the watertable above sea level. Studies by W Baydon-Ghyben (1888–89) and A Herzberg (1901) in the late nineteenth century have been widely cited, and have given rise to the Gyben-Herzberg principle (Fetter, 2001) which has been used to model where seawater occurs. It states that:

$$z_{(x,y)} = \rho_w / (\rho_s - \rho_w) h_{(x,y)}$$

Where :

 $z_{(x,y)}$ is the depth to the saltwater interface below sea level at location (x, y)

 $h_{(x,y)}$ is the elevation of the watertable above sea level at point (x, y)

 $\rho_{\rm w}$ is the density of fresh water (g/cm^3)

 ρ_s is the density of salt water (g/cm^3)

The salinity profile of SLE 69 and ULE 205 (App. A) identified the presence of a zone of diffusion. A diagrammatic projection of the observed mixing zone and calculated saline interface is illustrated in Figure 5. An arbitrary value of 2700 EC (1500 mg/L) has been used as the upper limit of the zone of diffusion. Research has shown that under natural conditions the zone of diffusion between the fresh and sea water will move seaward during periods of heavy recharge, which results in higher freshwater heads, and inland during periods of low freshwater head (Domenico and Schwartz, 1997).

The observed less symmetrical profile is presumed to be due to the difference between the hydraulic conductivity of the transmissive Bridgewater Formation and the less transmissive Wanilla Formation. Also the inland extent of the interface is likely to be influenced by aquifer permeability.

With the onset of groundwater extraction there is a risk of the lowering of the watertable, thus disturbing the dynamic balance between fresh and sea water, and permitting the saline interface to progress inland.

Now that the saline interface and zone of diffusion have been benchmarked, regular monitoring over time should reveal changes (natural and induced) in the shape of the salinity profile. It is expected that the salinity profile in the salinity curve will change with changes in groundwater level over the year. However, it is uncertain what influence this will have on the saline interface.

ULE 205 has been equipped with a transducer. The data logger monitoring graph (App. D) shows a large amplitude in water-level peaks and troughs over time, although the general curve trend relates well to the manually collected data. Compared to data from other wells this water-level amplitude is uncharacteristically large. Due to the close proximity to the coast, both SLE 69 and ULE 205 are influenced by the tides. In addition, these wells experience high-velocity air movement through the dry portion of the karst limestone due to changes in air pressure. Therefore it is possible that these influences are having an impact on the pressure transducer resulting in an increase in amplitude (noise) of water-level data.



Figure 5. Diagrammatic projection of observed saline–freshwater interface

6 CONCLUSIONS

The Stage 2 Augmentation Project has successfully established a total of three new, five rehabilitated and two replacement wells within the Uley South Lens. These wells will augment the current observation well network providing a more comprehensive knowledge base to effectively observe changes in the basin over time.

- These wells, in addition to other selected current observation wells underwent:
 - purging
 - sampling
 - chemical analysis
 - geophysical logging
 - salinity profiling.
- Salinity profiling successfully established and benchmarked the position of the saline interface and zone of diffusion within two coastal wells, SLE 69 and ULE 205, for future monitoring.
- Pressure transducers with data loggers were installed in new wells ULE 205 and 208.
- Data loggers are downloaded on a two-month frequency and preliminary data is providing important information. However, there is not enough logged data at this time to make valid judgement on the impact of rainfall on recharge. It will be necessary to collect at least 12 months to two years of data before a clear relationship can be established.
- SA Water monitoring of water level has continued on a monthly frequency.

Several recommendations from Clarke et al. (2003) have not been addressed. These are issues that may impact on the integrity of the Uley South and Coffin Bay Lenses and should be actioned. They are:

- 1. Clarke et al. (2003) stated that there are more than 50 open hole historical observation wells constructed in the Uley South Lens. These well are not currently monitored and not rehabilitated, and therefore potentially allow surface runoff to enter the mix with the aquifer formation water and also aquifer mixing through the open column. These wells may be used as observation wells in the future as information is required, however, the expense of rehabilitation at this stage may not be warranted. It is a requirement under the *Water Resources Act 1997* that the occupier of land on which a well is situated must ensure that the well is properly maintained. If they are not required they should be appropriately abandoned.
- The results indicate that SA Water still undertakes salinity sampling using the bailing technique for Coffin Bay observation wells. This sampling procedure does not provide a representative sample of the formation water. A more appropriate sample technique should be used.

7 RECOMMENDATIONS

The work completed in Uley South has shown that further work is required as follows:

- Establish a monitoring program to profile the saline interface and zone of diffusion at a frequency of once every 2–3 months during the first 12 months to determine an annual range for wells SLE 69 and ULE 205. It is understood that the saline interface in coastal aquifers can be dynamic with movement caused by tidal fluctuations and aquifer water-level changes.
- It is critical that surface geophysical surveys be repeated in future programs. Correlation of geophysical data with the geological borehole logs and downhole salinity profiles of the proposed new and rehabilitated wells, will enable a more precise position of any saline interface to be interpreted and monitored. This knowledge will greatly improve the ability to manage the groundwater resources to protect them from induced migration of saline water into the aquifer due to pumping pressures.
- SA Water to review the future of abandoned/disused observation wells and action as required.
- Investigate the feasibility of an integrated telemetry system to automatically download (gather) realtime data from the automated monitoring equipment.
- Establish the receipt of regular extraction data from SA Water to overlay with the transducer data, to establish a relationship between extraction and water level.
- SA Water to review their groundwater sampling technique to ensure that samples are representative of the aquifer. It is recommended to collect a pumped sampling using the Australian Standard groundwater quality sampling technique (AS/NZS 5667.11:1998).
- SA Water to pursue options of investigating the extent of the Coffin Bay Lens.

In addition the Eyre Peninsula Water Management Board has requested to establish additional observation wells and pluviometer in the up-hydraulic gradient of the original wellfield to give a more complete coverage of rainfall distribution, e.g. near ULE 197.

8 REFERENCES

AS/NZS 5667.11.1998. Australian/New Zealand Standard, Water quality — Sampling, Part 11: Guidance on sampling of groundwaters. Australia.

Clarke, D.S., Berens, V. and Dennis, K.J., 2003. Uley South – Coffin Bay Observation Well Network Review. South Australia. Department of Water, Land and Biodiversity Conservation. Report, DWLBC 2003/04.

Baydon-Ghyben, W., 1888–89. Nota in verband met de voorgenomen putboring nabij Amsterdam. Koninklyk Instituut Ingenieurs Tijdschrift (The Hague), 8-22.

Herzberg, A., 1901. Die Wasserversorgung einiger Nordseebader. Journal Gasbeleuchtung und Wasserversorgung (Munich) 44:8150-19, 842-44.

Fetter, C.W., 2001. Applied hydrogeology. 4th edn. Prentice-Hall Inc., New Jersey.

Domenico, P.A., and Schwartz, F.W., 1997. Physical and chemical hydrogeology. 2nd edn. John Wiley & Sons, Inc. New York.

9 APPENDIX A



COFFIN BAY AND ULEY SOUTH OBSERVATION WELL INFORMATION SHEETS AND SONDING RESULTS



OBERVATION WELL NUMBER: LKW 37 MONITORING STATUS WELL UNIT NUMBER: 592800301 SWL: Current COORDINATES EASTING: 544192 **FREQUENCY: 1 monthly** NORTHING: 6167594 **SALINITY: Historical Datum GDA 94 Projection UTM MGA Zone 53 FREQUENCY:** 6 monthly **ELEVATION (mAHD)** REFERENCE: 12.408 **GROUND:** 12.174 AQUIFER MONITORED: **BRIDGEWATER FORMATION** LATEST STANDING WATER LEVEL (M): 11.52 DATE READ: 7/07/2004 LATEST SALINITY: EC(uS/cm) 722 TDS(mg/L) DATE READ: 7/07/2004 397 CONSTRUCTION DETAILS TOTAL DEPTH DRILLED (m): 42 **CURRENT DEPTH (m):** 36.2

CASED TO: 36 CASED FROM (m): 0 MINIMUM CASING DIAMETER (mm): 80 PRODUCTION ZONE FROM (m): 36 **SCREEN TYPE: Slotted Casing**

DATE: 3/05/1985 DATE: 31/05/2002 TYPE: PVC

PRODUCTION ZONE TO (m): 37 SCREEN DIAMETER (mm): 80

WORK COMPLETED 2003

PUMPED AND PURGED: yes TRANSDUCER INSTALLATION: no **RAINGAUGE ADJACENT:** no SALINITY PROFILING: yes

SALINITY PROFILING DATA



Sonde Data Coffin Bay 'A' Lens - LKW 037 Aquifer Monitored - Bridgewater Formation - Quaternary Aquifer 6/6/2004

OBERVATION WELL NUMBER: LKW 38 MONITORING STATUS WELL UNIT NUMBER: 592800303 SWL: Current COORDINATES EASTING: 544106 **FREQUENCY: 1 monthly** NORTHING: 6167428 **SALINITY: Historical Datum GDA 94 Projection UTM MGA Zone 53 FREQUENCY:** 6 monthly **REFERENCE: 2.764 ELEVATION (mAHD) GROUND:** 2.741 AQUIFER MONITORED: **BRIDGEWATER FORMATION** LATEST STANDING WATER LEVEL (M): 1.98 DATE READ: 7/07/2004 LATEST SALINITY: EC(uS/cm) 1442 DATE READ: 7/07/2004 TDS(mg/L) 795 CONSTRUCTION DETAILS TOTAL DEPTH DRILLED (m): 49 DATE: 16/03/1985 CURRENT DEPTH (m): 19.1 DATE: 31/05/2002 CASED TO: 15 TYPE: PVC CASED FROM (m): 0 MINIMUM CASING DIAMETER (mm): 80 PRODUCTION ZONE FROM (m): 15 PRODUCTION ZONE TO (m): 21.5 SCREEN TYPE: Slotted Casing SCREEN DIAMETER (mm): 80

WORK COMPLETED 2003

PUMPED AND PURGED: yes TRANSDUCER INSTALLATION: yes RAINGAUGE ADJACENT: yes SALINITY PROFILING: yes

SALINITY PROFILING DATA



Sonde Data Coffin Bay 'A' Lens - LKW 038 Aquifer Monitored - Bridgewater Formation - Quaternary Aquifer 6/6/2004

OBERVATION WELL NUMBER: LKW 39 MONITORING STATUS WELL UNIT NUMBER: 592800304 SWL: Current COORDINATES EASTING: 544098 **FREQUENCY: 1 monthly** NORTHING: 6167422 **SALINITY:** Current Datum GDA 94 Projection UTM MGA Zone 53 **FREQUENCY: 1 monthly ELEVATION (mAHD) REFERENCE: 3.005 GROUND:** 2.674 **AQUIFER MONITORED: BRIDGEWATER FORMATION** LATEST STANDING WATER LEVEL (M): 1.93 DATE READ: 7/07/2004 LATEST SALINITY: EC(uS/cm) 722 TDS(mg/L) DATE READ: 7/07/2004 397 CONSTRUCTION DETAILS TOTAL DEPTH DRILLED (m): 36 DATE: 19/03/1985 **CURRENT DEPTH (m):** 31.75 DATE: 31/05/2002 CASED TO: 27 TYPE: PVC CASED FROM (m): 0 MINIMUM CASING DIAMETER (mm): 80 PRODUCTION ZONE FROM (m): 27 PRODUCTION ZONE TO (m): 36 SCREEN TYPE: Slotted Casing SCREEN DIAMETER (mm): 80

WORK COMPLETED 2003

PUMPED AND PURGED: yes TRANSDUCER INSTALLATION: yes RAINGAUGE ADJACENT: no SALINITY PROFILING: yes

SALINITY PROFILING DATA



OBERVATION WELL NUMBER: LKW 40 MONITORING STATUS WELL UNIT NUMBER: 592800306 SWL: Current COORDINATES EASTING: 544296 **FREQUENCY: 1 monthly** NORTHING: 6167304 **SALINITY:** Current Datum GDA 94 Projection UTM MGA Zone 53 **FREQUENCY: 1 monthly ELEVATION (mAHD) REFERENCE: 4.646** GROUND: 4.33 AQUIFER MONITORED: WANILLA FORMATION LATEST STANDING WATER LEVEL (M): 3.56 DATE READ: 7/07/2004 LATEST SALINITY: EC(uS/cm) 2610 TDS(mg/L) 1446 DATE READ: 7/07/2004

CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m):60CURRENT DEPTH (m):53.5CASED FROM (m):0CASED TO:48MINIMUM CASING DIAMETER (mm):80PRODUCTION ZONE FROM (m):48SCREEN TYPE:Slotted Casing

DATE: 2/04/1985 DATE: 31/05/2002 TYPE: PVC

PRODUCTION ZONE TO (m): 54 SCREEN DIAMETER (mm): 80

WORK COMPLETED 2003

PUMPED AND PURGED: yes TRANSDUCER INSTALLATION: no RAINGAUGE ADJACENT: no SALINITY PROFILING: yes

SALINITY PROFILING DATA



Sonde Data Coffin Bay 'A' Lens - LKW 040 Aquifer Monitored - Wanilla Formation - Tertiary Aquifer 6/6/2004

OBERVATION WELL NUMBER: SLE 69 MONITORING STATUS WELL UNIT NUMBER: 602802320 SWL: Current **FREQUENCY: 1 monthly COORDINATES** EASTING: 551460 NORTHING: 6145299 SALINITY: Non Datum GDA 94 Projection UTM MGA Zone 53 FREQUENCY: Non **ELEVATION (mAHD) REFERENCE:** 132.088 **GROUND:** 131.644 **AQUIFER MONITORED: BRIDGEWATER FORMATION & Wanilla formation** LATEST STANDING WATER LEVEL (M): 131.37 DATE READ: 7/07/2004 LATEST SALINITY: EC(uS/cm) 35000 TDS(mg/L) DATE READ: 7/07/2004 24000 CONSTRUCTION DETAILS TOTAL DEPTH DRILLED (m): 160 DATE: 11/12/2003 **CURRENT DEPTH (m):** 154 DATE: 10/03/2004 CASED TO: 118 TYPE: PVC CASED FROM (m): 0 MINIMUM CASING DIAMETER (mm): 100 **PRODUCTION ZONE FROM (m):** PRODUCTION ZONE TO (m): 154 118 SCREEN TYPE: Slotted Casing SCREEN DIAMETER (mm): 90

WORK COMPLETED 2003

PUMPED AND PURGED: blocked TRANSDUCER INSTALLATION: no RAINGAUGE ADJACENT: no SALINITY PROFILING: yes

REPLACEMENT WELL FOR SLE10

SALINITY PROFILING DATA



Sonde Data Uley South - SLE 69 Aquifer Monitored - Bridgewater Formation - Quaternary Aquifer 11/11/2004

OBERVATION WELL NUMBER: ULE 77 MONITORING STATUS WELL UNIT NUMBER: 602800910 SWL: Current **COORDINATES** EASTING: 550671.64 **FREQUENCY: 1 monthly** NORTHING: 6161942.74 **SALINITY: Historical** Datum GDA 94 Projection UTM MGA Zone 53 **FREQUENCY:** 6 monthly **ELEVATION (mAHD)** REFERENCE: 46.285 **GROUND:** 45.269 **AQUIFER MONITORED: BRIDGEWATER FORMATION** LATEST STANDING WATER LEVEL (M): 26.58 DATE READ: 7/07/2004 LATEST SALINITY: EC(uS/cm) 969 DATE READ: 11/03/2004 TDS(mg/L) 500 CONSTRUCTION DETAILS TOTAL DEPTH DRILLED (m): 42.67 DATE: 8/11/1960 **CURRENT DEPTH (m):** 32.20 DATE: 11/03/2004 CASED TO: TYPE: PVC CASED FROM (m): 0 26 MINIMUM CASING DIAMETER (mm): 80 PRODUCTION ZONE TO (m): 29 **PRODUCTION ZONE FROM (m):** 26 SCREEN TYPE: Slotted Casing SCREEN DIAMETER (mm): UKN

WORK COMPLETED 2003

PUMPED AND PURGED: yes TRANSDUCER INSTALLATION: no RAINGAUGE ADJACENT: no SALINITY PROFILING: yes

EXISTING WELL

SALINITY PROFILING DATA



Sonde Data Uley South - ULE 077 Aquifer Monitored - Bridgewater Formation - Quaternary Aquifer 6/6/2004

OBERVATION WELL NUMBER: ULE 96 MONITORING STATUS WELL UNIT NUMBER: 602800657 SWL: Current **FREQUENCY: 1 monthly** COORDINATES EASTING: 548677.93 NORTHING: 6153738.58 SALINITY: Non Datum GDA 94 Projection UTM MGA Zone 53 **FREQUENCY:** Non **ELEVATION (mAHD)** REFERENCE: 11.227 **GROUND:** 10.576 **AQUIFER MONITORED: BRIDGEWATER FORMATION** LATEST STANDING WATER LEVEL (M): 10.04 DATE READ: 7/07/2004 LATEST SALINITY: EC(uS/cm) 1000 TDS(mg/L) 550 DATE READ: 11/03/2004 CONSTRUCTION DETAILS TOTAL DEPTH DRILLED (m): 80.77 DATE: 27/07/1961 **CURRENT DEPTH (m):** 13.56 DATE: 11/03/2004 CASED TO: TYPE: PVC CASED FROM (m): 0 7 MINIMUM CASING DIAMETER (mm): 125

PRODUCTION ZONE FROM (m): 7 SCREEN TYPE: Slotted Casing PRODUCTION ZONE TO (m): 13.7 SCREEN DIAMETER (mm):UKN

WORK COMPLETED 2003

PUMPED AND PURGED: yes TRANSDUCER INSTALLATION: no RAINGAUGE ADJACENT: no SALINITY PROFILING: yes

REHABILITATED WELL

SALINITY PROFILING DATA



Sonde Data Uley South - ULE 096 Aquifer Monitored - Bridgewater Formation - Quaternary Aquifer 6/6/2004

OBERVATION WELL NUMBER: ULE 97 MONITORING STATUS WELL UNIT NUMBER: 602800755 SWL: Current COORDINATES EASTING: 548796.55 **FREQUENCY: 1 monthly** NORTHING: 6152874.85 **SALINITY: Historical** Datum GDA 94 Projection UTM MGA Zone 53 **FREQUENCY:** 6 monthly **ELEVATION (mAHD)** REFERENCE: 5.351 **GROUND:** 5.774 **AQUIFER MONITORED: BRIDGEWATER FORMATION** LATEST STANDING WATER LEVEL (M): 4.73 DATE READ: 7/07/2004 LATEST SALINITY: EC(uS/cm) 1020 TDS(mg/L) DATE READ: 11/03/2004 561

CONSTRUCTION DETAILS

2

TOTAL DEPTH DRILLED (m):47.85CURRENT DEPTH (m):14.68CASED FROM (m):0CASED TO:MINIMUM CASING DIAMETER (mm):125PRODUCTION ZONE FROM (m):2SCREEN TYPE:Slotted Casing

DATE: 14/02/1961 DATE: 11/03/2004 TYPE: PVC

PRODUCTION ZONE TO (m): 14.4 SCREEN DIAMETER (mm): UKN

WORK COMPLETED 2003

PUMPED AND PURGED: yes TRANSDUCER INSTALLATION: no RAINGAUGE ADJACENT: no SALINITY PROFILING: yes

REHABILITATED WELL

SALINITY PROFILING DATA



Sonde Data Uley South - ULE 097 Aquifer Monitored - Bridgewater Formation - Quaternary Aquifer 6/6/2004

ULE 98 OBERVATION WELL NUMBER: MONITORING STATUS WELL UNIT NUMBER: 602800754 SWL: Current **COORDINATES** EASTING: **FREQUENCY: 1 Monthly** 547745.25 NORTHING: 6151751.64 SALINITY: Non Datum GDA 94 Projection UTM MGA Zone 53 **FREQUENCY: Non ELEVATION (mAHD)** REFERENCE: 5.615 **GROUND:** 5.032 **AQUIFER MONITORED: BRIDGEWATER FORMATION** LATEST STANDING WATER LEVEL (M): 4.65 DATE READ: 11/03/2004 LATEST SALINITY: EC(uS/cm) 1670 TDS(mg/L) DATE READ: 11/03/2004 921

CONSTRUCTION DETAILS

2.2

TOTAL DEPTH DRILLED (m):90.53CURRENT DEPTH (m):16.54CASED FROM (m):0CASED FROM (m):0CASED TO:MINIMUM CASING DIAMETER (mm):125PRODUCTION ZONE FROM (m):2.2SCREEN TYPE:Slotted Casing

DATE: 10/03/1961 DATE: 11/03/2004 TYPE: PVC

PRODUCTION ZONE TO (m): 15.2 SCREEN DIAMETER (mm):

WORK COMPLETED 2003

PUMPED AND PURGED: yes TRANSDUCER INSTALLATION: no RAINGAUGE ADJACENT: no SALINITY PROFILING: yes

REHABILITATED WELL

SALINITY PROFILING DATA



Sonde Data Uley South - ULE 098 Aquifer Monitored - Bridgewater Formation - Quaternary Aquifer 6/6/2004

OBERVATION WELL NUMBER: ULE 99 MONITORING STATUS WELL UNIT NUMBER: 602800752 SWL: Current **COORDINATES** EASTING: 549244.59 **FREQUENCY: 1 monthly** NORTHING: 6151804.47 **SALINITY: Historical** Datum GDA 94 Projection UTM MGA Zone 53 **FREQUENCY:** 6 monthly **ELEVATION (mAHD) REFERENCE: 3.222 GROUND:** 5.64 **AQUIFER MONITORED: BRIDGEWATER FORMATION** LATEST STANDING WATER LEVEL (M): 4.89 DATE READ: 7/07/2004 LATEST SALINITY: EC(uS/cm) 1050 DATE READ: 11/03/2004 TDS(mg/L) **578** CONSTRUCTION DETAILS TOTAL DEPTH DRILLED (m): 34.75 DATE: 16/02/1961 **CURRENT DEPTH (m):** 6.8 DATE: 4/06/2002 TYPE: PVC CASED FROM (m): 0 CASED TO: 0.5 MINIMUM CASING DIAMETER (mm): 80 PRODUCTION ZONE TO (m): 11.5 PRODUCTION ZONE FROM (m): 0.5 SCREEN TYPE: Slotted Casing SCREEN DIAMETER (mm): 80

WORK COMPLETED 2003

PUMPED AND PURGED: yes TRANSDUCER INSTALLATION: no RAINGAUGE ADJACENT: no SALINITY PROFILING: yes

EXISTING WELL

SALINITY PROFILING DATA



Sonde Data Uley South - ULE 099 Aquifer Monitored - Bridgewater Formation - Quaternary Aquifer 6/6/2004

OBERVATION WELL NUMBER: ULE 134 MONITORING STATUS WELL UNIT NUMBER: 602800744 SWL: Current COORDINATES EASTING: 550991.96 **FREQUENCY: 1 monthly** NORTHING: 6148604.15 **SALINITY: Historical** Datum GDA 94 Projection UTM MGA Zone 53 **FREQUENCY:** 6 monthly **ELEVATION (mAHD)** REFERENCE: 20.752 **GROUND:** 20.234 **AQUIFER MONITORED: BRIDGEWATER FORMATION** LATEST STANDING WATER LEVEL (M): 19.62 DATE READ: 7/07/2004 LATEST SALINITY: EC(uS/cm) 820 TDS(mg/L) DATE READ: 9/03/2004 418 CONSTRUCTION DETAILS TOTAL DEPTH DRILLED (m): 76.2 DATE: 3/02/1961 **CURRENT DEPTH (m):** 22.96 DATE: 9/03/2004 CASED TO: 17.5 CASED FROM (m): 0 TYPE: PVC MINIMUM CASING DIAMETER (mm): 125 PRODUCTION ZONE FROM (m): 17.5

SCREEN TYPE: Slotted Casing

PRODUCTION ZONE TO (m): 22 SCREEN DIAMETER (mm): UKN

WORK COMPLETED 2003

PUMPED AND PURGED: yes TRANSDUCER INSTALLATION: yes **RAINGAUGE ADJACENT:** no

SALINITY PROFILING: yes

REHABILITATED WELL

SALINITY PROFILING DATA



Sonde Data

OBERVATION WELL NUMBER: ULE 147 MONITORING STATUS WELL UNIT NUMBER: 602800759 SWL: Current COORDINATES EASTING: 552034.13 **FREQUENCY: 1 monthly** NORTHING: 6147706.42 **SALINITY: Historical** Datum GDA 94 Projection UTM MGA Zone 53 **FREQUENCY:** 6 monthly **ELEVATION (mAHD)** REFERENCE: 66.51 **GROUND:** 66.041 **AQUIFER MONITORED: BRIDGEWATER FORMATION** LATEST STANDING WATER LEVEL (M): 65.3 DATE READ: 30/09/2004 LATEST SALINITY: EC(uS/cm) 920 TDS(mg/L) DATE READ: 10/03/2004 506

CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m):83.21CURRENT DEPTH (m):78.00CASED FROM (m):0CASED FROM (m):0CASED TO:66MINIMUM CASING DIAMETER (mm):100PRODUCTION ZONE FROM (m):66SCREEN TYPE:Slotted Casing

DATE: 10/04/1962 DATE: 27/06/2003 TYPE: PVC

PRODUCTION ZONE TO (m): 78 SCREEN DIAMETER (mm): 100

WORK COMPLETED 2003

PUMPED AND PURGED: yes TRANSDUCER INSTALLATION: yes RAINGAUGE ADJACENT: no SALINITY PROFILING: yes

REHABILITATED WELL

SALINITY PROFILING DATA



Sonde Data Uley South - ULE 147 Aquifer Monitored - Bridgewater Formation - Quaternary Aquifer 6/6/2004

OBERVATION WELL NUMBER: ULE 188 MONITORING STATUS WELL UNIT NUMBER: 602800792 SWL: Current COORDINATES EASTING: 551243.75 **FREQUENCY: 1 monthly** NORTHING: 6152585.67 **SALINITY: Historical** Datum GDA 94 Projection UTM MGA Zone 53 **FREQUENCY:** 6 monthly **ELEVATION (mAHD) REFERENCE: 10.78 GROUND:** 10.651 **AQUIFER MONITORED: BRIDGEWATER FORMATION** LATEST STANDING WATER LEVEL (M): 7.15 DATE READ: 7/07/2004 LATEST SALINITY: EC(uS/cm) 1140 TDS(mg/L) DATE READ: 10/03/2004 626 CONSTRUCTION DETAILS TOTAL DEPTH DRILLED (m): 15.6 DATE: 16/11/1974 **CURRENT DEPTH (m):** 14.02 DATE: 10/03/2004 CASED TO: 8.2 TYPE: PVC CASED FROM (m): 0 MINIMUM CASING DIAMETER (mm): 76 PRODUCTION ZONE FROM (m): 8.2 PRODUCTION ZONE TO (m): 14.25 SCREEN TYPE: Slotted Casing SCREEN DIAMETER (mm): 76

WORK COMPLETED 2003

PUMPED AND PURGED: yes TRANSDUCER INSTALLATION: no RAINGAUGE ADJACENT: no SALINITY PROFILING: yes

EXISTING WELL

SALINITY PROFILING DATA

Sonde Data



OBERVATION WELL NUMBER: ULE 190 MONITORING STATUS WELL UNIT NUMBER: 602800793 SWL: Current COORDINATES EASTING: 551425.85 **FREQUENCY: 1 monthly** NORTHING: 6152066.25 **SALINITY: Historical** Datum GDA 94 Projection UTM MGA Zone 53 **FREQUENCY:** 6 monthly **ELEVATION (mAHD) REFERENCE: 9.845 GROUND:** 9.68 **AQUIFER MONITORED: BRIDGEWATER FORMATION** LATEST STANDING WATER LEVEL (M): 6.06 DATE READ: 7/07/2004 LATEST SALINITY: EC(uS/cm) 1130 TDS(mg/L) DATE READ: 10/03/2004 602 CONSTRUCTION DETAILS TOTAL DEPTH DRILLED (m): 14.85 DATE: 23/11/1947 CURRENT DEPTH (m): 14.04 DATE: 10/03/2004 CASED TO: 8.5 TYPE: PVC CASED FROM (m): 0 MINIMUM CASING DIAMETER (mm): 76 PRODUCTION ZONE FROM (m): 8.5 PRODUCTION ZONE TO (m): 14.85

SCREEN TYPE: Slotted Casing

PRODUCTION ZONE TO (m): 14.85 SCREEN DIAMETER (mm): 75

WORK COMPLETED 2003

PUMPED AND PURGED: yes TRANSDUCER INSTALLATION: no RAINGAUGE ADJACENT: no SALINITY PROFILING: yes

EXISTING WELL

SALINITY PROFILING DATA



OBERVATION WELL NUMBER: ULE 194 MONITORING STATUS WELL UNIT NUMBER: 602801747 SWL: Current COORDINATES EASTING: 547857.4 **FREQUENCY: 1 monthly** NORTHING: 6151029.43 **SALINITY: Historical** Datum GDA 94 Projection UTM MGA Zone 53 **FREQUENCY:** 6 monthly **ELEVATION (mAHD) REFERENCE: 8,458 GROUND:** 7.83 AQUIFER MONITORED: **BRIDGEWATER FORMATION** LATEST STANDING WATER LEVEL (M): 7.31 DATE READ: 7/07/2004 LATEST SALINITY: EC(uS/cm) 1390 TDS(mg/L) DATE READ: 5/06/2002 766 CONSTRUCTION DETAILS TOTAL DEPTH DRILLED (m): 57 DATE: 2/05/1990 CURRENT DEPTH (m): 13.32 DATE: 6/03/2004 CASED TO: 7 TYPE: PVC CASED FROM (m): 0 MINIMUM CASING DIAMETER (mm): 80 PRODUCTION ZONE FROM (m): 7 PRODUCTION ZONE TO (m): 12 SCREEN TYPE: Slotted Casing SCREEN DIAMETER (mm): 80

WORK COMPLETED 2003

PUMPED AND PURGED: yes TRANSDUCER INSTALLATION: yes RAINGAUGE ADJACENT: yes SALINITY PROFILING: yes

EXISTING WELL

SALINITY PROFILING DATA

Sonde Data Uley South - ULE 194 Aquifer Monitored - Bridgewater Formation - Quaternary Aquifer 6/6/2004

OBERVATION WELL NUMBER: ULE 201 MONITORING STATUS WELL UNIT NUMBER: 602802295 SWL: Current **COORDINATES** EASTING: 550347.78 **FREQUENCY: 1 monthly** NORTHING: 6150178.8 SALINITY: Non **Datum GDA 94 Projection UTM MGA Zone 53 FREQUENCY:** Non **ELEVATION (mAHD)** REFERENCE: 6.572 **GROUND:** 6.061 **AQUIFER MONITORED: BRIDGEWATER FORMATION** LATEST STANDING WATER LEVEL (M): 5.34 DATE READ: 7/07/2004 LATEST SALINITY: EC(uS/cm) 769 TDS(mg/L) DATE READ: 10/03/2004 494 CONSTRUCTION DETAILS TOTAL DEPTH DRILLED (m): 22 19.58 **CURRENT DEPTH (m):** TYPE: PVC CASED FROM (m): 0 CASED TO: 16 MINIMUM CASING DIAMETER (mm): 100 PRODUCTION ZONE FROM (m): 16 PRODUCTION ZONE TO (m): 22

SCREEN TYPE: Slotted Casing

SCREEN DIAMETER (mm):100

WORK COMPLETED 2003

PUMPED AND PURGED: yes TRANSDUCER INSTALLATION: no **RAINGAUGE ADJACENT:** no SALINITY PROFILING: yes

EXISTING WELL

SALINITY PROFILING DATA

Sonde Data Uley South - ULE 201 Aquifer Monitored - Bridgewater Formation - Quaternary Aquifer 6/6/2004

DATE: 22/03/1999 DATE: 10/03/2004

OBERVATION WELL NUMBER: ULE 202 MONITORING STATUS WELL UNIT NUMBER: 602800660 SWL: Current **FREQUENCY: 1 monthly** COORDINATES EASTING: 548850.89 NORTHING: 6154438.69 SALINITY: Non Datum GDA 94 Projection UTM MGA Zone 53 **FREQUENCY:** Non **ELEVATION (mAHD)** REFERENCE: 16.628 **GROUND:** 16.069 AQUIFER MONITORED: **BRIDGEWATER FORMATION** LATEST STANDING WATER LEVEL (M): 15.42 DATE READ: 7/07/2004 LATEST SALINITY: EC(uS/cm) 923 TDS(mg/L) DATE READ: 6/06/2002 518 CONSTRUCTION DETAILS TOTAL DEPTH DRILLED (m): 31.40 DATE: 6/03/2004 CURRENT DEPTH (m): 31.39 DATE: 21/02/1969 CASED TO: 12.2 **TYPE: steel** CASED FROM (m): 0 MINIMUM CASING DIAMETER (mm): 254

PRODUCTION ZONE FROM (m): 12.2 SCREEN TYPE: Slotted Casing PRODUCTION ZONE TO (m): 29.59 SCREEN DIAMETER (mm):254

WORK COMPLETED 2003

PUMPED AND PURGED: yes TRANSDUCER INSTALLATION: yes RAINGAUGE ADJACENT: yes SALINITY PROFILING: yes

EXISTING WELL

SALINITY PROFILING DATA

Sonde Data Uley South - ULE 202 Aquifer Monitored - Bridgewater Formation - Quaternary Aquifer 6/6/2004

OBERVATION WELL NUMBER: ULE 203 MONITORING STATUS WELL UNIT NUMBER: 602802157 SWL: Current COORDINATES EASTING: 548740.66 **FREQUENCY: 1 monthly** NORTHING: 6155231.41 SALINITY: Non Datum GDA 94 Projection UTM MGA Zone 53 **FREQUENCY:** Non **ELEVATION (mAHD)** REFERENCE: 29.054 **GROUND:** 28.963 **AQUIFER MONITORED: BRIDGEWATER FORMATION** LATEST STANDING WATER LEVEL (M): 27.7 DATE READ: 7/07/2004 LATEST SALINITY: EC(uS/cm) 880 TDS(mg/L) 484 DATE READ: 11/03/2004 CONSTRUCTION DETAILS TOTAL DEPTH DRILLED (m): 38 DATE: 19/08/1999 CURRENT DEPTH (m): 32.9 DATE: 11/03/2004 CASED TO: 27.8 TYPE: PVC CASED FROM (m): 0 MINIMUM CASING DIAMETER (mm): 78 PRODUCTION ZONE FROM (m): 27.8 PRODUCTION ZONE TO (m): 32.9 SCREEN TYPE: Slotted Casing SCREEN DIAMETER (mm): 78

WORK COMPLETED 2003

PUMPED AND PURGED: yes TRANSDUCER INSTALLATION: no RAINGAUGE ADJACENT: no SALINITY PROFILING: yes

EXISTING WELL

SALINITY PROFILING DATA

Sonde Data Uley South - ULE 203 Aquifer Monitored - Bridgewater Formation - Quaternary Aquifer 6/6/2004

OBERVATION WELL NUMBER: ULE 204 MONITORING STATUS WELL UNIT NUMBER: 602802165 SWL: Current COORDINATES EASTING: 551915 **FREQUENCY: 1 monthly** NORTHING: 6147884.16 SALINITY: Non Datum GDA 94 Projection UTM MGA Zone 53 **FREQUENCY:** Non **ELEVATION (mAHD)** REFERENCE: 58,987 **GROUND:** 58.966 **AQUIFER MONITORED: BRIDGEWATER FORMATION** LATEST STANDING WATER LEVEL (M): 57.75 DATE READ: 7/07/2004 LATEST SALINITY: EC(uS/cm) 875 TDS(mg/L) DATE READ: 10/03/2004 576 CONSTRUCTION DETAILS TOTAL DEPTH DRILLED (m): 72.5 DATE: 17/04/1999 **CURRENT DEPTH (m):** 72.5 DATE: 10/03/2004 TYPE: PVC CASED FROM (m): 0 CASED TO: 66.3 MINIMUM CASING DIAMETER (mm): 66 PRODUCTION ZONE FROM (m): 66.3 PRODUCTION ZONE TO (m): 72.3 SCREEN TYPE: Slotted Casing SCREEN DIAMETER (mm): 66

WORK COMPLETED 2003

PUMPED AND PURGED: yes TRANSDUCER INSTALLATION: no RAINGAUGE ADJACENT: no SALINITY PROFILING: yes

EXISTING WELL

SALINITY PROFILING DATA

OBERVATION WELL NUMBER: ULE 205 MONITORING STATUS WELL UNIT NUMBER: 602802319 SWL: Current COORDINATES EASTING: 549934.59 **FREQUENCY: 1 monthly** NORTHING: 6147386.49 SALINITY: Non Datum GDA 94 Projection UTM MGA Zone 53 **FREQUENCY:** Non REFERENCE: 67.717 **ELEVATION (mAHD)** GROUND: 67.071 **AQUIFER MONITORED: BRIDGEWATER FORMATION & Wanilla formation** LATEST STANDING WATER LEVEL (M): 66.91 DATE READ: 7/07/2004 LATEST SALINITY: EC(uS/cm) 2730 DATE READ: 10/03/2004 TDS(mg/L) 1670

CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 102 **CURRENT DEPTH (m):** 100 CASED FROM (m): 0 CASED TO: 39 MINIMUM CASING DIAMETER (mm): 100 PRODUCTION ZONE FROM (m): 39 SCREEN TYPE: Slotted Casing

DATE: 12/12/2003 DATE: 10/03/2004 TYPE: PVC

PRODUCTION ZONE TO (m): 99 SCREEN DIAMETER (mm): 98

WORK COMPLETED 2003

PUMPED AND PURGED: yes TRANSDUCER INSTALLATION: yes **RAINGAUGE ADJACENT:** no

SALINITY PROFILING: yes

NEW WELL

SALINITY PROFILING DATA

OBERVATION WELL NUMBER: ULE 206 MONITORING STATUS WELL UNIT NUMBER: 602802318 SWL: Current **FREQUENCY: 1 monthly** COORDINATES EASTING: 550117.23 NORTHING: 6147799.29 SALINITY: Non Datum GDA 94 Projection UTM MGA Zone 53 **FREQUENCY:** Non **ELEVATION (mAHD) REFERENCE: 56.883 GROUND:** 56.433 **AQUIFER MONITORED: BRIDGEWATER FORMATION** LATEST STANDING WATER LEVEL (M): 56.12 DATE READ: 7/07/2004 LATEST SALINITY: EC(uS/cm) 978 TDS(mg/L) DATE READ: 7/05/2004 568 CONSTRUCTION DETAILS TOTAL DEPTH DRILLED (m): 65.02 DATE: 16/12/2003 **CURRENT DEPTH (m):** 65.02 DATE: 10/03/2004 CASED TO: 46 TYPE: PVC CASED FROM (m): -0.53 MINIMUM CASING DIAMETER (mm): 45 PRODUCTION ZONE TO (m): 64 PRODUCTION ZONE FROM (m): 46 SCREEN TYPE: Slotted Casing SCREEN DIAMETER (mm): 45 WORK COMPLETED 2003 PUMPED AND PURGED: SALINITY PROFILING: yes yes TRANSDUCER INSTALLATION: no **RAINGAUGE ADJACENT:** no **REPLACEMENT WELL FOR ULE 133** SALINITY PROFILING DATA Sonde Data

Aquifer Monitored - Bridgewater Formation - Quaternary Aquifer 6/6/2004 200 400 600 800 1000 1200 1400 0 EC (uS/cm) 46 10.88 48 8.88 50 6.88 Bridgewater Formation 4.88 52 54 2.88 (mAHD) Depth (m) 56 0.88 Depth 58 -1.12 60 -3 12 62 -5.12 Wanilla Formation -7.12 64 Current Depth 66 -9.12

Uley South - ULE 206

OBERVATION WELL NUMBER: ULE 207 MONITORING STATUS WELL UNIT NUMBER: 602802316 SWL: Current **FREQUENCY: 1 monthly** COORDINATES EASTING: 548078.25 NORTHING: 6150372.8 SALINITY: Non **Datum GDA 94 Projection UTM MGA Zone 53 FREQUENCY:** Non REFERENCE: 46.154 **ELEVATION (mAHD) GROUND:** 45.687 **AQUIFER MONITORED: BRIDGEWATER FORMATION** LATEST STANDING WATER LEVEL (M): 44.92 DATE READ: 7/07/2004 LATEST SALINITY: EC(uS/cm) 1180 TDS(mg/L) 631 DATE READ: 8/03/2004

CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m):66CURRENT DEPTH (m):65.05CASED FROM (m):0CASED TO:41.5MINIMUM CASING DIAMETER (mm):100PRODUCTION ZONE FROM (m):41.5SCREEN TYPE:Slotted Casing

DATE: 14/12/2003 DATE: 8/03/2004 TYPE: PVC

PRODUCTION ZONE TO (m): 65.5 SCREEN DIAMETER (mm): 95

WORK COMPLETED 2003

PUMPED AND PURGED: yes TRANSDUCER INSTALLATION: no RAINGAUGE ADJACENT: no SALINITY PROFILING: yes

NEW WELL

SALINITY PROFILING DATA

Sonde Data Uley South - ULE 207 Aquifer Monitored - Bridgewater Formation - Quaternary Aquifer 6/6/2004

ON ZONE TO (m):

OBERVATION WELL NUMBER: ULE 208 MONITORING STATUS WELL UNIT NUMBER: 602802317 SWL: Current COORDINATES EASTING: **FREQUENCY: 1 monthly** 547735.88 NORTHING: 6153092.18 SALINITY: Non Datum GDA 94 Projection UTM MGA Zone 53 **FREQUENCY:** Non **ELEVATION (mAHD)** REFERENCE: 30.819 **GROUND:** 30.549 **AQUIFER MONITORED: BRIDGEWATER FORMATION** LATEST STANDING WATER LEVEL (M): 29.66 DATE READ: 7/07/2004 LATEST SALINITY: EC(uS/cm) 950 TDS(mg/L) 503 DATE READ: 8/03/2004 CONSTRUCTION DETAILS TOTAL DEPTH DRILLED (m): 42 CURRENT DEPTH (m): 37.4 CASED FROM (m): 0

PRODUCTION ZONE TO (m): 38

WORK COMPLETED 2003

PUMPED AND PURGED: yes TRANSDUCER INSTALLATION: yes **RAINGAUGE ADJACENT:** no

SALINITY PROFILING: yes

NEW WELL

SALINITY PROFILING DATA

Sonde Data Uley South - ULE 208

DATE: 15/12/2003 DATE: 8/03/2004

TYPE: PVC

SCREEN DIAMETER (mm): 100

CASED TO: 20 MINIMUM CASING DIAMETER (mm): 100 PRODUCTION ZONE FROM (m): 20 SCREEN TYPE: Slotted Casing

10 APPENDIX B

GROUNDWATER CHEMISTRY RESULTS

APPENDIX B

Observation Well Number	ULE 77	ULE 99	ULE 206	ULE 207	ULE 208	ULE 134	ULE 203	ULE 190	ULE 201	ULE 205	ULE 204	SLE 69	ULE 97	ULE 98	ULE 96	ULE 188	ULE 147
Sample date (2004)	11/06	11/06	7/05	8/03	8/03	9/03	10/03	10/03	10/03	10/03	10/3	1/7	11/3	11/3	11/3	10/3	10/3
pН	7.6	7.6	7.3	7.6	7.5	7.6	7.4	7.5	7.6	7.5	7.6	7.4	7.5	7.4	7.6	7.5	7.6
TDS (by EC) (mg/L)	530	560	540	650	520	450	470	620	420	1500	480	22000	540	890	530	630	490
Conductivity (uS/cm)	969	1010	978	1180	950	820	856	1130	769	2730	875	35000	975	1620	962	1140	888
Dissolved Solids by Calculation (mg/L)	500	511	568	631	503	418	446	602	494	1670	576	24000	497	923	500	626	436
Turbidity (NTU)	210	0.78	15	32	2	3.6	0.67	2.6	420	95	240	5900	0.68	3.4	0.72	61	3.0
Calcium (mg/L)	82.6	73.3	73.2	70.2	75.1	68.4	72.8	83.5	68.1	102	68.1	337	74.9	96.6	66.2	80.7	67.3
Magnesium (mg/L)	19.2	20.7	18.2	24.7	24.9	15.2	22.4	21.1	15.4	49.4	18.2	860	20.8	40.6	20.4	25.9	18.1
Potassium (mg/L)	2.3	2.9	4.7	4.8	2.8	2.4	2.2	2.8	2.4	9.7	2.8	252	3.3	6.4	3.1	3.2	2.5
Sodium (mg/L)	89.2	102	119	147	93.4	81.1	76.2	129	80.8	372	96.3	7300	103	192	105	123	91.0
Bicarbonate (mg/L)	265	214	347	255	286	205	278	272	375	217	445	254	207	282	233	339	184
Chloride (mg/L)	150	183	147	199	140	125	108	204	115	936	140	13300	158	259	164	199	141
Fluoride (mg/L)	0.19	0.39	0.43	0.52	0.38	0.35	0.57	0.33	0.39	0.4	0.45	0.92	0.41	0.71	0.38	0.45	0.41
Sulphate (mg/L)	26.9	23.4	33.9	59.7	26.1	24.7	27.4	28.1	28.1	89.9	31.9	1830	35.1	189	27	28.1	25.8
Ammonia as N	<0.005	<0.005	1	<0.005	0.031	<0.005	0.008	<0.005	<0.005	<0.005	<0.005	0.463	<0.005	<0.005	<0.005	<0.005	<0.005
Filt Reactive Phosphorus as P	<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	<0.005	<0.005	<0.005
Phosphorus - total as P	0.073	<0.005	<0.02	0.022	0.008	<0.005		0.012	0.079	0.012	0.230	8.03	0.007	0.010	0.008	0.152	0.008
TKN as Nitrogen	<0.05	<0.05	1.19	<0.05	<0.05	<0.05		<0.05	<0.05	<0.05	<0.05	3.98	<0.05	0.15	<0.05	<0.05	<0.05
Nitrate + Nitrite as N (mg/L)	5.18	3.88	2.78	5.9	4.77	4.37	4.49	3.64	4.79	5.66	6.52	0.896	4.40	0.079	4.06	3.63	6.49
Arsenic - Total	0.002	<0.001	0.017	0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.001	0.008	0.391	<0.001	0.002	<0.001	<0.001	0.001
Arsenic - Soluble	<0.001	<0.001	0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.001	0.002	<0.001	0.001	<0.001	<0.001	0.001
Iron - total (mg/L)	1.33	<0.03	1.99	0.521	<0.03	< 0.03	<0.030	<0.03	2.64	0.066	1.90	64.9		0.205	<0.030	0.069	<0.030
Alkalinity as CaCO3 (mg/L)	217	175	284	209	234	168	228	223	307	178	365	208	170	231	191	278	151
Langelier Index	0.29	0.18	0.07	0.25	0.21	0.16	0.09	0.17	0.38	0.16	0.46	0.65	0.07	0.12	0.10	0.27	0.04
Total hardness as CaCO3 (mg/L)	285.2	268.1	257.9	276.7	289.8	233.3	274	295.4	233.3	456.9	245	4384	272.5	408.5	249.2	308.2	242.7
Carbonate hardness as CaCO3 (mg/L)	217.2	175.4	257.9	209	234.4	168	227.8	222.9	233.3	177.8	245	208.2	169.6	231.1	190.9	277.8	150.8
Noncarbonate hardness as CaCO3 (mg/L)	68	92.8	0.0	67.8	55.5	65.3	46.2	72.6	0.0	279.1	0.0	4176	102.8	177.4	58.3	30.4	91.9
Free carbon dioxide (mg/L)	10.8	8.2	27.6	9.3	14	705	16.8	15	15	10.9	17.4	15.3	9.9	20	10.4	17.8	7.7
Total chlorides as NaCl (mg/L)	247	302	242	328	231	206	178	336	190	1540	231	21900	260	427	270	328	232
lon balance %					1.97												

45

11 APPENDIX C

DOWNHOLE GEOPHYSICS LOGGING RESULTS

	0	Gove	mment of South Austra treest of Water, Land an	alia 1	Wall Lie		COMPOSITE	WATE	RWE	LL LOG			
	DENTIEN	Hode	ersity Conservation	OPS LING DATA	well Un	IIT NO.	6028 2320	: Obser	vation	well Na	me SLE 06	9	Linite
FLOF LEA	Permit No. Jnit No. Dos. Nam Purpose OCATIC Hundred Allotment	o ne DN DA	62033 6028 2320 SLE 069 Observation TA Sileaford & No. A 1	Start Date Finish Date Driller Driller Max. Drilled Depth (m) Final Total Depth (m) Samples Longet By	11/12/2003 Underdale Rotary Mud 160.0 154.0	Backfilled	SPlugged	154 0.0	160.0 160 118.0	Fill PVC	pH TDS by EC EC TDS by calc. Ca Mg K	7.4 35000 24000 337 860 252	mgL µS/cm mgL mgL mgL mgL
E	Easting (r	m AM	G) 551460 MG) 6145299	POST-DEVELOPMENT DATA	D.a. Caner	Construction of the	100	0.0	110.0	1.40	Na HCO.	7300	mgl
20 8 0 8 5 1	Cone Datum ELEVAT Ground S Ref. Point Ref. Point Top of Op	KON D Surface t abov t pen In	53 GDA 94 ATA (m AHD) e 131.64 e Ground 0.45 132.09 terval 14.09	Date DTW (m below Ref. Point) SWL (m below Ground Level) RSWL (m AHD) TDS (mg/L - Lab) EC ("Sicm - Lab) Yield (Lis)	11/12/2003 131.9 131.5 0.14 24.000 35.000	Productio Grout Bentonite	on Zone 90 : Seal	118.0	154.0	Slotted PVC	CO ₃ CI SO ₄ NO ₂₅ as N NO ₃₅ as NO ₃ Boron	13300 1830 0.895	mgi mgi mgi mgi mgi mgi
8	Saise of C	Open I	nterval -21.91	Sample Method		Gravel Pa	ack	0.0	154.0	Gravel	GEOPHYSICS JOB	Vo. 7038	
(iii) that	on (m AHD)			LITHOLOGY			WELL CONSTRUCTIO DETAILS and	N GEOPH	IYSICAL	LOGS	too (atwin) too too (at the	Censity uptor	(000 +30
å	leval.	INIT	Hydrostratigraphy	Descript	ion		LITHOLOGICAL	gramma (All	3 100	Annual Station	the off all all all a	5 68	
0	130	2	14-1-1-1-1-1	0-6 CALCARENITE as Gravel, ca	icrete, Sand	80	- U U-	-	-		1	-	
				calcareous, light brown, tine to med calcarete gravel.	aum grained, so	me		Ŧ	_	15			
10				6-9 CALCARENITE as Gravel, Sa brown	ind calcareous, o	10/K	E	1		N	}		
10	120			9-12 SAND calcareous, well sorte light brown, some Gravel present 12-15 SAND as above, hard bars 1 15-18 SAND calcareous, medium	d, medium grain from about 13 to grained, with so	ed, 15m me		E					
20	110		3	gravel 15-24 GRAVEL calcareous, light b brown, and Sand, possible hardbard	rown to reddish S	-		and the			-		_
30				24-27 SAND calcareous, reddish t 27-30 GRAVEL calcareous light br Sand, possible hardbar	rown rownigrey, som			います		16			
	100			30-34 SAND calcareous, fine to m reddish orange 34-36 GRAVEL calcareous, light g	edium grained, l rey, fine, possibl	e .		ALL ALL					
40	90			36-54 SAND calcareous, with Gra handbars	vel grains, posa	ble	3	Harris		S			
50								The second		K			
	80		-	54-60 GRAVEL coarser, calcareox	us, possible hard	bers		Antes a		- 15			
60	70			60-66 SAND sample at the beginn possible contamination from above	ing of day's drilli	ng-				4			
				66-81 GRAVEL calcareous, light b hardbars	rown, possible			1		1			
10	60	ternary	Qpcb(US)					-					
80	50	Qua		81-87 SAND calcareous, with Gra to medium grain, light grey to light	vei interbedded, reddish brown	fine		Ser.	_				
90	40			81-160 NO RETURNS lost circula drilling suspendeded until bentonite	ation, no sample added			the way	_		<u></u>		
	40							1 the		1			
100	30							-					
								they want		11			
110	20							and and		S-quin			
120								the second		1			
	10							1		t			
130	0						v	A AND	*	-1-		Ŧ	1
140								the state	ŝ	-	1	1-	
	-10							A A A	The		X	/	3
150	.20							F	1	16	1		5
160	-20	Tertiary	Thw				0-0	F		= 21 2	21	1	-1
100		-				TOTAL	DEDTH 450.0						

(\mathbf{e})	Geve	mment of South Austra mont of Water, Land an entity Contenuation	alla f	Well Un	it No.	COMPOS 6028 231	TE 9 :	WATE	R WEI	LL LOG Well Na	me ULE 205	5	
IDENTIFI Permit Ne Unit No. Obs. Nan Purpose EOCATK Hundred Allotment Easting () Northing Zone Datum ELEVATI Ground S Ref. Poin Ref. Poin Top of O	ICATI Io. In e Im AM (m AM (m AM (m AM (m AM (m AM (m AM)) (m AM) (m AM) (m AM)	ON DATA 62040 6028 2319 ULE 205 Observation ATA Uley \$ No. 535 (G) 54934 (G) 54934 (G) 6147386 5433 (G) 94 (G) 647386 67.07 (G) 67.07 (G)	DRILLING DATA Start Date Start Date Drilling Method Circulation Max. Drilled Depth (m) Final Total Depth (m) Samples Logged By POST-DEVELOPMENT DATA Date DTW (m below Ref. Point) SWL (m below Ground Level) RSWL (m AHO) TDS (mg)L - Lab) EC (LiStem - Lab) Yield (LiS)	12/12/2003 12/12/2003 Underdate Ratary Aar 102.0 D.S. Clarke 12/12/2003 65.55 1.52 1500 2730	COMPLE Borehole Backfilled Cesing Di Productio Grout Bentonite	TION DATA mm Diameter 240 152 Plugged ameter 150 n Zone 100 5eel		From (m) 0.0 36.0 99.0 0.0 39.0 39.0 0.0	To (m) 36.0 102.0 36.0 39.0 99.0 2.0	Type/Material Hammer Rotary Air cuttings PVC PVC Slotted PVC Cement	CHEMISTRY DATA pH TDS by EC EC TDS by calc. Ca Mg K Na HCO ₃ CO ₃ CO ₃ CO ₃ CO ₃ CO ₃ SO ₄ NO ₃₅ as N NO ₃₅ sa NO ₃ Boron	7 5 1500 2730 1670 102 49.4 9.7 372 217 936 89.9 5.66	Units mgL mgL mgL mgL mgL mgL mgL mgL mgL mgL
Base of C	Open	interval -31.0	Sample Method		Gravel Pa	WELL	TION	2.0 GEOPH	89.0	Gravel	GEOPHYSICS JOB N 1000 Conductivity (LSIDE)	10000 H0000	
ui uoquwaga 60 50 40 30 20 10 -10	Quaternary	Hydrostratigraphy Opcb(US)	Descripti 0-15 SAND & GRAVEL the to met brown, calcareous, Gravel content of 15-30 CALCARENITE consolidate hardbars, with some sand 30-33 SAND calcareous, fine to me subrounded, consistant light redds? 33-45 SAND calcareous, fine to me subrounded, consistant light redds? 31-54 SAND calcareous, fine to me subrounded, consistant light redds? 51-54 SAND calcareous, fine to me 51-54 SAND calcareous, fine to me 51-54 SAND calcareous, fine to me 51-54 SAND calcareous, fine to me 54-57 CALCARENITE as graveling brown aand 10% 57-60 CALCARENITE as fine grav corse light brown sand 60-78 SANDSTONE hardbar, 90%	Dit ium light reddis lecreasing with d calcarente gra dium grained, trown sand fine calcarente d 20% fine grave arker reddish or grains/hardban ed, 60%, fine ardbars 90%, lig el, softer hardba grained yellow i 10%	h depth avel, svel, el ange, h sand, rel	DETAIL: and LITHOLOG LOG	S						
-20	rtiary	Tow	90-102 SAND abundant quartz grai grains, gravel grains, last 6m difficu is collapsing	ns, very course It to drill as the f	hole			Wernard	and have	12		-	1

	Gover	mment of South Austra ment of Water, Land and	alia 1	Well Lin	it No	COMP	OSITE	WATE	R WEI	L LOG	me IIIE 206		
IDENTIFIC Permit No	ATK	N DATA 62035	DRILLING DATA Start Date	2/12/2003	COMPLE Borehole	Diameter	2310 . TA mm 240	From (m)	To (m) 12.0	Type Material Rotary Air	CHEMISTRY DATA	7.3	Units
Unit No. Obs. Name Purpose		6028 2318 ULE 206 Observation	Finish Date Driller Drilling Method	3/12/2003 Underdale Rotary			140	12.0	66.0	Rotary Mud	TDS by EC EC TDS by calc.	540 978 568	mgL µS/cm mgL
Hundred	DA	TA Uley 5 No. 5 35	Max. Drilled Depth (m) Final Total Depth (m)	66.0 64.0	Backfiller	1Plugged		64.0	66.0	outtings	Ca Mg K	73.2 18.2	mgL mgl
Easting (m Northing (m	AMO n AM	3) 550117 (G) 6147799	Samples Logged By POST-DEVELOPMENT DATA	D.S. Clarke	casing D	lameter	150	0.0	46.0	PVC	Na HCO,	119 347	mg1.
Datum ELEVATIO	N D	GDA 94	Date DTW (m below Ref. Point) SMI (m below Ground Level)	3/12/2003	Productio	n Zone	45	45.0	64.0	Slotted PVC	CO, CI	147	mg/L mg/L
Ground Sur Ref. Point a	abov	e Ground 0.45	RSWL (m AHD) TDS (mg/L + Lab)	0.83 540	-		45		2.0	C	NO ₂₅ as N NO ₂₅ as NO ₅	2.78	mg'L
Top of Ope Base of Op	en int en ir	erval iterval	Yield (L/s) Sample Method	978	Bentonite Gravel P	Seal ack		2.0	64.0	Gravel	Boron GEOPHYSICS JOB No.	6883	mgi
(m AHD)			LITHOLOGY			CONST	VELL TRUCTION	GEOPH	IYSICAL	LOGS	1000 Conductivity (LiSions)	0000 007, (1954) 8000 1	ejico er
levation .	MIT	Hydrostratioraphy	Description	0.0		LITHO	and	Carrier and	100 200		100 1000200 ed 1000200 00 00 00	Mu No	
	<i></i>	() a social graph ()	0-3 SAND calcareous, fine, some	clay and silt		- UI	1	E	-	- 3			
50			3-6 CLAY plastic dark reddish or an sand	ge, small perce	rtage		121		-				
			6-9 CLAY sandy, some silt, malles plastic, Light brown 9-12 SAND calcareous, medium or	ble and griffy bu	t not		1.00	-	-	1		_	-
			mixed with dark brown silts, friable 12-15 SAND calcareous, light rede	non plastic; Ish brown, roun	ded				-	-1			
40			subrounded, medium to fine grained 15-21 SAND calcarous, light redd grained, medial autoromiad 30.4	1, 20% gravel siz sh brown fine									
4	~		21-24 SAND Similar to above, with plastic dark reditish orange clay lan	approx 2m of s ninated within th	ticky e					1			
30	ranc	0.100	1 timestone 24-30 SAND calcareous, light redo	ish brown fine	-	1		N.	-	1			
	uate	upro(US)	30-48 GRAVEL calcareous hardba .90% gravel content	rs at approx 31n	'n	2		1		1			
20	a						21		-	1			
							1.0			1			-
10							-	(internet	-	1			
			48-66 SAND majority medium, fin sand with calcareous sand, light rec	e to very fine qui Idish brown	ertz.		- 22		-	1			-
							7		2 _	_1-	1	_	-
-	≥								<	1		-	-
	Lertia	Thw						F	-		1 774		

TOTAL DEPTH 65.02 m

Derumitiescation bata Description CodePL Ethon bata	Imm From (m) To (m) Type/Material CHEMISTRY DATA 1 400 0.0 24.0 Hammer pH TDS by EC 650 7.6 52 24.0 66.0 Rotary Mud TDS by EC 650 1180 65.5 66.0 Cuttings Mag 24.7 Mag 24.7 50 0.0 24.0 PVC Na 147 147 0.0 41.5 PVC HCO ₃ 2255 CO ₃ 147 0.0 41.5 65.5 Slotted PVC No as as N 0.005 159.7 00 0.0 2.0 Cement Boron 0.005 1000 2.0 65.5 Gravel 1000 Conductivity (affirm 1000 1000 L GEOPHYSICAL LOGS 1000 Conductivity (affirm 1000 1000 SICAL 100 100 100 100 100 100 100 100 100 100 10
Purpose Observation Drilling Method Retary Mathematical Control of the control of	65.5 66.0 Cuttings TDS by calc. 631 50 0.0 24.0 PVC Mg 24.7 0.0 41.5 PVC Na 147 0.0 41.5 PVC C0, 255 00 41.5 65.5 Stothed PVC C1 199 00 0.0 2.0 Cement NOpg as N 0.005 NOpg as N 2.0 65.5 Gravel GEOPHYSICAL LOGS 1000 <
undred Uley Final Total Depth (m) 66.0 Casing Diameter 11 Sating (m AMG) 545072 Samples Logged By D.S. Clarks Casing Diameter 11 Gotting (m AMG) 6150372 POST-DEVELOPMENT DATA Date 14/12/2003 Production Zone 11 Sature GAA 64 Utwith below Ref. Point) 45.20 Production Zone 11 Structe 45.00 DS (mg1 - Lab) 45.20 Production Zone 11 Structe 45.05 DS (mg1 - Lab) 45.00 Scoord Grout Grout 10 Stef Point 0.56 C (JSCm - Lab) 45.00 Scoord Grout Grout Grout Grout Grout Grout Grout Grout Grout DETAIL Grout LITHOLOGY UDETAIL Grout LITHOLOGY UDETAIL And LITHOLOGY UDETAIL Grout LICONSTRU DESC LICONSTRU DETAIL Grout LICONSTRU LICG LICG LICONSTRU LICONSTRU LICON </td <td>S0 0.0 24.0 PVC Na 147 0.0 41.5 PVC Na 147 0.0 41.5 PVC Na 147 0.0 41.5 PVC C0 255 00 41.5 85.6 Stoffed PVC S0, 59.7 00 0.0 2.0 Cement NO₅₀ as NO₅ 0005 2.0 65.5 Gravel GEOPHYSICS JOB No. 6699 L GEOPHYSICAL LOGS 1000 1000 1000 1000 SICAL 90 90 100 100 100 1000</td>	S0 0.0 24.0 PVC Na 147 0.0 41.5 PVC Na 147 0.0 41.5 PVC Na 147 0.0 41.5 PVC C0 255 00 41.5 85.6 Stoffed PVC S0, 59.7 00 0.0 2.0 Cement NO ₅₀ as NO ₅ 0005 2.0 65.5 Gravel GEOPHYSICS JOB No. 6699 L GEOPHYSICAL LOGS 1000 1000 1000 1000 SICAL 90 90 100 100 100 1000
Stating (m, AMG) 549078 Date 14/12/2003 Find AAA Stum Gravel Pack Forduction Zone 11 Stum 0.55 Forduction Zone 11 Stum 0.56 Forduction Zone 11 Stum 0.56 TDS (mpL - Lab) 650 Stumple Method 650 Gravel Pack CONSTRU Of E LITHOLOGY CONSTRU E LITHOLOGY CONSTRU E Hydrostratigraphy Description LITHOLOGY E 12/24 SAND fine to medium, calcareous, light brown LITHOLOGY	0.0 41.5 PVC 00 41.5 65.5 Slotted PVC 00 0.0 2.0 Cement 2.0 65.5 Gravel GEOPHYSICS JOB No. 6699 CTION LS GICAL
Open Levation GDA 64 (a)um Date (a)um Description Date (a)um Date (a)um <thdate (a)um Date (a)um Da</thdate 	00 41.5 85.5 Slotted PVC Cit 199 00 0.0 2.0 Cement NO ₂₀ as NO ₃ Boron 2.0 65.5 Gravel GEOPHYSICS JOB No. 6609 L GEOPHYSICAL LOGS 1000 Conductivity (stime) 1000 LS GEOPHYSICAL LOGS 1000 Conductivity (stime) 1000 SICAL 100 100 Conductivity (stime) 1000
Add Add Status Add Status Add Status 0.95 11 Add Status Add Status Add Status Add Status 0.95 11 Bert Add Line Add Status Status Status Status Status Add Status Add Status Status Status Status Status Status Status Add Status Add Status Status <td>00 0.0 2.0 Cement NO₂₇₀ as N 0.005 NO₂₇₀ as NO₅ 2.0 65.5 Gravel GEOPHYSICS JOB No. 6699 L GEOPHYSICAL LOGS 1000 1000 1000 LS GEOPHYSICAL LOGS 1000 1000 1000 SICAL Geophysics 1000 1000 1000 1000</td>	00 0.0 2.0 Cement NO ₂₇₀ as N 0.005 NO ₂₇₀ as NO ₅ 2.0 65.5 Gravel GEOPHYSICS JOB No. 6699 L GEOPHYSICAL LOGS 1000 1000 1000 LS GEOPHYSICAL LOGS 1000 1000 1000 SICAL Geophysics 1000 1000 1000 1000
er, Porm 46.15 EC ("Stern - Lab) 520 Group go of Open Interval Sample Method Bentonite Seal gravel Pack LITHOLOGY CONSTRU gravel Pack LITHOLOGY DETAIl gravel Pack LITHOLOGY LITHOLOGY gravel Pack CONSTRU DETAIl gravel Pack Gravel Pack CONSTRU gravel Pack CONSTRU DETAIl gravel Pack Gravel Pack CONSTRU gravel Pack CONSTRU DETAIl gravel Pack Gravel Pack CONSTRU gravel Pack CONSTRU DETAIl gravel Pack Gravel Pack CONSTRU gravel Pack CONSTRU DETAIl gravel Pack Gravel Pack CONSTRU gravel Pack Construction LITHOLOC gravel Pack Gravel Pack CONSTRU gravel Pack Gravel Pack LITHOLOC gravel Pack Gravel Pack CONSTRU gravel Pack Gravel Pack LITHOLOC gravel Pack	2.0 65.5 Gravel Boron 2.0 65.5 Gravel BOOM State Stat
LITHOLOGY LITHOLOGY	L GEOPHYSICAL LOGS 1000 Conductivity (utility) 10000
A0 T2-24 SAND fine to medium, calcareous, light brown, T2-24 SAND fine to medium, calcareous, light brown,	LLS instant of Section 200 million and 100 million 100
Hydrostratigraphy Description LOG O-12 SAND fine to medium, calcareous, light brown 12-24 SAND fine to medium, calcareous, light brown,	
40 12-24 SAND fine to medium, calcareous, light brown,	- 3 2
12-24 SAND fire to medium, catcareous, light brown,	
12-24 SAND The to medium, carcaneous, light brown,	
30 alternating with consolidated calcarente gravel.	
20 E 24-30 SAND calcareous, with abundant calcarerite and calcrete gravel 10-15%	
O Open(US) 30:36 SAND calcareous, dark brown to pale red, mainly G fine to medium grained, calcarente gravel < 5%	
10 36-45 SAND calcareous, light brownlight reddish	2 2 2
depth, fossils-bivalve, fossil/terous calcarentite	
0 45-54 SAND similar to above, quarte Sand starting to	1 7 7 7 5 5
appear, line to medium Gravel mostly calcarente	
54-66 NO RETURNS lost circulation, no samples,	
drilling pressure indicates claylinguitard approx Gm, obtained a calcaneous cohesive light red sandy clay sample from drilling bit where reduced where removed	
TpQau	
-20	

TOTAL DEPTH 65.05 m

	0	Gove Depa	ernment of South Austr streent of Water, Land an emity Conservation.	alla 1	COMPOSITE WATER WELL LOG Well Unit No. 6028 2317 : Observation Well Name ULE 208									
IDENTIFICA Permit No. Unit No. Obs. Name Purpose LOCATION Hundred Allotment TJ Easting (m. Zone Datum ELEVATIO Ground Sur Ref. Point Top of Ope Base of Op Base of Op		ICATI o me ON D/ t Type m AM (m AM (m AM Surfac ti abov ti pen In Doen In	CONDATA 600 DATA 6026 2317 ULE 208 Observation ATA Uley 5 No 5 28 (G) 547735 (G) 547735 (G) 6153092 53 (G) 6153092 53 (G) 647735 (G) 547735 (G) 647735 (G) 64774 (G) 647745 (G) 6477755 (G) 647745 (G) 6477755 (G) 647755 (G) 647755 (G) 6	VVEIT UT DRILLING DATA Start Date 14/12/2003 Finish Date 15/12/2003 Driller Underdale Drilling Method Rotary Circulation Mud Max. Drilled Depth (m) 42.0 Final Total Depth (m) 35.0 Samples Logged By D.S. Clarke Date 15/12/2003 DTW (m below Ref. Point) 29.44 SWL (m AHD) 1.38 TDS (mg/L - Lab) 520 EC (J.SiCm - Lab) 550 Yield (Liw) Sample Method		It No. 6028 23 COMPLETION DATA in Borehole Diameter 2: 11 Backfiled:Plugged Casing Diameter 11 1 Production Zone 11 Grout Bentionite Seal Carvel Pack		317 : Obs mm From 240 0.0 152 30.0 38. 350 150 0.0 100 0.0 100 20.0	From (m) 0.0 30.0 38.0 0.0 20.0 20.0 20.0	IDSERVATION om (m) To (m) 0.0 30.0 38.0 41.0 38.0 0.0 30.0 20.0 38.0 0.0 38.0 0.0 38.0 0.0 20.0 38.0 0.0 20.0 38.0	Type-Material Hammer Hammer Cuttings PVC PVC Slotted PVC Cement Gravel	Ne ULE 208 CHEMISTRY DATA pH TDS by EC EC TDS by calc. Ca Mg K Na HCO ₃ C0, Cl SO ₄ NO ₂₉ as N NO ₂₉ as N NO ₂₉ as N Boron GEOPRIVENCE OR No.	7.5 520 950 503 751 24.9 2.8 93.4 286 140 26.1 4.77	Units mgl mgl mgl mgl mgl mgl mgl mgl mgl mgl
	(DHV III) u			LITHOLOGY	c		WELL CONSTRUCTION DETAILS		GEOPH	IYSICAL	LOGS	1000 Conductivity (LSVINS) 1 1000 1001 (Janvin) Pyot Haugh 10		27900
	Elevatio	INN	Hydrostratigraphy	Descript	lion		LITHOLO	GICAL	Comme (APR)	100 110	the states		1	
)	30 20 10	Quatemary	Qpcb(US)	0-3 CLAY calcareous, paie red bro 3-6 SAND calcareous, fine to med brown 6-15 SAND calcareous, fine to me brown, calcrenite handbars, dotomi 15-24 CALCARENITE as fine gran	sh brown		TAL SUBJUC	and a survey where						
0	o	sement	ALS	24-42 NO RETURNS Lost circula suspected that granite was struck a drilling	ition, no samples et 36m, very hard	1	, 3		ALC			1		A A IA

12 APPENDIX D

AUTOMATED MONITORING EQUIPMENT — DATALOGGING HYDROGRAPHS

Coffin Bay A Lens

Uley South Datalogger Monitoring

Uley South Datalogger Monitoring

Uley South Datalogger Monitoring

Uley South Datalogger Monitoring

Uley South Datalogger Monitoring

Uley South Datalogger Monitoring

Uley South Datalogger Monitoring

Uley South Datalogger Monitoring

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