The Department of
Water, Land and
Biodiversity
Conservation

Uley South – Coffin Bay Observation Well Network Review

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Resource Assessment
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Foreword

South Australia's natural resources are fundamental to the economic and social wellbeing 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 a 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 quality 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, Resource Assessment Division
Department of Water, Land and Biodiversity Conservation

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EXECUTIVE SUMMARY

South Australian Water Corporation (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 underground water supplies, particularly from the Southern Basin Prescribed Wells Area, are managed sustainably.

At this time, the Uley South Lens appears to be utilised within its sustainable limits. However, with the expansion of the Uley South Public Water Supply wellfield in 1999–2000, extraction pressures have changed within the lens. Future residential and irrigation demand on the water resources of the Peninsula will require effective management of the lens with reliance on accurate monitoring of storage and recent recharge history to assure sustainability.

A review of the current monitoring networks to evaluate the condition of the Uley South and Coffin Bay observation wells was undertaken between May and July 2002. The adequacy of the information provided by the wells was investigated and positions within the basin where knowledge gaps exist were identified. In addition, surface geophysical surveys were undertaken to establish the position of the saline water interface, pressure transducers were installed in some wells and pluviometers were established in order to provide more accurate storage and recharge information.

The aims of this review were:

- increasing the information base required for effective management of the resource
- augmentation of the network
- rehabilitation of ineffective wells where required
- installation and application of investigative equipment
- carrying out geological surveys.

These elements provide important information to enable efficient management, competent volume prediction, and effective recharge and extraction modelling of this complex groundwater system. The ultimate aim is to ensure current and future extraction will be within the available yield of the resource.

The project outcomes are:

- Establishment of a more rigorous monitoring framework to facilitate the management of the resource.
- Identification of the scope of works to be undertaken to understand the hydrodynamic behaviour of these systems in response to recharge and pumping demands.
- Definition of variability of salinity within the Uley South and Coffin Bay ‘A’ portions of the Southern Basins Prescribed Wells Area (PWA).

Hydrogeological knowledge gaps have been identified at strategic positions within the basin. It is recommended that four historical observation wells are rehabilitated and three new wells drilled and included in the current monitoring network. It has also been identified that three wells within the current network have not been rehabilitated and therefore should be incorporated in the rehabilitation upgrade. There are ~55 openhole historical observation wells within the Uley South Lens. These wells are not currently monitored and not rehabilitated and therefore potentially allow surface runoff to enter and mix with the aquifer formation water and also aquifer mixing through the open column. These wells may be used as future observation wells as information is required, however, the expense of rehabilition at this stage may not be warranted. It is recommended that SA Water and DWLBC review the future of these wells.

Information from salinity profiling of purged wells can identify the presence of salinity stratification within the aquifer. Well purging, sampling and salinity profiling with sonde was performed on most observation wells. Sonding of all the purged wells indicated a consistant salinity profile with depth in the majority of wells. However, two wells showed stratification. One well is positioned near the lens boundary where no confining layer exists and the other near the swamp where complex recharge and discharge processes may be occurring.

Results from transient electromagnetic (TEM) surface geophysics may assist in defining the extent of the groundwater lens and map the saline interface. The analysis of the results of the Uley South survey identified broad hydraulic zones beneath the surface indicative of changes in groundwater salinity. A possible saline interface has been identified in Uley South Lens about 700 m from the coast on transect 1000N at an approximate depth of 85 m. The interpretation is that the saline water body is within the Tertiary Wanilla Formation. However, as there is no clay aquitard beneath the Quaternary sequence in this area there is a potential risk to induce a saline intrusion by groundwater extraction from pump stations USPB 15, 16 and 17. The TEM survey results indicate that at present there is freshwater within the Quaternary Bridgewater Formation at this site and it is uncertain whether this interface is mobile. Future monitoring will determine the risk to the Quaternary Aquifer. It is recommended that an observation bore is drilled to groundtruth the geophysical results and define the geological, hydrogeological and geochemical profile to identify possible salinity stratification, and that 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 tidal fluctuations and changes in groundwater level. Monitoring will be necessary to identify the natural range of movement, setting a benchmark to identify any induced intrusion as a result of groundwater extraction.

Access for geophysical surveying into the sand dunes south of the Coffin Bay borefield was unachievable by the impedance of the dense vegetation, but several geophysical transects were achieved at Coffin Bay . Unfortunately the data is of lower quality than that from Uley South. Preliminary results show an area of higher resistivity to a depth of ~50 m correlating with geological logs. It is difficult to define whether there is a saline interface present or this confined formation is naturally saline throughout from this data. Analysis is continuing.

Ten pressure transducers recording water level changes have been installed in selected wells — two in Coffin Bay and eight in Uley South. Four pluviometers logging rainfall intensities have been also been installed — one in Coffin Bay and three in Uley South. All pluviometers are associated with nearby pressure transducers to enable rainfall recharge relationships to be further researched. This data will provide important long-term information on the aquifer response to rainfall intensity and subsequent recharge and pumping pressures.

Groundwater samples show a salinity trend of no change, and in most wells it appears that the previous or current extraction regime is not influencing the salinity. However, a slight expansion of the higher salinity zone about the original wellfield in the Uley South

Lens is evident. The erratic salinity curve in several Coffin Bay wells is likely due to the bailed method of sampling. Bailed sampling has been shown to give unreliable representation of aquifer salinity. The recommendation is that water samples be collected using accepted sampling standards to give representative salinity measurements of the aquifer formation water. The predominant baseline trend indicates that aquifer salinity is likely to be not increasing.

With the expansion of the Uley South Public Water Supply wellfield in 1999, re-distribution of extraction pressures has occurred within the lens. An analysis of the changes in water level from 1997 to 2002 was carried out by contouring the water level changes over this period. Current extraction does not appear to alter the regional water level trends apart from what is estimated to be a short-term adjustment period adjacent to the new production wells. At this time, the Uley South Lens appears to be utilised within its sustainable limits.

The work completed in Uley South has shown that further work is required to address the following known knowledge gaps to:

- Better define the aquifer and groundwater characteristics throughout the basin by rehabilitating strategic observation wells and constructing up to three new wells that will be geologically and geophysically logged and chemically analysed.
- Better define basin geometry by undertaking strategic TEM geophysical surveys and monitor movement of the saline interface.
- Establish the extent and thickness of the lens by completing a second series of salinity profiling of wells; comparison with existing salinity profiling results will determine any trend in groundwater salinity and lens size.
- Relate aquifer extraction demands to enable salinity and water level trends to recharge events, and sound management decisions.

Augmentation and rehabilitation of the monitoring network will provide a more comprehensive knowledge base to effectively observe changes in the basin over time. It is recommended that:

- Current observation wells ULE 97, 134 and 147 be rehabilitated.
- Historical observation wells SLE 10, ULE 133, ULE 98 and ULE 96 be rehabilitated and included in the current monitoring network.
- Three new wells be drilled at strategic positions in the basin where hydrogeological knowledge gaps have been identified. It is further recommended that all drilled wells be geophysically logged. This standard procedure carried out at the completion of drilling provides a high degree of certainty to geological and hydrogeological interpretation.
- SA Water and DWLBC review the future of openhole historical wells.
- Monitoring frequency remains monthly due to the irregularity of timing and magnitude of recharge events.

The assessment of the ongoing monitoring records of water level changes and chemical analyses from sites within the Uley South groundwater monitoring network will give confidence that the current management framework is appropriate for this lens. It is recommended that:

- The current observation wells, including the new and rehabilitated wells, undergo salinity profiling (with the exception of those wells without casing and completion details). 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 which 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.

Other recommendations are:

- The strategic placement of two additional transducers in either the new or rehabilitated wells to provide an effective coverage for water level monitoring. This will, over time, provide confidence that the current management framework is appropriate and assist with the determination of the extent and sustainability of the resources.
- An investigation well is drilled to groundtruth the geophysical results and define the geological, hydrogeological and geochemical profile to identify possible salinity stratification. This well should be installed with one of the transducers to monitor any water level changes. It is understood that the saline interface in coastal aquifers can be dynamic with movement cased by tidal fluctuations and aquifer water level changes. Monitoring will be necessary to identify the natural range of movement setting a benchmark to identify a negative shift due to saline intrusion.
- It is critical that geophysical surveys are repeated in future programs. By correlating the geophysical data with the geological borehole logs, and downhole salinity profiling of the proposed new and rehabilitated wells, a more precise position of any saline interface can 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.
- It is recommended that SA Water and DWLBC review other 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. If the saturated depth and the water quality are similar to that within the borefield it is proposed that another series of wells be drilled some distance south of the original series. Further suggestions may include a remote geophysical investigative method such as aerial surveys. In addition environmental tracer analysis may be useful to delineate recharge processes.
- No interpretation is currently available from TEM surveys on the coast due to data collection difficulties. It may be necessary to conduct a survey and water quality testing of private wells situated in the township to establish any change in salinity with distance from the coastline in both aquifers.

INTRODUCTION

SA Water and DWLBC have been working cooperatively on Eyre Peninsula to ensure that extractions of water from underground water supplies, particularly from the Southern Basin PWA, are managed sustainably.

SA Water relies on groundwater from the Southern Basins PWA for a major component of its public reticulated water supply for Eyre Peninsula. SA Water requires a sufficient allocation of water to satisfy the demands for the public water supply in the region. Approximately 10 000 ML/y is used across the Eyre Peninsula (ERWRPC, 2000). The ratio of groundwater to surface water resources (Tod Reservoir) used in the Eyre region varies each year. Over the period 1995 and 1996, 68% of supplied water was groundwater. The percentage increased to 96% for 2001 and 2002, and 100% groundwater is anticipated in this 2002–03 financial year (D Cliff, SA Water Corporation, Port Lincoln, per. comm., 22 January 2003).

The potable groundwater resources occur as isolated shallow watertable lenses within the Quaternary limestone (Bridgewater Formation). These resources are delineated by geological structure and the 1000 mg/L isohaline, and occur on the southern and western parts of Eyre Peninsula. The principal lens, Uley South, has been developed for water supply extraction and is the prime source of groundwater for the Peninsula. The Coffin Bay ‘A’ Lens is utilised to supply reticulated public water supply to the Coffin Bay township (Fig. 1).

At this time, the Uley South Lens appears to be utilised within its sustainable limits. However, with the expansion of the Uley South Public Water Supply wellfield in 1999–2000, extraction pressures have changed within the lens. Future residential and irrigation demand on the water resources of the Peninsula will require effective management of the lens with reliance on accurate monitoring of storage and recent recharge history to assure sustainability.

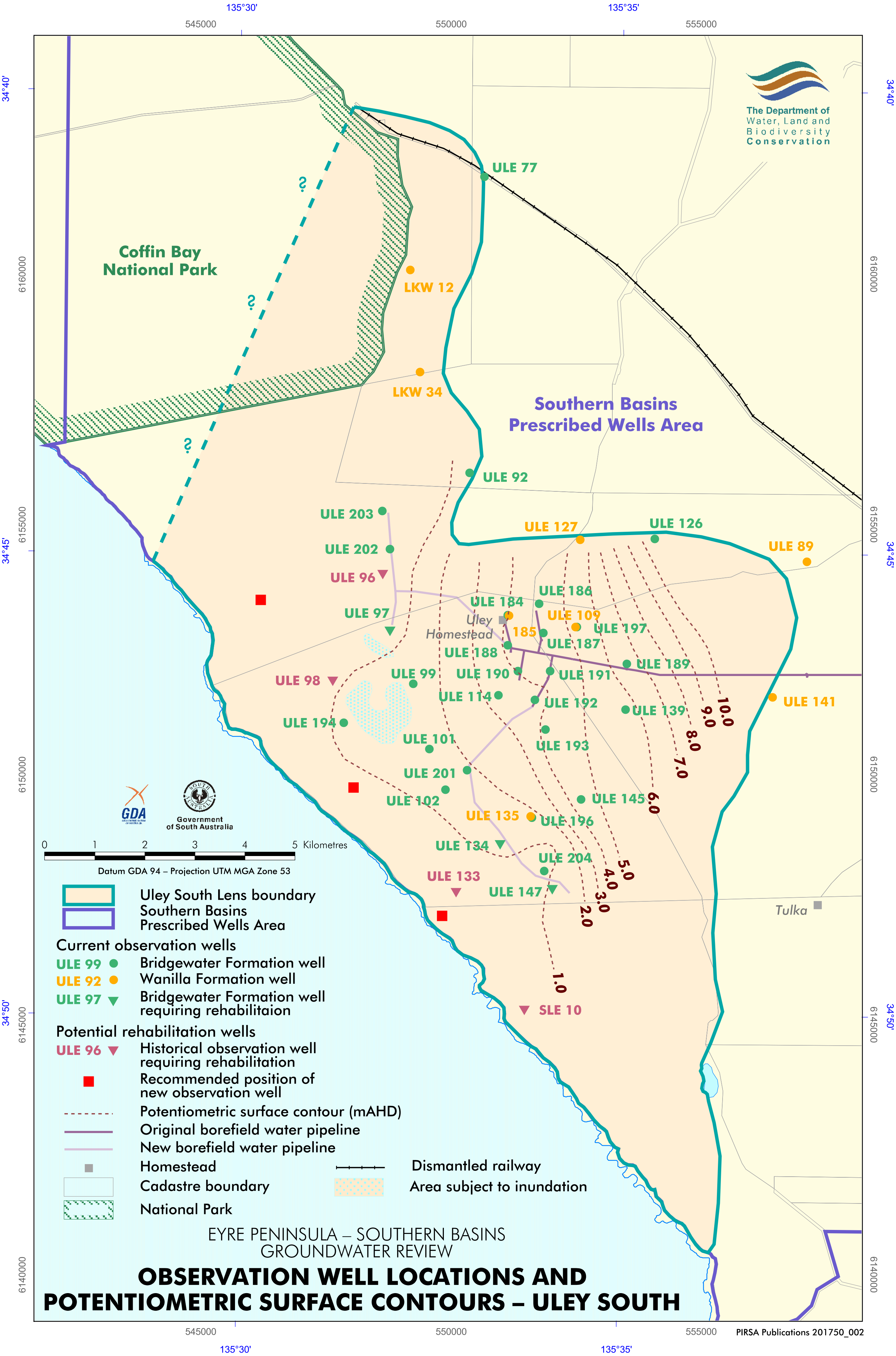
A review of the current monitoring networks to evaluate the condition of the Uley South (within the lens boundary and including ULE 89 and 141; Fig. 2) and Coffin Bay (within SA Water boundary; Fig. 3) observation wells was undertaken between May and July 2002. The adequacy of the information provided by the wells was investigated and positions within the basin where knowledge gaps exist were identified. In addition, surface geophysical surveys were undertaken to establish the position of the saline water interface, and pressure transducers were installed in some wells and pluviometers were established in order to provide more accurate storage and recharge information.

EYRE PENINSULA – SOUTHERN BASINS GROUNDWATER REVIEW

LOCATION OF COFFIN BAY 'A' AND ULEY SOUTH LENS AREAS OVER LANDSAT IMAGERY

Figure 1

PIRSA Publications 201750_001



135°30'
135°35'
545000
550000
555000
34°40'
34°45'
34°50'
6160000
6155000
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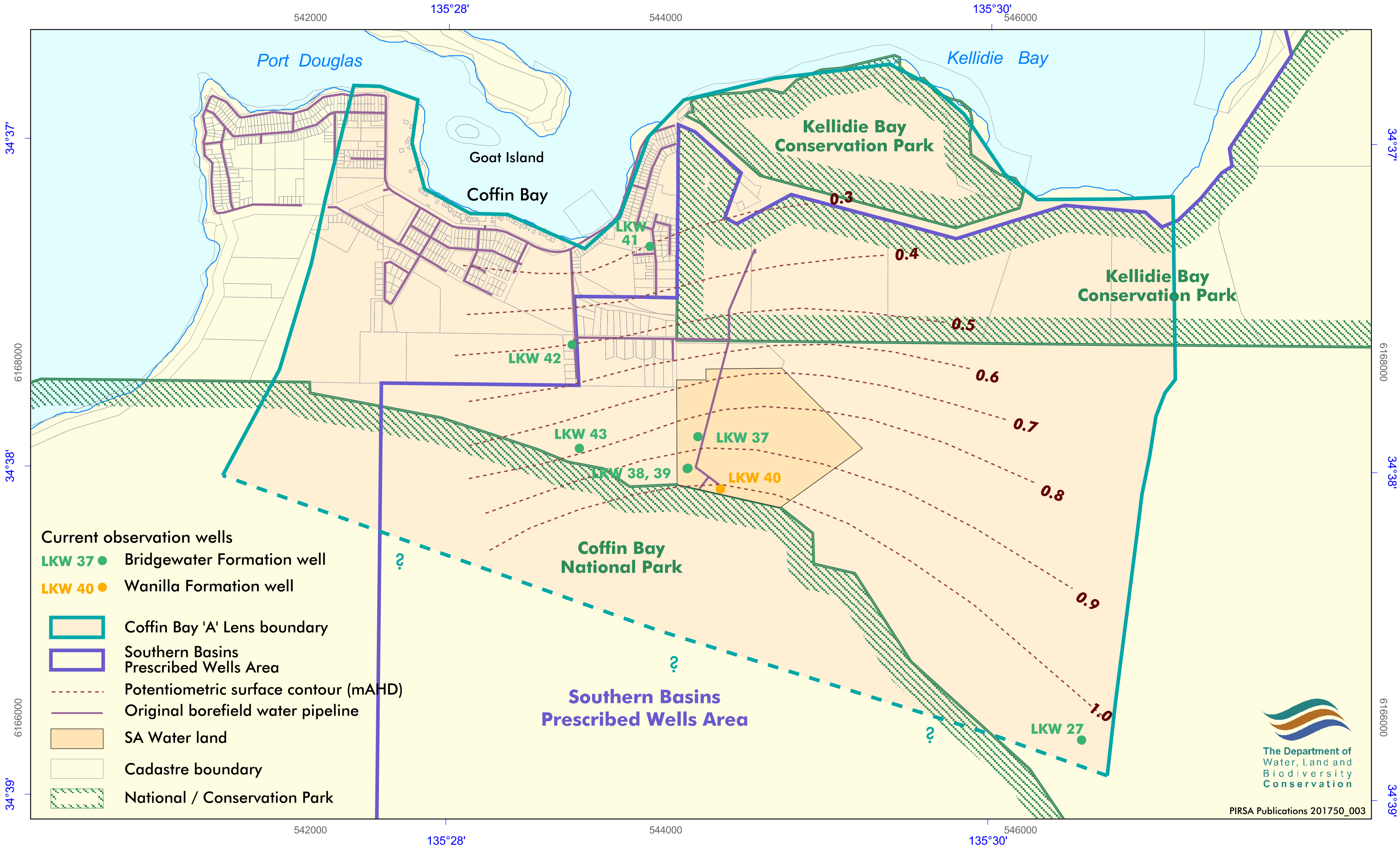
The Department of Water, Land and Biodiversity Conservation
Coffin Bay National Park
Southern Basins Prescribed Wells Area
ULE 77
LKW 12
LKW 34
ULE 92
ULE 203
ULE 202
ULE 96
ULE 97
ULE 127
ULE 126
ULE 89
ULE 186
ULE 184
ULE 109
ULE 197
Uley Homestead
185
ULE 187
ULE 188
ULE 189
ULE 99
ULE 190
ULE 191
ULE 98
ULE 114
ULE 192
ULE 139
ULE 141
ULE 194
ULE 101
ULE 193
ULE 201
ULE 102
ULE 145
ULE 135
ULE 196
ULE 134
ULE 204
ULE 133
ULE 147
Tulka
SLE 10
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
GDA
Government of South Australia
0 1 2 3 4 5 Kilometres
Datum GDA 94 – Projection UTM MGA Zone 53
Uley South Lens boundary
Southern Basins Prescribed Wells Area
Current observation wells
ULE 99 Bridgewater Formation well
ULE 92 Wanilla Formation well
ULE 97 Bridgewater Formation well requiring rehabilitaion
Potential rehabilitation wells
ULE 96 Historical observation well requiring rehabilitation
Recommended position of new observation well
Potentiometric surface contour (mAHD)
Original borefield water pipeline
New borefield water pipeline
Homestead
Cadastre boundary
National Park
Dismantled railway
Area subject to inundation
EYRE PENINSULA – SOUTHERN BASINS GROUNDWATER REVIEW
OBSERVATION WELL LOCATIONS AND POTENTIOMETRIC SURFACE CONTOURS – ULEY SOUTH
PIRSA Publications 201750_002

Figure 2



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0 500 1000 1500 Metres

Datum GDA 94 – Projection UTM MGA Zone 53

GDA

EYRE PENINSULA – SOUTHERN BASINS
GROUNDWATER REVIEW

OBSERVATION WELL LOCATIONS AND POTENTIOMETRIC SURFACE CONTOURS – COFFIN BAY

Figure 3

GEOLOGY AND HYDROGEOLOGY

Detailed geology and hydrogeology of the Southern Basins are described previously (Evans,1997; Martin and Clarke, 2000).

In summary, the groundwater predominantly occurs in rocks and sediments of three different geological environments: Quaternary Bridgewater Formation limestone, Tertiary Uley Formation clay and Wanilla Formation sand sediments overlaying a volcano-metasedimentary basement sequence.

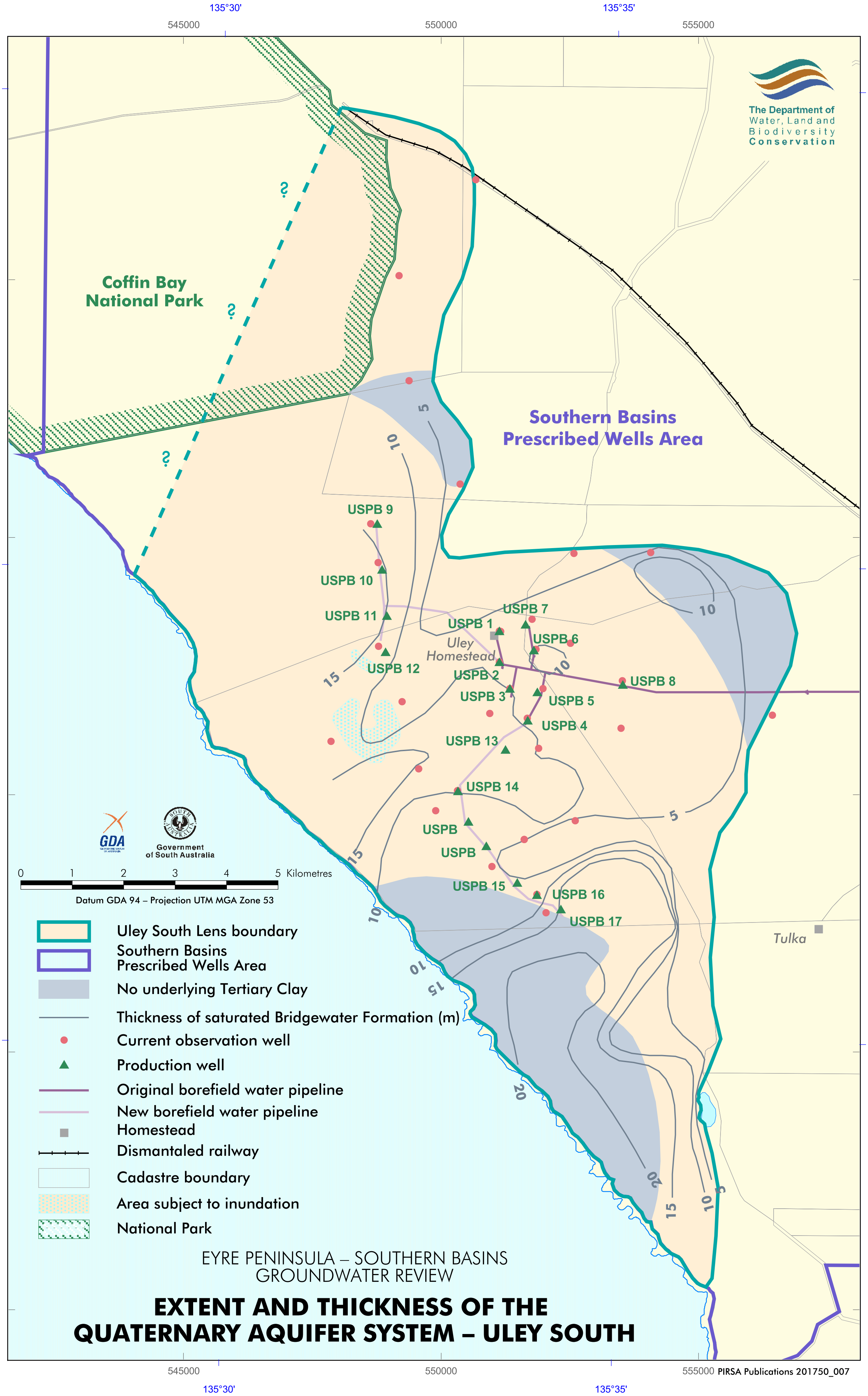
The Bridgewater Formation unconfined aquifer has been primarily developed for reticulated public water supply. The aquifer occurs as isolated lenses with generally high yields and low salinity. The Bridgewater Formation aquifer overlies the Wanilla Formation aquifer. A clay sequence, the Uley Formation, exists at the top of the Wanila Formation and behaves as an aquitard between the Bridgwater Formation and the Wanilla Sands aquifer However, there are several areas to the SE and north (Fig. 4), where the confining layer is absent from the profile and there is potential for local hydraulic connection between the aquifers. Figure 4 illustrates the Bridgewater Formation saturated thickness within the Uley South Lens boundary.

These unconfined groundwater resources receive recharge via direct infiltration of incident rainfall only. Dominant groundwater flow within the Uley South Lens SW toward the Southern Ocean and westward toward the Coffin Bay National Park (illustrated by the potentiometric surface contours Fig. 2). No groundwater investigations have been undertaken beneath the sand dunes of Coffin Bay National Park.

The Coffin Bay Basin comprises three freshwater lenses, Coffin Bay A, B and C. The SA Water wellfield is within the Coffin Bay 'A' Lens. The principal direction of groundwater flow is NW towards Kellidie Bay (illustrated by the potentiometric surface contours, Fig. 3). Groundwater discharge is evident as surface springs along the southern shore line of Kellidie Bay.

Water level behaviour within the Quaternary lenses reveals that recharge occurs after intense rainfall events, where short lived overland flow is directed to solution features (sinkholes; Fig. 5) and infiltrate to the watertable rapidly. The sinkholes are often characterised by washouts with no soil. Research of the Uley Basin system (Evans, 1997) indicates that these resources show an annual water level rise when they receive more than 10 days of >10 mm of rainfall between the months of May and October. It is estimated that up to 30% of the annual rainfall will infiltrate as recharge to these Quaternary lenses.

It has been reported in the Southern Basins Prescibed Wells Area groundwater monitoring status report 2002 (Evans, 2003) that there has been a general groundwater level decline in all lenses in the Southern Basins irrespective of wellfield development. This highlights the dominance of effective rainfall on storage.



EYRE PENINSULA – SOUTHERN BASINS GROUNDWATER REVIEW

EXTENT AND THICKNESS OF THE QUATERNARY AQUIFER SYSTEM – ULEY SOUTH

Figure 4

Figure 5. Example of solution feature — a point recharge site typical across Uley South Lens

AIM

The aims of this review were:

- increasing the information base required for effective management of the resource
- augmentation of the network
- rehabilitation of wells which are declining in condition
- installation and application of investigative equipment
- carrying out geological surveys.

These elements provide important information to enable efficient management, competent volume prediction, and effective recharge and extraction modelling of this complex groundwater system.

The ultimate aim is to ensure current and future extraction will be within the available yield of the resource.

Project objectives

The project objectives were to:

- review spatial extent and adequacy of existing monitoring wells, and frequency of monitoring
- purge, clean and survey wells to obtain true downhole salinity profiles using SONDE and collect pumped samples for electrical conductivity (EC) determinations
- identification of sites to establish additional monitoring wells to enable an assessment of the potential threat from saline intrusion
- identification of sites for the installation of automated monitoring devices.

Project outcomes

The project outcomes are:

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

METHODOLOGY

Fieldwork was completed in the Uley South and Coffin Bay Observation Well Networks in July 2002 and are summarised below, represented spatially in Figures 6 and 7 and presented in Tables A1 and A2 in Appendix A.

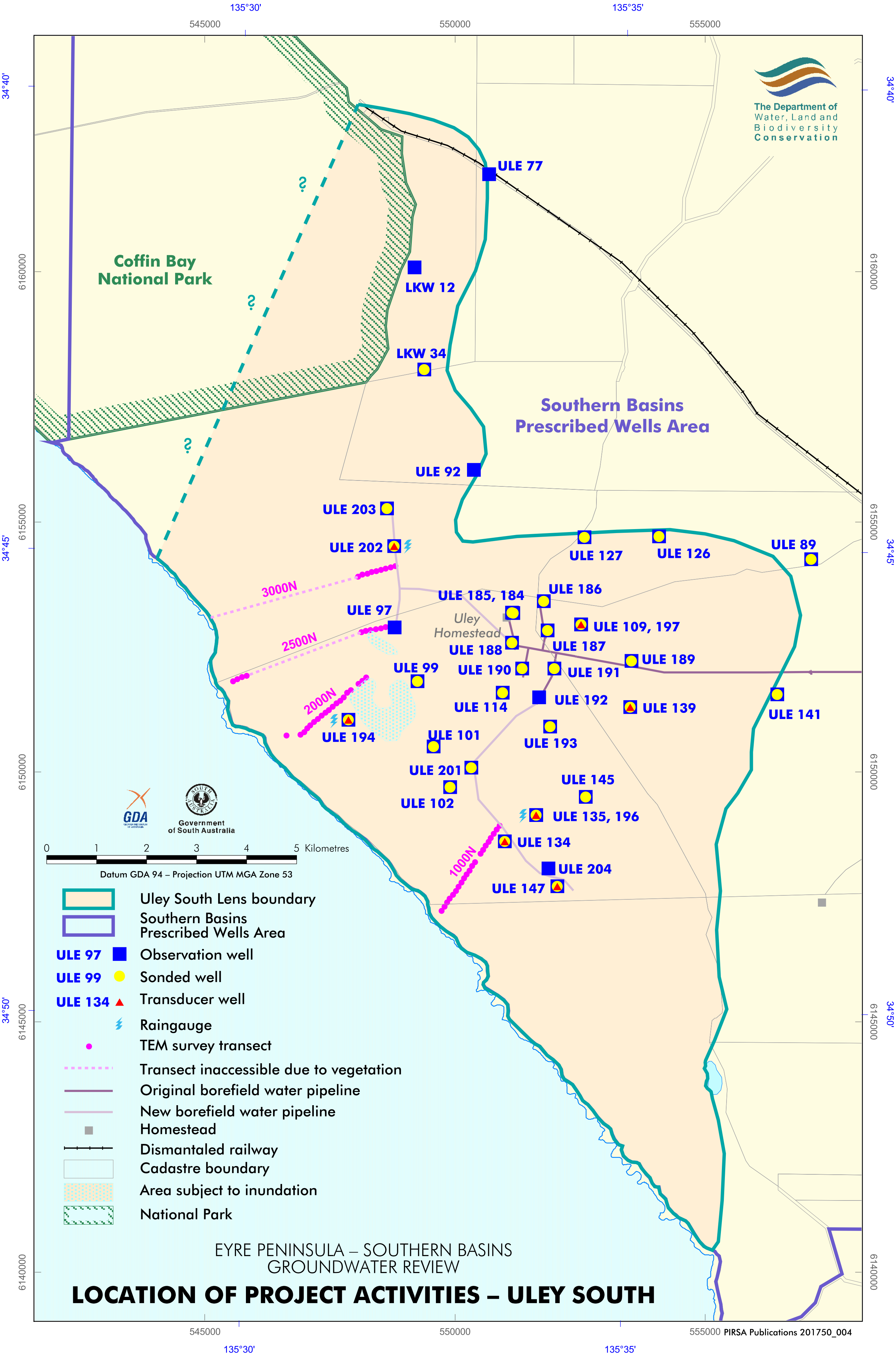
Establishment of a more rigorous monitoring framework to facilitate the management of the resource

- The total well depth and water levels were recorded for all current observation bores within the total Southern Basins Observation Well Network and the database updated. Water levels will continue to be recorded monthly as part of the Observation Well Monitoring Program by SA Water personnel.
- Maintenance was completed on all Uley South (within the lens boundary and including ULE 89 and 141) and Coffin Bay (within the SA Water Waterworks Reserve) observation wells. This included tagging, capping and general repairs. It is recommended that selected wells (three currently and four not currently monitored (historical) at this time) are rehabilitated and monitored to fill recognised spatial knowledge gaps.
- A total of 23 of the 36 Uley South observation wells were purged and/or pumped. The remaining 13 were not purged for the following reasons:
  - three wells were completed with 63 mm casing, which is too small a diameter to accommodate the pump (ULE 97, 134, 147)
  - one well could not be located (ULE 204)
  - two wells were dry (ULE 92, LKW 12)
  - in two wells the sampling pump jammed (ULE 184, ULE 192)
  - could not get access to one well (ULE 203)
  - technical problems involving the pump resulted in four unpurged wells (ULE 77, 188, 190, 201).
- The four Coffin Bay observation wells where not purged due to technical problems involving the pump (LKW 37, 38, 39, 40).

It is recommended that these 17 unpurged wells be purged in further work.

Identification of the scope of works to be undertaken to understand the hydrodynamic behaviour of these systems in response to recharge and pumping demands

- Ten pressure transducers were installed — two at Coffin Bay and eight at Uley South. They have been programmed to record water level readings every four hours and data is downloaded every two months. Results of the first collected data are presented in the results section.
- Four pluviometers logging rainfall intensities have been installed — one in Coffin Bay and three in Uley South — all pluviometers are associated with nearby pressure transducers. The pluviometer at Coffin Bay and the one positioned at ULE 196/135 are triple channel instruments simultaneously recording rainfall intensities and water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ULE 77
LKW 12
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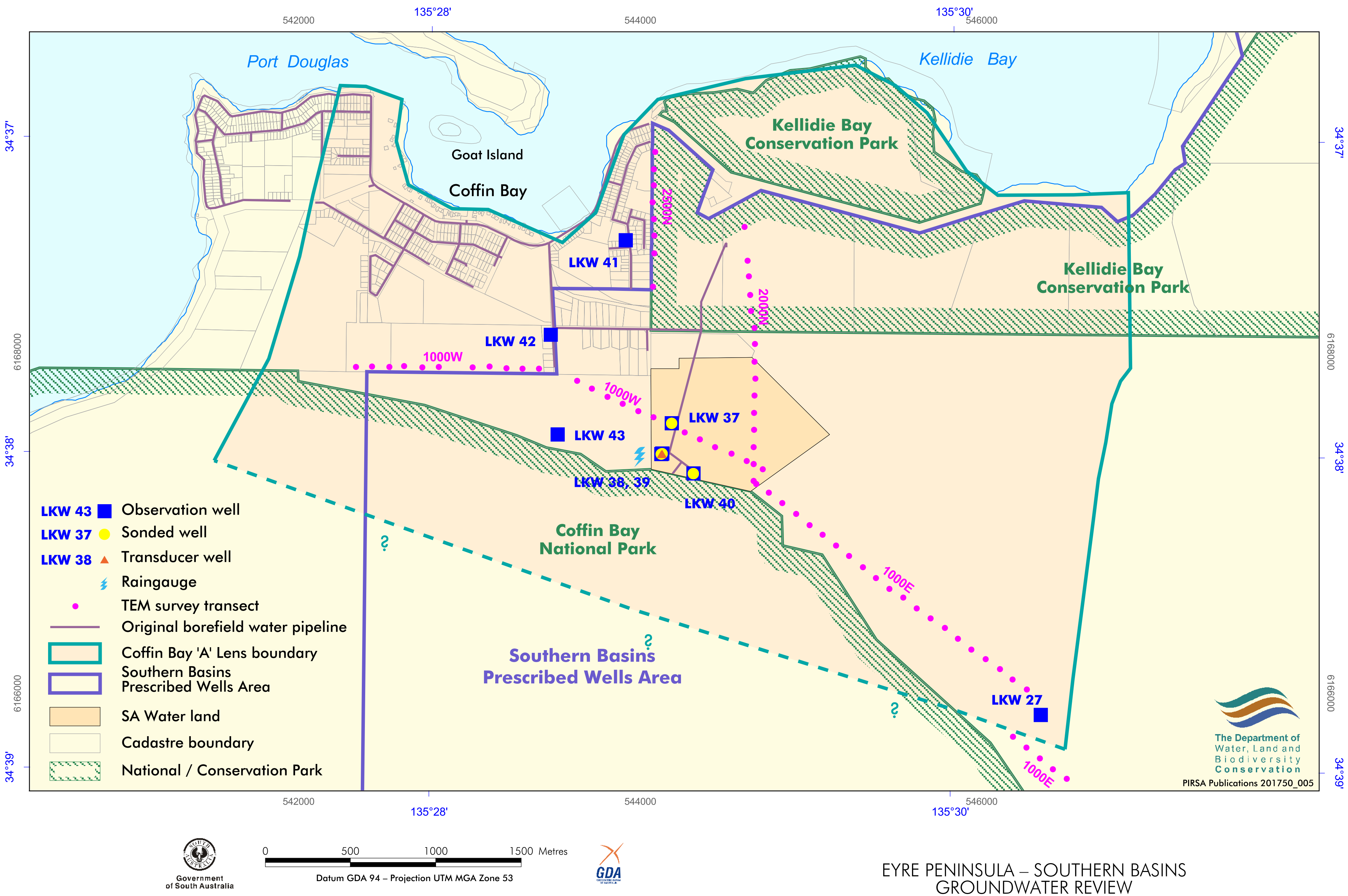
ULE 92
ULE 203
ULE 202
ULE 127
ULE 126
ULE 89
3000N
ULE 185, 184
ULE 186
ULE 97
Uley Homestead
ULE 109, 197
2500N
ULE 188
ULE 187
ULE 189
ULE 99
ULE 190
ULE 191
2000N
ULE 114
ULE 192
ULE 139
ULE 141
ULE 194
ULE 101
ULE 193
ULE 201
ULE 145
ULE 102
ULE 135, 196
ULE 134
1000N
ULE 204
ULE 147
GDA
Government of South Australia
0 1 2 3 4 5 Kilometres
Datum GDA 94 – Projection UTM MGA Zone 53
Uley South Lens boundary
Southern Basins Prescribed Wells Area
ULE 97 Observation well
ULE 99 Sonded well
ULE 134 Transducer well
Raingauge
TEM survey transect
Transect inaccessible due to vegetation
Original borefield water pipeline
New borefield water pipeline
Homestead
Dismantaled railway
Cadastre boundary
Area subject to inundation
National Park
EYRE PENINSULA – SOUTHERN BASINS GROUNDWATER REVIEW
LOCATION OF PROJECT ACTIVITIES – ULEY SOUTH
PIRSA Publications 201750_004

Figure 6



EYRE PENINSULA – SOUTHERN BASINS
GROUNDWATER REVIEW

LOCATION OF PROJECT ACTIVITIES – COFFIN BAY

Figure 7

levels. In Coffin Bay the transducers are installed in LKW 38 and 39 both monitoring the Quaternary Aquifer. In Uley South both the Quaternary (ULE 196) and the Tertiary Aquifers (ULE 135) are montiored. The results of the first download (July–Nov. 2002) are presented in the results section. This data will provide important information on the aquifer response to rainfall intensity and subsequent recharge and pumping pressures.

- TEM geophysical survey transects and several point penetrations were completed in Coffin Bay and Uley South. The location of these transects are illustrated in Figures 6 and 7. Analysis of the TEM data will clarify the lens extent (aquifer geometry), and assist in the identification and position of the saline interface and possible saline intrusion (a negative consequence of over-pumping on the resource) in both study areas. A detailed report of the results is presented in the 'TEM surveys' section.

Definition of current spatial variability of salinity within Southern Basins PWA

- Water samples to analyse full chemistry and EC were collected from the 23 purged wells. Results are discussed in the Results section and detailed in Table A3, Appendix A.
- A total of 32 Uley South and four Coffin Bay observation wells have been sonded to profile any salinity changes in the groundwater with depth. Of these wells 29 produced suitable data for analysis and are presented in the Observation Well Information sheets in Appendix B. Four were not sonded for the following reasons:
  - one could not be located (ULE 204)
  - two were dry (ULE 92, LKW 12)
  - one was obstructed (ULE 192).

The purpose of salinity profiling is to map the changes in groundwater salinity with increasing depth. The changes can identify a saline interface, setting a benchmark for future monitoring. The montioring of saline interfaces using this method may establish whether there is an induced migration of saline water into the aquifer due to the current groundwater extraction regime.

The equipment installed within the basin is presented in the 'Uley South and Coffin Bay automated monitroing equipment' section.

RESULTS

Observation well rehabilitation and augmentation

The earliest Uley South observation wells were drilled from the late 1950s for the then E&WS Department to investigate the hydrogeology of the groundwater resources and used to monitor water level behaviour. These wells were originally left as openholes. Later 65 mm steel pipes were place in the holes to assist with monitoring but were never completed or sealed to standard (Fig. 8). In the1990s the observation wells chosen for continued monitoring were rehabilitated. The process involved the removal of the metal casing, redrilling the hole, installing PVC casing, gravel packing, cement sealing and capping (Fig. 9). Rehabilitation of openhole wells is required for the following reasons:

- The aquifer formation water in open wells is at risk of water quality changes as the well provides a point of entry for rainfall runoff and contamination.
- The formation waters from aquifers will mix if the column is open across different aquifers. Aquifer mixing not only alters water quality, but it can also alter the hydraulics of the aquifer with a net negative effect.
- The 65 mm steel pipes will not permit entry of pump equipment and therefore well purging or water sampling can not be achieved.

The deeper holes penetrating the Tertiary sands and left with openhole completion have collapsed infilling the well to the base of the Quaternary sequence. Water level information from these holes is likely to reflect the Quaternary Aquifer behaviour.

The field survey revealed that three wells within the current network (ULE 97, 134, 147) have not been rehabilitated (Fig. 2). It is recommended that these well be rehabilitated in further work.

There are ~55 openhole historical observation wells within the Uley South Lens. These wells are not currently monitored and not rehabilitated and therefore potentially allow surface runoff to enter and 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 rehabilition at this stage may not be warranted. It is recommended that SA Water and DWLBC review the future of these wells.

Hydrogeological knowledge gaps have been identified at strategic positions within the basin. It is recommended that historical observation wells SLE 10, ULE 133, ULE 98 and ULE 96 are rehabilitated and three new wells drilled and included in the current monitoring network (Fig. 2).

It is suggested that two new observation wells be drilled in close proximity to the coast (Fig. 2) to obtain geological logs that will:

- provide essential hydrogeological information
- assist the interpretation of surface and well logging geophysical data by correlating, validating and truthing the information from all techniques. This provides added certainty, resulting in more reliable analysis.

Figure 8. Original Uley South observation well, openhole with 65 mm steel piping. A potential site for aquifer water quality changes and aquifer mixing.

Figure 9. A rehabilited monitored observation well; PVC casing, cement sealed, capped and tagged

In addition the drilling of new wells and the rehabilitation of historical wells SLE 10 and ULE 133 will provide vital salinity profiling sites to establish a strong definition of the saline interface to benchmark for future monitoring.

Another area where there is limited hydrogeological information is in the western region of the Uley South Lens, down hydraulic gradient from the wellfields (Fig. 2). The additional montoring data from a new well and two rehabilitated historical wells ULE 98 and ULE 96 in this vicinity will provide further understanding as to the extent of the lens and behaviour of the resource.

It is further recommended that all drilled wells be geophysically logged. Geophysical well logging (downhole geophysics) involves lowering a series of logging probes down a borehole. The probes transmit signals to the recorder at the surface. Important information about the borehole and the geological formations encountered are achieved and are correlated with the geological log recorded during drilling. This standard procedure carried out at the completion of drilling provides a high degree of certainty to geological and hydrogeological interpretation.

Salinity profiling

Information from salinity profiling of purged wells can identify the presence of salinity stratification within the aquifer. Successful well purging should remove all the stagnant groundwater in the casing or column (Fig. 10). This 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 is monitored during pumping. The stabilisation of these parameters indicates that formation water is being pumped. The removed water is naturally replaced with formation water within the column. Sonding after pumping will how a constant salinity profile within the column. Re-equilibration of the water within the casing is achieved after an undisturbed period of several months. Sonding may show a salinity stratification within the production zone of the well with a deviation from the constant casing profile and can indicate:

- recharge processes for different water bodies
- the position of a saline interface or saline intrusion within coastal aquifers.

This type of investigation was undertaken for the project to identify and map the position of a saline interface, thereby setting a benchmark for future monitoring. Once a saline interface has been identified, monitoring using salinity profiling may establish whether there is an induced migration of saline water, or saline intrusion, into the aquifer, caused by groundwater extraction.

Well purging occurred in May and salinity profiling with sonde occurred in July 2002. The results of the salinity profiling are detailed in the Observation Well Information sheets, Appendix B.

As stated earlier, only 23 of the 40 observation wells were purged. Of the 33 wells sonded, 22 had been purged. It is recommended that the remainder be purged in future work.

Figure 10. Well purging in Uley South — observation well ULE 139, May 2002

FINDINGS

Coffin Bay

The Coffin Bay wells LKW 37, 38, 39 and 40 were not purged therefore the sonding and results show stratification that may not be representative of the aquifer. However the results do illustrate the unreliablility of the SA Water bailed sampling method.

The sonding data for LKW 37 shows a constant salinity of 750 EC throughout the cased column which rapidly increases to >1200 EC in the production zone. The results indicate that the representative salinity of the Bridgewater Formation at this location is ~1300 EC. However the latest salinity recorded on 18 November 2002 was 721 EC. This indicates that the water sampling technique by SA Water is likely to be flawed. It is recommended that only pumped groundwater samples be collected where the pump is placed just above the production zone to sample groundwater representative of the aquifer monitored.

The representative salinity in LKW 38 is located within the production zone at ~900 EC. As identified in LKW 37 the sampling technique is not reflecting the formation water. The sudden reduction of salinity in the last three readings is representative of the sonde penetrating sediment at the base of the hole. This well has suffered some infill of sediment.

The representative salinity of the Bridgewater Formation aquifer located within observation well LKW 39 may be >1800 EC which has been profiled in the production zone. However, the latest salinity record of 18 November 2002 is 687 EC. Additonally, LKW 40, monitoring the Wanilla Formation, shows a similar result. The representative salinity profiled in the production zone is >5000 EC, increasing to >25000 EC with depth, while the latest salinity reading by SA Water is 2760 EC. A review of SA Water’s sampling techniques is recommended to ensure that samples are representative of the aquifer.

Uley South

The salinity profiling results of the Uley South observation well LKW 34 show a deviation at the last recorded point. The point is likely to be anomalous and should be compared to future sondings. It is considered that the first four readings in the profile represent the salinity of the formation.

The ULE 89 salinity profile shows a deviation part way down the column. This position may be where the pump was placed and while the water below was successfully purged, the water above, in the column, remained. Therefore, the first readings profile the old unpurged water and those below signify the salinity of the formation. The last reading was possibly taken when the sonde penetrated the mud at the bottom of the hole. This type of reading can be seen in several of the profiles presented and is anomalous.

Observation wells ULE 99, 101,102, 114, 139, 141, 145, 185, 186, 189, 191, 193, 196, 202 and 203 show constant salinity profiles indicative of successfully purged wells with no stratification. The salinity in some of the wells is slightly higher than that of the latest monitoring record. This may be a result of seasonal variation due to recharge in the zone of the well.

The ULE 126 salinity profile shows stratification, although it is only slight. The salinity of the groundwater may be increasing with depth. This well is situated on the upgradient lens boundary where there is no confining layer between the Quaternary and Tertiary, and therefore may be mixing with minor lateral inflow groundwater.

There are no casing and production zone details for ULE 127 and 134 and therefore it is difficult to analyse the results. It is recommended that these wells are not sonded until these details are established.

It is possible that the salinity stratification of the ULE 135 profile indicates the mixing of the groundwater between the Wanilla Formation and the weathered basement.

ULE 147 and 184 were not purged. The latest salinity record for ULE 147 was taken in 1964 when the well was drilled. It is recommended that these wells are purged, sampled and sonded in further work.

The reduction in salinity in the last two readings in ULE 187 is representative of the sonde prentrating sediment at the base of the hole.

ULE 188, 190 and 201 were not purged. The salinity profiles within the production zones possibly represent formation water salinity.

The salinity profile for ULE 194 increases with depth at a constant rate. This well is situated on the boundary of the swamps, a zone of potential discharge. Flow processes around the swamp may vary slightly to the understood regional processes causing stratification.

ULE 197 may not have been purged successfully. The representative salinity profile is probably within the production zone about the 1200 EC range.

Surface geophysics

TEM surface geophysics is used to indirectly determine the extent and nature of geologic and hydrogeological materials beneath the surface. This non-invasive technique uses electromagnetically induced eddy currents to establish the ground resistivity or conductivity as a function of depth.

Current is more easily transmitted through fluids in pore spaces and at fluid-grain interfaces than through the mineral grains. Strong current transmission is analogous to conductive structure such as saline fluid, porous mediums and clays. The results identify boundaries shown by changes in conductivity that can be caused by formation changes or groundwater salinity changes. Results from TEM surface geophysics may assist in defining the extent of the groundwater lens and map the saline interface. Several transects were undertaken in Coffin Bay and Uley South (Figs 6, 7). A comprehensive report of the geophysical results can be found in the 'TEM surveys' section.

The analysis of the results of the Uley South survey identified broad hydraulic zones beneath the surface indicative of changes in groundwater salinity. This geophysical method cannot identify the changes between dry and wet limestone therefore the boundaries do not necessarily identify different aquifers but different salinities within or across aquifers. A possible saline interface has been identified ~700 m from the coast on transect 1000N at an approximate depth of 85 m. The interpretation is that the saline water body is within the Tertiary Wanilla Formation. However as there is no clay aquitard beneath the Quaternary sequence in this area there is a potential risk to induce a saline intrusion by groundwater extraction from pump stations USPB 15,16 and 17 (Fig. 4). The TEM survey results indicate that at present there is freshwater within the Quaternary Bridgewater Formation at this site and it is uncertain whether this interface is mobile. Future monitoring will determine the risk to the Quaternay Aquifer. It is recommended that an observation bore (Fig. 2) is drilled to groundtruth the geophysical results and define the geological, hydrogeological and geochemical profile to identify possible salinity stratification, and a transducer if installed to monitor any water level changes. It is understood that the saline interface in coastal aquifers can be dynamic with movement caused by tidal fluctuations and changes in groundwater level. Monitoring will be necessary to identify the natural range of movement, setting a benchmark to identify any induced intrusion as a result of groundwater extraction.

The analysis of the results also showed that there is some evidence of closure on the west side of the lens, identified by a resistive rise in the profile, possibly caused by a basement high. The transects 3000N and 2500N also indicate that groundwater salinity may be higher on the western side of the lens compared to the eastern side. Evans (1997) observed this salinity anomaly and suggested that the Tertairy system was isolated from the eastern portion by a N–S basement ridge (see Fig. 23).

A geophysical survey was conducted in Coffin Bay to investigate whether, and how far, the lens extends southward under the sand dunes, and to identify the presence of a saline interface and possible saline intrusion around the northern coast line.

Unfortunately access for geophysical surveying into the sand dunes south of the Coffin Bay borefield was unachievable by the impedance of the dense vegetation. This area is unsuitable for this type of investigative method. It is recommended that SA Water and DWLBC review other 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. If the saturated depth and the water quality are similar to that within the borefield it is proposed that another series of wells be drilled some distance south of the original series. Further suggestions include a remote geophysical investigative method such as aerial surveys and environmental tracer analysis to delineate recharge processes.

Figure 11. Geophysicists operating the SIROTEM unit at Coffin Bay, May 2002

Several geophysical transects were achieved at Coffin Bay, but the data is of lower quality than that from Uley South. Successful analysis of information and models of subsurface trends are expected. The task, however, is rather more arduous and hence a delay with the Coffin Bay interpretation. Preliminary results show an area of higher resistivity to a depth of ~50 m correlating with the hydrogeology derived from geological logs. Salinity readings from the Coffin Bay Bridgewater Formation observation wells indicate an average TDS of 370 mg/L and from the Wanilla Formation observation wells of

~1500 mg/L. It is difficult to define whether there is a saline interface present or this confined formation is naturally saline throughout from this data; analysis is still continuing. It is unclear how competent the aquitard is between the Bridgewater and Wanilla Formation aquifers, thereby leaving the fresher Bridgewater Formation aquifer vulnerable to saline intrusion when under pumping stresses greater than the resource is currently subject to.

No interpretation is available from TEM surveys on the coast due to data collection difficulties. It may be necessary to conduct a survey, and water quality testing of private wells situated in the township, to establish whether there is any change in salinity with distance from the coastline in both aquifers.

Water level and rainfall monitoring

Ten pressure transducers automatically recording water level changes have been installed in selected wells — two in Coffin Bay and eight in Uley South. Four pluviometers automatically logging rainfall intensities have been also been installed — one in Coffin Bay and three in Uley South. All pluviometers are associated with nearby pressure transducers to enable understanding of rainfall recharge relationships. The spatial positioning of these remote recording instuments is detailed in Figures 6 and 7. Eight of the loggers were downloaded in November 2002. Table 1 details well location and instrument information.

Table 1. Well location and instrument information

Obs. well number	Fig. no.	Instrument	Aquifer monitored	Lens
ULE 196 ULE 135	12	Pressure transducer and pluviometer	Bridgewater Formation Wanilla Formation	Uley South
ULE 134 ULE 147 ULE 197 ULE 202	13 14 15 16	Pressure transducer	Bridgewater Formation	Uley South
LKW 38 LKW 39	17	Pressure Transducer and pluviometer	Bridgewater Formation	Coffin Bay

This data will provide important long-term information on the aquifer response to rainfall intensity and subsequent recharge and pumping pressures.

FINDINGS

Uley South Lens

In Uley South the Quaternary (ULE 196) and the Tertiary Aquifers (ULE 135) and rainfall intensities are recorded four hourly. The results of the first download for this logger is detailed are Figure 12.

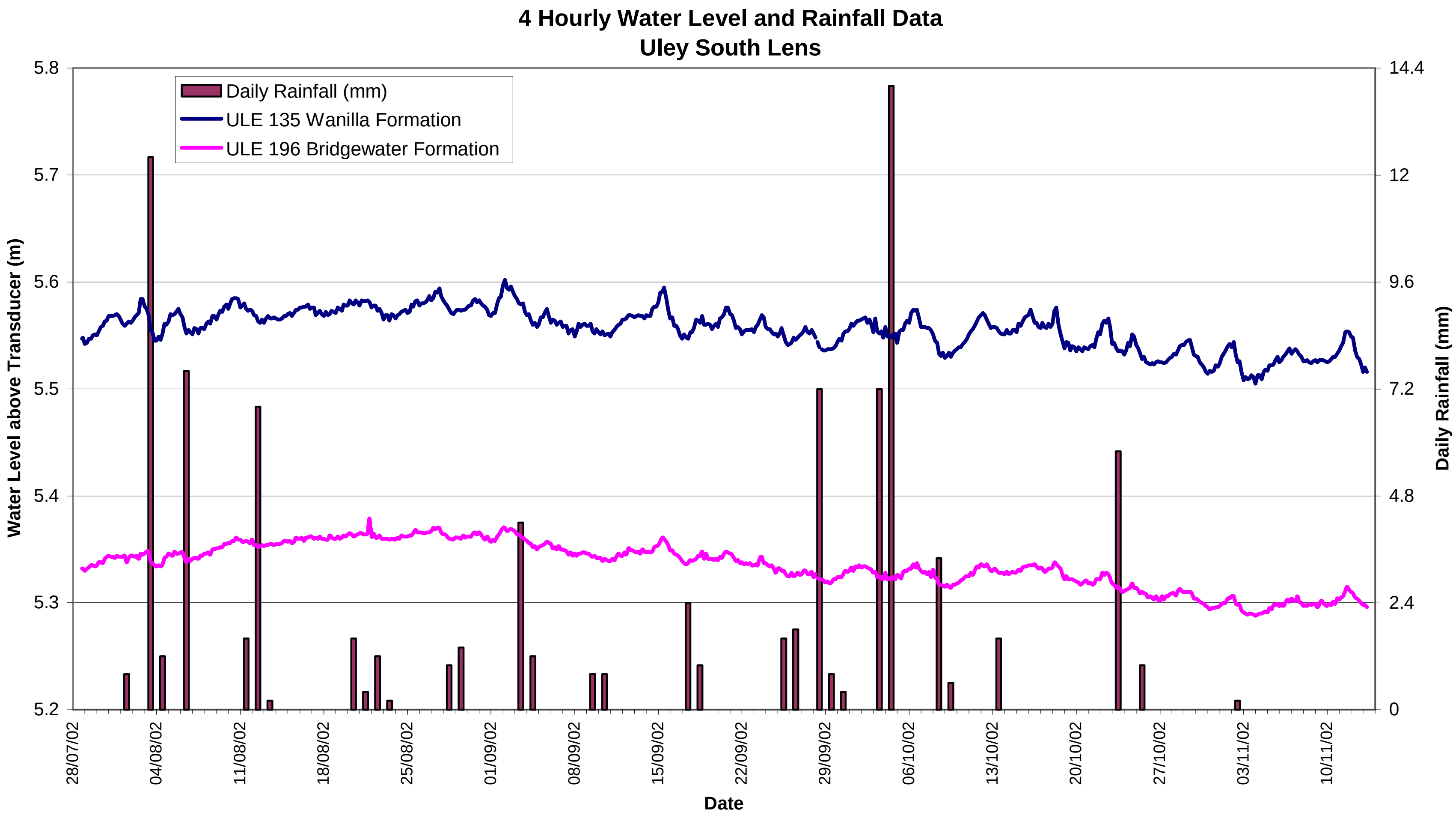


Figure 12. Four-hourly water level and rainfall data, Uley South Lens

The hyrodgraphs indicate the change in water level above the transducers while the bar graph represents the daily rainfall. The Bridgewater Formation hydrograph shows a recharge response to significant rainfall events (>5 mm/d) which occurred on the 3, 7 and 12 August 2002. After which the water level declines until the next set of significant rainfall events from 3 to 4 August 2002, where a recharge response is evident by the levelling trend in the hydrograph. Due to the distance of the observation wells from the extraction wellfield (~800 m), pumping pressure may influence the water level decline marginally. The influence of pumping can be better defined with the additional SA Water extraction information. The frequency of the peak and troughs are irregular and thus tend to exclude natural influences such as tidal changes.

The Tertiary Aquifer hydrograph is reflecting the Quaternary water level changes with increased amplitude. The response is typical of a confined aquifer responding to load pressure changes from varying water level (storage volume) in the Quaternary Aquifer system. It is postualted, in the Evans (1997) study, that the variation in water levels exhibited by the Teritary sand aquifer may reflect the direct pressure loading of the variation in the level of saturation of the unconfined Quaternary system.

The hydrographs for observation wells ULE 134, 147, 197 and 202 (Figs 13–16) are all situated within 700 m of pump stations and show similar water level trends. An increase in water level is evident until 12 August 2002 were it remains stable then declines near the end of October 2002 with ULE 197 declining much earlier at the end of September 2002. The water level increase is likely a result of recharge from recent rainfall events. The rainfall information from the pluviometers (not attained at this time) in the western and northern parts of the lens will assist in verifying this result. The water level decline is likely due to natural discharge exceeding recharge and, to a minor extent, the influence of pumping pressures. The amplitudes of the hydrographs are very similar indicating similar transmissitives, except observation well ULE 147 where the behavour indicates a site of lower transmissivity. The sudden dropoff of the reading after the 31 October 2002 indicates that the position of the transducer may have changed and will be investigated and readjusted.

This initial logged data has added to the understanding of the aquifer response to rainfall and discharge events. The absolute information potential of the remote monitoring instruments coupled with SA Water extraction data will assist in the future management of the system. It is recommended that to broaden the knowledge base two addition transducers are installed in several of the wells proposed for rehabilitation.

The assessment of the ongoing monitoring will give confidence that the current management framework is appropriate for the lens.

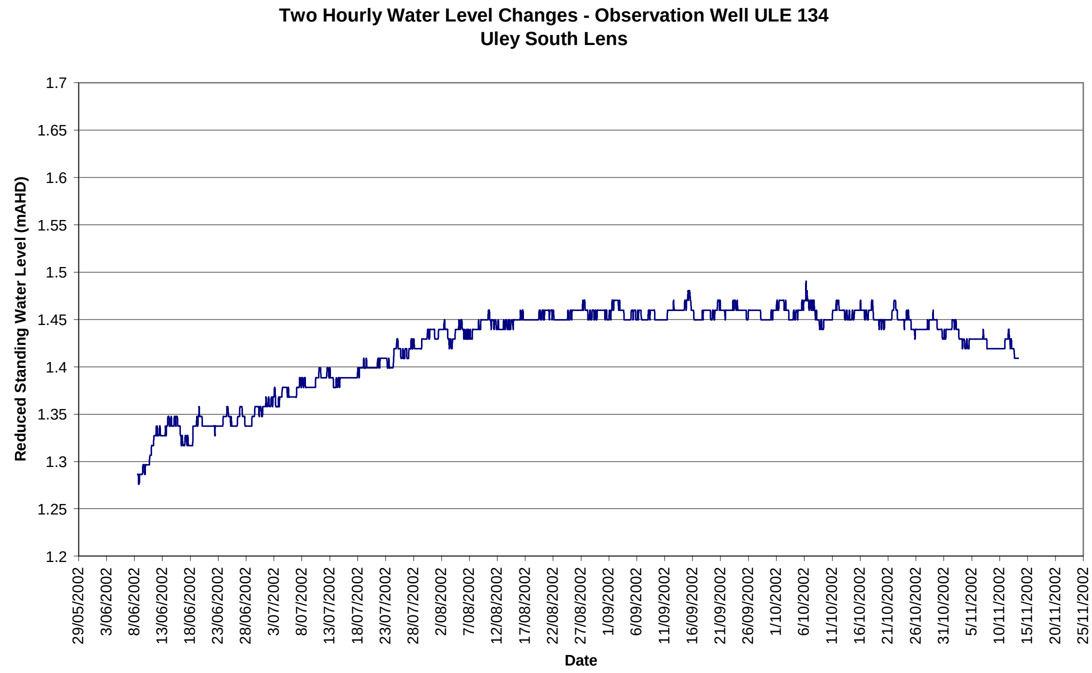


Figure 13. Hydrograph of the water level changes in observation well ULE 134

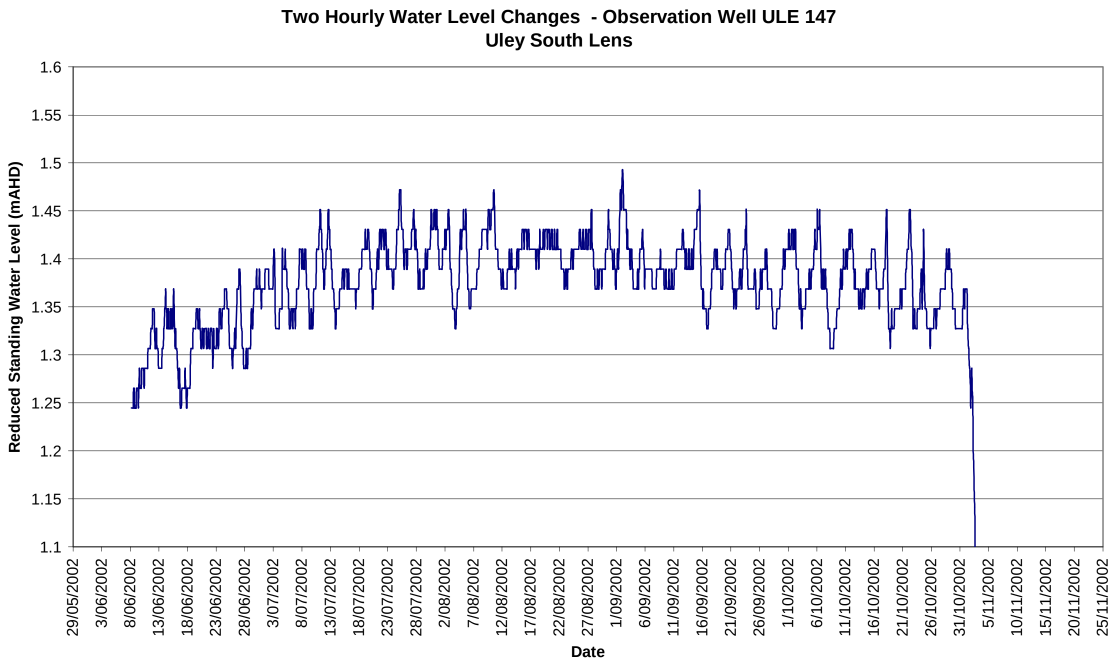


Figure 14. Hydrograph of the water level changes in observation well ULE 147

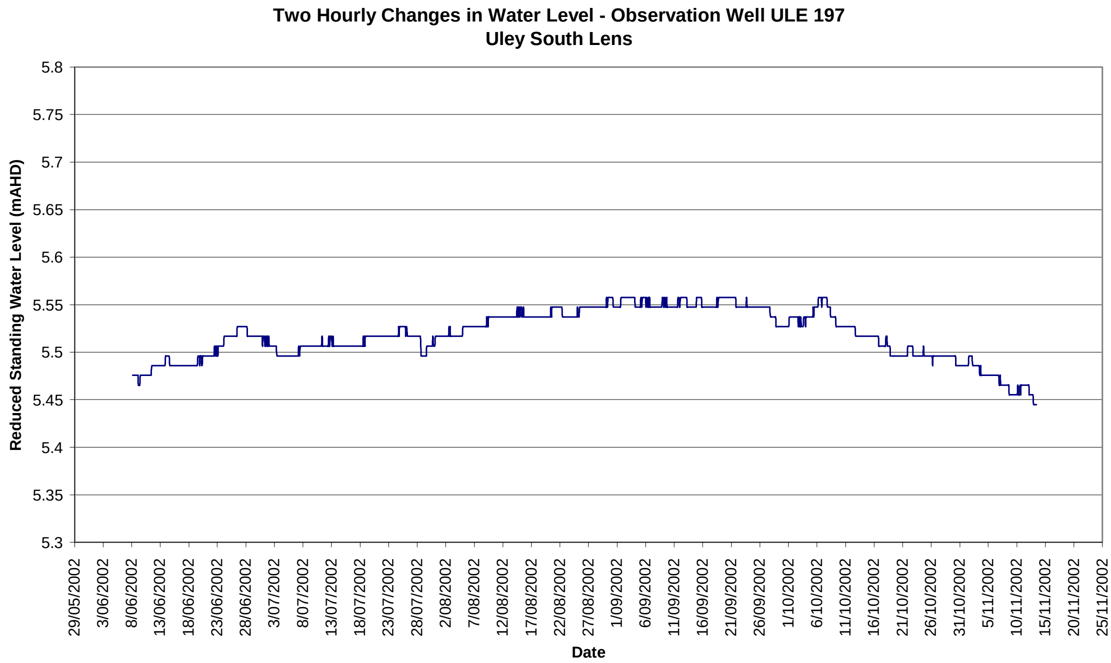


Figure 15. Hydrograph of the water level changes in observation well ULE 197

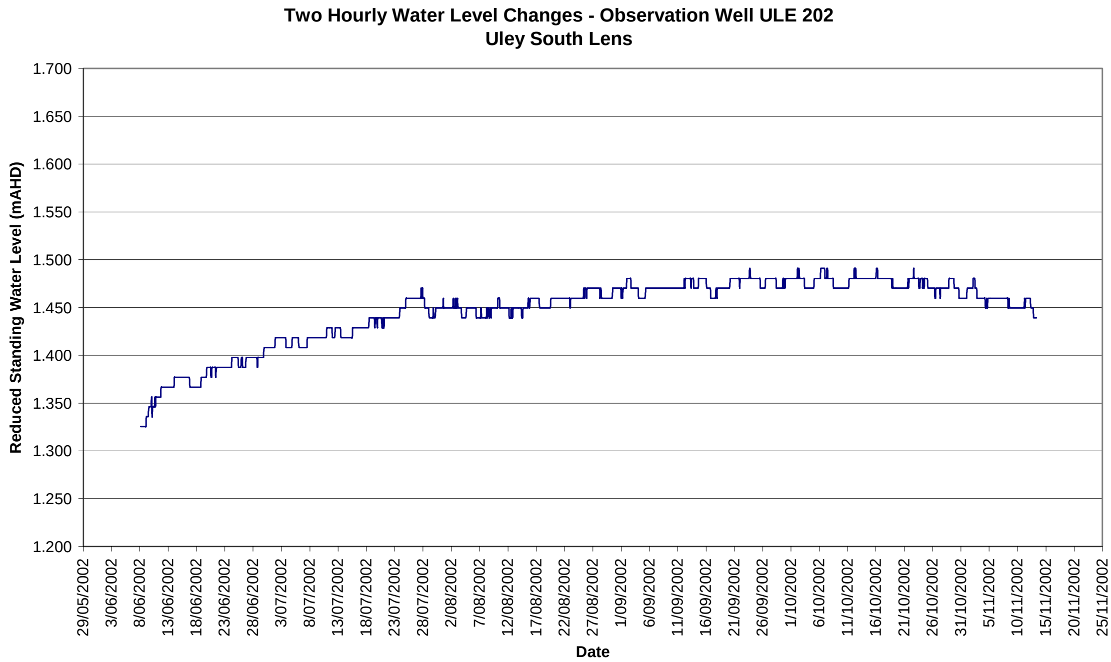


Figure 16. Hydrograph of the water level changes in observation well ULE 202

Coffin Bay Lens

In Coffin Bay rainfall intensities and Quaternary Aquifer water levels in LKW 38 and 39 are monitored four hourly. The results of the first download for this logger are detailed in Figure 17.

LKW 38 is a shallower well with a production zone between 15 and 21.5 m while LKW 39 is a deeper well with a production zone between 27 and 36 m (although current depth is now 31.75 m). The two wells monitor different sections of the Bridgewater Formation. The hydrographs show a recharge response to rainfall events greater than ~3 mm between 3 and 12 August 2002, declining after the 17 August 2002 until the next recharge event on the 2 and 3 September 2002 where the hydrograph stablises then gradually declines after 1 October 2002. The hydrographs show two distinct patterns. The daily fluctuations indicate the influence of the adjacent extracton wellfield (50 m). The troughs coincide with nightly pumping. The broadscale trends indicate the aquifer response to recharge and discharge. The near full recovery of the daily drawdowns and the regional response to significant rainfall events indicates that the current extraction regime is not dominating water level behaviour in this aquifer.

Water quality

Groundwater samples were collected during purging and sent to the Australian Water Quality Centre for analysis. The results of the full chemical analyses can be found in Table A3, Appendix A.

The data and comprehensive report of the historical chemistry characteristics of Uley South Lens groundwater is detailed in Evans (1997). The report details TDS measurement from the initial drilling programs in the 1950s and early 1960s prior to the stresses of extraction. The average production well salinity shows seasonal variations between summer maxima and winter minima of up to 50mg/L. The observed long term behaviour for salinity is influenced by significant rainfall events and recharge causing up to 80mg/L variations in average TDS levels.

The long term salinity trends for the Uley South Bridgewater Formation are illustrated in Figures 18 and 19 and Uley South Wanilla Formation Figure 20. The long-term salinity trend for both Coffin Bay aquifers are illustrated in Figure 21.

FINDINGS

Uley South Lens

Bridgewater Formation observation well salinity monitoring

Figure 18 illustrates that in general the salinity levels in this selection of wells monitoring the Bridgewater Formation has been stable over time. ULE 187, 188 and197 have salinity values that range between 600 and 700 mg/L. These wells are located in the vicinity of the original wellfield where salinity has been historically above 500 mg/L (Evans, 1997). The increase in salinity between April 1993 and November 1996 in ULE 190 is probably related to a slight expansion of the higher salinity zone about the original wellfield.

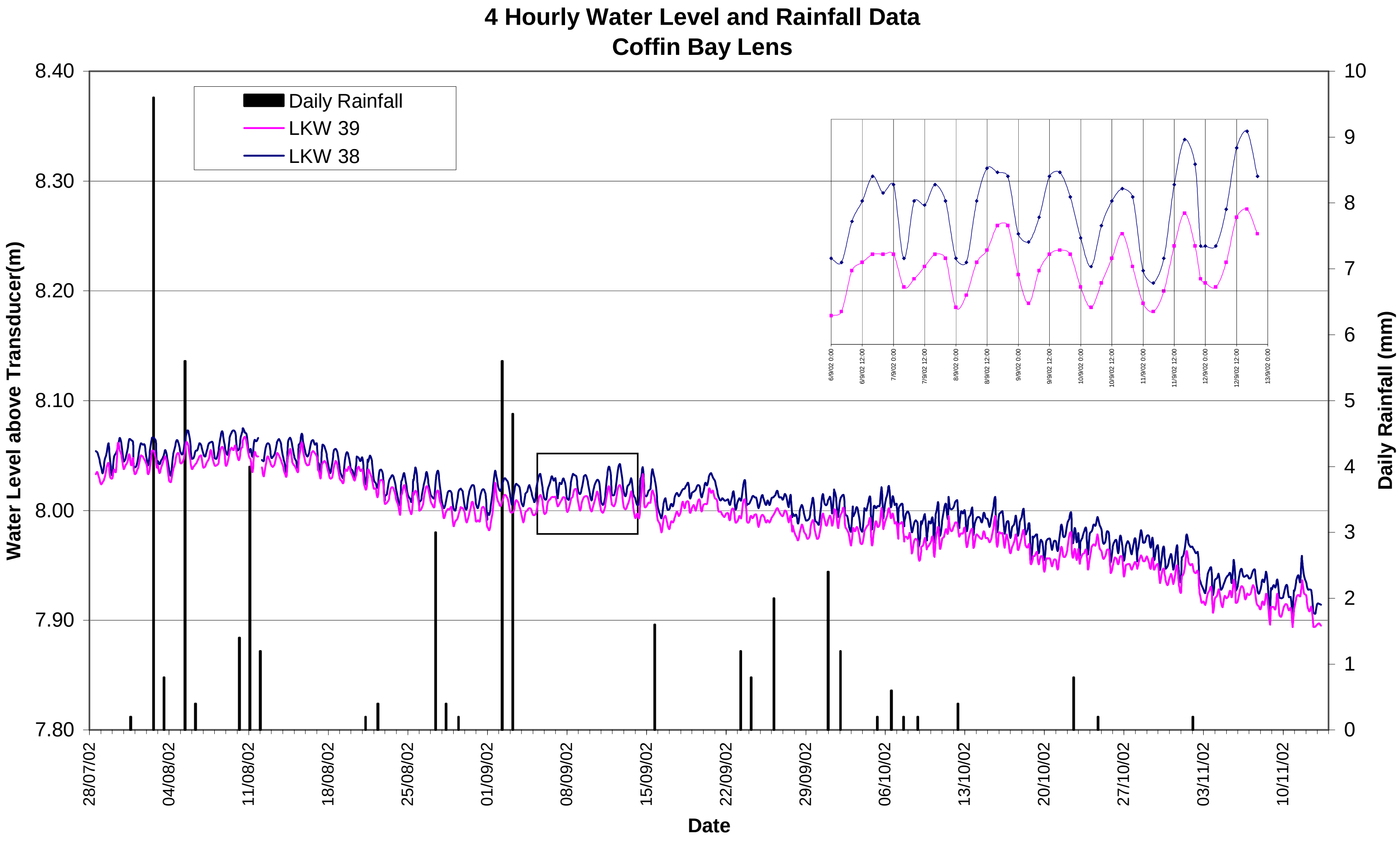


Figure 17. Four-hourly water level and rainfall data, Coffin Bay Lens

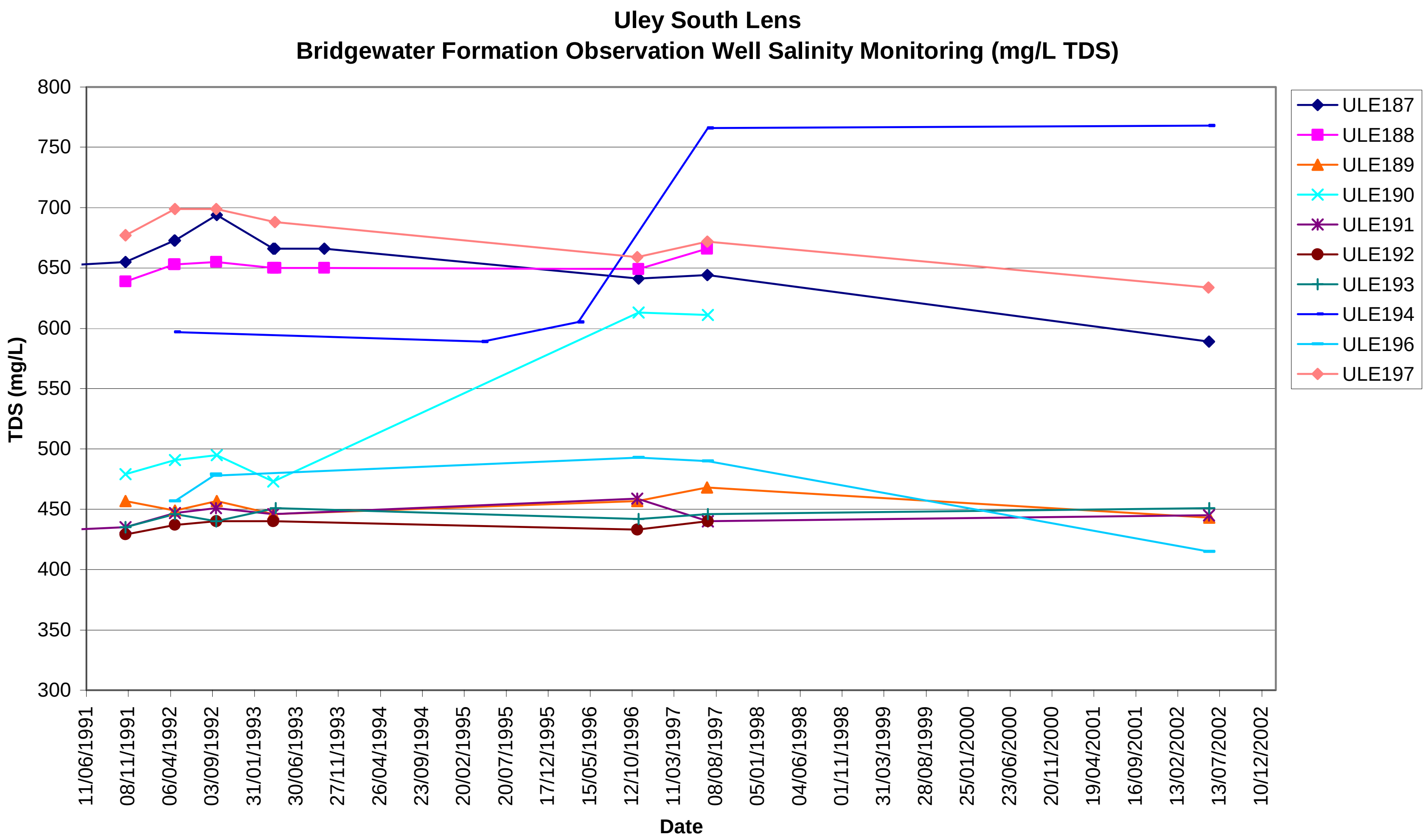


Figure 18. Uley South Lens: Quaternary Bridgewater Formation observation well salinity monitoring

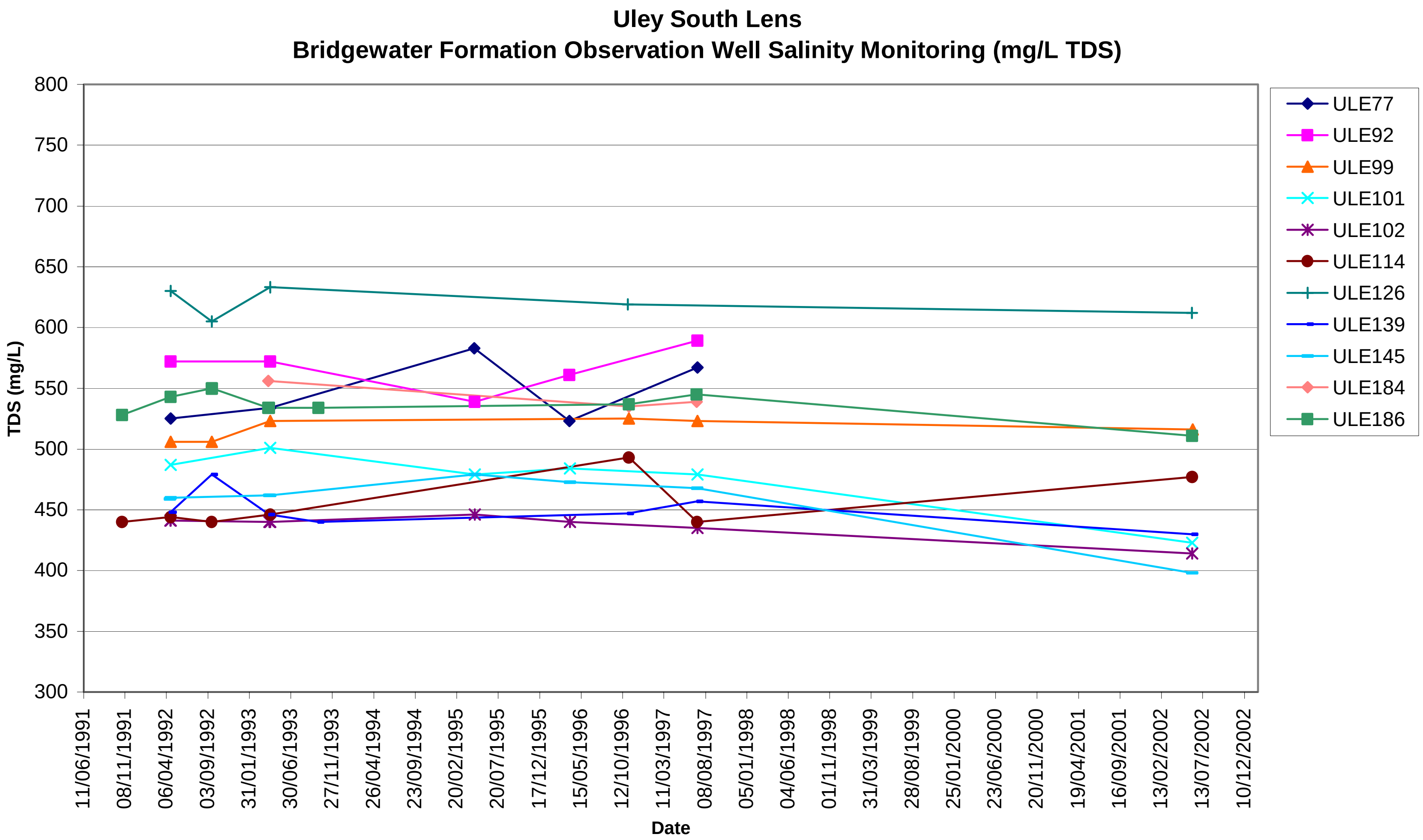


Figure 19. Uley South Lens: Quaternary Bridgewater Formation observation well salinity monitoring

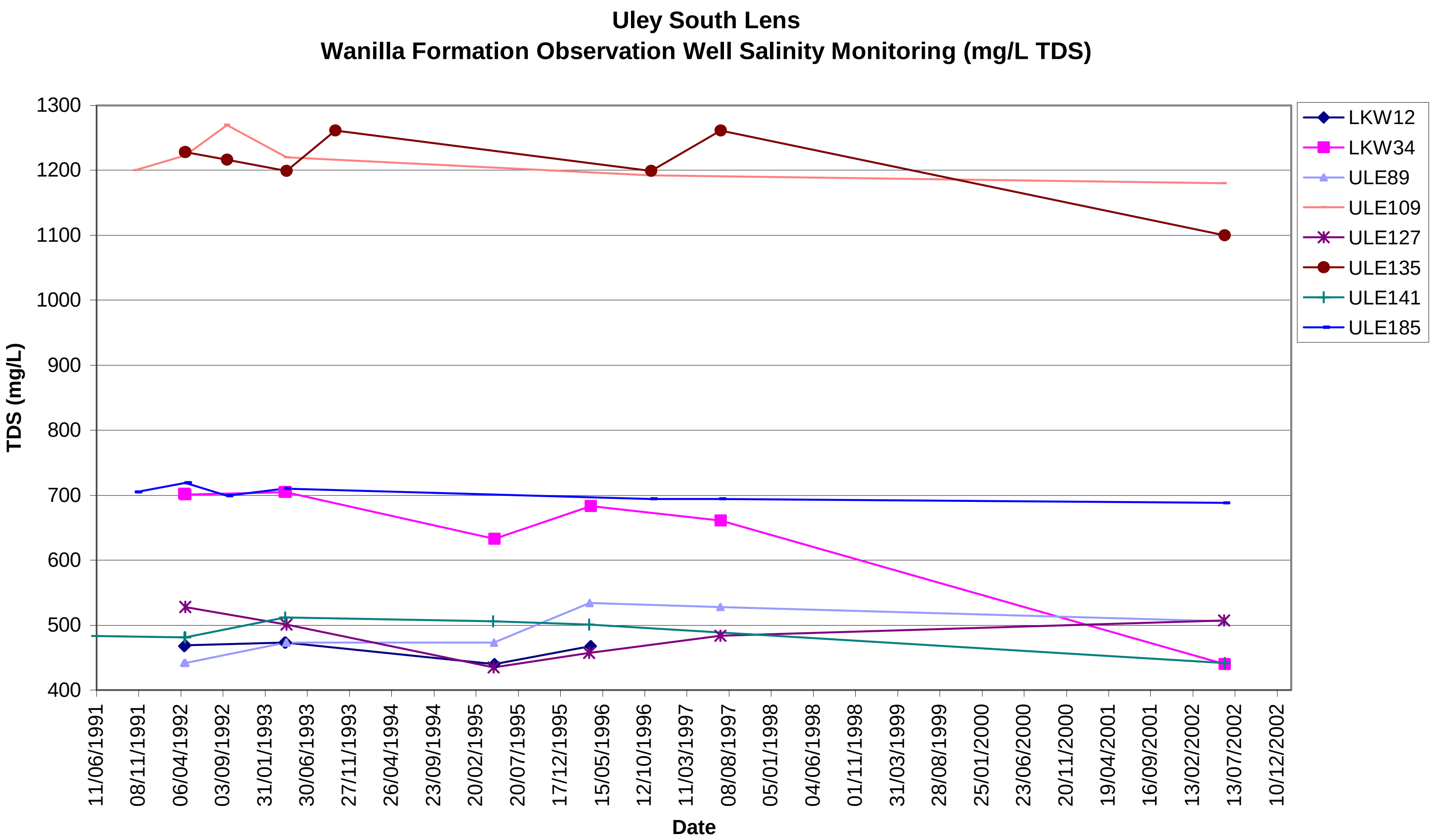


Figure 20. Uley South Lens: Tertiary Wanilla Formation observation well salinity monitoring

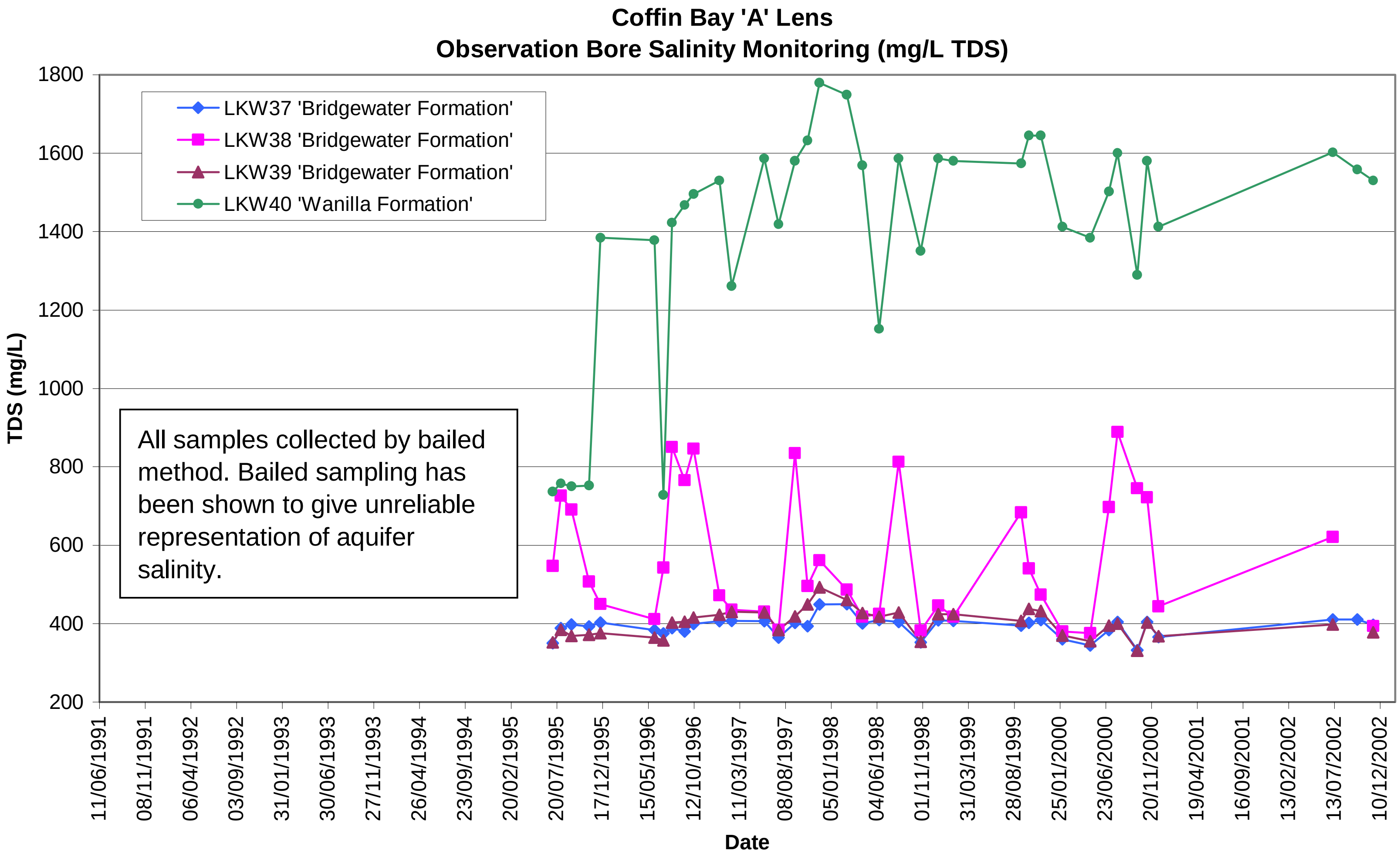


Figure 21. Coffin Bay 'A' Lens: observation bore salinity monitoring

ULE 196, 189, 193, 192 and 191 range between 400 and 500 mg/L and level remain constant. ULE 194 has experienced a salinity increase from approximately 600 mg/L to >750 mg/L between April 1996 and July 1997. Salinity profiling of this well showed stratification. The close proximity well to the swamp area may have some influence. Sampling techniques may be the cause of this increase. Ongoing monitoring will further define salinity variation in this well. The proposed drilling of an observation well within that region will provide opportunity to further investigate and monitor this salinity increase.

All the wells in Figure 19 show a constant salinity trend ranging between 400 and 650 mg/L and it appears that the previous or current extraction regime is not influencing the salinity.

Wanilla Formation observation well salinity monitoring

All the wells in Figure 20 show a constant salinity trend. Observation wells LKW 12, 34, ULE 89, 127 and 141 range between 400 and 800 mg/L. These wells are all situated on the periphery of the Quaternary lens boundary. ULE 109 and 135, situated within the lens in the vicinity of the wellfields, both show a higher but level salinity trend ranging between 1100 and 1300 mg/L. It appears that the new extraction regime is not influencing changes in the salinity within the Tertiary Wanilla Formation.

Coffin Bay Lens

Coffin Bay 'A' Lens observation well salinity monitoring

The salinity values in Figure 21 for the Quaternary Bridgewater Formation aquifer range between 300 and 900 mg/L in the Coffin Bay 'A' Lens. The erratic salinity curve in LKW 38 and 40 is likely due to the bailed method of sampling. Bailed sampling has been shown to give unreliable representation of aquifer salinity. The recommendation is that water samples be collected using accepted sampling standards to give representative salinity measurements of the aquifer formation water. The predominant baseline trend indicates that aquifer salinity is likely to be not increasing.

DISCUSSION

Impact of extraction on the Quaternary Aquifer System

With the expansion of the Uley South Public Water supply wellfield in 1999, re-distribution of extraction pressures has occurred within the lens. Figure 22 illustrates the changes in water level that have occurred from 1997 to 2002

- before the new wellfield went on line between 1997 and 1999,
- during the change over between 1999 and 2000 and
- after the new wellfield became fully functional between 2000 and 2002.

The water level difference contours illustrate the broad scale water level response of pumping within the wellfield.

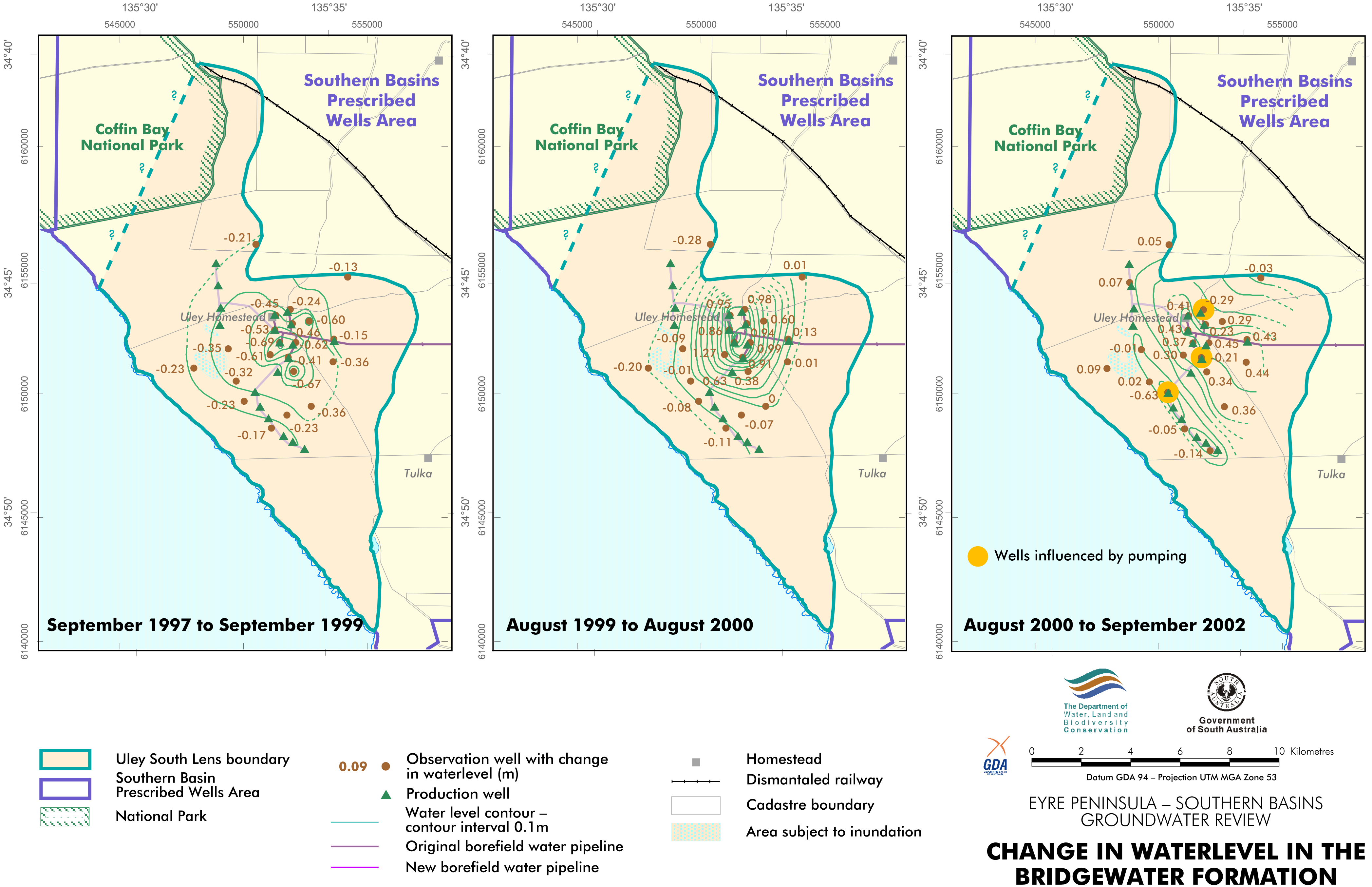
The purpose of the difference maps is to monitor whether the impact of pumping causes water levels to vary at a rate different from the natural trends. A settling in period is expected where decline around the new wellfield will be greater than that of regional trends. This impact of the new wellfield should placate overtime providing extraction is within sustainable limits. Contouring the differences can identify the need for additional regional observation wells to better understand the regional changes and impact of the wellfield.

CHANGE IN WATER LEVEL BETWEEN 1997 AND 1999

The highest negative changes in water level are centred on the original wellfield with values – 0.67 to – 0.60 m. These high negative values are possibly recorded during pumping of adjacent production wells. The value in the northern area of the original wellfield of (– 0.24) is lower, possibly indicating that levels were read while the adjacent production well was off. There is a general negative trend throughout the area due to the regional decline in water levels from low recharge influence by low rainfall from 1993. The zone of influence of extraction induced drawdown extends downgradient from the wellfield in the direction of the regional hydraulic gradient.

CHANGE IN WATER LEVEL BETWEEN 1999 AND 2000

During the year 1999 – 2000 the new wellfield, which includes the southern and western branches, went online. The redistribution in extraction pressure caused a considerable impact on the system, illustrated by the change in water level contours. There has been a significant water level recovery in the region of the original wellfield with the reduction of extraction rate. The water level change in the region of the new wellfield is not significantly negative. However, there had been a moderately good recharge season during this period (2000) and it is likely that the impact of pumping was negated by the general rise in groundwater from recharge.



The Department of Water, Land and Biodiversity Conservation

Government of South Australia

EYRE PENINSULA – SOUTHERN BASINS GROUNDWATER REVIEW

CHANGE IN WATERLEVEL IN THE BRIDGEWATER FORMATION

Figure 22

PIRSA Publications 201750_006

CHANGE IN WATER LEVEL BETWEEN 2000 AND 2002

Three values were disregarded from the contours as they are highly negative, indicating that pumping of adjacent production wells influenced the water levels in these observation wells during monitoring and are therefore not regionally representative. The contours indicate that the system is gradually reaching equilibrium, with a slight elongated depression in the vicinity of the new wellfield. It is expected that this water level difference contour distribution will even out as the changes in water level become less extreme.

At this time, the Uley South Lens appears to be utilised within its sustainable limits.

TEM SURVEYS

The equipment used for the survey was the SIROTEM MK3. The instrumentation is sensitive to conductive material in the sub surface. It is well suited to the detection of conductors such as saline groundwater or groundwater in porous media. Strong conductors of large extent will tend to dominate TEM results, sometimes resulting in the concealment of more resistive layers.

Electromagnetic geophysical methods make use of electromagnetic induction to measure the electrical resistivity of the ground. The system consists of a transmitter loop or coil through which a time-varying current is passed. This current produces a time-varying magnetic field, which induces current flow in nearby electrical conductors, such as clay rich or water saturated geologic materials. The induced currents, in turn, produce a secondary magnetic field, which is detected as a voltage in the receiver coil. The strength of this voltage is influenced by the electrical resistivity of the subsurface material. The amplitude and dissipation of signal are a function of the ground resistivity with signal dissipation greater through resistive ground.

By transmitting electrical pulses through cable loops that are laid on the ground surface, the SIROTEM records transient voltage decay. The Transmitter loop doubles as the receiver and detects the strength of the induced secondary electromagnetic field. The induced voltage is measured at series of delay times after current cut-off. Since the eddy currents migrate and decay with time the representative depth is greater at later times. The delay time can be related qualitatively to depth for interpretation purposes. The voltages measured are very small, so stacking of multiple readings (256 common) is done to improve the signal to noise ratio. The measured voltages are a measure of the apparent resistivity of the ground (Dodds, 1991).

TEM inversions

Raw data are retrieved from the SIROTEM internal memory and pre processed using Sirosoft software produced by Sandy Dodds (DWLBC). At this stage data is visually inspected for quality and the gain splicing operation produce resistivity calculation outputs for the line files. The line or station data can then be inverted and this is done so using GRENOCC or EMVISION (GRENDL) software.

GRENDL is designed to operate on a single TEM sounding using either a forward or inverse approach. GRENDL assumes a one-dimensional earth and examines only the response of a single sounding at a time. In situations with rapidly changing lateral layering, GRENDL can be unreliable or inaccurate in its solutions.

In the process called inversion, the model parameters (layer thickness and resistivity) are adjusted to reduce the average squared misfit error between the observed and computed responses. The philosophy used in inverting the data is to determine the model with the fewest layers whose response adequately fits the data. The inversion process is automated but requires the user to define a reasonable starting model from which a solution can converge.

The numbers of layers that are selected are quite critical and need to reflect the raw data. If too many or too few layers are selected the resultant model is bound to be in error. If additional layers can be adequately resolved, they are retained; otherwise, the simpler model is used. The resulting models had three layers in this investigation.

The data are modelled using a layered Earth that comprises a series of horizontal, stratified layers each of definable thickness and electrical property. The extent of the layers is infinite laterally and defined by the thickness parameter vertically. The bottom layer is assumed to represent basement and so has resistivity properties but no thickness definition. While the data are modelled with sharp transitions between resistivity values, actual variations in pore water conductivity, geology, and formation resistivity, are likely to be transitional over a finite distance. This point should be kept in mind when using the TEM model results.

Survey details

SLEAFORD SHEET (1:50 000)

Three lines were proposed for this area, Lines 1000N, 2000N and 3000N (Fig. 23). Satellite and air photos were initially inspected to determine best line access suitable to our needs. Lines 1000N and 2000N were completed as proposed but Line 3000N was hampered with access difficulties, due to dense vegetation.

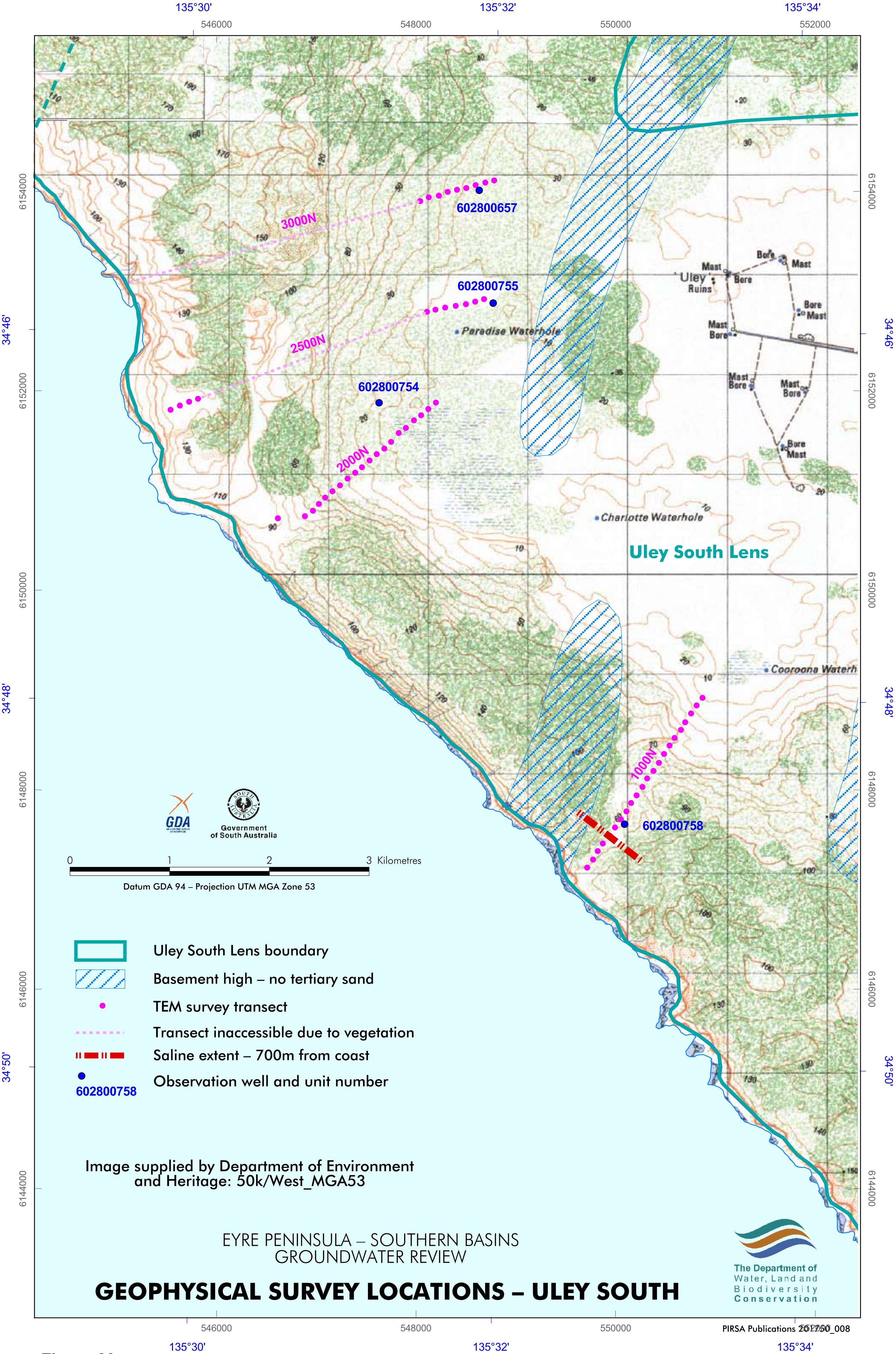
Line 1000N provided 2 line kilometres of data and gave access within 200 metres of the coastal cliff face. This coastal proximity was also desired for Line 2000N. A combination of access and instrument difficulties limited surveying to within 400 metres of the coastal cliffs. Interpretation has not been affected, as trends in the sub surface structure have been suitably determined.

Access to the western (coastal) end of Line 3000N was not possible and the survey was begun from the eastern end. 1 line kilometre of survey was achieved before again being restricted by access difficulties. This section proved to be too short to interpret whether a suitable fresh to saline contrast was present. In light of the truncation of Line 3000N, Line 2500N was proposed. Starting at the coastal end, 400 metres of survey was completed. The line, restarted from the eastern end managed 700 metres before surveying was again restricted.

The single loop configuration was used for this survey, both current transmission and response voltage measurements being done on a single loop of wire. The loop size for all reading was 100 metres square with a 100-metre spacing between readings (stations). The results are used to locate the extent of seawater intrusion in the Uley South aquifer systems and to map the base of the Wanilla and Bridgewater aquifers in regions where well coverage is sparse.

Presentation of results

The data for each survey line are presented as three-layered resistivity model sections. Line locations are given (Fig. 23). The horizontal axis is the station location and vertical axis represents the depth as calculated by the software. The models are simplistically displayed for reader convenience. Layers are interpreted as representing geologic formation or combinations of formations. For each station and each layer there is a calculated value of resistivity. Profiles displaying these values (Ohm.metre) are given in Appendix C.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6150000
6148000
6146000
6144000
34°46'
34°48'
34°50'
3000N
2500N
2000N
1000N
602800657
602800755
602800754
602800758
Paradise Waterhole
Charlotte Waterhole
Cooroona Waterh
Uley South Lens
Uley Ruins
Mast
Bore
Government of South Australia
GDA
0
1
2
3 Kilometres
Datum GDA 94 – Projection UTM MGA Zone 53
Uley South Lens boundary
Basement high – no tertiary sand
TEM survey transect
Transect inaccessible due to vegetation
Saline extent – 700m from coast
Observation well and unit number
602800758
Image supplied by Department of Environment and Heritage: 50k/West_MGA53
EYRE PENINSULA – SOUTHERN BASINS GROUNDWATER REVIEW
GEOPHYSICAL SURVEY LOCATIONS – ULEY SOUTH
The Department of Water, Land and Biodiversity Conservation
PIRSA Publications 202750_008

Figure 23

Topographic corrections have been applied to those profiles where actual topography has been variable enough to suffice a correction. Line 1000N, 2000N and 3000N have had a topographic correction applied, with the vertical axis then representing elevation (AHD) rather than depth.

The resistivity depth sections resulting from measured surveys data represent a simple distribution of resistivity. Such inversions are not unique and the accuracy of the interpretation needs to be checked with geological logs before reliance can be placed on the results (Love et al., 1994). The drill logs are required before the geological cause of the geophysical parameter can be positively identified.

Discussion of results

The profiles created indicate zones of differing resistivity. A variation in resistivity can be a result of varying geological structure or a change in saturation or saline content within the structure. Not all geological formations will be resolvable from one another and the solution is never unique. That is, there is likely to be more than one possible geological cause for the geophysical response and careful consideration need be applied in identifying the most probable scenario.

Sections have been created using a 3-layer model. Analogies between structural geology and zones of resistivity can be made but are not always unique. An understanding of how geological and hydrogeological properties affect resistance is important. A less porous medium will generally be more resistive than a more porous medium. Saline water within a medium will cause the resistance of the medium to be lower.

With an understanding of the formation geology in the region it has been possible to correlate formations or combinations of formations with zones of resistive continuity. The major geological units of concern in this interpretation are given.

The Bridgewater formation: A Quaternary limestone aquifer that is dry above the watertable. The TEM survey has not been able to delineate between the unsaturated (vadose) and saturated (phreatic) zone. This can be explained by the fact that the fresh groundwater is resistive and the limestone in which it is contained is also resistive, thus bearing insufficient contrast.

The Uley formation: A Tertiary clay aquitard; a discontinuous confining layer beneath the Quaternary Aquifer. The geophysical response is expected to be different to that of the Bridgewater formation. That is, it is expected that clay, due to immobile pore fluid and salt accumulation, is less resistive than the Bridgewater formation.

The Wanilla formation: A semi confined to confined Tertiary sand aquifer. The salinity in this aquifer is variable and generally higher than the overlying unconfined aquifer. The resistivity of a sand aquifer would be lower than the limestone formation above or crystalline basement below. Further to this, the resistivity measured is strongly dependent on the salinity of the water contained within. Variation in the saline content of the groundwater may be resolvable if the contrast in actual salinity is large enough. This Tertiary sand aquifer, a conductor is not resolvable from the Tertiary clay aquitard, which is also a conductor.

Weathered basement and basement: Weathered basement, although composed of resistive crystalline structure, is considered more conductive than crystalline basement on its own. Weathered basement bears groundwater and provides sufficient conduits for electrical current transmission. For this reason weathered basement is not uniquely resolvable from the Wanilla formation above. Its presence is inferred but the distribution is not interpretable. True basement (crystalline) will produce a resistive response. Basement does not contain water evenly throughout its matrix but predominately in fractures. To TEM basement is highly resistive due to this apparent 'no water'. It bears no water and will resist current unless there are conductors within the structure. The contrast in resistance between basement and weathered basement is sufficient to delineate the two.

To summerise, the formation resistivities are such that the resistive Bridgewater formation can be resolved from the conductive Uley, Wanilla and weathered basement formations. The Uley, Wanilla and weathered basement are not resolvable from each other. The conductive zone that represents them, interprets as some combination of those formations. Below the conductors, the resistive basement is resolvable from the structure above.

ULEY 1000N

The continuous 2 km transect displayed good subsurface contrast between the NE (inland) and SW (coastal) ends. A 3-layer model (Fig. 24, App. C) was used to invert the data with good quality fits throughout the profile. The major features are basement topography and the presence of saline groundwater (saline interface) extending inland from the coast.

The three distinct layers are used to represent the profiles sub-structure. The top layer (yellow) describes the distribution of the Bridgewater formation, a Quaternary limestone aquifer. This formation is generally known to have low salinity with permeability ranges from low to very high. The combined signal of the fresher water and the structure of the Bridgewater formation have a signal distinct to that of the two formations lying beneath it, the Uley and Wanilla formations.

The Uley formation aquitard is generally a confining layer beneath the Quaternary Bridgewater aquifer. This Tertiary clay aquitard is expected to produce a characteristic low resistivity (high conductivity) response. The model suggests, and it is reasonable to assume, that the signal retrieved from the lower Wanilla formation is not dissimilar to that of the Uley formation and hence a distinction cannot be made between the two. It is known that the Wanilla formation in this location bears water of a higher salinity than that of the Bridgewater formation. This will give rise to a lower resistance.

It is also reasonable to assume that the fresh-water saturated Quaternary limestone aquifer will represent greater resistance than both the Tertiary clay aquitard and the saturated Tertiary sand aquifer of higher salinity. Therefore a strong to moderate amount of reliance can be placed on the conclusion that the bottom of the first layer represents the base of the Bridgewater formation and the top of the Uley formation where it is present.

The third layer, of much higher resistivity, more than likely represents crystalline basement structure. A distinction can be made between weathered basement and basement. That is, the weathered basement, a conductor, is most likely represented within the second layer. The boundary between the second and third layers is interpreted as the top of crystalline basement. With this in mind, the interpretation gives a basement high at the SW end, peaking at ~ -50m AHD between stations 1100 and 1500. This feature correlates

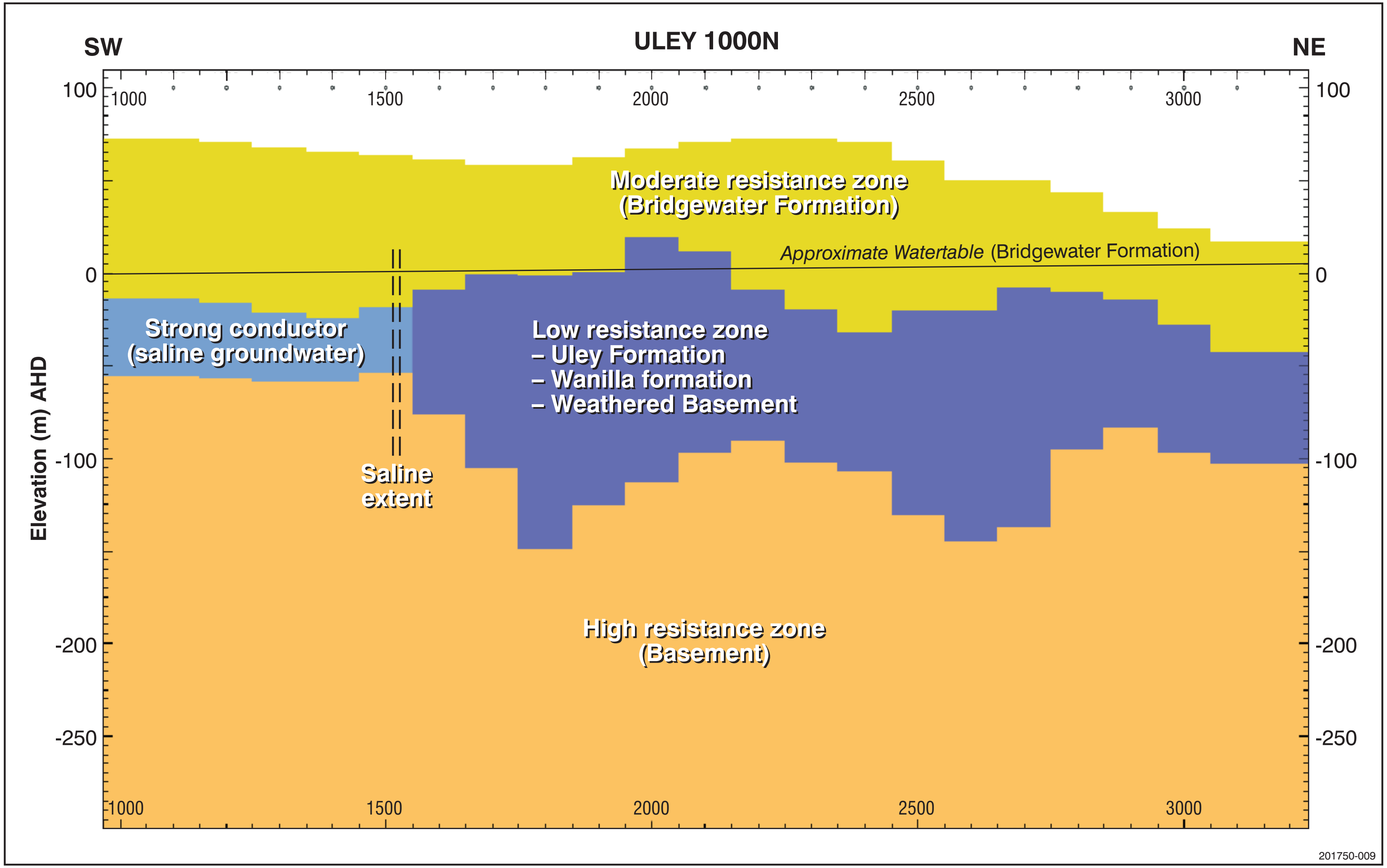

Figure 24 Geophysical interpretation if subsurface structure. Line 1000N, Uley South

well with a known basement high interpreted from geological logs. The extent of these highs are illustrated (Fig. 23). From the profile, additional undulations in basement topography can be observed with highs at stations 2200 and 2900.

The critical feature in this profile is a zone of high conductivity within the interpreted Wanilla formation. The feature, which is only present from the coastal end, leads interpretation towards a saline ground water interface that extends to station 1500 (700 m from the coast). Another indicator that supports this interpretation is the gradual progression of values (App. C) within the saline zone from low to slightly higher resistivity as you move away from the coast. This gradation could arise from decreasing saline content in the direction away from the coast.

Within the first layer (interpreted as Bridgewater formation) between stations 1100 to 1300, resistivity values (App. C) indicate lower resistance relative to the rest of the layer. It is not likely that this represents a saline interface within the Bridgewater Formation as the values themselves are too resistive and elevation of the formation above sea level too great. The cause could be explained as salt spray from the ocean that has penetrated the unsaturated part of the formation through rainfall infiltration. Alternatively, the lowered resistance could indicate a more porous region of the formation.

Above the saline conductor (2nd layer, Stations 1100 – 1500) and below sea level, is a zone of interpreted Bridgewater Formation (1st layer). Current understanding of this formation gives the watertable in this location at 1 to 2 metres above sea level. The model has defined the zone as resistive, suggesting that saline water has not entered the formation. The presence of fresh water within this layer will not alter the resistance of the formation markedly.

Drill logs and hydrostratigraphic logs are required to validate geophysical data. Near this profile one drillhole (6028 758) was suitable to aid interpretation. Further validation of the data may require that new holes be drilled. The hydrostratigraphic log for well 6028 758 defines the base of the Bridgewater Formation at 55 m, the base of the Wanilla at 87 m and crystalline basement below. Adjacent to the well, stations 2500 and 2600 compare well to the base of the Bridgewater (55 and 65 m). The model suggests that the depth to basement is somewhat deeper than the log suggests (130 m compared with 90 m). Comparisons here may be tricky, as the basement appears to rise sharply in this region. It is plausible that weathered basement is represented in the zone 90–130 m and that the log is somewhat incorrect without definition of a weathered zone.

ULEY 2000N

The continuous 2 km transect produced good quality data with high confidence in interpretation. A 3-layer model was used to invert the data with good fits throughout. The major features are formation boundary trends and the absence of saline intrusion. As with 1000N it is reasonable to assume that the fresh, water saturated Quaternary limestone aquifer will bear greater resistance than the Tertiary clay aquitard, the saturated Tertiary sand aquifer and weathered basement.

At stations 1400 to 2500 (Fig. 25), the 3-layered structure interprets as described in line 1000N. That is, the top layer is interpreted to represent the Bridgewater formation. The middle layer interprets as the Uley, Wanilla and weathered basement formations and the

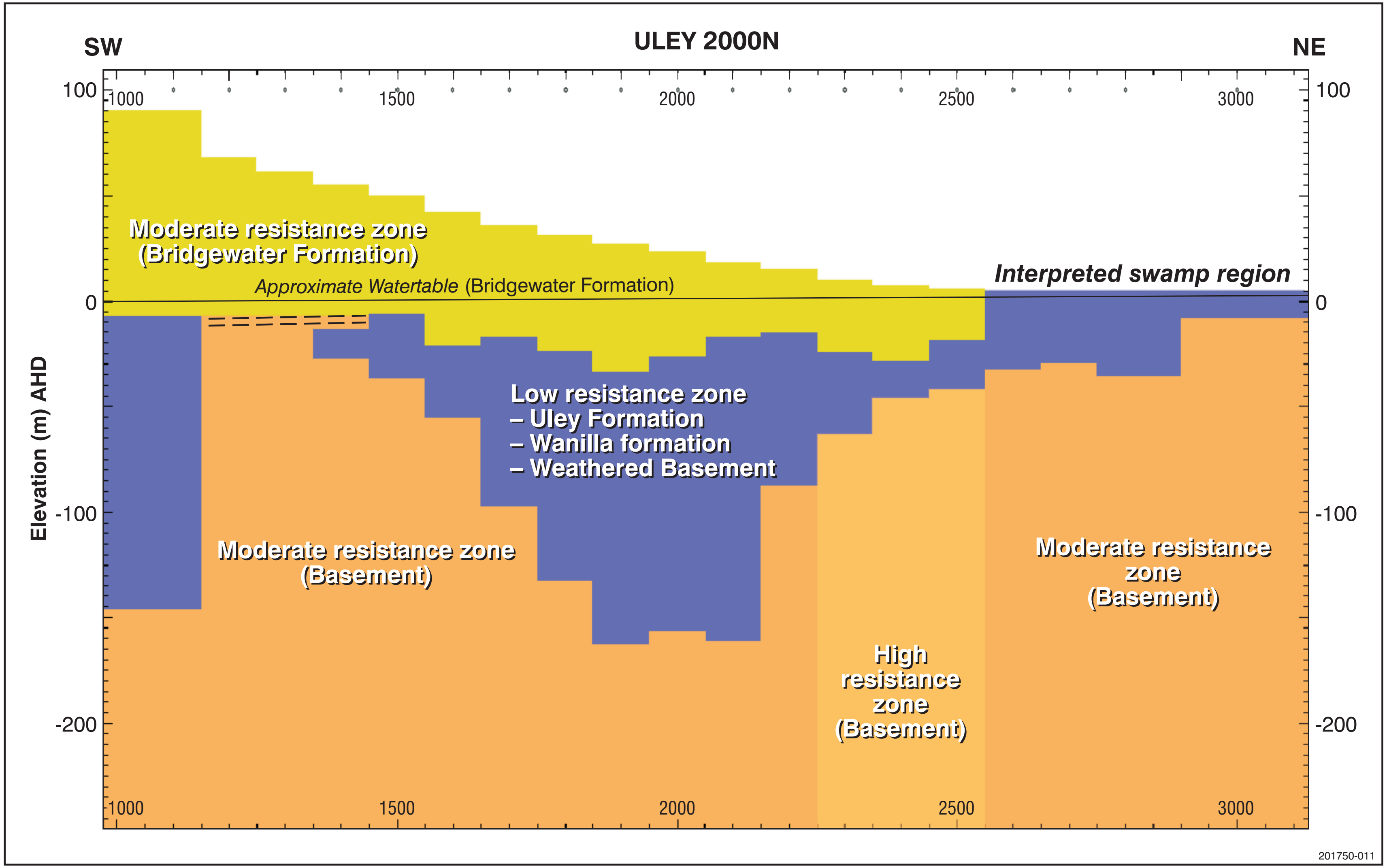

Figure 25 Geophysical interpretation of subsurface structure. Line 2000N, Uley South

bottom layer represents crystalline basement. The main differences are at stations 2600 to 3000 where the Wanilla is represented at the surface and given in the first layer. At these stations the model can be considered as two-layer. Also, between stations 1100 to 1300, the interpreted Wanilla Formation becomes non-resolvable or not present and the model can be considered as two layered.

The noticeable difference between profiles 1000N and 2000N is distribution of the interpreted Wanilla formation. 1000N displays coastal connection. Importantly this is not the trend in line 2000N. From the model it is interpreted that the formation is pinched out at station 1300. This is due to the presence of a basement high that peaks between stations 1200 and 1300. An important result, it suggests there are no connections between the Wanilla aquifer and the sea at this point. Rather, there is a zone of resistance that may act as a barrier to saline intrusion and aquifer drainage

At the eastern end of the line between stations 2600 and 3000 the data represents a known, low lying swamp region where conductive structure appears to rise towards ground surface. The presence of a basement high below this region, may have forced the formations above to pinch and become narrow. In this region the Bridgewater formation is not represented in the model. However, it is likely that the Bridgewater formation is still present but simply too thin to resolve until station 2500, where a resistor is modelled in the first layer. This is a plausible result, as thin resistors are not easily resolved by the TEM technique.

The profile is bounded in the SW and NE by basement highs. These highs peak at stations 1300 and 2800 respectively. In between, a basement low is filled with deepening Tertiary sediment and weathered basement material. In the third layer, between stations 2300 to 2500 a zone of high resistance is displayed. The resistivity values are unique from the surrounding basement material (App. C) but only represent a zone of greater basement resistance.

The nearest geological log for validation (well 6028 754) is some 500 metres from the survey line and is considered unsuitable for validation. Only general comparisons should be made as stratigraphy could vary considerably over this distance. Stations 2500 and 2600, nearest to borehole 754 suggest that the Bridgewater formation is thin. The bore log gives the thickness of the Bridgewater formation as 14 metres, which in comparison with the interpreted formation thickness towards the sea, is thin. Further comparisons should not be drawn. This is a region of basement rise and quick variations in formation thickness should be expected. It is recommended that new drillholes be logged for validation of the geophysical interpretation. New drillholes are recommended to validate geophysical interpretation.

ULEY 2500N

This line segment is broken into two separate segments (Fig. 23). The western (coastal) segment represents 400m of line data and the eastern (inland) segment represents 700 m of line data.

Discussion on the western segment is limited and a profile is not provided. Both modelling programs (Grenocc and Grendl) had difficulty fitting the data. Inspection of the apparent resistivity section (App. C) indicates that there is little conductivity within the structure and what there is, does not fit a one-dimensional model. The data suggests high resistive values increasing with depth that correlate with current knowledge of a basement high in that region. If there were saline groundwater present here, it would be expected that the apparent resistivities recorded would be noticeably different. It is therefore concluded that no intrusion of saline water is present at this location.

For the eastern Line segment (Fig. 26), interpretation provides distinction between the major units only. This profile has not needed corrections for surface topography, as the terrain was relatively flat throughout the survey section. The major features presented are formation boundary trends.

The model is similarly interpreted as the previously presented line profiles. The interpretation presented is simple with model layers continuous throughout the profile. The model layers are interpreted as; the Bridgewater Formation (1st layer), the Uley, Wanilla and weathered basement formations (2nd layer) and crystalline basement (3rd layer). Variations in layer thickness represent variations in formation thickness. Interpretation of the model gives the Bridgewater Formation for the transect as continuous and ranging in thickness from 40 metres at station 800 (east) to 5 metres at station 500 (west).

At stations 900 to 1100 (NE end) the model interprets the existence of a thick second layer overlying a basement trough (layer 3). At stations 500 to 800 the model interprets a basement ridge with corresponding thinning of the second layer sequence. At station 800, the model (App. C) displays a thin conductive second layer. The models presented are not unique and a conductive layer such as this may be a result of a 'conductivity thickness product'. That is, a thin more conductive layer can produce the same geophysical response as a thicker less conductive layer. It is possible that the second layer at this location (station 800) is thicker and less conductive than presented in the model.

Correlation with drillhole 602800755 to the bottom of the Bridgewater Formation at station 500 is good (15m compared with 17m). Correlation with depth to crystalline basement cannot be drawn as the drillhole penetrates only to weathered basement. Further drillholes are required to validate the geophysical model.

ULEY 3000N

The model displays 1.1 km of line data (Fig. 26) and produced good quality fits to the data. The major features are formation boundary trends. Interpretation is based on the identification of the formations in the region. That is, interpretation provides distinction between some of the major units only. For consistency, a 3-layer model is used. The first layer is given as the Bridgewater Formation, the second layers as the Uley, Wanilla and weathered basement formations and the third layer as crystalline basement. Such is the case for most stations along this profile. With the exception of stations 200 to 400, where the presence of a basement high appears to pinch out the conductive sequence modelled as the second layer. At this location (stations 200 to 400) the transition of structure from the surface is interpreted as Quaternary limestone overlying a thin weathered basement zone then crystalline basement.

At station 600 a thin, conductor is modelled in the second layer. The thickness of the layer appears to disjoint the structure to either side. The resistivity value (App. C) is also noticeably different. It is likely the result of a 'conductivity thickness product' problem. That is, the presented solution, and an alternate solution (with twice the thickness but half the conductivity) will fit the source data equally well. With consideration of the neighboring structure it could be reasonable to assume that the second (thicker less conductive) solution is the most likely scenario.

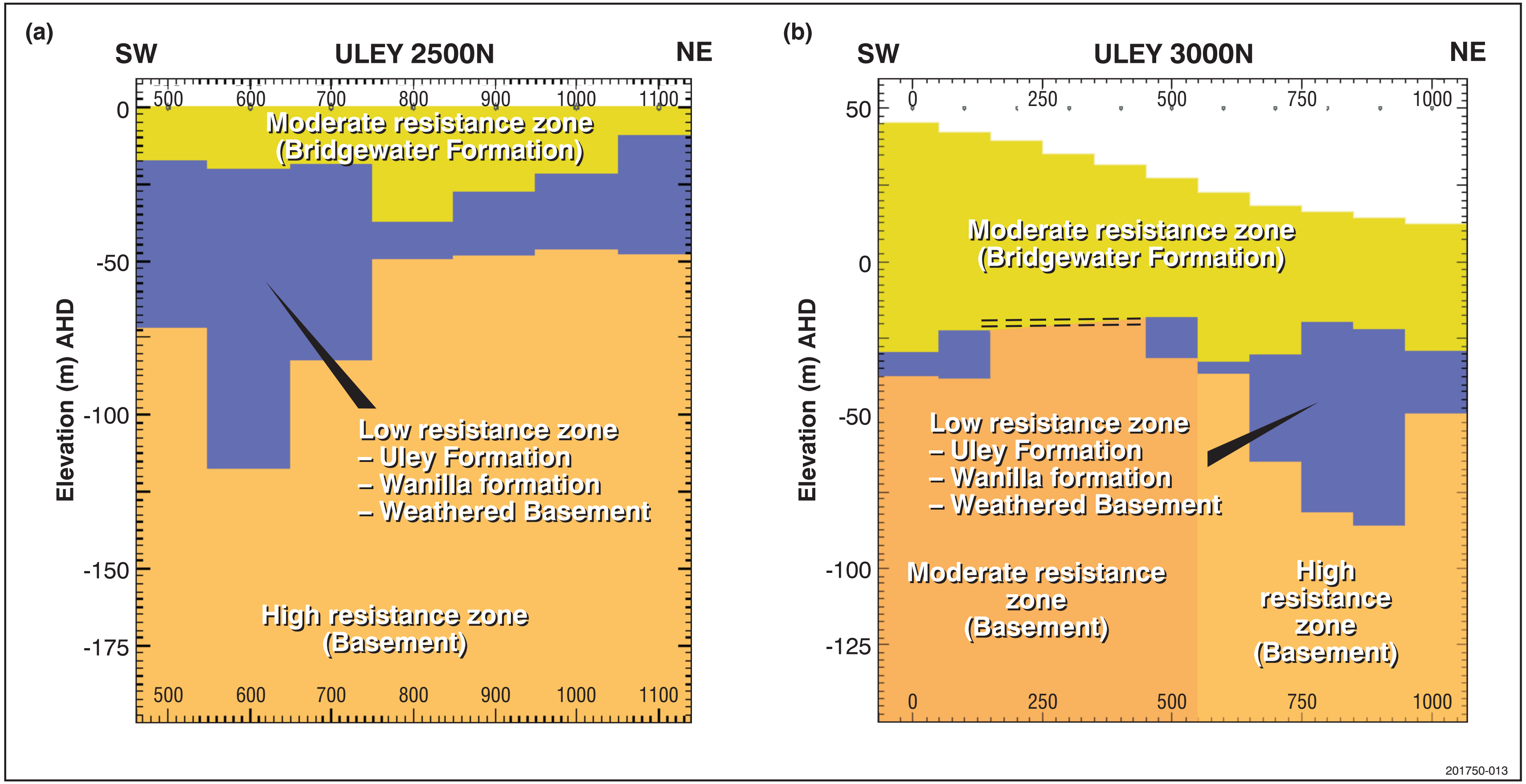

Figure 26 Geouphysical interpretation of subsurface structure. Line 2500N and 3000N, Uley South

Interesting features (App. C) are the low resistivity values in the conductive second layer, some part of which represents the Tertiary Wanilla sands aquifer. The values are noticeably lower in comparison to the values of similar structure given in the other profiles. This is interpreted as either groundwater of higher salinity, or an aquifer medium of higher porosity. The former is more probable with salinity near this location known to be higher.

Correlation with borehole 6028 657 at station 800 gives the thickness of the Bridgewater formation as 26 metres compared with 32 metres produced by the model. This result is reasonable. New drillholes will assist in model validation.

Conclusions

The use of the TEM technique in the search for saline intrusion and definition of formation boundaries in this environment has proved successful. The survey has not been able to discriminate all geological formations, only those where suitable resistive contrast exists between adjacent sequences. The survey results have been successful in delineation of the Quaternary limestone over the conductive sequence below, where it is present. The conductive Tertiary clay, Tertiary sands and weathered basement are not resolvable from one another, but distinction between this combined sequence and the resistive limestone above and the crystalline basement below has been achieved.

Where it is present high salinity groundwater yields sufficient resistive contrast and allows interpretation to be placed on its extent. The inversions have been able to discriminate between regions of saline water, fresher water and dry or crystalline rock. Identification of a saline intrusion at the SW end of line 1000N gives the extent 700 m NE from the coast.

Interpretation of line 2000N suggests a basement high at the coastal end that prevents connectivity between the aquifer systems and a potential saline intrusion. Results from lines 2500N and 3000N have provided no evidence of a saline intrusion at those locations. All lines have been useful in defining the configuration of the basement and Quaternary limestone. The veracity of these interpretations must be checked by drilling before reliance can be placed on the results. The correlations between the resistivity and geology are not unique, so other evidence such as drilling is required.

ULEY SOUTH AND COFFIN BAY AUTOMATED MONITORING EQUIPMENT

Uley South Lens

In conjunction with the survey work carried out during the Uley South – Coffin Bay Observation Well Network Review, eight (8) monitoring wells were fitted with water level sensors and adjacent to three of these wells tipping bucket rainfall gauges were also installed in Uley South Lens. All monitoring equipment is fitted with data logging devices to store the data collected.

WATER LEVEL SENSORS

Six (6) of the eight (8) level sensors (transducers) were Innovonics MD4W (Water Level Recorder) stand alone sensor/logging units and the remaining two (2) were Greenspan PS100, 4-20 Ma output sensors linked to a GreenspanSL300 three (3) channel data logger.

RAINGAUGES

Of the three tipping bucket rain gauges (pluviometers) two were linked to Cherryville single channel data loggers but these have since been changed out and replaced with Greenspan SL300 data loggers for reliability and ease of downloading. The remaining rain gauge is linked to a Greenspan SL300 data logger in conjunction with the two PS100 level sensors mentioned above.

The rational for choosing a particular observation well for remote monitoring equipping with water level sensing and rainfall gauging equipment (Fig. 6) was based on the following

- distribution of the existing production wellfields
- effects of pumping on individual aquifers
- areas most likely to react quickly to recharge events
- where existing monitoring infrastructure could be utilized most effectively without modification.

The selected observation wells, ULE147, 196, 134, 139, 197, 202 and 194, are all completed in the Bridgewater Formation, the main producing aquifer.

Two adjacent wells ULE 135 and 196 are completed in the Wanilla and Bridgewater Formations respectively. An automatic rainfall gauge adjacent to the site is also linked to the same data logger enabling the capture of both rainfall and water level data simultaneously. The automatic monitoring provides an opportunity to research the rainfall recharge relationship and to some extent the effects that pumping within the basin has on both aquifers.

Details of the selected observation wells, automated equipment installed, logging interval and relative position to the wellfield is detailed in Table 2.

Table 2. Uley South automated monitoring equipment

Unit number	6028 711	6028 759	6028 660	6028 1747	6028 744	6028 1751	6028 1750	6028 745
Formation	Bridgewater	Bridgewater	Bridgewater	Bridgewater	Bridgewater	Bridgewater	Bridgewater	Wanilla
Easting	553492	552035	548779	547859	550991	552511	551618	551618
Northing	6151286	6147708	6154502	6151029	6148603	6152937	6149131	6149131
Obs Well Number	ULE 139	ULE 147	ULE 202	ULE 194	ULE 134	ULE 197	ULE 196	ULE 135
Transducer Sensor type	MD4W	MD4W	MD4W	MD4W	MD4W	MD4W	PS100	PS100
Data logger	MD4W	MD4W	MD4W	MD4W	MD4W	MD4W	SL300	SL300
Serial number	46692	48773	45002	46772	48771	45001	17698	17700
Span (m)	0-10	0-20	0-10	0-20	0-20	0-10	0-10	0-10
Logging Interval (hrs)	2	2	2	2	2	2	Background 4 hourly, significant events every 10 mins	Background 4 hourly, significant events every 10 mins
Set to start	8/06/2002 2:00	8/06/2002 2:00	8/06/2002 2:00	8/06/2002 2:00	8/06/2002 2:00	8/06/2002 2:00	28/07/2002 18:00	28/07/2002 18:00
Installed	7/06/2002	7/06/2002	7/06/2002	8/06/2002	7/06/2002	7/06/2002	27/07/2002	27/07/2002
Depth set (m)	21	72	23	13	22.3	13	8	8
Water Level Response to pumping pressure	Regional	Local	Local	Regional	Local	Regional	Regional	Regional
Position in Reference to Wellfields	Upgradient	Central	Central	Downgradient	Cental	Upgradient	Upgradient	Upgradient
Rain Gauge Adj			yes	yes			yes	
Rain Gge Data logger			SL300	SL300			SL300	

Coffin Bay Lens

Two (2) Coffin Bay monitoring wells were fitted with water level sensors and a tipping bucket rainfall gauge. The water level sensors and automatic rainfall gauge adjacent to the site are linked to the same data logger enabling the capture of both rainfall and water level data simultaneously.

WATER LEVEL SENSORS

The two wells adjacent to each other were fitted with Greenspan PS100, 4-20 mA output sensors linked to a Greenspan SL300 three (3) channel data logger.

RAINGAUGE

The rain gauge is linked to a Greenspan SL300 data logger and cumulative rainfall is recorded on a four hourly interval in conjunction with the water level change.

The Bridgewater Formation monitoring wells are within the wellfield and monitor the aquifer response to recharge and pumping.

Wells LKW 38 and 39 are completed in the upper and lower portions of the Bridgewater Formations respectively. These portions appear to be separated by a clay layer which may act as partially confining. The wells, adjacent to each other, provide an opportunity to monitor the effects that pumping within the basin, has on the different sections of the Bridgewater Formation.

Details of the selected observation wells, automated equipment installed, logging interval and relative position to the wellfield is detailed in Table 3.

Down loading and calibrating of the monitoring equipment will occur every two (2) months and data will be stored in the DWLBC groundwater monitoring data base. Water samples collected from the rain gauges will be analysised for chloride. The comparison of chloride concentration in groundwater with local rainwater will assist in determining recharge values within the region.

Table 3. Coffin Bay automated monitoring equipment

Unit number	5928 303	5928 304
Formation	Bridgewater	Bridgewater
Easting	544305	544304
Northing	6167359	6167359
Obs Well Number	LKW 38	LKW 39
Transducer Sensor type	PS100	PS100
Data logger	SL300	SL300
Logging Interval (hrs)	Background 4hourly, significant events every 10 mins	Background 4hourly, significant events every 10 mins
Set to start	28/07/2002 13:30	28/07/2002 13:30
Installed	27/07/2002	27/07/2002
Water Level Response to pumping pressure	Local	Local
Position in Reference to Wellfields	Central	Central
Rain Gauge Adj	yes	
Rain Gge Data logger	SL300	

CONCLUSIONS

Hydrogeological knowledge gaps have been identified at strategic positions within the basin. It is recommended that four historical observation wells are rehabilitated and three new wells drilled and included in the current monitoring network. It has also be identified that three wells within the current network have not been rehabilitated and therefore should be incorporated in the rehabilitation upgrade. There are approximately 55 openhole historical observation wells within the Uley South Lens. These wells are not currently monitored and not rehabilitated and therefore potentially allow surface runoff to enter and mix with the aquifer formation water and also aquifer mixing through the open column. These wells may be used as future observation wells as information is required, however, the expense of rehabilition at this stage may not be warranted. It is recommended that SA Water and DWLBC review the future of these wells.

Sonding of all the purged wells indicated a consistant salinity profile with depth in the majority of wells. However two wells showed stratification. One well is positioned near the lens boundary where no confining layer exists and the other near the swamp where complex recharge and discharge processes may be occurring. Further salinity profiling will provide a better understanding of the reasons for stratification.

The analysis of the TEM surface geophysics results of the Uley South survey identified broad hydraulic zones beneath the surface indicative of changes in groundwater salinity. A possible saline interface has been identified in Uley South Lens about 700m from the coast on transect 1000N at an approximate depth of 85 m. The interpretation is that the saline water body is within the Tertiary Wanilla Formation. However as there is no clay aquitard beneath the Quaternary sequence in this area there is a potential risk to induce a saline intrusion by groundwater extraction from pump stations USPB 15,16 and 17. The TEM survey results indicate that at present there is freshwater within the Quaternary Bridgewater Formation at this site and it is uncertain whether this interface is mobile. Future monitoring will determine the risk to the Quaternary Aquifer. It is recommended that an observation bore is drilled to groundtruth the geophysical results and define the geological, hydrogeological and geochemical profile to identify possible salinity stratification and install a transducer to monitor any water level changes. It is understood that the saline interface in coastal aquifers can be dynamic with movement caused by tidal fluctuations and changes in groundwater level. Monitoring will be necessary to identify the natural range of movement, setting a benchmark to identify any induced intrusion as a result of groundwater extraction.

Unfortunately access for geophysical surveying into the sand dunes south of the Coffin Bay borefield was unachievable by the impedance of the dense vegetation. Nevertheless several geophysical transects were achieved at Coffin Bay. Unfortunately the data is of lower quality than that from Uley South. Preliminary results show an area of higher resistivity to a depth of about 50 metres correlating with geological logs. It is difficult to define whether there is a saline interface present or this confined formation is naturally saline throughout from this data. Analysis is continuing.

Ten pressure transducers recording water level changes have been installed in selected wells - two in Coffin Bay and eight in Uley South. Four pluviometers logging rainfall intensities have been also been installed - one in Coffin Bay and three in Uley South. All pluviometers are associated with nearby pressure transducers to enable rainfall recharge relationships to be further researched. This data will provide important long term information on the aquifer response to rainfall intensity and subsequent recharge and pumping pressures.

Groundwater samples show a salinity trend of no change, and in most wells it appears that the previous or current extraction regime is not influencing the salinity. However a slight expansion of the higher salinity zone about the original wellfield in the Uley South Lens is evident. The erratic salinity curve several Coffin Bay wells is likely due to the bailed method of sampling. Bailed sampling has been shown to give unreliable representation of aquifer salinity. The recommendation is that water samples be collected using accepted sampling standards to give representative salinity measurements of the aquifer formation water. The predominant baseline trend indicates that aquifer salinity is likely to be not increasing.

With the expansion of the Uley South Public Water supply wellfield in 1999, re-distribution of extraction pressures has occurred within the lens. An analysis of the changes in water level from 1997 to 2002 was carried by contouring the water level changes over this period. Current extraction appears not be alter the regional water level trends apart from what is estimated to be a short-term adjustment period adjacent to the new production wells. At this time, the Uley South Lens appears to be utilised within its sustainable limits.

RECOMMENDATIONS

The work completed in Uley South has shown that further work is required to address the following:

- better define the aquifer and groundwater characteristics throughout the basin by rehabilitating strategic observation wells and constructing up to three new wells that will be geologically and geophysical logged and analysed chemically
- better define basin geometry by undertaking strategic transient electromagnetic (TEM) geophysical surveys and monitor movement of the saline interface
- establish the extent and thickness of the lens by completing a second series of salinity profiling of wells and compare with existing salinity profiling results to determine any trend in groundwater salinity and lens size
- relate aquifer extraction demands, salinity and water level trends to recharge events to enable sound management decisions to be made.

Augmentation and rehabilitation of the monitoring network will provide a more comprehensive knowledge base to effectively observe changes in the basin over time. It is recommended that:

- current observation wells ULE 97, 134 and 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)
- three new wells be drilled at strategic positions in the basin where hydrogeological knowledge gaps have been identified (Fig. 2). It is further recommended that all drilled wells be geophysically logged. This standard procedure carried out at the completion of drilling provides a high degree of certainty to geological and hydrogeological interpretation.
- SA Water and DWLBC review the future of openhole historical wells
- Monitoring frequency remains monthly due to the irregularity of timing and magnitude of recharge events.

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 is recommended that:

- The current observation wells, including the new and rehabilitated wells, undergo salinity profiling (with the exception of those wells without casing and completion details). 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 this is conducted during Autumn, the results will assist in determining any trend in lens salinity, aid in establishing the extent and thickness of the lens, and assist in defining the saline interface when compared to 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.

The strategic placement of two additional transducers in either the new or rehabilitated wells will provide an effective coverage for water level monitoring. This will provide confidence that the current management framework is appropriate, and assist with determination of the extent and sustainability of the resources.

It is recommended that an investigation well be drilled to groundtruth the geophysical results and define the geological, hydrogeological and geochemical profile to identify possible salinity stratification. This well should be installed with one of the transducers to monitor any water level changes. It is understood that the saline interface in coastal aquifers can be dynamic with movement caused by tidal fluctuations and aquifer water level changes. Monitoring will be necessary to identify the natural range of movement and set a benchmark to identify any negative shift due to saline intrusion.

It is critical that geophysical surveys be repeated in future programs. Correlating the geophysical data with the geological borehole logs, and downhole salinity profiling 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 it from induced migration of saline water into the aquifer due to pumping pressures.

It is recommended that SA Water and DWLBC review other 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. If the saturated depth and water quality are similar to that within the borefield, it is proposed that another series of wells be drilled some distance south of the original series. Further suggestions may include a remote geophysical investigative method such as aerial surveys. In addition, environmental tracer analysis may be useful to delineate recharge processes.

No interpretation is currently available from TEM surveys on the coast due to data collection difficulties. It may be necessary to conduct a survey and water quality testing of private wells situated in the township to establish any change in salinity with distance from the coastline in both aquifers.

SHORTENED FORMS

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	µg	10^{-6} g	mass
Milligram	mg	10^{-3} g	mass
Gram	g		mass
Kilogram	kg	10^{3} g	mass

Abbreviations commonly used within text

Abbreviation		Name	Units of measure
TDS	=	Total Dissolved Solids *(milligrams per litre)*	mg/L
EC	=	Electrical Conductivity *(micro Siemens per centimetre at 25^{o}C)*	µS/cm
pH	=	Acidity	
δD	=	Hydrogen isotope composition	**$^{o}/_{oo}$**
CFC	=	Chlorofluorocarbon *(parts per trillion volume)*	pptv
δ^{18}O	=	Oxygen isotope composition	**$^{o}/_{oo}$**
^{14}C	=	Carbon-14 isotope *(percent modern Carbon)*	pmC
ppm	=	Parts per million	
ppb	=	Parts per billion	
mAHD	=	Metres above Australian Height Datum	m

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APPENDIX A

Fieldwork completed on observation wells and groundwater chemistry results

Table A1. Fieldwork completed July 2002 on the Coffin Bay observation wells

Well unit number.	Observation Well number.	Aquifer Monitored	Purged	Sonded	Raingauge	Transducer	Rehabilitation	site
592800301	LKW 37	BRIDGEWATER FORMATION	Not Done	Yes	No	No	No	Coffin Bay
592800303	LKW 38	BRIDGEWATER FORMATION	Not Done	Yes	Yes	Yes	Yes	Coffin Bay
592800304	LKW 39	BRIDGEWATER FORMATION	Not Done	Yes	No	Yes	No	Coffin Bay
592800306	LKW 40	WANILLA FORMATION	Not Done	Yes	No	No	No	Coffin Bay

Table A2. Fieldwork completed July 2002 on the Uley South observation wells

Well unit number.	Observation Well number.	Aquifer Monitored	Purged	Sonded	Raingauge	Transducer	Rehabilitation	site
602801068	LKW 12	WANILLA FORMATION	Dry	Dry	No	No	No	Uley South
602801072	LKW 34	WANILLA FORMATION	Yes	Yes	No	No	No	Uley South
602800910	ULE 77	BRIDGEWATER FORMATION	Pump Seized	No data	No	No	No	Uley South
602800666	ULE 89	WANILLA FORMATION	Yes	Yes	No	No	No	Uley South
602800876	ULE 92	BRIDGEWATER FORMATION	Dry	Dry	No	No	No	Uley South
602800755	ULE 97	BRIDGEWATER FORMATION	Too Narrow	No data	No	No	Yes	Uley South
602800752	ULE 99	BRIDGEWATER FORMATION	Yes	Yes	No	No	No	Uley South
602800773	ULE 101	BRIDGEWATER FORMATION	Yes	Yes	No	No	No	Uley South
602800743	ULE 102	BRIDGEWATER FORMATION	Yes	Yes	No	No	No	Uley South
602800706	ULE 109	WANILLA FORMATION	Yes	no data	No	No	No	Uley South
602800775	ULE 114	BRIDGEWATER FORMATION	Yes	Yes	No	No	No	Uley South
602800894	ULE 126	BRIDGEWATER FORMATION	Yes	Yes	No	No	No	Uley South

Well unit number.	Observation Well number.	Aquifer Monitored	Purged	Sonded	Raingauge	Transducer	Rehabilitation	site
602800895	ULE 127	WANILLA FORMATION	Yes	Yes	No	No	No	Uley South
602800744	ULE 134	BRIDGEWATER FORMATION	Too Narrow	Yes	No	Yes	Yes	Uley South
602800745	ULE 135	WANILLA FORMATION	Yes	Yes	No	Yes	No	Uley South
602800711	ULE 139	BRIDGEWATER FORMATION	Yes	Yes	No	Yes	No	Uley South
602800715	ULE 141	WANILLA FORMATION	Yes	Yes	No	No	No	Uley South
602800746	ULE 145	BRIDGEWATER FORMATION	Yes	Yes	No	No	No	Uley South
602800759	ULE 147	BRIDGEWATER FORMATION	Too Narrow	Yes	No	Yes	Yes	Uley South
602800767	ULE 184	BRIDGEWATER FORMATION	Jammed	Yes	No	No	No	Uley South
602800766	ULE 185	WANILLA FORMATION	Yes	Yes	No	No	No	Uley South
602800735	ULE 186	BRIDGEWATER FORMATION	Yes	Yes	No	No	No	Uley South
602800734	ULE 187	BRIDGEWATER FORMATION	Yes	Yes	No	No	No	Uley South
602800792	ULE 188	BRIDGEWATER FORMATION	Pump Seized	Yes	No	No	No	Uley South
602800721	ULE 189	BRIDGEWATER FORMATION	Yes	Yes	No	No	No	Uley South

Well unit number.	Observation Well number.	Aquifer Monitored	Purged	Sonded	Raingauge	Transducer	Rehabilitation	site
602800793	ULE 190	BRIDGEWATER FORMATION	Pump Seized	Yes	No	No	No	Uley South
602800733	ULE 191	BRIDGEWATER FORMATION	Yes	Yes	No	No	No	Uley South
602800794	ULE 192	BRIDGEWATER FORMATION	Pump Jammed	Blockage	No	No	No	Uley South
602800795	ULE 193	BRIDGEWATER FORMATION	Yes	Yes	No	No	No	Uley South
602801747	ULE 194	BRIDGEWATER FORMATION	Yes	Yes	Yes	Yes	No	Uley South
602801750	ULE 196	BRIDGEWATER FORMATION	Yes	Yes	Yes	Yes	No	Uley South
602801751	ULE 197	BRIDGEWATER FORMATION	Yes	Yes	No	Yes	No	Uley South
602802295	ULE 201	BRIDGEWATER FORMATION	Pump Seized	Yes	No	No	No	Uley South
602800660	ULE 202	BRIDGEWATER FORMATION	Yes	Yes	Yes	Yes	No	Uley South
602802157	ULE 203	BRIDGEWATER FORMATION	No Access	Yes	No	No	No	Uley South
602802165	ULE 204	BRIDGEWATER FORMATION	Not Located	Not Located	No	No	No	Uley South

Table A3 Groundwater chemistry analysis

Observation Well Number	LKW034	ULE202	ULE089	ULE099	ULE101	ULE102	ULE109	ULE114	ULE126	ULE127	ULE135
Sampling date	6/06/2002	6/06/2002	4/06/2002	6/06/2002	5/06/2002	5/06/2002	3/06/2002	4/06/2002	3/06/2002	4/06/2002	5/06/2002
	Wanilla Formation	Bridgewater Formation	Wanilla Formation	Bridgewater Formation	Bridgewater Formation	Bridgewater Formation	Wanilla Formation	Bridgewater Formation	Bridgewater Formation	Wanilla Formation	Wanilla Formation
pH	7.8	7.6	7.6	7.7	7.6	7.7	7.2	7.6	7.3	7.8	7.4
TDS (by EC) (mg/L)	440	510	520	520	430	420	650	490	640	510	1100
Conductivity (uS/cm)	792	923	937	940	783	768	1180	895	1160	921	1970
Dissolved Solids by Calculation (mg/L)	440	218	506	516	423	414	652	477	612	507	1100
Calcium (mg/L)	49.6	73.6	51	72.7	66.9	67.7	72.3	73.9	91.5	70.4	86.1
Magnesium (mg/L)	17.5	24.9	32.2	20.4	16.6	14.2	25.1	17.7	27.2	28.6	43.7
Potassium (mg/L)	2.4	2.5	3.1	2.7	2.2	2.1	3	2.3	2.7	2.1	6.4
Sodium (mg/L)	97.6	96.2	104	101	82.1	78	143	93.5	121	94.1	262
Bicarbonate (mg/L)	212	302	260	247	244	223	308	248	333	319	256
Chloride (mg/L)	136	147	156	173	112	115	219	145	177	129	524
Fluoride (mg/L)	0.13	0.43	0.78	0.44	0.43	0.45	0.43	0.38	0.46	0.6	0.46
Sulphide (mg/L)	33.1	25.7	30.9	24.6	23.2	27.7	37.8	22.5	28.7	25.5	55.1
Nitrate + Nitrite as N (mg/L)	2.52	4.38	3.22	3.97	5.01	4.98	0.018	3.9	3.86	3.95	0.019
Nitrate + Nitrite as NO^3 (mglL)	11.2	19.4	14.3	17.6	22.2	22.1	0.08	17.3	17.1	17.5	0.09
Iron - total (mg/L)	1.01	0.351	1.22	<0.030	0.093	2.03	1.75	0.26	1.32	1.96	0.952
Alkalinity as CaCO3 (mg/L)	174	247	213	202	200	183	252	203	273	261	210
Langelier Index	0.18	0.31	0.06	0.27	0.22	0.23	-0.1	0.19	0.18	0.51	0.05
Sodium Absorption Ration	3.04	2.47	2.82	2.7	2.33	2.25	3.7	2.54	2.86	2.39	5.73
Total hardness as $CaCO^3$ (mg/L)	196	286.2	260.3	265.4	235.7	227.6	283.9	257.5	340.6	293.6	395.1
Ion balance (%)	0.22	-0.01	1.27	0.15	1.92	0.9	-0.23	1.91	3.39	1.53	-1.79

Observation Well Number	ULE139	ULE141	ULE145	ULE185	ULE186	ULE187	ULE189	ULE191	ULE193	ULE194	ULE196	ULE197
Sample date	5/06/2002	5/06/2002	5/06/2002	3/06/2002	4/06/2002	4/06/2002	5/06/2002	4/06/2002	5/06/2002	5/06/2002	5/06/2002	3/062002
	Bridgewater Formation	Wanilla Formation	Bridgewater Formation	Wanilla Formation	Bridgewater Formation	Bridgewater Formation	Bridgewater Formation	Bridgewater Formation	Bridgewater Formation	Bridgewater Formation	Bridgewater Formation	Bridgewater Formation
pH	7.5	7.5	7.6	7.1	7.4	7.4	7.5	7.5	7.5	7.4	7.6	7.3
TDS (by EC) (mg/L)	450	450	420	700	510	600	440	450	430	740	430	650
Conductivity (uS/cm)	817	815	756	1270	934	1090	800	817	782	1340	786	1180
Dissolved Solids by Calculation (mg/L)	430	442	398	697	511	589	443	445	417	768	415	634
Calcium (mg/L)	74.7	73.8	62.8	75.6	75.7	78.3	77.3	78.5	71.4	87.4	68.6	83.3
Magnesium (mg/L)	15.7	15.1	14.9	29.1	28.4	25.6	15.4	16.6	15.4	28.8	14.9	27.9
Potassium (mg/L)	2	2.4	2.1	4	2	2.8	2	2.2	2.2	4.2	2	3.1
Sodium (mg/L)	78.8	79.3	79.3	152	90.3	118	75.8	79.2	76.9	159	79.2	133
Bicarbonate (mg/L)	244	239	206	323	327	303	257	261	232	306	217	306
Chloride (mg/L)	118	123	114	242	127	187	114	120	116	238	120	206
Fluoride (mg/L)	0.34	0.43	0.43	0.46	0.68	0.45	0.33	0.33	0.35	0.53	0.4	0.42
Sulphide (mg/L)	21.3	18.1	23.9	35.3	26.2	28.2	20.2	20.7	21	99.7	23.7	29.8
Nitrate + Nitrite as N (mg/L)	4.24	4.78	5.88	<0.005	4.42	3.69	3.95	4.05	4.32	0.134	4.7	3.7
Nitrate + Nitrite as NO^3 (mg/L)	18.8	21.2	26	0.02	19.6	16.3	17.5	18	19.2	0.6	20.8	16.4
Iron - total (mg/L)	<0.03	0.192	<0.030	15.4	<0.030	0.117	<0.03	0.381	5.79	0.506	0.036	<0.030
Alkalinity as CaCO3 (mg/L)	200	196	169	265	268	248	211	214	190	251	178	251
Langelier Index	0.17	0.09	0.11	-0.14	0.16	0.09	0.14	0.14	0.07	0.13	0.12	0.08
Sodium Absorption Ration	2.16	2.2	2.34	3.76	2.25	2.97	2.06	2.12	2.15	3.78	2.26	3.23
Total hardness as $CaCO^3$ (mg/L)	251.5	246.5	218.2	308.5	305.8	300.8	256.5	264.4	241.6	336.7	232.7	322.8
Ion balance (%)	2.48	1.85	2.13	-0.04	1.26	0.53	1.96	2.21	2.43	-0.27	2.23	2.44

APPENDIX B

Coffin Bay and Uley South observation well information sheets and sonding results

COFFIN BAY LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: **LKW 37**
WELL UNIT NUMBER: 592800301
COORDINATES EASTING: 544182
NORTHING: 6167580
ZONE 53
ELEVATION (mAHD) REFERENCE : 12.41
GROUND: 12.17
AQUIFER MONITORED: BRIDGEWATER FORMATION
LATEST STANDING WATER LEVEL (m): 11.54 DATE READ: 18/11/2002
LATEST SALINITY: EC(uS/cm) 721
TDS(mg/L) 397 DATE READ: 18/11/2002

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

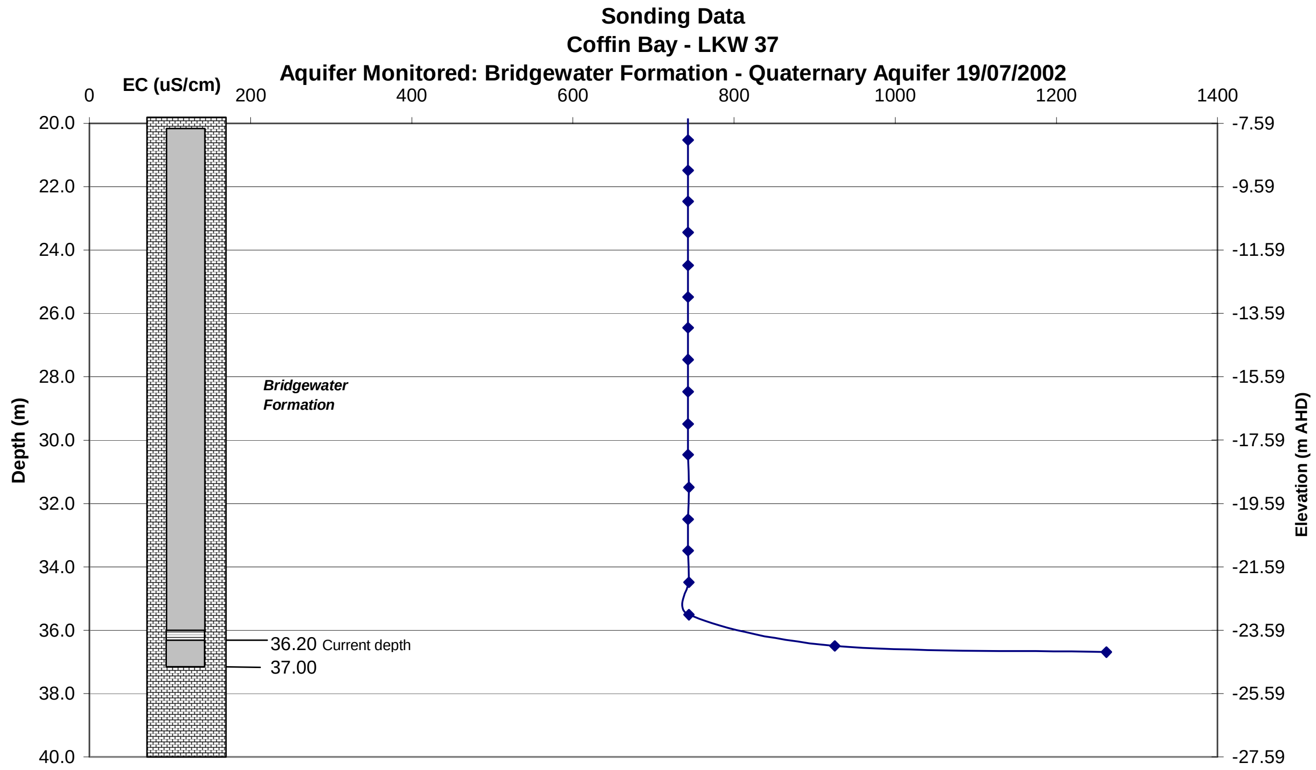
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 42 DATE: 3/05/1985
CURRENT DEPTH (m): 36.2 DATE: 31/05/2002
CASED FROM (m): 0 CASED TO (m): 36 TYPE: PVC
MINIMUM CASING DIAMETER (mm): 80
PRODUCTION ZONE FROM (m): 36 PRODUCTION ZONE TO (m): 37
SCREEN TYPE: Slotted Casing SCREEN DIAMETER (mm): 80

WORK COMPLETED 2002

PUMPED AND PURGED: Not Done SALINITY PROFILING: Yes
TRANSDUCER INSTALLATION: No
RAINGAUGE ADJACENT: No REQUIRES REHABILITATION: No

SALINITY PROFILING DATA



COFFIN BAY LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: **LKW 38**
WELL UNIT NUMBER: 592800303
COORDINATES EASTING: 544127
NORTHING: 6167401
ZONE 53
ELEVATION (mAHD) REFERENCE : 2.76
GROUND: 2.74
AQUIFER MONITORED: BRIDGEWATER FORMATION
LATEST STANDING WATER LEVEL (m): 2.07
LATEST SALINITY: EC(uS/cm) 716
TDS(mg/L) 394

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

DATE READ: 18/11/2002
DATE READ: 18/11/2002

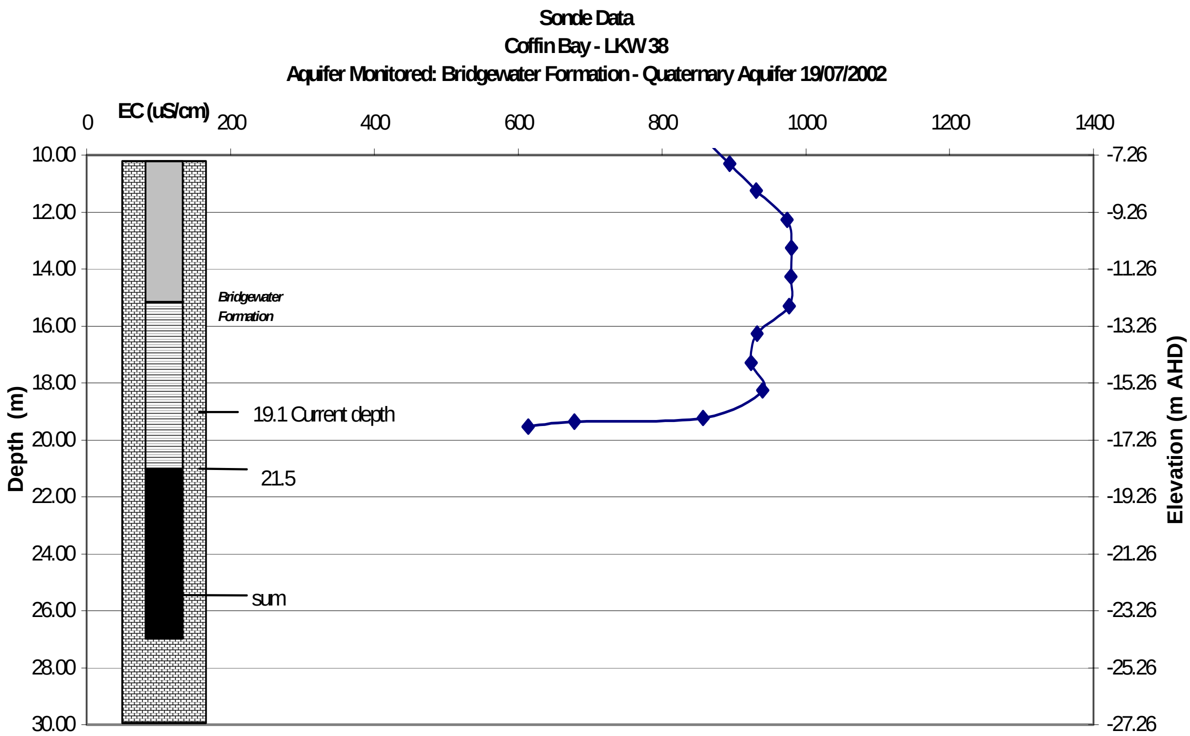
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 49 DATE: 16/03/1985
CURRENT DEPTH (m): 19.1 DATE: 31/05/2002
CASED FROM (m): 0 CASED TO (m): 21 TYPE: PVC
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 2002

PUMPED AND PURGED: Not Done
SALINITY PROFILING: Yes
TRANSDUCER INSTALLATION: Yes
RAINGAUGE ADJACENT: Yes
REQUIRES REHABILITATION: Yes

SALINITY PROFILING DATA



COFFIN BAY LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: **LKW 39**
WELL UNIT NUMBER: 592800304
COORDINATES EASTING: 544122
NORTHING: 6167400
ZONE 53
ELEVATION (mAHD) REFERENCE : 3.01
GROUND: 2.67
AQUIFER MONITORED: BRIDGEWATER FORMATION
LATEST STANDING WATER LEVEL (m): 1.71
LATEST SALINITY: EC(uS/cm) 687
TDS(mg/L) 378

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

DATE READ: 18/11/2002
DATE READ: 18/11/2002

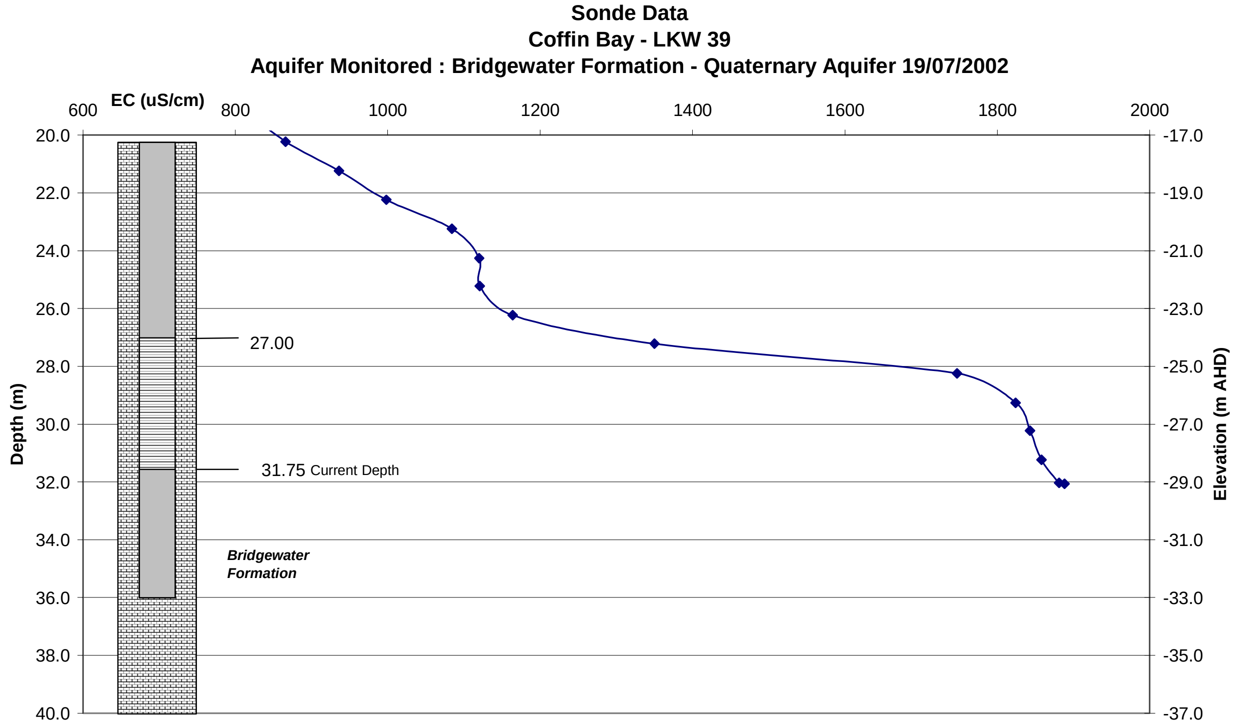
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 36 DATE: 19/03/1985
CURRENT DEPTH (m): 31.75 DATE: 31/05/2002
CASED FROM (m): 0 CASED TO (m): 27 TYPE: PVC
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 2002

PUMPED AND PURGED: Not Done SALINITY PROFILING: Yes
TRANSDUCER INSTALLATION: Yes
RAINGAUGE ADJACENT: No REQUIRES REHABILITATION: No

SALINITY PROFILING DATA



COFFIN BAY LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: **LKW 40**
WELL UNIT NUMBER: 592800306
COORDINATES EASTING: 544310
NORTHING: 6167286
ZONE 53
ELEVATION (mAHD) REFERENCE : 4.65
GROUND: 4.33
AQUIFER MONITORED: WANILLA FORMATION
LATEST STANDING WATER LEVEL (m): 3.3
LATEST SALINITY: EC(uS/cm) 2760
TDS(mg/L) 1530

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

DATE READ: 18/11/2002
DATE READ: 18/11/2002

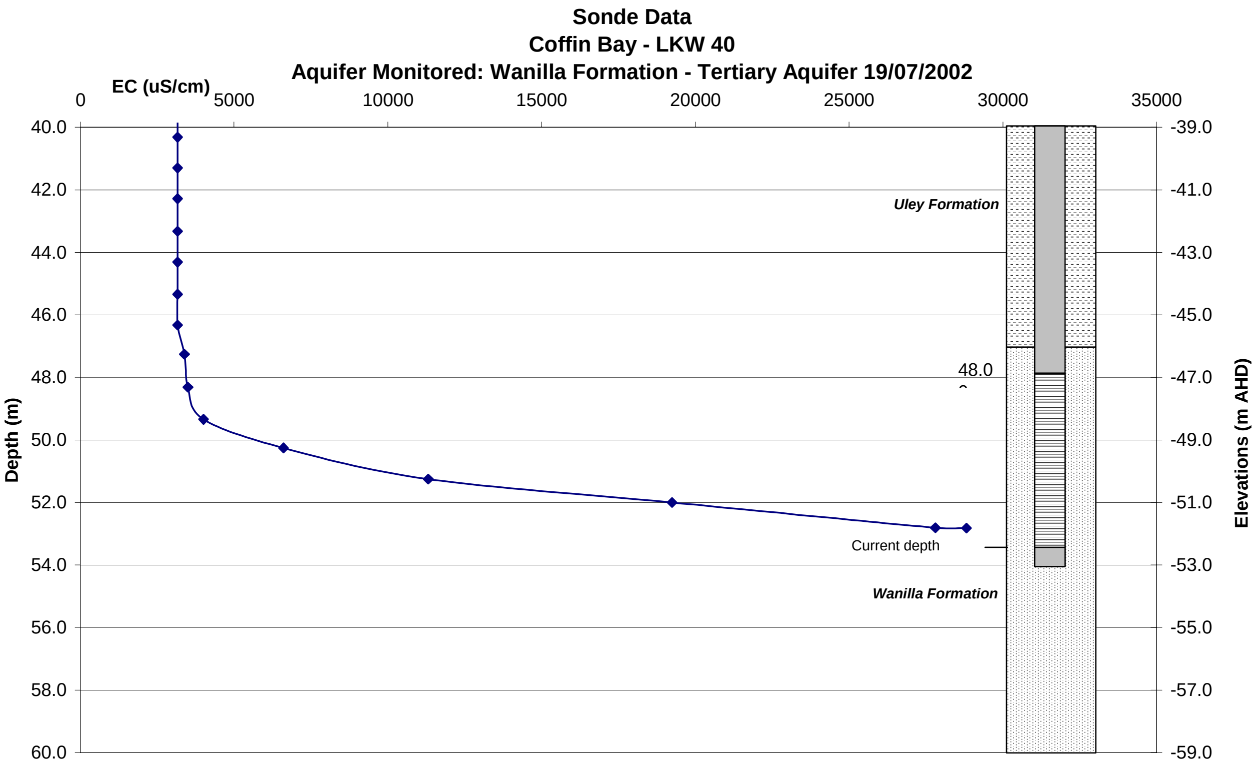
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 60 DATE: 2/04/1985
CURRENT DEPTH (m): 53.5 DATE: 31/05/2002
CASED FROM (m): 0 CASED TO (m): 48 TYPE: PVC
MINIMUM CASING DIAMETER (mm): 80
PRODUCTION ZONE FROM (m): 48 PRODUCTION ZONE TO (m): 54
SCREEN TYPE: Slotted Casing SCREEN DIAMETER (mm): 80

WORK COMPLETED 2002

PUMPED AND PURGED: Not Done SALINITY PROFILING: Yes
TRANSDUCER INSTALLATION: No
RAINGAUGE ADJACENT: No REQUIRES REHABILITATION: No

SALINITY PROFILING DATA



ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: **LKW 12**
WELL UNIT NUMBER: 602801068
COORDINATES EASTING: 549182.57
NORTHING: 6160076.97
ZONE 53
ELEVATION (mAHD) REFERENCE : 32.67
GROUND: 32.65
AQUIFER MONITORED: WANILLA FORMATION
LATEST STANDING WATER LEVEL (m): Dry
LATEST SALINITY: EC(uS/cm) 830
TDS(mg/L) 457

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly
DATE READ: 14/11/2002
DATE READ: 10/07/1997

CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 61.87 DATE: 4/11/1960
CURRENT DEPTH (m): 25 DATE: 01/06/2002
CASED FROM (m): 0 CASED TO (m): 36 TYPE: PVC
MINIMUM CASING DIAMETER (mm): 80
PRODUCTION ZONE FROM (m): 36 PRODUCTION ZONE TO (m): 39
SCREEN TYPE: Slotted Casing SCREEN DIAMETER (mm): 80

WORK COMPLETED 2002

PUMPED AND PURGED: Dry SALINITY PROFILING: Dry
TRANSDUCER INSTALLATION: No
RAINGAUGE ADJACENT: No REQUIRES REHABILITATION: No

SALINITY PROFILING DATA

ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: LKW 34
WELL UNIT NUMBER: 602801072
COORDINATES EASTING: 549381
NORTHING: 6158040
ZONE 53
ELEVATION (mAHD) REFERENCE : 28.41
GROUND: 28.448
AQUIFER MONITORED: WANILLA FORMATION
LATEST STANDING WATER LEVEL (m): 26.89
LATEST SALINITY: EC(uS/cm) 810
TDS(mg/L) 446

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

DATE READ: 14/11/2002
DATE READ: 6/06/2002

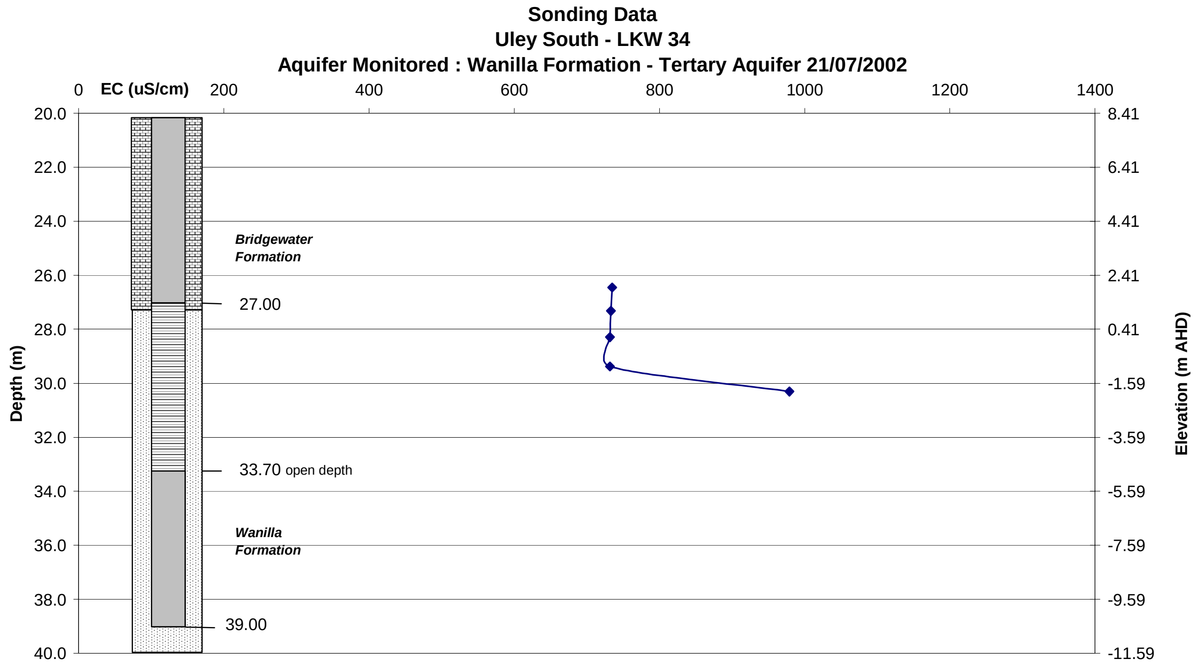
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 64.01 — **DATE:** 2/12/1960
CURRENT DEPTH (m): 33.7 — **DATE:** 01/06/2002
CASED FROM (m): 0 — **CASED TO (m):** 27 — **TYPE:** PVC
MINIMUM CASING DIAMETER (mm): 80
PRODUCTION ZONE FROM (m): 27 — **PRODUCTION ZONE TO (m):** 39
SCREEN TYPE: Slotted Casing — **SCREEN DIAMETER (mm):** 80

WORK COMPLETED 2002

PUMPED AND PURGED: Yes — **SALINITY PROFILING:** Yes
TRANSDUCER INSTALLATION: No
RAINGAUGE ADJACENT: No — **REQUIRES REHABILITATION:** No

SALINITY PROFILING DATA



ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: **ULE 77**
WELL UNIT NUMBER: 602800910
COORDINATES EASTING: 550671.64
NORTHING: 6161942.74
ZONE 53
ELEVATION (mAHD) REFERENCE : 46.29
GROUND: 45.27
AQUIFER MONITORED: BRIDGEWATER FORMATION
LATEST STANDING WATER LEVEL (m): 26.89 DATE READ: 14/11/2002
LATEST SALINITY: EC(uS/cm) 1030
TDS(mg/L) 567 DATE READ: 10/07/1997

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 42.67 DATE: 8/11/1960
CURRENT DEPTH (m): 32.12 DATE: 01/06/2002
CASED FROM (m): 0 CASED TO (m): 26 TYPE: PVC
MINIMUM CASING DIAMETER (mm): 80
PRODUCTION ZONE FROM (m): 26 PRODUCTION ZONE TO (m): 29
SCREEN TYPE: Unknown SCREEN DIAMETER (mm): Unknown

WORK COMPLETED 2002

PUMPED AND PURGED: Pump Seized SALINITY PROFILING: Not done
TRANSDUCER INSTALLATION: No
RAINGAUGE ADJACENT: No REQUIRES REHABILITATION: No

SALINITY PROFILING DATA

ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: **ULE 89**
WELL UNIT NUMBER: 602800666
COORDINATES EASTING: 557114
NORTHING: 6154243
ZONE 53
ELEVATION (mAHD) REFERENCE : 42.82
GROUND: 42.43
AQUIFER MONITORED: WANILLA FORMATION
LATEST STANDING WATER LEVEL (m): 27.02
LATEST SALINITY: EC(uS/cm) 960
TDS(mg/L) 528

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

DATE READ: 14/11/2002

DATE READ: 4/06/2002

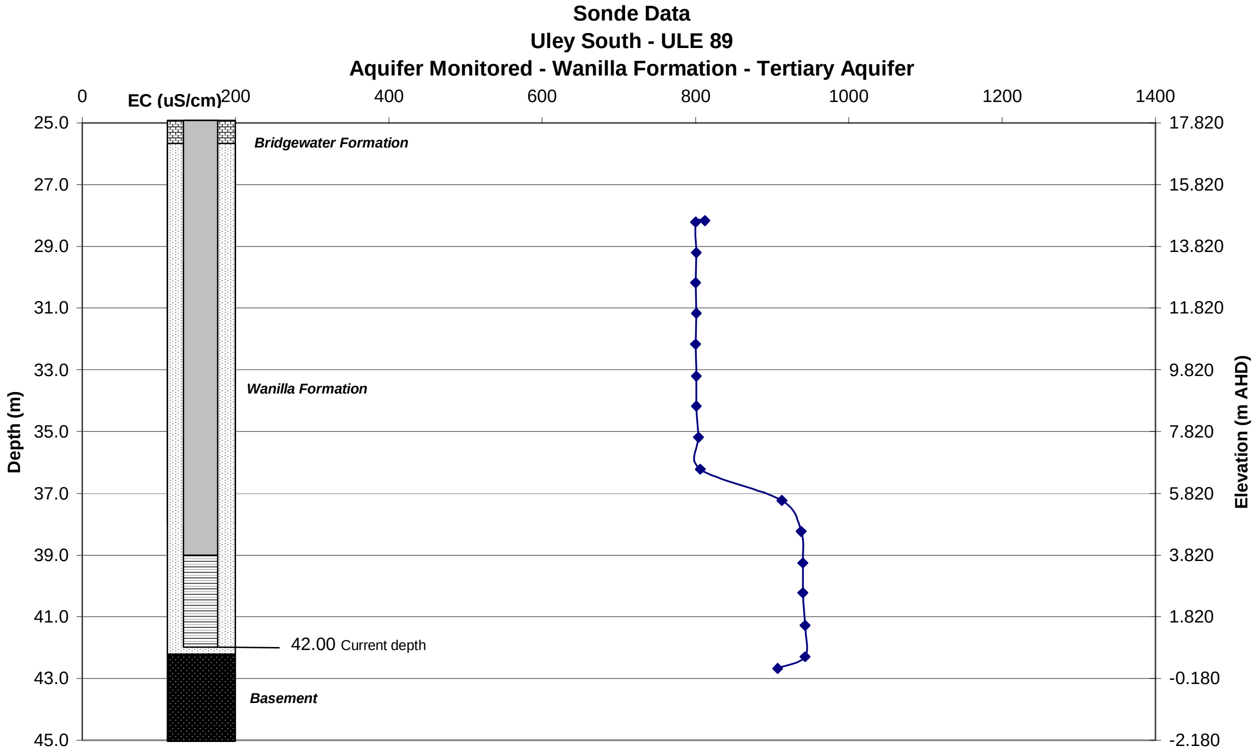
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 57 DATE: 26/05/1961
CURRENT DEPTH (m): 42.45 DATE: 03/06/2002
CASED FROM (m): 0 CASED TO (m): 39 TYPE: PVC
MINIMUM CASING DIAMETER (mm): 80
PRODUCTION ZONE FROM (m): 39 PRODUCTION ZONE TO (m): 42
SCREEN TYPE: Slotted Casing SCREEN DIAMETER (mm): 80

WORK COMPLETED 2002

PUMPED AND PURGED: Yes SALINITY PROFILING: Yes
TRANSDUCER INSTALLATION: No
RAINGAUGE ADJACENT: No REQUIRES REHABILITATION: No

SALINITY PROFILING DATA



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ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: **ULE 92**
WELL UNIT NUMBER: 602800876
COORDINATES EASTING: 550371
NORTHING: 6156026
ZONE 53
ELEVATION (mAHD) REFERENCE : 25.53
GROUND: 25.491
AQUIFER MONITORED: BRIDGEWATER FORMATION
LATEST STANDING WATER LEVEL (m): 24.34 DATE READ: 14/11/2002
LATEST SALINITY: EC(uS/cm) 1070
TDS(mg/L) 589 DATE READ: 10/07/1997

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 38.1 DATE: 28/11/1960
CURRENT DEPTH (m): 24.8 DATE: 01/06/2002
CASED FROM (m): 0 CASED TO (m): 21 TYPE: PVC
MINIMUM CASING DIAMETER (mm): 80
PRODUCTION ZONE FROM (m): 21 PRODUCTION ZONE TO (m): 27
SCREEN TYPE: Slotted Casing SCREEN DIAMETER (mm): 80

WORK COMPLETED 2002

PUMPED AND PURGED: Dry SALINITY PROFILING: Dry
TRANSDUCER INSTALLATION: No
RAINGAUGE ADJACENT: No REQUIRES REHABILITATION: No

SALINITY PROFILING DATA

ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: **ULE 97**
WELL UNIT NUMBER: 602800755
COORDINATES EASTING: 548789
NORTHING: 6152876
ZONE 53
ELEVATION (mAHD) REFERENCE : 5.42
GROUND: 5.42
AQUIFER MONITORED: BRIDGEWATER FORMATION
LATEST STANDING WATER LEVEL (m): 4.2 DATE READ: 14/11/2002
LATEST SALINITY: EC(uS/cm) 4334
TDS(mg/L) 2416 DATE READ: 13/02/1961

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 47.85 DATE: 14/02/1961
CURRENT DEPTH (m): 47.85 DATE: 14/02/1961
CASED FROM (m): 0 CASED TO (m): 6.4 TYPE: Steel
MINIMUM CASING DIAMETER (mm): 63
PRODUCTION ZONE FROM (m): 6.4 PRODUCTION ZONE TO (m): 47.85
SCREEN TYPE: Unknown SCREEN DIAMETER (mm):

WORK COMPLETED 2002

PUMPED AND PURGED: Too Narrow SALINITY PROFILING: Not done
TRANSDUCER INSTALLATION: No
RAINGAUGE ADJACENT: No REQUIRES REHABILITATION: Yes

SALINITY PROFILING DATA

ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: ULE 99
WELL UNIT NUMBER: 602800752
COORDINATES **EASTING:** 549244
NORTHING: 6151805
ZONE 53
ELEVATION (mAHD) **REFERENCE :** 6.23
GROUND: 5.65
AQUIFER MONITORED: BRIDGEWATER FORMATION
LATEST STANDING WATER LEVEL (m): 4.07
LATEST SALINITY: **EC(uS/cm)** 980
TDS(mg/L) 539

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

DATE READ: 14/11/2002
DATE READ: 06/06/2002

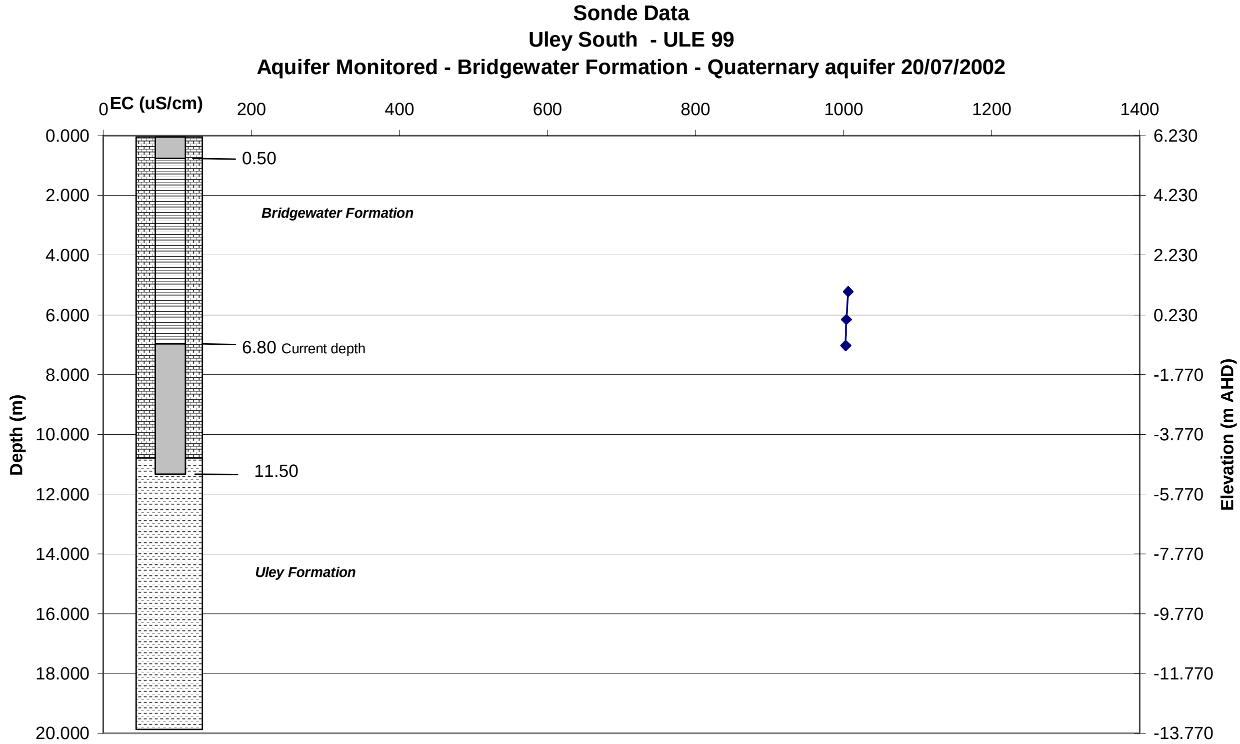
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 34.75 **DATE:** 16/02/1961
CURRENT DEPTH (m): 6.8 **DATE:** 04/06/2002
CASED FROM (m): 0 **CASED TO (m):** 0.5 **TYPE:** PVC
MINIMUM CASING DIAMETER (mm): 80
PRODUCTION ZONE FROM (m): 0.5 **PRODUCTION ZONE TO (m):** 11.5
SCREEN TYPE: Slotted Casing **SCREEN DIAMETER (mm):** 80

WORK COMPLETED 2002

PUMPED AND PURGED: Yes **SALINITY PROFILING:** Yes
TRANSDUCER INSTALLATION: No
RAINGAUGE ADJACENT: No **REQUIRES REHABILITATION:** No

SALINITY PROFILING DATA



ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: **ULE 101**
WELL UNIT NUMBER: 602800773
COORDINATES EASTING: 549565
NORTHING: 6150500
ZONE 53
ELEVATION (mAHD) REFERENCE : 5.91
GROUND: 5.46
AQUIFER MONITORED: BRIDGEWATER FORMATION
LATEST STANDING WATER LEVEL (m): 3.64
LATEST SALINITY: EC(uS/cm) 800
TDS(mg/L) 440

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

DATE READ: 14/11/2002
DATE READ: 5/06/2002

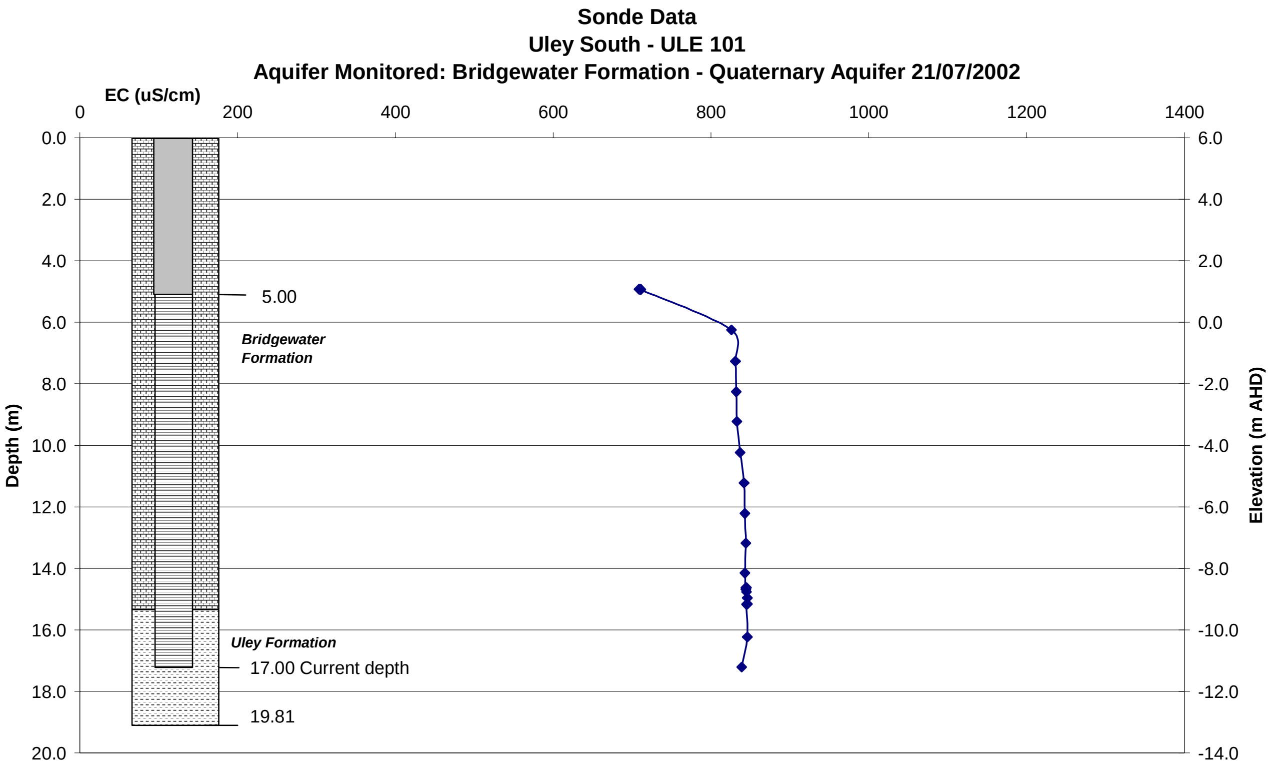
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 19.81 DATE: 1/10/1965
CURRENT DEPTH (m): 17 DATE: 04/06/2002
CASED FROM (m): 0 CASED TO (m): 5 TYPE: PVC
MINIMUM CASING DIAMETER (mm): 75
PRODUCTION ZONE FROM (m): 5 PRODUCTION ZONE TO (m): 17
SCREEN TYPE: Slotted Casing SCREEN DIAMETER (mm): 75

WORK COMPLETED 2002

PUMPED AND PURGED: Yes SALINITY PROFILING: Yes
TRANSDUCER INSTALLATION: No
RAINGAUGE ADJACENT: No REQUIRES REHABILITATION: No

SALINITY PROFILING DATA



ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: **ULE 102**
WELL UNIT NUMBER: **602800743**
COORDINATES EASTING: **549893**
NORTHING: **6149686**
ZONE **53**
ELEVATION (mAHD) REFERENCE : **11.18**
GROUND: **10.57**
AQUIFER MONITORED: **BRIDGEWATER FORMATION**
LATEST STANDING WATER LEVEL (m): **9.08**
LATEST SALINITY: EC(uS/cm) **790**
TDS(mg/L) **435**

MONITORING STATUS
SWL: **Current**
FREQUENCY: **1 monthly**
SALINITY: **Historical**
FREQUENCY: **6 monthly**
DATE READ: **14/11/2002**
DATE READ: **5/06/2002**

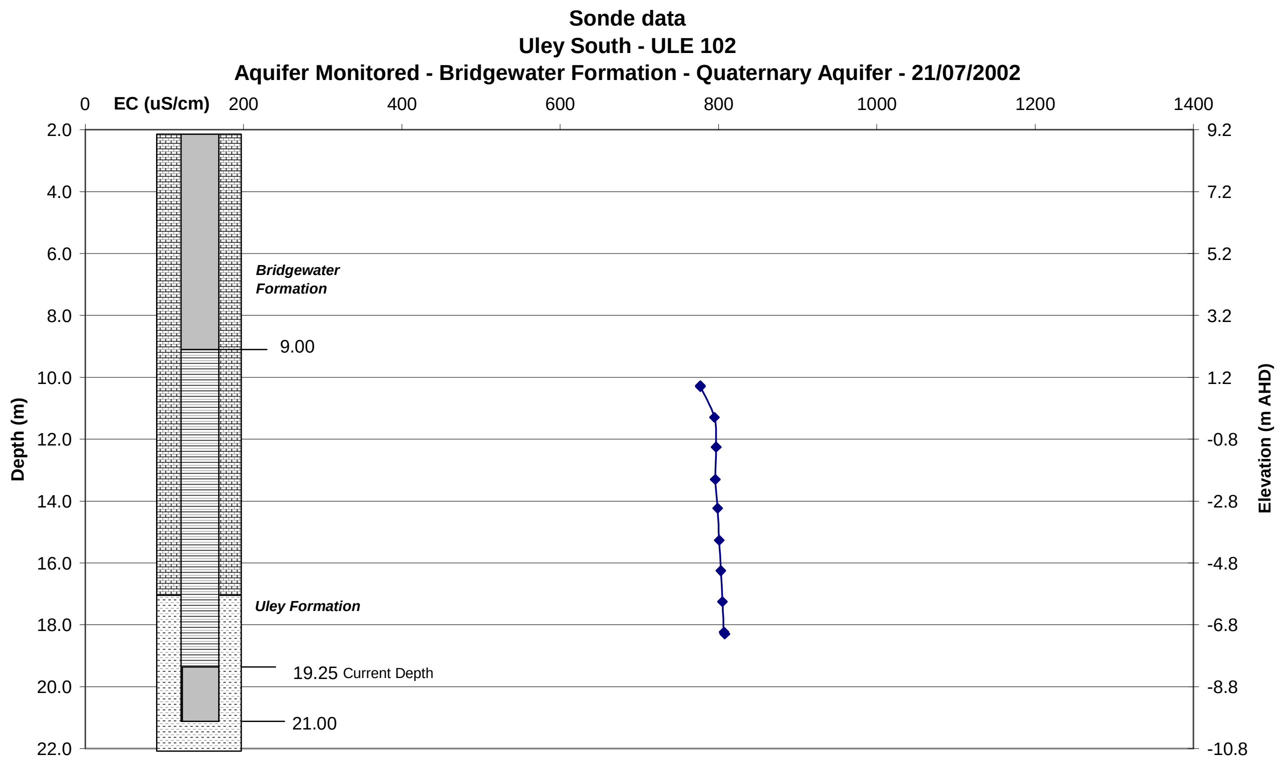
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): **42.67** DATE: **17/03/1961**
CURRENT DEPTH (m): **18** DATE: **04/06/2002**
CASED FROM (m): **0** CASED TO (m): **9** TYPE: **PVC**
MINIMUM CASING DIAMETER (mm): **76**
PRODUCTION ZONE FROM (m): **9** PRODUCTION ZONE TO (m): **21**
SCREEN TYPE: **Slotted Casing** SCREEN DIAMETER (mm): **76**

WORK COMPLETED 2002

PUMPED AND PURGED: **Yes** SALINITY PROFILING: **Yes**
TRANSDUCER INSTALLATION: **No**
RAINGAUGE ADJACENT: **No** REQUIRES REHABILITATION: **No**

SALINITY PROFILING DATA



ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: **ULE 109**
WELL UNIT NUMBER: 602800706
COORDINATES EASTING: 552511
NORTHING: 6152937
ZONE 53
ELEVATION (mAHD) REFERENCE : 11.96
GROUND: 11.8
AQUIFER MONITORED: WANILLA FORMATION
LATEST STANDING WATER LEVEL (m): 6.57
LATEST SALINITY: EC(uS/cm) 1190
TDS(mg/L) 655

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

DATE READ: 14/11/2002

DATE READ: 3/06/2002

CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 51.82 DATE: 21/02/1961
CURRENT DEPTH (m): 40.75 DATE: 03/06/2002
CASED FROM (m): 0 CASED TO (m): 38 TYPE: PVC
MINIMUM CASING DIAMETER (mm): 80
PRODUCTION ZONE FROM (m): 38 PRODUCTION ZONE TO (m): 41
SCREEN TYPE: Slotted Casing SCREEN DIAMETER (mm): 80

WORK COMPLETED 2002

PUMPED AND PURGED: Yes SALINITY PROFILING: no data
TRANSDUCER INSTALLATION: No
RAINGAUGE ADJACENT: No REQUIRES REHABILITATION: No

SALINITY PROFILING DATA

ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: **ULE 114**
WELL UNIT NUMBER: 602800775
COORDINATES — EASTING: 550945
NORTHING: 6151573
ZONE 53
ELEVATION (mAHD) — REFERENCE : 10.53
GROUND: 9.97
AQUIFER MONITORED: BRIDGEWATER FORMATION
LATEST STANDING WATER LEVEL (m): 6.48 — DATE READ: 14/11/2002
LATEST SALINITY: EC(uS/cm) 880
TDS(mg/L) 484 — DATE READ: 4/06/2002

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

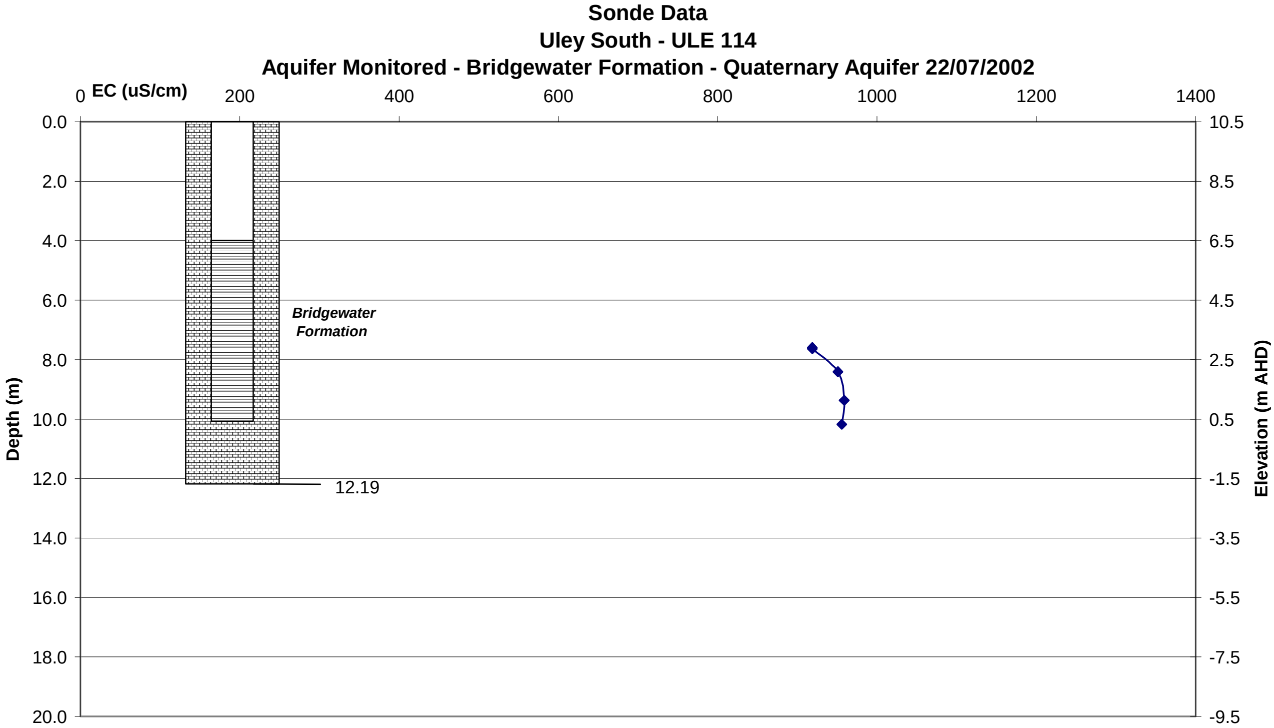
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 12.19 — DATE: 21/10/1965
CURRENT DEPTH (m): 10.1 — DATE: 05/06/2002
CASED FROM (m): 0 — CASED TO (m): 4 — TYPE: PVC
MINIMUM CASING DIAMETER (mm): 75
PRODUCTION ZONE FROM (m): 4 — PRODUCTION ZONE TO (m): 10
SCREEN TYPE: Slotted Casing — SCREEN DIAMETER (mm): 75

WORK COMPLETED 2002

PUMPED AND PURGED: Yes — SALINITY PROFILING: Yes
TRANSDUCER INSTALLATION: No
RAINGAUGE ADJACENT: No — REQUIRES REHABILITATION: No

SALINITY PROFILING DATA



ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: **ULE 126**
WELL UNIT NUMBER: 602800894
COORDINATES EASTING: 554070
NORTHING: 6154700
ZONE 53
ELEVATION (mAHD) REFERENCE : 26.39
GROUND: 25.9
AQUIFER MONITORED: BRIDGEWATER FORMATION
LATEST STANDING WATER LEVEL (m): 14.81 DATE READ: 14/11/2002
LATEST SALINITY: EC(uS/cm) 1160
TDS(mg/L) 639 DATE READ: 4/06/2002

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

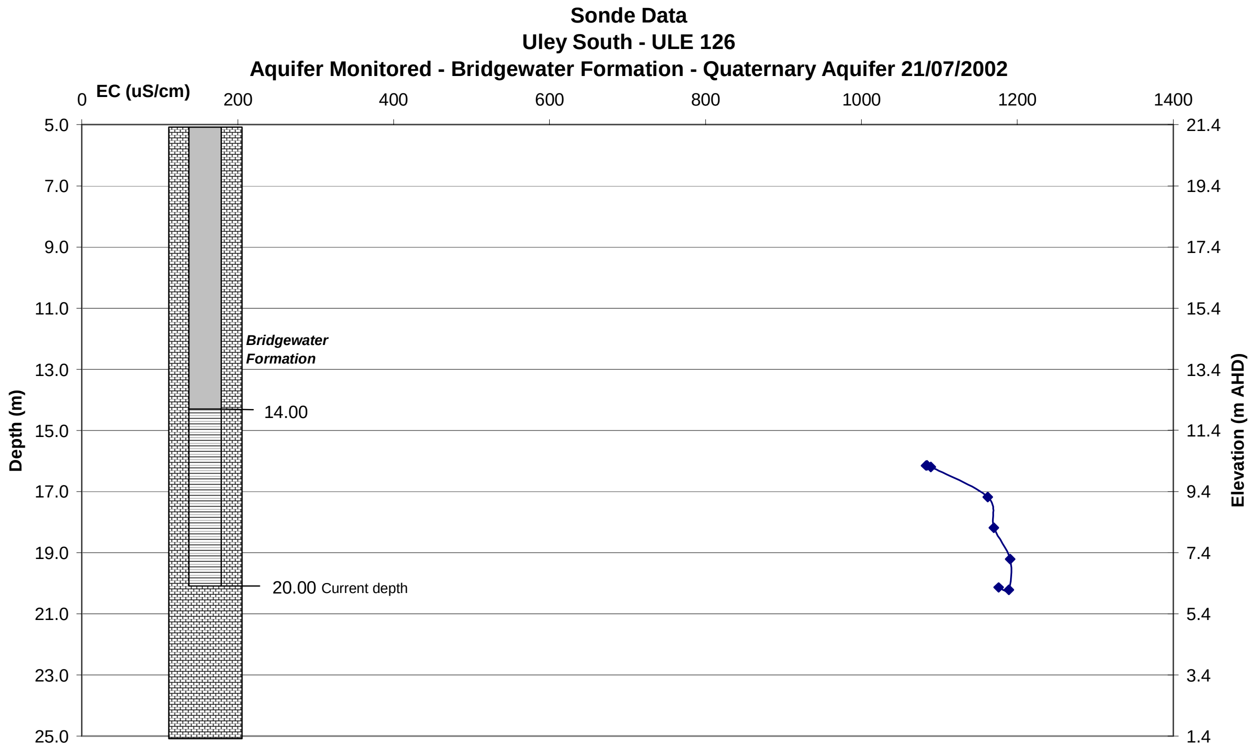
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 50.29 DATE: 2/05/1961
CURRENT DEPTH (m): 19.9 DATE: 03/06/2002
CASED FROM (m): 0 CASED TO (m): 14 TYPE: PVC
MINIMUM CASING DIAMETER (mm): 80
PRODUCTION ZONE FROM (m): 14 PRODUCTION ZONE TO (m): 20
SCREEN TYPE: Slotted Casing SCREEN DIAMETER (mm): 80

WORK COMPLETED 2002

PUMPED AND PURGED: Yes SALINITY PROFILING: Yes
TRANSDUCER INSTALLATION: No
RAINGAUGE ADJACENT: No REQUIRES REHABILITATION: No

SALINITY PROFILING DATA



ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: ULE 127
WELL UNIT NUMBER: 602800895
COORDINATES EASTING: 552582
NORTHING: 6154685
ZONE 53
ELEVATION (mAHD) REFERENCE : 21.22
GROUND: 21.46
AQUIFER MONITORED: WANILLA FORMATION
LATEST STANDING WATER LEVEL (m): 15.84
LATEST SALINITY: EC(uS/cm) 970
TDS(mg/L) 534

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

DATE READ: 14/11/2002
DATE READ: 4/06/2002

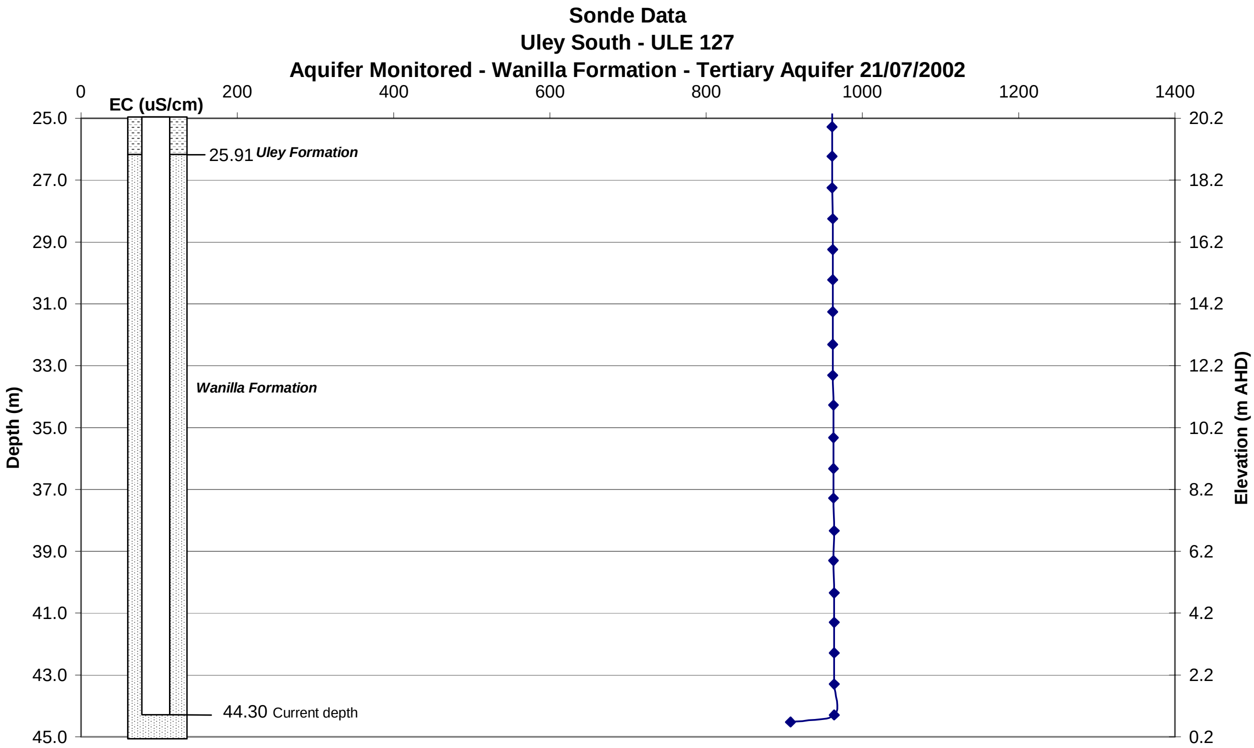
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 74.68 **DATE:** 12/04/1961
CURRENT DEPTH (m): 45.2 **DATE:** 04/06/2002
CASED FROM (m): Unknown **CASED TO (m):** Unknown **TYPE:** Steel
MINIMUM CASING DIAMETER (mm): 100
PRODUCTION ZONE FROM (m): Unknown **PRODUCTION ZONE TO (m):** Unknown
SCREEN TYPE: Unknown **SCREEN DIAMETER (mm):** Unknown

WORK COMPLETED 2002

PUMPED AND PURGED: Yes **SALINITY PROFILING:** Yes
TRANSDUCER INSTALLATION: No
RAINGAUGE ADJACENT: No **REQUIRES REHABILITATION:** No

SALINITY PROFILING DATA



ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: ULE 134
WELL UNIT NUMBER: 602800744
COORDINATES EASTING: 550991
NORTHING: 6148603
ZONE 53
ELEVATION (mAHD) REFERENCE : 20.13
GROUND: 20.13
AQUIFER MONITORED: BRIDGEWATER FORMATION
LATEST STANDING WATER LEVEL (m): 18.75
LATEST SALINITY: EC(uS/cm) 850
TDS(mg/L) 468

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

DATE READ: 14/11/2002
DATE READ: 4/04/1996

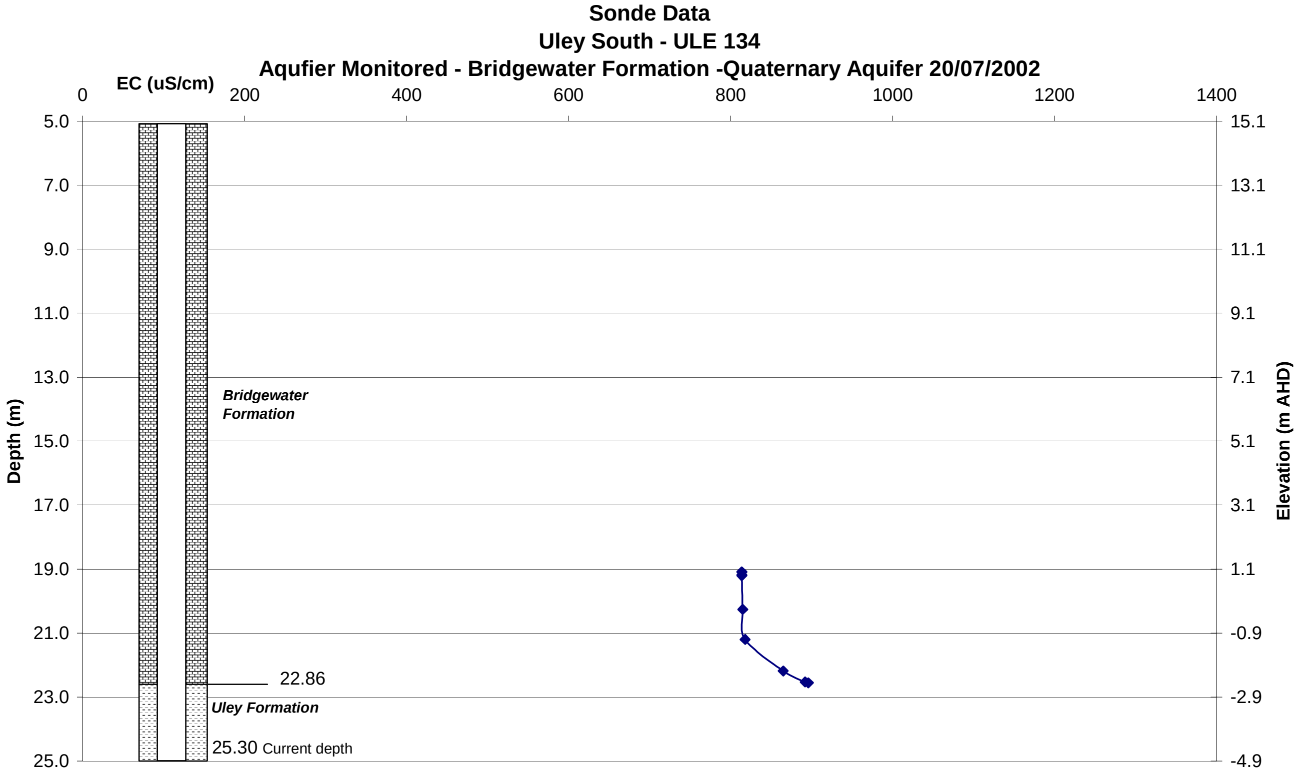
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 76.2 **DATE:** 3/02/1961
CURRENT DEPTH (m): 25.3 **DATE:** 05/06/2002
CASED FROM (m): Unknown **CASED TO (m):** Unknown **TYPE:** Steel
MINIMUM CASING DIAMETER (mm): 63
PRODUCTION ZONE FROM (m): Unknown **PRODUCTION ZONE TO (m):** Unknown
SCREEN TYPE: Slotted Casing **SCREEN DIAMETER (mm):** 63

WORK COMPLETED 2002

PUMPED AND PURGED: Too Narrow **SALINITY PROFILING:** Yes
TRANSDUCER INSTALLATION: Yes
RAINGAUGE ADJACENT: No **REQUIRES REHABILITATION:** Yes

SALINITY PROFILING DATA



ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBSERVATION WELL NUMBER: ULE 135
WELL UNIT NUMBER: 602800745
COORDINATES EASTING: 551618
NORTHING: 6149131
ZONE 53
ELEVATION (mAHD) REFERENCE : 7.32
GROUND: 6.73
AQUIFER MONITORED: WANILLA FORMATION
LATEST STANDING WATER LEVEL (m): 4.84 **DATE READ:** 04/07/2002
LATEST SALINITY: EC(uS/cm) 2050
TDS(mg/L) 1132 **DATE READ:** 7/06/2002

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

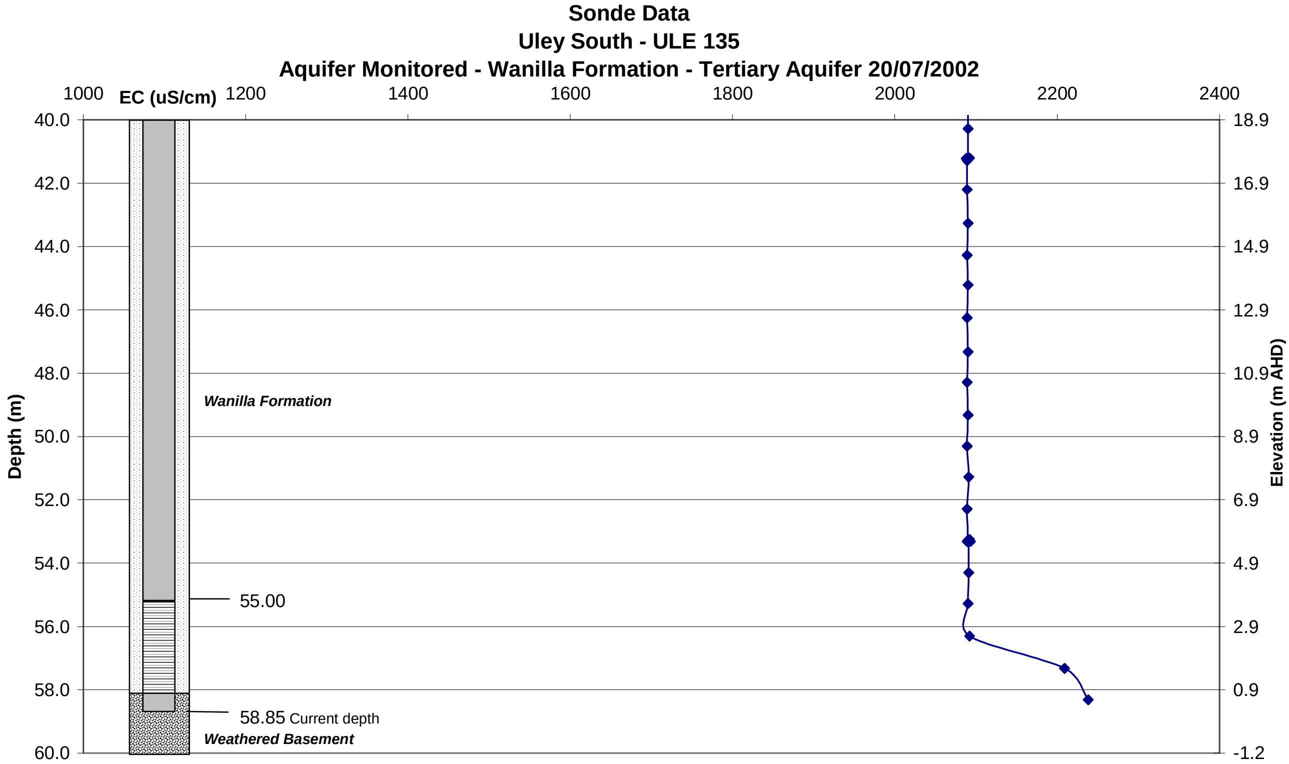
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 83.82 **DATE:** 3/02/1961
CURRENT DEPTH (m): 58.85 **DATE:** 04/06/2002
CASED FROM (m): 0 **CASED TO (m):** 55 **TYPE:** PVC
MINIMUM CASING DIAMETER (mm): 75
PRODUCTION ZONE FROM (m): 55 **PRODUCTION ZONE TO (m):** 58
SCREEN TYPE: Slotted Casing **SCREEN DIAMETER (mm):** 75

WORK COMPLETED 2002

PUMPED AND PURGED: Yes **SALINITY PROFILING:** Yes
TRANSDUCER INSTALLATION: Yes
RAINGAUGE ADJACENT: No **REQUIRES REHABILITATION:** No

SALINITY PROFILING DATA



ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: **ULE 139**
WELL UNIT NUMBER: 602800711
COORDINATES EASTING: 553492
NORTHING: 6151286
ZONE 53
ELEVATION (mAHD) REFERENCE : 21.96
GROUND: 21.49
AQUIFER MONITORED: BRIDGEWATER FORMATION
LATEST STANDING WATER LEVEL (m): 15.59
LATEST SALINITY: EC(uS/cm) 830
TDS(mg/L) 457

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY 6 monthly
DATE READ: 14/11/2002
DATE READ: 5/06/2002

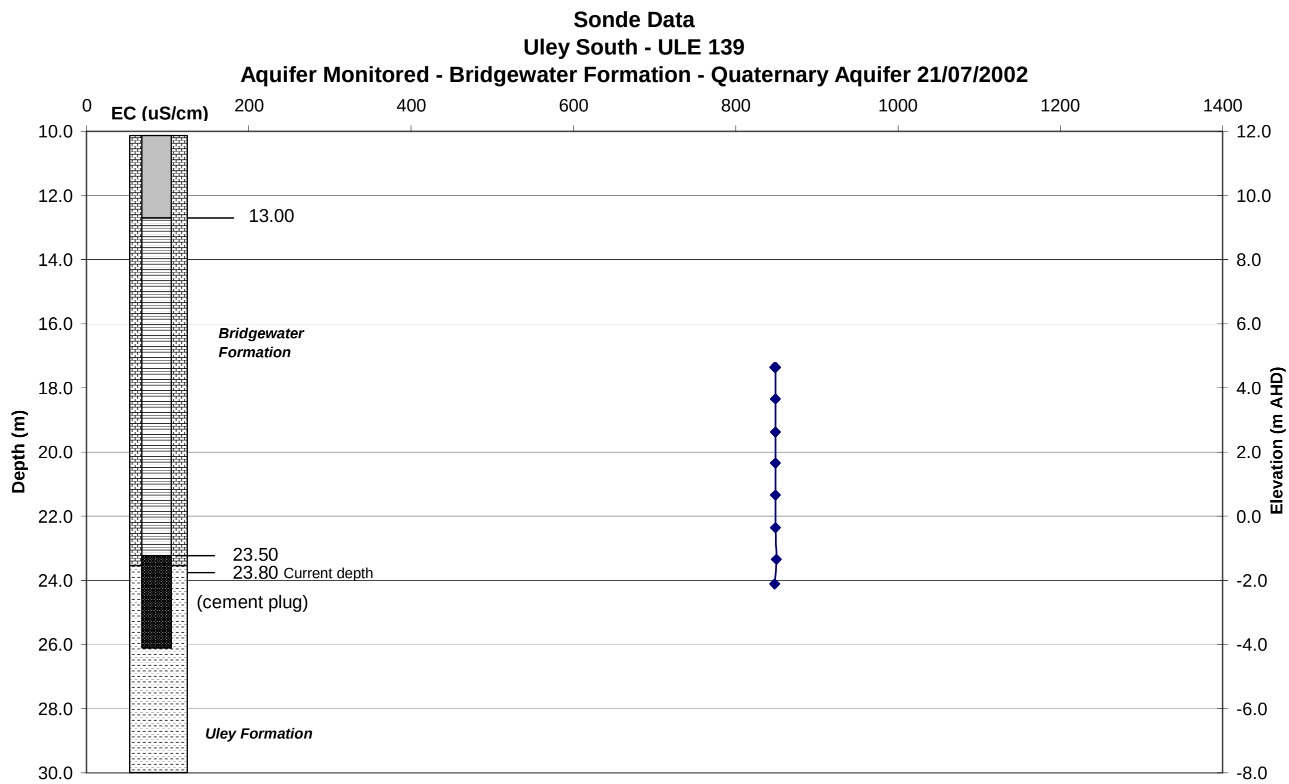
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 60.96 DATE: 12/07/1961
CURRENT DEPTH (m): 23.8 DATE: 05/06/2002
CASED FROM (m): 0 CASED TO (m): 13 TYPE: PVC
MINIMUM CASING DIAMETER (mm): 80
PRODUCTION ZONE FROM (m): 13 PRODUCTION ZONE TO (m): 23.5
SCREEN TYPE: Slotted Casing SCREEN DIAMETER (mm): 80

WORK COMPLETED 2002

PUMPED AND PURGED: Yes SALINITY PROFILING: Yes
TRANSDUCER INSTALLATION: Yes
RAINGAUGE ADJACENT: No REQUIRES REHABILITATION: No

SALINITY PROFILING DATA



ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: **ULE 141**
WELL UNIT NUMBER: 602800715
COORDINATES EASTING: 556430
NORTHING: 6151537
ZONE 53
ELEVATION (mAHD) REFERENCE : 27.9
GROUND: 27.09
AQUIFER MONITORED: WANILLA FORMATION
LATEST STANDING WATER LEVEL (m): 15.06
LATEST SALINITY: EC(uS/cm) 850
TDS(mg/L) 468

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

DATE READ: 14/11/2002
DATE READ: 5/06/2002

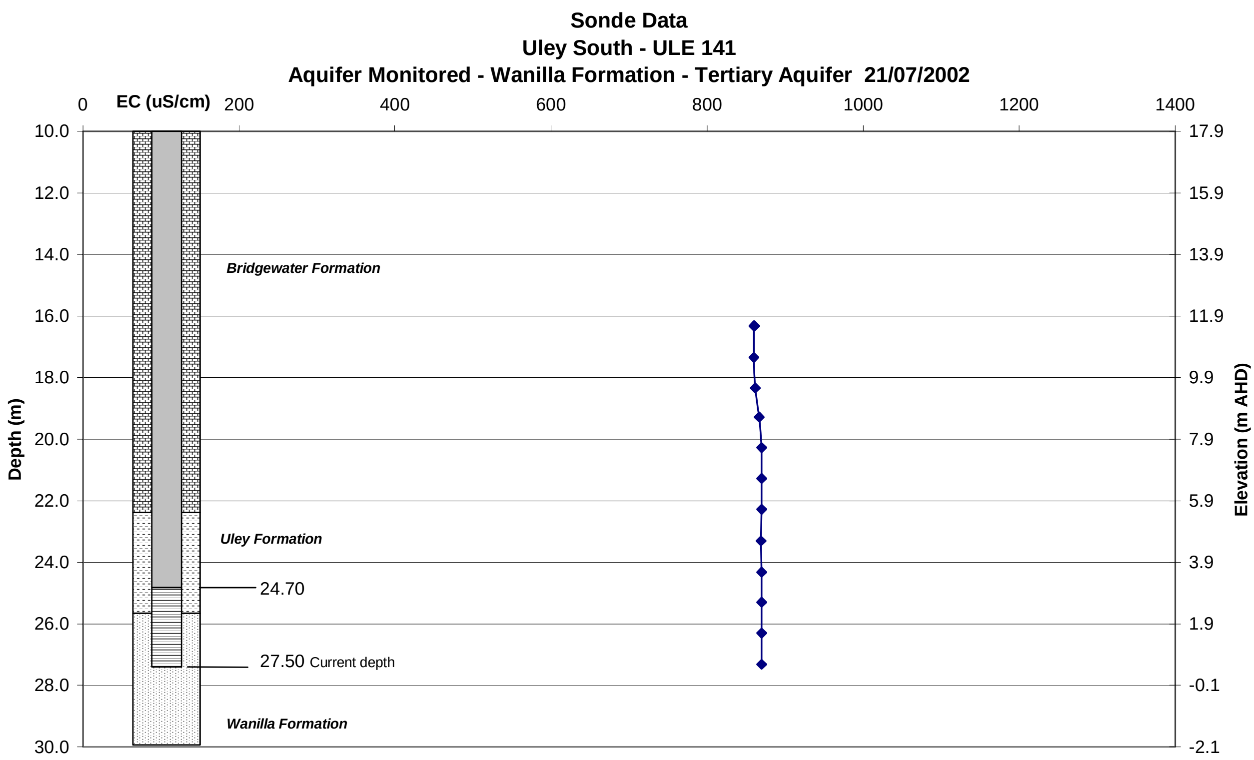
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 47.24 DATE: 21/04/1961
CURRENT DEPTH (m): 27.55 DATE: 05/06/2002
CASED FROM (m): 0 CASED TO (m): 24.7 TYPE: PVC
MINIMUM CASING DIAMETER (mm): 80
PRODUCTION ZONE FROM (m): 24.7 PRODUCTION ZONE TO (m): 27.5
SCREEN TYPE: Slotted Casing SCREEN DIAMETER (mm): 80

WORK COMPLETED 2002

PUMPED AND PURGED: Yes SALINITY PROFILING: Yes
TRANSDUCER INSTALLATION: No
RAINGAUGE ADJACENT: No REQUIRES REHABILITATION: No

SALINITY PROFILING DATA



ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: **ULE 145**
WELL UNIT NUMBER: 602800746
COORDINATES EASTING: 552601
NORTHING: 6149494
ZONE 53
ELEVATION (mAHD) REFERENCE : 12.29
GROUND: 11.75
AQUIFER MONITORED: BRIDGEWATER FORMATION
LATEST STANDING WATER LEVEL (m): 6.86
LATEST SALINITY: EC(uS/cm) 790
TDS(mg/L) 435

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

DATE READ: 14/11/2002
DATE READ: 5/06/2002

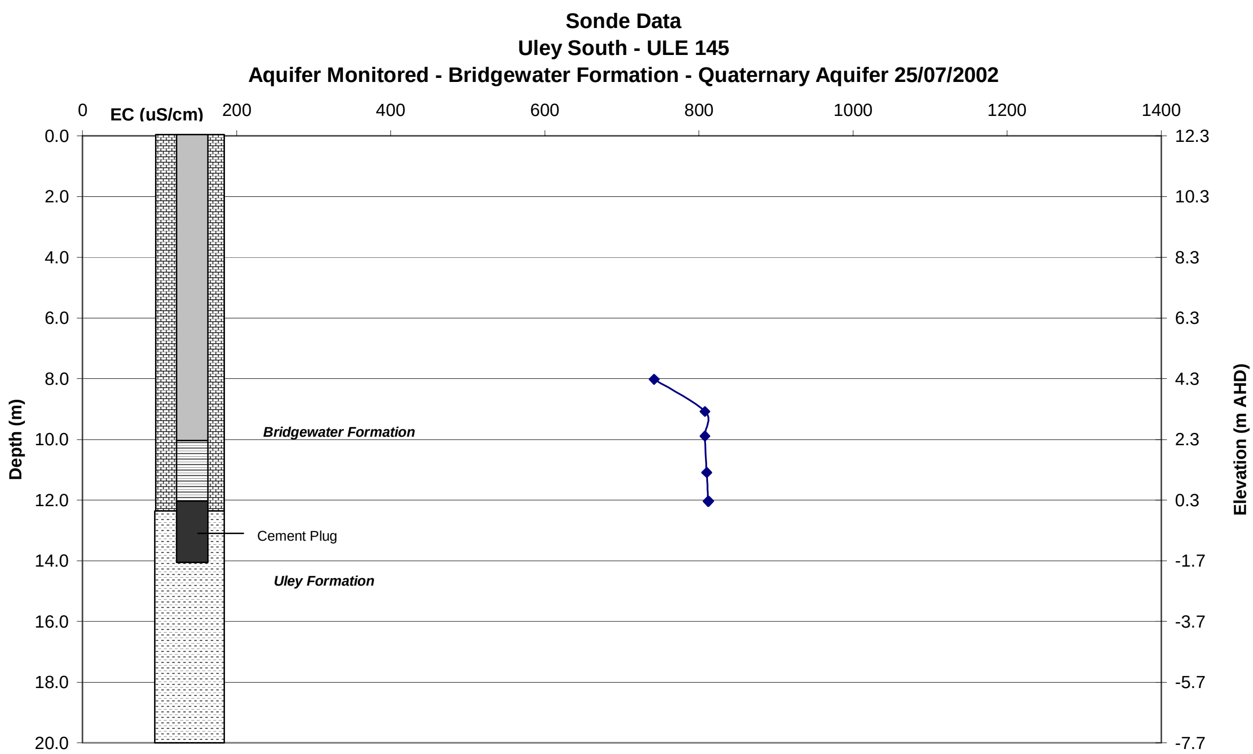
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 45.72 DATE: 24/01/1961
CURRENT DEPTH (m): 12.1 DATE: 05/06/2002
CASED FROM (m): 0 CASED TO (m): 10 TYPE: PVC
MINIMUM CASING DIAMETER (mm): 75
PRODUCTION ZONE FROM (m): 10 PRODUCTION ZONE TO (m): 12
SCREEN TYPE: Slotted Casing SCREEN DIAMETER (mm): 75

WORK COMPLETED 2002

PUMPED AND PURGED: Yes SALINITY PROFILING: Yes
TRANSDUCER INSTALLATION: No
RAINGAUGE ADJACENT: No REQUIRES REHABILITATION: No

SALINITY PROFILING DATA



ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: ULE 147
WELL UNIT NUMBER: 602800759
COORDINATES **EASTING:** 552035
NORTHING: 6147708
ZONE 53
ELEVATION (mAHD) **REFERENCE :** 66.72
GROUND: 66.72
AQUIFER MONITORED: BRIDGEWATER FORMATION
LATEST STANDING WATER LEVEL (m): 65.44 **DATE READ:** 14/11/2002
LATEST SALINITY: **EC(uS/cm)** 958
TDS(mg/L) 527 **DATE READ:** 9/04/1962

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

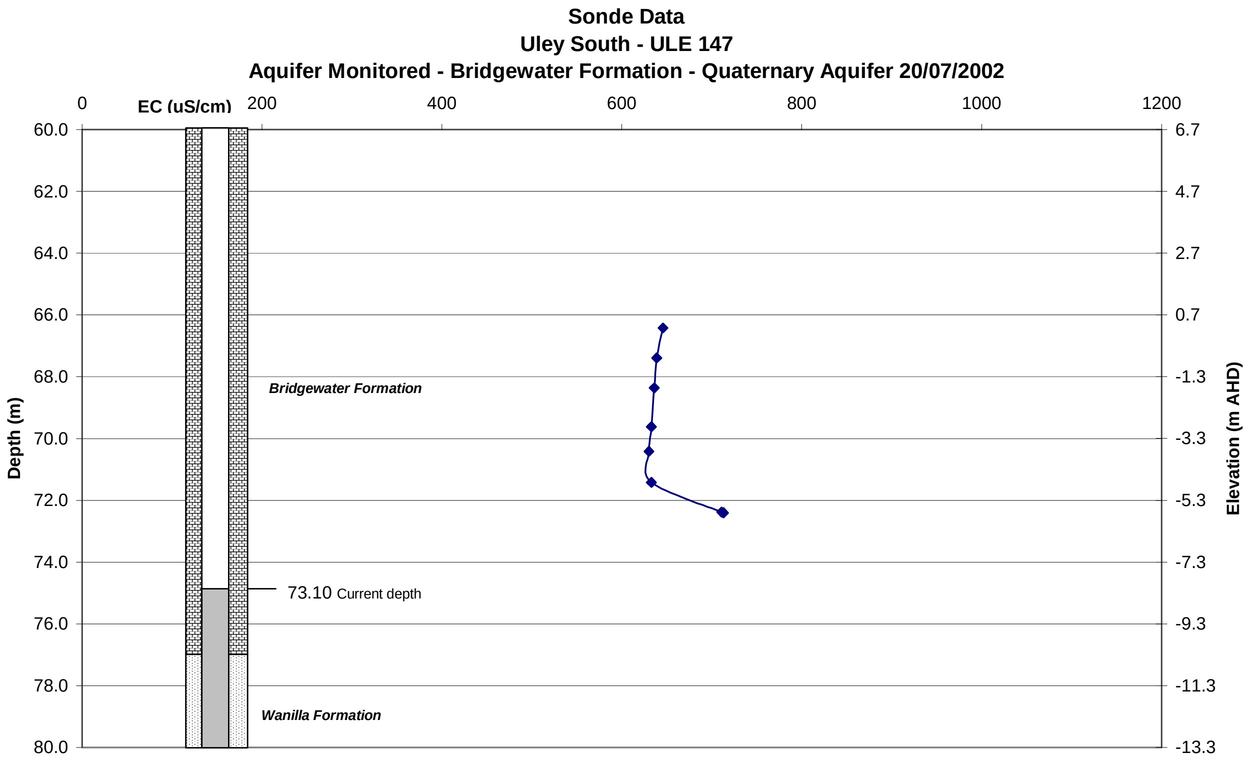
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 83.21 **DATE:** 10/04/1962
CURRENT DEPTH (m): 73.1 **DATE:** 05/06/2002
CASED FROM (m): 0 **CASED TO (m):** 78.64 **TYPE:** Steel
MINIMUM CASING DIAMETER (mm): 63
PRODUCTION ZONE FROM (m): Unknown **PRODUCTION ZONE TO (m):** Unknown
SCREEN TYPE: Unknown **SCREEN DIAMETER (mm):** Unknown

WORK COMPLETED 2002

PUMPED AND PURGED: Too Narrow **SALINITY PROFILING:** Yes
TRANSDUCER INSTALLATION: Yes
RAINGAUGE ADJACENT: No **REQUIRES REHABILITATION:** Yes

SALINITY PROFILING DATA



ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: **ULE 184**
WELL UNIT NUMBER: 602800767
COORDINATES EASTING: 551157
NORTHING: 6153167
ZONE 53
ELEVATION (mAHD) REFERENCE : 8.13
GROUND: 8.09
AQUIFER MONITORED: BRIDGEWATER FORMATION
LATEST STANDING WATER LEVEL (m): 4.33 DATE READ: 14/11/2002
LATEST SALINITY: EC(uS/cm) 980
TDS(mg/L) 539 DATE READ: 7/07/1997

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

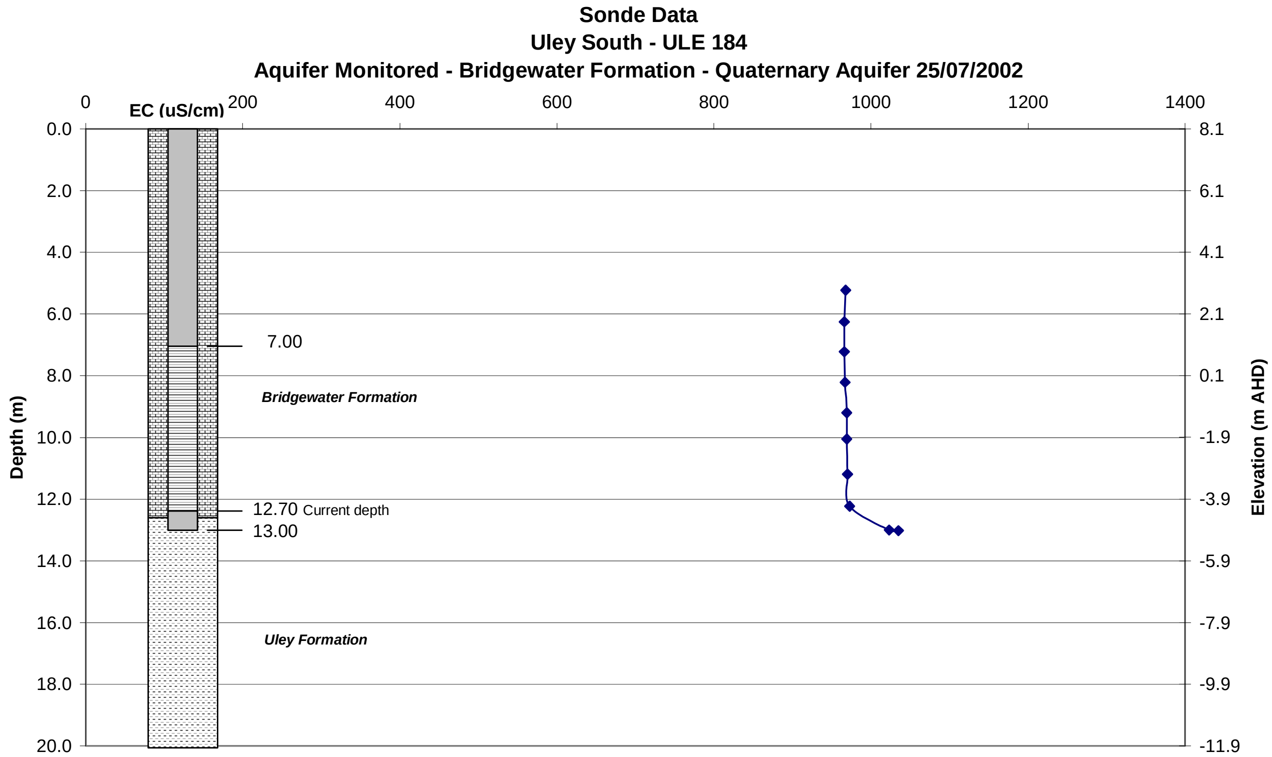
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 45.11 DATE: 20/05/1964
CURRENT DEPTH (m): 12.7 DATE: 04/06/2002
CASED FROM (m): 0 CASED TO (m): 7 TYPE: PVC
MINIMUM CASING DIAMETER (mm): 75
PRODUCTION ZONE FROM (m): 7 PRODUCTION ZONE TO (m): 13
SCREEN TYPE: Slotted Casing SCREEN DIAMETER (mm):

WORK COMPLETED 2002

PUMPED AND PURGED: Jammed SALINITY PROFILING: Yes
TRANSDUCER INSTALLATION: No
RAINGAUGE ADJACENT: No REQUIRES REHABILITATION: No

SALINITY PROFILING DATA



ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: ULE 185
WELL UNIT NUMBER: 602800766
COORDINATES **EASTING:** 551131.78
NORTHING: 6153174.85
ZONE 53
ELEVATION (mAHD) **REFERENCE :** 8.00
GROUND: 8.029
AQUIFER MONITORED: WANILLA FORMATION
LATEST STANDING WATER LEVEL (m): 4.12
LATEST SALINITY: **EC(uS/cm)** 1250
TDS(mg/L) 688

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

DATE READ: 14/11/2002
DATE READ: 3/06/2002

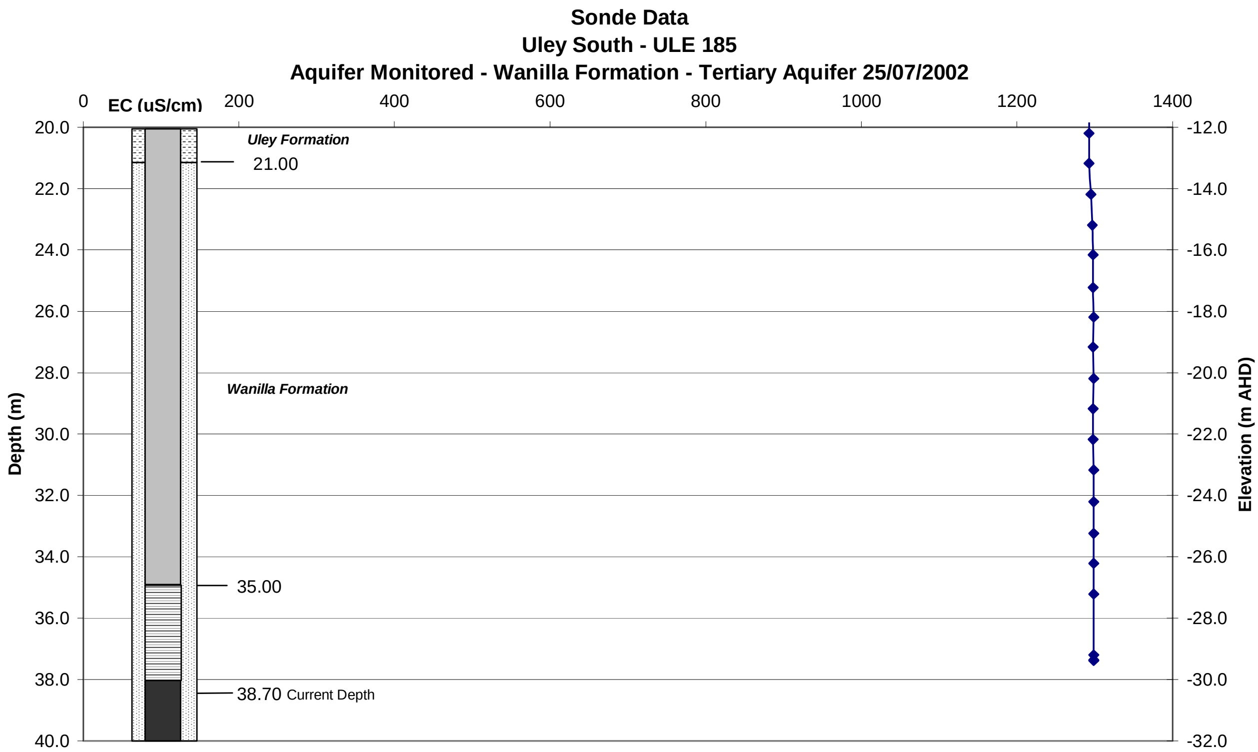
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 40 **DATE:** 5/04/1990
CURRENT DEPTH (m): 38.7 **DATE:** 04/06/2002
CASED FROM (m): 0 **CASED TO (m):** 35 **TYPE:** PVC
MINIMUM CASING DIAMETER (mm): 80
PRODUCTION ZONE FROM (m): 35 **PRODUCTION ZONE TO (m):** 38
SCREEN TYPE: Slotted Casing **SCREEN DIAMETER (mm):** Unknown

WORK COMPLETED 2002

PUMPED AND PURGED: Yes **SALINITY PROFILING:** Yes
TRANSDUCER INSTALLATION: No
RAINGAUGE ADJACENT: No **REQUIRES REHABILITATION:** No

SALINITY PROFILING DATA



ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: ULE 186
WELL UNIT NUMBER: 602800735
COORDINATES **EASTING:** 551763
NORTHING: 6153404
ZONE 53
ELEVATION (mAHD) **REFERENCE :** 10.87
GROUND: 10.22
AQUIFER MONITORED: BRIDGEWATER FORMATION
LATEST STANDING WATER LEVEL (m): 5.82 **DATE READ:** 14/11/2002
LATEST SALINITY: **EC(uS/cm)** 970
TDS(mg/L) 534 **DATE READ:** 4/06/2002

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

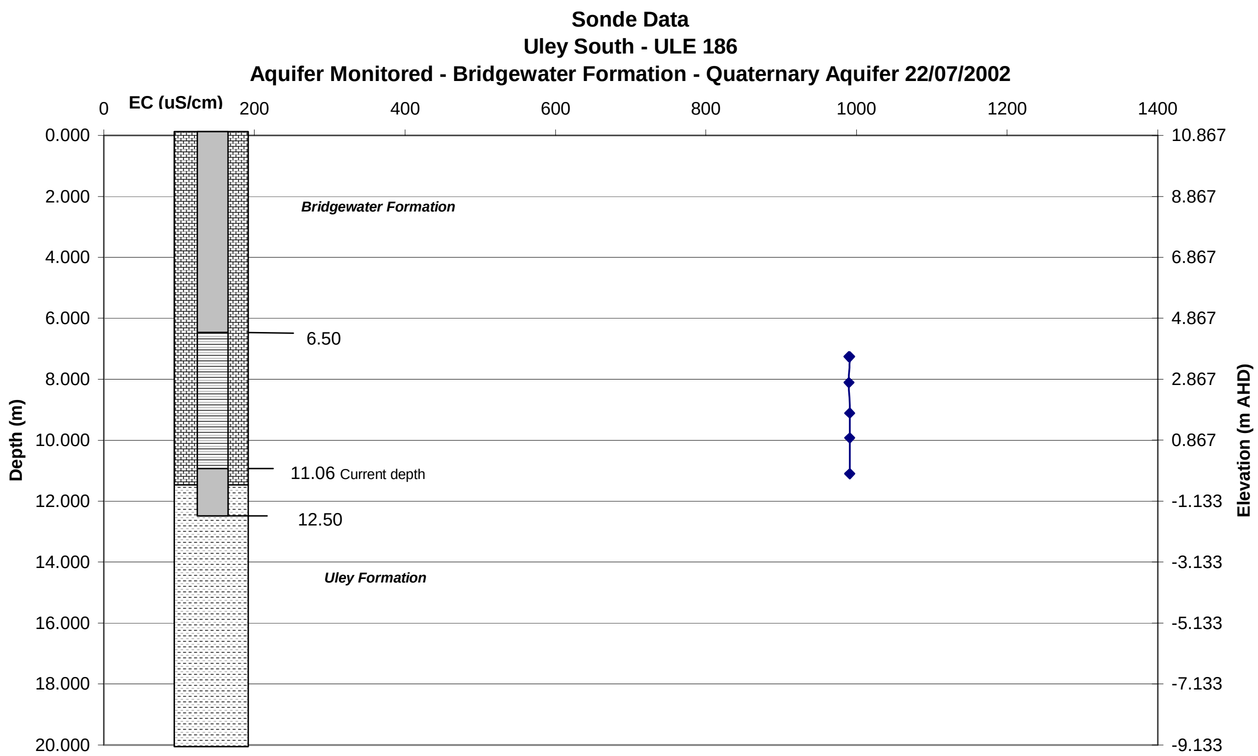
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 12.5 **DATE:** 18/03/1975
CURRENT DEPTH (m): 11.07 **DATE:** 04/06/2002
CASED FROM (m): 0 **CASED TO (m):** 6.5 **TYPE:** PVC
MINIMUM CASING DIAMETER (mm): 76
PRODUCTION ZONE FROM (m): 6.5 **PRODUCTION ZONE TO (m):** 12.5
SCREEN TYPE: Slotted Casing **SCREEN DIAMETER (mm):** 76

WORK COMPLETED 2002

PUMPED AND PURGED: Yes **SALINITY PROFILING:** Yes
TRANSDUCER INSTALLATION: No
RAINGAUGE ADJACENT: No **REQUIRES REHABILITATION:** No

SALINITY PROFILING DATA



ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: **ULE 187**
WELL UNIT NUMBER: 602800734
COORDINATES EASTING: 551844
NORTHING: 6152819
ZONE 53
ELEVATION (mAHD) REFERENCE : 12.09
GROUND: 11.32
AQUIFER MONITORED: BRIDGEWATER FORMATION
LATEST STANDING WATER LEVEL (m): 6.62 DATE READ: 14/11/2002
LATEST SALINITY: EC(uS/cm) 1120
TDS(mg/L) 617 DATE READ: 4/06/2002

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

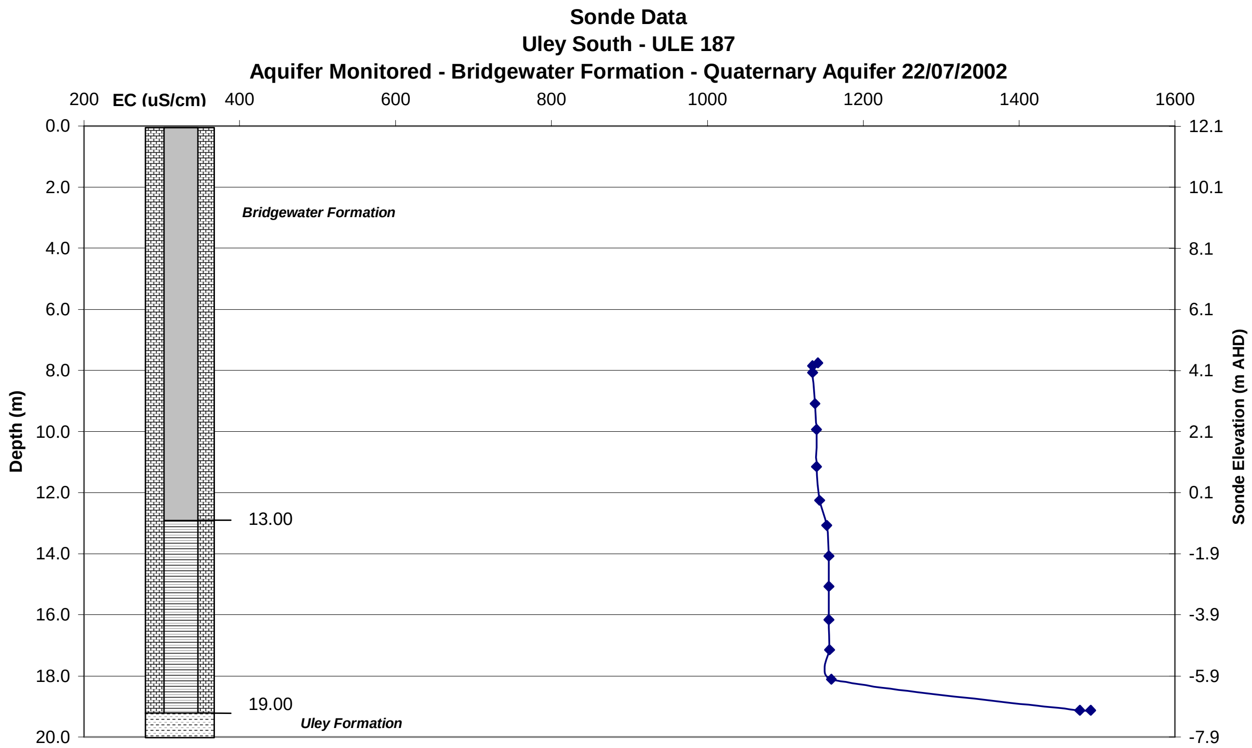
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 22 DATE: 5/03/1975
CURRENT DEPTH (m): 19.1 DATE: 05/06/2002
CASED FROM (m): 0 CASED TO (m): 13 TYPE: PVC
MINIMUM CASING DIAMETER (mm): 75
PRODUCTION ZONE FROM (m): 13 PRODUCTION ZONE TO (m): 19
SCREEN TYPE: Slotted Casing SCREEN DIAMETER (mm): 76

WORK COMPLETED 2002

PUMPED AND PURGED: Yes SALINITY PROFILING: Yes
TRANSDUCER INSTALLATION: No
RAINGAUGE ADJACENT: No REQUIRES REHABILITATION: No

SALINITY PROFILING DATA



ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: ULE 188
WELL UNIT NUMBER: 602800792
COORDINATES EASTING: 551133.72
NORTHING: 6152573.71
ZONE 53
ELEVATION (mAHD) REFERENCE : 10.64
GROUND: 10.63
AQUIFER MONITORED: BRIDGEWATER FORMATION
LATEST STANDING WATER LEVEL (m): 6.53 **DATE READ:** 14/11/2002
LATEST SALINITY: EC(uS/cm) 1210
TDS(mg/L) 666 **DATE READ:** 7/07/1997

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

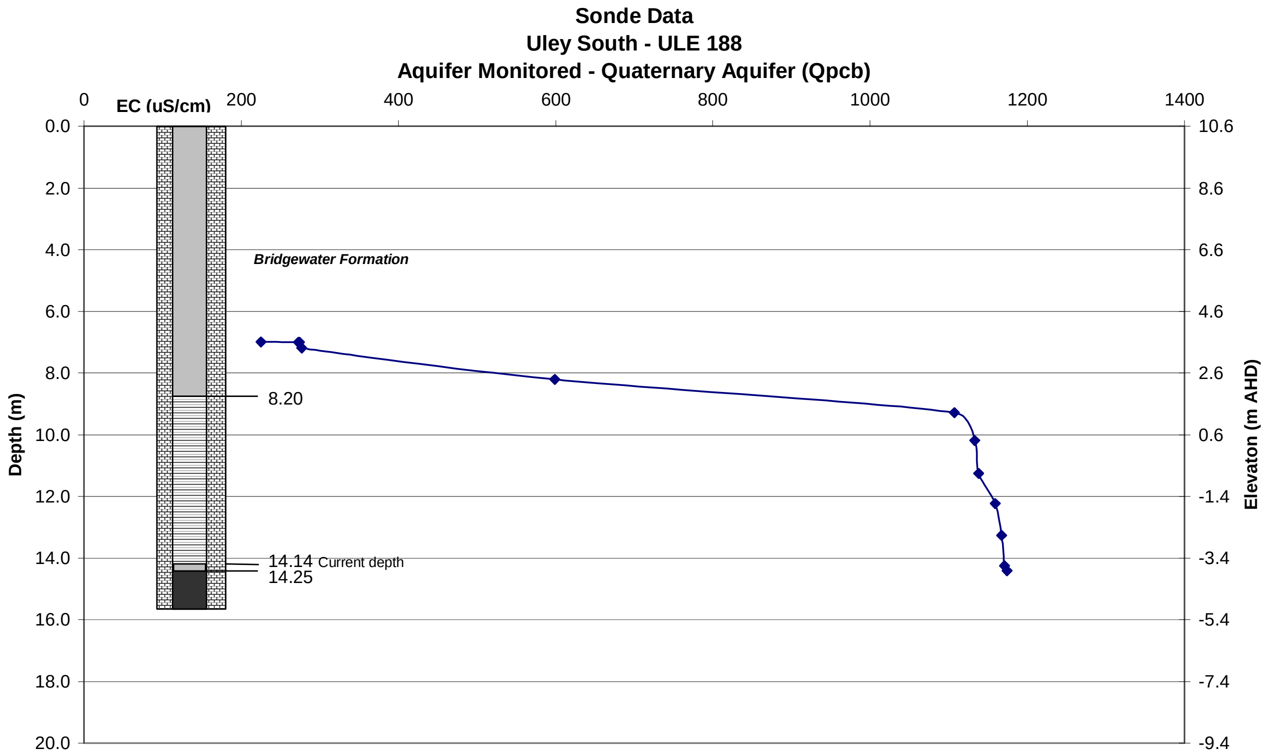
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 15.6 **DATE:** 16/11/1974
CURRENT DEPTH (m): 14.14 **DATE:** 05/06/2002
CASED FROM (m): 0 **CASED TO (m):** 8.2 **TYPE:** PVC
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 2002

PUMPED AND PURGED: Pump Seized **SALINITY PROFILING:** Yes
TRANSDUCER INSTALLATION: No
RAINGAUGE ADJACENT: No **REQUIRES REHABILITATION:** No

SALINITY PROFILING DATA



ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: **ULE 189**
WELL UNIT NUMBER: 602800721
COORDINATES EASTING: 553516
NORTHING: 6152207
ZONE 53
ELEVATION (mAHD) REFERENCE : 15.19
GROUND: 14.23
AQUIFER MONITORED: BRIDGEWATER FORMATION
LATEST STANDING WATER LEVEL (m): 8.17 DATE READ: 14/11/2002
LATEST SALINITY: EC(uS/cm) 830
TDS(mg/L) 457 DATE READ: 5/06/2002

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

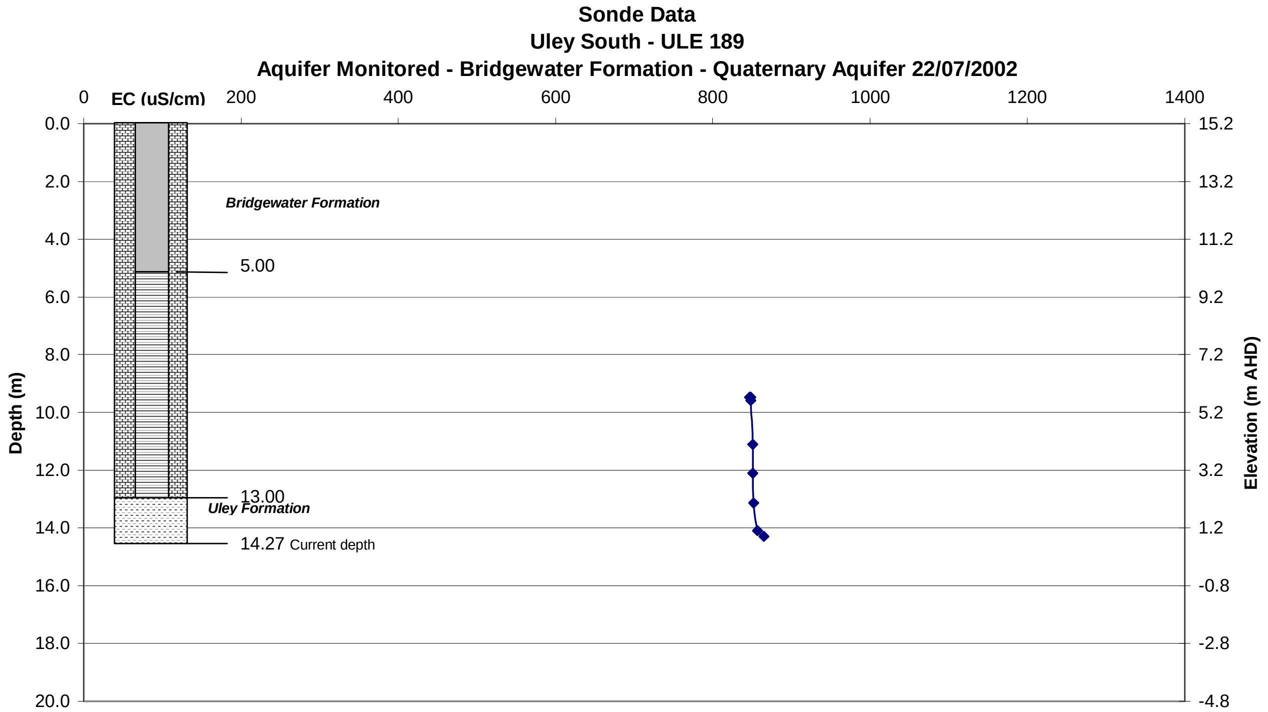
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 13.72 DATE: 13/02/1969
CURRENT DEPTH (m): 14.27 DATE: 05/06/2002
CASED FROM (m): 0 CASED TO (m): 5 TYPE: PVC
MINIMUM CASING DIAMETER (mm): 80
PRODUCTION ZONE FROM (m): 5 PRODUCTION ZONE TO (m): 13
SCREEN TYPE: Slotted Casing SCREEN DIAMETER (mm): 80

WORK COMPLETED 2002

PUMPED AND PURGED: Yes SALINITY PROFILING: Yes
TRANSDUCER INSTALLATION: No
RAINGAUGE ADJACENT: No REQUIRES REHABILITATION: No

SALINITY PROFILING DATA



ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: **ULE 190**
WELL UNIT NUMBER: 602800793
COORDINATES EASTING: 551334.75
NORTHING: 6152060.91
ZONE 53
ELEVATION (mAHD) REFERENCE : 9.75
GROUND: 9.65
AQUIFER MONITORED: BRIDGEWATER FORMATION
LATEST STANDING WATER LEVEL (m): 5.8
LATEST SALINITY: EC(uS/cm) 1110
TDS(mg/L) 611

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly
DATE READ: 14/11/2002
DATE READ: 9/07/1997

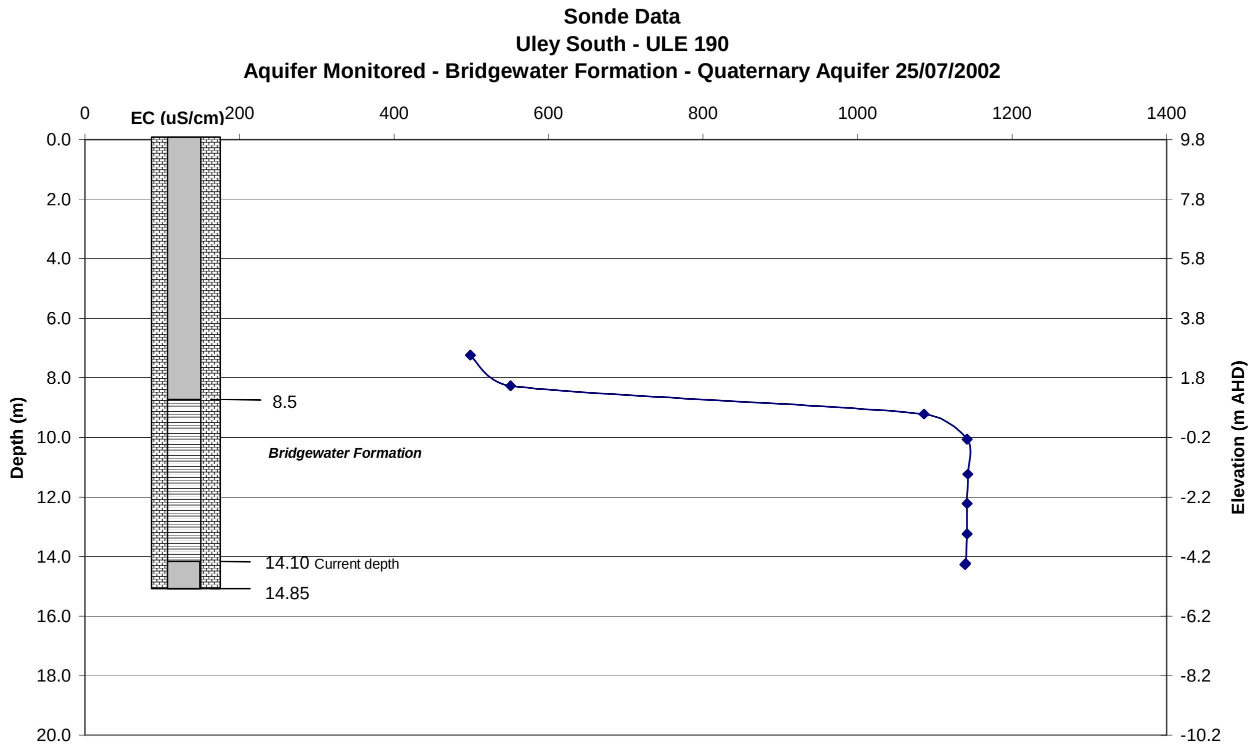
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 14.85 DATE: 23/11/1974
CURRENT DEPTH (m): 14.1 DATE: 05/06/2002
CASED FROM (m): 0 CASED TO (m): 8.5 TYPE: PVC
MINIMUM CASING DIAMETER (mm): 76
PRODUCTION ZONE FROM (m): 8.5 PRODUCTION ZONE TO (m): 14.85
SCREEN TYPE: Slotted Casing SCREEN DIAMETER (mm): 75

WORK COMPLETED 2002

PUMPED AND PURGED: Pump Ceased SALINITY PROFILING: Yes
TRANSDUCER INSTALLATION: No
RAINGAUGE ADJACENT: No REQUIRES REHABILITATION: No

SALINITY PROFILING DATA



ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: **ULE 191**
WELL UNIT NUMBER: 602800733
COORDINATES EASTING: 551982
NORTHING: 6152061
ZONE 53
ELEVATION (mAHD) REFERENCE : 10.47
GROUND: 9.83
AQUIFER MONITORED: BRIDGEWATER FORMATION
LATEST STANDING WATER LEVEL (m): 5.77
LATEST SALINITY: EC(uS/cm) 850
TDS(mg/L) 468

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

DATE READ: 14/11/2002

DATE READ: 4/06/2002

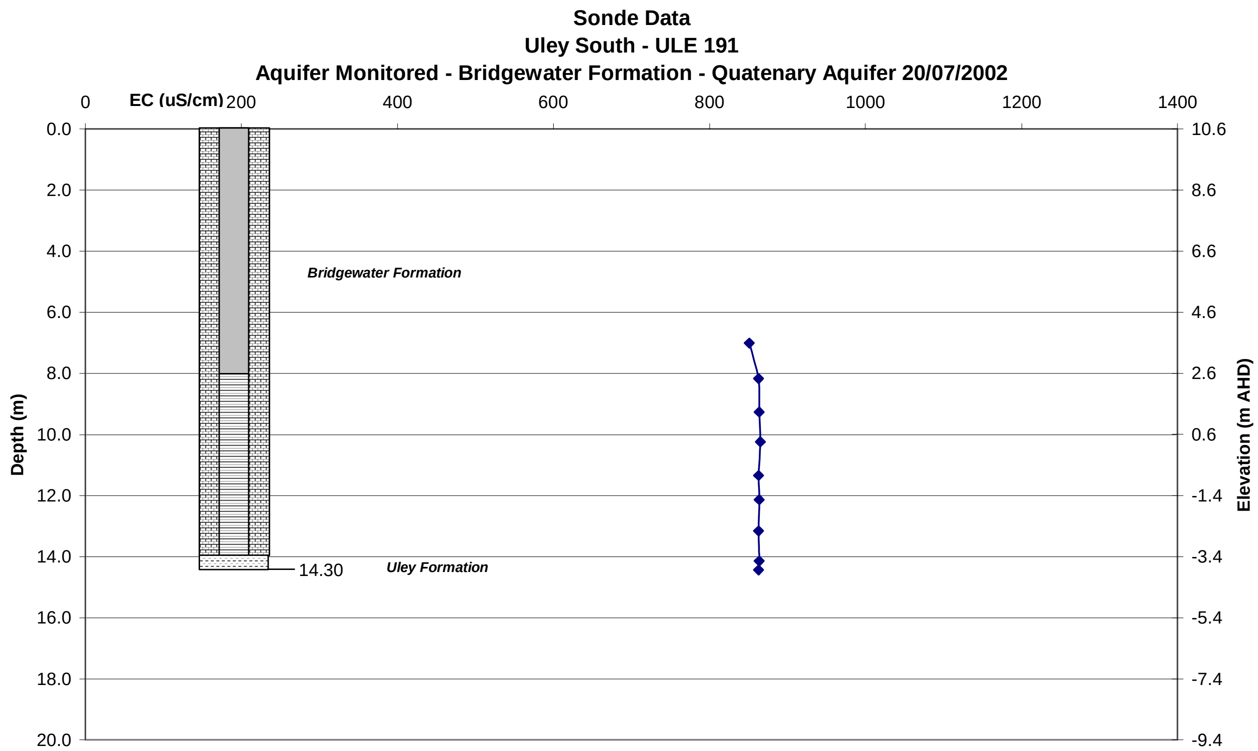
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 14.30 DATE: 17/02/1975
CURRENT DEPTH (m): 14.3 DATE: 05/06/2002
CASED FROM (m): 0 CASED TO (m): 8 TYPE: PVC
MINIMUM CASING DIAMETER (mm): 76
PRODUCTION ZONE FROM (m): 8 PRODUCTION ZONE TO (m): 14
SCREEN TYPE: Slotted Casing SCREEN DIAMETER (mm): 76

WORK COMPLETED 2002

PUMPED AND PURGED: Yes SALINITY PROFILING: Yes
TRANSDUCER INSTALLATION: No
RAINGAUGE ADJACENT: No REQUIRES REHABILITATION: No

SALINITY PROFILING DATA



ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: **ULE 192**
WELL UNIT NUMBER: 602800794
COORDINATES EASTING: 551672
NORTHING: 6151480
ZONE 53
ELEVATION (mAHD) REFERENCE : 10.55
GROUND: 10.6
AQUIFER MONITORED: BRIDGEWATER FORMATION
LATEST STANDING WATER LEVEL (m): 7.18 DATE READ: 14/11/2002
LATEST SALINITY: EC(uS/cm) 800
TDS(mg/L) 440 DATE READ: 9/07/1997

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 15.5 DATE: 12/12/1974
CURRENT DEPTH (m): 14.64 DATE: 04/06/2002
CASED FROM (m): 0 CASED TO (m): 15.5 TYPE: Unknown
MINIMUM CASING DIAMETER (mm): 76
PRODUCTION ZONE FROM (m): 9.5 PRODUCTION ZONE TO (m): 15.50
SCREEN TYPE: Slotted Casing SCREEN DIAMETER (mm): Unknown

WORK COMPLETED 2002

PUMPED AND PURGED: Pump Jammed SALINITY PROFILING: Blockage
TRANSDUCER INSTALLATION: No
RAINGAUGE ADJACENT: No REQUIRES REHABILITATION: No

SALINITY PROFILING DATA

ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: ULE 193
WELL UNIT NUMBER: 602800795
COORDINATES EASTING: 551891
NORTHING: 6150894
ZONE 53
ELEVATION (mAHD) REFERENCE : 10.13
GROUND: 9.19
AQUIFER MONITORED: BRIDGEWATER FORMATION
LATEST STANDING WATER LEVEL (m): 5.07
LATEST SALINITY: EC(uS/cm) 820
TDS(mg/L) 451

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

DATE READ: 14/11/2002
DATE READ: 5/06/2002

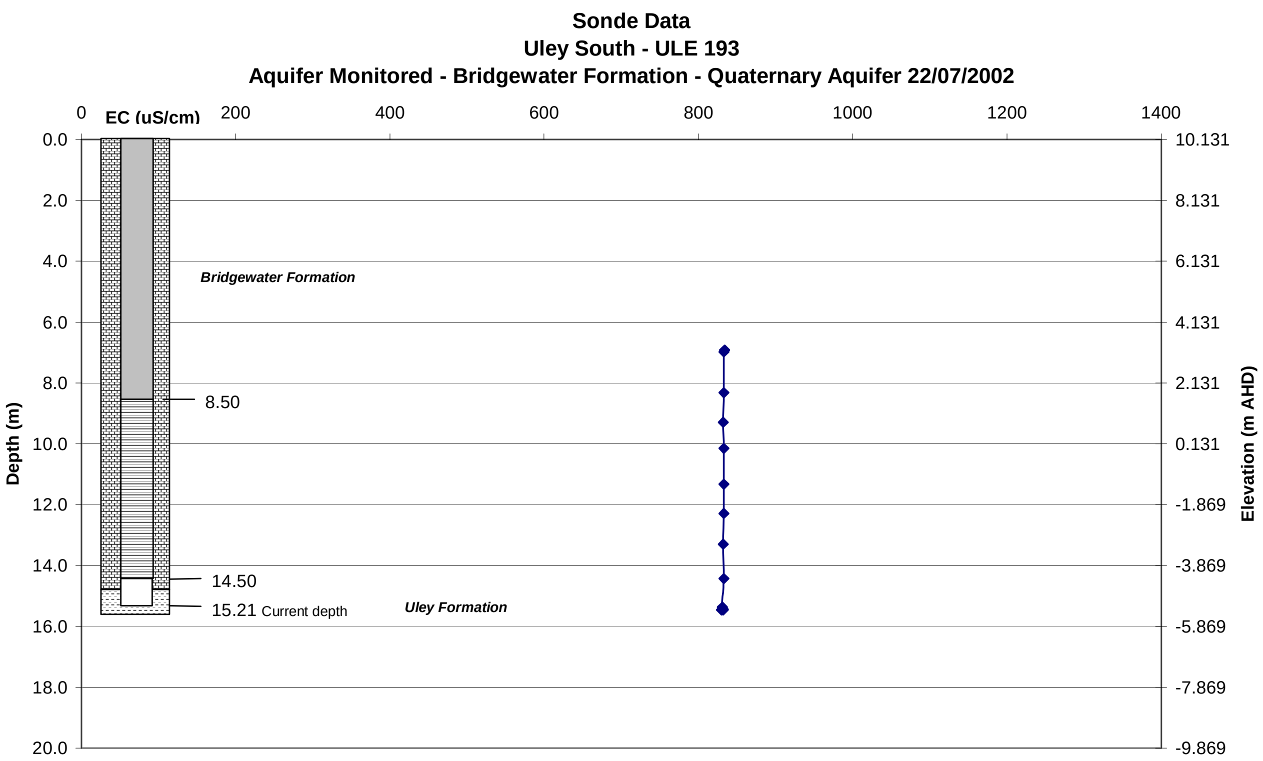
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 15.5 — DATE: 4/02/1975
CURRENT DEPTH (m): 15.21 — DATE: 05/06/2002
CASED FROM (m): 0 — **CASED TO (m):** 8.5 — **TYPE:** PVC
MINIMUM CASING DIAMETER (mm): 76
PRODUCTION ZONE FROM (m): 8.5 — **PRODUCTION ZONE TO (m):** 14.5
SCREEN TYPE: Slotted Casing — **SCREEN DIAMETER (mm):** 75

WORK COMPLETED 2002

PUMPED AND PURGED: Yes — **SALINITY PROFILING:** Yes
TRANSDUCER INSTALLATION: No
RAINGAUGE ADJACENT: No — **REQUIRES REHABILITATION:** No

SALINITY PROFILING DATA



ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: ULE 194
WELL UNIT NUMBER: 602801747
COORDINATES EASTING: 547859
NORTHING: 6151029
ZONE 53
ELEVATION (mAHD) REFERENCE : 8.62
GROUND: 7.88
AQUIFER MONITORED: BRIDGEWATER FORMATION
LATEST STANDING WATER LEVEL (m): 6.53 **DATE READ:** 14/11/2002
LATEST SALINITY: EC(uS/cm) 1390
TDS(mg/L) 766 **DATE READ:** 5/06/2002

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

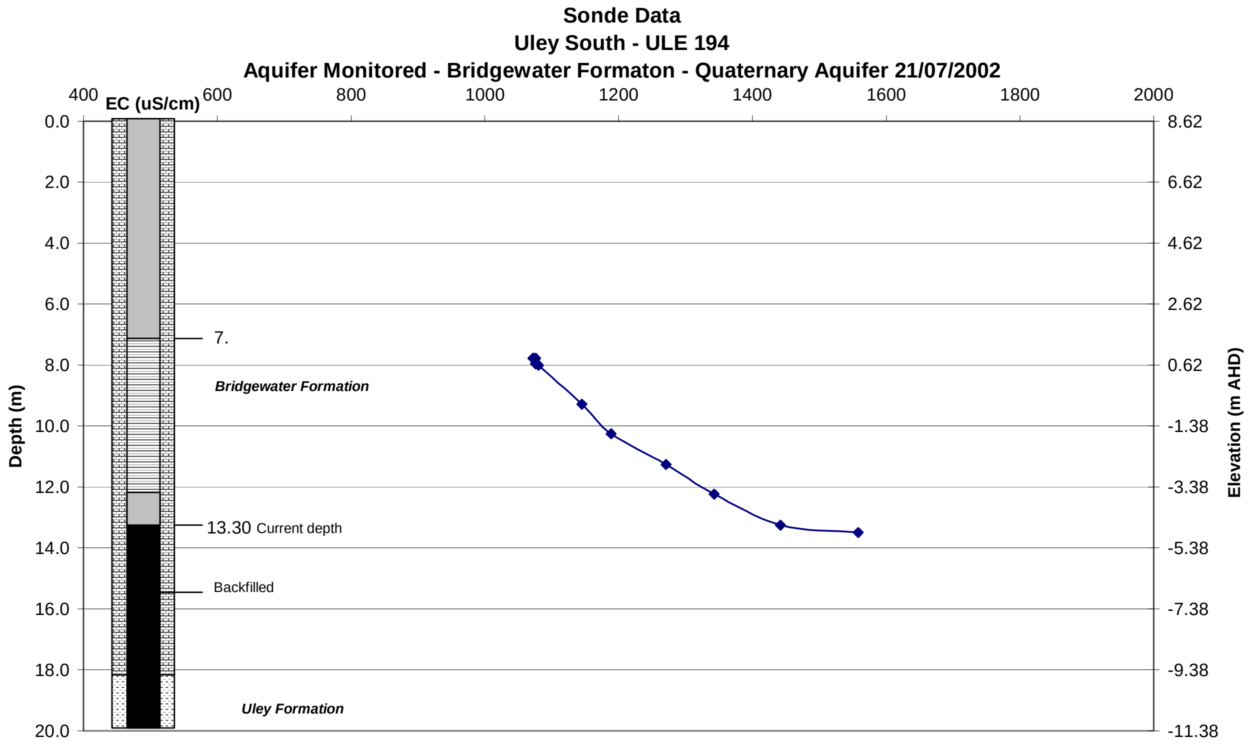
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 57 **DATE:** 2/05/1990
CURRENT DEPTH (m): 13.3 **DATE:** 04/06/2002
CASED FROM (m): 0 **CASED TO (m):** 7 **TYPE:** PVC
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 2002

PUMPED AND PURGED: Yes **SALINITY PROFILING:** Yes
TRANSDUCER INSTALLATION: Yes
RAINGAUGE ADJACENT: Yes **REQUIRES REHABILITATION:** No

SALINITY PROFILING DATA



ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBSERVATION WELL NUMBER: ULE 196
WELL UNIT NUMBER: 602801750
COORDINATES EASTING: 551618
NORTHING: 6149131
ZONE 53
ELEVATION (mAHD) REFERENCE : 7.32
GROUND: 6.73
AQUIFER MONITORED: BRIDGEWATER FORMATION
LATEST STANDING WATER LEVEL (m): 5.07 **DATE READ:** 04/07/2002
LATEST SALINITY: EC(uS/cm) 810
TDS(mg/L) 446 **DATE READ:** 5/06/2002

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Historical
FREQUENCY: 6 monthly

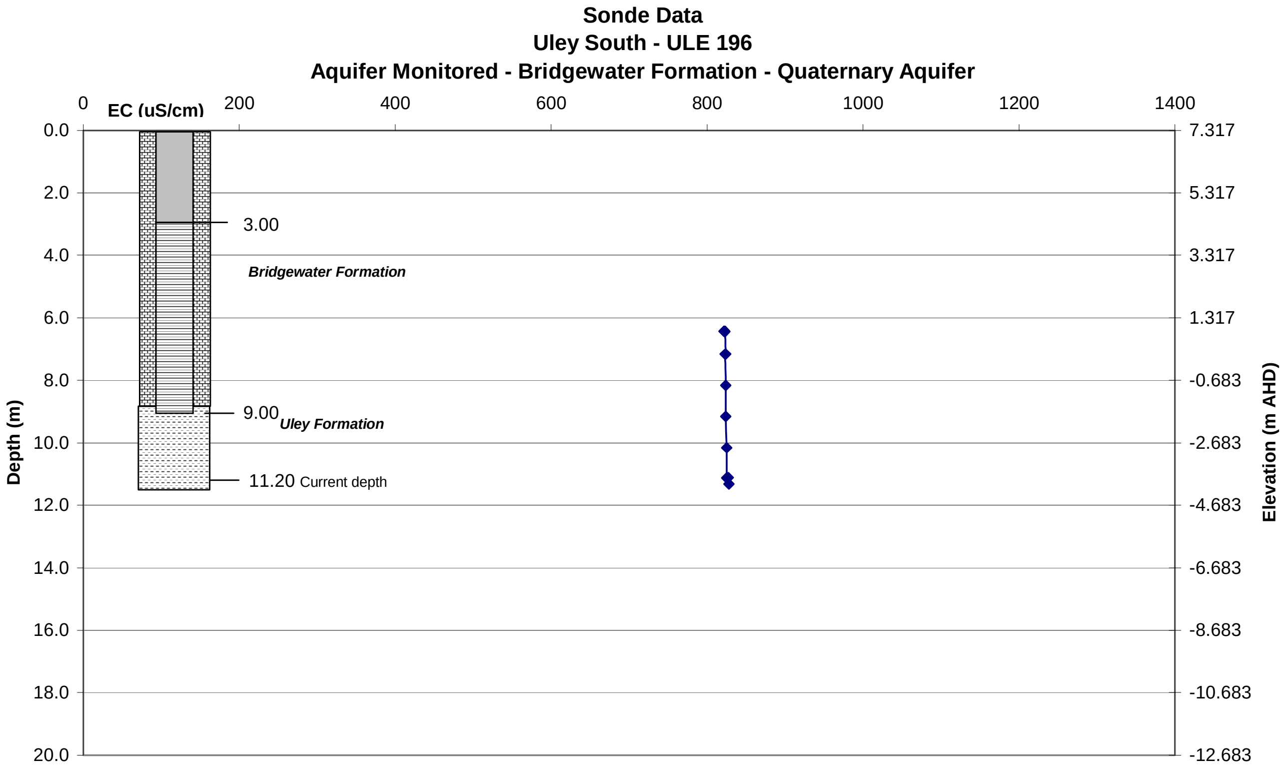
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 11.36 **DATE:** 8/09/1992
CURRENT DEPTH (m): 11.2 **DATE:** 04/06/2002
CASED FROM (m): 0 **CASED TO (m):** 3 **TYPE:** PVC
MINIMUM CASING DIAMETER (mm): 80
PRODUCTION ZONE FROM (m): 3 **PRODUCTION ZONE TO (m):** 9
SCREEN TYPE: Slotted Casing **SCREEN DIAMETER (mm):** 80

WORK COMPLETED 2002

PUMPED AND PURGED: Yes **SALINITY PROFILING:** Yes
TRANSDUCER INSTALLATION: Yes
RAINGAUGE ADJACENT: Yes **REQUIRES REHABILITATION:** No

SALINITY PROFILING DATA



ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBSERVATION WELL NUMBER:	ULE 197	MONITORING STATUS	
WELL UNIT NUMBER:	602801751	SWL:	Current
COORDINATES	EASTING: 552511	FREQUENCY:	1 monthly
	NORTHING: 6152937	SALINITY:	Historical
	ZONE 53	FREQUENCY:	6 monthly
ELEVATION (mAHD)	REFERENCE : 11.96		
	GROUND: 11.79		
AQUIFER MONITORED:	BRIDGEWATER FORMATION		
LATEST STANDING WATER LEVEL (m):	6.54	DATE READ:	14/11/2002
LATEST SALINITY:	EC(uS/cm) 1200		
	TDS(mg/L) 661	DATE READ:	3/06/2002

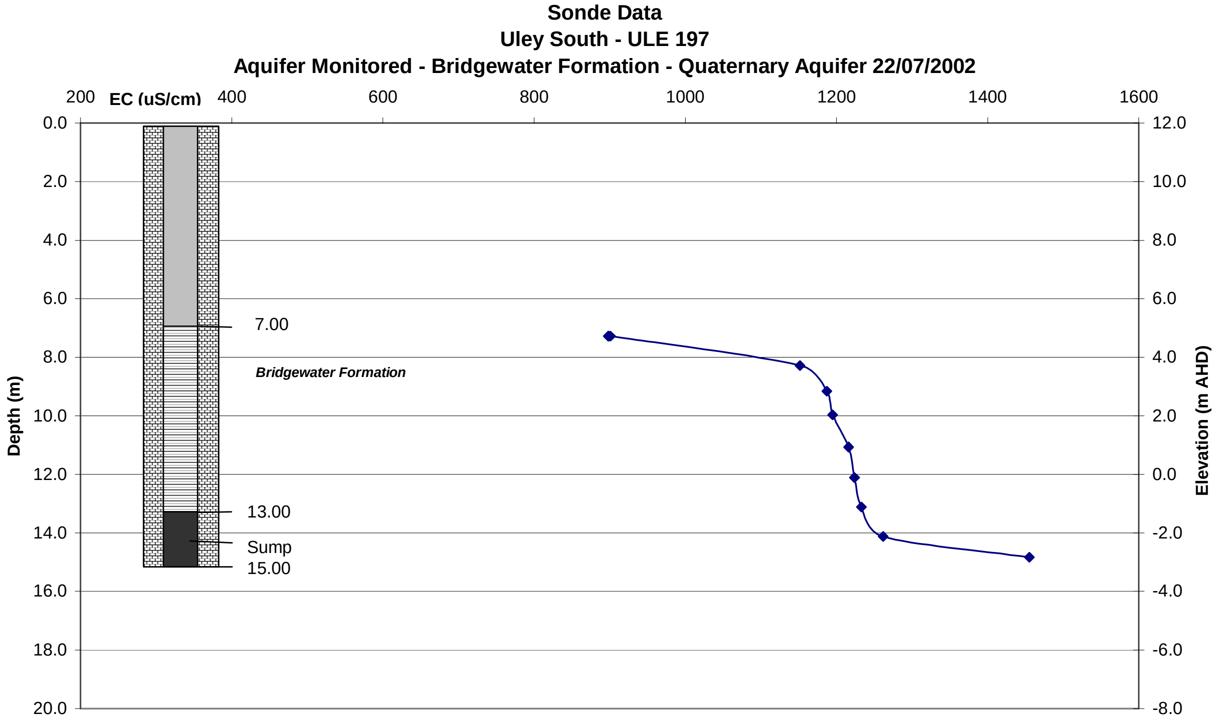
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 15		DATE: 7/05/1990	
CURRENT DEPTH (m): 17.1		DATE: 03/06/2002	
CASED FROM (m): 0	CASED TO (m): 7	TYPE: PVC	
MINIMUM CASING DIAMETER (mm): 80			
PRODUCTION ZONE FROM (m): 7		PRODUCTION ZONE TO (m): 13	
SCREEN TYPE: Slotted Casing		SCREEN DIAMETER (mm): 80	

WORK COMPLETED 2002

PUMPED AND PURGED:	Yes	SALINITY PROFILING:	Yes
TRANSDUCER INSTALLATION:	Yes		
RAINGAUGE ADJACENT:	No	REQUIRES REHABILITATION:	No

SALINITY PROFILING DATA



ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: ULE 201
WELL UNIT NUMBER: 602802295
COORDINATES EASTING: 550321.97
NORTHING: 6150073.98
ZONE 53
ELEVATION (mAHD) REFERENCE : 6.44
GROUND: UKN
AQUIFER MONITORED: BRIDGEWATER FORMATION
LATEST STANDING WATER LEVEL (m): 5.05 DATE READ: 14/11/2002
LATEST SALINITY: EC(uS/cm) Unknown
TDS(mg/L) Unknown DATE READ: Unknown

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Non
FREQUENCY once: Non

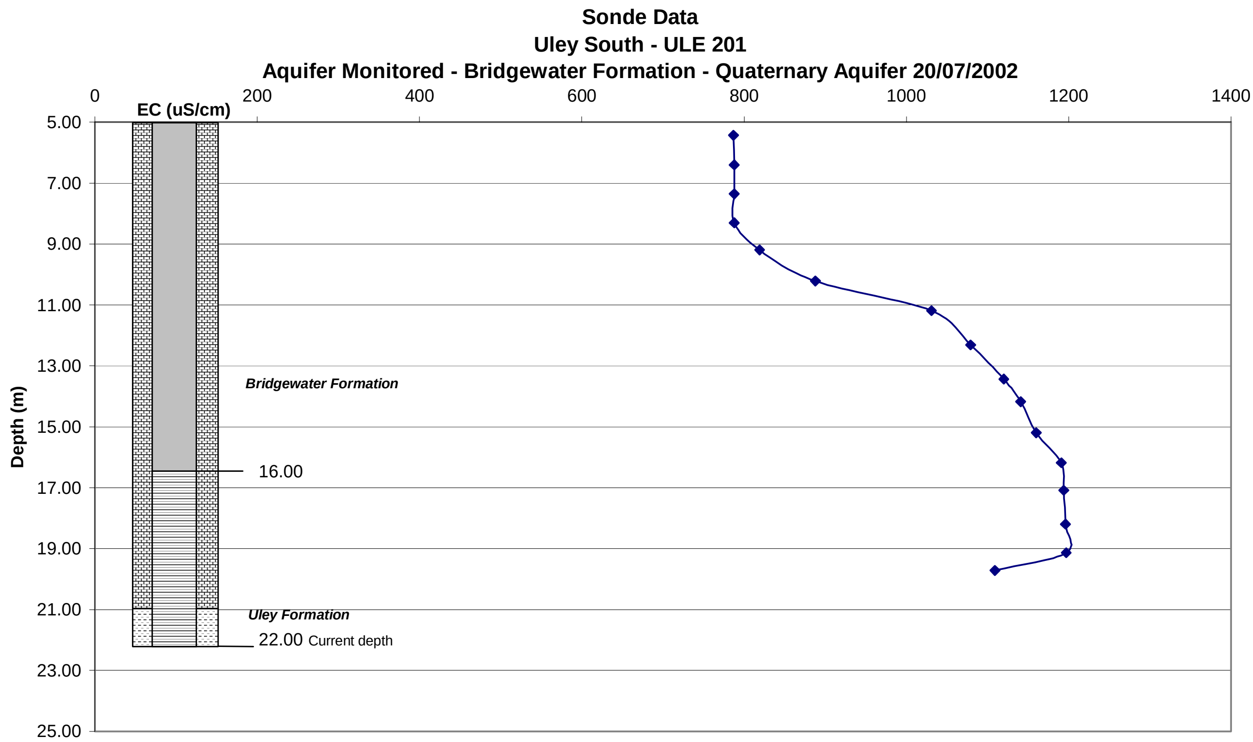
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 22 DATE: 22/03/1999
CURRENT DEPTH (m): 22 DATE: 22/03/1999
CASED FROM (m): 0 CASED TO (m): 16 TYPE: PVC
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 2002

PUMPED AND PURGED: Pump Seized SALINITY PROFILING: Yes
TRANSDUCER INSTALLATION: No
RAINGAUGE ADJACENT: No REQUIRES REHABILITATION: No

SALINITY PROFILING DATA



ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: ULE 202
WELL UNIT NUMBER: 602800660
COORDINATES EASTING: 548778.63
NORTHING: 6154501.98
ZONE 53
ELEVATION (mAHD) REFERENCE : 16.73
GROUND: 16.07
AQUIFER MONITORED: BRIDGEWATER FORMATION
LATEST STANDING WATER LEVEL (m): 14.78
DATE READ: 14/11/2002
LATEST SALINITY: EC(uS/cm) 923
TDS(mg/L) 518
DATE READ: 6/06/2002

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Non
FREQUENCY once: Non

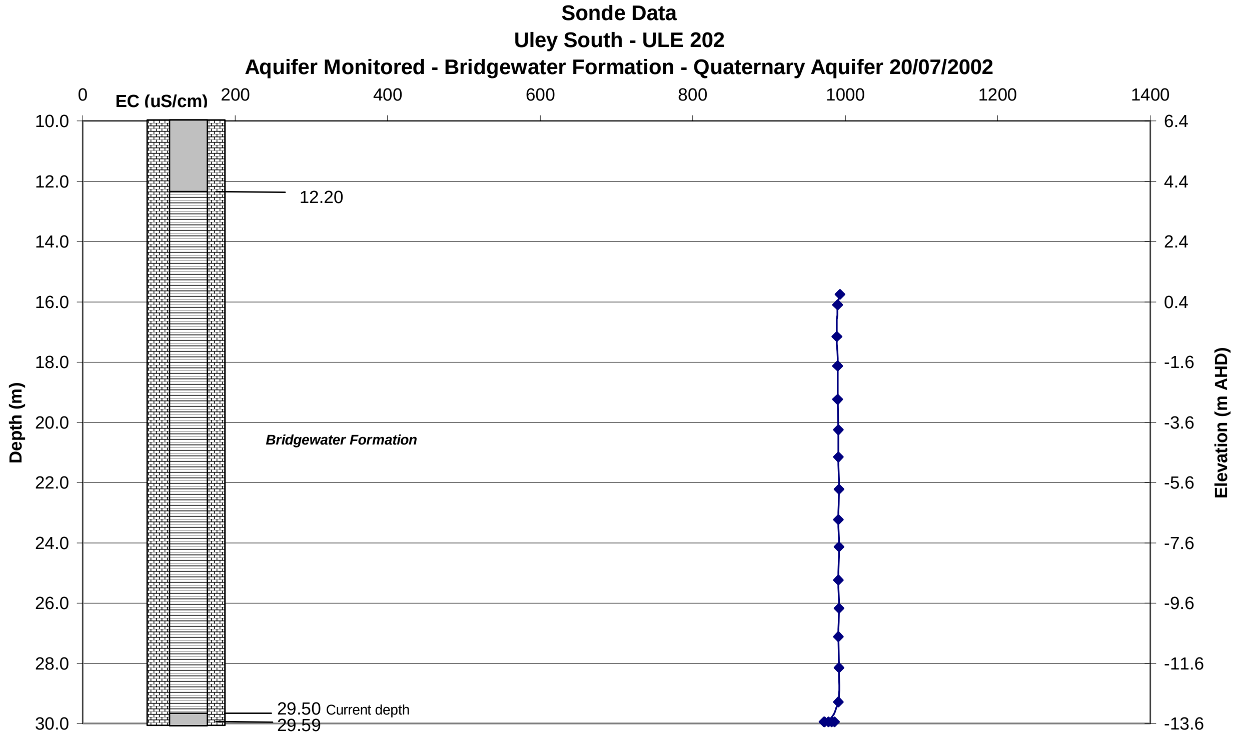
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 31.39 **DATE:** 21/02/1969
CURRENT DEPTH (m): 29.5 **DATE:** 04/06/2002
CASED FROM (m): 0 **CASED TO (m):** 12.2 **TYPE:** Steel
MINIMUM CASING DIAMETER (mm): 254
PRODUCTION ZONE FROM (m): 12.2 **PRODUCTION ZONE TO (m):** 29.59
SCREEN TYPE: Slotted Casing **SCREEN DIAMETER (mm):** 254

WORK COMPLETED 2002

PUMPED AND PURGED: Yes **SALINITY PROFILING:** Yes
TRANSDUCER INSTALLATION: Yes
RAINGAUGE ADJACENT: Yes **REQUIRES REHABILITATION:** No

SALINITY PROFILING DATA



ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: ULE 203
WELL UNIT NUMBER: 602802157
COORDINATES **EASTING:** 548628.65
NORTHING: 6155260.77
ZONE 53
ELEVATION (mAHD) **REFERENCE :** Unknown
GROUND: Unknown
AQUIFER MONITORED: BRIDGEWATER FORMATION
LATEST STANDING WATER LEVEL (m): 27.72 **DATE READ:** 14/11/2002
LATEST SALINITY: **EC(uS/cm)** Unknown
TDS(mg/L) Unknown **DATE READ:** Unknown

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Non
FREQUENCY once: Non

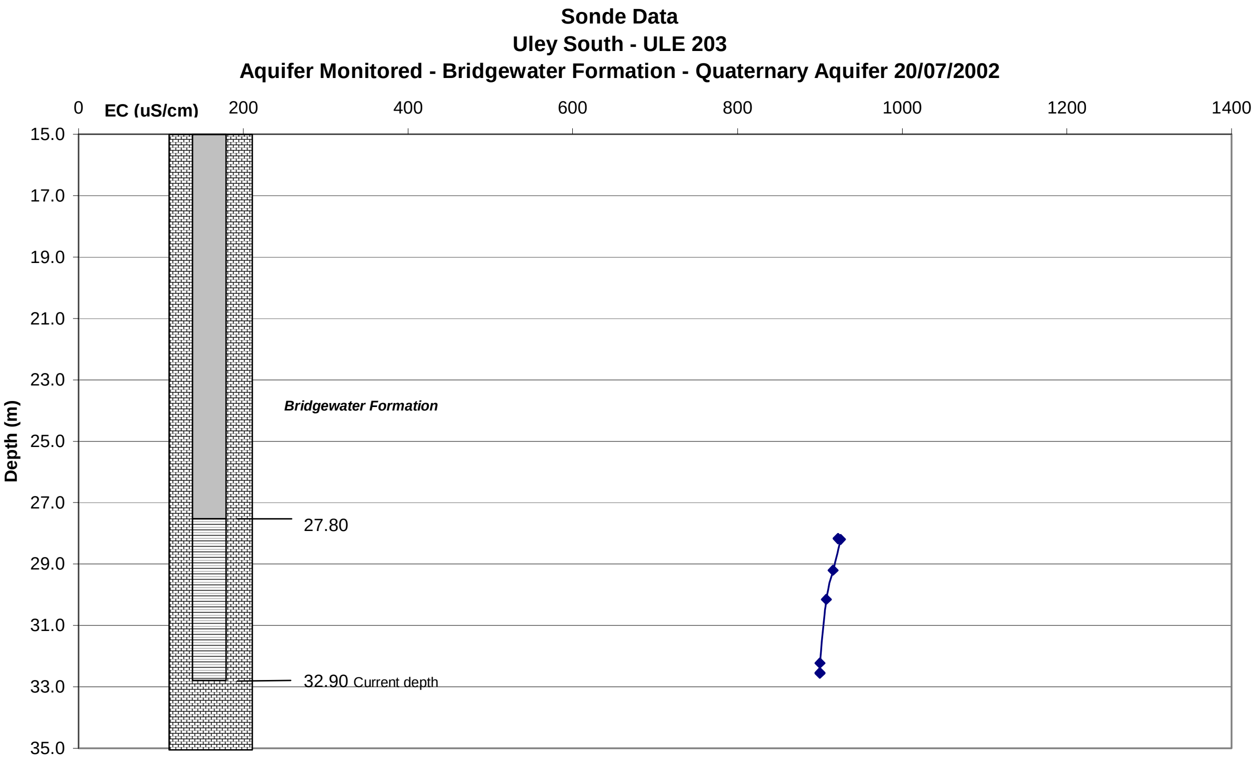
CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 38 **DATE:** 19/08/1999
CURRENT DEPTH (m): 33 **DATE:** 19/08/1999
CASED FROM (m): 0 **CASED TO (m):** 27.8 **TYPE:** PVC
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 2002

PUMPED AND PURGED: No Access **SALINITY PROFILING:** Yes
TRANSDUCER INSTALLATION: No
RAINGAUGE ADJACENT: No **REQUIRES REHABILITATION:** No

SALINITY PROFILING DATA



ULEY SOUTH LENS
OBSERVATION WELL INFORMATION SHEET

OBERVATION WELL NUMBER: **ULE 204**
WELL UNIT NUMBER: 602802165
COORDINATES EASTING: 551858.7
NORTHING: 6148060.86
ZONE 53
ELEVATION (mAHD) REFERENCE : 58.81
GROUND: Unknown
AQUIFER MONITORED: BRIDGEWATER FORMATION
LATEST STANDING WATER LEVEL (m): 58.5 DATE READ: 17/04/1999
LATEST SALINITY: EC(uS/cm) Unknown
TDS(mg/L) Unknown DATE READ: Unknown

MONITORING STATUS
SWL: Current
FREQUENCY: 1 monthly
SALINITY: Non
FREQUENCY: Non

CONSTRUCTION DETAILS

TOTAL DEPTH DRILLED (m): 72.5 DATE: 17/04/1999
CURRENT DEPTH (m): 72.5 DATE: 17/04/1999
CASED FROM (m): 0 CASED TO (m): 66.3 TYPE: PVC
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 2002

PUMPED AND PURGED: Not Located SALINITY PROFILING: Not Located
TRANSDUCER INSTALLATION: No
RAINGAUGE ADJACENT: No REQUIRES REHABILITATION: No

SALINITY PROFILING DATA

APPENDIX C

Geophysical interpretation and resistivity values

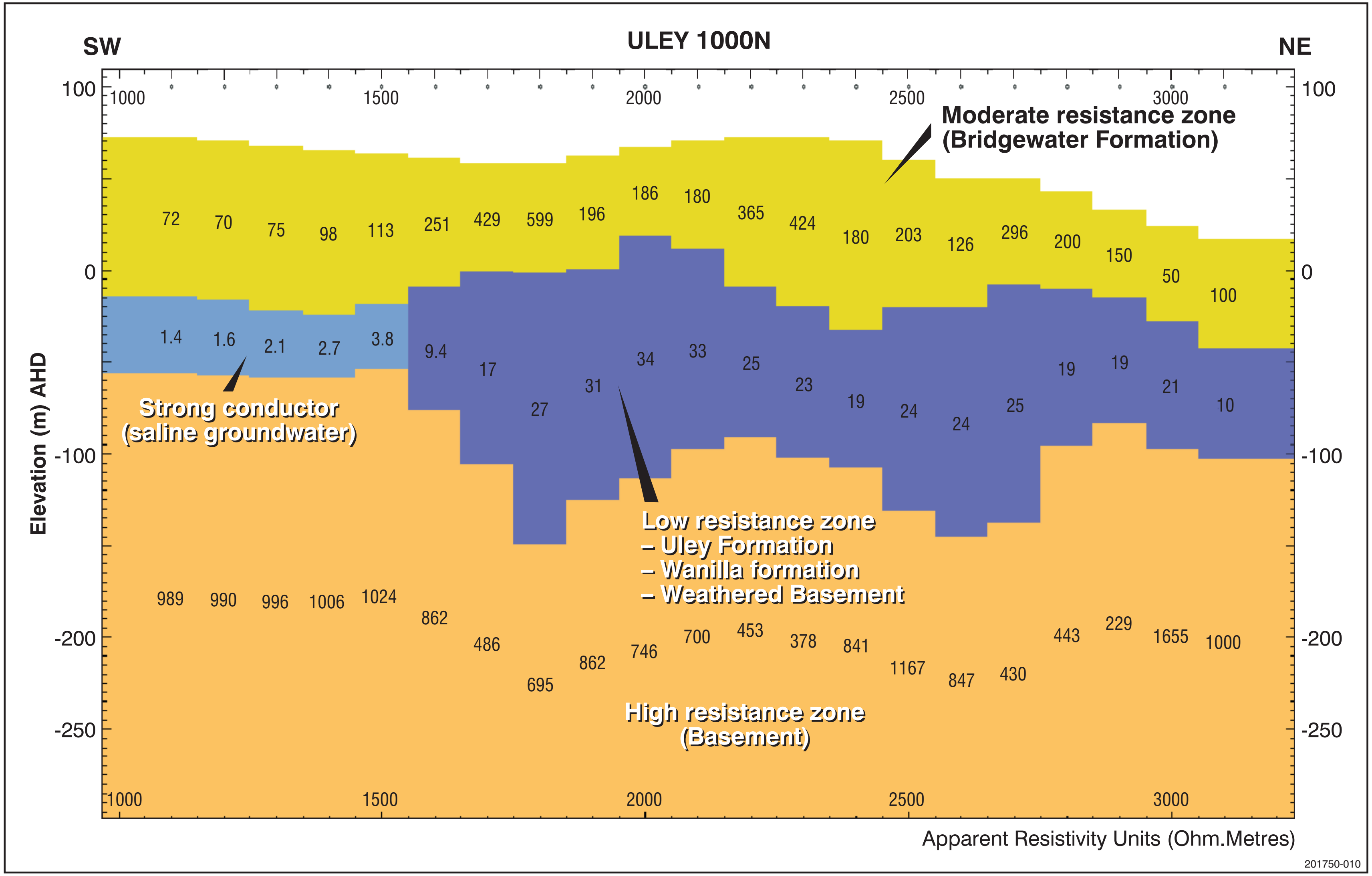


Figure C1. Geophysical interpretation of subsurface structure with resistivity values. Line 1000N, Uley South

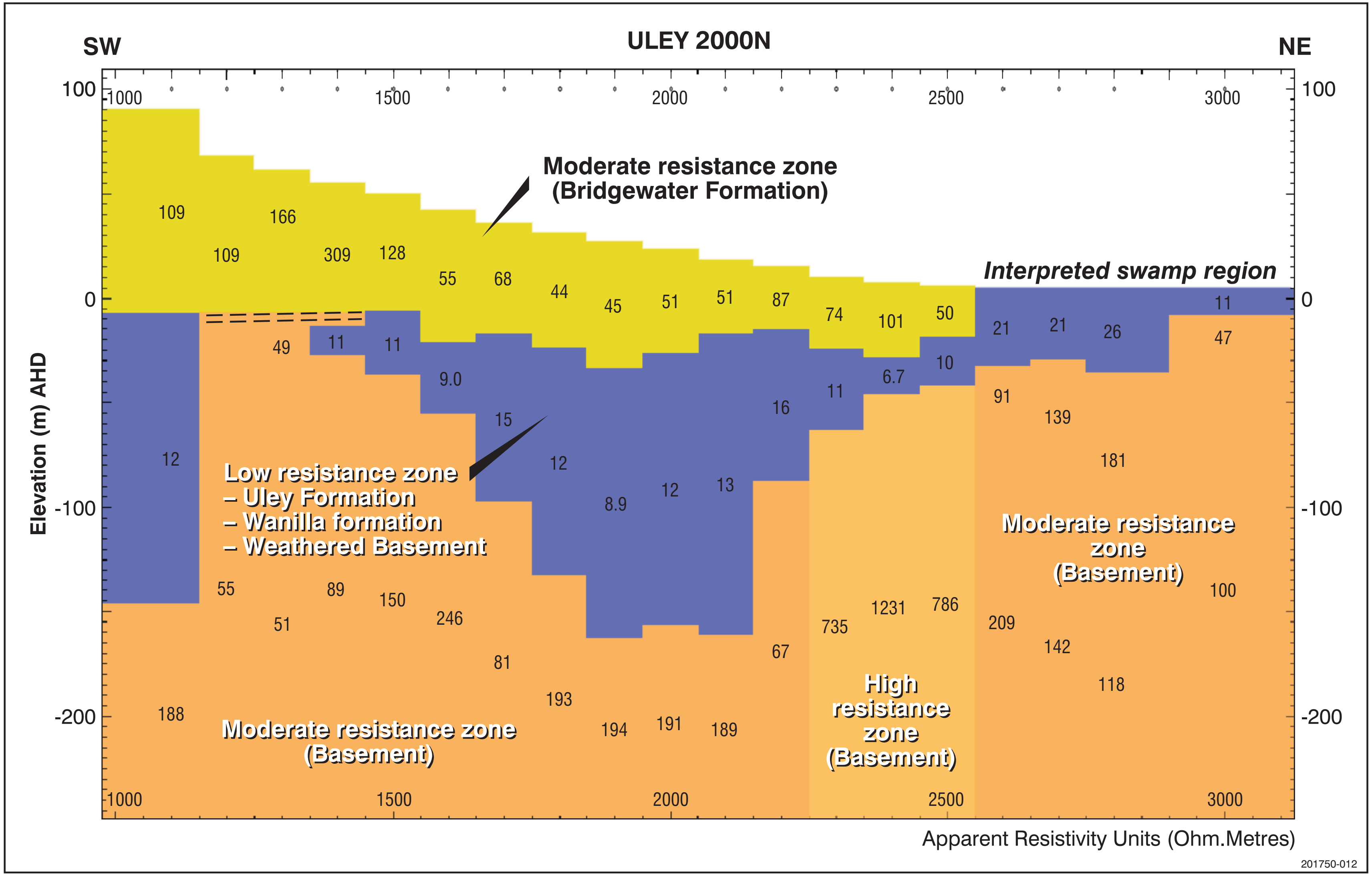


Figure C2. Geophysical interpretation of subsurface structure with resistivity values. Line 2000N, Uley South

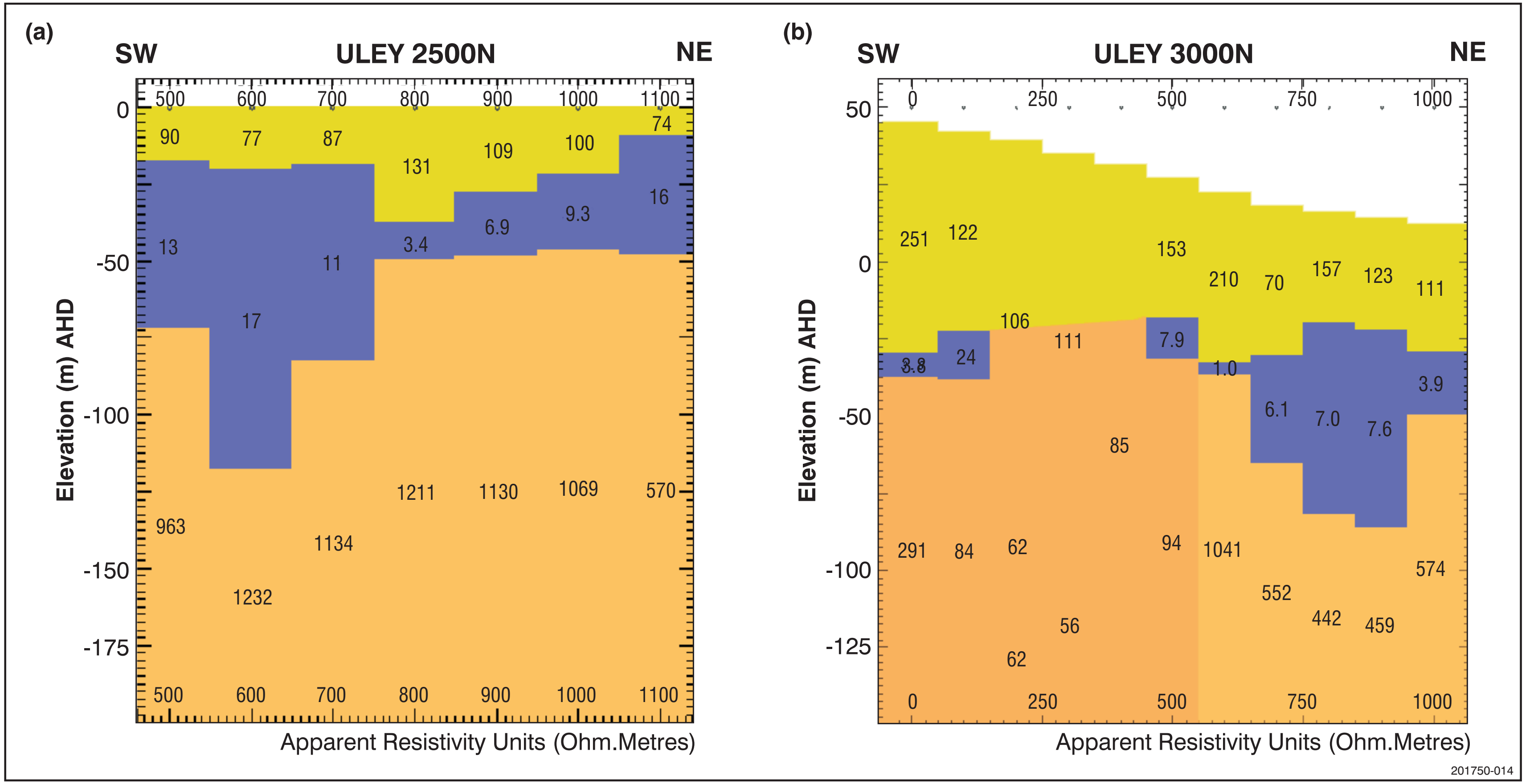


Figure C3. Geophysical interpretation of subsurface structure with resistivity values. Line 2500N and 3000N, Uley South

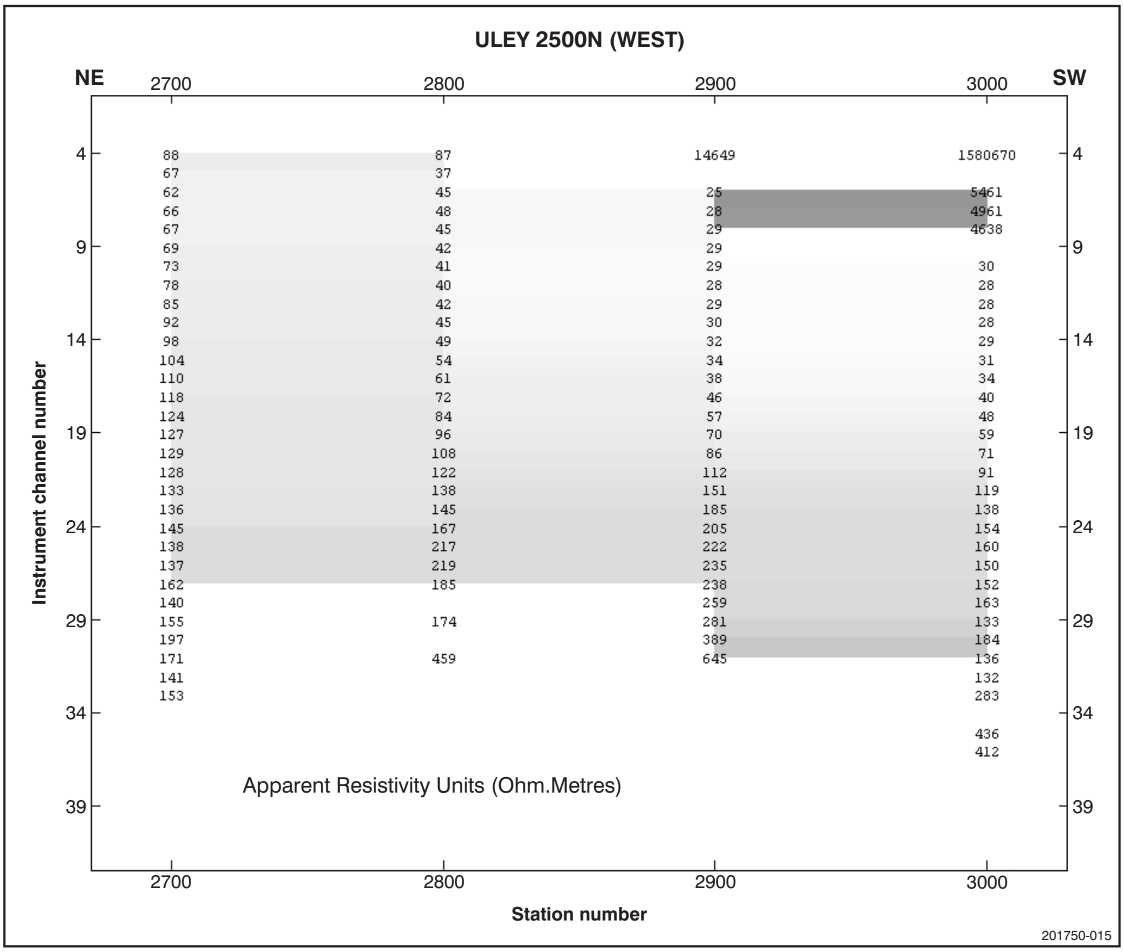


Figure C4. Resistivity data for survey line 2500N (west), Uley South