Regional Disposal Strategy - Renmark Group Deep Injection: Phase 1 Desktop Study

DWLBC REPORT 2005/29

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

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Natasha Rammers, Tony Hill and Wei Yan

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

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Department of Water, Land and Biodiversity Conservation

25 Grenfell Street, Adelaide

GPO Box 2834, Adelaide SA 5001

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

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FOREWORD

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

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

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

Rob Freeman
CHIEF EXECUTIVE
DEPARTMENT OF WATER, LAND AND BIODIVERSITY CONSERVATION

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EXECUTIVE SUMMARY

Due to unsatisfactory results from investigation works into deep aquifer disposal within the Murray Group Limestone in Chowilla Flood Plain area, it has been past proposed to investigate the feasibility of injecting into the deeper Renmark Group Aquifer. This new investigation has a phased approach to minimise cost risks:

- Phase I: Desktop Study
- Phase 2: Feasibility Study
- Phase 3: Injection Trial.

A review of all existing data over a large part of the central/western Murray Basin indicates that the basal Warina Formation represents the most permeable and high yielding formation of the Renmark Group. The formation is predominantly interbedded sands, silts and gravels with the basal section representing the most attractive target for injection. The unit attains a maximum known thickness of 231 m near the Renmark region and is between 235–511 m below ground surface.

The exact thickness and extent of the Warina Formation in the Chowilla region is unknown and, at best, sparse in the Renmark region. However, relatively recent seismic data suggest that the unit is regionally extensive. Phase 2 propose to use the seismic data (in conjunction with well data) to provide a better indication of Warina Formation distribution.

Numerical groundwater modelling indicates that there is no significant impact from deep injection of up to 600 L/sec over 100 years upon the River Murray and the maximum head pressure rise in the Warina Formation from injection is about 50 to 60 m. Modelling indicates the main impact of injection is an increase in head pressure of about 0.1–0.2 m in the Murray Group Limestone aquifer in the Woolpunda region. Furthermore particle tracking modelling indicates that groundwater flowing westwards after injection is forced in north east, south west and upwards direction along the Hamley Fault (because it has been modelled as a barrier boundary), away from the River Murray.

The major risk with injecting water from the Monoman Formation into the Warina Formation is chemical and physical clogging. This will be investigated in detail in the Phase 2 Feasibility study. To determine clogging potential on the local scale (at the likely trial site at Chowilla) it is recommended to drill and construct an observation well to provide crucial in-situ water and sediment samples for analyses. The regional clogging potential will also be assessed by sampling existing wells.

1. INTRODUCTION

Salt Interception Schemes (SIS) have been designed to intercept saline groundwater before it reaches the River Murray. The engineering solution to this has been to drill an array of production wells that pump groundwater into a pipeline that discharges to evaporation basins. Such basins result in a significant footprint on the landscape and have a high cost.

A novel solution is proposed that minimises the footprint on the landscape, results in less adverse environmental consequences, and may have a construction cost significantly less than the current disposal option that involves lengthy pipelines and evaporation basins. This solution is to pump saline groundwater from the unconfined aquifer and inject it into the deep confined Renmark Group aquifer. The Renmark Group is known to contain high permeability sands and is up to twice the thickness of the Murray Group Limestone (MGL). The Ettrick Formation separates the Renmark Group from the MGL. A similar investigation that targeted the overlying Murray Group Limestone was undertaken in the Gum Flat area of Chowilla during 2005, which included drilling and coring of an injection well and subsequent aquifer testing. The results of this investigation indicate that deep aquifer disposal to the Murray Group Limestone is not feasible due to the low permeability of the aquifer. Consequently only limited chemical analyses were undertaken, which indicated that the Monoman Formation (unconfined aquifer) requires filtration prior to injection due to high particulate matter and has elevated levels of iron bacteria.

Extensive investigations into the Renmark Group Injection will be required to confirm the feasibility of deep aquifer disposal. The proposed project is to be undertaken in a staged approach to minimise risk. This report summarises the Phase I desktop study review of existing data and provides recommendations for Phase 2 investigations.

2. OBJECTIVES

The objectives of the Phase-1 desktop study include:

- Undertake a literature review of previous works on deep aquifer disposal into the Renmark Group.
- Collate and review existing data from reports (water resources and petroleum) and SAGEODATA database to gain a better understanding of the hydrogeology of the Renmark Group and overlying Ettrick Formation.
- Define the nature, areal extent and thickness of the Ettrick Formation and Renmark Group (Olney and Warina Formations).
- Determine the most suitable target aquifer within the Renmark Group for injection.
- Undertake preliminary numerical groundwater modelling to determine the local and regional impacts of by deep aquifer injection.
- Provide recommendations and a detailed scope of a works for Phase 2 Feasibility study.

3. LITERATURE REVIEW

3.1 OVERSEAS

Injection of salt water (brine) is used commonly in the US oil and gas production industry. Large amounts of saline formation water are produced when hydrocarbons are extracted from deep reservoirs. The US EPA stipulates that this brine be injected into formations similar to those from which it was extracted to reduce risks of saline intrusion of unconfined aquifers. Over two billion gallons of brine are injected daily into injection wells in the US. The majority of these wells are located in the southern part of the country with Texas having the largest number (53 000) and California, Oklahoma and Kansas following some distance behind with 25 000, 22 000 and 15 000 wells respectively.

Due to the advanced nature of brine injection in the USA more literature should be sought in Phase 2 to better understand the processes and potential difficulties encountered during injection to assist with our understanding prior to committing to a Phase 3 injection trial.

3.2 LOCALLY

3.2.1 NOORA EVAPORATION BASIN DEEP AQUIFER DISPOSAL STUDY

A feasibility study to investigate the potential for deep aquifer disposal was undertaken at Noora Evaporation Basin in 1979 (Forth & Reed, 1979). The aim of the study was to determine a target aquifer for deep aquifer disposal of 200 000 mg/L salt solution at 1.5 Ml/day or bitterns at 0.8 Ml/day over a period of at least 50 years. The aquifers considered were Cretaceous (Monash Formation), basal Tertiary (Renmark Group) and Top Tertiary (Morgan/Mannum Limestone, Pata Limestone, Bookpurnong Beds and Loxton Sands).

The Top Tertiary was ruled out due to connectivity with the River Murray. Basal Tertiary was also ruled out as an option mainly due to the consideration that pressure effects could affect New South Wales and Victoria and these states would need to be satisfied that disposal would not cause harm to the resource. The Cretaceous was deemed suitable for saline water disposal (below Tertiary) due to its high salinity and 100 m of overlying shales and silts. The respective states would also need to be satisfied that injection would not cause harm to the resource but due to its salinity it was deemed a viable option. However, the considerable depths to the target aquifer at 600–1000 m below the ground proved to be a major obstacle.

The study also found that the Cretaceous aquifer has the capacity to accept saline water at a continuous pumping rate of 1.5 Ml/day for more than 50 years with no adverse hydrogeological impacts. However, the scheme was not advanced due to the expected substantial running costs. The study recommended that before a design could be finalised, that a field investigation into aquifer hydraulic properties and possible chemical reactions resulting from mixing of injected water with aquifer water was required.

3.2.2 DISPOSAL OF SALINE WATER INTO DEEP AQUIFERS IN THE KERANG LAKES AREA

Sinclair Knight Merz (SKM), on behalf of Goulburn-Murray Water undertook investigations to assess the feasibility of deep groundwater injection as a means of brine disposal in the Kerang Lakes district of Victoria, located SE of Swan Hill and NW of Kerang (SKM 2003, 2004).

SKM proposed the following staged approach:

- Stage 1 – Sampling of bores and lakes and chemical modelling.
- Stage 2 – Investigation of aquifer characteristics of the Renmark Group aquifer and prediction of impacts of deep injection.
- Stage 3 – Development and costing of conceptual design.
- Stage 4 – Construction of a pilot bore for field trials.

The investigation involved the feasibility of disposing brine from Lake Tutchewop and Lake William into the Renmark Group Aquifer. To date SKM has completed Stage 1 and preliminary PHREEQC modelling of Stage 2 investigations. The study comprised sampling the Lakes, Upper Renmark, Parilla Sands and one Lower Renmark well. The salinities of the Renmark Group in Kerang district are typically around 40 000 mg/L, which are about twice the observed values in the Renmark region. The Lower Renmark Group is also a lot shallower in the Kerang Lakes area, being around 200–225 m below ground surface and around 100 m thick.

The preliminary findings of Stage 2 identified potential for chemical clogging to occur when high calcium lake water combines with high iron groundwater. The reducing environment of the Renmark Group indicates that precipitation of carbonate, particularly iron carbonate, is likely to occur. The distance at which this would occur away from the injection well is unknown, but would be dependant upon aquifer properties. Precipitation of iron carbonates within the well screens or gravel pack would be minimal. Due to the lack of data on the Renmark Group resulting from deterioration of surrounding bores, the study was truncated.

Recommendations from the report included investigating potential of biological clogging, and assessing the hydraulic properties of the Loxton-Parilla Sands and Renmark Group formations and completing a more comprehensive sampling programme.

3.2.3 STOCKYARD PLAIN DISPOSAL BASIN – ASSESSMENT OF RENMARK GROUP INJECTION POTENTIAL

Australian Water Environments (AWE) were engaged by MDBC to explore the potential for deep injection into the Renmark Group at the Stockyard Plain Disposal Basin to address future disposal options required in the Woolpunda-Waikerie district.

The report identified that neither the Olney Formation nor Warina Formation represented viable target aquifers for deep injection. The Olney Formation was dismissed on the grounds of low porosity and high clay content, which is consistent with the views expressed in this report.

Whilst sands of the Warina Formation were considered to be suitable for injection, the generally thin to absent nature of the unit was considered to be an impediment for viable long term injection. This current study suggests that whilst there is a general thinning of the unit on the western side of the Hamley Fault, no single well has fully intersected the Warina Formation in grabens between the Morgan and Hamley faults to the south of Waikerie.

Accordingly, this area should not be totally dismissed when reviewing future deep injection options in the Woolpunda-Waikerie region.

4. GEOLOGY

The Murray Basin is a saucer shaped Tertiary basin covering an area of 300 000 km2 which extends approximately 850 km east to west and 750 km north to south (Brown & Stephenson, 1991). The majority of the western Murray Basin is shallow but the basin deepens towards the tri-state corner where two deep northeast trending troughs (Renmark and Tararra) are located. On the north western side of the Renmark Trough lies the Canegrass Lobe and to the south eastern side is the Paringa Embayment (Fig. 1). The Paringa Embayment is a complex area of basement ridges separated by erosional valleys with a gradient towards the Renmark trough (Thornton, 1974). The Canegrass Lobe is a large, gently shallowing depression with depth to basement rising to about 200 m (Drexel & Preiss, 1995).

The Renmark Trough lies within the focus study area and is a north-northeast trending feature where it is deepest at its northern end (Fig. 1). The trough is bound to the northwest by the Hamley Fault, which extends up into the Lower Cretaceous where the Tertiary sediments are draped on top. The eastern region of the trough is bound by the Chowilla Fault (Fig. 1). The Chowilla Fault possibly does not extend into the Lower Cretaceous, therefore not as vertically extensive as the Hamley Fault. (Thornton, 1974).

4.1 TERTIARY

The Tertiary sequence of the Murray Basin in the Renmark region unconformably overlies the Monash Formation (Lower Cretaceous) acting as a drape (Fig. 2). Pockets of relatively thick sediments are usually coincident with underlying troughs (Renmark Trough) and thinner sequences tend to occur over faulted basement highs including eg. The Canegrass Lobe (Brown & Stephenson, 1991). Indicative geology in the region of interest is best illustrated in EW and NS cross sections (Fig. 4), show the structural features mentioned above.

The Tertiary can be split into three phases:

- Predominantly freshwater Paleocene to Eocene sands (Renmark Beds).
- Marine Limestone of Oligocene to Miocene age (Ettrick Formation, Gambier Limestone, Mannum Formation, Morgan Limestone and Pata Limestone).
- Pliocene Marine to fresh water silts and sands (Bookpurnong beds and Loxton sands) (Fig. 2) (Thornton, 1974).

4.2 RENMARK GROUP

4.2.1 STRUCTURE

The Renmark Group is the oldest and thickest sequence within the Tertiary succession, averaging 117 m in thickness over the contoured area (Fig. 5). Depth to the Renmark Group ranges from 4 m (basin margins) to 345 m in the deep west-central part of the basin near the tri-state border (Fig. 6). Structural contours of the Base Tertiary, Top Tertiary and Ettrick Marl (Figs 7–9) indicate that local highs and lows mimic the underlying basement.

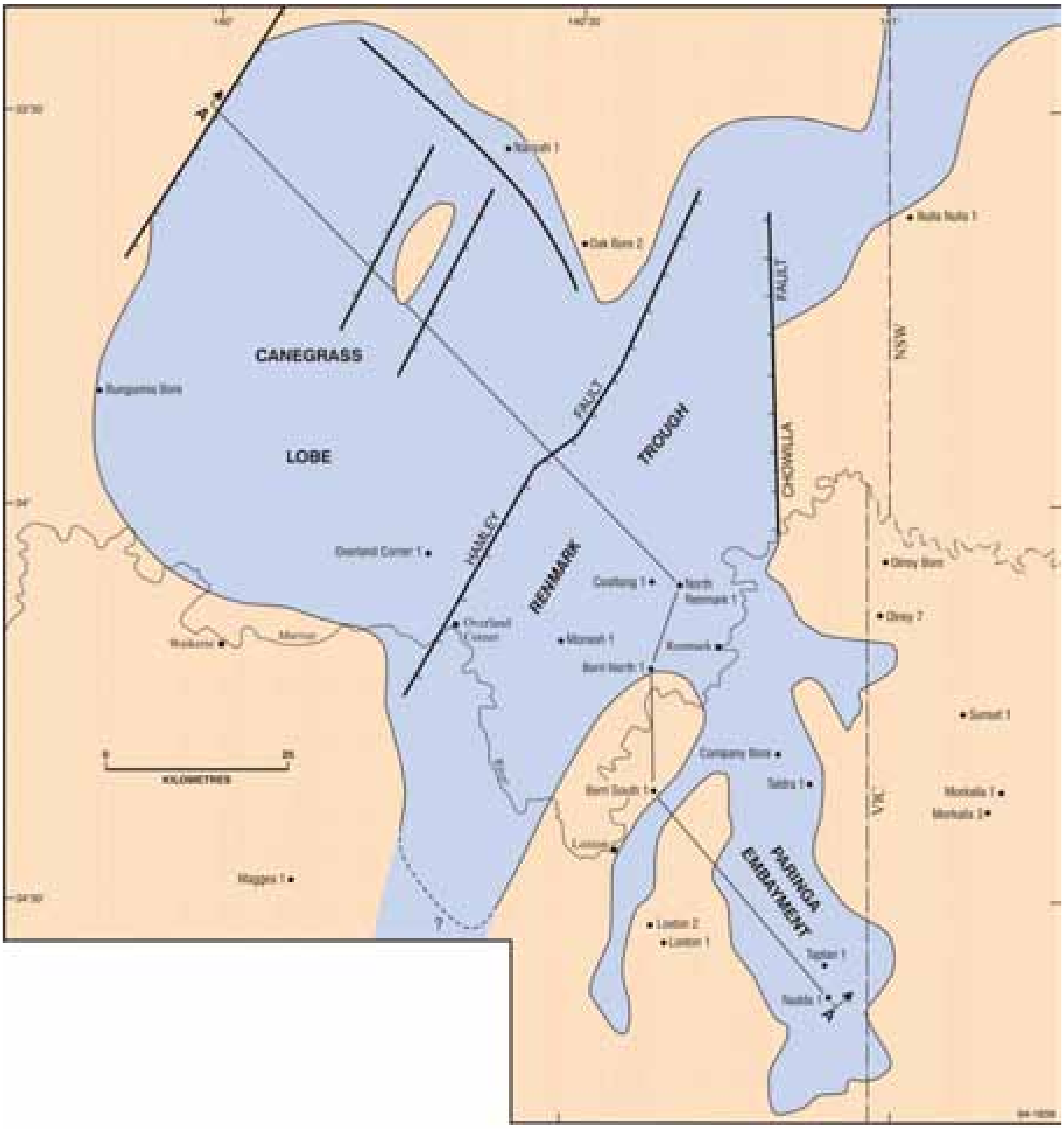

Figure 1. **Major Structural features within the Murray Basin tri-state border region (Drexel & Priess, 1995).**

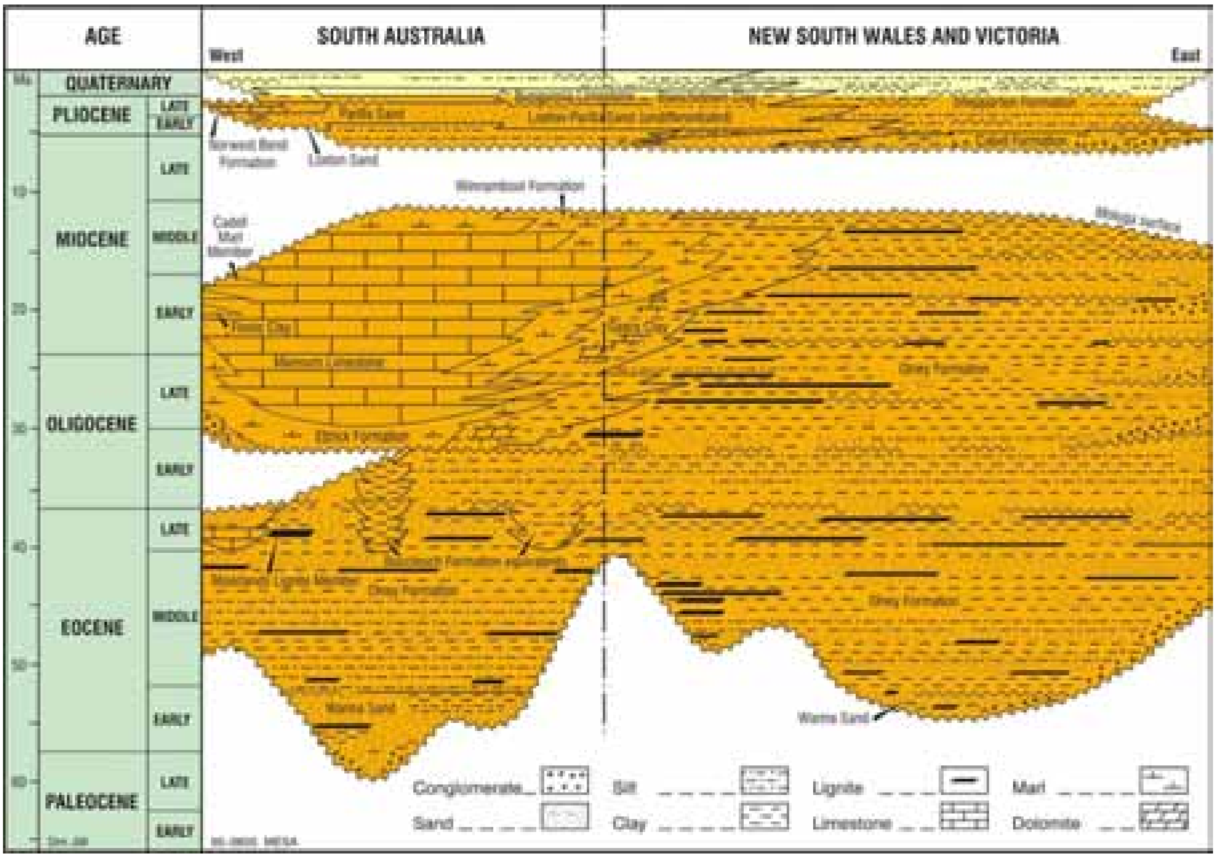

Figure 2. Tertiary hydrostratigraphy of the Murray Basin (Drexel & Priess, 1995)

Figure 3. Major structural features in the Murray basin and location of Cross sections of Figure 4 (Drexel & Priess, 1995).

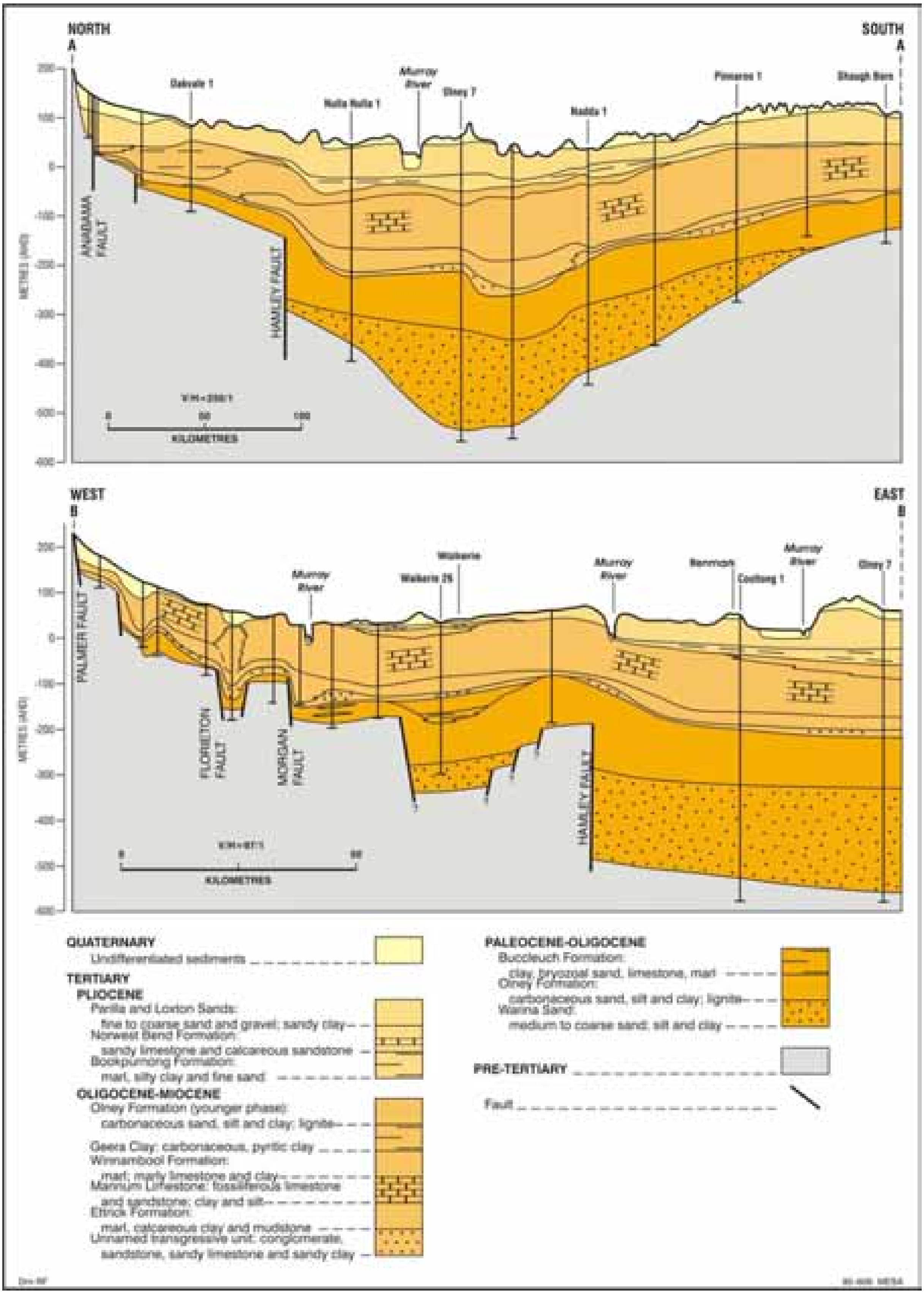

Figure 4. **NS and EW cross-sections of the Murray Basin Tertiary units (Drexel & Priess, 1995)**

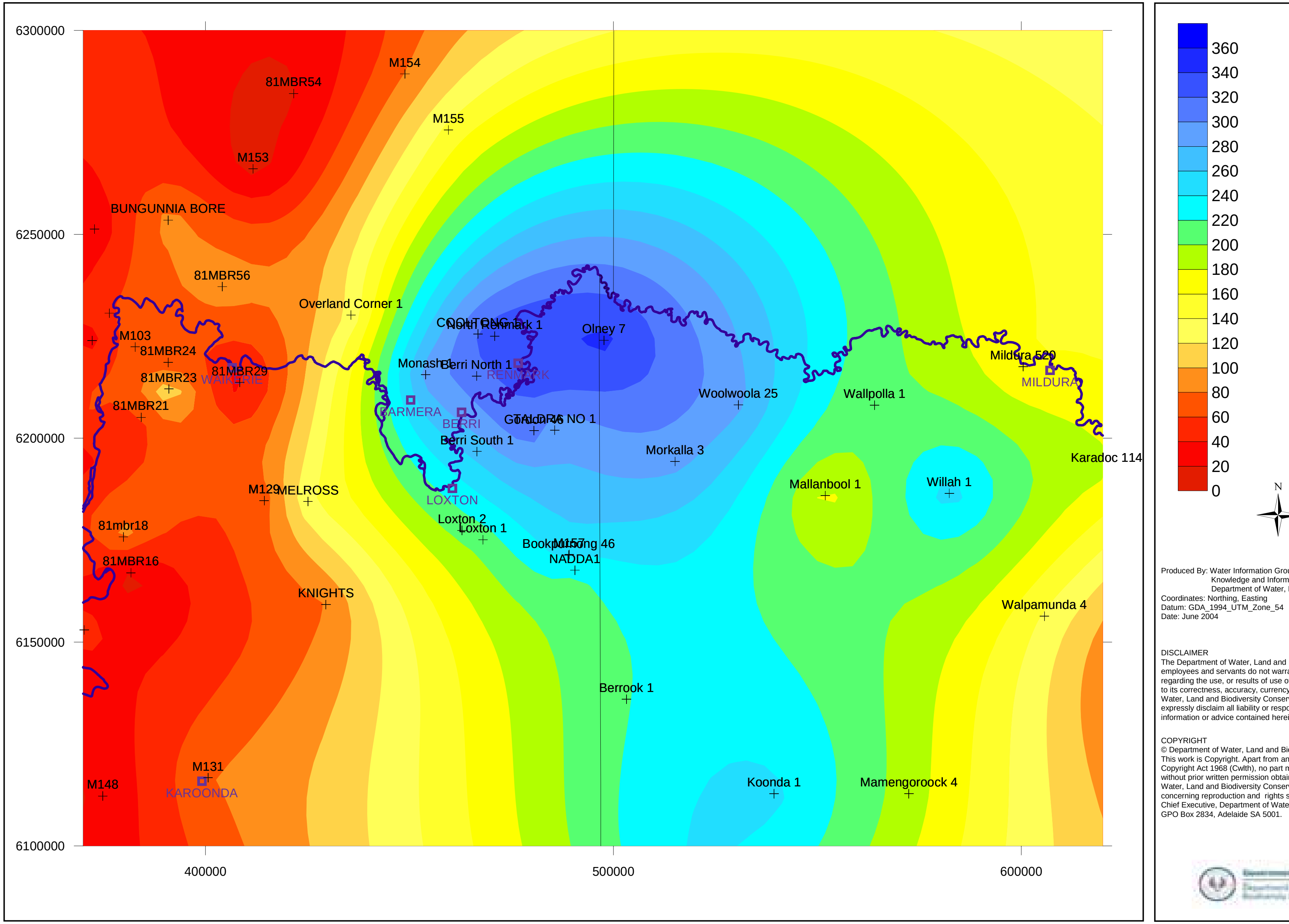

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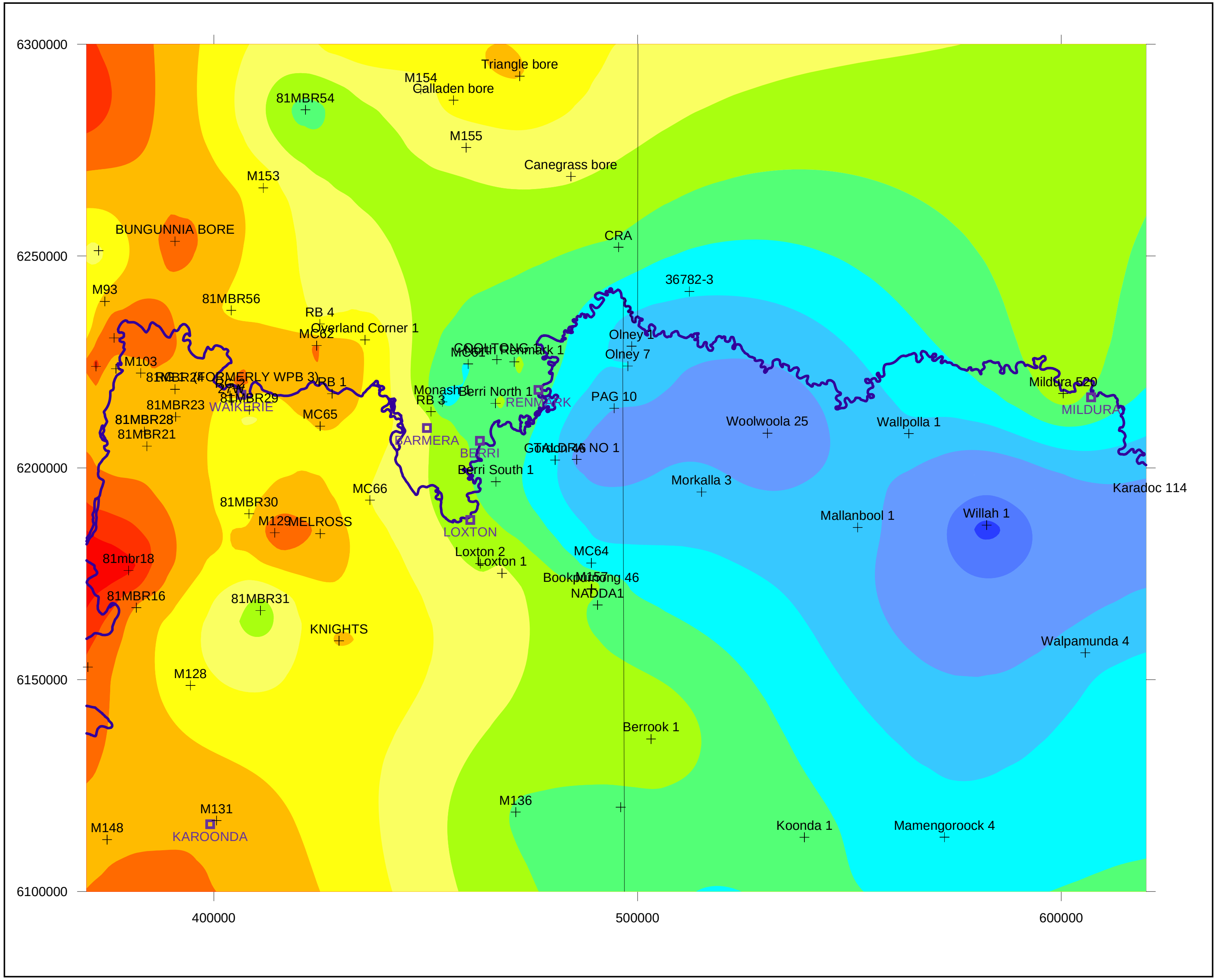
Figure 5 Renmark Group Isopach (m)



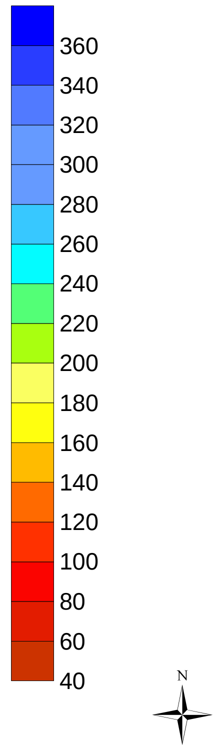


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Figure 6 Depth to Renmark Group (Olney Formation) (m)

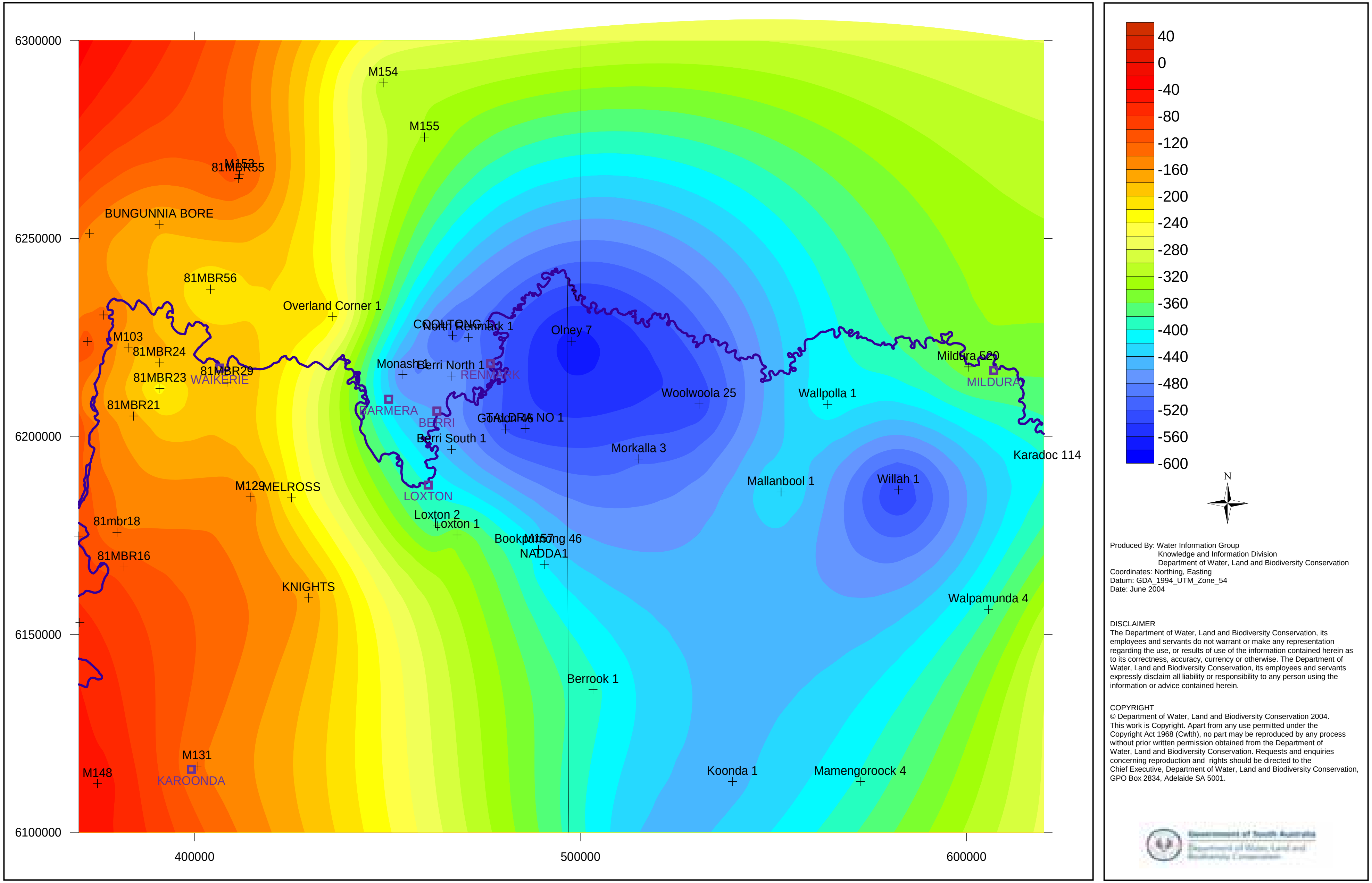
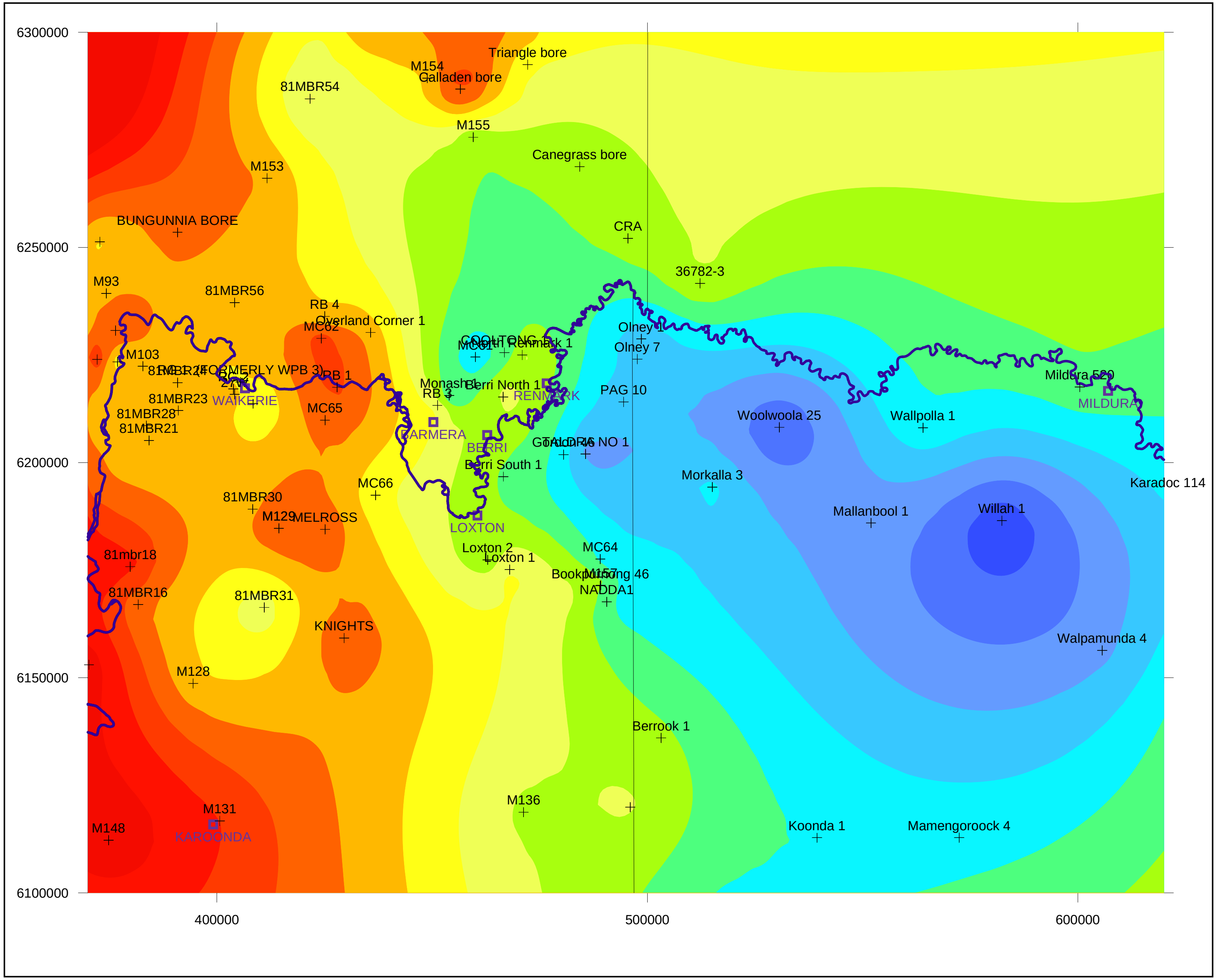


Figure 7 Structural Contours of Base Tertiary (mAHD)



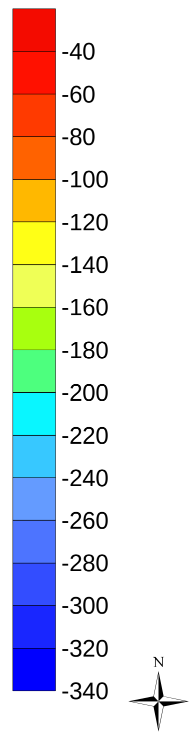


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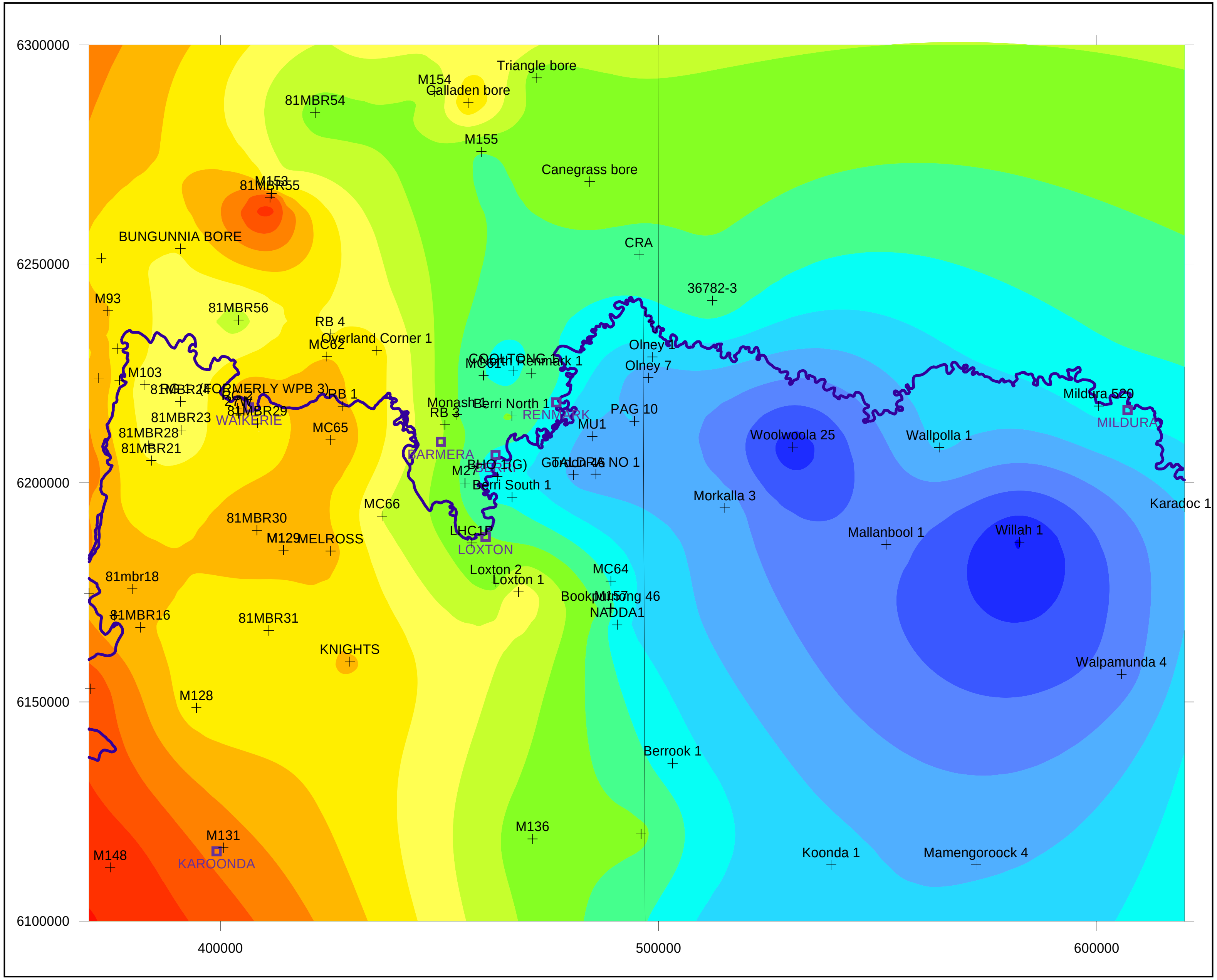
Figure 8 Structure Contours of Top Tertiary (Top Olney mAHD)



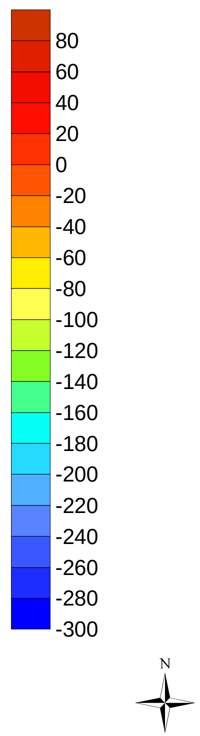


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Figure 9 Structure Contours of Top Ettrick Formation (mAHD)

The Renmark Group is split into two formations:

- Olney Formation (formerly Upper Renmark Beds) and
- Warina Formation (formerly Lower Renmark Beds)

4.3 WARINA FORMATION

4.3.1 LITHOLOGY

The Warina Formation comprises pale grey to pale brown, medium to coarse quartz sand with minor carbonaceous fine silt, clay and minor pebble conglomerate. (Brown & Stephenson, 1991). The formation is weakly consolidated, loose and friable in places, occasionally lithified in part by siliceous cement, intergranular clay, carbonaceous material, and or quartz pyrite aggregates.

In some bores these aggregates have been oxidised to form ferruginous cement. The upper boundary is lithologically similar to the basal Olney Formation in places, making differentiation of the two units difficult. It generally overlies several metres of white to grey clay of the upper Cretaceous weathering profile. The formation is characterised by clean sand, high porosity good permeability and is high a yielding confined aquifer (Brown & Stephenson, 1991).

4.3.2 DEPOSITION

The formation is believed to be deposited by large, high-discharge rivers in a non-marine environment that deposited stacked sand bodies possibly under braided stream conditions at the base of the formation. The increase of silt, clay and lignite towards the top of the unit indicates a loss of energy in deposition caused possibly by a shift from braided/anastomosed to a meandering channel conditions (Brown & Stephenson, 1991). Examination of core and cuttings from the Loxton 1 well confirms a thick coarse sand to gravel unit at the base of the formation up to 30 metres thick, consistent with high energy fluvial depositional conditions.

4.3.3 DISTRIBUTION

The formation represents the basal unit of the Renmark Group and is mainly restricted in distribution to the central-western part of the basin. The formation is predominantly bound by the Hamley Fault to the west although there appears to be an isolated graben between the Morgan and Hamley Faults where a possible intersection up to 12 metres of Warina Formation has been proposed at Waikerie 26 observation well. This well didn’t fully penetrate the formation and was terminated at a depth of 329 metres. Whilst the lateral and vertical extent of the unit in this vicinity does not look favourable for injection purposes, it will be investigated as part of the seismic review in Phase 2.

Information is sparse and largely restricted to deep petroleum and mineral exploration wells and a deep drilling program conducted in 1986 by Water Victoria. The formation is thickest in the Renmark Trough, reaching a maximum known thickness of 231 m (Monash 1), thinning to a minimum of 32 m near Mildura (Fig. 10). The Warina Formation occurs at depths between 235 to 511 m below ground surface in the Renmark region with an average 316 m (Fig. 11).

There is no well information north of Renmark and it is unknown what impact the Chowilla Fault has on thickness or presence of Warina Formation in the Chowilla region. Thornton (1974) suggested that there was a basement high in the Chowilla region, however this older seismic data, is now considered to be of poor quality. Modern and reprocessed seismic data will assist in better defining this possible basement high.

The cored hole (Unit number 7030-797) at Gum Flat is the deepest drillhole in the Chowilla region and indicates that the top of the Ettrick Formation is at -177 mAHD. Comparing this depth to known Ettrick depths in the Renmark trough east of the Hamley Fault (North Renmark: -142 mAHD, Berri North -134 mAHD, CRA -151 mAHD) and west of the Hamley Fault (Overland Corner -73 mAHD) suggests that there is little to no uplift caused by the Chowilla Fault (Fig. 9). By interpolating from Ettrick to Warina Formation, it is possible that the Warina Formation lies at depths between 370 to 420 m below the ground surface, at similar elevations to those in the Renmark Trough (-270 to -300 mAHD, Fig. 12).

4.4 OLNEY FORMATION

4.4.1 LITHOLOGY

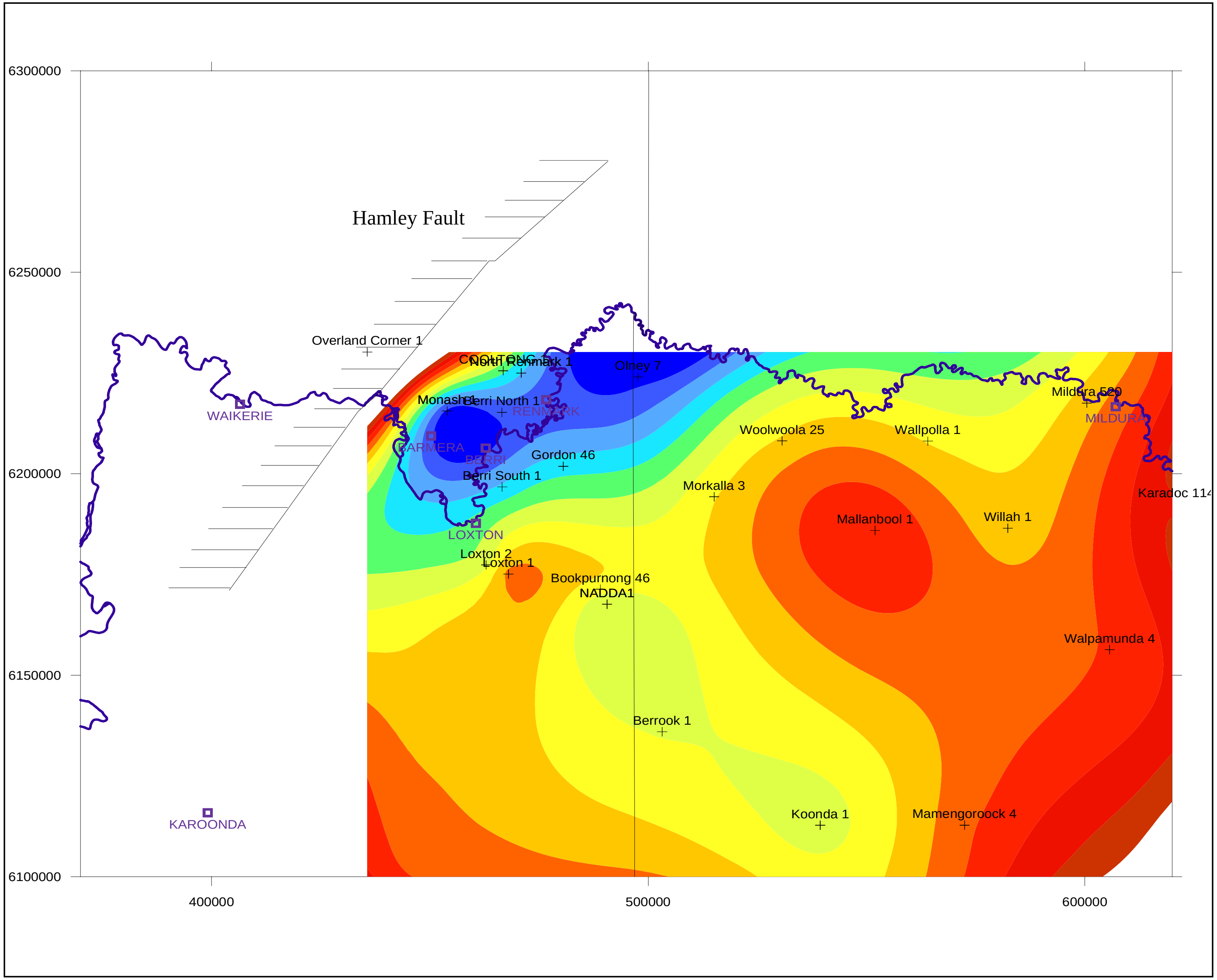
The Olney Formation is a heterogenous unit comprising intercalated, laterally discontinuous thin beds of unconsolidated to poorly consolidated coarse to fine ferruginous clastics. The dominant lithology is carbonaceous silt, siltstone, sand, clay, claystone with common interbeds of lignitic brown coal and peat. The sand is dark brown, grey, black, carbonaceous, pyritic and locally micaceous. It is commonly laminated with carbonised plant fragments and abundant scattered lignitic wood debris is common. Sand sorting is highly variable and locally occurs in distributary fans adjacent to areas of riverine plain and highlands (Brown & Stephenson, 1991).

4.4.2 DEPOSITION

The high content of coal, peat and abundance of carbonaceous detritus indicates the Olney Formation was deposited under fluvio-lacustrine conditions with localised distributary fans contributing to high sand content (up to 80%) where rivers exited from the highlands. Within the basin the sand content diminishes to less than 50%, contributing to its high variability (Brown & Stephenson).

4.4.3 DISTRIBUTION

The formation extends across most of the Murray Darling Basin, although it is absent over a few concealed basement ridges. The depth to the Olney Formation varies from 160 m (west of the Hamley Fault) to 350 m at its deepest point within the Renmark Trough, east of Hamley Fault (Fig. 13) in the study region.



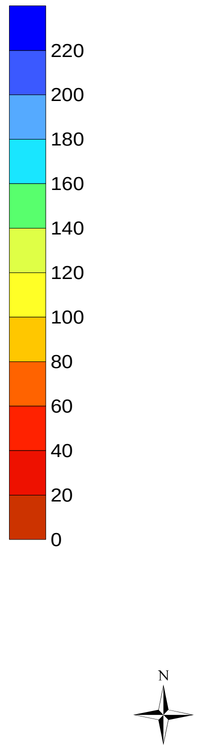


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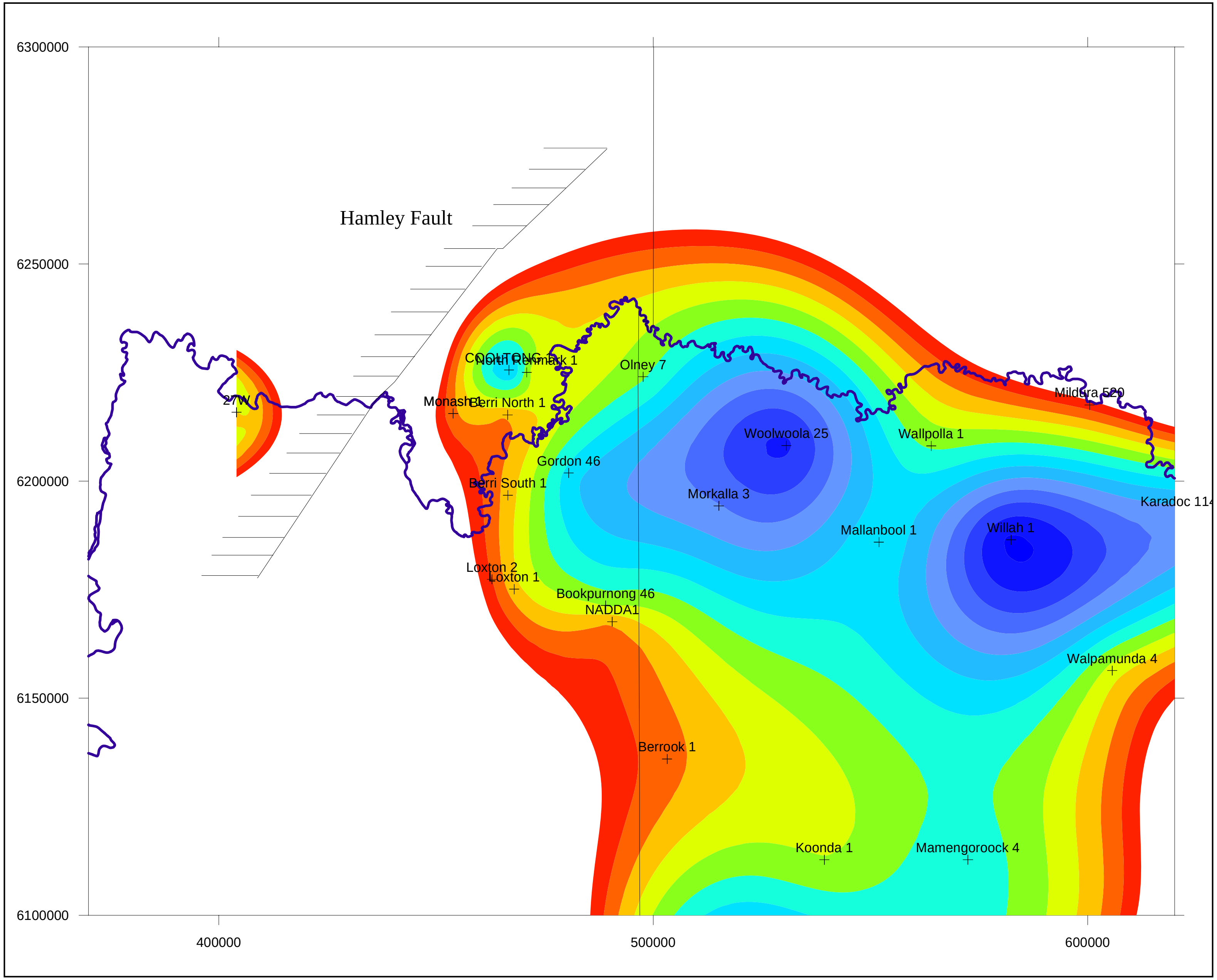
Figure 10 Warina Formation Isopach (m)



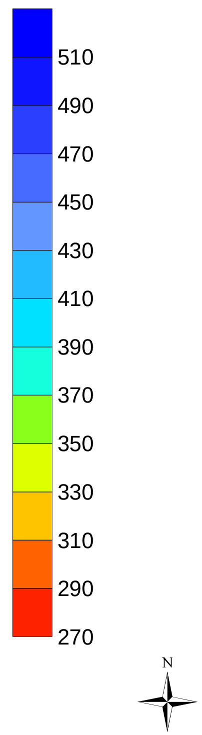


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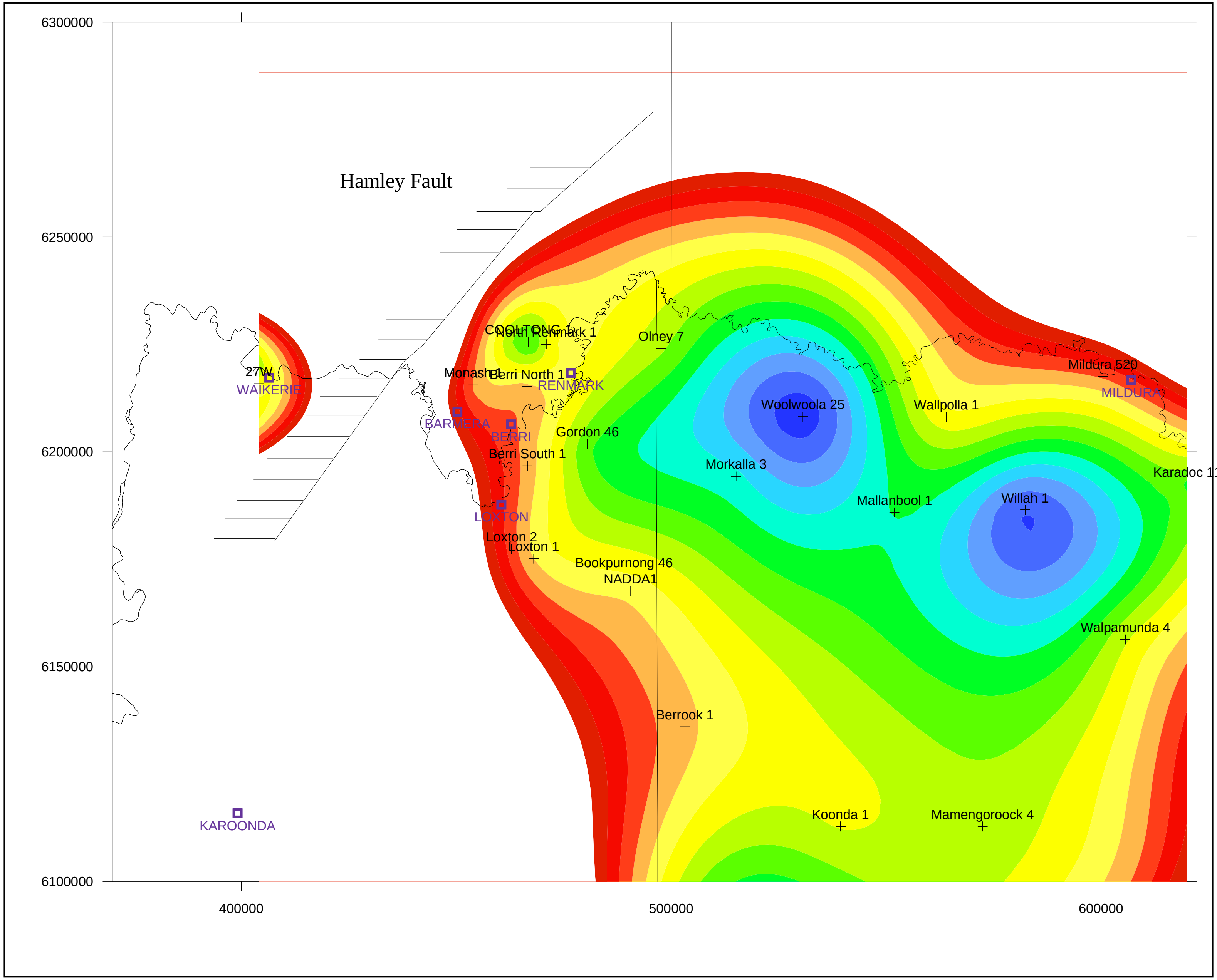
Figure 11 Depth to Top of Warina Formation (m)



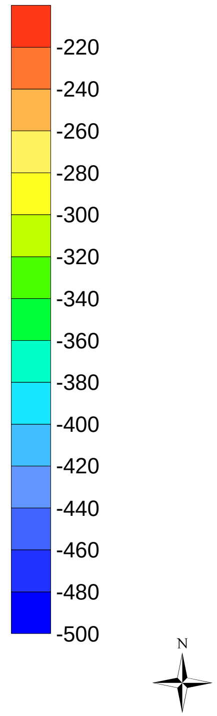


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Figure 12 Structure Contours of the Warina Formation (mAHD)

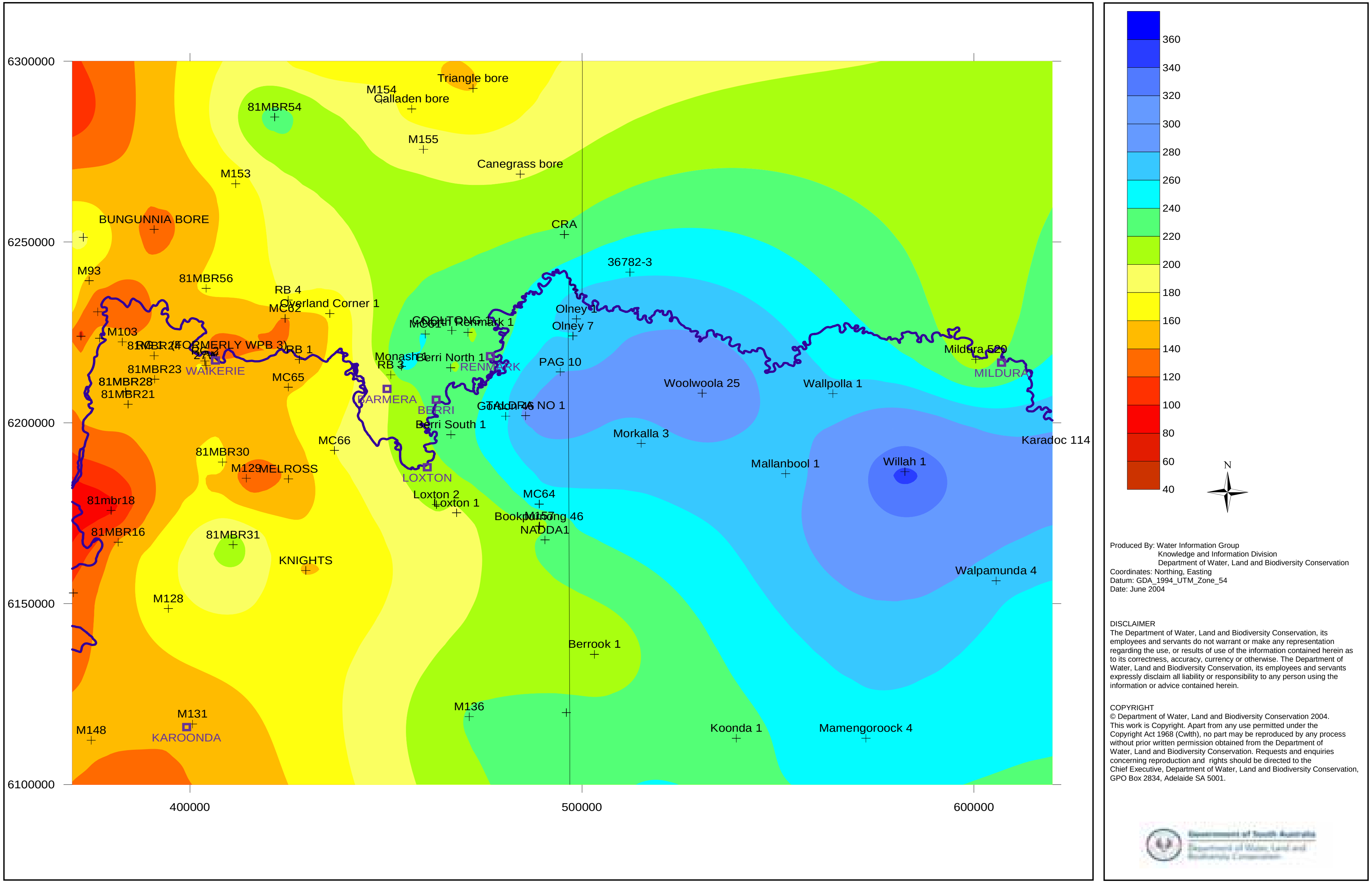

Figure 13 Depth to Olney Formation (m)

4.5 ETTRICK FORMATION

4.5.1 LITHOLOGY

The formation comprises grey and green glauconitic highly fossiliferous calcareous clay, commonly described as marl. In places it is a calcareous clay with high content of quartz sand and skeletal material, locally grading into sandy skeletal clay and calcareous silt (Brown & Stephenson, 1991).

4.5.2 DEPOSITION

The Ettrick Formation is a continuous blanket of highly glauconitic calcareous clay lithologically distinct from underlying and overlying stratigraphy units. The formation was deposited in a low-energy shallow marine shelf environment giving its confining bed properties (Brown & Stephenson, 1991).

4.5.3 DISTRIBUTION

The formation is at its deepest on the eastern side of the Hamley Fault (Renmark trough), extending to 336 m below ground surface and at its shallowest on the western side of the Hamley Fault at 40 m below surface (Fig. 14). The formation is relatively thin in comparison to other Tertiary stratigraphic units and is uniform in thickness across the Murray Basin. It averages 25 m in thickness (Fig. 15). The formation is believed to contain high salinity waters.

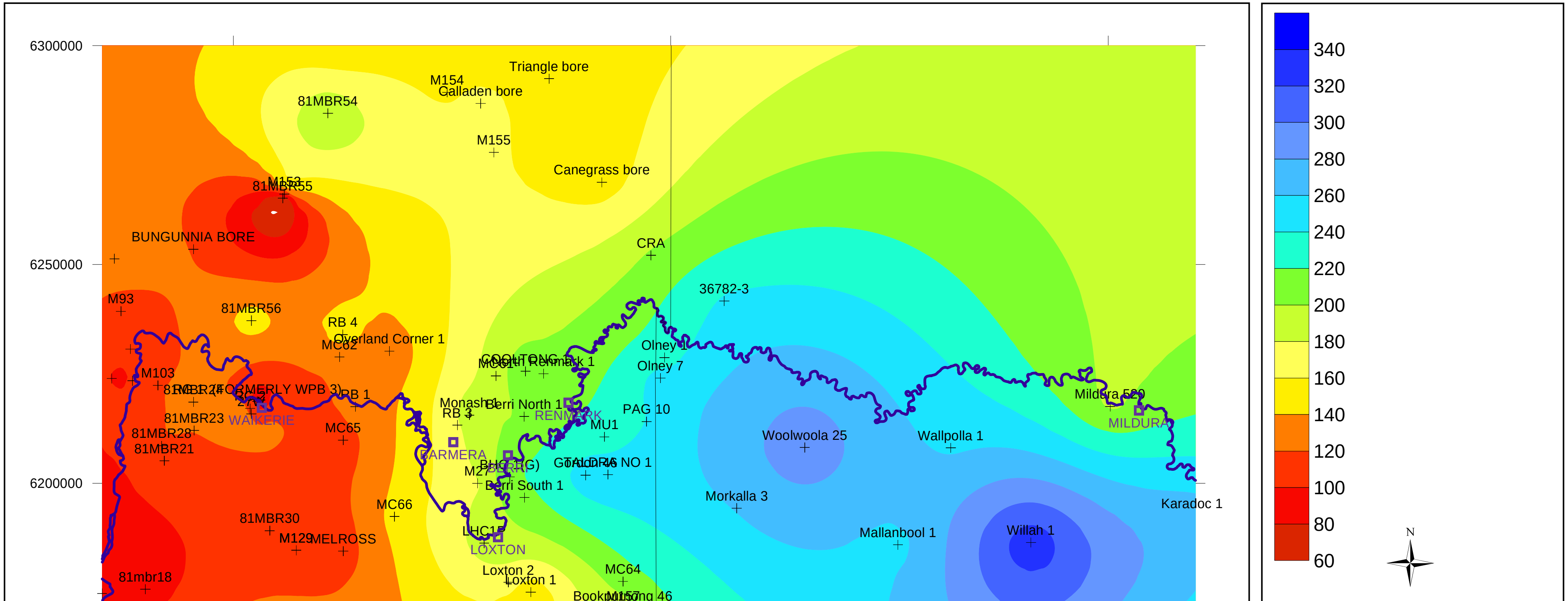

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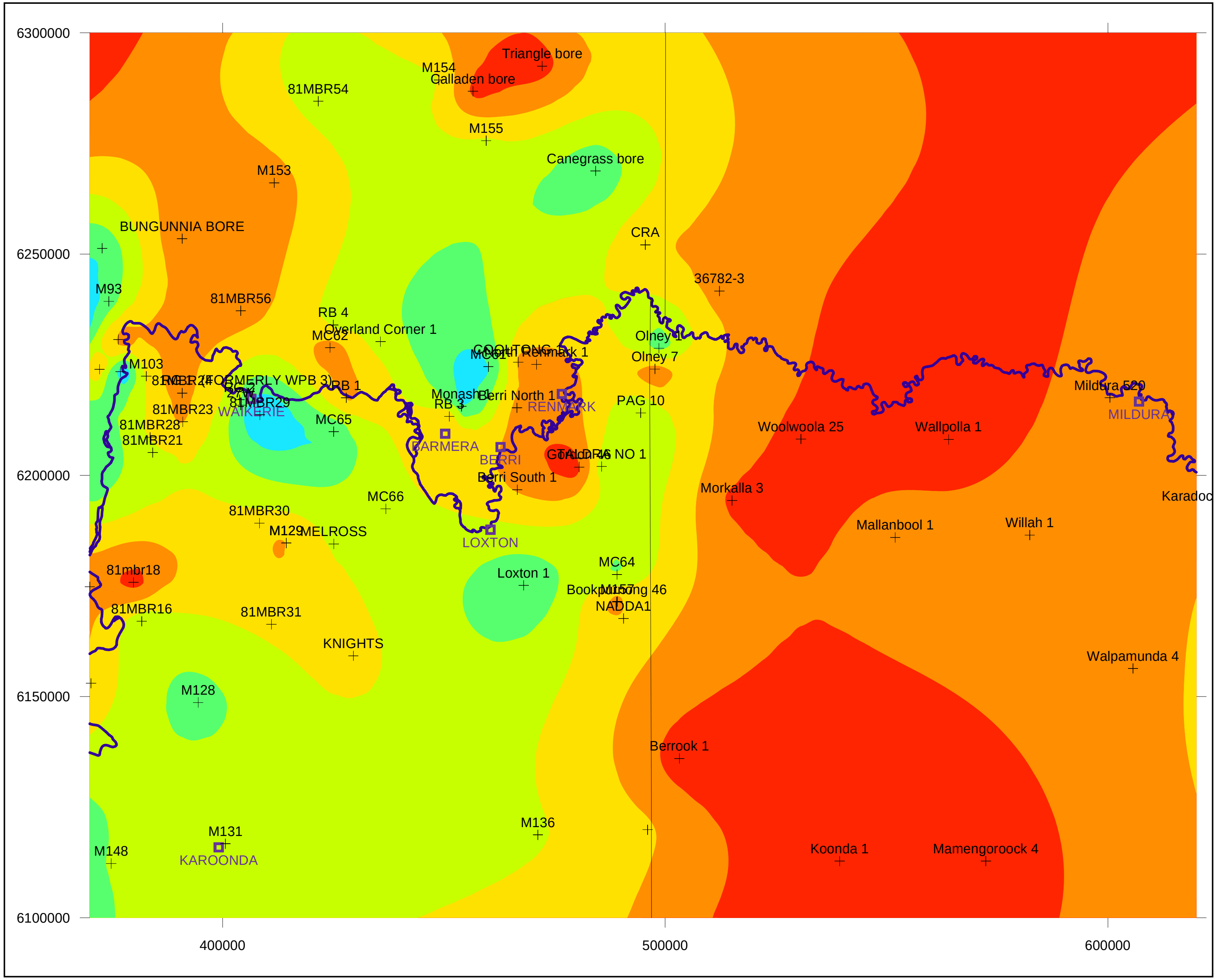
Figure 14 Depth to Ettrick Formation (m)



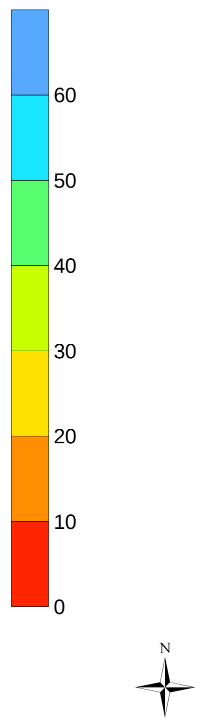


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Figure 15 Ettrick Formation Isopach (m)

5. HYDROGEOLOGY

Groundwater in the Renmark Group flows generally from east to west. In the Waikerie region, just past the Hamley Fault, there is a potentiometric surface low indicating that the Renmark Group maybe recharging the overlaying Murray Group Limestone, from which the Wakerie-Woolpunda SIS has been abstracting groundwater for many years (Fig. 16). The Murray Group Limestone potentiometric surface reflects the recharging feature of the Hamley Fault and also shows three main areas of mounding; Waikerie, east of Hamley Fault and Loxton (Fig. 17). Figure 18 is a subtraction of Renmark group potentiometric surface and the water table. The resulting surface shows regions where the head difference is high or low. There are two main regions where there is little head difference; just past the Hamley Fault and near Waikerie. This indicates that at these locations the Murray Group Limestone head rises near to the level of the Renmark Group. Near Waikerie this is caused by increased recharge from irrigation whereas the second reduction, near the Hamley Fault, reflects upward leakage of Renmark Group waters into the Murray Group Limestone.

There is very limited salinity information in the region, mainly due to the lack of interest in developing the Renmark Group. The salinity varies from 200–36 000 mg/L (Fig. 19). Salinity to the south of about 6190000mN is generally below 5000 mg/L whereas above Lock 4, to the north, salinity is generally above 10 000 mg/L. The average salinity of the region of interest is 8500 mg/L. The limited information of the Warina Formation indicates that average salinity is 14 000 mg/L of all known wells. In the Chowilla region of interest the salinity of the Warina Formation is approximately 20 000 mg/L.

5.1 TARGET INJECTION AQUIFER

Due to the heterogenous nature of the Olney Formation, it is deemed that the clean uniform Warina Formation provides the best target aquifer. Yields from airlifting vary from 1–32 L/second over approximately 6 m screen intervals.

It is proposed in Phase 2 to conduct a short-term pump test on bores monitoring the Warina Formation to verify that the formation is as high yielding as predicted. Note that the pump test result will be a qualitative yield determination as the bores were not constructed for pump testing purposes and will only be pumped at very low rate (<0.4 L/sec). These bores will then be sampled for chemistry and analysed to provide an indication of potential physical and chemical clogging issues that could arise.

5.2 SEISMIC SURVEY SUMMARY

Primary Industries and Resources (PIRSA) has a database of all seismic surveys completed in South Australia. Figure 20 shows seismic surveys conducted in the Riverland region.

Currently there is no seismic-generated Base Tertiary depth structure plan in the Riverland to inform of structural highs and lows and provide a better indication of fault intensity. Phase 2 will incorporate production of such a plan by PIRSA that incorporates drillhole and seismic data.

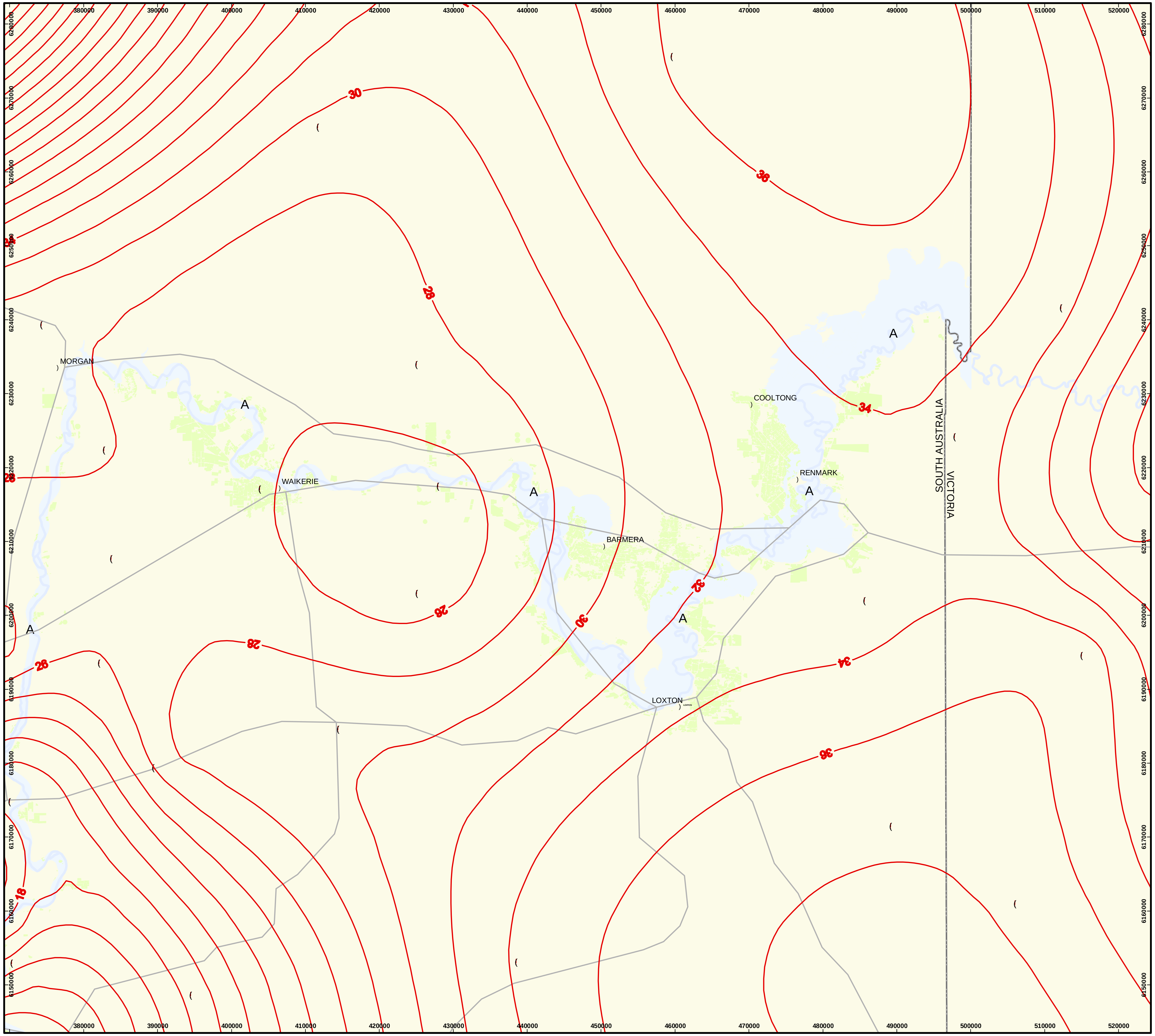

Figure 16

Renmark Group Potentiometric Surface (2000) (mAHD)

Towns
Locks
Renmark Group Bores
Renmark Group Potentiometric surface
SA / VIC Border
Roads
River Murray
Irrigated Areas 2001
1956 Flood Level

0 5 10 20 km

Datum: GDA94
Map Projection: MGA Zone 54

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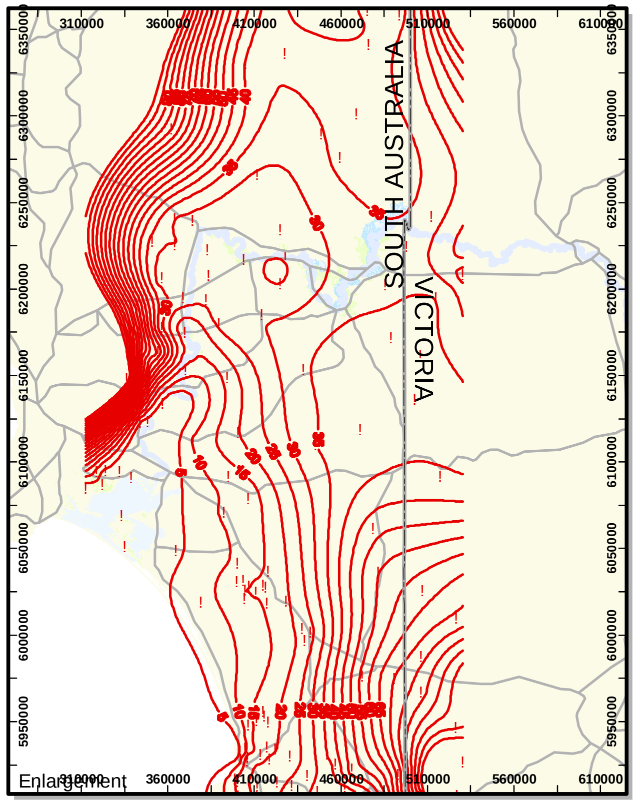

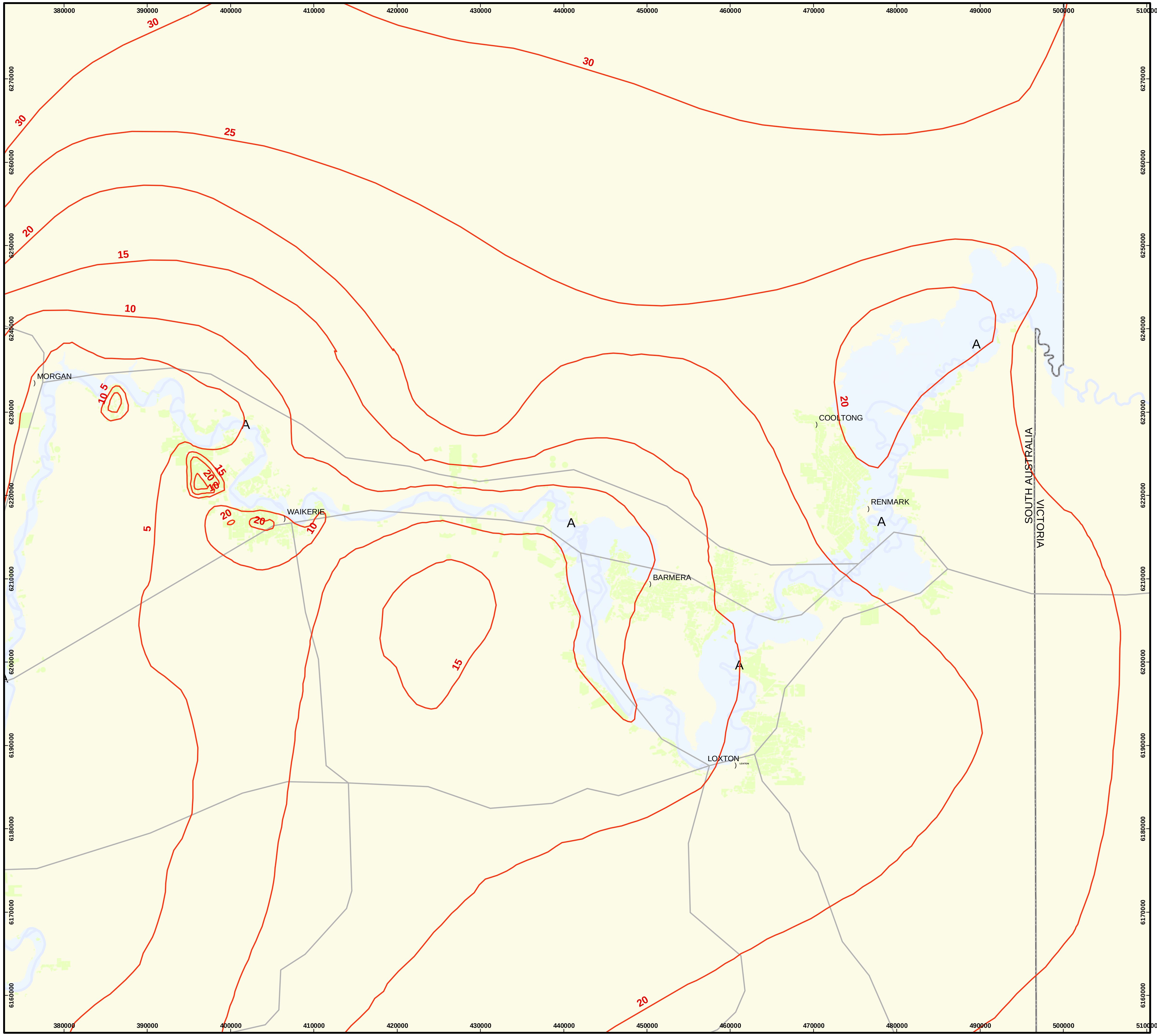

Figure 17

Murray Group Potentiometric Surface mAHD (1995)

- Towns
- A Locks
- MGL 1995
- SA / VIC Border
- Roads
- River Murray
- Irrigated Areas 2001
- 1956 Flood level

0 5 10 20 km

Datum: GDA94
Map Projection: MGA Zone 54

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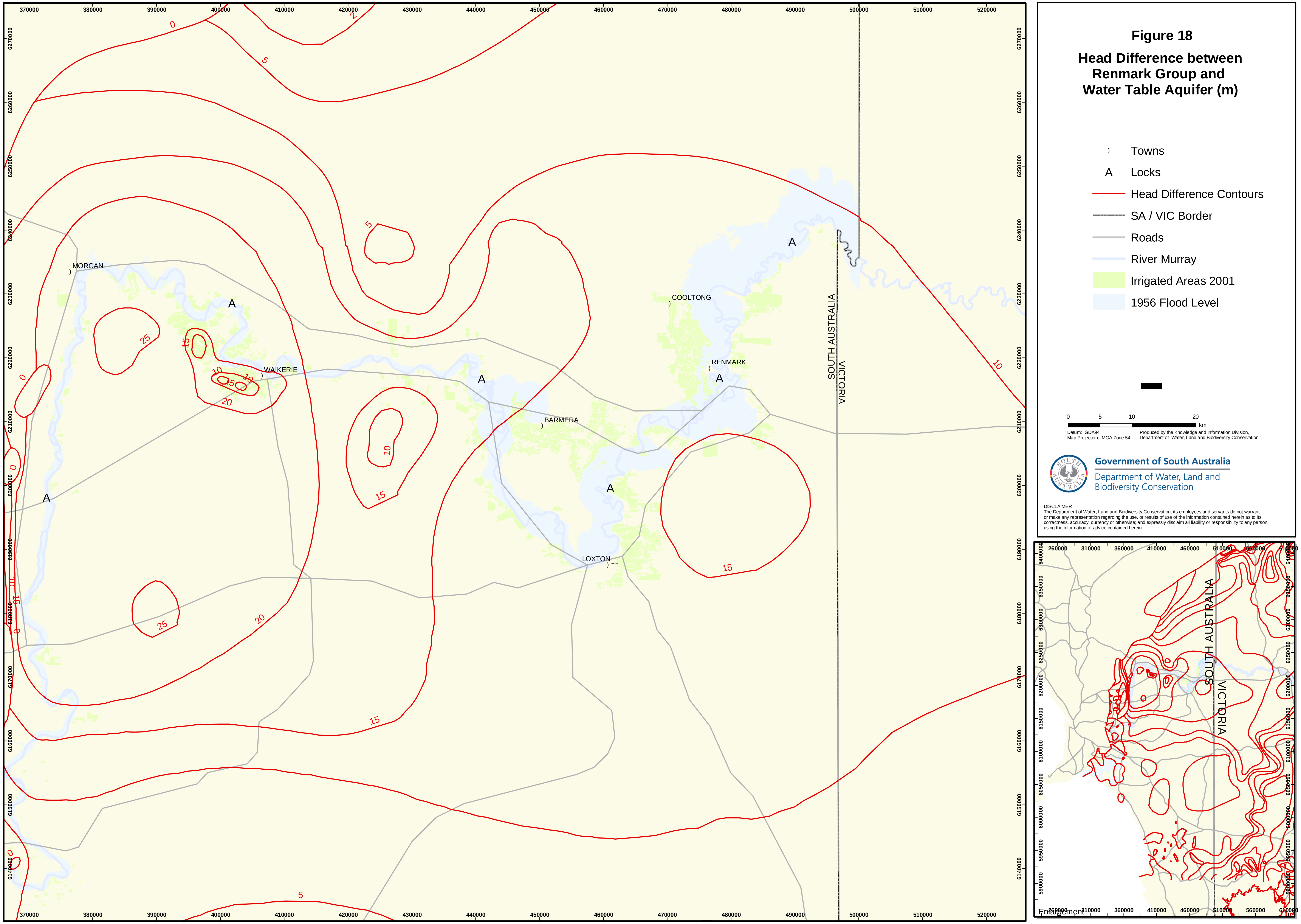
Figure 18

Head Difference between Renmark Group and Water Table Aquifer (m)



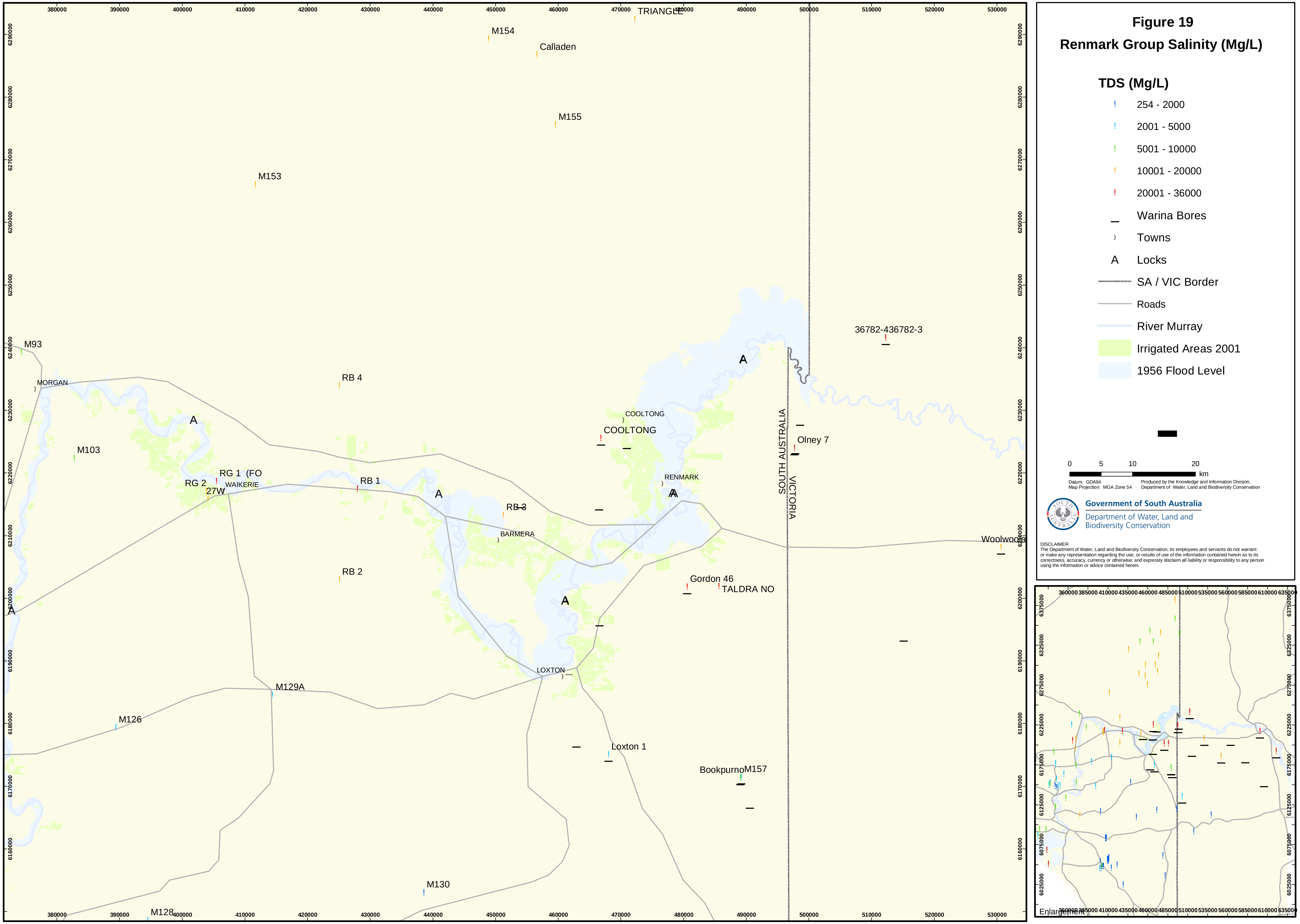


Figure 19
Renmark Group Salinity (Mg/L)
TDS (Mg/L)
254 - 2000
2001 - 5000
5001 - 10000
10001 - 20000
20001 - 36000
Warina Bores
Towns
Locks
SA / VIC Border
Roads
River Murray
Irrigated Areas 2001
1956 Flood Level
0 5 10 20 km
Datum: GDA94
Map Projection: MGA Zone 54
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TRIANGLE
M154
Calladen
M155
M153
M93
MORGAN
RB 4
M103
RG 1 (FO
RG 2
27W
WAIKERIE
RB 1
RB 3
BARMERA
RB 2
COOLTONG
COOLTONG
RENMARK
Olney 7
36782-436782-3
SOUTH AUSTRALIA
VICTORIA
Woolwoola
Gordon 46
TALDRA NO
LOXTON
M129A
M126
Loxton 1
BookpurnoM157
M130
M128
Enlargement

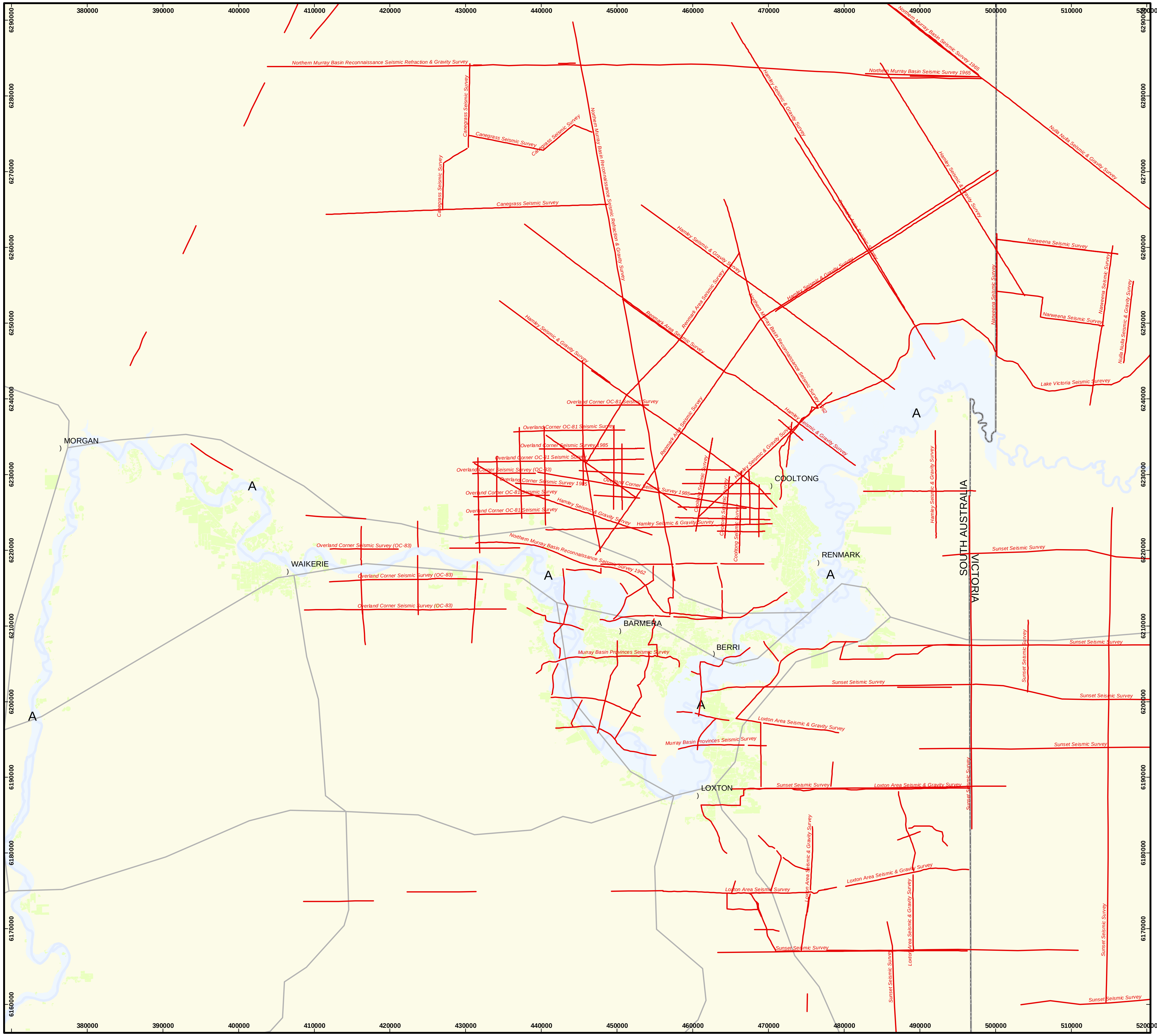

Figure 20
Seismic Survey Locations

- Towns
- A — Locks
- Seismic Lines
- SA / VIC Border
- Road
- River Murray
- Irrigated Areas 2001
- 1956 Flood Level

0 4.5 9 18 km

Datum: GDA94
Map Projection: MGA Zone 54

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This map aid selection of potential drilling targets and will also be used to refine the groundwater model and will assist in better understanding tectonic risks as a result of injection loading

5.3 MONITORING STATUS

There are 107 wells currently completed in the Renmark Group in South Australia however the condition of a majority of these wells is unknown (App. A). In the study area there are 7 current wells monitoring the formation (Fig. 21). These wells will be surveyed, geophysically logged and pumped.

5.4 WARINA CORE

There are currently no core samples but mud cuttings of lithology in the Glenside core library, despite indications of core existence in the SA Geodata database. Inspection of cuttings from Monash 1 and Loxton 2 wells indicate that the Warina Formation is highly variable, with the best sands occurring at the base of the sequence. It is proposed in Phase 2 to conduct sieve analyses on selected Warina Formation cuttings in the core library to determine best target zones or semi-quantitative estimates of hydraulic conductivity.

Due to the uncertainty of the thickness and depth to the Warina Formation in the Chowilla region, as part of Phase 2 it is proposed to drill either an investigation hole or an observation well to the base of the Warina Formation.

The benefits of drilling an observation well rather than an investigation hole are outlined below:

- An investigation hole only will give mineralogy results, Warina Formation samples to conduct the column experiments and a qualitive indication of well yield. An observation well (completed within the investigation hole) will achieve results that an investigation hole will, but also importantly obtain an in-situ water chemistry sample from the proposed injection site. If a water chemistry sample from the likely trial injection site is not obtained in Phase 2 then all chemical and biological assessment of clogging potential will be based on two existing Warina wells that are located an extensive distance away from the likely injection site. To reduce the risks associated with the Warina Formation groundwater being chemically and biologically different at the injection site from the regional wells, we are proposing to drill a well at the injection site.
- Should Phase 3 (trial injection) proceed, then an observation well is needed in addition to the production/injection well anyway, thus installation of an observation well in Phase 2 would potentially deliver some cost saving for Phase 3.
- An observation well will also give a semi-quantitative indication of the yield of any nearby injection wells and provide useful information for the costs of Phase 3.

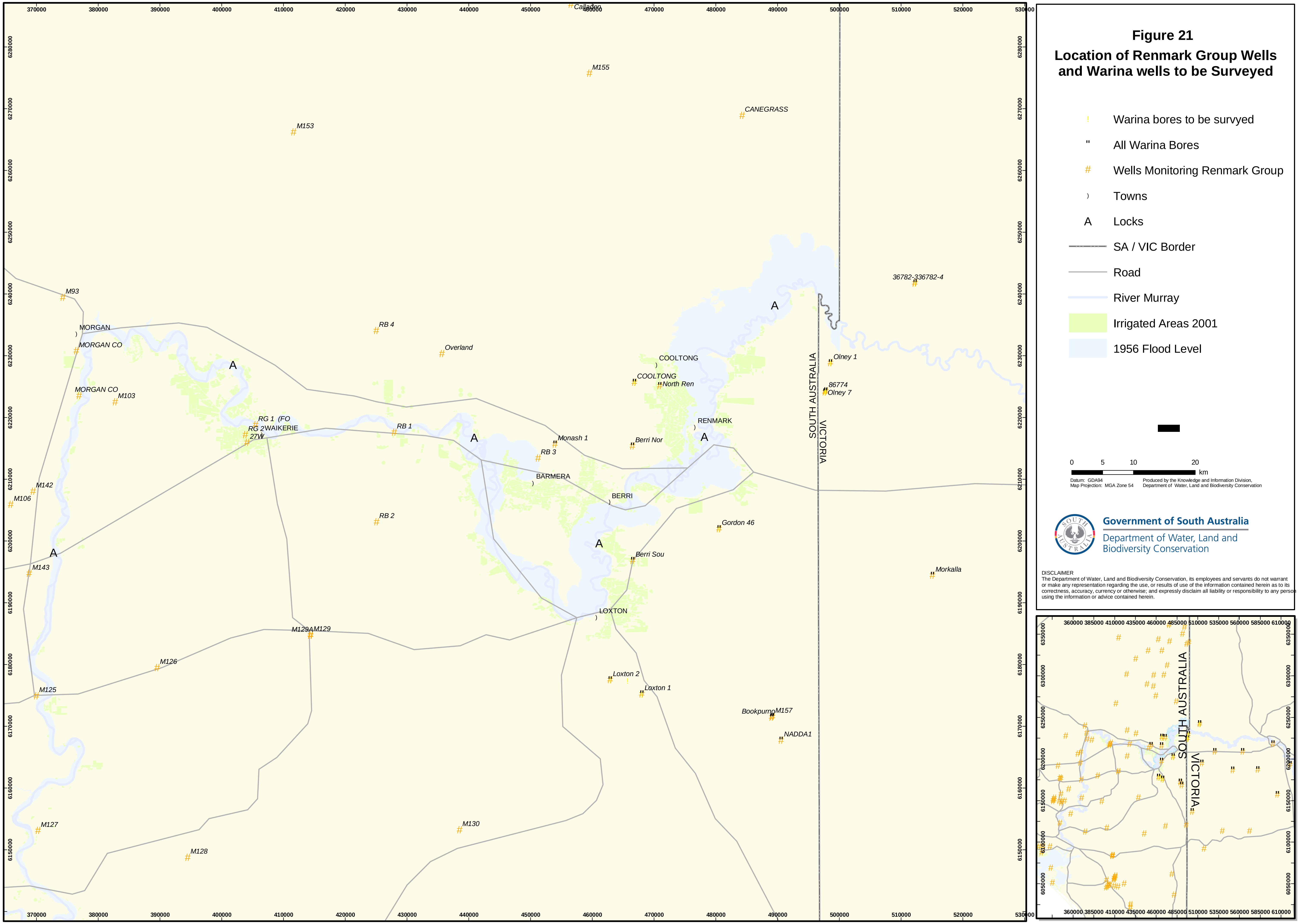

Figure 21
Location of Renmark Group Wells and Warina wells to be Surveyed

6. REGIONAL GROUNDWATER MODEL

6.1 BACKGROUND

The MODFLOW model was adapted from a pre-existing regional numerical groundwater model to simulate the regional impact of deep aquifer injection.

6.2 MODEL CONSTRUCTION

6.2.1 MODEL DOMAIN

The regional model domain extends east west from Lake Victoria to Morgan, and north south from 10 km above Chowilla to 20 km below Loxton. The bounding MGA coordinates are (southwest) E340000 N6060000 and (northeast) E540000 N6260000 (GDA1994). The grid size is 500 m by 500 m and the model layers structure contours are from the Murray Basin Hydrogeological map series – Renmark South Australia (Barnett S.R., 1991)

6.2.2 MODEL LAYERS

MODFLOW layer options for the regional model are provided in Table 1.

Table 1. Regional model layer options

Layer No	Hydrogeological unit	Aquifer/Aquitard
Layer-1	Loxton Sands, Monoman Formation	Aquifer
Layer-2	Lower Loxton Clay and Shells, Bookpurnong Formation	Aquitard
Layer-3	Murray Group Limestone	Aquifer
	Ettrick Formation (simulated as leakage)	Aquitard
Layer-4	Renmark Group – Olney Formation	Aquifer
Layer-5	Renmark Group – Warina Formation	Aquifer

6.2.3 MODEL AQUIFER AND AQUITARD HYDRAULIC PARAMETERS

Hydraulic parameters used in the regional model are provided in Table 2.

Table 2. Calibrated model aquifer and aquitard hydraulic parameters

Aquifer / aquitard	Kh (m/day)	KV (m/day)	SY (-)	SS (-)
Monoman Formation	15	1.5	0.05	-
Loxton Sands/shells/clay	5	0.05	0.05	-
Bookpurnong Formation	0.0001	0.0001	-	10-6
Murray Group Limestone	1	0.1	-	10-6
Ettrick Formation	10-6 - 10-7	10-6 - 10-7	-	-
Renmark Group – Olney Formation	5-15	0.1-0.5	-	10-6
Renmark Group - Warina Formation	6-10	0.5-10	-	10-5

6.3 MODELLING SCENARIOS AND RESULTS

6.3.1 MODEL CALIBRATION

Steady state calibration is undertaken to develop a broad-scale hydraulic conductivity distribution by matching modelled to observed potentiometric heads. Steady state calibration was performed by adjusting hydraulic conductivities (within reasonable limits) and model boundary conditions. Dynamic stresses and storage effects are excluded from steady state calibration.

A modelled potentiometric surface was achieved that closely matches the constructed (groundwater table) potentiometric surface in the Loxton Sands, Murray Group Limestone and the Renmark Group Aquifer. Potentiometric surfaces were matched to those created by the Murray Basin Hydrogeological map series – Renmark South Australia (Barnett S.R., 1991).

6.3.2 MODEL ASSUMPTIONS

This transient scenario predicts the response of both the Monoman Formation, Loxton Sands, Murray Group Limestone and the Warina Formation aquifers.

The SIS and part Environmental Scheme (ES) involves a curtain of continuously pumping production wells located on the eastern side of the River Murray from Loxton to Murtho and on the northern side of the river at Chowilla. The number of production wells was not simulated, only the predicted total volumes of water intercepted in each scheme formed the basis of this simulation. This amounted to 190 L/sec from the Loxton-Bookpurnong, 250 L/sec from the Pike-Murtho area and 100 L/sec in the Chowilla region (Fig. 22). The intercepted groundwater is then disposed through 60 injection wells completed in the Warina Formation (at a rate of 10 L/sec per well) over a large area from Loxton to Chowilla (Fig. 22). It is worth noting that 10 L/sec is likely to be a conservative value. The Warina Formation could possibly be injected at rates between 25 to 50 L/sec, which would be determined during Phase 3.

The Hamley Fault is modelled as a barrier boundary to lateral flow in the Warina formation.

Although the range of the hydraulic conductivity of the Olney Formation is greater than the Warina Formation (Table 2), in most situations the Warina Formations hydraulic conductivity was greater than the Olney Formations.

6.3.3 MODEL RESULTS

Modelling indicates that the salt load impact upon injection to the River Murray is insignificant as there are no head pressure changes induced within the Loxton Sands (which forms the water table aquifer discharging saline groundwater in the modelled area) over 100 year period.

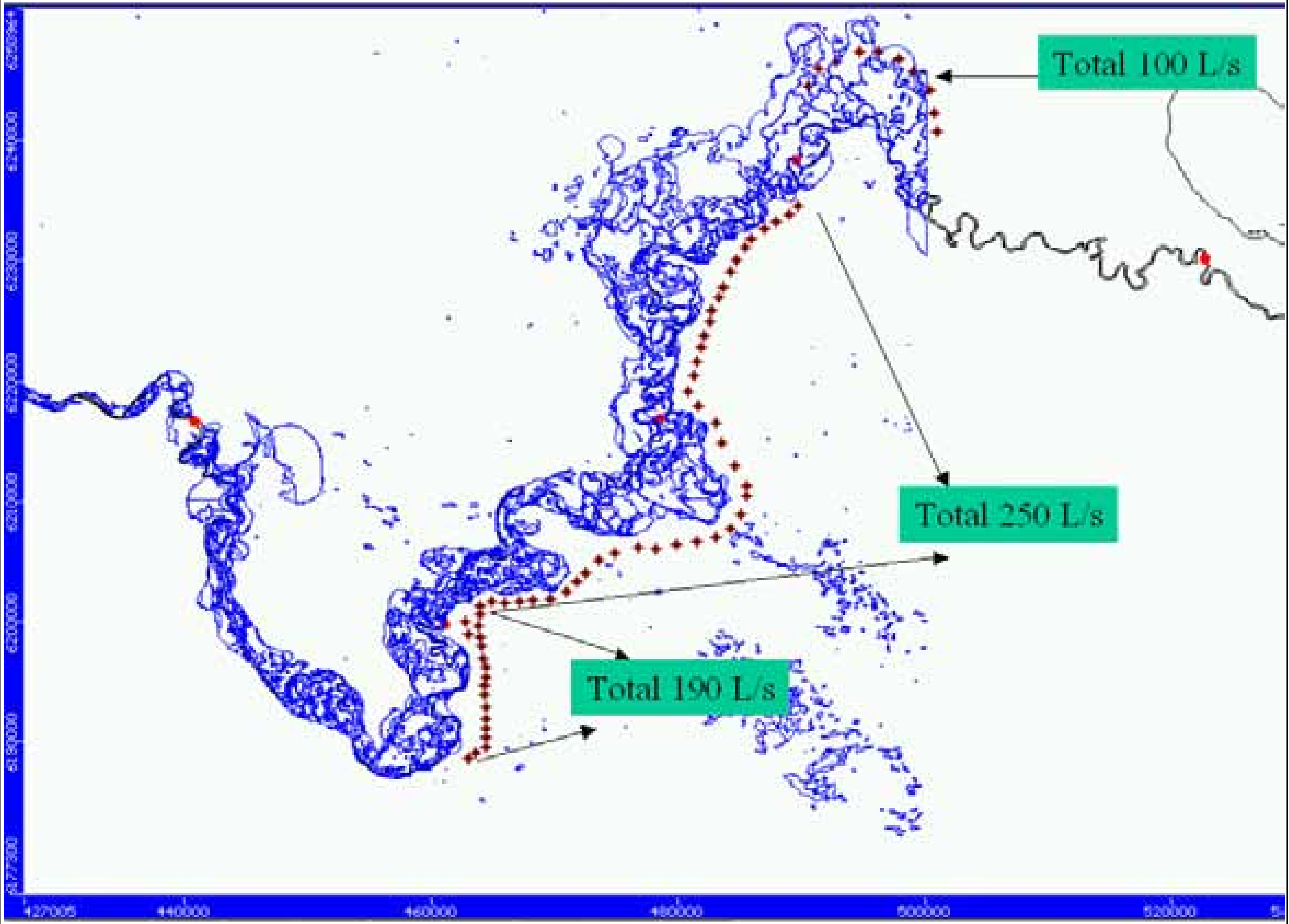

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Figure 22 Modelled Interception Volumes and Injection wells Locations.

Figure 23 shows particle (solute) travel distance in steady state simulation with each arrow on the line representing 1000 years of movement. Particles move in a radial direction from the injections sites. The model indicates that the maximum head pressure change in the Warina Formation is 50–60 m.

Some injected water flows within the Warina Formation in a southeast direction towards and along the Hamley Fault. At the Hamley Fault, some groundwater is forced upwards, causing potential leakage into the Murray Group Limestone (Fig. 24). Modelling predicts that within 100 years of commencement of injection, there at will only be an increase in head of 0.1–0.2 m in the Murray Group Limestone at Woolpunda on the western side of the Hamley Fault (Fig. 25).

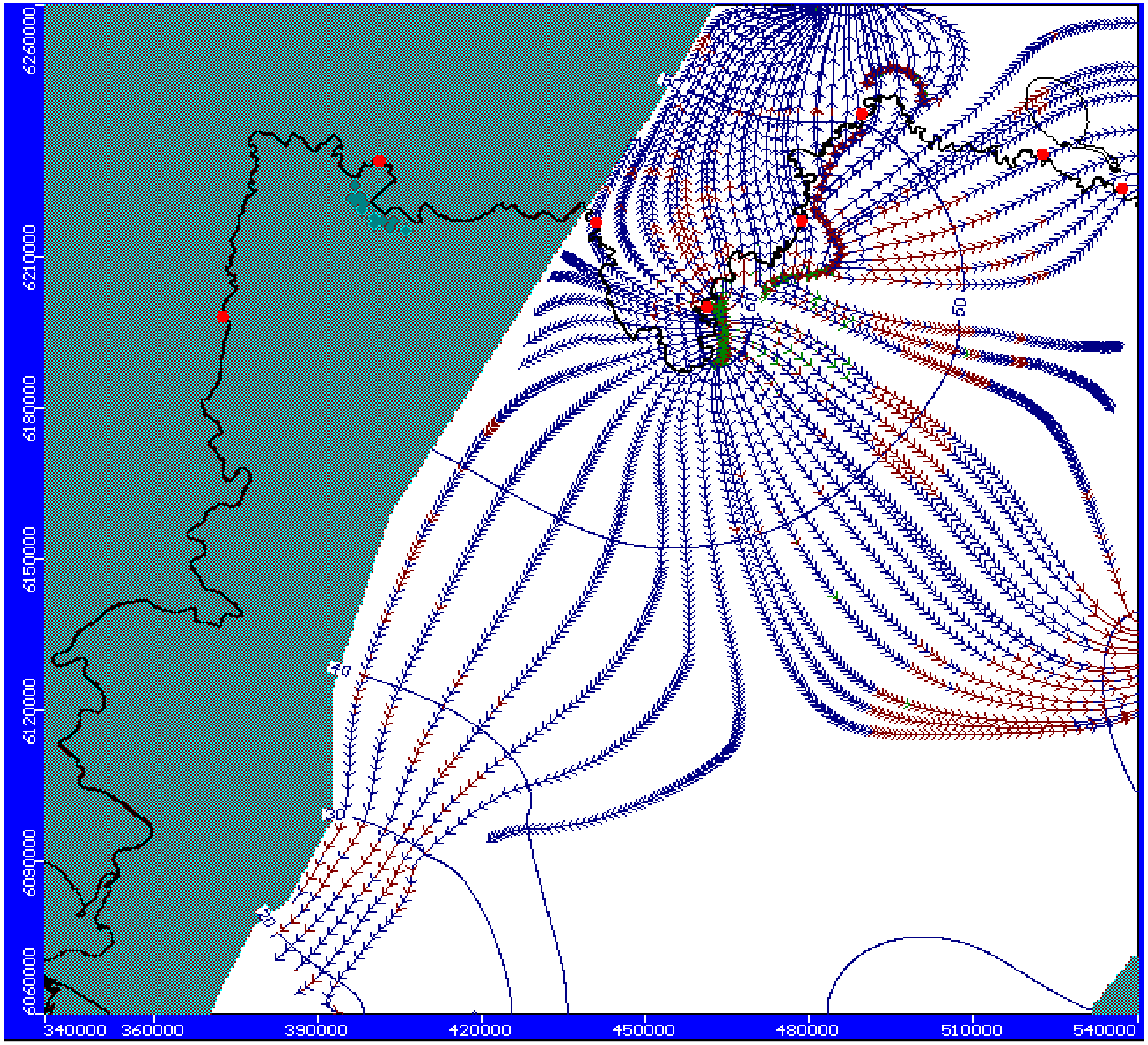

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Figure 23 Modelled Particle Travel from Injection sites and Maximum head increase in Warina Sands

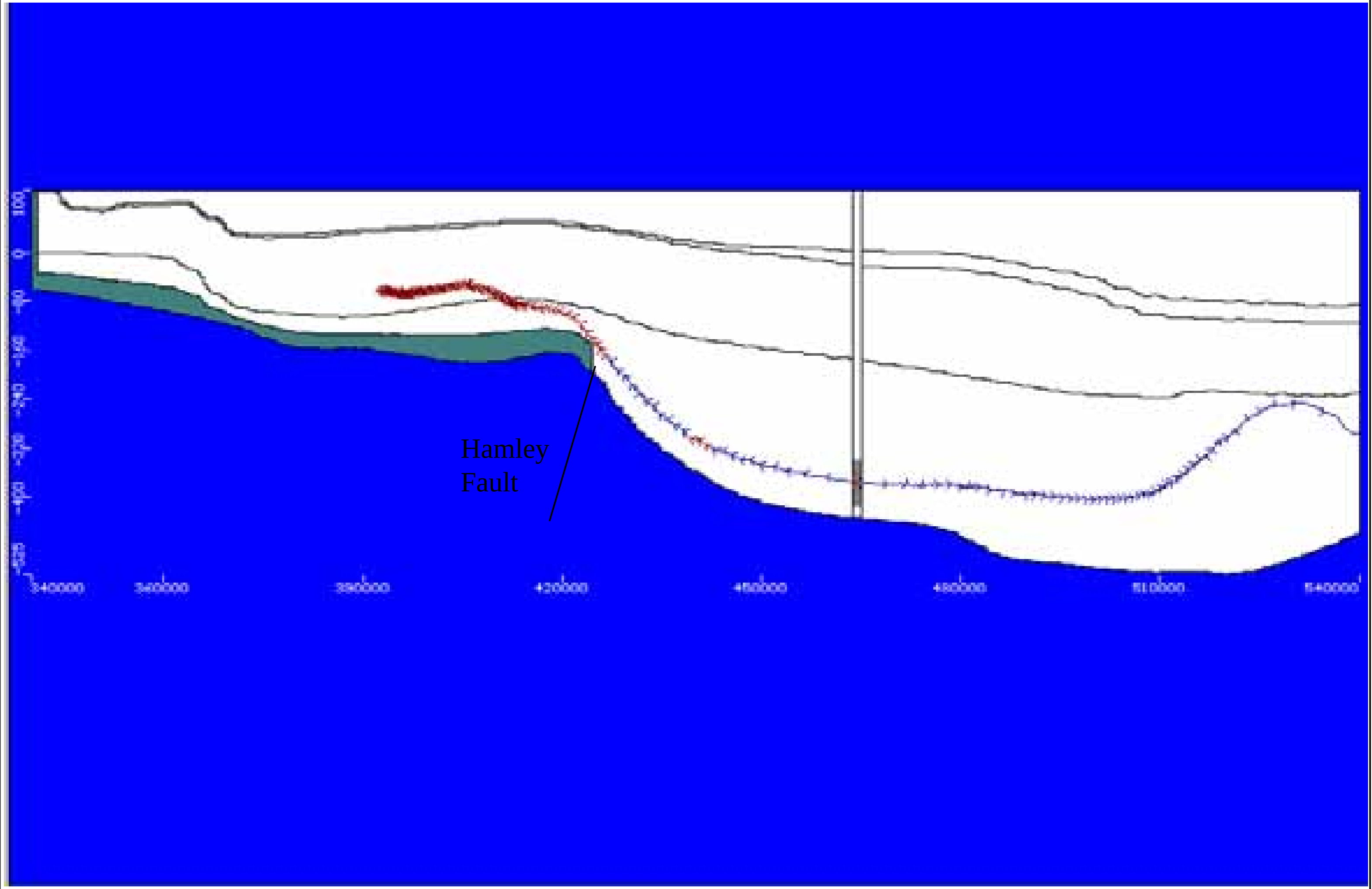

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Figure 24 Modelled Cross-section of particle travel over the Hamley Fault

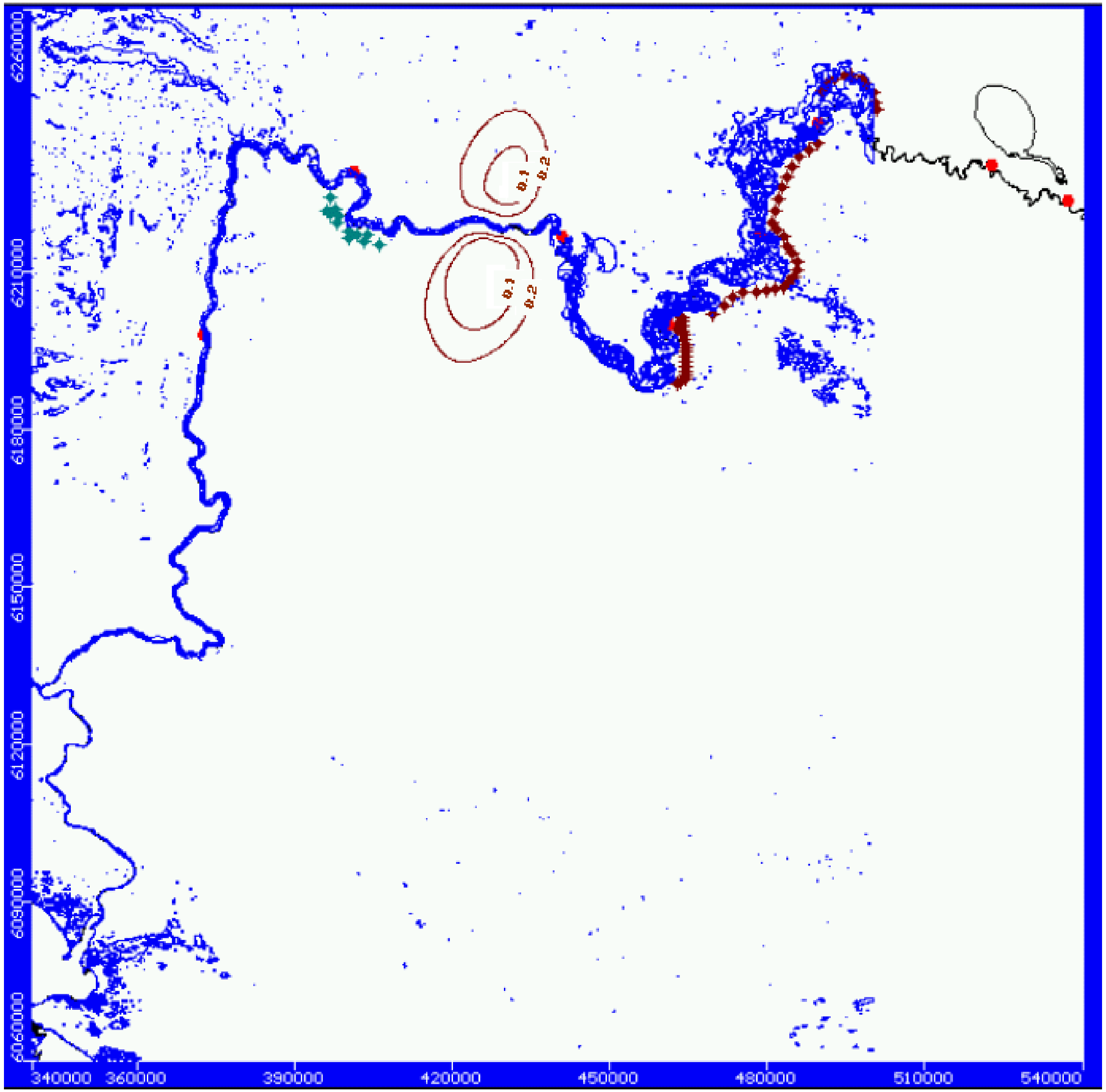

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Figure 25 Modelled head increase in the Murray Group Limestone over 100year period

7. CONCLUSIONS

- Deep aquifer injection of brines occurs extensively in the US oil and gas industry. Additional literature should be sought into operational issues that are encountered in the US to assist this Renmark Group Injection.
- High yielding basal sands of the Warina Formation (Lower Renmark Group) represent the best target aquifer for saline groundwater disposal (1-32 L/sec). In the study area, the Warina Formation has a known maximum thickness of 231 m although there is no information in the Chowilla region. The Ettrick Formation is a competent confining bed averaging 25 m over the study area, away from basement highs.
- The Warina Formation is best developed east of the Hamley Fault, although there are indications that it may occur in isolated grabens south of Waikerie between the Morgan and Hamley Faults.
- Numeric groundwater flow modelling with MODFLOW indicates that injection has no significant impact to the River Murray or little impact on overlying aquifers. Whilst there is an expected 50–60 m increase in head pressure within the Renmark Group, an increase of only 0.1–0.2 m is modelled for the overlying Murray Group Limestone aquifer.
- Particle track analysis and numerical modelling indicate that a significant groundwater flow path arising from injection into the Renmark Group is to the south west, parallel with the Hamley Fault, possibly the salt load could discharge into Lake Alexandrina in excess of 100 000 years from the commencement of injection.
- Physical, biological and chemical clogging represents the greatest technical risk to project viability and comprises the main issue addressed by the recommended Phase 2 feasibility study.

8. RECOMMENDATIONS FOR PHASE 2

1. Conduct a broader literature review of brine injection and problems encountered in the US and Europe.
2. Locate the existing seven Warina Formation monitoring wells in the Renmark region to assess status and condition.
3. Geophysically log the existing seven Warina Formation wells (number of wells subject to well audit).
4. Pump the existing seven Warina Formation wells to obtain groundwater samples for full chemistry analyses. In addition, pump several Monoman Formation wells at Chowilla to obtain groundwater samples for full chemistry analyses, which will allow assessment of injected water - native groundwater interaction.
5. Drill an observation well at Chowilla at the likely trial injection site to determine if the Warina Formation fully viable for injection in that local area.
6. Determine the potential for clogging of the well(s) and aquifer resulting from water-water interaction, rock-water interaction, biogeochemical interactions, physical and mechanical clogging at both local and regional scale.
7. Refine Isopachs of the Warina Formation with PIRSA seismic data.
8. Recommend a site to drill an injection well into the Renmark group to enable a disposal trial (Phase 3) and:
    - Determine the specifications for construction of the well(s) and associated cost of the program.
    - Determine the various aquifer and injection testing that will be required (and the cost) for Phase3.
    - Determine the chemical sampling that will be required (and the cost) for Phase 3.
9. Undertake further more detailed numerical groundwater modelling:
    - Input updated structure contours.
    - Further calibrations.
    - Run predicted scenarios i.e. injection only in the Chowilla region etc.

APPENDICES

A. RENMARK GROUP WELL INFORMATION IN MURRAY BASIN SOUTH AUSTRALIA

Unit No	Name	Depth (m)	Max Drilled Depth (m)	Grnd Elevn (m)	Ref Elevn (m)	Easting	Northing	Permit No	Well Class	Purpose	Status	Drilling Method	Drillers Log	Litho Log	Hydro strat Log	Strat Log	Water Chemistry	Rock Sample	Geophysical Log	Geophysic Job No	Core	Cored length	Latest Yeild date	Yeild L/sec	Yield extraction code	Salinity Date	EC	TDS (mg/L)	SWL	RSWL	SWL Date	Case From	Case to	Casing Material	Casing Diameter	Cement from	Cement to	Pzone From	Pzone To	Pzone Material	Pzone Diameter	Aquifer Mon
672702238		76	76	11.23	11.54	332340	6094106	14962	WW	OBS		Rotary - Air	Y	Y	Y	N	Y	Y	Y	240	Y		25-Aug-84	1.5		04-May-05	12220	7029	9.07	2.16	06-Jul-05	0	73	GLI	125	0	65	68	73		110	Tr
672702241		71	71.3	29.41	29.974	324137	6094826	14965	WW	OBS		Rotary - Air	Y	Y	Y	N	Y	N	Y	245	Y		11-Sep-84	1		02-May-05	9630	5481	23.84	5.57	06-Jul-05	0	62	GLI	125	0	59	62	64	SST	110	Tr
672702243		105	105.3	23.16	23.298	319094.8	6094051.2	14967	WW	OBS		Rotary - Air	Y	Y	Y	N	Y	N	Y	251	Y		22-Sep-84	2		27-Apr-05	1799	993	13.37	9.79	06-Jul-05	0	81	GLI	125	0	73	76	78	SST	110	Tr
662707198		125	125	17.22	17.721	312839.7	6084681.2	14705	WW	OBS		Rotary - Air	Y	Y	Y	N	Y	N	Y	311	Y		11-Dec-84	1		19-May-05	18200	10702	15.04	2.18	06-Jul-05	0	97.3	GLI	125	0	88.5	92	94	SST	110	Tr
672702266		150	150	9.35	9.693	322333.8	6086943.2	14710	WW	OBS		Rotary - Air	Y	Y	Y	N	Y	N	Y	358	N		28-Feb-85	4		11-May-05	4460	2488	5.82	3.53	06-Jul-05	0	103.7	GLI	125	0	96.7	98.7	100.7	SST	110	Tr
692900760	RB 2	138	138	63.29		425072	6202978.1	28113	WW	OBS		Rotary	N	N	Y	N	Y	N	Y	1713	Y		20-Aug-92	1	AIRL	20-Aug-92	23300	13946	38.43	24.86	01-Apr-00	0	134.5		75							Tr(RG)
682600041	COONALPYN TWS NO 4	117	116.74			402331.7	6047997.1		WW	TWS		Cable Tool	N	N	Y	N	Y	N	Y	2839	Y		19-Nov-65	5.05	PUMP	11-Sep-67	15382	8930	13.72		19-Nov-65	0	112.8	STL	152			112.78	116.74		152	Tr(RG)
672800408		74	73.76	94		343625.8	6148829.2					Rotary - Percussion	N	N	Y	N	Y	N	N		N		21-Jun-52	0.1		21-Jun-52	3397	1886	49.68	44.32	21-Jun-52	0	66.35		127			66.35	73.76			Tr
672800565		94	94.49			337446.8	6150509.3						N	N	N	N	N	N	N		N		01-Jan-51	0.16		22-Jan-81	9000	5109	46.35		22-Jan-81	0	94.49		152							Tr
672802410	COFFEY PART PL	73	73.2		90.25	344257.9	6176821.2					Rotary - Mud	N	N	N	N	N	N	N		N		21-Oct-81	0.1		14-Mar-83	7600	4291	29.47	60.78	06-Feb-86	0	64		80							Tr(RG)
672802407	COFFEY PART PL	72	72		90.37	344262.9	6176839.3					Rotary - Mud	N	N	N	N	N	N	N		Y		11-Oct-81	0.15		14-Mar-83	4650	2596	29.55	60.82	06-Feb-86	0	72		100							Tr(RG)
682600040		104	103.94			401562.8	6045835.9						N	N	Y	N	N	N	N		N		26-Feb-53	0.76	WMLL	15-Nov-78	461	254	10.36		15-Nov-78											Tr(RG)
692600701		134	134			429203	6021008					Rotary - Mud	Y	N	N	N	N	N	N		N		29-Sep-04	5.5					8		29-Sep-04	-0.5	128	PVC	157	0	128	128	133	SST	115	Tr(RG)
692600693		192	192			421514	6049681					Rotary - Mud	Y	N	N	N	N	N	N		N		06-May-04	15		06-May-04	1853	1023	15		06-May-04	-0.5	121	PVC	200	0	121	117.7	125.3	SST	156	Tr(RG)
713000008	36782-3	272	272	43.34	44.472	512247.7	6241639						Y	N	Y	N	N	N	N		N					29-May-90	40303	25541	11.96	32.52	05-Feb-03							264	272			Tr(RG)
713000009	36782-4	488	488	43.24	44.355	512256.5	6241642.2						Y	N	N	N	N	N	N		N					29-May-90	34918	21736	10.93	33.43	05-Feb-03							448	460			Tr(RG)
692600647		146	146	36.39	36.326	429148	6025008		WW	DOM		Rotary	Y	N	N	N	N	N	N		N		08-Feb-02	5		06-Oct-02	2310	1278	9.19	27.2	07-Apr-05	0	132	PVC	157	0	132	132	142.7	SST	115	Tr(URG)
672802605		70	70	88		345665.9	6176165.2		WW	EXP		Rotary	Y	N	Y	N	N	N	N		N	0	06-Mar-87	0.01					26.3	61.7	05-Apr-87	0	66.5		50							Tr
682601253	COOMA PARK NO 1	195	195	25.9	25.896	409235.1	6054729		WW	IRR		Rotary - Mud	Y	N	N	N	N	N	N		N		03-May-01	15		03-May-01	2030	1121	16.73	9.17	04-May-01	0	172	FRP	203	0	172	172	188	SST	153	Tr(RG)
682701877	BORE 2	162	162		32.487	407034	6083744		WW	IRR		Rotary	Y	N	N	N	N	N	N		N		07-Jun-02	20	AIRL	13-May-02	2530	1401	19.5	12.99	20-Oct-03	-0.5	147	FRP	200	0	147	145.5	149.5	SST	115	Tr(RG)
682701889	BORE 3	166	166.3		34.905	408007	6083287		WW	IRR		Rotary - Mud	Y	N	N	N	N	N	N		N		05-Feb-04	30		01-Mar-04	2380	1317	23.5	11.41	05-Feb-04	-0.6	140	FRP	255	0	140	135	150	SST	224	Tr(RG)
682701893	BORE 6	160	160		26.511	407181	6082902		WW	IRR		Rotary - Mud	Y	N	N	N	N	N	N		N		19-Mar-04	35		19-Mar-04	2440	1351	20.98	5.53	19-May-05	0	21	WST	343	0	137	134	146	SST	225	Tr(RG)
692600520		201	201			414281	6046055		WW	IRR		Rotary - Mud	Y	N	N	N	N	N	N		N		06-May-99	50		06-May-99	1930	1066	19.18		23-Jul-02	0	166	FRP	250	0	166	166	198	SST	200	Tr(RG)
692600695		196	196			409599	6046792		WW	IRR		Rotary - Mud	Y	N	N	N	N	N	N		N		18-May-04	50					15.6		18-May-04	-0.5	178.5	FRP	257	0	179	174	186	SST	225	Tr(RG)
702700873		300	300	78.13	78.93	496016	6119890		WW	OBS		Rotary - Mud	Y	N	Y	N	N	N	N		N		10-Jul-03	3		11-Jul-03	2230	1233	40.37	37.76	11-Nov-04	0	250	FRP	76	0	250	250.5	252.5	SST	51	Tr(RG)
703200023	M88	90	90		104.338	475496.2	6360609.3		WW	OBS		Rotary - Mud	N	N	Y	N	N	N	N		Y		26-Sep-81	0.03					63.82	40.52	14-Jul-92	0	78	PVC	80	54	59	78/87	80/89	SST	80	Tr(URG)
703100002	Postmark bore	163	162.76		84.41	499375.2	6339991.2		WW	STK		Cable Tool	N	N	Y	N	N	N	N		N		01-Jan-53	1.01		11-Aug-81	15000	8708	47.3	37.11	11-Aug-81	0	155.4	STL	127							Tr
703000001	Calladen bore	185	184.71		56.12	456569	6286789.3		WW	STK		Cable Tool	N	N	Y	Y	Y	N	N		N					21-Aug-52	18368	10781	20.3	35.82	05-Nov-85	0	173.1	STL	127			173.13	184.71			Tr
703100007	CHRISTMAS BORE	175	175.26		67.05	456967	6300269.3		WW	STK			N	N	N	N	Y	N	N		Y					14-Nov-52	23928	14322	32.7	34.35	12-Aug-81	0.1	7		127			7	175.26			Tr
682600019	CK SHILLING & CO	100	99.67			399815.8	6045217		MW	STK		Cable Tool	N	N	Y	N	Y	N	N		Y	0	24-Nov-60	2.1	PUMP	24-Nov-60	3722	2070	8.23		24-Nov-60	0	95.4		127			95.4	98.2		127	Tr(RG)
692900495	M129A	214	213.5		63.522	414409	6184605.2	94763	WW	OBS	ABD	Rotary	N	N	N	N	Y	N	Y	791	Y		01-Jul-87	3	PUMP	11-Mar-88	5181	2898	34.31	29.21	21-Mar-05	0	203.5		76							Tr(RG)
672800555		110	109.73	150.91	151.061	337378.9	6152806.2				ABD		N	N	Y	N	Y	N	N		N		15-Aug-50	0.1	WMLL	15-Aug-50	4304	2399	49.9	101	24-Oct-85	0.4	103		127			103.02	109.73			Tr
672800561		108	107.59	180		335935.8	6150429.2				ABD	Cable Tool	N	N	Y	N	Y	N	N		N		16-Aug-48	0.2		08-Dec-47	4127	2299	73.15	106.9	16-Aug-48				152			77.11	107.59			Tr
682600036	COONALPYN TWS NO 3	128	128.02			404065.8	6047968.9		WW		ABD	Cable Tool	N	N	Y	N	Y	N	N		Y		21-Sep-62	5.05		16-Sep-60	2374	1313	10.36		21-Sep-62	0	116.4		203			115.82	118.87		152	Tr(RG)
702800001	Loxton 1	488	488.29	41.15	54.864	468016.3	6175119.5		PW	EXP	ABD	Diamond Bit - Coring	N	N	N	Y	Y	Y	N		Y	33.8	20-Nov-56	1.26		20-Nov-56	5341	2989	-10.98	52.12	20-Nov-56											
692900429	Overland Corner 1	655	654.7	69.19	71	435683.3	6230212.5		PW	EXP	ABD	Diamond Bit - Coring	N	N	Y	Y	N	Y	N		Y	330.7																				
702800002	Loxton 2	550	549.86	0	0	462885.5	6177379.7		PW	EXP	ABD	Diamond Bit - Coring	N	N	N	Y	N	Y	N		Y	19.2										0	431		127			430.99	549.86			
702800003	NADDA1	1041	1041.2	28.96	32.614	490574.6	6167623.5		PW	EXP	ABD	Rotary - Mud	N	N	N	Y	N	Y	N		Y	5.18										0	153		229			153.01	1041.2			
702900001	Berri South 1	664	663.55	51.82	55.169	466562.4	6196737.7		PW	EXP	ABD	Diamond Bit - Coring	N	N	N	Y	N	N	N		Y	8.23										0	146.3		244			146.3	663.55			
702900004	North Renmark 1	1225	1224.69	23.6	24.515	470918.5	6225028		PW	EXP	ABD	Diamond Bit - Coring	N	N	N	Y	Y	Y	N		Y	51.82				01-Jan-46	3861	2148				0	530.7		127			530.66	1224.7			
702900005	Berri North 1	945	944.88	41.76	45.72	466496	6215249.3		PW	EXP	ABD	Diamond Bit - Coring	N	N	N	Y	Y	Y	N		Y	12.19				01-Jan-46	4084	2274				0	139.9		244			139.9	944.88			
702901330	Monash 1	1050	1050.04	33.22	34.442	453969.9	6215581.1		PW	EXP	ABD	Diamond Bit - Coring	N	N	N	Y	N	Y	N		Y	17.68				26-Nov-64	64144	42449				0	537.7		127			537.67	1050			
702800469	M157	602	601.7		29.13	489184.1	6171479.1		WW	OBS	ABD	Rotary - Air	N	N	N	Y	Y	Y	N		Y	0	09-Jun-88	25		11-Dec-96	8000	4524	-8.31	37.44	01-Dec-97				152			387.1	601.7			Tr(RG)
703100009	CANOPUS NO 2	306	306.02		77.24	473238	6312219.2		WW	STK	ABD	Cable Tool	N	N	Y	N	Y	N	N		Y		13-Feb-54	0.45	PUMP	20-Nov-53	19022	11185	42	35.24	24-May-77	0	304	STL	102			304	306	SST		Tr
703100003	TOP BORE	174	173.74		77.43	466866.2	6329785.1		WW	STK	ABD		N	N	Y	N	N	N	N		N		17-Jul-53	0.61		17-Jul-53	16051	9353	40.58	36.85	05-Nov-85											Tr
703100004	Box Swamp Bore	173	172.52		71.13	462557.2	6343423.2		WW	STK	ABD	Cable Tool	N	N	Y	Y	N	N	N		N		27-Jul-70	1.21	PUMP	27-Jul-70	14958	8684	34.46	36.67	10-Aug-81	0	168	STL	127			167.95	171	SST	127	Tr
703000004	CANEGRASS BORE	207	207.26		30.49	484264.2	6268784.2		WW	STK	ABD	Cable Tool	N	N	Y	Y	Y	N	N		N		21-Jan-27	2.5256		21-Jan-27	24705	14839														Tr
693100016	COCKATOO BORE	193	192.63		82.83	424446	6301455.4		WW	STK	ABD	Unknown	N	N	Y	Y	N	N	N		N	0							48.3	34.53	05-Nov-85											Tr
682800731	M126	96	96		52.52	389412.9	6179431.2		WW	OBS	BKF	Rotary - Mud	N	N	Y	N	N	N	Y	67	Y					11-Mar-88	5200	2909	26.31	26.21	21-Mar-05	0	2		152			2	96			Tr(RG)
683000291	M98	224	224	62.91	62.91	372816.9	6251293.5		WW	OBS	BKF	Rotary - Mud	N	N	Y	Y	N	Y	Y	2769	Y	0										0	2		143			172.4	189.6	SST	153	
682900802	M101	234	234		59.44	364242.9	6225395.3		WW	OBS	BKF	Rotary - Air	N	N	Y	Y	N	Y	Y	2770	Y	0	29-Mar-82	0.04		27-Mar-82	6600	3712	29.16	30.28	12-Mar-88			STL	80	102	198	205	207	SST	80	Tr(RG)
702900984	TALDRA NO 1	730	730.3		42.31	485646	6201983.1		WW	OBS	BKF	Rotary - Mud	N	N	Y	Y	Y	Y	N		Y	0	27-Apr-88	8.3	AIRL	19-Sep-90	34100	21191	16.92	25.39	04-Mar-98			STL	152	0	110	496	502	SST	152	Tr(RG)
703000005	TRIANGLE BORE	175	175.26		54.45	472201	6292469.2		WW	STK	BKF	Cable Tool	N	N	Y	Y	N	N	N		N		21-Aug-52	1.2628		21-Aug-52	23440	14006	19.8	34.65	21-Aug-52											Tr
682900807	M106	153	153.4		77.18	365860.9	6205806.5	9884	WW	OBS	CAP	Rotary - Air	N	N	Y	Y	Y	N	Y	17	Y	0	13-Apr-83	0.4		13-Apr-83	22748	20541	47.67	29.51	19-Apr-84	0	134.5	STL	80	18	121	126	128	SST	82	Tome1(CC)
702700585	M136	248	248.3	83.73	84.487	471249	6118740.2	92859	WW	OBS	CAP	Rotary - Mud	N	N	Y	Y	Y	N	Y	33	Y	0	21-May-83	0.07		08-Mar-89	2070	1142	47.59	36.14	07-Apr-05	0	144.8		80							Tr(RG)
672901170	M124	116	116		105.11	341784.9	6191448.3		WW	EXP	CAP	Rotary - Mud	N	N	N	Y	Y	N	Y	57	Y	0				19-Jun-84	11890	6826	39.46	65.65	21-Apr-92	0	78		80							Tr(RG)

Unit No	Name	Depth (m)	Max Drilled Depth (m)	Grnd Elevn (m)	Ref Elevn (m)	Easting	Northing	Permit No	Well Class	Purpose	Status	Drilling Method	Drillers Log	Litho Log	Hydro strat Log	Strat Log	Water Chemistry	Rock Sample	Geophysical Log	Geophysic Job No	Core	Cored length	Latest Yeild date	Yeild L/sec	Yield extraction code	Salinity Date	EC	TDS (mg/L)	SWL	RSWL	SWL Date	Case From	Case to	Casing Material	Casing Diameter	Cement from	Cement to	Pzone From	Pzone To	Pzone Material	Pzone Diameter	Aquifer Mon
682900809	M142	230	229.5		47.1	369451.9	6207914.1		WW	EXP	CAP	Rotary - Mud	N	N	Y	Y	Y	N	Y	169	Y	0	29-May-84	1.2626		28-May-84	29300	17906	23.01	24.09	28-May-92	-0.7	216	STL	75	0	204	211	213	SST	75	Tr(RG)
682900811	M143	221	221		45.88	368858.9	6194624.2	93511	WW	OBS	CAP	Rotary - Mud	N	N	Y	Y	Y	N	Y	171	Y	0	09-Jun-84	0.55		09-Jun-84	21351	12667	17.17	28.71	28-May-92	0	141	STL		0	130	136.5	138.5	SST	75	Tome1(CC)
672802487	M145	120	120	109.39	110.184	345444	6157383		WW	EXP	CAP	Rotary - Air	N	Y	Y	Y	Y	N	Y	390	N	0	13-May-85	0.5	PUMP	01-Sep-87	3710	2064	38.08	71.31	20-May-05	-0.3	103	STL	75	0	94	98	100	SST	70	Tr(RG)
693000017	M153	179	179		66.23	411666.1	6266093.3	94436	WW	OBS	CAP	Rotary - Air	N	N	Y	Y	Y	N	Y	617	Y	3.3	26-Jun-86	0.12	AIRL	27-Jun-86	22650	13534	36.55	29.68	11-Jul-92	0	175	STL	75	0	164	171	173	SST	75	Tome1(CC)
693000018	M154	415	415		67.613	448881	6289335.2	95070	WW	OBS	CAP	Rotary - Air	N	N	Y	Y	Y	Y	Y	998	Y	0	10-Dec-88	3.5	AIRL	10-Dec-89	16900	10374	32.84	34.77	20-Mar-94	0	225	SST	76	0	118	225	227.5	SST	76	Tr(RG)
703100015	M74	158	157.5		98.68	476226.1	6341004.2	8652	WW	OBS	CAP	Rotary - Mud	N	N	Y	Y	Y	N	Y	2691	Y	0	05-Jun-81	2.5	AIRL	05-Jun-81	18576	11314	62.69	35.99	13-Jul-92	0	154	PVC	80			154	156	SST	80	Tr(RG)
703200022	M87	160	160		104.31	475496.2	6360609.3		WW	OBS	CAP	Rotary - Mud	N	N	Y	Y	N	N	Y	2725	Y	0	23-Sep-81	0.06					65.6	38.71	14-Jul-92	0	151	PVC	80	46	107	151	153	SST	80	Tr(RG)
703200020	M92	138	138		123.89	494032.2	6382301.3		WW	OBS	CAP	Rotary - Mud	N	N	Y	Y	Y	Y	Y	2730	Y	0	20-Oct-81	0.5		20-Oct-81	17210	10083	84.05	39.84	14-Jul-92	0	108	PVC	80	81	101	108	126	PVC	80	Tr(URG)
683000286	M93	187	187	50	50.38	374289.9	6239303.2	91702	WW	OBS	CAP	Rotary - Air	N	N	Y	Y	Y	N	Y	2741	Y	0	05-Dec-81	0.5	AIRL	11-May-83	12210	7023	20.6	29.4	20-Jan-94	0	163	PVC	80	112	124	155	157	SST	82	Tome1(CC)
682900804	M103	224	224		31.35	382769.1	6222387.3	9881	WW	OBS	CAP	Rotary - Air	N	N	Y	Y	Y	N	Y	2773	Y	0				21-Jun-85	13083	7539	3.06	28.29	21-Apr-92	0	156.5	STL	80	85	141	148	150	SST	80	Tome1(CC)
672802489	M146	86	86	56.39	57.213	354655	6163582		WW	EXP	CAP	Rotary - Air	N	N	Y	Y	N	N	Y	2257/414	Y	0				16-Dec-87	5461	3058	7.79	48.6	20-May-05	-0.3	69	STL	75	0	64	64	66	SST	70	Tr(RG)
682701562	M148	170	170		99.67	374831.8	6112242.1		WW	OBS	CAP	Rotary - Air	N	N	N	Y	Y	N	N		Y	0	30-Jun-85	1.3	PUMP	05-May-92	18713	11023	89.73	9.94	19-Sep-85	0	166.6		100							Tr(RG)
672702277	M149	171	170.6	45.71	46.546	344218.8	6122529.2	16058	WW	EXP	CAS	Rotary - Air	N	N	Y	Y	Y	N	Y	413	Y	0	10-Jul-85	3.6	PUMP	01-Jul-85	15560	9067	43.07	2.65	16-Mar-05	0	163.4		75							Tr(RG)
672600216	M161	159	158.6		11.33	333235.7	6068679.1	23070	WW	EXP	CAS	Diamond Bit - Coring	N	N	N	Y	Y	Y	Y	1098	Y	0.6	12-Aug-89	1		23-Jan-90	48700	35170	11.97	-0.64	07-Apr-05	0	131.9		80			131.85	158.6			Tr(RG)
672600502	M163	168	168.2		7	335275.7	6050837.1	23075	WW	EXP	CAS	Diamond Bit - Coring	N	N	N	Y	Y	N	Y	1103	Y	2	24-Aug-89	2		23-Jan-90	36800	26068	6.28	0.72	11-Apr-05	0	150.8		80			150.8	168.2			Tr(RG)
692900763	RB 3	230	230		15.72	451231.9	6213288.2	28114	WW	OBS	FL	Rotary - Air	N	N	Y	N	N	N	Y	1712	Y		27-Aug-92	0.13	AIRL	03-Sep-92	27328	16587	0	15.72	27-Aug-92	0	216	FRP	75	26	30	222.5	224.5	SST	75	Tr(RG)
682800730	M125	135	135	32.59	33.429	370003.9	6174803.2		WW	INV	OPR	Rotary - Air	N	Y	Y	Y	N	N	Y	64	Y	0	31-Aug-83	0.06	AIRL	12-Sep-83	16400	9574	15.32	17.27	20-May-05	0	123.5	STL	80	10	108	115	117	SST	80	Tome1(CC)
692900465	RB 1	245	245	59.31	60.03	427928	6217506.1	94361	WW	EXP	OPR	Rotary - Air	Y	N	Y	Y	Y	N	Y	556	Y	2.25	09-Apr-86	3		17-Jan-89	35342	22000	34.15	25.16	01-Apr-00	0	166	SST	75	0	156	160	163	SST	75	Tr(RG)
682900992	RG 1 (FORMERLY	146	146		10.36	405471.9	6218688	95437	WW	OBS	OPR	Rotary - Air	N	Y	Y	N	Y	N	Y	1209	N		04-Apr-90	8		04-Apr-90	34000	21094	0	10.36	22-Mar-01	0	144	PVC	150	0	130	30.3/144	84./145	PVC	150	Tr(RG)
692900762	RB 4	202	202		72.31	425021.9	6233978.2	28116	WW	OBS	OPR	Rotary - Air	N	N	Y	N	N	Y	Y	1711	Y		04-Sep-92	2	AIRL	04-Sep-92	25502	15398	44.79	27.52	03-Aug-99	0	190	FRP	75	0	190	196.7	198.7	SST	75	Tr(RG)
703200027		156	156		100.86	493973.2	6358228.4	91456	WW	STK	OPR	Rotary - Mud	N	N	Y	Y	Y	N	Y	2731	Y		15-Sep-81	0.57		20-Oct-84	17000	9942	63.7	37.16	15-Sep-81	0	144	PVC	100	60	134	144	147	SST	100	Tr
623000018	BUNGUNNIA BORE	389	20.12			669410	6286238.1				OPR	Cable Tool	Y	N	N	N	Y	N	N		N		07-Jun-37	1.8942	UKN	07-Jun-37	16903	9867	19.2		07-Jun-37	0	16.76					16.76	20.12			
682600037	COONALPYN TWS NO. 1	148	147.83			403332	6048007		WW	DOM	OPR	Cable Tool	N	N	Y	N	Y	N	N		Y		26-May-54	5.05		23-Jul-02	2400	1328	13.14		07-Apr-05	0	117.9		152			115.2	119.79		152	Tr(RG)
#########	OLD MANNUM COAL	64	64.47			347606.8	6149119.2		WW	IRR	OPR		N	N	N	N	Y	N	N		N		18-Aug-48	0.1	PUMP	18-Aug-48	5807	3256	13.72		18-Aug-48											Tr
682601242	COOMA PARK NO. 6	202	201.5	31.36	31.678	409243	6056942		WW	IRR	OPR	Rotary - Mud	Y	N	N	N	N	N	N		N		26-Feb-99	15		15-Jun-99	1930	1066	28.75	2.61	11-Nov-04	0	183	FRP	203	0	183	183	194.8	SST	152	Tr(RG)
692600505	COOMA PARK NO. 5	203	203	31.41	31.406	410262	6056439		WW	IRR	OPR	Rotary - Mud	Y	N	N	N	N	N	N		N		19-Feb-99	15		10-Jun-99	1890	1043	26.31	5.1	05-Aug-04	0	186	FRP	203	0	186	186	198	SST	155	Tr(RG)
692600498	COOMA PARK NO. 2	190	189.6	28.76	28.756	410254	6055225		WW	IRR	OPR	Rotary - Air	Y	N	N	N	N	N	N		N		07-Dec-98	20		14-Dec-98	2000	1105	18.58	10.18	13-Dec-98	0	176	FRP	200							Tr(RG)
702901420	86774	638	638.07	59.36	60.44	497807	6224200		WW	OBS	OPR	Unknown	N	N	N	N	N	N	N		N		18-Apr-87	31.56					26.12	33.24	20-May-03	0	482.4	STL	164			468.56	474.91			Tr(RG)
682901140	RG 2	194	194		42.43	403846.9	6217103.3		WW	OBS	OPR	Rotary - Air	N	N	Y	N	Y	N	N		Y					23-Nov-91	21200	12600	16.75	25.68	15-Jul-03	0	194	PVC	75	0	140	168	170	PVC	75	Tr(RG)
672800421		60	59.74			349724.8	6149173.2		WW	STK	OPR		N	N	N	N	Y	N	N		N		31-Aug-48	0.1		22-Oct-48	5659	3170	57		31-Aug-48	0	59.74		102							Tr
703100005	NEW POSTMARK BORE	150	149.96			496660.1	6337686.2		WW	STK	OPR	Cable Tool	N	N	Y	N	Y	N	N		N		01-Jan-70	1.52	PUMP	20-Jan-70	15077	8769				0	141	STL	152			141	149.96	SST	152	Tr
672800580		96	96.01			336355.8	6148741.2		WW	STK	OPR		N	N	N	N	N	N	N		N					17-Aug-70	3715	2067														Tr
693100005	DICKS PADDOCK BORE	148	148.44		88.48	450273	6329761.4		WW	STK	OPR	Unknown	N	N	Y	Y	Y	N	N		N	0				24-May-77	14300	8286	52.7	35.78	10-Aug-81	0.4			152							Tr
702900985	COOLTONG 1	1380	1379.83	46.77	46.889	466804.9	6225568.7		PW	EXP	RHB	Diamond Bit - Coring	Y	N	Y	Y	Y	Y	N		Y	371	23-Jul-88	0.5		17-Jan-89	35342	22000	13.79	32.98	21-Sep-89	0	516.5	STL	76	400	500	507	510	SST		Trw(RG)
682600064	L. A. DENT	131	130.76			400203.9	6053909				UEQ	Cable Tool	N	N	Y	N	Y	N	N		Y		15-Jun-55	1.52		15-Jun-55	3063	1699	20.12		15-Jun-55				127							Tr(RG)
692600535	COOMA PARK NO. 7	211	211	33.37	33.807	410937	6057908		WW	IRR	UEQ	Rotary - Mud	Y	N	N	N	N	N	N		N		22-Oct-99	20		22-Oct-99	1990	1099	30.46	2.91	11-Nov-04	0	196	FRP	210	0	196	196	205	SST	154	Tr(RG)
692600538	COOMA PARK NO. 8	207	207	32.87	33.246	410952	6059307		WW	IRR	UEQ	Rotary - Mud	Y	N	N	N	N	N	N		N		15-Oct-99	20		15-Oct-99	2020	1116	29.6	3.28	11-Nov-04	0	189	FRP	203	0	189	189	201	SST	154	Tr(RG)
692700587	M133	235	234.6	85.7	86.582	445530.9	6109756.1	12870	WW	OBS	UKN	Rotary - Mud	N	N	Y	Y	Y	N	Y	37	Y	0	09-Jun-83	0.86		20-Jun-83	1810	999	50.96	34.74	07-Apr-05	0	211.7		81							Tr
672901165	M119	150	150	114.2	114.914	351146.9	6227434.3		WW	OBS	UKN	Rotary - Mud	N	N	N	Y	N	N	Y	42	Y		02-Jul-83	0.62					79.66	34.54	20-Jan-94	0.3	142.5		80							Tr(RG)
702600110	M138	257	257.4	114.68	115.64	478839.1	6061134	12872	WW	OBS	UKN	Rotary - Mud	N	N	Y	Y	Y	N	Y	51	Y	0	25-Jul-83	1.34	PUMP	26-Jul-83	1386	764	66.27	48.41	07-Apr-05	0	226.6		80							Tr
702600112	M140	257	257.2	124.33	125.104	481559.1	6036218.8	7026	WW	OBS	UKN	Rotary - Mud	N	Y	Y	Y	Y	N	Y	58	Y	0	16-Aug-83	1.68	PUMP	15-Sep-83	1490	759	69.37	54.96	21-Sep-04	0	230.3		80							Tr(RG)
682701530	M131	225	225.4	61.91	62.754	400654.9	6116736.1	12874	WW	OBS	UKN	Rotary - Air	N	N	N	Y	Y	N	Y	70	Y	0	28-Sep-83	1.2		28-Sep-83	3370	1872	42.27	19.63	21-Mar-05	0	211.7		80							Tr(RG)
692800542	M130	280	280	71.78	72.628	438532	6153097.2	12875	WW	OBS	UKN	Rotary - Mud	N	N	Y	Y	Y	N	Y	76	Y	0	10-Oct-83	2.53		15-Oct-84	2729	1512	37.4	34.38	07-Apr-05	0	216.9		80							Tr
692900423	M129	230	230		63.78	414391.1	6184692.2	12876	WW	OBS	UKN	Rotary - Air	N	N	Y	Y	N	Y	Y	78	Y	0	19-Oct-83	0.06					35.15	28.63	24-Sep-86	0	213.5		80							Tr(RG)
682800736	M128	201	201.1	70.04	70.9	394496.9	6148653.2	12877	WW	OBS	UKN	Rotary - Mud	N	N	Y	Y	Y	N	Y	89	Y	0	28-Oct-83	0		11-Mar-88	4914	2747	52.84	17.2	21-Mar-05	0	176.2		80							Tr(RG)
672802449	M141	147	147		81.068	357081.9	6133752.2	93512	WW	OBS	UKN	Rotary - Mud	N	N	N	Y	Y	N	Y	165	Y	0	15-May-84	0.05		24-May-84	9341	5310	78.33	2.74	08-Feb-94	0	147		75							Tr(RG)
672802486	M144	90	90		94.863	345781.9	6146785.2		WW	OBS	UKN	Rotary - Mud	N	N	Y	Y	Y	N	Y	386	Y	0	06-May-85	0.5	PUMP	01-Sep-87	2500	1384	49.31	45.55	08-Feb-94	0	68		75							Tr(RG)
682900578	27W	329	329.49		33.13	404108	6215849	95069	WW	DRN	UKN	Cable Tool	N	N	Y	Y	N	N	Y	986	Y	0	21-Nov-88	0.5		18-Nov-88	25529	15415	8.46	24.67	16-Aug-00	0	196.5		76							Tr(RG)
703100008	Canopus no 1	290	289.97		66.95	469059.1	6300726.2		WW	STK	UKN	Cable Tool	N	N	Y	Y	Y	Y	Y	987	Y	0	19-Jun-53	0.76	PUMP	05-Jun-67	22322	13291	30.3	36.65	05-Nov-85	0	288	STL	127			288	289.97	SST	102	Tr
682800732	M127	174	174		57.04	370275.9	6152990.1		WW	OBS	UKN	Rotary - Air	N	N	Y	Y	N	N	Y	2573	N	0	05-Oct-83	0.12		16-Dec-87	9193	5222	41.69	15.35	21-Mar-05	0	150.5		80							Tr(RG)
703200025	Oakvale 1	176	175.68		82.87	491856.3	6349989.3		SW	SCI	UKN	Diamond Bit - Coring	N	N	Y	Y	N	Y	Y	2694	Y	175.7										0	132	STL	102							
682900995	82FS6RM	126	126	76	77.56	366242.1	6194878.1		MW	EXP	UKN	Rotary - Mud	N	N	N	Y	N	Y	Y	2695	N	0																				
682900264	MORGAN COAL 1	196	196.29	40		376452.9	6230678.3				UKN	Unknown	N	N	Y	Y	N	N	N		N																					
682900269	MORGAN COAL 3	175	175.41	30		376936.9	6223409.3				UKN	Unknown	N	N	Y	Y	N	N	N		N																					
702900002	Olney 1	614	614.17		59	498589	6228723.2				UKN	Rotary - Mud	N	N	N	Y	N	N	N		N																					

Unit No	Name	Depth (m)	Max Drilled Depth (m)	Grnd Elevn (m)	Ref Elevn (m)	Easting	Northing	Permit No	Well Class	Purpose	Status	Drilling Method	Drillers Log	Litho Log	Hydro strat Log	Strat Log	Water Chemistry	Rock Sample	Geophysical Log	Geophysic Job No	Core	Cored length	Latest Yeild date	Yeild L/sec	Yield extraction code	Salinity Date	EC	TDS (mg/L)	SWL	RSWL	SWL Date	Case From	Case to	Casing Material	Casing Diameter	Cement from	Cement to	Pzone From	Pzone To	Pzone Material	Pzone Diameter	Aquifer Mon
703000152	pd1	91	91.44	48		491761.1	6240495.2				UKN	Cable Tool	N	N	Y	N	N	N	N		Y					07-Jun-60	28184	17136														
703200250	MT59	128	128.2		92	494572.1	6392678.3				UKN	Rotary	N	N	N	Y	N	N	N		N																					
703200251	MT60	92	91.5		97	493572.1	6393778.2				UKN	Rotary	N	N	N	Y	N	N	N		N																					
673000236	81MBR40	170	169.5		139	353533	6283211.3		MW	EXP	UKN	Rotary - Mud	N	N	N	Y	N	Y	N		Y	0																				
682800733	81MBR16	204	204		50	381721.9	6167001.2		MW	EXP	UKN	Rotary - Mud	N	N	N	Y	N	Y	N		Y	0																				
682800776	81MBR17	154	154		40	375821.9	6169756.2		MW	EXP	UKN	Rotary - Mud	N	N	N	Y	N	N	N		Y	0																				
682800777	81mbr18	182	182		39	379879.9	6175794.2		MW	EXP	UKN	Rotary - Mud	N	N	N	Y	N	Y	N		N	0																				
682900966	81MBR21	204	204	30		384222	6205128.4		MW	EXP	UKN	Rotary - Mud	N	N	Y	Y	N	Y	N		N	0																				
682900968	81MBR23	270	270		30	391021.9	6212078.3		MW	EXP	UKN	Rotary - Mud	N	N	N	Y	N	Y	N		N	0																				
682900969	81MBR24	204	204		31	390872.1	6218578.2		MW	EXP	UKN	Rotary - Mud	N	N	N	Y	N	Y	N		N	0																				
682900970	81MBR28	174	174	35		383621.9	6208578.3		MW	EXP	UKN	Rotary - Mud	N	N	Y	Y	N	Y	N		N	0																				
682900971	81MBR56	273	273	40		404121.9	6237178.1		MW	EXP	UKN	Rotary - Mud	N	N	Y	Y	N	N	N		Y	0																				
682900978	82MP1	244	244	70		367189	6233254.4		MW	EXP	UKN	Rotary - Mud	N	N	Y	Y	N	Y	N		N	0																				
682900996	82FS6P1	152	152		75	366242.1	6194878.1		MW	EXP	UKN	Rotary - Percussion	N	N	Y	Y	N	Y	N		N	0																				
683000285	81MBR38	164	164.1	120		366131.1	6285287.3		MW	EXP	UKN	Rotary - Mud	N	N	Y	Y	N	N	N		Y	0																				
692800568	KNIGHTS	238	238		73	429543.9	6159194.2		MW	EXP	UKN	Rotary - Mud	N	N	N	Y	N	N	N		N	0																				
692800569	81MBR31	246	246		60	411013.9	6166318		MW	EXP	UKN	Rotary - Mud	N	N	N	Y	N	Y	N		Y	0																				
692900647	MELROSS	280	280		57	425121.9	6184478.1		MW	EXP	UKN	Rotary - Mud	N	N	N	Y	N	N	N		N	0																				
692900649	81MBR30	222	222		63	408322	6189178.2		MW	EXP	UKN	Rotary - Mud	N	N	N	Y	N	Y	N		N	0																				
693000068	81MBR54	251	250.8	71.38	71.38	421621	6284540.4		MW	EXP	UKN	Rotary - Mud	N	N	Y	Y	N	Y	N		N	0																				
693000069	81MBR55	184	183.5	65.96	65.96	411304.1	6265146.2		MW	EXP	UKN	Rotary - Mud	N	N	N	Y	N	N	N		Y	0																				
693100030	81MBR35	238	238.1		83	432065	6307000.4		MW	EXP	UKN	Rotary - Mud	N	N	Y	Y	N	Y	N		Y	0																				
693100031	81MBR36	233	233.2		105	430442.1	6326176.4		MW	EXP	UKN	Rotary - Mud	N	N	Y	Y	N	N	N		Y	0																				
693100034	81MBR77	224	223.7		102	431747.1	6323210.3		MW	EXP	UKN	Rotary - Mud	N	N	N	Y	N	N	N		Y	223.7																				
693100036	82PVDD	358	357.9		98	429520	6308934.3		MW	EXP	UKN	Diamond Bit - Coring	N	N	N	Y	N	Y	N		Y	52.9																				
703000361		381	381		60	495515	6252094.1		MW	EXP	UKN	Rotary - Mud	N	N	N	Y	N	N	N		N	0																				
703100006	81MBR 34	207	207		84	456226.1	6329241.2		MW	EXP	UKN	Rotary - Mud	N	N	Y	Y	N	Y	N		Y	0																				Tr(RG)
682800737	M126	188	188		53.34	389537	6179368.2		WW	OBS	UKN	Rotary - Mud	N	N	Y	Y	Y	N	N		N	0	08-Sep-83	0		11-Mar-88	4430	2471				0	179.5		80							Tr
693100002	Moonlight bore	150	152.4	134.66		414796.2	6345485.4		WW	STK	UKN	Unknown	N	N	Y	Y	Y	N	N		N	0				24-Sep-24	21234	12598														
693100006	MOONLIGHT BORE	150	150		96.22	435492.2	6319932.4		WW	STK	UKN	Unknown	N	N	Y	Y	N	N	N		N	0	19-Aug-52	0.63		24-May-77	17800	10448	61.4	34.82	05-Nov-85											Tr
703000002	M155	420	420.1		70.99	459558.1	6275618.2	95071	WW	EXP	WWT	Auger (Mechanised)	Y	Y	Y	Y	Y	Y	Y	1023	Y	0	16-Feb-89	2.5	AIRL	14-Feb-89	18700	12133	34.93	36.06	09-Jun-94	0	242.5	STL	76	0	228	233.5	236	SST	75	Tr(RG)

B. FORMATION TOPS

Unit Number	Name	Total Depth (m)	Easting	Northing	Grnd Elev	Top Coon	Top Mon	clay layer	Top Q	top blanchtown	Northwest bend fm	Top Pliocene	Top Booky	Top of Winn	Top Ty	Geera Clay	Ettrick	Buccleuch Fm	Top Ren Olney	Top Ren Warina	Base of Ren
623000018	BUNGUNNIA BORE	388.62	390856	6253477	40				0			9		22	46		119		130		218
672600216	M161	158.60	333235	6068679	11.33				0						87		105		138		142
672600502	M163	168.20	335275	6050837	7.00				0						58		98		142		
672702277	M149	170.60	344218	6122529	46.55				0	1					18		76		149		163
672802449	M141	147.00	357081	6133752	81.07							0			22		85		122		134
672802486	M144	90.00	345781	6146785	94.86				0	2					13				49		82
672802487	M145	120.00	345444	6157383	110.18					0					47				93		
672802489	M146	86.00	354655	6163582	57.21				0						10				57		86
672901165	M119	150.00	351146	6227434	114.91				0	2					12		70		96		140
672901170	M124	116.00	341784	6191448	105.11					0					32		68		80		116
673000236	81MBR40	169.5	353533	6283211	139				0			2.1			62.7				131.7		146
682600019	CK SHILLING & CO	99.67	399815	6045217	19.00				0						20.4		60	62.5	91.4		98.5
682600036	COONALPYN TWS NO. 3	128.02	404065	6047968	27.00				0						17.3			60	103.6		
682600037	COONALPYN TWS NO. 1	147.83	403332	6048007	28.00				0										92		138
682600040		103.94	401562	6045835	19.00				0						13.7			57	85		
682600041	COONALPYN TWS NO. 4	116.74	402331	6047997	19.00				0						15.2			62.5	99		
682600064	L. A. DENT	130.76	400203	6053909	19.00				0						13.7			68.5	103.6		
682701530	M131	225.40	400654	6116736	62.75				0			8			31		112		142		221
682701562	M148	170.00	374831	6112242	99.67				0			12			80?		102		141		164
682800730	M125	135	370004	6174803	32.59				0						2		112				130
682800731	M126	96.00	389412	6179431	52.52					0					10						
682800732	M127	174.00	370275	6152990	57.04				0			2			19		105		127		174
682800733	81MBR16	204	381722	6167001	50				0						6		108		146		156
682800736	M128	201.10	394496	6148653	70.90				0	2		22			35		128		172		
682800776	81MBR17	154.00	375822	6169756	40.00				0						2		92				
682800777	81mbr18	182.00	379880	6175794	39.00				0						1		86		90		180
682900264	MORGAN COAL 1	196.29	376453	6230678	40										0		101		112		172
682900269	MORGAN COAL 3	175.41	376937	6223409	30										0		102		168		
682900578	27W	329.49	404107	6215849	33.13				0		2.13				6.1		117.35		161.54	312.42	
682900802	M101	234.00	364242	6225395	59.44					0					27		140		190		234
682900803	M102	188	372199	6223956	49.8										0		94		110		142
682900804	M103	224	382769	6222387	31.35				0						4		118		142		215
682900807	M106	153.4	365861	6205806	77.18										0		67				128
682900809	M142	229.50	369451	6207914	47.10				0						4.5		102		150		214
682900811	M143	221	368859	6194624	45.88				0	3					6		90		133		162
682900966	81MBR21	204	384222	6205128	30				0						2		110		145		200
682900968	81MBR23	270	391022	6212078	30				0						42		120		138		262
682900969	81MBR24	204	390872	6218578	31				0		2				16		126		144		202
682900970	81MBR28	174	383622	6208578	35				0						6		120		148		
682900971	81MBR56	273.00	404122	6237178	40.00				0			5.8			21.4		150.1		165		256.9
682900978	82MP1	244	367189	6233254	70					0					32		128		193		231
682900992	RG 1 (FORMERLY WPB 3)	146.00	405471	6218688	10.36	0	6								22		83		130		
682900995	82FS6RM	126	366242	6194878	76				0						6		40				70
682900996	82FS6P1	152	366242	6194878	77.56				0						8		70		96		130
682901140	RG 2	194.00	403846	6217103	42.43				0						15		129		164		
683000285	81MBR38	164.1	366131	6285287	120					0		25		47					100		163
683000286	M93	187	374290	6239303	50					0					15		108		154		
683000291	M98	224	372817	6251293	62.91					0				28			138		187		210
692800568	KNIGHTS	238.00	429544	6159194	73.00							0			28		130		157		237
692800569	81MBR31	246.00	411014	6166318	60.00				0	4		16			26		138		214		
692900332	MC66	258.00	436857	6192401	45.96				0			9			28		148		182		
692900333	MC65	300	425107	6209853	71				0	2		9			27		110		160		
692900337	MC62	232.60	424272	6228857	66.90							0		24	35		125		138		
692900423	M129	230.00	414391	6184692	63.78				0			2			7		105		123		201
692900423	M129	230	414391	6184692	63.78				0			2			7		100		130		201
692900429	Overland Corner 1	654.70	435683	6230212	69.19										25		125		160		285
692900465	RB 1	245.00	427928	6217506	59.31				0			6			18		129		146	235	
692900647	MELROSS	280.00	425122	6184478	57.00				0			4			33		110		142		279
692900649	81MBR30	222	408322	6189178	63				0			6			22		104		168		
692900762	RB 4	202.00	425021	6233978	72.31				0	16		21	52		60		150		184		
692900763	RB 3	230.00	451231	6213288	15.72	0	13						26		38		176		198		
693000017	M153	179	411666	6266093	66.23					0		8	39	44	89		153		168		179
693000018	M154	415.00	448881	6289335	67.61					0		6		78	123		157		188		347
693000068	81MBR54	250.8	421621	6284540	71.38					0		13		51	146		198		232		250
693000069	81MBR55	183.5	411304	6265146	66.96				0						7.5		40.1				181.8
693100002	Moonlight bore	150.00	435492	6319932	96.22					0		18				61	137		146		
693100005	Dicks paddock bore	148.44	450273	6329761	88.48					0		30				76	145		148		
693100016	Cockatoo bore	192.63	424446	6301455	82.83					0		16			108	56	134		174		
693100030	81MBR35	238.1	432065	6307000	83					0		8		65	120		139.8		153.2		
693100031	81MBR36	233.2	430442	6326176	105					0		13.5		125		70	141		148		
693100034	81MBR77	223.7	431747	6323210	102				0	0.5		10.8			67.8				148.7		218.4
693100036	82PVDD	357.9	429520	6308934	98					0		7	75		80				233		263
702600112	M140	257.20	481559	6036218	125.10				0			30	74		77		172		196		
702700585	M136	248.30	471249	6118740	84.49							0	51		58		192		223		
702700629		227	489865	6235285	36.128							0	60	76	104						
702700873		300.00	496016	6119890	78.93							0	45		70		205		227		
702800001	Loxton 1	488.29	468016	6175119	41.15					0		4.57	24.38		41.15		143.26		193.55	323	402.34
702800002	Loxton 2	549.86	462885	6177380	40.00				0			6.1	24.38		30.48		17.069		204.22	289.5	412.09
702800003	NADDA1	1041.20	490575	6167624	28.96				0			9	30		56		204		230	317	449
702800421	MC64	283	489084	6177568	48.19							0	58	82	96		210		252		

Unit Number	Name	Total Depth (m)	Easting	Northing	Grnd Elev	Top Coon	Top Mon	clay layer	Top Q	top blanchtown	Northwest bend fm	Top Plioscene	Top Booky	Top of Winn	Top Ty	Geera Clay	Ettrick	Buccleuch Fm	Top Ren Olney	Top Ren Warina	Base of Ren
702800469	M157	601.70	489184	6171479	29.13							0	36	47	70		190		205		455
702900001	Berri South 1	663.55	466562	6196739	51.82				0			9.1	61.6		79.2		213		232	324	498
702900002	Olney 1	614.17	498589	6228723	59					0		20	80	114	144		230		278		
702900004	North Renmark 1	1224.69	470918	6225028	23.601				0			18.3	42.7		61		200		215.2	345	548.64
702900005	Berri North 1	944.88	466496	6215248	41.758				0			9	47		62		201		216	311	525
702900361	CRA	381	495515	6252094	60				0			21	62		84		203		222.95		
702900614	MC61	286	460049	6224533	29.07							0	42		60		188		242		
702900615	PAG 10	338.5	494477	6214087	49.69				0	5		6	70	100	118		240		282		
702900616	M27	183.3	455822	6199978	31.66				0			4	24		40		177				
702900627	RMK 247	90	471528	6216119	20.423	3	8					18	28	52	62						
702900630		90	472598	6235017	32.5				0			3	39	60	68						
702900632	M57	48	481562	6237145	21.31	0	4						36								
702900984	TALDRA NO 1	730.30	485646	6201983	42.31					0		15	74	85	120		250		288		570
702900985	COOLTONG 1	1379.83	466805	6225569	46.77				0	4		20.4	58.5		82.3		219.5		236.2	405.08	557.5
702901330	Monash 1	1050.04	453970	6215581	33.223				0			9.1	33.5		51.8		192		246.9	304.8	536.4
702901356	LHC1P	195	457340	6186295	44.587				0			1	32.9		36		190.4				
702901420	86774	638.07	497807	6224200	60.44																
702901425	BHO 1(G)	223	463205	6201443	51.76				0			8.5	67.4		71.2		216.5				
702901541	MU1	233.5	484855	6210614	28.17				0			3	67.7		71		229				
703000001	Calladen bore	184.71	456569	6286789	56.12				0			3			122	61	165		171		
703000002	M155	420.10	459558	6275618	70.99					0		6	50	72	90		162		194		340
703000004	Canegrass bore	207.26	484264	6268784	30.49					0		2	44	49	116		149		198		
703000005	Triangle bore	175.26	472201	6292469	54.45					0		11	31	63	90		152		158		
703000152	pd1	91.44	491761	6240495	48							0	71								
703000361		381	495515	6252094	60					0		21	62		84		203		222.95		
703000370		49.07	492460	6239880	53.22					0		10.4									
703000383	CHW 1	138	493718	6286590	45.69				0	4		13	63	105	125						
703000435	CHW 29	202.2	495932	6259940	52.96				0	2		13	79	96	117						
703000435	M58	202.2	495932	6259940	52.96				0	2		13	79	96	117						
703000492		96	488046	6241045	19.881	0	4					29	42	60	81						
703000493	CHW 46	15	499228	6244419	23.183	0	7														
703000495	LL1C	100	499233	6244414	23.246	0	7					39		54	68						
703000578		30	497689	6247109	19.084	0	2					22									
703000582		30	497606	6246925	19.169	0	4	15				24									
703000695		8	483756	6239123	19.62	0	2														
703000696		20	483755	6239118	19.62	0	3														
703100002	Postmark bore	162.76	499375	6339991	84.41							0	44	74			152		157		
703100003	Top bore	140.21	466866	6329785	77.43														157		
703100004	Box Swamp Bore	172.52	462557	6343423	71.13					0		2		110		19	124		137		
703100005	New Postmark bore	149.96	496660	6337686	77					0		5		121		41	129		135		
703100006	81MBR 34	207.00	456226	6329241	84.00							0		64.2		53			146.5		
703100008	Canopus no 1	289.97	469059	6300726	66.95					0		6	53	63	128		148		158		
703100009	CANOPUS NO 2	306.02	473238	6312219	77.24					0		9		62.5	124		155		195		
703100011	CHW 3	150	490756	6311947	71.41				0	2		4	66	123	138						
703100013	M63	144	461617	6308453	78.88					0		5	68	87	128						
703100015	M74	157.50	476226	6341004	98.68				0	4		15	53		75		140				
703200022	M87	160.00	475496	6360609	104.31				0	10		28	61	89	128						
703200025	Oakvale 1	175.68	491856	6349989	82.87				0			3			32				125		153
703200250	MT59	128.2	494572	6392678	92				0	27		60			91.5						
703200251	MT60	91.5	493572	6393778	97				0	6					58.5						82.5
713000008	36782-3	272.00	512247	6241639	44.47				0	10		19	79		112		243		258		
	Olney 7	638.07	497685	6224022	59.44				0			18.5	82	94	117		249		257	372	602
	Berrook 1	458	503200	6136000	58				0			8	28		55		198		203	301	422
	Bookpurnong 46	601.6	489050	6171350	28.42				0			3	36	45	70		195		205	348	455
	Darragan 4	107	599900	5921300	142				0			1.5				20			54		95
	Drung Drung 3	85	619000	5934000	133				0			10				35			50		79
	Gordon 46	730.3	480550	6201850	41.3				0			15	74	86	120		250		254	400	570
	Gunamalary 2	717.6	517681	6091643	66.39				0			6	47	60	84		241		246	408	487
	Karadoc 114	495.4	620934	6192499	41.8				0			32	107	175	2118		271		289	441	473
	Kewell East 3	144.2	619200	5966150	139				0			6		32					52		101
	Koonda 1	551.43	539400	6112800	58				0			3	45	60	71		225		233	350	477
	Liparoo 2	281.02	645009	6148814	50.74				0			7	84	130	168.5		200		231		241
	Mallanbool 1	561.6	551948	6185942	69.95				0			13	84.5	107.5	139		254		268	398.5	441
	Mamengoroock 4	563.11	572441	6112811	60				0			3	82	110	137		250		255	380	445
	Manangatang 3	351.5	664000	6119100	58							0				116.5			272.4		351
	Mildura 520	404	600453	6217549	35.98				0			12	61	122.5	149		196		208.5	279.5	369
	Morkalla 3	653.52	515100	6194300	39.5				0			12	86	106.5	132		261		268.5	452	555
	Natimuk 1	147	584000	5930200	135				0			15				32					
	Piangil West 2	392	701700	6118150	51				0			9	81.5			102			232		380
	Quantong 2	163	588400	5942800	118				0			18				35			74		159
	Tol Tol 2	490.14	666338	6164518	62.67				0			60	140	220		286			338		429
	Vectis East 16	130.6	593950	5934750	122				0			7				33			66		120
	Wallpolla 1	501.23	564032	6208097	48.38				0			34	80	110	150		257		263	364	466
	Wallup 2	122	610000	5977500	123				0			3		31.5		66			105		121
	Walpamunda 4	466	605669	6156345	34.22				0			36	108	125	168		249		265	345	402
	Watchegatheca 3	119	591500	5963000	120				0			3	30	50							76
	Willah 1	640.56	582355	6186487	48.61				0			60	122.5	180	225		336		350	511	600
	Woolwoola 25	649.92	530659	6208177	52.28				0			52	12	137	162.5		294		301.5	491	587

C. RENMARK GROUP CHEMISTRY DATA

Unit No	Name	Total Depth (m)	Collected Date	Ph	EC	TDS	TDS calculated from EC	Calculated TDS	CA	MG	NA	K	HCO3	SO4	CL	F	NO3 N	TKN N	NOX N	PO4 P	SIO2	BR	FE	HARD	CARB	NON CARB	ALK
662707198		125	11/12/1984	8.3	19700		13000	11900	320	330	3750	58	483	950	6260		0.1							2160	396	1760	396
672600216	M161	159	23/01/1990	8.2	48700		39322	35170	983	1025	10940	210	153.1	2451	19479		5.2							6670	121	6549	121
672600502	M163	168.2	23/01/1990	7.5	36800		27470	26068	484	891	8132	206	321.9	2753	13439		2							4873	255	4618	255
672702238		76	25/08/1984	7.4	15000		9520	11900	860	355	2850	52	239	2270	5430		11							3610	196	3410	196
672702241		71.3	11/09/1984	8.3	8000		4790	5680	180	160	1700	23	589	510	2820		0.4							1110	1110		482
672702243		105.3	22/09/1984	7.9	2250		1280	932	47	26	270	10	270	67	379		0.1							224	224		221
672702266		150	28/02/1985	7.7	5100		2970	2920	172	130	740	21	382	230	1440		0.1							964	964		313
672800408		73.76	21/06/1952					1886	156.1	74.5	440.5		227.5	344.9	643.7									696			
672800411	OLD MANNUM COAL	64.47	01/01/1927					4410	248.9	84.8	1329.8		326.6	286.2	2135.1									971			
672800421		59.74	01/01/1948					3168	214.3	115.4	837.5		423.5	255.6	1317								6	1021			
672800555		109.73	01/01/1950					2387	167.4	106.4	592.3		206.4	172.8	1143.7									856			
672800561		107.59	01/01/1947					2297	136.8	69.3	648.9		185.4	138.1	1119.6									627			
672802449	M141	147	15/05/1984	8.9				6114	15	45	2250	50	709	410	2991		4							223	223	1	581
672802486	M144	90		6.6	2550		1418	1442	114	31	365	19	289.9	210	558		0.4							412	264	149	264
672802487	M145	120	13/05/1985	7.9	4150		2400	2380	110	75	660	17	282	180	1150		49							583	583		232
672901170	M124	116	16/04/1984	7.6				6567	149	123	2168	54	78	654	3379		1							878	64	814	64
682600019	CK SHILLING & CO	99.67	24/11/1960					2070	38.5	31.4	728.2			85.6	979.6									228			
682600036	COONALPYN TWS NO. 3	128	16/09/1960					1313	32.8	17.1	459.8			74.2	539.7									157			
682600037	COONALPYN TWS NO. 1	147.83	26/05/1954					1356	22.8	24.2	475.5			79.9	571.1									157			
682600041	COONALPYN TWS NO. 4	116.74	01/01/1966					1322	23	24	465			67	555		0							156			
682600064	L. A. DENT	131	31/03/1955					1713	22.8	22.8	618.3			79.9	765.4									157			
682701530	M131	225	28/09/1983	8.3	3440			1965	9.4	7.4	760	13	639	110	751		1							54			
682701530	M131	225		8.29	3500			2128	7.18	3.32	738	15.9	620	99.6	702						5.53	2.61	0.02				
682701562	M148	170	01/01/1987	7.4	19000		10601	11267	78	154	4100	53	756.4	920	5584		0.1							828	620	208	620
682701562	M148	170	01/01/1987	7.4	19000		10601	11267	78	154	4100	53	756.4	920	5584		0.1							828	620	208	620
682800736	M128	201	04/02/1988	10	5000		2914	2488	1.8	0.6	1000	9	394.8	2.3	1007		0.3							7	7		865
682800737	M126	188	11/03/1988	11	5800		3405	2871	1	0.3	1100	15	99	102	1217		1.8							4	4		799
682900804	M103	224	21/06/1985					7539	148	377	1941	74	79	1248	3623												
682900807	M106	153	13/04/1983	7.8	22748			20541	550	800	5750	110	301	2250	10932		1							4665			
682900809	M142	230	23/05/1984	8.3	28500		20100	17	300	340	5800	110	365	1260	9860		14							2150	290	1850	299
682900811	M143	221	09/06/1984	8.1				12667	398	476	3718	76	350	1414	6412		1								2953	287	2665
682900992	RG 1 (FORMERLY WPB 3)	146		8.18	25000			15042	286	378	5110	95.8	421	1233	8297						5.7	24.9	0.33				
682901140	RG 2	194	23/11/1991	7.7	21200			12600	213	329	4160	80	480	912	6620	1.49		3.13	0.03	0.056	15		0.57	1887			
683000286	M93	187	04/12/1981	7.8	12653			8125	250	400	2200	50	56	1400	3797									2270			
692700587	M133	234.6	20/06/1983	8.3	1877			1052	40	34	315	15	307	87	410		1							240			
692700587	M133	234.6																									
692700587	M133	234.6																									
692700587	M133	234.6		8.25	1840			1069	39.2	33.2	281	14.5	291	66.9	380						6.2	1.51	0.026				
692800542	M130	280	15/10/1984	8.1		1512			41	42	483	14	664	192	752						25						
692800542	M130	280	10/10/1983	8.1	2840			1577	6.8	5.5	620	11	677	33	565		3							40			
692800542	M130	280		8.33	2850			1855	6.39	5.07	594	18.5	668	32.4	544						6.19	2.01	0.488				
692900465	RB 1	245	17/01/1989	7.82		22000			528	608	6810	94.2		879	11700	20	20			20		25.7	0.05				
692900465	RB 1	245	06/10/1987					22307	636	480	6633	125	342	1008	12936												
692900465	RB 1	245																									
692900495	M129A	213.5	30/06/1987	8	5200		2898	2983	19	18	1100	17	699.6	125	1344		0.1							121	121		636
692900495	M129A	213.5	30/06/1987	8	5200			2983	19	18	1110	17	700	125	1344									121			
692900495	M129A	213.5		8.35	5300			3212	17.6	18.2	1114	21.6	690	116.7	1301						6.05	4.32	0.334				
692900760	RB 2	138		8.23	23800			14282	354	397	4490	77.1	555	432	8223						4.09	23.6	0.13				
693000017	M153	179	26/06/1986	8	23000		15500	15100	220	475	4700	73	284	1700	7760		1							2500	233	2270	233
693000017	M153	179	27/06/1986	8	23000			15100	220	475	4700	73	284	1700	7760		1							2500			
693000018	M154	415	10/12/1989	7.7	16900			10374	194	280	3354	64	655.3	930	5224		0.4							1636			
693100002	Moonlight bore	150	24/09/1924					12598	453.2	587.5	3287			2631.3	5450.6						13			3585			
693100005	DICKS PADDOCK BORE	148.44	31/05/1929					9785	222	407.7	2857.3			1312.9	4823.8									2233			

Unit No	Name	Total Depth (m)	Collected Date	Ph	EC	TDS	TDS calculated from EC	Calculated TDS	CA	MG	NA	K	HCO3	SO4	CL	F	NO3 N	TKN N	NOX N	PO4 P	SIO2	BR	FE	HARD	CARB	NON CARB	ALK
702600110	M138	257.4	26/07/1983	8.2	1406			756	64	27	190	249	249	61	283		1							271			
702600112	M140	257.2																									
702600112	M140	257.2	15/09/1983	8.3	1490			759	63	32	175	8.9	248	60	297		1							289			
702600112	M140	257.2		8.23	1540			848	56.4	33.4	172	8.92	248	54.9	300						9.47	1.04	0.037				
702600112	M140	257.2		8.45	1470			860	57.9	32.5	178	9.51	242	61.2	307						11.1	1.23	0.126				
702700585	M136	248	08/03/1989	7.8	2070		1172	1142	13.6	13.1	410	16.9	402.2	57	426		3.7							88	88		361
702700585	M136	248	27/05/1983	7.8	2140			1142	14	13	410	17	402	57	426		4							962			
702700585	M136	248		8.44	2040			1242	14.2	13	384	16.2	375	50.7	415						6.41	1.32	0.065				
702800001	Loxton 1	488	06/11/1956					40628	436.1	1712.9	12436		340.6	4491.6	21214								6	8137			
702800469	M157	601.7	11/02/1989	7.76	8580	4930			80	96.3	1490	40.5	350	332	2480	0.1	0.4					10.5	1.39				
702900004	North Renmark 1	1225	01/01/1946					2148	49.9	77	668.3		201.8	216.6	937.7									439			
702900005	Berri North 1	945	01/01/1946					2274	27.1	38.5	809.4		281.7	186.7	932									228			
702900984	TALDRA NO 1	730.3	27/04/1988	7.8				22000	690	700	6700	90		690	13000				0.15		16		6.5				
702900984	TALDRA NO 1	730.3		9.3	8190			4511	3.65	66.9	1628	44.1	339	188.4	2356						0.316	7.21	0.02				
702900985	COOLTONG 1	1379.83	28/11/1987	7.7	37500		28127	22258	534	541	7016	98.2	169	1688	12296		0.1							3559	180	3379	180
702900985	COOLTONG 1	1379.83	28/11/1987	7.7	37500		28127	22258	534	541	7016	98.2	169.1	1688	12296		0.1							3559	180	3379	180
702900985	COOLTONG 1	1379.83	17/01/1989	5.76		22000			500	537	6930	102		1240	11100	20	20			20		22.8	0.05				
703000002	M155	420.1	14/02/1989	8.2	18700			12133	269	286	3940	6.3	479.5	1337	6055		0.3								431	1417	431
703100007	CHRISTMAS BORE	175.26	14/11/1952					14322	257.6	463.4	4478.8			1697	7261.8									2550			
703100015	M74	158	05/06/1981	8	18576			11314	235	360	3550	67.5	422	1420	5473		1							2068			
703200027		156	15/10/1984			9930																					

UNITS OF MEASUREMENT

Units of measurement commonly used (SI and non-SI Australian legal)

Name of unit	Symbol	Definition in terms of other metric units	Quantity
day	d	24 h	time interval
gigalitre	GL	10^6 m^3	volume
gram	g	10^{-3} kg	mass
hectare	ha	10^4 m^2	area
hour	h	60 min	time interval
kilogram	kg	base unit	mass
kilolitre	kL	1 m^3	volume
kilometre	km	10^3 m	length
litre	L	10^{-3} m^3	volume
megalitre	ML	10^3 m^3	volume
metre	m	base unit	length
microgram	µg	10^{-6} g	mass
microlitre	µL	10^{-9} m^3	volume
milligram	mg	10^{-3} g	mass
millilitre	mL	10^{-6} m^3	volume
millimetre	mm	10^{-3} m	length
minute	min	60 s	time interval
second	s	base unit	time interval
tonne	t	1000 kg	mass
year	y	356 or 366 days	time interval

δD	hydrogen isotope composition
$\delta^{18}O$	oxygen isotope composition
^{14}C	carbon-14 isotope (percent modern carbon)
CFC	chlorofluorocarbon (parts per trillion volume)
EC	electrical conductivity (µS/cm)
pH	acidity
ppm	parts per million
ppb	parts per billion
TDS	total dissolved solids (mg/L)

GLOSSARY

Act (the). In this document, refers to The *Natural Resources Management Act* (South Australia) 2004.

Adaptive management. A management approach, often used in natural resource management, where there is little information and/or a lot of complexity and there is a need to implement some management changes sooner rather than later. The approach is to use the best available information for the first actions, implement the changes, monitor the outcomes, investigate the assumptions and regularly evaluate and review the actions required. Consideration must be given to the temporal and spatial scale of monitoring and the evaluation processes appropriate to the ecosystem being managed.

Algal bloom. A rapid accumulation of algal biomass (living organic matter) which can result in deterioration in water quality when the algae die and break down consuming the dissolved oxygen and releasing toxins.

Ambient. The background level of an environmental parameter (e.g. a background water quality like salinity).

Anabranch. A branch of a river that leaves the main stream.

Annual adjusted catchment yield. Annual catchment yield with the impact of dams removed.

Aquifer. An underground layer of rock or sediment which holds water and allows water to percolate through.

Aquifer, confined. Aquifer in which the upper surface is impervious and the water is held at greater than atmospheric pressure. Water in a penetrating well will rise above the surface of the aquifer.

Aquifer, storage and recovery (ASR). The process of recharging water into an aquifer for the purpose of storage and subsequent withdrawal.

Aquifer test. A hydrological test performed on a well, aimed to increase the understanding of the aquifer properties, including any interference between wells, and to more accurately estimate the sustainable use of the water resource available for development from the well.

Aquifer, unconfined. Aquifer in which the upper surface has free connection to the ground surface and the water surface is at atmospheric pressure.

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

Arid lands. In South Australia arid lands are usually considered to be areas with an average rainfall of less than 250 mm and support pastoral activities instead of broad acre cropping.

Artesian. Under pressure such that when wells penetrate the aquifer water will rise to the ground surface without the need for pumping.

Artificial recharge. The process of artificially diverting water from the surface to an aquifer. Artificial recharge can reduce evaporation losses and increase aquifer yield. *(See recharge, natural recharge, aquifer.)*

Barrage. Specifically any of the five low weirs at the mouth of the River Murray constructed to exclude seawater from the Lower Lakes.

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

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

Benchmark condition. Points of reference from which change can be measured.

Biological diversity (biodiversity). The variety of life forms: the different life forms including plants, animals and micro-organisms, the genes they contain and the *ecosystems (see below)* they form. It is usually considered at three levels — genetic diversity, species diversity and ecosystem diversity.

Biota. All of the organisms at a particular locality.

Bore. *See well.*

Buffer zone. A neutral area that separates and minimises interactions between zones whose management objectives are significantly different or in conflict (e.g. a vegetated riparian zone can act as a buffer to protect the water quality and streams from adjacent land uses).

Catchment. A catchment is that area of land determined by topographic features within which rainfall will contribute to runoff at a particular point.

Catchment water management board. A statutory body established under Part 6, Division 3, s. 53 of the Act whose prime function under Division 2, s. 61 is to implement a catchment water management plan for its area.

Catchment water management plan. The plan prepared by a CWMB and adopted by the Minister in accordance with Part 7, Division 2 of the Water Resources Act 1997.

Codes of practice. Standards of management developed by industry and government, promoting techniques or methods of environmental management by which environmental objectives may be achieved.

Cone of depression. An inverted cone-shaped space within an aquifer caused by a rate of groundwater extraction which exceeds the rate of recharge. Continuing extraction of water can extend the area and may affect the viability of adjacent wells, due to declining water levels or water quality.

Conjunctive use. The utilisation of more than one source of water to satisfy a single demand.

Council of Australian Governments (COAG). A council of the Prime Minister, State Premiers, Territory Chief Ministers and the President of the Australian Local Government Association which exists to set national policy directions for Australia.

CWMB. Catchment Water Management Board.

Dams, off-stream dam. A dam, wall or other structure that is not constructed across a watercourse or drainage path and is designed to hold water diverted, or pumped, from a watercourse, a drainage path, an aquifer or from another source. Off-stream dams may capture a limited volume of surface water from the catchment above the dam.

Dams, on-stream dam. A dam, wall or other structure placed or constructed on, in or across a watercourse or drainage path for the purpose of holding and storing the natural flow of that watercourse or the surface water.

Dams, turkey nest dam. An off-stream dam that does not capture any surface water from the catchment above the dam.

Diffuse source pollution. Pollution from sources such as an eroding paddock, urban or suburban lands and forests; spread out, and often not easily identified or managed.

District Plan. (District Soil Conservation Plan) An approved soil conservation plan under the repealed *Soil Conservation Act 1989*. These plans are taken to form part of the relevant regional NRM plans under the transitional provisions of the *Natural Resources Management Act 2004* (Schedule 4 – subclause 53[4] until regional NRM plans are prepared under Chapter 4, Part 2 of the Act.

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

Domestic wastewater. Water used in the disposal of human waste, for personal washing, washing clothes or dishes, and swimming pools.

DSS (decision support system). A system of logic or a set of rules derived from experts, to assist decision making. Typically they are constructed as computer programs.

DSS. Dissolved suspended solids.

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

EC. Abbreviation for electrical conductivity. 1 EC unit = 1 micro-Siemen per centimetre (µS/cm) measured at 25 degrees Celsius. Commonly used to indicate the salinity of water.

Ecological processes. All biological, physical or chemical processes that maintain an ecosystem.

Ecological values. The habitats, the natural ecological processes and the biodiversity of ecosystems.

Ecologically sustainable development (ESD). Using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased.

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

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

Ecosystem Services. All biological, physical or chemical processes that maintain ecosystems and biodiversity and provide inputs and waste treatment services that support human activities.

Effluent. Domestic wastewater and industrial wastewater.

EIP. Environment improvement program.

EMLR. Eastern Mount Lofty Ranges.

Entitlement flows. Minimum monthly River Murray flows to South Australia agreed in the Murray-Darling Basin Agreement 1992.

Environmental values. The uses of the environment that are recognised as of value to the community. This concept is used in setting water quality objectives under the Environment Protection (Water Quality) Policy, which recognises five environmental values — protection of aquatic ecosystems, recreational water use and aesthetics, potable (drinking water) use, agricultural and aquaculture use, and industrial use. It is not the same as ecological values, which are about the elements and functions of ecosystems.

Environmental water provisions. Those parts of environmental water requirements that can be met, at any given time. This is what can be provided at that time with consideration of existing users' rights, social and economic impacts.

Environmental water requirements. The water regimes needed to sustain the ecological values of aquatic ecosystems, including their processes and biological diversity, at a low level of risk.

EP. Eyre Peninsula.

EPA. Environment Protection Agency.

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

Erosion. Natural breakdown and movement of soil and rock by water, wind or ice. The process may be accelerated by human activities.

ESD. Ecologically sustainable development *(see above for definition)*.

Estuaries. Semi-enclosed waterbodies at the lower end of a freshwater stream that are subject to marine, freshwater and terrestrial influences and experience periodic fluctuations and gradients in salinity.

Eutrophication. Degradation of water quality due to enrichment by nutrients (primarily nitrogen and phosphorus), causing excessive plant growth and decay. *(See algal bloom).*

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

Fishway. A generic term describing all mechanisms that allow the passage of fish along a waterway. Specific structures include fish ladders (gentle sloping channels with baffles that reduce the velocity of water and provide resting places for fish as they 'climb' over a weir) and fishlifts (chambers, rather like lift-wells, that are flooded and emptied to enable fish to move across a barrier).

Floodplain. Of a watercourse means: (a) the floodplain (if any) of the watercourse identified in a catchment water management plan or a local water management plan; adopted under Part 7 of the Water Resources Act 1997; or (b) where paragraph (a) does not apply — the floodplain (if any) of the watercourse identified in a development plan under the Development Act 1993, or (c) where neither paragraph (a) nor paragraph (b) applies — the land adjoining the watercourse that is periodically subject to flooding from the watercourse.

Flow bands. Flows of different frequency, volume and duration.

GAB. Great Artesian Basin.

Gigalitre (GL). One thousand million litres (1 000 000 000).

GIS (geographic information system). Computer software allows for the linking of geographic data (for example land parcels) to textual data (soil type, land value, ownership). It allows for a range of features, from simple map production to complex data analysis.

GL. *See gigalitre.*

Greenhouse effect. The balance of incoming and outgoing solar radiation which regulates our climate. Changes to the composition of the atmosphere such as the addition of carbon dioxide through human activities, have the potential to alter the radiation balance and to effect changes to the climate. Scientists suggest that changes would include global warming, a rise in sea level and shifts in rainfall patterns.

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

Greywater. Household wastewater excluding sewage effluent. Wastewater from kitchen, laundry and bathroom.

Groundwater. *See underground water.*

Habitat. The natural place or type of site in which an animal or plant, or communities of plants and animals, lives.

Heavy metal. Any metal with a high atomic weight (usually, although not exclusively, greater than 100), for example mercury, lead and chromium. Heavy metals have a widespread industrial use, and many are released into the biosphere via air, water and solids pollution. Usually these metals are toxic at low concentrations to most plant and animal life.

Hydrogeology. The study of groundwater, which includes its occurrence, recharge and discharge processes and the properties of aquifers. *(See hydrology.)*

Hydrography. The discipline related to the measurement and recording of parameters associated with the hydrological cycle, both historic and real time.

Hydrology. The study of the characteristics, occurrence, movement and utilisation of water on and below the earth's surface and within its atmosphere. *(See hydrogeology.)*

Hyporheic zone. The wetted zone among sediments below and alongside rivers. It is a refuge for some aquatic fauna.

Indigenous species. A species that occurs naturally in a region.

Industrial wastewater. Water (not being domestic wastewater) that has been used in the course of carrying on a business (including water used in the watering of irrigation of plants) that has been allowed to run to waste or has been disposed of or has been collected for disposal.

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

Integrated catchment management. Natural resources management that considers in an integrated manner the total long-term effect of land and water management practices on a catchment basis, from production and environmental viewpoints.

Intensive farming. A method of keeping animals in the course of carrying on the business of primary production in which the animals are confined to a small space or area and are usually fed by hand or by mechanical means.

Irrigation. Watering land by any means for the purpose of growing plants.

Irrigation season. The period in which major irrigation diversions occur, usually starting in August–September and ending in April–May.

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

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

Land capability. The ability of the land to accept a type and intensity of use without sustaining long-term damage.

Leaching. Removal of material in solution such as minerals, nutrients and salts through soil.

Licence. A licence to take water in accordance with the Water Resources Act 1997. *(See water licence.)*

Licensee. A person who holds a water licence.

Local water management plan. A plan prepared by a council and adopted by the Minister in accordance with Part 7, Division 4 of the Act.

Macro-invertebrates. Animals without backbones that are typically of a size that is visible to the naked eye. They are a major component of aquatic ecosystem biodiversity and fundamental in food webs.

MDBC. Murray-Darling Basin Commission.

Megalitre (ML). One million litres (1 000 000).

ML. *See megalitre.*

MLR. Mount Lofty Ranges.

Model. A conceptual or mathematical means of understanding elements of the real world which allows for predictions of outcomes given certain conditions. Examples include estimating storm runoff, assessing the impacts of dams or predicting ecological response to environmental change.

Mount Lofty Ranges Watershed. The area prescribed by Schedule 1 of the regulations.

Natural recharge. The infiltration of water into an aquifer from the surface (rainfall, streamflow, irrigation etc.) *(See recharge area, artificial recharge.)*

NHMRC. National Health and Medical Research Council.

NHT. Natural Heritage Trust.

Natural Resources. Soil; water resources; geological features and landscapes; native vegetation, native animals and other native organisms; ecosystems.

Natural Resources Management (NRM). All activities that involve the use or development of natural resources and/or that impact on the state and condition of natural resources, whether positively or negatively.

Occupier of land. A person who has, or is entitled to, possession or control of the land.

Owner of land. In relation to land alienated from the Crown by grant in fee simple — the holder of the fee simple; in relation to dedicated land within the meaning of the *Crown Lands Act 1929* that has not been granted in fee simple but which is under the care, control and management of a Minister, body or other person — the Minister, body or other person; in relation to land held under Crown lease or licence — the lessee or licensee; in relation to land held under an agreement to purchase from the Crown — the person entitled to the benefit of the agreement; in relation to any other land — the Minister who is responsible for the care, control and management of the land or, if no Minister is responsible for the land, the Minister for Environment and Heritage.

Palaeochannels. Ancient buried river channels in arid areas of the state. Aquifers in palaeochannels can yield useful quantities of groundwater or be suitable for ASR.

Pasture. Grassland used for the production of grazing animals such as sheep and cattle.

Percentile. A way of describing sets of data by ranking the data set and establishing the value for each percentage of the total number of data records. The 90th percentile of the distribution is the value such that 90% of the observations fall at or below it.

Permeability. A measure of the ease with which water flows through an aquifer or aquitard.

Personal property. All forms of property other than real property. For example, shares or a water licence.

Phreaphytic vegetation. Vegetation that exists in a climate more arid than its normal range by virtue of its access to groundwater.

Phytoplankton. The plant constituent of organisms inhabiting the surface layer of a lake; mainly single-cell algae.

PIRSA. (Department of) Primary Industries and Resources South Australia.

Pollution, diffuse source. Pollution from sources that are spread out and not easily identified or managed (e.g. an eroding paddock, urban or suburban lands and forests).

Pollution, point source. A localised source of pollution.

Potable water. Water suitable for human consumption.

Potentiometric head. The potentiometric head or surface is the level to which water rises in a well due to water pressure in the aquifer.

Precautionary principle. Where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

Prescribed area, surface water. Part of the State declared to be a surface water prescribed area under the Water Resources Act 1997.

Prescribed lake. A lake declared to be a prescribed lake under the Water Resources Act 1997.

Prescribed water resource. A water resource declared by the Governor to be prescribed under the Act, and includes underground water to which access is obtained by prescribed wells. Prescription of a water resource requires that future management of the resource be regulated via a licensing system.

Prescribed watercourse. A watercourse declared to be a prescribed watercourse under the Water Resources Act 1997.

Prescribed well. A well declared to be a prescribed well under the Water Resources Act 1997.

Property right. A right of ownership or some other right to property, whether real property or personal property.

Proponent. The person or persons (who may be a body corporate) seeking approval to take water from prescribed water.

PWA. Prescribed Wells Area.

PWCA. Prescribed Watercourse Area.

PWRA. Prescribed Water Resources Area.

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

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

Reclaimed water. Treated effluent of a quality suitable for the designated purpose.

Rehabilitation (of waterbodies). Actions that improve the ecological health of a waterbody by reinstating important elements of the environment that existed prior to European settlement.

Remediation (of waterbodies). Actions that improve the ecological condition of a waterbody without necessarily reinstating elements of the environment that existed prior to European settlement.

Restoration (of waterbodies). Actions that reinstate the pre-European condition of a waterbody.

Reticulated water. Water supplied through a piped distribution system.

Riffles. Shallow stream section with fast and turbulent flow.

Riparian landholder. A person whose property abuts a watercourse or through whose property a watercourse runs.

Riparian rights. These were old common law rights of access to, and use of water. These common law rights were abolished with the enactment of the Water Resources Act 1997, which now includes similar rights under s. 7. Riparian rights are therefore now statutory rights under the Act. Where the resource is not prescribed (Water Resources Act 1997, s. 8) or subject to restrictions (Water Resources Act 1997, s. 16), riparian landholders may take any amount of water from watercourses, lakes or wells without consideration to downstream landholders, if it is to be used for stock or domestic purposes. If the capture of water from watercourses and groundwater is to be used for any other purpose then the right of downstream landholders must be protected. Landholders may take any amount of surface water for any purpose without regard to other landholders, unless the surface water is prescribed or subject to restrictions.

Riparian zone. That part of the landscape adjacent to a water body, that influences and is influenced by watercourse processes. This can include landform, hydrological or vegetation definitions. It is commonly used to include the in-stream habitats, bed, banks and sometimes floodplains of watercourses.

Seasonal watercourses or wetlands. Those watercourses and wetlands that contain water on a seasonal basis, usually over the winter/spring period, although there may be some flow or standing water at other times.

State water plan. The plan prepared by the Minister under Part 7, Division 1, s. 90 of the Act.

Stock Use. The taking of water to provide drinking water for stock other than stock subject to intensive farming (as defined by the Act).

Stormwater. Runoff in an urban area.

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

Taxa. General term for a group identified by taxonomy — which is the science of describing, naming and classifying organisms.

To take water. From a water resource includes (a) to take water by pumping or syphoning the water; (b) to stop, impede or divert the flow of water over land (whether in a watercourse or not) for the purpose of collecting the water; (c) to divert the flow of water in a watercourse from the watercourse; (d) to release water from a lake; (e) to permit water to flow under natural pressure from a well; (f) to permit stock to drink from a watercourse, a natural or artificial lake, a dam or reservoir.

Total kjeldhal nitrogen (TKN). The sum of aqueous ammonia and organic nitrogen. Used as a measure of probable sewage pollution.

Transfer. A transfer of a licence (including its water allocation) to another person, or the whole or part of the water allocation of a licence to another licensee or the Minister under Part 5, Division 3, s. 38 of the Act. The transfer may be absolute or for a limited period.

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

Volumetric allocation. An allocation of water expressed on a water licence as a volume (e.g. kilolitres) to be used over a specified period of time, usually per water use year (as distinct from any other sort of allocation).

Wastewater. *See domestic wastewater, industrial wastewater.*

Water affecting activities. Activities referred to in Part 4, Division 1, s. 9 of the Act.

Water allocation. (a) in respect of a water licence means the quantity of water that the licensee is entitled to take and use pursuant to the licence; (b) in respect of water taken pursuant to an authorisation under s. 11 means the maximum quantity of water that can be taken and used pursuant to the authorisation.

Water allocation, area based. An allocation of water that entitles the licensee to irrigate a specified area of land for a specified period of time usually per water use year.

Water allocation plan (WAP). A plan prepared by a CWMB or water resources planning committee and adopted by the Minister in accordance with Division 3 of Part 7 of the Act.

Water licence. A licence granted under the Act entitling the holder to take water from a prescribed watercourse, lake or well or to take surface water from a surface water prescribed area. This grants the licensee a right to take an allocation of water specified on the licence, which may also include conditions on the taking and use of that water. A water licence confers a property right on the holder of the licence and this right is separate from land title.

Water plans. The State Water Plan, catchment water management plans, water allocation plans and local water management plans prepared under Part 7 of the Act.

Water service provider. A person or corporate body that supplies water for domestic, industrial or irrigation purposes or manages wastewater.

Waterbody. Waterbodies include watercourses, riparian zones, floodplains, wetlands, estuaries, lakes and groundwater aquifers.

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

Water-dependent ecosystems. Those parts of the environment, the species composition and natural ecological processes, which are determined by the permanent or temporary presence of flowing or standing water, above or below ground. The in-stream areas of rivers, riparian vegetation, springs, wetlands, floodplains, estuaries and lakes are all water-dependent ecosystems.

Water-use year. The period between 1 July in any given calendar year and 30 June the following calendar year. This is also called a licensing year.

Well. (a) an opening in the ground excavated for the purpose of obtaining access to underground water; (b) an opening in the ground excavated for some other purpose but that gives access to underground water; (c) a natural opening in the ground that gives access to underground water.

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

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