The Department of Water, Land and Biodiversity Conservation

Mallee PWA and Murrayville WSPA Groundwater Monitoring Status Report 2003

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Report DWLBC 2003/29

Government of South Australia

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Foreword

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

Bryan Harris

Director, Knowledge and Information

Department of Water, Land and Biodiversity Conservation

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ABSTRACT

This review of monitoring trends (both water level and salinity) in the Mallee PWA and the Murrayville WSPA has found no major adverse impacts due to irrigation extractions from the Murray Group Limestone aquifer, and confirms the appropriateness of the current management approach.

Drawdowns have reached an equilibrium where irrigation has been established for some time and extractions are relatively stable. Conversely, in areas where extractions have steadily increased, downward trends are expected to continue until pumping has stabilised. The rising trend in pumping is not expected to increase indefinitely because there are few unused allocations in the areas of good quality groundwater. In areas where the salinity is over 1500 mg/L, usage is likely to remain low.

Monitoring has also confirmed the robustness of the groundwater resource, which is recovering well from the impacts of the 2002 drought. Salinity trends are stable, or decreasing in some areas where drawdown is accelerating the inflow of lower salinity groundwater from the south.

An area of groundwater flow reversal has been identified north of Peebinga. This area in Zone 11A should be carefully monitored to determine if this flow reversal is a permanent occurrence, or drought-induced. Management action may be required as part of the review of the Mallee WAP.

The Mallee groundwater model should be recalibrated using recent monitoring data and more accurate pumping figures from meters. Recommendations have been made to improve the coverage of monitoring networks, particularly to the north of Peebinga, to the east of Cowangie, and the Berrook area.

1 INTRODUCTION

The Department of Water, Land and Biodiversity Conservation (DWLBC) is responsible for the management of the State's underground water resources. As part of its role, the DWLBC monitors and maintains an extensive statewide groundwater monitoring network. It has been doing this in the Mallee area (Fig. 1) for about 20 years. The two main parameters measured to assess the condition of the underground resources are water levels and salinity from various observation wells located throughout the Mallee Prescribed Wells Area (PWA). Over time, a history of the condition of the underlying aquifers has been established. This has provided important baseline information so that long-term trends and short-term changes in the status of the resource can be readily identified.

In this region, the aquifer developed for irrigation extends across the State border into Victoria and consequently, observation bore data from the Murrayville Water Supply Protection Area (WSPA) is also included in this report.

The purpose of this report is to provide the River Murray Catchment Water Management Board, Wimmera Mallee Water and interested stakeholders with vital information on the historical and current trends for both water level and salinity, the current condition of the groundwater resources; and to summarise water usage information.

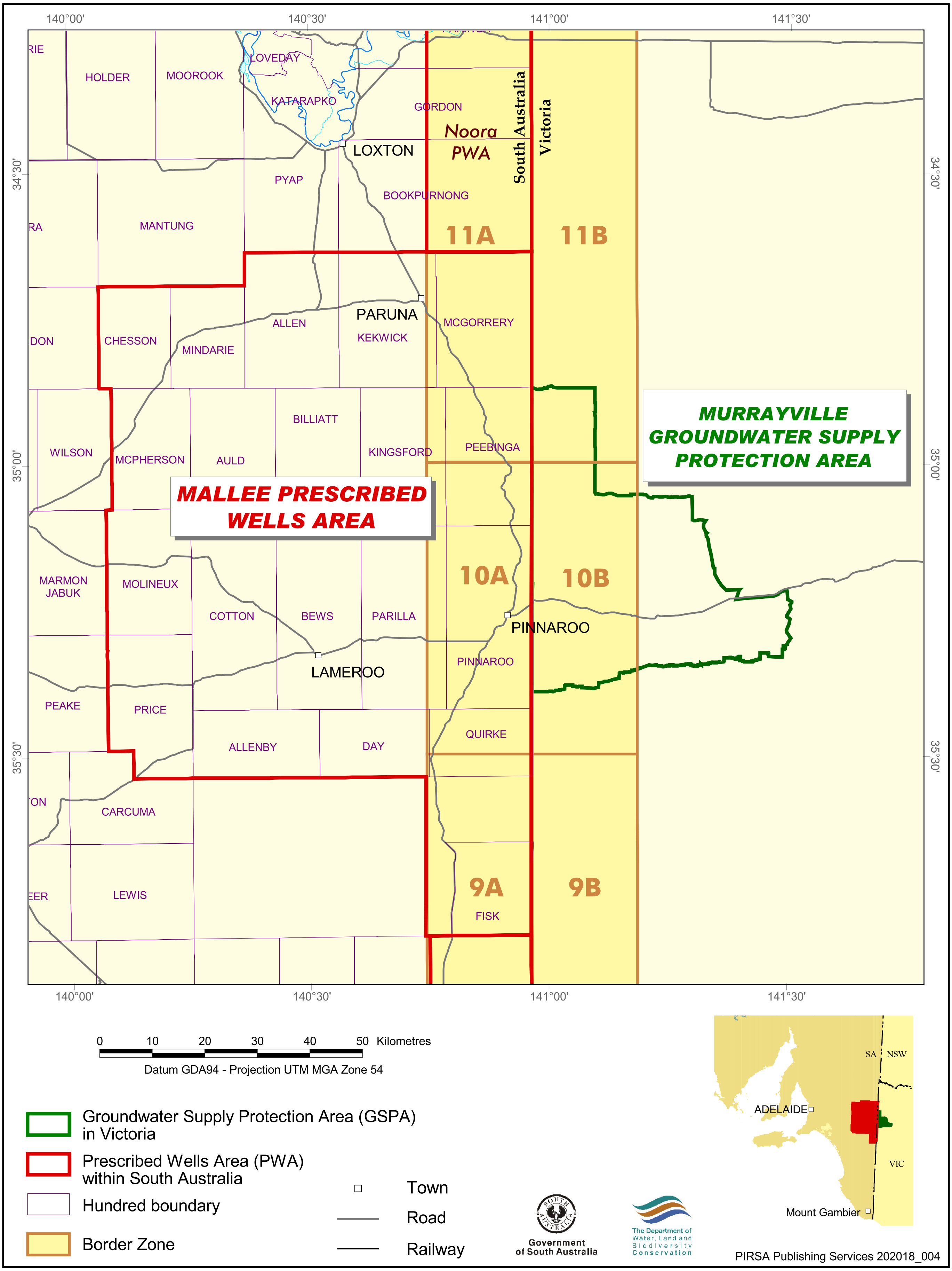


Figure 1. Location of Mallee PWA and Murrayville GSPA

2 SUMMARY OF AQUIFERS

The Murray Basin contains marine and non-marine sequences which have been deposited over the last 65 million years to form three main aquifer systems: the unconfined Pliocene Sands (shallowest), the Murray Group Limestone and the Renmark Group (deepest). These aquifers are separated by clay and marl confining layers. Table 1 summarises the hydrogeological units within the Mallee region.

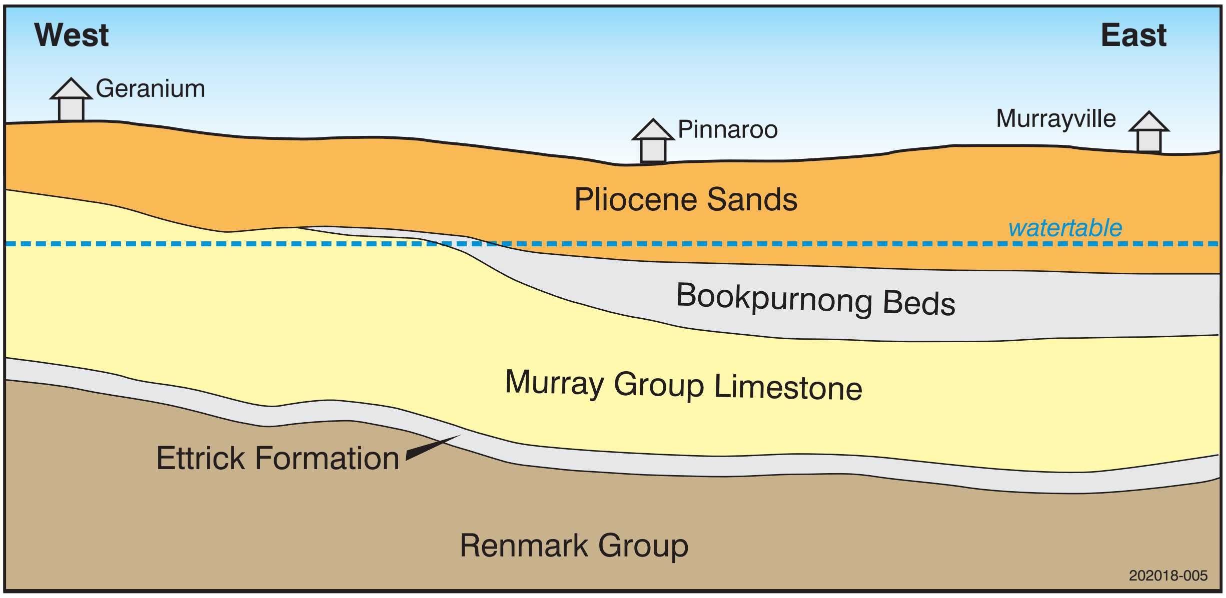


Figure 2. Hydrogeological cross section

Table 1. Hydrogeological units within the Mallee region

Aquifer	Lithology	Thickness (m)	Comments
Pliocene Sands	Fine to coarse sands, clayey in part. Red–orange to grey	0 – 15	Unconfined aquifer. Absent in west of Mallee PWA
Bookpurnong Beds	Grey–green fossiliferous silts and clay	0 – 30	Confining layer. Absent in west of Mallee PWA
Murray Group Limestone	Grey to off-white fossiliferous limestone	80 - 140	Aquifer developed for irrigation
Ettrick Formation	Grey–green stiff marl	15 - 20	Confining layer
Renmark Group	Interbedded sands and clays	100 - 200	Confined aquifer. Not developed

The Murray Group Limestone aquifer is by far the most widely developed aquifer in the region for irrigation, stock, domestic, town water supply and in the near future, mineral sands production.

The Renmark Group confined aquifer underlies all of the Mallee region, and although it contains good quality groundwater below 3000 mg/L in most areas, there are no wells developing this aquifer because of its depth and unreliable yield for irrigation supplies. Because it is a sand aquifer, sandscreen completions are required which are much more expensive than the open hole construction used in the overlying limestone aquifer.

The Pliocene Sands aquifer only contains groundwater in the eastern part of the region. Salinities increase to the north and east, from 1500 mg/L near Pinnaroo to over 20 000 mg/L at the northern margin of the Mallee PWA and to the east of Murrayville. There are only a few stock bores using this aquifer to the north of Pinnaroo where the salinities are low.

3 CLIMATE

Five rainfall stations located in the Mallee region were selected as representative of the rainfall pattern throughout the area. The rainfall records are available for a period of up to 115 years. Rainfall is winter dominant, with the monthly averages for these five stations shown in Table 2.

Table 2. Average monthly rainfall within the Mallee region (mm)

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Geranium	18	21	19	29	44	44	46	39	44	39	26	25
Pinnaroo	17	22	18	24	35	36	36	39	36	34	25	20
Mindarie	17	19	14	20	30	30	32	34	33	33	20	19
Paruna	15	19	14	19	29	29	31	30	29	30	20	19
Murrayville	19	24	13	21	35	33	35	35	33	34	24	22

The annual average rainfall decreases to the northeast, from 404 mm at Geranium, 343 mm at Pinnaroo and 331 mm at Murrayville in the south, to 300 mm at Mindarie and 283 mm at Paruna further north.

Figure 3 shows the monthly rainfall recorded at Pinnaroo for the period 1907 to 2003. The cumulative deviation is also plotted and measures the difference between the actual measured rainfall and the long term average rainfall on a monthly basis. An upward trend in this line indicates above average rainfall, and conversely, a downward trend indicates below average rainfall. Although the records span over a 110-year period, the period shown is selected for comparison against groundwater level monitoring data.

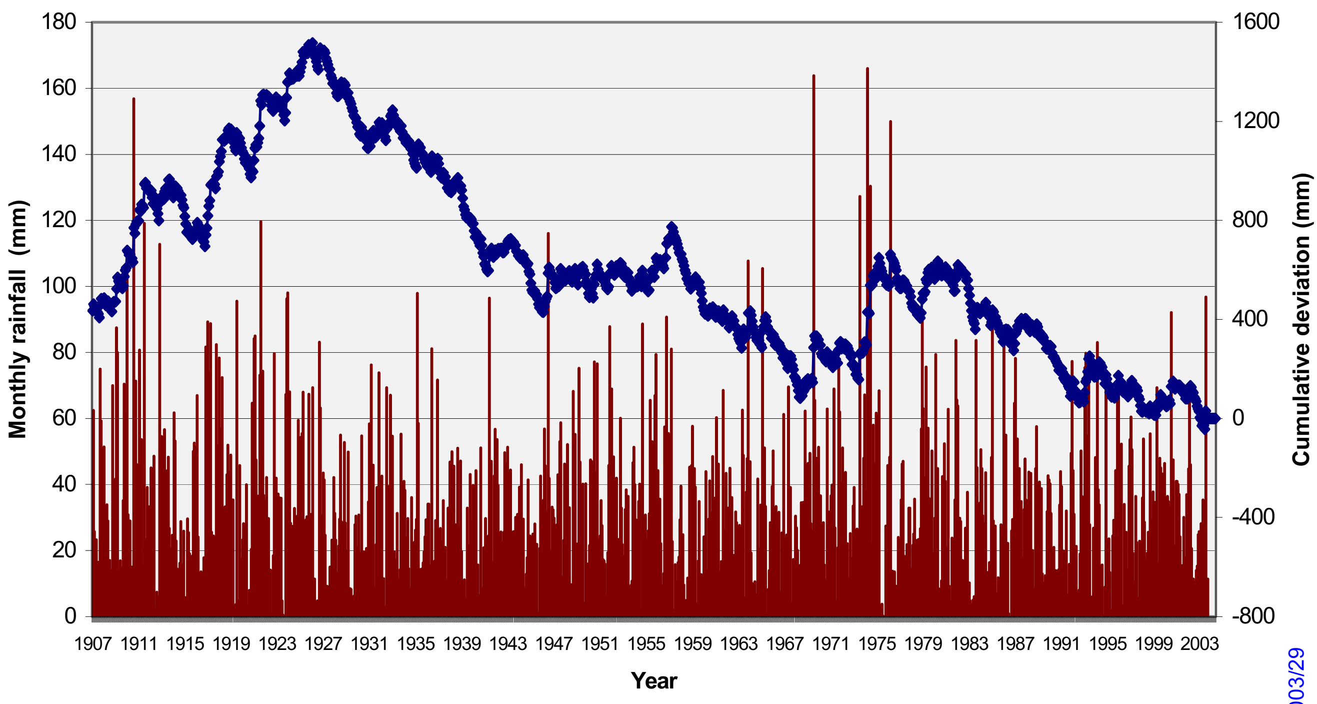


Figure 3. Monthly rainfall for Pinnaroo

The rainfall records show an above average trend from 1907 until around 1925, with a long period of below average rainfall until 1945. The next ten years were generally near average, ending with a high rainfall period in 1956. Another period of below average rainfall occurred until 1968. Some wetter years then occurred over the next ten years until 1979. Since then, the graph shows a continuous declining trend, suggesting that the rainfall has been below average, with the exception of wet years in 1987, 1992 and 2000.

Because of the large depth to the watertable of 40 – 60 m, there is little direct correlation between groundwater levels and variations in rainfall. However, there may be an indirect correlation in that dry years (such as 2002), will result in increased groundwater pumping that may lead to a lowering of groundwater levels.

4 OBSERVATION NETWORKS

4.1 Mallee PWA

4.1.1 GROUNDWATER LEVEL

Water level and salinity monitoring began in the Mallee PWA in 1982 with a regional network of some 90 bores. This network has been rationalised over the years, with additions from drilling programs and deletions due to duplication and access difficulties. Recent additions include the conversion of disused Murray Group Limestone stock bores to observation bores in the overlying Pliocene Sands watertable aquifer, and the drilling of a new Renmark Group observation bore near the SA/Victoria border in the area of maximum drawdown in the Murray Group Limestone aquifer.

There are two types of monitoring carried out in the Mallee PWA. As part of the requirements of the Groundwater (Border Agreement) Act 1985, monitoring at three monthly intervals is carried out by DWLBC personnel in the Border Zones. Selected bores in the remainder of the Mallee PWA are also monitored six monthly by DWLBC.

Additional monitoring is carried out by a Catchment Board contractor to determine seasonal irrigation drawdown impacts. Modifications to this network are made as irrigation development extends into new areas.

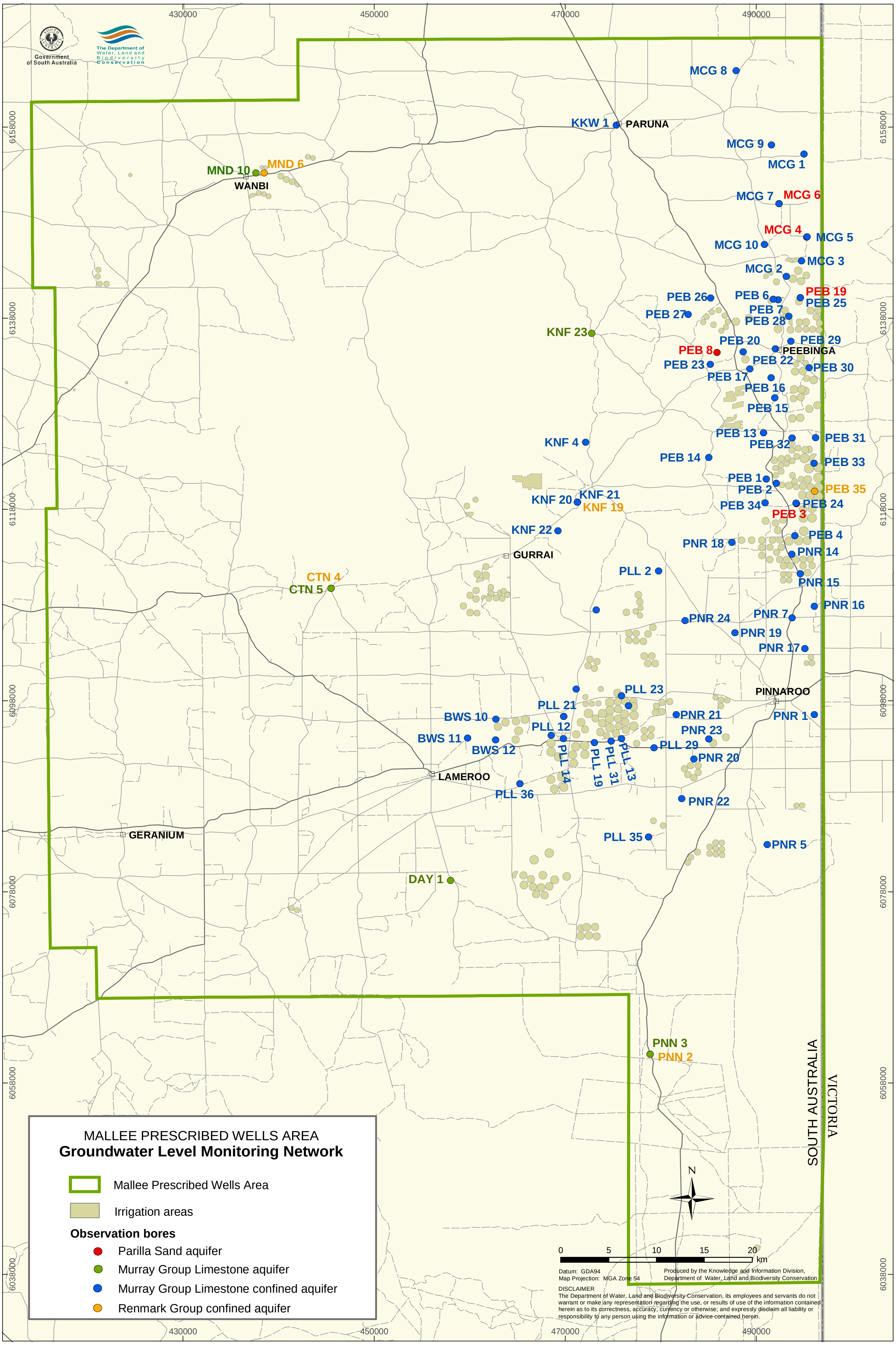
Table 3 shows the current status of the Mallee PWA monitoring network, and Figure 4 displays the locations of the bores.

Table 3. Network summary for groundwater levels in the Mallee PWA

Aquifer	Total number of observation bores	Data loggers	Comments
Pliocene Sands	7	0	5 bores 3 monthly 0 bores 6 monthly 2 bores seasonal
Murray Group Limestone	74	2	34 bores 3 monthly 3 bores 6 monthly 39 bores seasonal
Renmark Group	5	1	2 bores 3 monthly 2 bores 6 monthly 0 bores seasonal

4.1.2 GROUNDWATER SALINITY

Again, as part of the requirements of the Groundwater (Border Agreement) Act 1985, 11 bores are monitored at three monthly intervals by DWLBC personnel, both in the Border Zones and the Parilla area (Fig. 5). Selected irrigation bores in the remainder of the Mallee PWA are also sampled for salinity every one to two years by DWLBC. Submission of annual samples by all irrigators for salinity testing should be encouraged.



Government of South Australia
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MALLEE PRESCRIBED WELLS AREA
Groundwater Level Monitoring Network
Mallee Prescribed Wells Area
Irrigation areas
Observation bores
Parilla Sand aquifer
Murray Group Limestone aquifer
Murray Group Limestone confined aquifer
Renmark Group confined aquifer
PARUNA
WANBI
PEEBINGA
GURRAI
PINNAROO
LAMEROO
GERANIUM
SOUTH AUSTRALIA
VICTORIA
MCG 8
KKW 1
MCG 9
MCG 1
MND 10
MND 6
MCG 7
MCG 6
MCG 4
MCG 5
MCG 10
MCG 3
MCG 2
PEB 26
PEB 6
PEB 19
PEB 25
PEB 27
PEB 7
PEB 28
KNF 23
PEB 20
PEB 29
PEB 8
PEB 22
PEB 23
PEB 30
PEB 17
PEB 16
PEB 15
PEB 13
PEB 31
KNF 4
PEB 32
PEB 14
PEB 33
PEB 1
PEB 2
PEB 35
KNF 20
KNF 21
KNF 19
PEB 34
PEB 24
PEB 3
KNF 22
PEB 4
PNR 18
PNR 14
CTN 4
CTN 5
PLL 2
PNR 15
PNR 16
PNR 7
PNR 24
PNR 19
PNR 17
PLL 23
PLL 21
BWS 10
PNR 21
PLL 12
PNR 1
BWS 11
PNR 23
BWS 12
PLL 29
PLL 14
PLL 19
PLL 31
PLL 13
PNR 20
PLL 36
PNR 22
PLL 35
PNR 5
DAY 1
PNN 3
PNN 2
N
0
5
10
15
20
km
430000
450000
470000
490000
6158000
6138000
6118000
6098000
6078000
6058000
6038000
Datum: GDA94
Map Projection: MGA Zone 54
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Figure 4

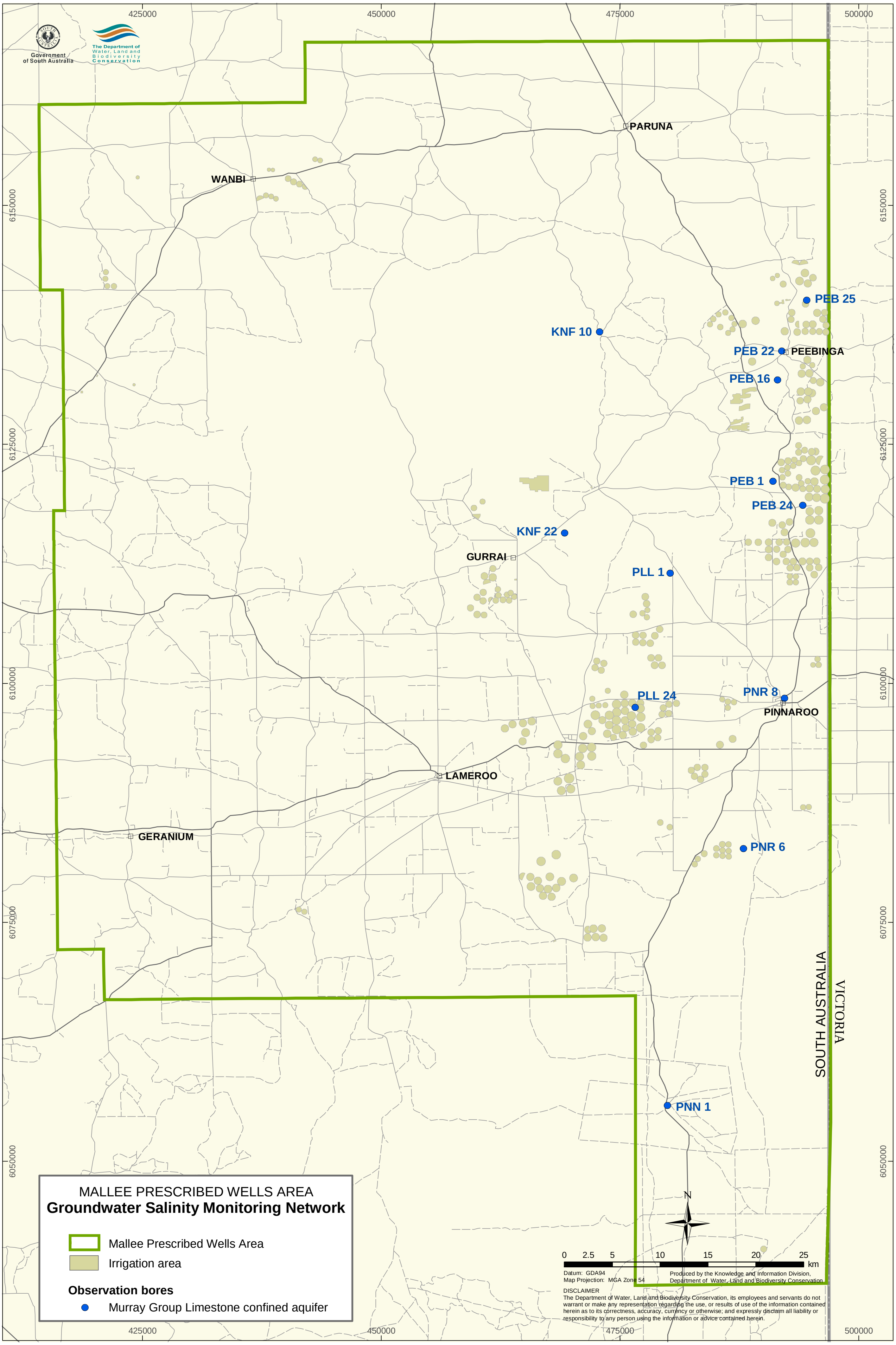

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Figure 5

4.2 Murrayville WSPA

4.2.1 GROUNDWATER LEVEL

The groundwater monitoring network in the Murrayville Water Supply Protection Area has increased substantially since observations of water levels of some bores commenced during the 1960's. There are two monitoring programs being undertaken in the area, three monthly and monthly.

A contractor for the Victorian Department of Sustainability and Environment (DSE) undertakes quarterly monitoring of most bores as part of the Groundwater (Border Agreement) Act 1985 requirement. For those bores designated as requiring monthly monitoring in the Murrayville Area Groundwater Management Plan 2001, monitoring has been undertaken since 1998 by a private contractor on behalf of Wimmera Mallee Water.

Table 4. Network summary for groundwater levels in the Murrayville WSPA

Aquifer	Total number of observation bores	Data loggers	Comments
Pliocene Sands	7	0	7 bores monthly
Murray Group Limestone	25	4	16 bores monthly 9 bores 3 monthly
Renmark Group	2	0	1 bore monthly 1 bore 3 monthly

4.2.2 GROUNDWATER SALINITY

Prior to the implementation of the Murrayville Area Groundwater Management Plan in 2001, salinity monitoring was undertaken either on a 3 monthly or six monthly basis by DSE as part of the requirements of the Groundwater (Border Agreement) Act 1985. Since 2001, the salinity monitoring network has increased to incorporate an additional eight bores, four of which have been monitored by WMW since 1982. The salinity monitoring network now consists of 14 bores, five of which are monitored three monthly, with the remaining 11 bores monitored on a six monthly basis.

In order to obtain a 'snapshot' of the chemical composition of the Murray Group Limestone aquifer, over 50 bores in and around the Murrayville WSPA were sampled in November 2003 and May/June 2004, and analysed for the major ions, nutrients, herbicides, pesticides and biological pathogens. The results confirmed the increase in salinity toward the northeast, with a shift from calcium bicarbonate type water at lower salinities, to a sodium chloride water at higher salinities (SKM, 2004).

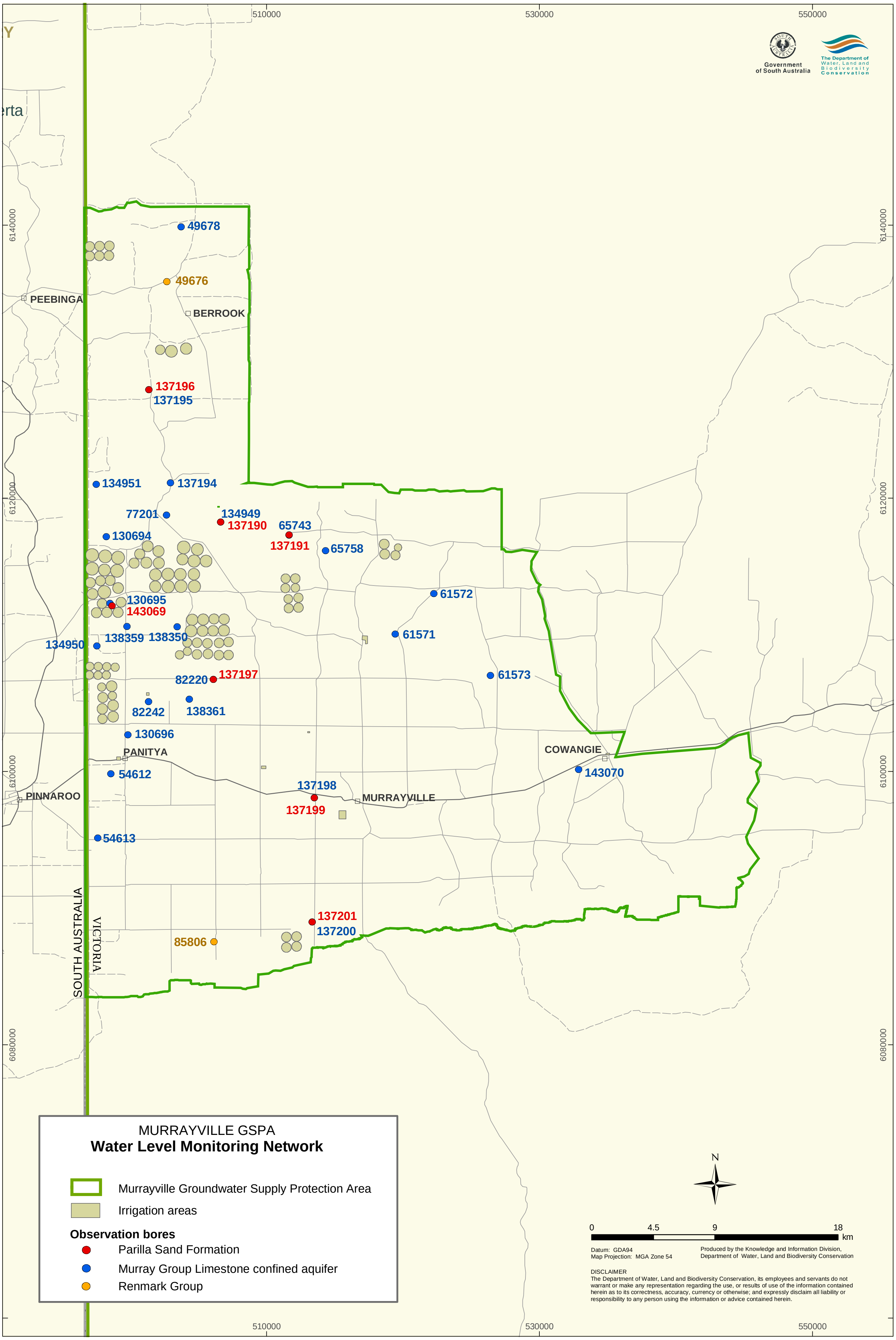

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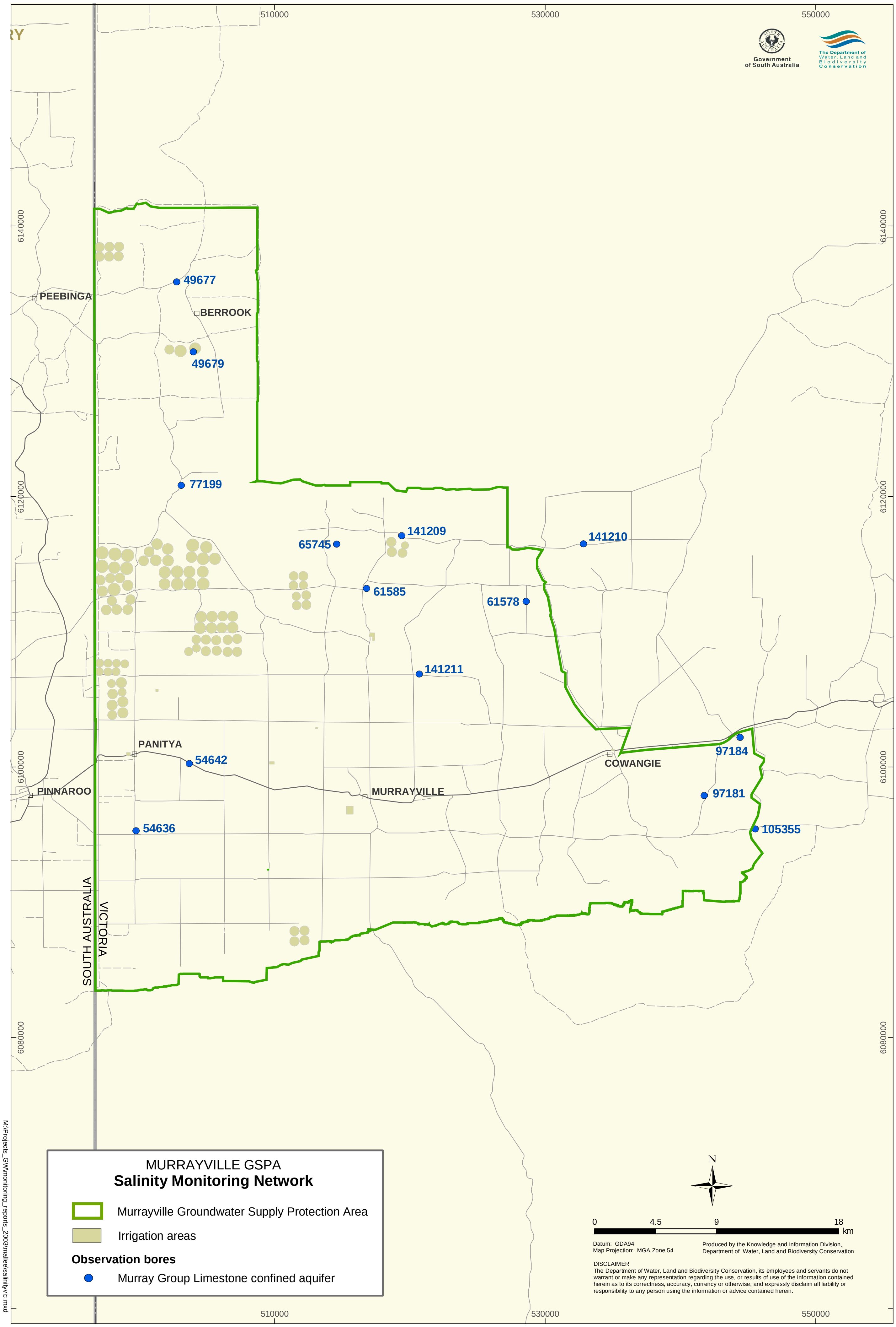
Figure 6


MURRAYVILLE GSPA
Salinity Monitoring Network
Murrayville Groundwater Supply Protection Area
Irrigation areas
Observation bores
Murray Group Limestone confined aquifer
Government of South Australia
The Department of Water, Land and Biodiversity Conservation
510000
530000
550000
6140000
6120000
6100000
6080000
PEEBINGA
BERROOK
PANITYA
PINNAROO
MURRAYVILLE
COWANGIE
SOUTH AUSTRALIA
VICTORIA
49677
49679
77199
65745
141209
141210
61585
61578
141211
54642
54636
97184
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Datum: GDA94
Map Projection: MGA Zone 54
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Figure 7

5 GROUNDWATER EXTRACTIONS

Before examining trends from the observation networks, it is important to study the history of groundwater extraction that is driving the changes in groundwater levels. In the Mallee PWA, estimates of historical extraction were achieved by interviewing each irrigator where possible at the end of each irrigation season to obtain the number of hours of pumping and the pumping rate of each bore. This method was considered accurate to within 10-15% with a tendency to overestimate extractions (pumping rates are usually overestimated).

Meters have been progressively installed on almost all irrigation bores in the Mallee PWA, which will result in more accurate estimates in the future. In the Murrayville WSPA, meters have been installed on all irrigation bores at the time of drilling.

Figure 8 shows the irrigation extractions for both the Mallee PWA and the Murrayville WSPA. A gradual rise in the Mallee P0WA was observed until 1994/95 when a sharp increase took place until 1998/99 when the rate of increase began to diminish. Extractions for 2002/03 increased markedly to about 27 100 ML (Mallee) and 3500 ML (Murrayville) due to the drought conditions experienced in the region. The rising trend is not expected to increase indefinitely because there are few unused allocations in the areas of good quality groundwater. In areas where the salinity is over 1500 mg/L (2700 EC), usage is likely to remain low.

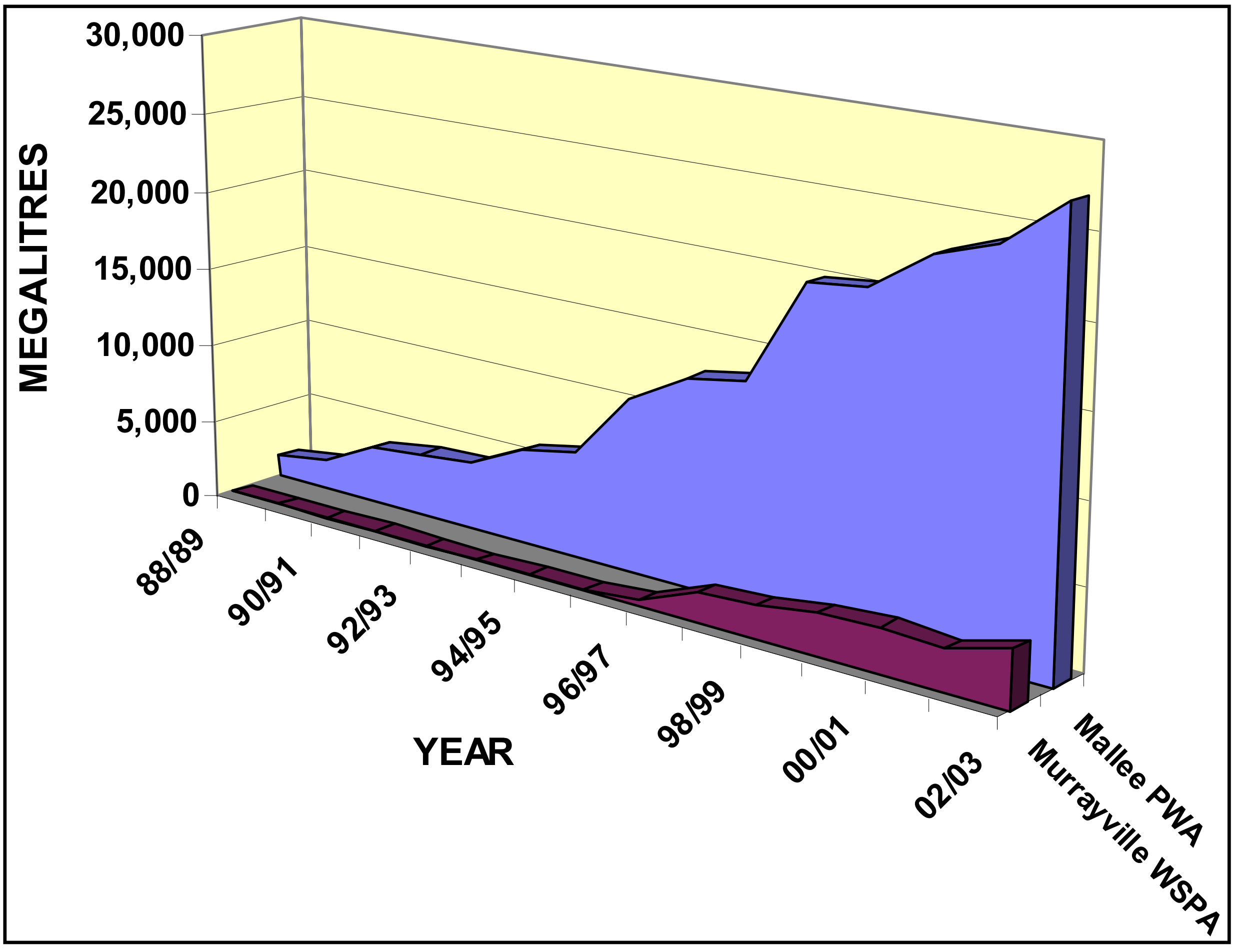

Figure 8. Groundwater extractions for Mallee PWA and Murrayville WSPA

6 WATER LEVEL TRENDS

Long term monitoring has detected drawdowns as a result of irrigation withdrawals from the Murray Group Limestone aquifer. The magnitude of the drawdowns depends on several factors – whether the aquifer is confined or not, and how concentrated the irrigation bores are located.

Drawdowns in the confined portion of the aquifer occur more quickly and are greater than drawdowns in the unconfined portion because they are an instant pressure response to pumping. In an unconfined aquifer, drawdowns only occur when water physically drains out of the sediments as a result of pumping, which is a much slower process. Drawdowns are a natural response to pumping, and should be monitored to ensure there are no adverse impacts that affect the sustainability of the resource.

Obviously, drawdowns are going to be greater in areas of concentrated pumping, and this tends to occur in areas of low groundwater salinity and suitable soils. In areas where there is no irrigation, there is no regional drawdown and water levels are relatively constant. Monitoring results will be discussed for distinct areas within the management regions.

6.1 Parilla area

Monitoring commenced in this area in 1987 and Figure 9 shows the gradually increasing seasonal drawdown observed as the extractions increased over the years. In recent years, the seasonal drawdowns have virtually stabilised. Recovery levels this year are higher than the drought affected level of last year.

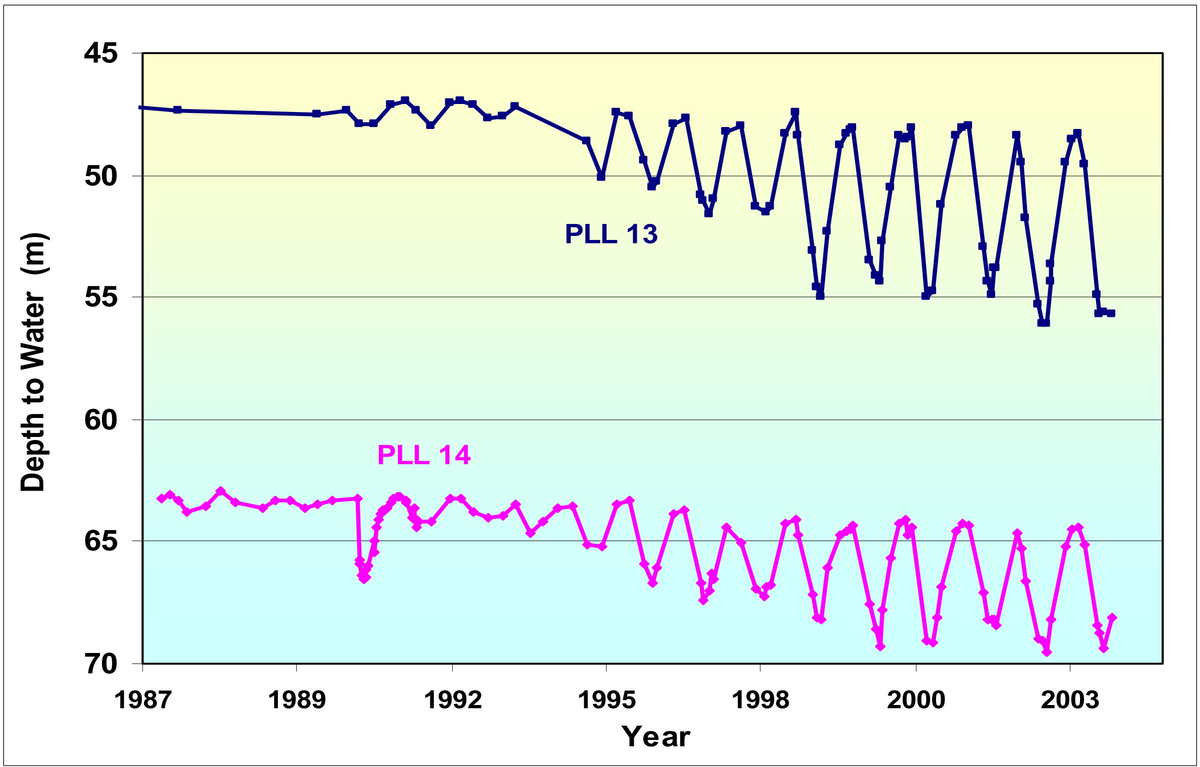

Figure 9. Parilla water level hydrographs

6.2 *Pinnaroo – Peebinga area*

The trends in this area are similar to Parilla, with increasing drawdowns as extractions increased. Figure 10 shows the levels from three observation bores in the confined limestone aquifer. The influence of the drought is more pronounced than in the Parilla area, with the recovery level in 2002 much lower than 2001, because pumping started a month earlier due to the dry winter. This did not allow the water levels to recover back to the previous year's levels.

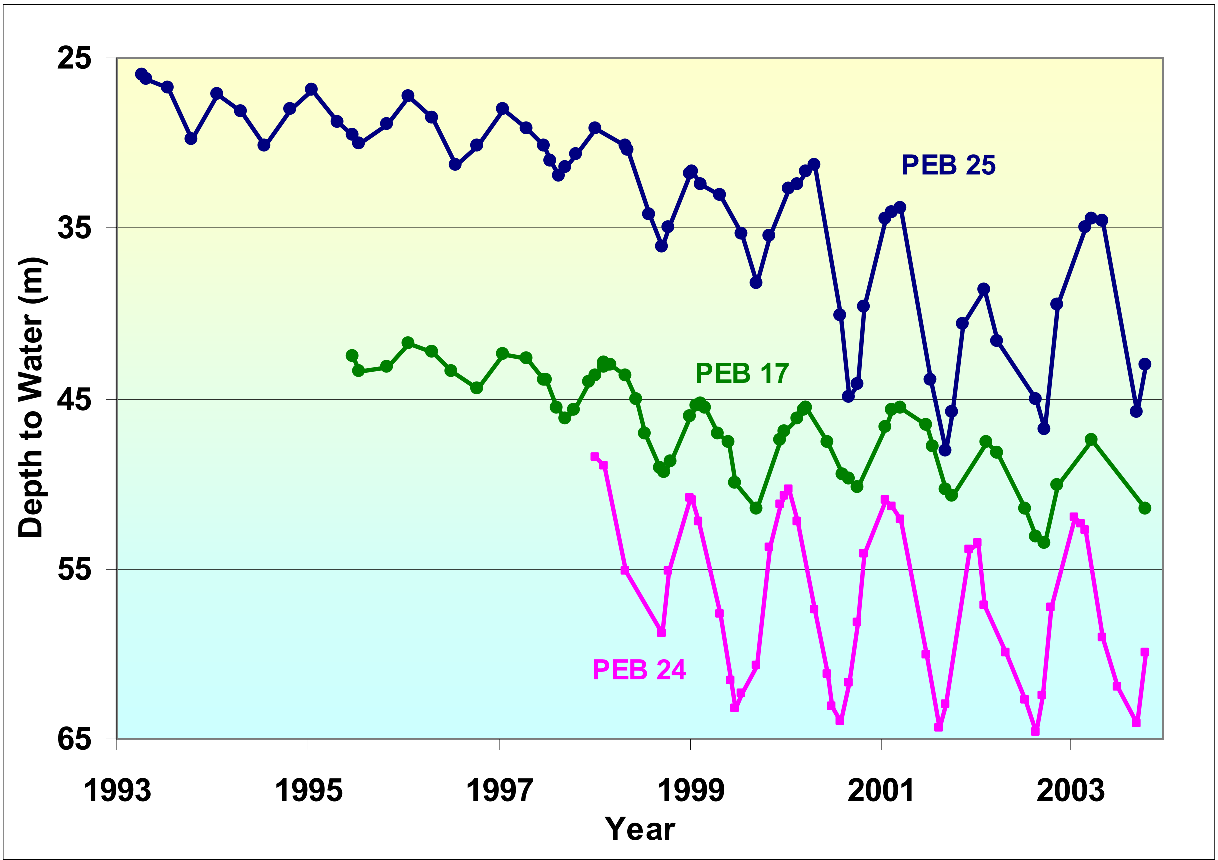

Figure 10. Pinnaroo – Peebinga water level hydrographs

It was expected that the seasonal drawdown would be greater because of the increased pumping due to the drought, however this was not the case in all areas. The reason for this can be seen in Figure 11 which shows data logger records from PEB 2. A 96 mm rainfall event in February allowed cessation of pumping for a short time that resulted in a recovery of 4 m.

The observable downward trend is a response to gradual increases in extraction (Fig.8). When this stabilises, the drawdowns are also expected to do so. In fact, PEB 24 and 25 are demonstrating the resilience of the aquifer by recovering back to pre-drought conditions.

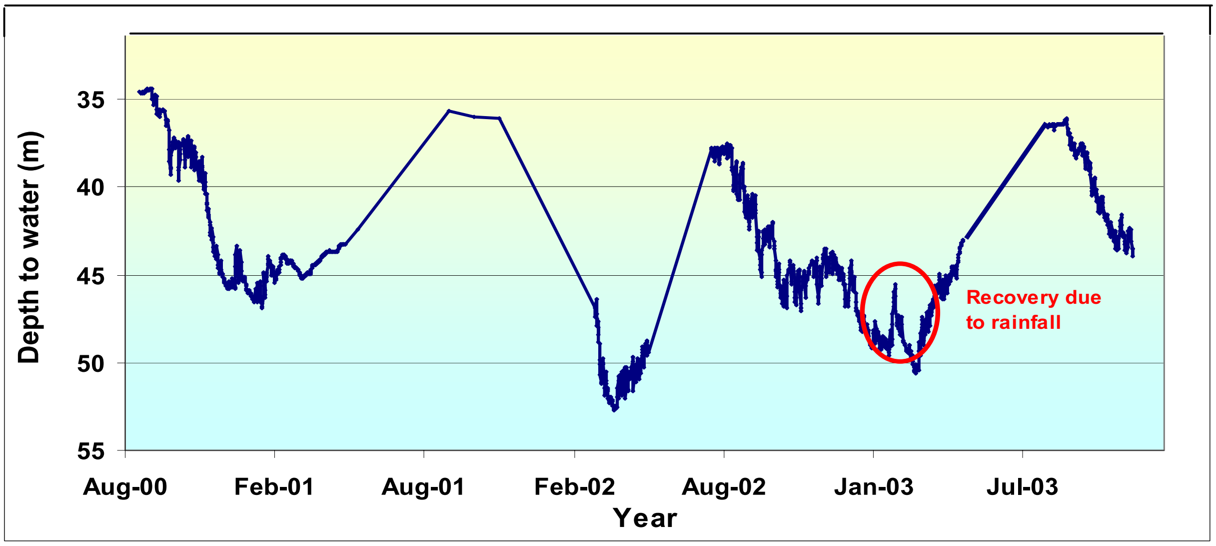

Figure 11. PEB 2 groundwater levels from data logger

6.3 Panitya North area

Monitoring in this area commenced in 1997 when irrigation was first established in Victoria (Fig. 12). Water levels here were probably influenced by extraction in SA before this time, and hence monitoring generally does not show the pre-irrigation situation (with the exception of bores located near new irrigation eg 137195 and 65758).

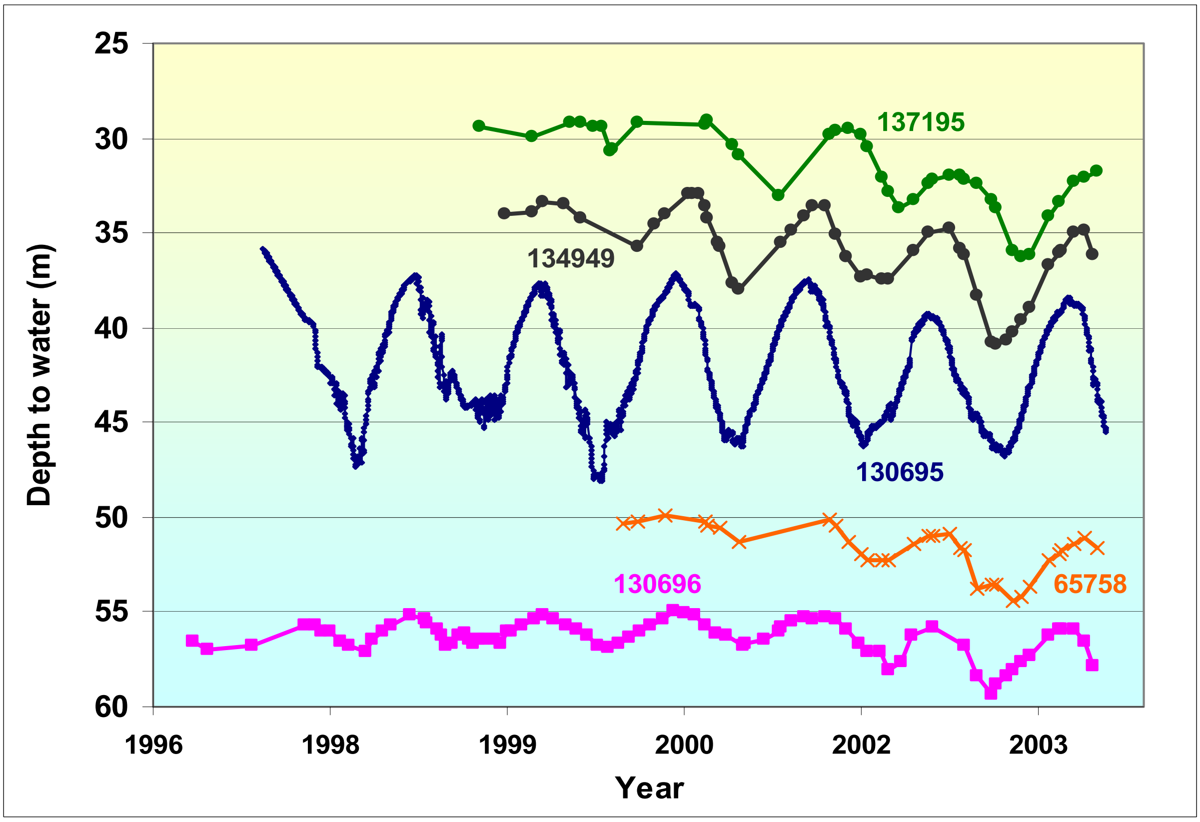

Figure 12. Panitya North water level hydrographs

Trends here are similar to those experienced in the Pinnaroo – Peebinga area of SA. In the area of concentrated pumping, 130695 shows a stabilisation of seasonal drawdowns and a good recovery after the very dry 2002/03 irrigation season. The other bores depict relatively small increases in drawdown due to increasing extractions in their vicinity.

Again, these downward trends will only continue if extractions continue to increase. As with 130695, seasonal drawdowns will stabilise when extractions become relatively constant.

6.4 Non-irrigated areas

In areas located at some distance from irrigation, there is very little change in water levels. This is certainly the case in the Mallee PWA as seen in Figure 13, although KKW 1 seems to be showing a very slight rising trend. Generally, the depth to the watertable where the limestone aquifer is unconfined is so deep (about 40 – 50 m), the effects of clearing have not yet percolated down far enough to have an impact.

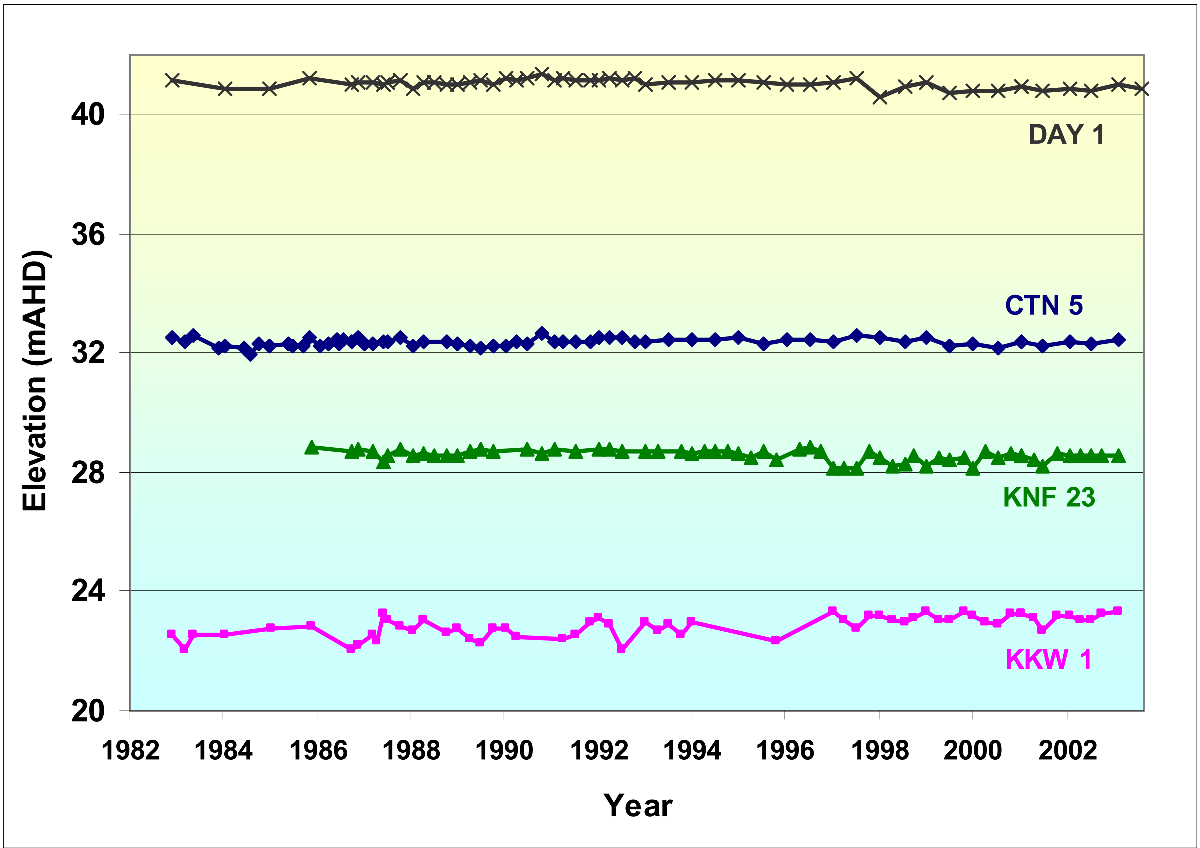

Figure 13. Hydrographs from non-irrigated areas in the Mallee PWA

The Murrayville WSPA also contains areas where there is little change in water levels, as shown in Figure 14. Importantly, these areas include to the east of Murrayville (bore 143070) where if a significant drop in water level occurred, a movement of saline groundwater from the east could result. The likelihood of such inflows should be tested when the Mallee groundwater model (Barnett and Yan, 2000) is recalibrated.

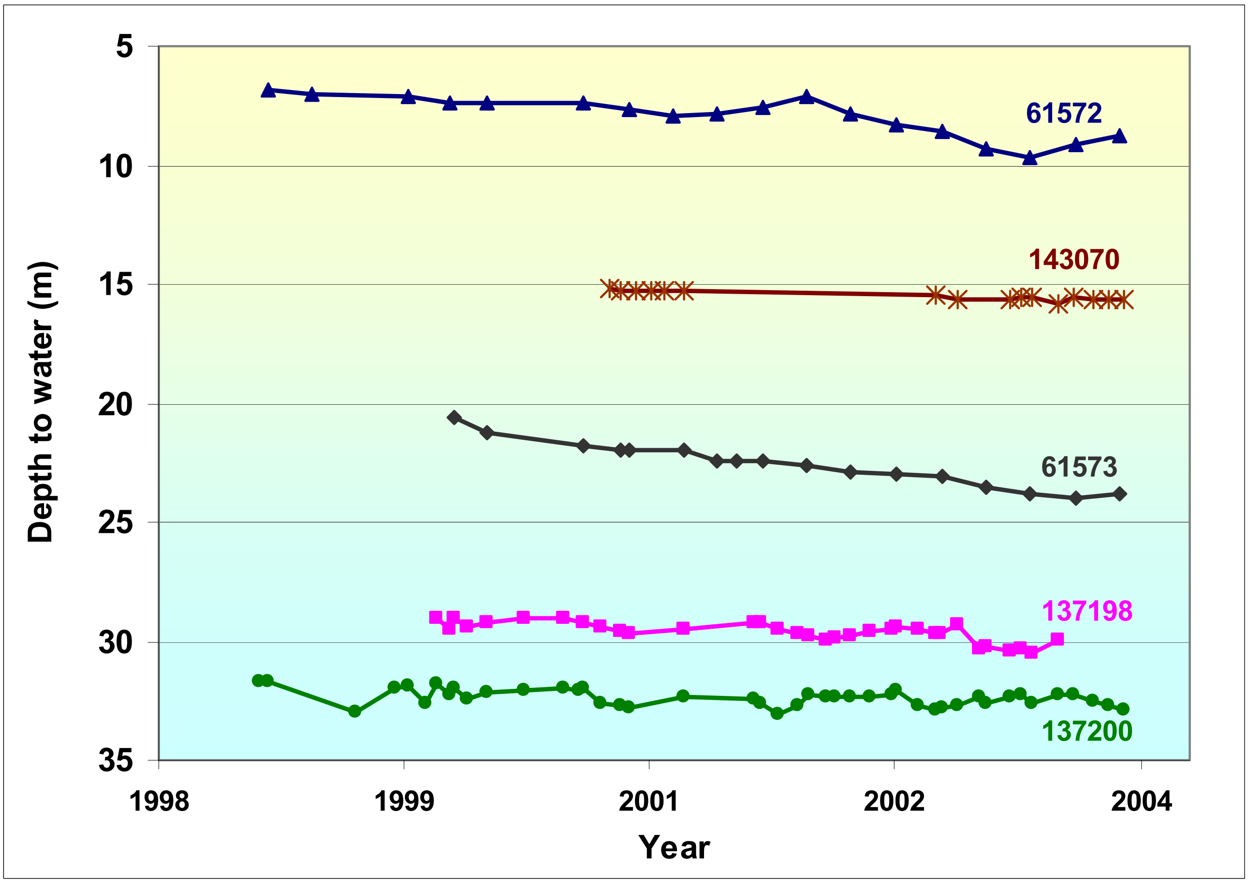

Figure 14. Hydrographs from non-irrigated areas in the Murrayville WSPA

Of interest in Figure 14 is the continually falling water level in bore 61573, which is located far from any irrigation. This suggests a casing failure that is allowing connection with the saline Pliocene Sands watertable aquifer. Because the pressure level for the limestone aquifer (and consequently the water level inside the casing) is higher than the surrounding watertable, a hole in the casing will allow water to leak out of the casing until it balances with the watertable level. This connection has been verified by the November sampling which returned a salinity of 41 000 mg/L for this bore.

6.5 Pliocene Sands and Renmark Group Aquifers

As mentioned previously, there are no extractions from the Renmark Group confined aquifer, and only isolated stock use from the Pliocene Sands watertable aquifer. It can also be seen in Figure 15 that the watertable aquifer hydrographs show no observable response to either irrigation or the increased recharge following clearing in both management areas.

Similarly, the Renmark Group hydrographs show no response to irrigation from the overlying aquifer. However the observation bores shown are located some distance away from the irrigated areas. To overcome this problem, a new bore (PEB 35) was drilled on the SA/Vic Border close to the area of maximum drawdown in order to detect any upward leakage that should occur. It was completed at a depth of 265 m and is equipped with a data logger. A composite log of this new bore is presented in Appendix A.

The lack of response in the Pliocene Sands aquifer suggests that there is a poor connection with the underlying confined limestone aquifer, and that volumes of induced leakage are very low. This is not surprising given the thickness of the Bookpurnong Beds confining layer is 20 – 30 m thick. Estimates of leakage volumes can be obtained from the recalibrated groundwater model.

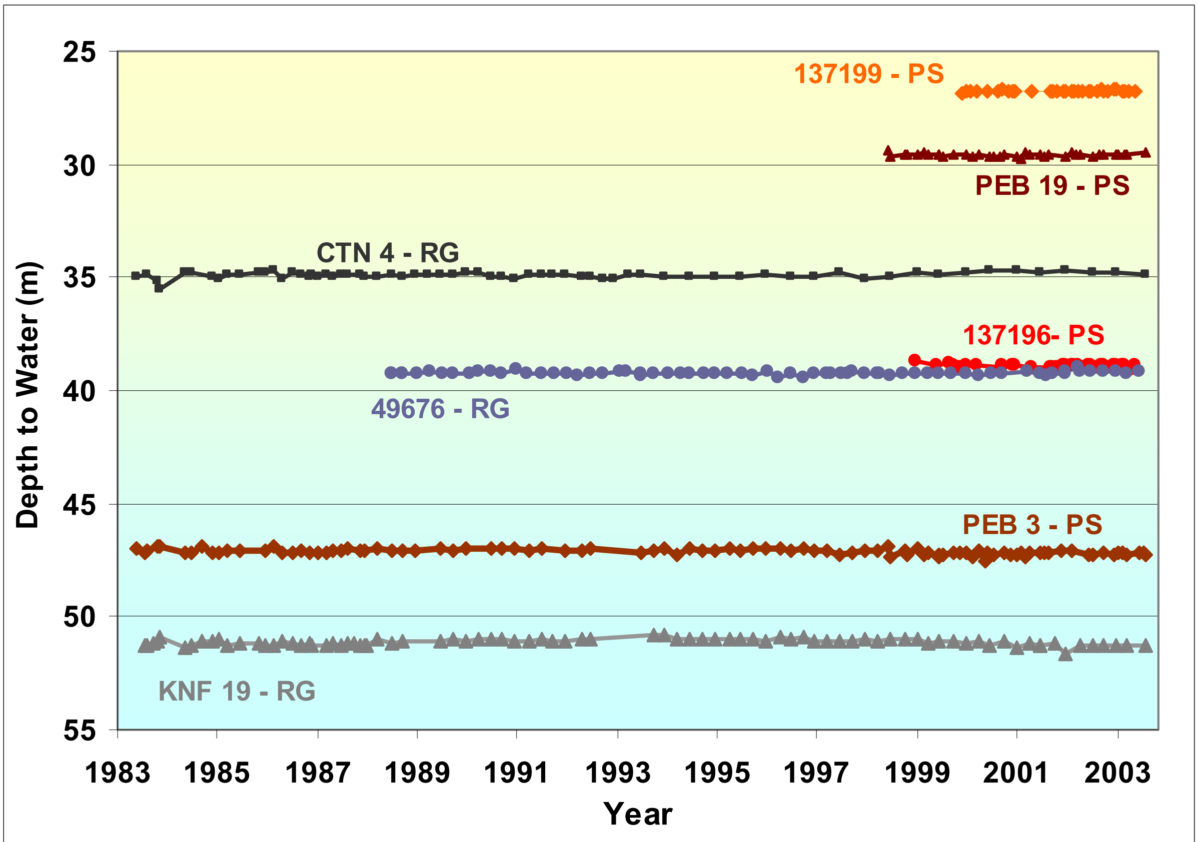

Figure 15. Hydrographs from Pliocene Sands and Renmark Group aquifers

7 SALINITY TRENDS

The salinity monitoring has shown no real changes over the years, which is not surprising given the slow movement of groundwater (about one metre per year). There are some exceptions where a gradual falling trend is noticed (Fig. 16).

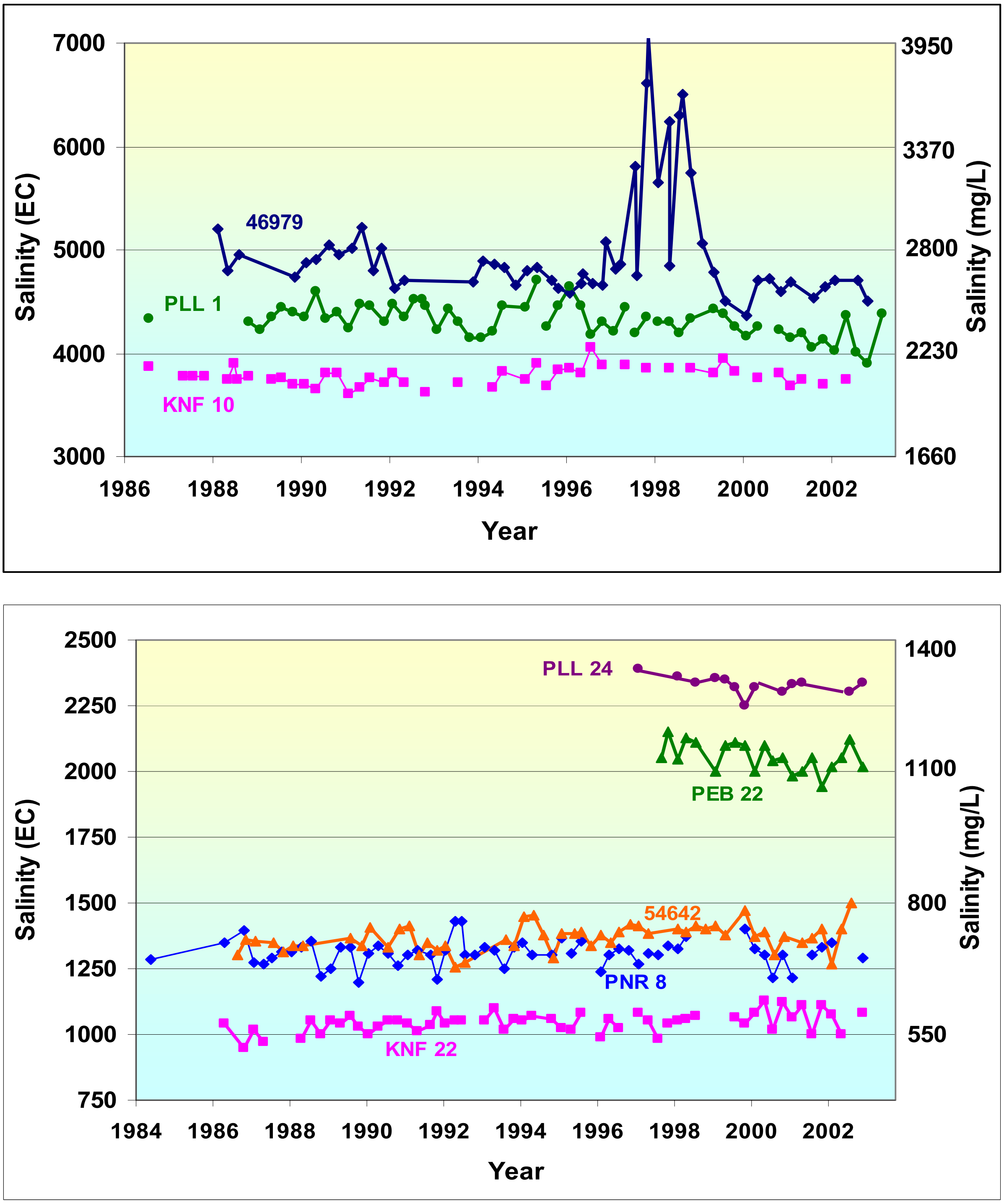

Figure 16. Salinity trends for the limestone aquifer

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Bores PLL 24 and PEB 22 are located near concentrations of pumping and the resultant drawdown is accelerating the inflow of lower salinity groundwater from the south, and causing a slight decrease in salinity. This trend is also noticeable in bores PLL 1 and 46979 and several irrigation bores. The marked salinity changes in 46979 were the result of casing corrosion that allowed contamination from the overlying saline Pliocene Sands aquifer (it was relined in 1999).

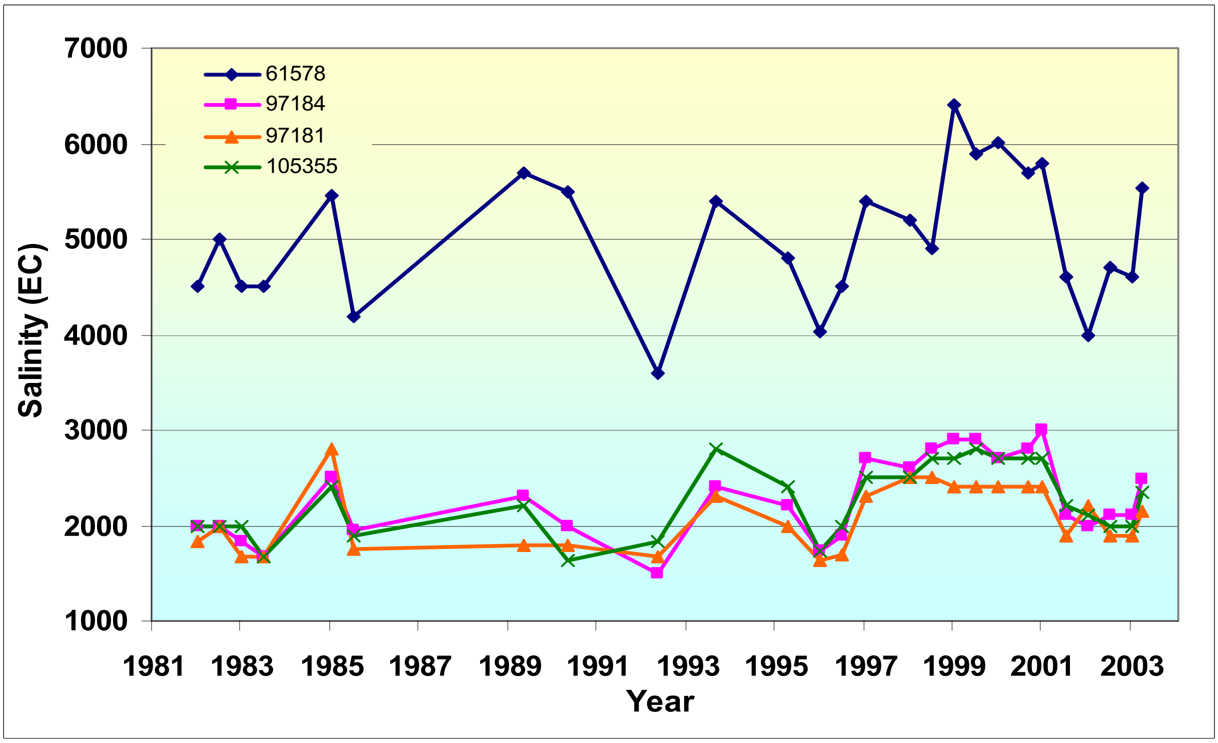


Figure 17. Salinity trends for the limestone aquifer in the Cowangie area

Trends displayed in Figure 17 for the Cowangie area are quite different from those in Figure 16. The fact that the four bores have parallel trends immediately raises suspicions that the instrument used to measure the conductivities has not been regularly calibrated with a standard solution. The EC variations are therefore almost certainly due to instrument 'drift' rather than changes in aquifer salinity. Wimmera Mallee Water is changing analysis procedures for these bores from now on.

8 REGIONAL FLOW PATTERNS

The previous discussions have examined trends at individual sampling points. To help obtain a regional perspective, contour plans have been prepared of the seasonal drawdown during the last three irrigation seasons. In addition, contours of the pressure surface of the limestone aquifer were created at the time of peak recovery to determine regional groundwater flow patterns at this time. Contours of residual drawdown since 1990 were also constructed to depict the long term impacts of irrigation. These terms are explained in Figure 18.

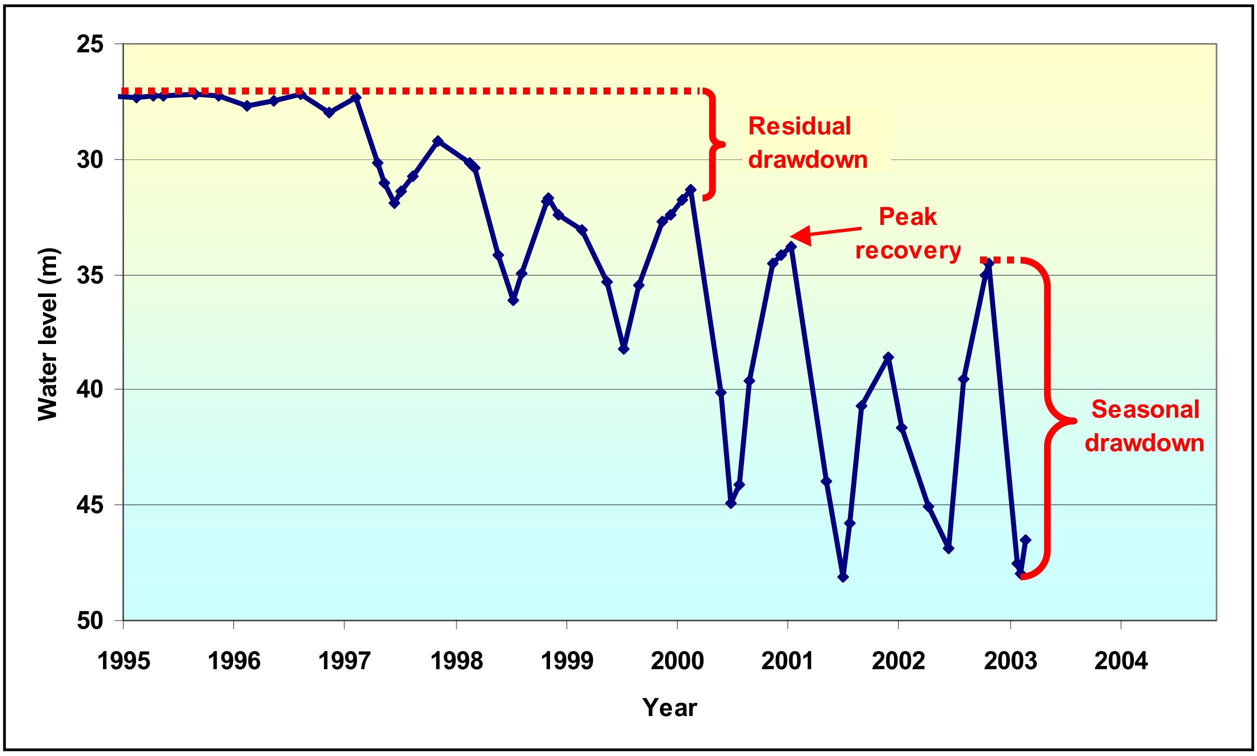


Figure 18. Explanation of contour plans

It should be stressed that the areas of irrigation shown in green in Figures 4 – 7 and these drawdown plans in this report represent the total extent, and not the area irrigated in any one season. The actual irrigated area at any time is about 30 % of the green areas shown due to the rotational requirements of vegetable irrigation.

Contours are presented for the irrigation seasons from 2000/01 to 2002/03. Figure 19A shows the pressure surface contours for 2000 indicating groundwater flow to the north with some concentration of flow toward Peebinga due to irrigation drawdowns. There is a very small area where reversal of groundwater flow from the north is observed in this area, driven by very small gradients. The seasonal drawdowns for 2000/01 (Fig. 19B) show similar patterns to previous years with some exceptions. In the Parilla area, pumping has been more dispersed leading to a decrease in the depth of the cone of depression, but a lateral spread to the west and northeast. To the northeast of Peebinga, new irrigation in SA and Vic has intensified drawdown in this area. Pumping has also spread to the east in the Panitya North area and has locally increased drawdowns by a small amount.

The impact of the increased pumping near Peebinga is shown in Figure 20 (Zone 11A extractions increased from 2850 ML in 1999/2000, to 3700 ML in 2001/02). The pressure surface contours for 2001 (Fig. 20A) show incomplete recovery and a small cone of depression in this area, which resulted in an increase in the area reversal of groundwater flow from the north. The 2001/02 seasonal drawdowns (Fig. 20B) are very similar to the previous season except for a deepening of the cone of depression in the Peebinga area by 1 – 2 m.

The impact of the very dry year in 2002 is quite evident in Figure 21A. Irrigation pumping started several months earlier than normal before water levels recovered to their normal levels, as can be seen in the hydrographs (Figs 10 – 12). A larger cone of depression in the elevation contours up to 10 m deep in the Peebinga area was the result, which is considered to be an extreme event. The area of flow reversal increased significantly. There was also evidence of incomplete recovery in the Parilla area. The seasonal drawdown contours for 2002/03 (Fig. 21B) show a surprising decrease in the drawdown to north and south of Peebinga. New irrigation to the north of Murrayville extended the drawdown impacts further to the east by several kilometres.

The resilience of the aquifer can be seen in Figure 22A where a recovery of four metres in the elevation contours occurred in the Peebinga area during 2003, although levels were not back to their 2001 levels. The area of flow reversal also decreased in size. Figure 22B displays the long term residual drawdown from 1990 to 2003 due to irrigation pumping (see explanation in Fig. 18). The largest residual drawdowns of up to 9 m occur at centres of concentrated pumping where seasonal drawdowns are greatest.

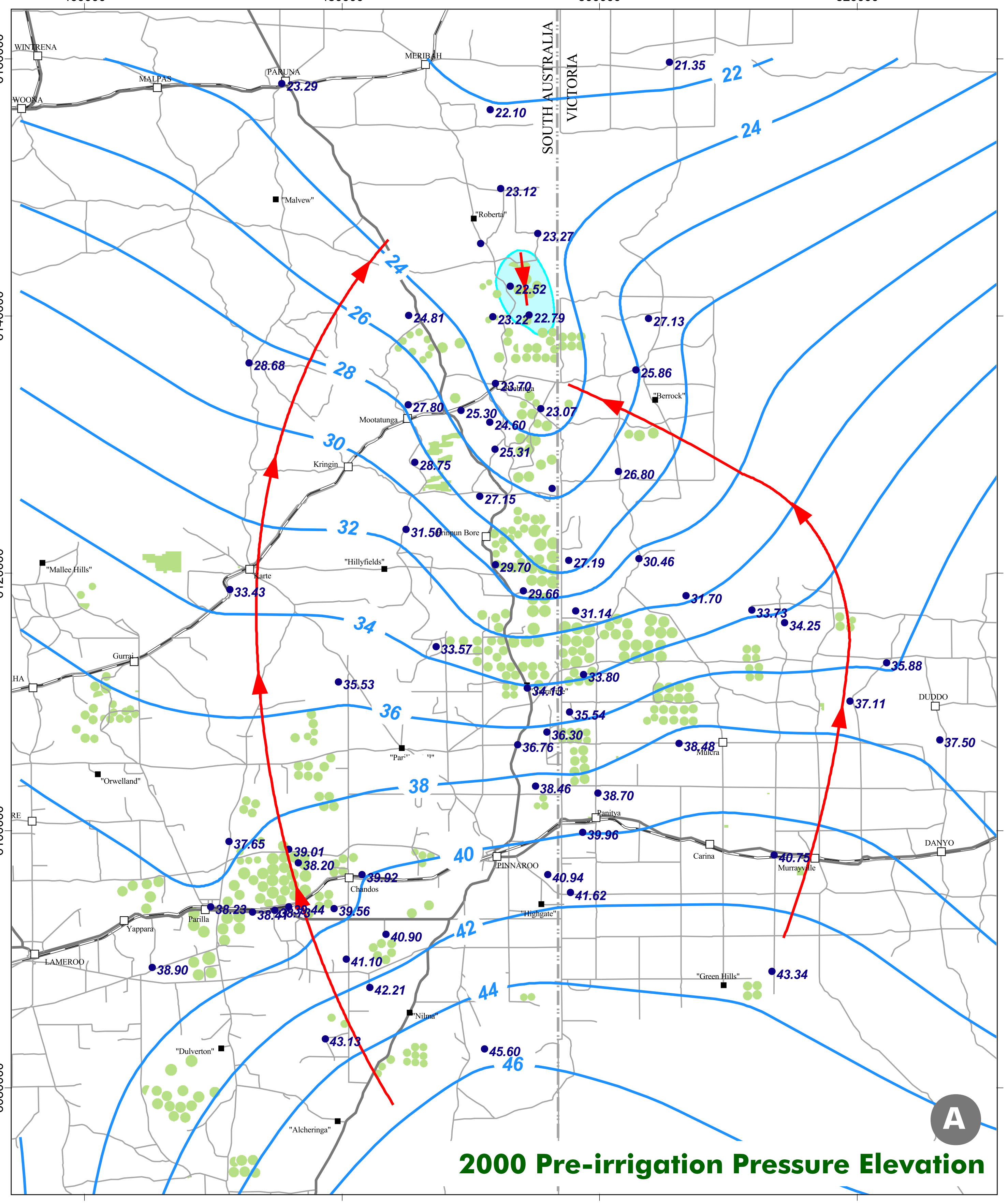
8.1 Discussion

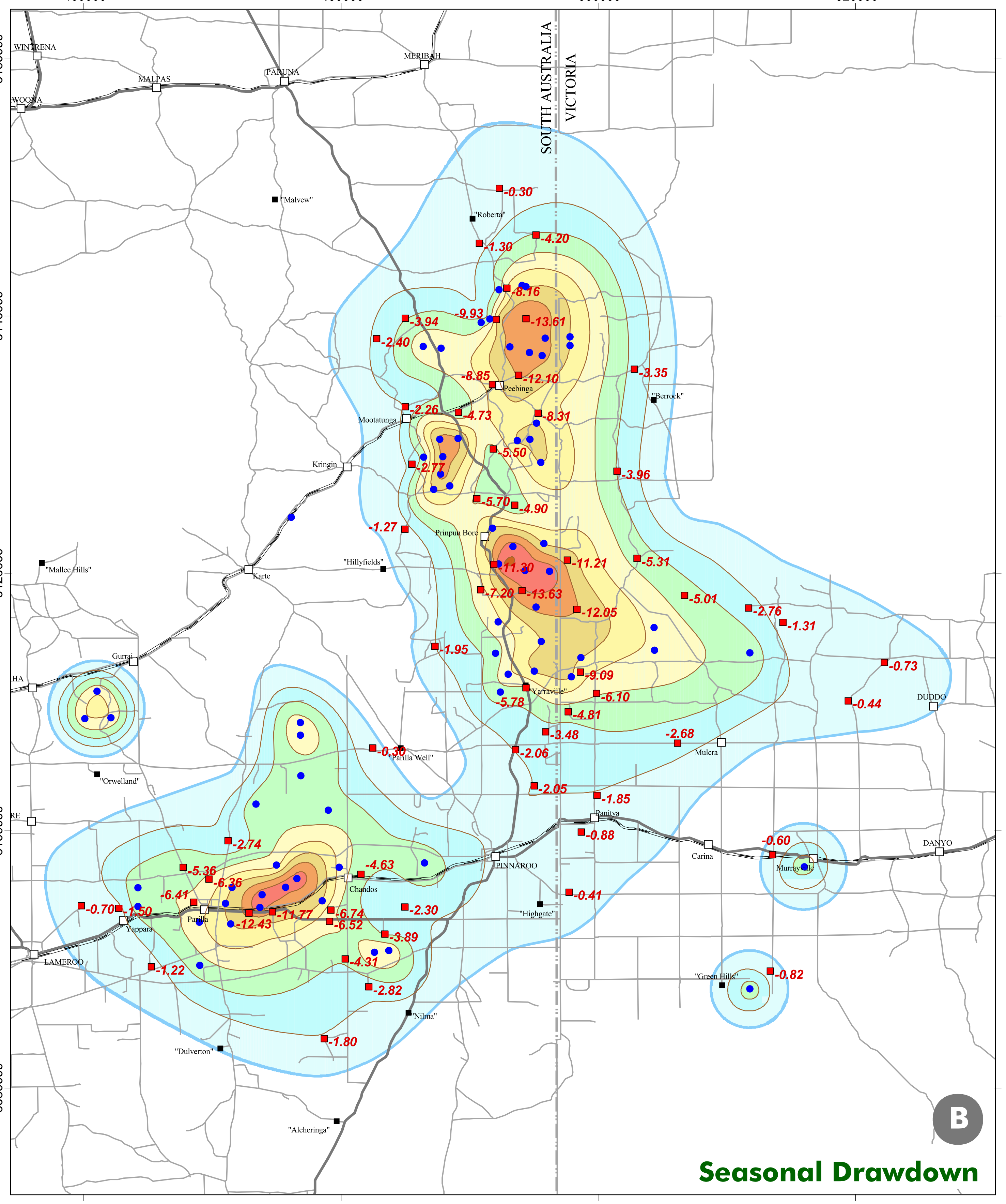
Reversals in groundwater flow toward centres of concentrated pumping are normally a matter of concern if such reversals lead to salinity increases, impacts due to reduced discharge downgradient, or a significant decline in groundwater storage within the aquifer. The situation described above is not yet a cause for concern because;

- the water level gradients driving the flow reversal are very small, resulting in groundwater movement at a rate of 2 - 3 m/year. A recovery of less than a metre is required to eliminate this reversal.
- the groundwater salinity in the area of flow reversal is 1000 – 2000 mg/L (1800-3600 EC)
- there is potential for further recovery in pressure levels in the critical area due to the mild weather experienced in December 03 and January 04
- the area of flow reversal is to the north of the most northern (or downgradient) extent of irrigation, and may be an artifact of monitoring. Because it is just outside the extent of irrigation, monitoring has been less frequent and may have missed the peak recovery.

The situation should be examined during the review of the Mallee Water Allocation Plan, which will consider further monitoring results over the next few years, and whether this flow reversal is a permanent occurrence requiring management action.

There is no evidence of any flow reversal during the non-pumping season in the Murrayville WSPA, with northerly flow paths maintained until the Boltons – Berrook area. It is only in this area that there is a permanent westerly gradient. Also shown in Figure 22A are the salinity contours for the limestone aquifer, which show that in this area of westward movement, salinities are less than 3000 mg/L (5400 EC). Rates of groundwater movement are in the order of 5 - 10 m/year.





TOPOGRAPHIC FEATURES

- Town / locality
- Homestead
- Railway
- Highway / major road
- Secondary / minor road

WELL LOCATIONS

- Pre-irrigation water pressure well with elevation in metres (AHD)
- Irrigated area

- Groundwater flow direction
- Area of flow reversal

ELEVATION IN METRES (AHD)

- Contour interval 2m

WELL LOCATIONS

- Observation with drawdown in metres
- Irrigation wells

DRAWDOWN IN METRES

- 0 to 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- 10 to 12
- 12 to 14
- 14 to 16
- 16 to 18

0 5 10 15 Kilometres

DATUM AGD66 - MAP PROJECTION AMG ZONE 54

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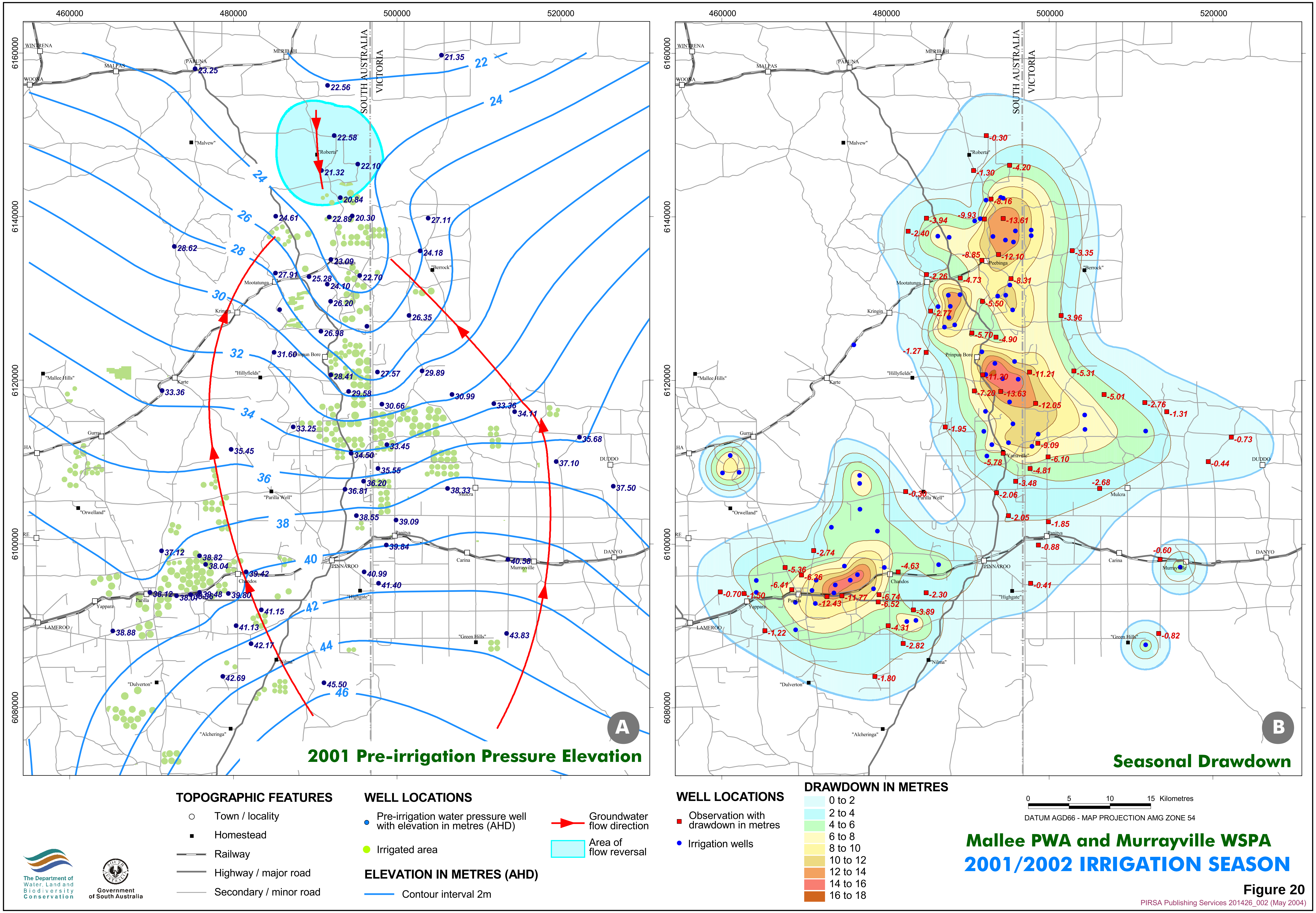
Government of South Australia

Mallee PWA and Murrayville WSPA
2000/2001 IRRIGATION SEASON

Figure 19

PIRSA Publishing Services 201426_001 (May 2004)

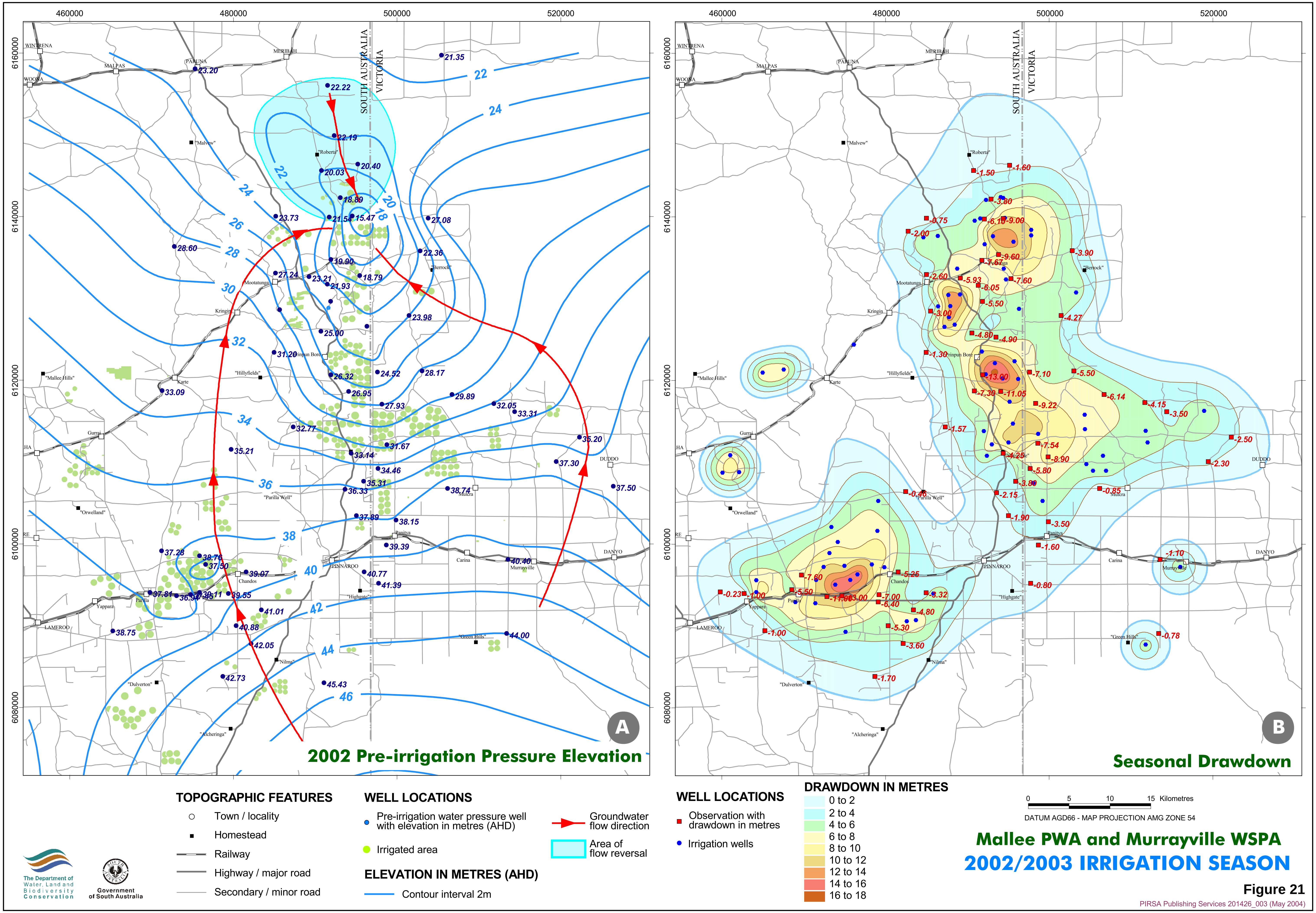


Mallee PWA and Murrayville WSPA

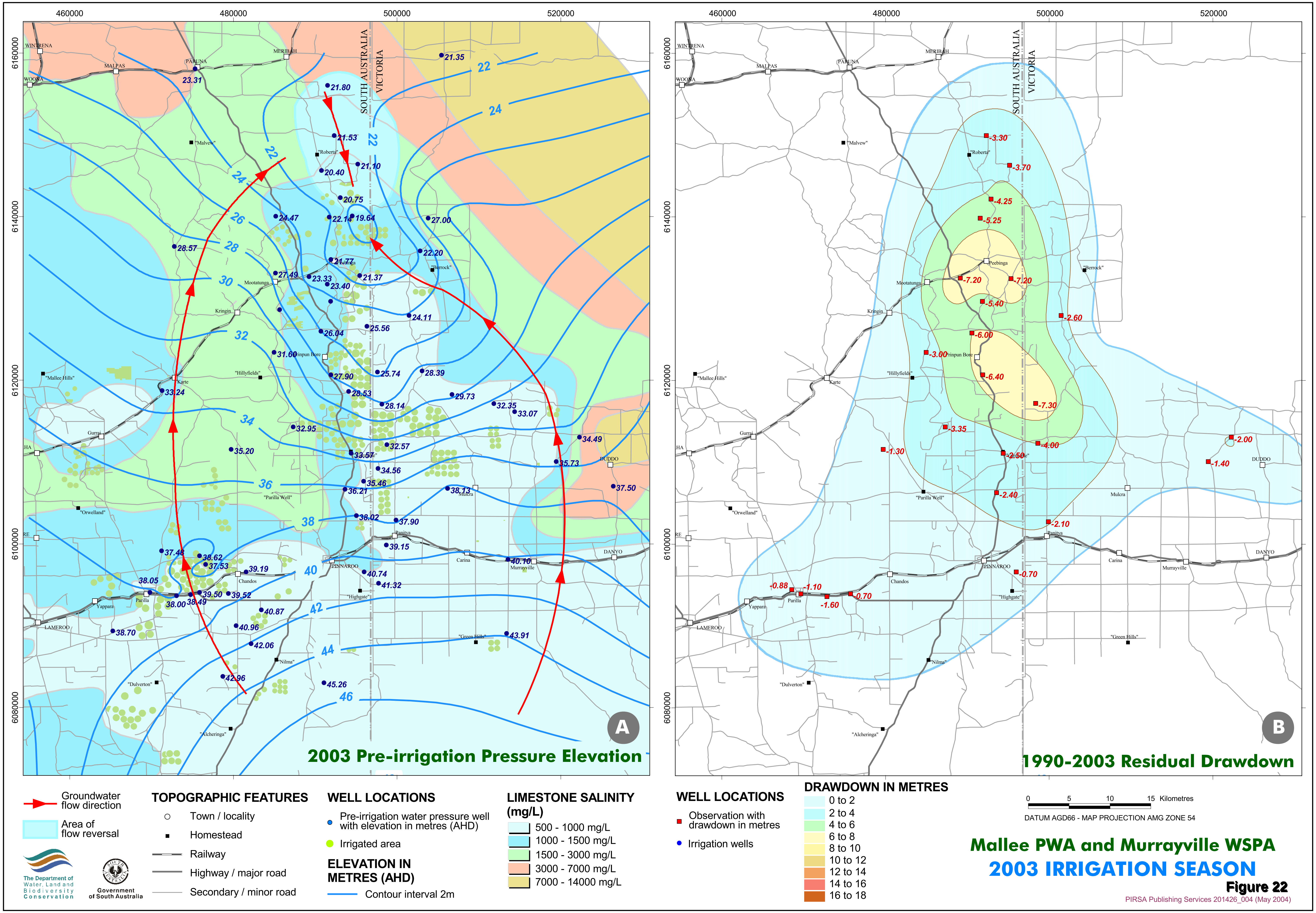
2001/2002 IRRIGATION SEASON

Figure 20

PIRSA Publishing Services 201426_002 (May 2004)



2002 Pre-irrigation Pressure Elevation
Seasonal Drawdown
A
B
SOUTH AUSTRALIA
VICTORIA
TOPOGRAPHIC FEATURES
Town / locality
Homestead
Railway
Highway / major road
Secondary / minor road
WELL LOCATIONS
Pre-irrigation water pressure well with elevation in metres (AHD)
Irrigated area
Groundwater flow direction
Area of flow reversal
ELEVATION IN METRES (AHD)
Contour interval 2m
WELL LOCATIONS
Observation with drawdown in metres
Irrigation wells
DRAWDOWN IN METRES
0 to 2
2 to 4
4 to 6
6 to 8
8 to 10
10 to 12
12 to 14
14 to 16
16 to 18
0 5 10 15 Kilometres
DATUM AGD66 - MAP PROJECTION AMG ZONE 54
Mallee PWA and Murrayville WSPA
2002/2003 IRRIGATION SEASON
Figure 21
PIRSA Publishing Services 201426_003 (May 2004)
The Department of Water, Land and Biodiversity Conservation
Government of South Australia



Mallee PWA and Murrayville WSPA
2003 IRRIGATION SEASON
Figure 22

9 NETWORK UPGRADE

9.1 Mallee PWA

There are some areas where the monitoring network in the limestone aquifer can be improved by expansion and bore rehabilitation. These include areas of new irrigation between Parilla and Yarraville, potential new irrigation north of Lameroo and a better coverage of existing irrigation in the Gurrai – Karte area and south of Parilla, and the important 'early warning' area of flow reversal north of Peebinga.

A network in the Wanbi area should also be established to monitor the impacts of pumping for the impending mineral sand mining operation. This monitoring will be carried out by consultants acting for the mining company and should commence before mining starts.

Locations of these 'gap' areas are shown in Figure 23. Existing bores should be used where possible, especially if drilled in the last 15 years or so, ensuring that they are at least 150 mm in diameter and over 100 m deep.

Several existing observation bores need deepening, namely – PLL 19, PLL 24, PEB 12, PEB 15, and MCG 3.

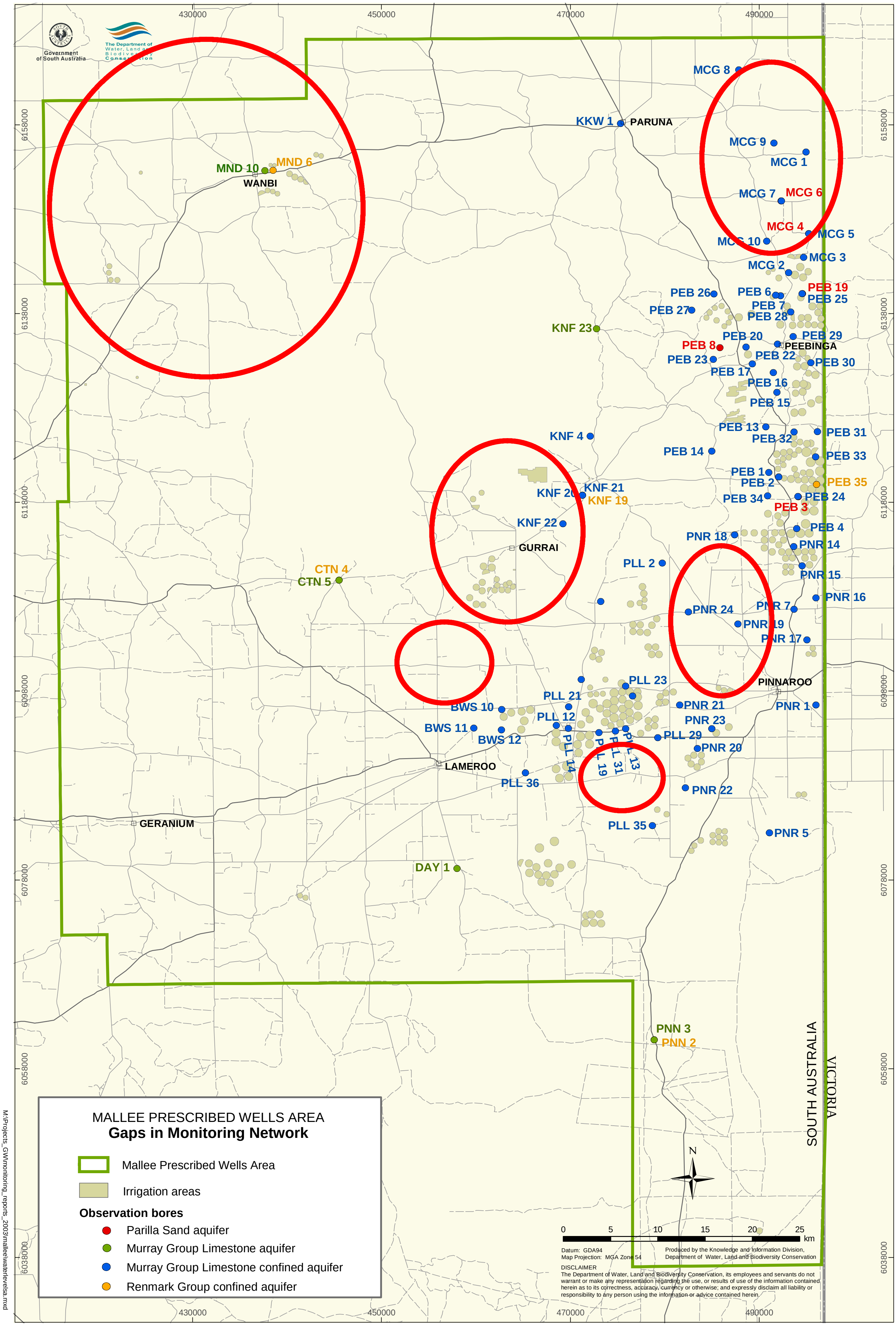
9.2 Murrayville WSPA

The areal coverage of the limestone aquifer network is generally adequate with only three possible gaps to fill in order to upgrade the network. First is to the north and northwest of Murrayville for monitoring the limestone aquifer as shown in Figure 24. The second is more important and occurs in the Berrook area to the north where groundwater movement turns westerly. Several more bores are required in the area to confirm this movement, including a replacement for bore 49678.

From a community perspective, more observation bores in the Tutye area to the east of Cowangie are important to detect any changes in levels that could initiate movement of saline groundwater from the east.

The accuracy of the drawdown and elevation contours would be improved if the frequency of monitoring bores 54612, 54613, 61571, 61572 and 49677 were increased to monthly.

As mentioned previously, an improved salinity testing method is required for the monitoring bores in the Cowangie area.



MALLEE PRESCRIBED WELLS AREA
Gaps in Monitoring Network
Mallee Prescribed Wells Area
Irrigation areas
Observation bores
Parilla Sand aquifer
Murray Group Limestone aquifer
Murray Group Limestone confined aquifer
Renmark Group confined aquifer
Government of South Australia
The Department of Water, Land and Biodiversity Conservation
430000
450000
470000
490000
6158000
6138000
6118000
6098000
6078000
6058000
6038000
WANBI
PARUNA
PEEBINGA
GURRAI
PINNAROO
LAMEROO
GERANIUM
SOUTH AUSTRALIA
VICTORIA
MND 10
MND 6
KKW 1
MCG 8
MCG 9
MCG 1
MCG 7
MCG 6
MCG 4
MCG 5
MCG 10
MCG 3
MCG 2
PEB 26
PEB 6
PEB 19
PEB 25
PEB 27
PEB 7
PEB 28
KNF 23
PEB 20
PEB 29
PEB 8
PEB 22
PEB 23
PEB 30
PEB 17
PEB 16
PEB 15
PEB 13
PEB 31
PEB 32
KNF 4
PEB 14
PEB 33
PEB 1
PEB 2
PEB 35
KNF 20
KNF 21
KNF 19
PEB 34
PEB 24
PEB 3
KNF 22
PEB 4
PNR 18
PNR 14
PLL 2
PNR 15
CTN 4
CTN 5
PNR 16
PNR 24
PNR 7
PNR 19
PNR 17
PLL 23
PLL 21
BWS 10
PNR 21
PNR 1
PLL 12
PNR 23
BWS 11
BWS 12
PLL 29
PLL 14
PLL 19
PLL 31
PLL 13
PNR 20
PLL 36
PNR 22
PLL 35
PNR 5
DAY 1
PNN 3
PNN 2
N
0 5 10 15 20 25 km
Datum: GDA94
Map Projection: MGA Zone 54
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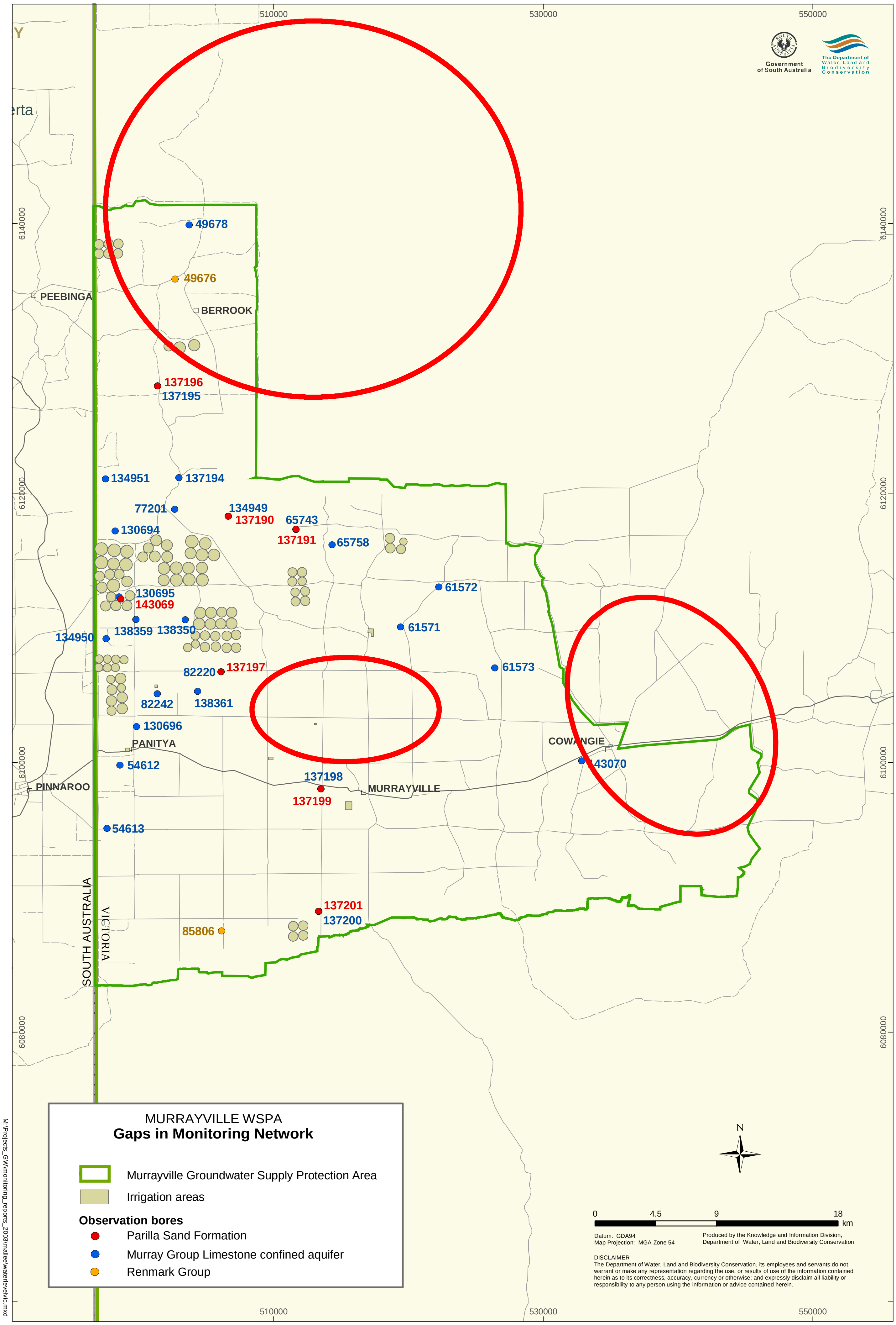
Figure 23



MURRAYVILLE WSPA
Gaps in Monitoring Network
Murrayville Groundwater Supply Protection Area
Irrigation areas
Observation bores
Parilla Sand Formation
Murray Group Limestone confined aquifer
Renmark Group
Government of South Australia
The Department of Water, Land and Biodiversity Conservation
510000
530000
550000
6140000
6120000
6100000
6080000
PEEBINGA
BERROOK
PANITYA
PINNAROO
MURRAYVILLE
COWANGIE
SOUTH AUSTRALIA
VICTORIA
49678
49676
137196
137195
134951
137194
77201
134949
137190
65743
137191
65758
130694
61572
130695
143069
138359
138350
134950
61571
82220
137197
61573
82242
138361
130696
54612
43070
137198
137199
54613
137201
137200
85806
N
0
4.5
9
18
km
Datum: GDA94
Map Projection: MGA Zone 54
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Figure 24

10 CONCLUSIONS & RECOMMENDATIONS

This review of monitoring trends (both water level and salinity) in the Mallee PWA and the Murrayville WSPA has found no major adverse impacts due to irrigation extractions from the Murray Group Limestone aquifer, and confirms the appropriateness of the current management approach.

Generally, in areas where irrigation has been established for some time and extractions are relatively stable, eg Parilla, drawdowns have reached an equilibrium. Conversely, in areas where extractions have steadily increased, downward trends are expected to continue until pumping has stabilised. This is also the case with olive or pistachio plantations where extractions are expected to increase as the trees mature. However, the rising trend in pumping is not expected to increase indefinitely because there are few unused allocations in the areas of good quality groundwater. In areas where the salinity is over 1500 mg/L, usage is likely to remain low.

Monitoring has also confirmed the robustness of the groundwater resource, which is recovering well from the impacts of the 2002 drought. Salinity trends are stable, or decreasing in some areas where drawdown is accelerating the inflow of lower salinity groundwater from the south.

An area of groundwater flow reversal has been identified north of Peebinga. This area in Zone 11A should be carefully monitored to determine if this flow reversal is a permanent occurrence, or drought-induced. Management action may be required as part of the review of the Mallee WAP.

Although the observed trends are similar to those predicted by the Mallee groundwater model in 1999, the model should be recalibrated using recent monitoring data and more accurate pumping figures from meters. Improved predictions of drawdowns and salinity impacts (especially in the area of groundwater flow reversal) could then be carried out.

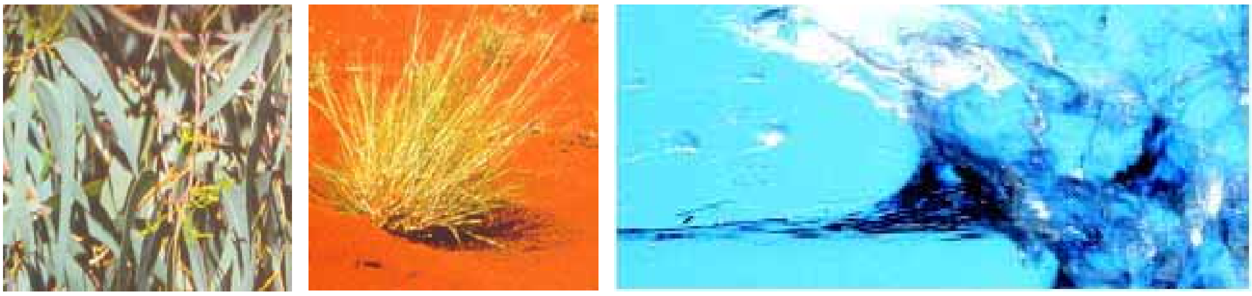
Recommendations have been made to improve the coverage of monotoring networks, particularly to the north of Peebinga, to the east of Cowangie, and the Berrook area in Zone 11.

11 REFERENCES

Barnett, S.R. and Yan, W., 2000. Mallee Region groundwater modelling. Report No. 1. *South Australia. Department of Primary Industries and Resources. Report Book*, 2000/00004 (unpublished).

SKM, 2004. Murrayville groundwater quality, data assessment and reporting. Reporting and analysis of groundwater sampling program.

12 APPENDIX A



COMPOSITE LOG OF RENMARK GROUP OBSERVATION BORE PEB 35

Government of South Australia

The Department of Water, Land and Biodiversity Conservation

Mallee Prescribed Wells Area

PEB 35 - Composite Bore Log

Bore data	
Permit No.	62571
Unit No.	7027001OW00873
Obs. No.	PEB 35
Purpose	Observation

Location Data	
Hundred	Peebinga
Section No.	14
Easting (m AMG)	496016
Northing (m AMG)	6119890
Datum	GDA 94

Elevation data	m AHD
Ground Surface	78.130
Ref. Point above Ground	0.800
Ref. Point	78.930
Top of open interval	-172.4
Bottom of open interval	-170.4

Drilling data	
Start date	19/06/2003
Finish date	10/07/2003
Driller	DWLBC
Drilling Method	Rotary
Circulation	Mud
Maximum depth (m)	300.0
Completed depth (m)	264.5
Samples logged by	Zoe Marsden

Post-development data	
Date	04/12/2003
Depth to water below Ref. Pt. (m)	41.05
Depth to SWL below GL (m)	40.25
RSWL (m AHD)	37.88
Salinity Lab (mg/L)	1233
EC Lab (uS/cm)	2230
Yield (L/s)	3
Method	Airlift

Completion data				
Hole Diameter	mm	From	To	Bit
	250	0.0	5.5	Blade
	150	5.5	300.0	Blade
Backfilled		From	To	Material
Casing Diameter	mm	From	To	Material
	200	0.0	5.5	PVC
	76	0.0	250.0	Fibreglass
Screen Diameter	mm	From	To	Material
	51 ID 60 OD	250.5	252.5	Stainless steel
		From	To	Type
Grout		0.0	250.0	Cement
Bentonite Seal				
Gravel Pack				

GEOLOGICAL DETAIL

GEOPHYSICAL LOGS