MALLEE PWA

GROUNDWATER LEVEL AND SALINITY STATUS REPORT

2009–10

DEPARTMENT FOR WATER

Government of South Australia
Department for Water

SUMMARY 2009–10

Groundwater extractions in the Mallee Prescribed Wells Area occur from a robust limestone aquifer that is up to 100 m thick. Irrigated crops are predominantly potatoes and onions (by centre pivot) and olives and pistachios (by drip irrigation).

Metered extractions in the 2009–10 water use year totalled 38 438 ML, a 10% reduction from the previous year and reflects the increase in seasonal rainfall and in general a return to pre-drought extraction levels.

Most extractions occur in the confined portion of the Murray Group Limestone aquifer to the northeast. Here, water levels have recovered to pre-drought levels in response to reductions in pumping. In the unconfined part of the aquifer to the west, there is little or no change in water levels. Seasonal drawdowns due to irrigation are generally less than five metres.

Within irrigated areas, there has not been any significant change in groundwater salinity over the past 20–30 years due to the slow movement of groundwater in these areas.

Monitoring within the Mindarie area has detected impacts from the clearing of native vegetation. As predicted by CSIRO, small rises in the watertable have occurred as well as an increase in groundwater salinity of up to 100 mg/L/y in shallow wells completed near the top of the unconfined Murray Group Limestone aquifer.

ASSESSMENT OF STATUS

The Mallee Prescribed Wells Area has been assigned a green status of "No adverse trends, indicating a stable or improving situation" for the 2009–10 water use year. This status is supported by:

- a recovery in groundwater levels in areas of concentrated extraction
- no significant changes in salinity levels in areas of concentrated extraction where the Murray Group Limestone aquifer is confined.

STATUS (2009–10)

<u>No adverse trends, indicating a stable or improving situation</u>

Trends are either stable (no significant change) or improving (i.e. decreasing salinity or rising water levels).

<u>Adverse trends, indicating low risk to the resource in the medium term</u>

Observed adverse trends are gradual and if continued, will not lead to a change in the current beneficial uses of the groundwater resource for at least 15 years. Beneficial uses may be drinking water, irrigation or stock watering.

<u>Adverse trends, indicating high risk to the resource eventuating in the short to medium term</u>

Observed adverse trends are significant and if continued, will lead to a change in the current beneficial uses of the groundwater resource in about ten years.

<u>Degradation of the resource compromising present use within the short term</u>

Trends indicate degradation of the resource is occurring, or will occur, within five years. Degradation will result in a change to the beneficial use (i.e. no longer suitable for drinking or irrigation purposes) and may take the form of increasing groundwater salinities or a fall in the groundwater levels such that extractions from the aquifer may not be possible.

BACKGROUND

The Mallee Prescribed Wells Area (PWA) is located about 150 km east of Adelaide (Fig. 1) and is underlain by sediments of the Murray Basin. It is a regional-scale resource for which groundwater resources are prescribed under South Australia's *Natural Resources Management Act 2004*. A Water Allocation Plan provides for the sustainable management of the groundwater resources.

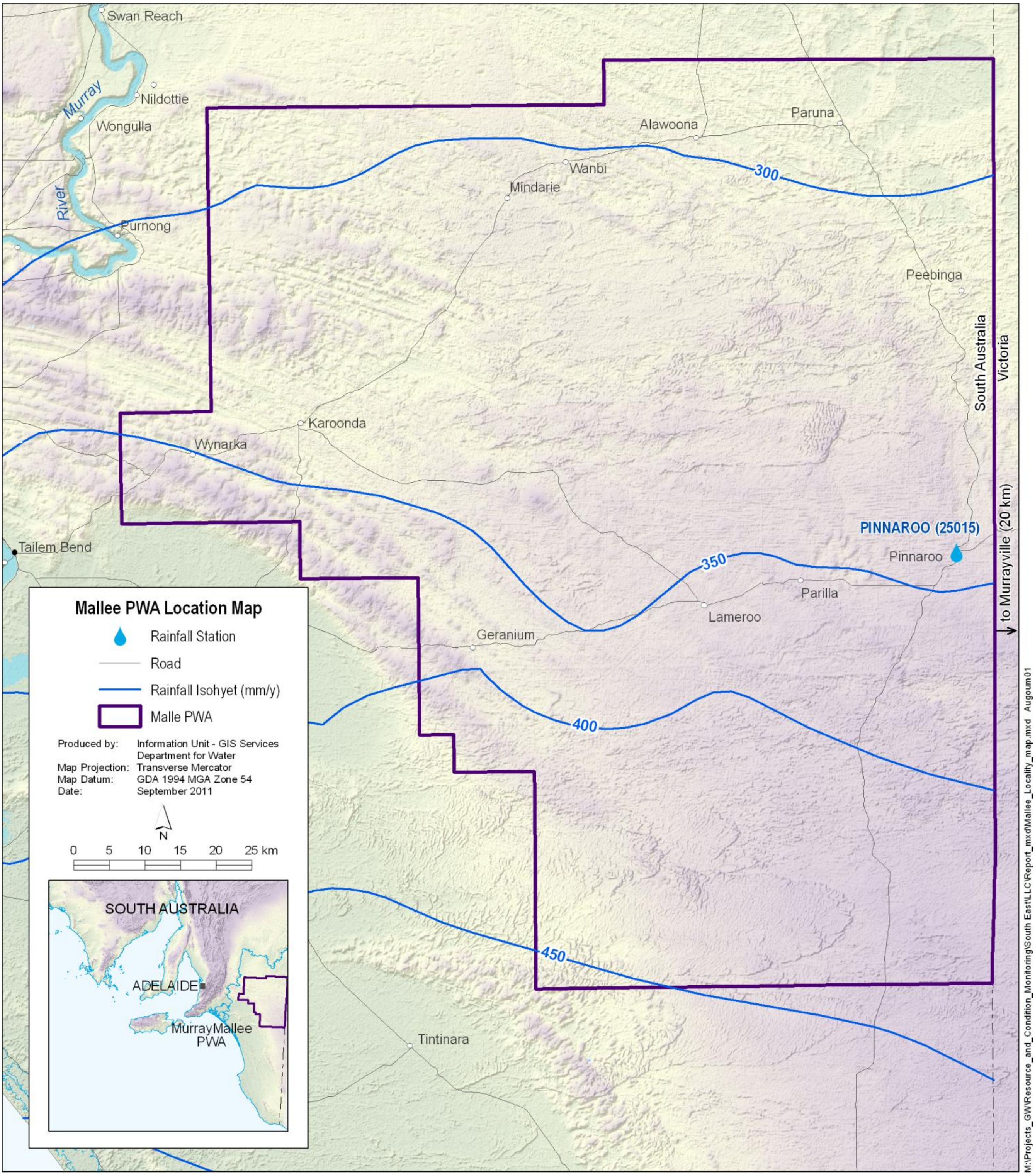

Figure 1. Location of the Mallee PWA

HYDROGEOLOGY

The Murray Basin extends over 300 000 km^2 of inland southeastern Australia and encompasses three states – South Australia, Victoria and New South Wales. It contains Cainozoic sediments comprising sand, clay and limestone deposited in shallow-marine, fluvio-lacustrine and aeolian environments (i.e. river, lake and wind deposited sediments). These sediments attain a maximum thickness of about 600 m in the Renmark area.

There are three main aquifer systems in the Mallee region; the Renmark Group confined aquifer, the Murray Group Limestone aquifer and the Pliocene Sands aquifer. These aquifers are recharged primarily in the high rainfall areas around the basin margins. Groundwater flows along extended flowpaths under low gradients before discharging to the River Murray, either by upward leakage from confined aquifers or from direct hydraulic connection to the watertable (unconfined) aquifers.

The five main hydrogeological units found in the Mallee region include, in order of increasing depth, the Pliocene Sands aquifer, Bookpurnong Beds confining layer, Murray Group Limestone aquifer, the Ettrick Formation confining layer and the Renmark Group aquifer (Fig. 2; Table 1).

Pliocene Sands aquifer (PS)

The Pliocene Sands aquifer is an unconfined aquifer which is absent in the west of the Mallee PWA. The unit comprises unconsolidated to weakly-cemented, fine to coarse sand and is generally over 50 m thick. The groundwater flow is generally towards the north where discharge occurs to the River Murray. Salinity in the aquifer ranges from 1000 mg/L in the south to over 35 000 mg/L to the north. As the aquifer is thin and contains saline groundwater, there are no significant extractions.

Bookpurnong Beds (confining layer)

The Bookpurnong Beds are absent over most of the SA Mallee, however it dips down gradually to the east and increases in thickness into Victoria. It commonly occurs as a low-permeability unit between the Pliocene Sands aquifer and the underlying Murray Group Limestone aquifer. It comprises poorly-consolidated plastic silts, clays and sands up to 30 m in thickness.

Murray Group Limestone aquifer (MGL)

The Murray Group Limestone (MGL) aquifer comprises a consolidated, highly fossiliferous fine to coarse bioclastic limestone (made up of broken fragments of organic skeletal material) which has an average thickness of 100 m. Groundwater movement is generally under low gradients, from recharge areas in southwest Victoria towards the north and northwest of the Mallee PWA. The volume of irrigation-quality groundwater in storage in the MGL aquifer is estimated at 100 million ML, with a rate of groundwater movement towards the north of only half a metre per year. Salinities in the aquifer slowly increase downgradient from less than 1000 mg/L in recharge areas, to over 20 000 mg/L in the north and northwest where the aquifer discharges to the River Murray.

Ettrick Formation (confining layer)

The Ettrick Formation occurs between the Murray Group Limestone aquifer and the underlying Renmark Group aquifer. The unit is around 15 m thick and comprises a glauconitic (dull green) and fossiliferous marl.

Renmark Group aquifer (RG)

The Renmark Group aquifer is a confined aquifer underlying the Ettrick Formation. The unit comprises unconsolidated carbonaceous sands, silt and clay, with an average thickness of 150 m. Groundwater flow is from the southeast to the west and northwest, similar to the overlying MGL aquifer. Groundwater salinity ranges from 500 to 3000 mg/L, again in a similar distribution to the MGL aquifer. Due to the sizable depth to the aquifer (over 200 m) and uncertainty in finding large supplies from the interbedded sands and clays, no extraction occurs.

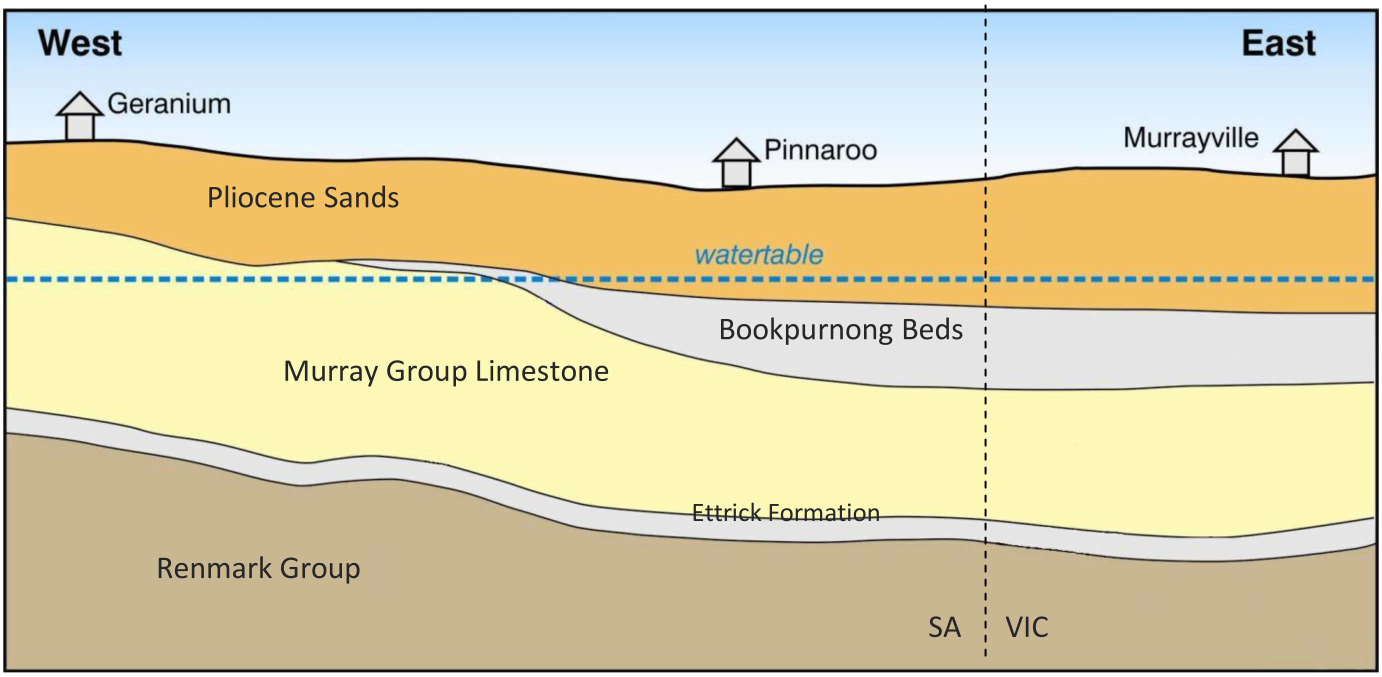

Figure 2. Cross section through the Mallee region

Table 1. Hydrogeological units within the Mallee region

Aquifer	Lithology	Thickness (m)	Comments
Pliocene Sands	Fine to coarse sands, clayey in part. Orange-grey	0–15	Unconfined aquifer. Absent in the west of the Mallee PWA
Bookpurnong Beds	Grey–green fossiliferous silts and clay	0–30	Confining layer. Absent in the west of the Mallee PWA
Murray Group Limestone	Grey to off-white fossiliferous limestone	80–140	Confined in the east of the Mallee PWA, unconfined in the west. 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

GROUNDWATER FLOW AND SALINITY

Groundwater elevation contours indicate groundwater flow within the MGL aquifer is to the west and north (Fig. 3). There is an indication of flow reversal in the northeast corner of the PWA due to irrigation-induced drawdowns in areas of concentrated extractions along the South Australian – Victorian border. Monitoring has not detected evidence of adverse impacts on the resource in this area.

There is a general increase in salinity of the MGL aquifer toward the west and north, away from the recharge areas (Fig. 3). These areas are located where deep unconsolidated sand has allowed infiltration of rainfall in much wetter climates in the past (20 000 years ago).

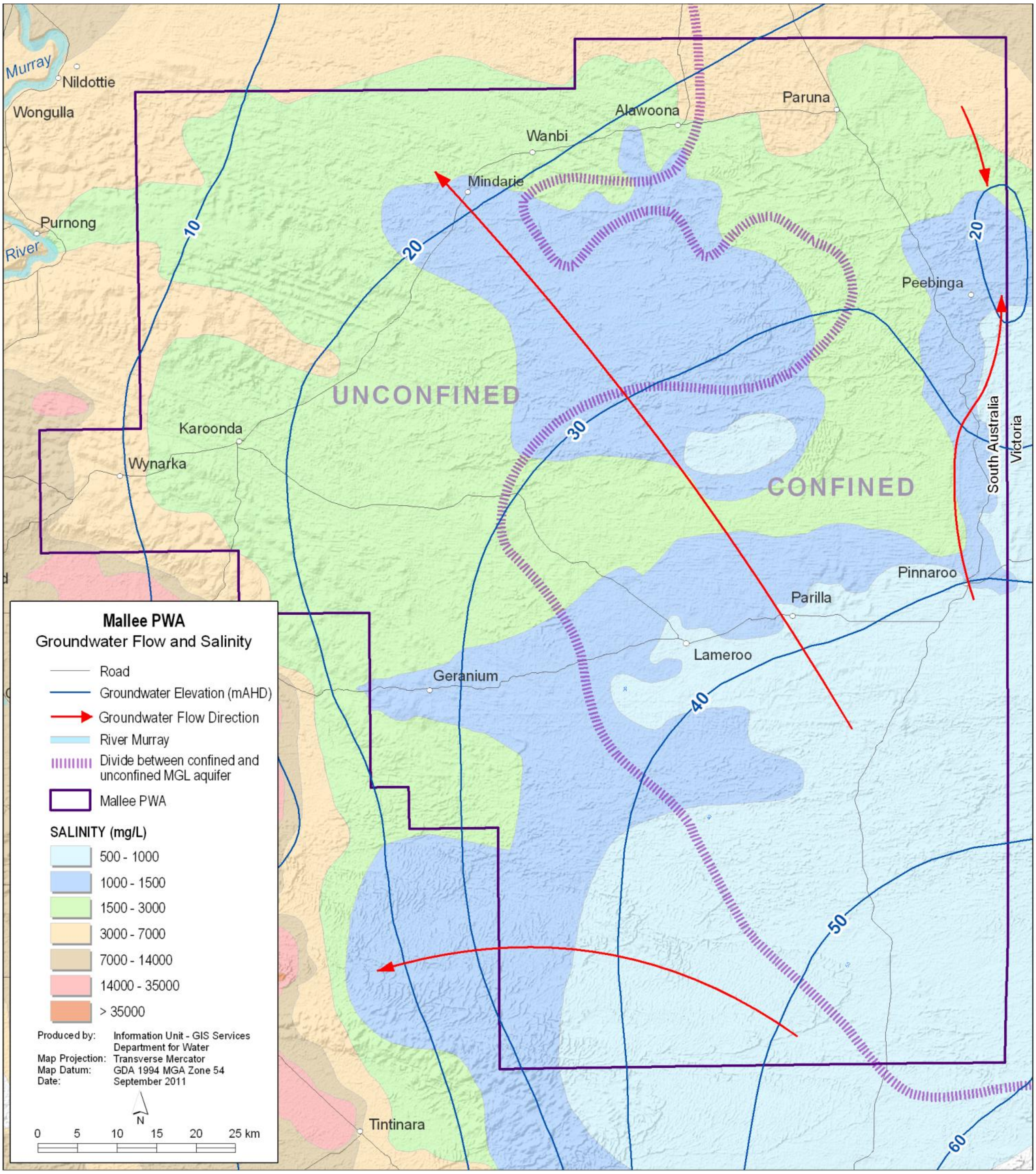

Figure 3. **Groundwater flow direction and salinity distribution of March 2010 in the MGL aquifer in the Mallee PWA**

GROUNDWATER DEPENDENT ECOSYSTEMS

Whilst groundwater dependent ecosystems (GDEs) have not been considered in the assessment of the status of the groundwater resource, it is important to note the presence and ecological characteristics of the GDEs in the Mallee PWA. Water Allocation Plans must include an assessment of the water required by ecosystems; this includes water from both surface water and groundwater resources. Groundwater dependent ecosystems can be defined as ecosystems where groundwater provides all or part of the water quantity, chemistry or temperature requirements, either permanently, seasonally or intermittently. It is generally considered that shallow watertables less than ten metres below the surface are more likely to support GDEs than deeper watertables. The exception to this is stygofauna (animals that inhabit water-filled spaces and pools below the ground) which can be found at greater depths.

A study was undertaken in October 2003 to identify the existence of stygofauna (animals that inhabit water filled spaces and pools beneath the ground) within the Mallee PWA. The study found no evidence of stygofauna within the MGL aquifer. However, it was recognised that it was difficult to comprehensively sample such an aquifer, particularly where samples can only be taken from disturbed sites.

The Murray Group Limestone and Renmark Group sand aquifers are too deep below the surface to support any terrestrial vegetation or wetlands. Both aquifers contribute flow towards the River Murray; however, this is mostly saline water, some of which is intercepted by salt interception schemes where they exist.

RAINFALL

Rainfall within the Mallee PWA is winter dominant with average annual rainfall increasing to the south: 300mm and 283 mm at Mindarie and Paruna respectively and 404 mm and 343 mm at Geranium and Pinnaroo, respectively (Fig. 1).

The annual rainfall has been recorded at the Pinnaroo rainfall station (25015) since 1907 (Fig. 4). The cumulative deviation measures the difference between the actual measured rainfall and the long-term average rainfall on a monthly basis. An upward trend in the cumulative deviation indicates above-average rainfall and conversely, a downward trend indicates below-average rainfall.

Rainfall was generally above average from 1907 until around 1925, with a long period of below-average rainfall until 1945. Rainfall in the following ten years was generally on 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, rainfall has been consistently below average, particularly since 2006, with the exceptions of 1987, 1992, 2000, 2004 and 2009.

The large depth to the watertable (40–60 m) means that there is little direct correlation between groundwater levels and variations in rainfall. However, there may be an indirect correlation in that dry years (e.g. 2002, 2006) will result in increased groundwater pumping that may lead to a lowering of groundwater levels. In particular, a dry winter may lead to an earlier start to pumping for the irrigation season which may prevent water levels from recovering to their normal levels in spring. Conversely, a wet spring may delay the start of irrigation, leading to a higher than normal recovery in water levels.

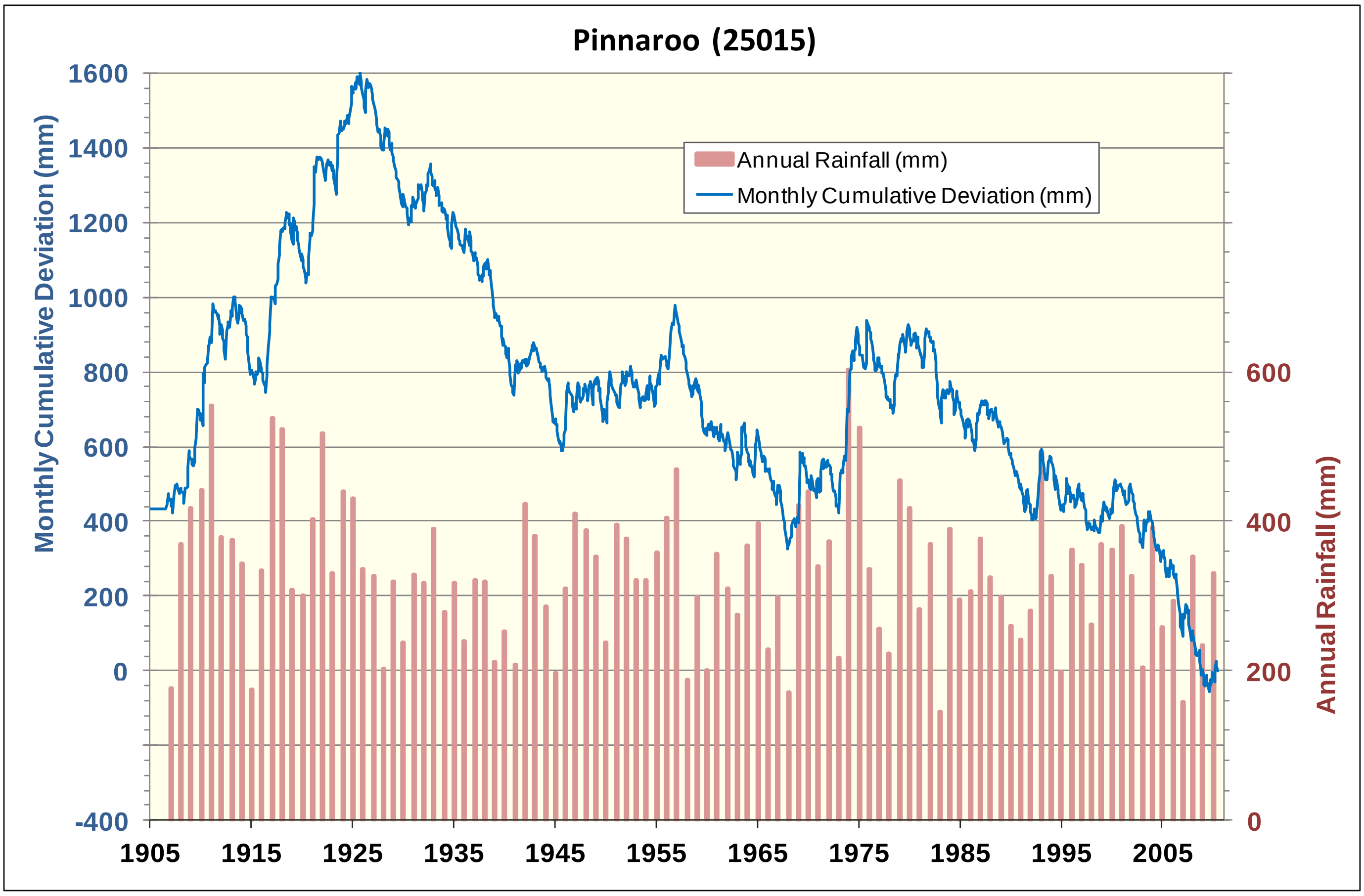

Figure 4. Annual rainfall and cumulative deviation for mean monthly rainfall for the Pinnaroo station in the Mallee PWA

GROUNDWATER USE

Metered groundwater extractions for licensed purposes (excluding stock and domestic use) in the Mallee PWA for the 2009–10 water use year totalled 38 438 ML (Fig. 5). This represents a decrease of just over ten percent from the previous water use year.

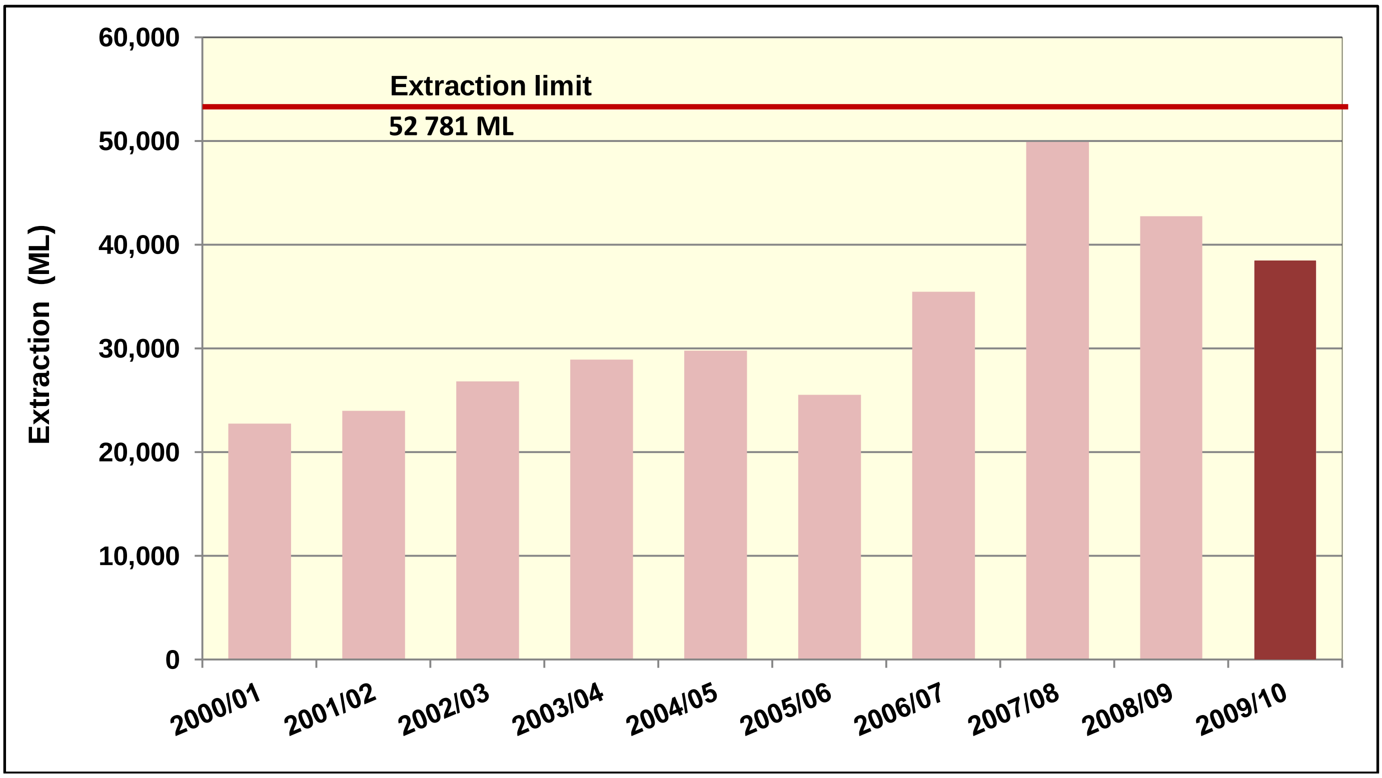

Figure 5. Historical licensed groundwater use and extraction limit in the Mallee PWA

The irrigation of crops accounted for 97% of the 38 438 ML of groundwater extracted in the 2009–10 water use year (Table 2).

Table 2. Groundwater use volumes per type of licensed use in the Mallee PWA

WATER USE	2009–10 (ML)	% of use	2008–09 (ML)	% of use	2007–08 (ML)	% of use
Irrigation	37 119	97.0	40 118	93.8	48 097	96.3
Industrial / Mining	489	1.3	1799.5	4.3	846.7	1.7
Recreation	359	0.9	367	0.8	434	1.0
Town Water Supply	268	0.7	306.7	0.7	308.7	0.6
Intensive farming	203	0.5	188.6	0.4	214.8	0.4
Total Use (ML)	38 438	100	42 780	100	49 901	100

Figure 6 shows that the majority of this water was used for the cultivation of potatoes with 67% of the total, followed by onions (11.5%) and carrots (6.5%).

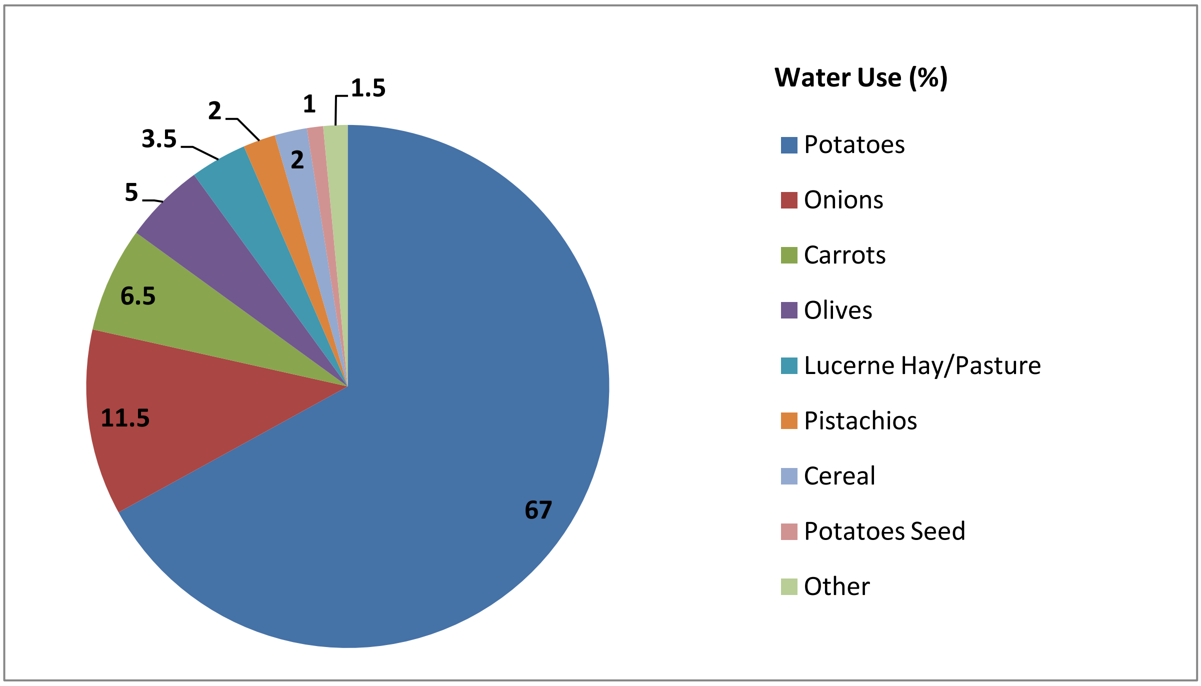

Figure 6. Groundwater proportions extracted per type of use (ML) in the Mallee PWA for the 2009–10 water use year

The spatial distribution of extractions from licensed wells within the Mallee PWA is presented in Figure 7. The view is looking toward the northeast, with the height of the column relating to the volume extracted from each well during the 2009–10 water use year.

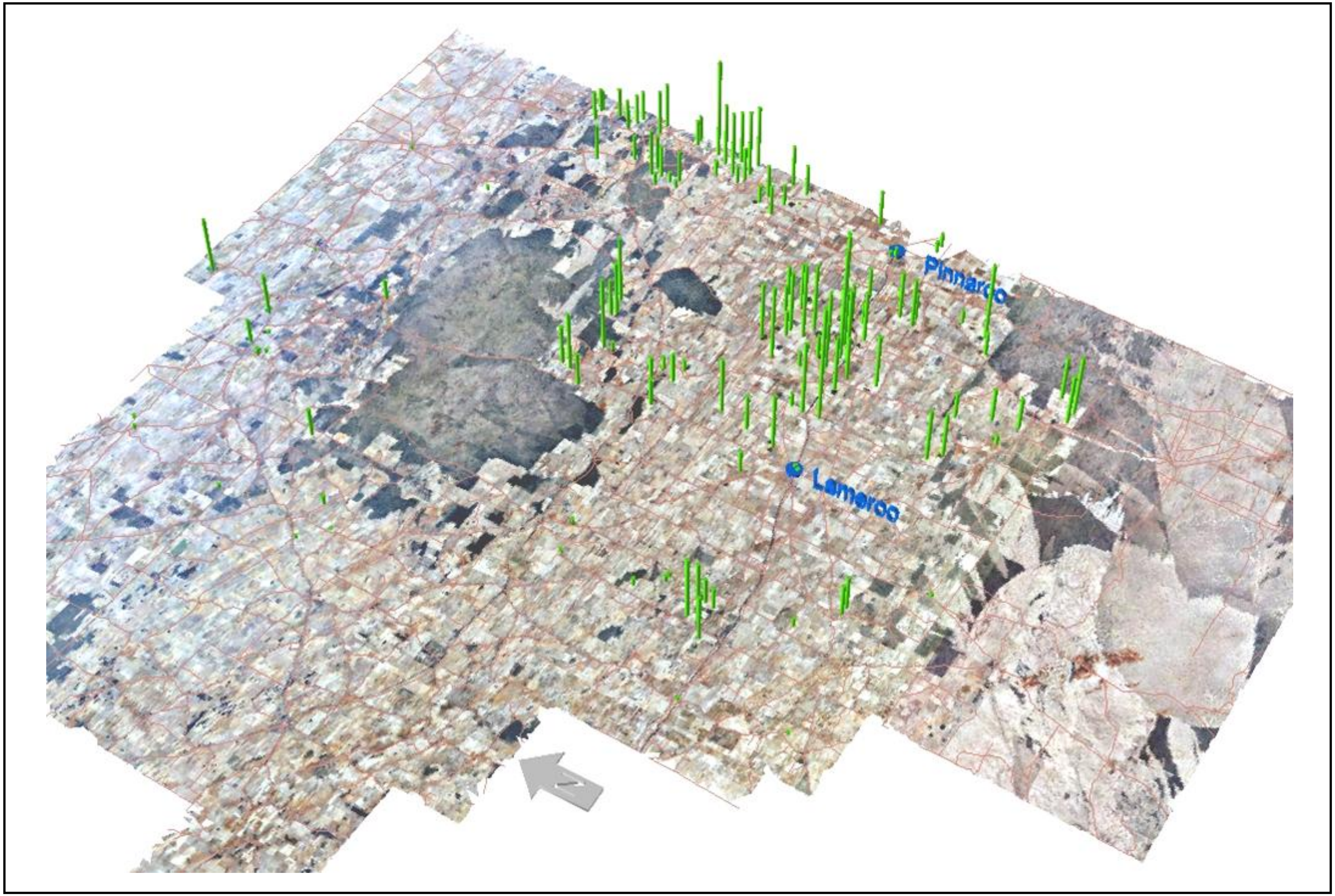

Figure 7. Spatial distribution of licensed groundwater extraction from each well in the Mallee PWA during the 2009–10 irrigation season.

WATER LEVEL NETWORK

Groundwater monitoring began in 1983 and there are currently 98 wells within the Mallee PWA water level observation network (Fig. 8). The main concentration of observation wells is located in the Parilla–Pinnaroo–Peebinga area in the eastern part of the PWA. This is to monitor the drawdown impacts of irrigation extractions from the confined MGL aquifer. A small number of wells monitor the overlying Pliocene Sands aquifer in this area.

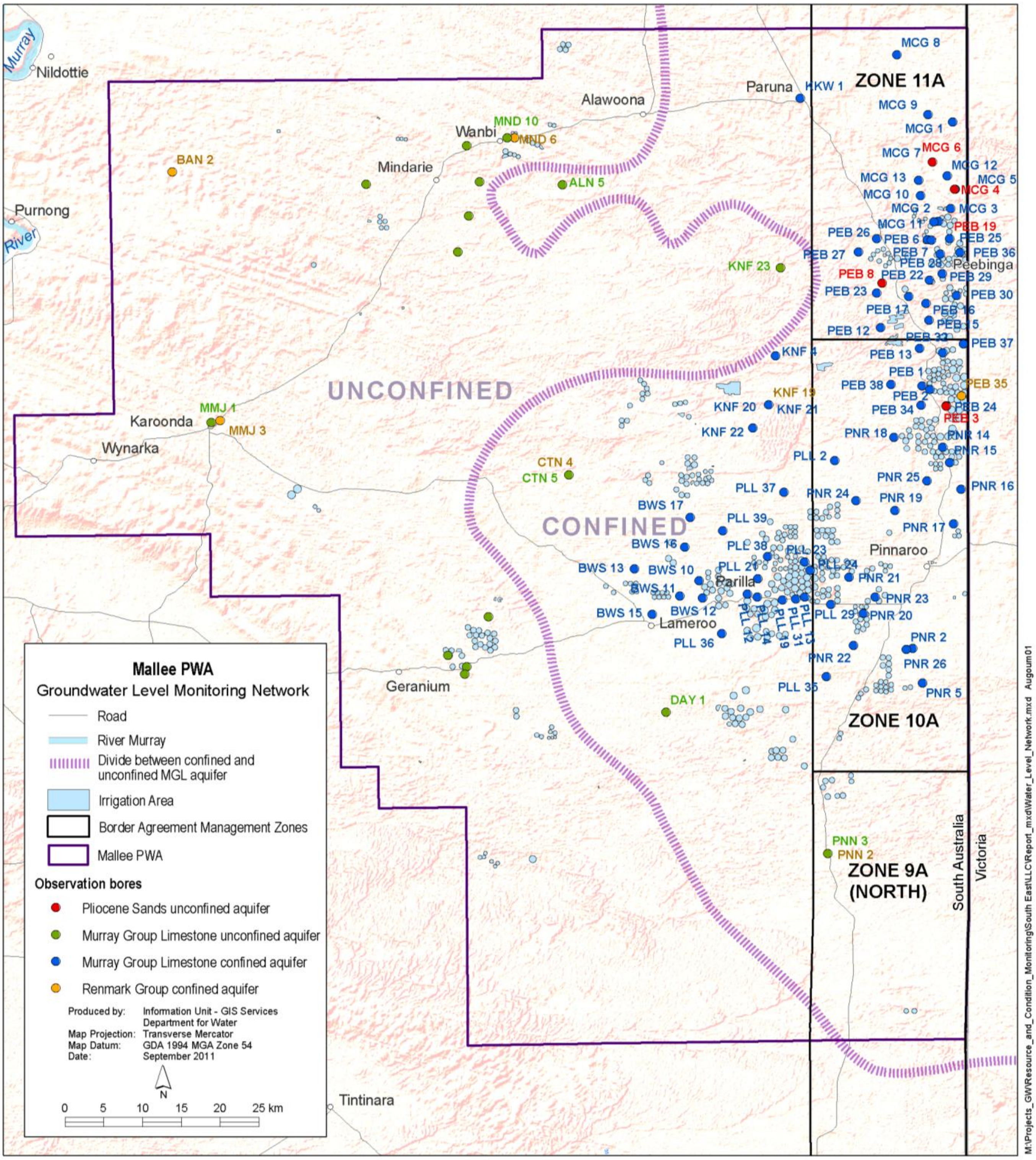

Figure 8. Location of groundwater level observation wells in the Mallee PWA

SALINITY NETWORK

There are currently 25 wells within the Mallee PWA salinity observation network (Fig. 9). The observation wells located in the Parilla–Pinnaroo–Peebinga area in the eastern part of the PWA monitor changes in salinity due to irrigation extractions from the confined MGL aquifer. Potential sources of salinity increases are the downward leakage of saline water from the overlying Pliocene Sands aquifer and the lateral inflow of more-saline groundwater from the north.

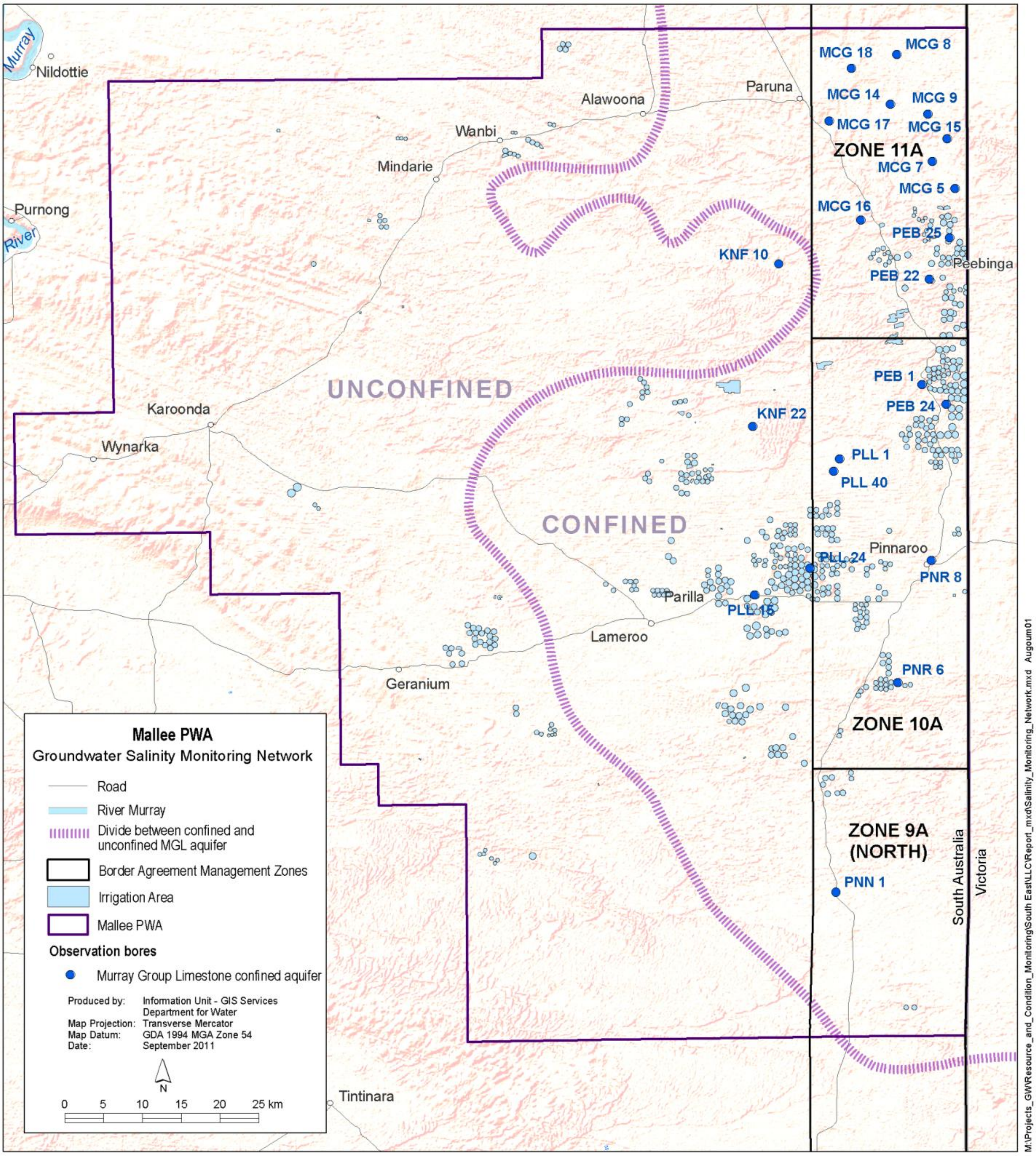

Figure 9. Location of groundwater salinity observation wells in the Mallee PWA

MURRAY GROUP LIMESTONE AQUIFER

Long-term monitoring has recorded drawdowns as a result of irrigation withdrawals from the MGL aquifer. The magnitude of the drawdowns depends on whether the aquifer is confined or unconfined and the concentration of irrigation bores in a given location.

Drawdowns in the confined portion of an 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.

In the Mallee PWA, drawdowns are greater in areas of concentrated pumping such as the Parilla–Pinnaroo–Peebinga area due to the occurrence of low groundwater salinity and suitable soils. This area is jointly managed with Victoria through the *South Australian – Victorian Border Groundwaters Agreement* and monitoring results will be discussed for various zones within this area.

Zone 10A includes Pinnaroo and the area further north (Figs. 8 & 9). Water level trends in this area reached an equilibrium between 2000 and 2006 (Fig. 10). In 2007, changes in irrigation management as a result of the drought lead to an increase in seasonal drawdowns. A reduction in extractions in recent years (including 2009–10) has resulted in the recovery of water levels, demonstrating the robust nature of the groundwater resource.

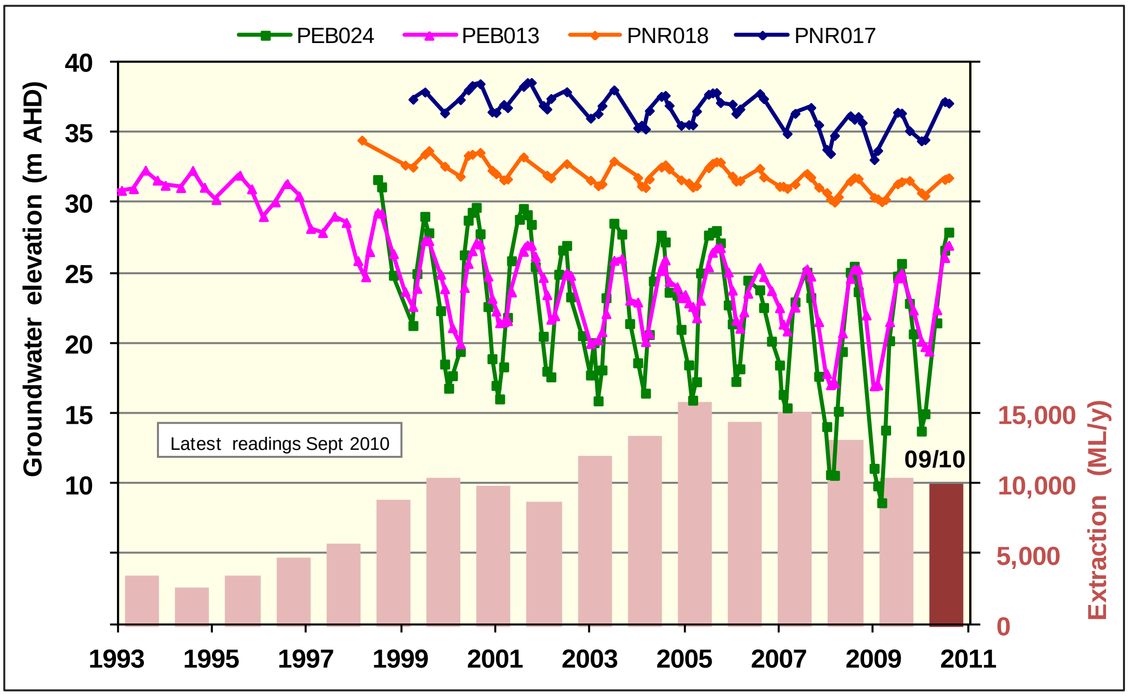

Figure 10. Groundwater levels in Zone 10A of the Mallee PWA

Zone 11A extends north from the Peebinga area (Figs. 8 & 9). As with Zone 10A, groundwater level trends reached an equilibrium between 2000 and 2006, after an earlier downwards trend (Fig. 11). The activation of previously unused allocations and changes in irrigation management has led to an increase in seasonal drawdowns since 2007. Again, the recovery during the 2009–10 water use year has occurred in response to a reduction in extractions.

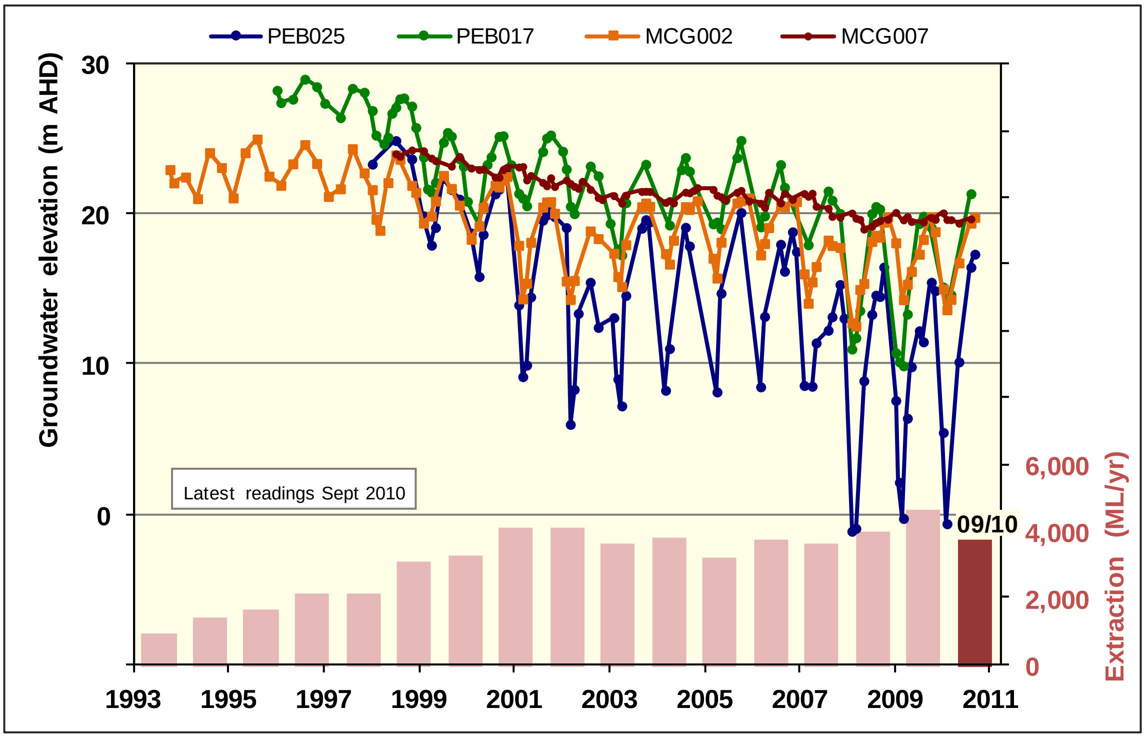

Figure 11. Groundwater levels in Zone 11A of the Mallee PWA

Water levels in the Parilla area have been relatively stable for a number of years, and no change is anticipated in the foreseeable future (Fig. 12).

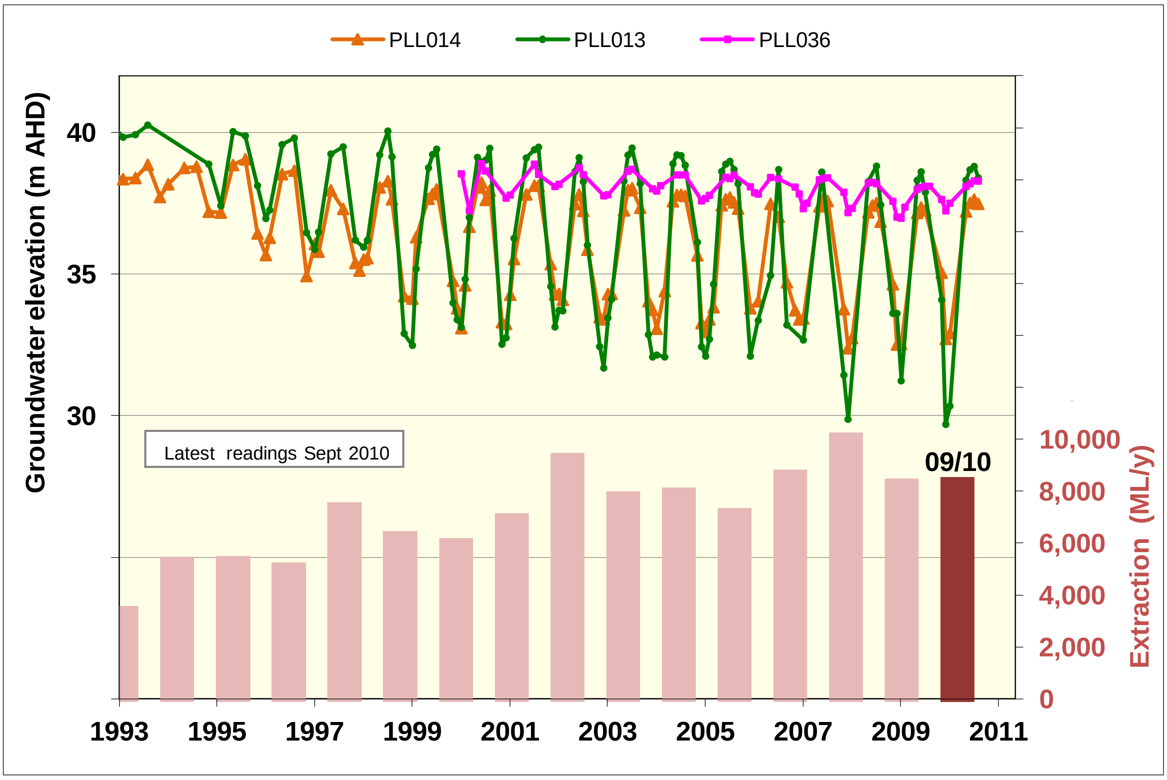

Figure 12. Groundwater levels in the Hundred of Parilla in the Mallee PWA

In areas located at some distance from irrigation (where salinities are generally over 1500 mg/L), there is very little change in water levels in the unconfined portion of the MGL aquifer (Fig. 13). Observation wells CTN005 and KNF023 show typical trends. Observation wells KKW001 and MMJ001 are showing a response to the increased recharge following the clearing of native vegetation.

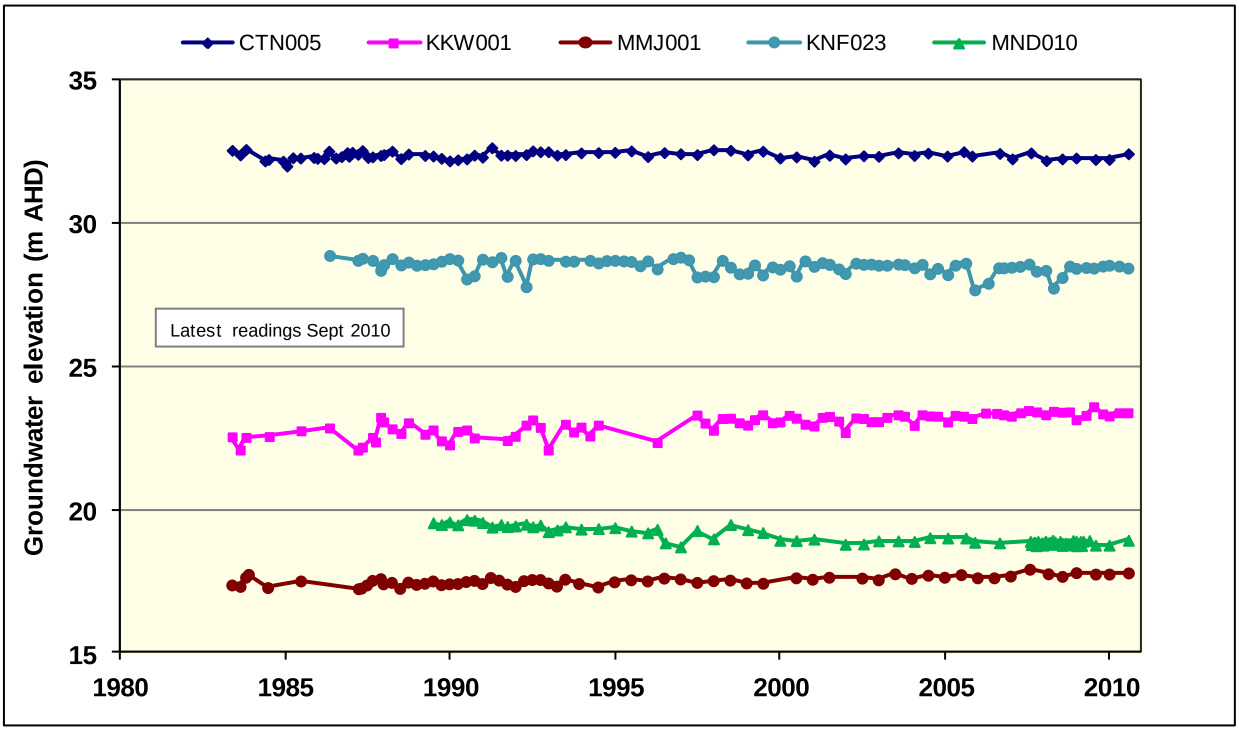

Figure 13. Groundwater levels in areas remote from irrigation in the Mallee PWA

PLIOCENE SANDS AQUIFER

The Pliocene Sands aquifer only occurs in the northeastern part of the Mallee PWA with only isolated extractions for stock watering. As a result of the large depth to the watertable in this area, the increased recharge due to the clearing of native vegetation is yet to be seen. Consequently, groundwater levels are stable (Fig. 14).

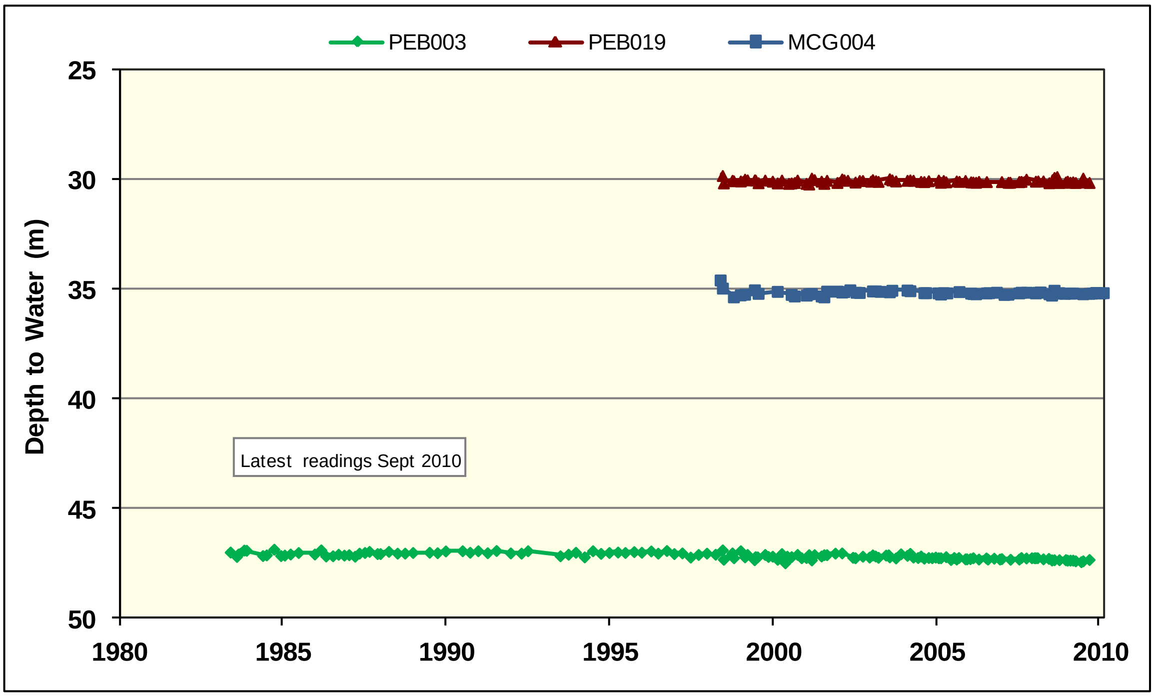

Figure 14. Groundwater level trends in Pliocene Sands aquifer of the Mallee PWA

RENMARK GROUP AQUIFER

There are no extractions from the Renmark Group confined aquifer and water levels show little or no response to irrigation extractions from the overlying MGL aquifer (Fig. 15). Observation well PEB035 is located on the South Australia – Victoria border, close to the area of maximum drawdown in the MGL aquifer and shows a decreasing trend of 0.09 m/y, which may indicate a small volume of induced upward leakage into the MGL aquifer.

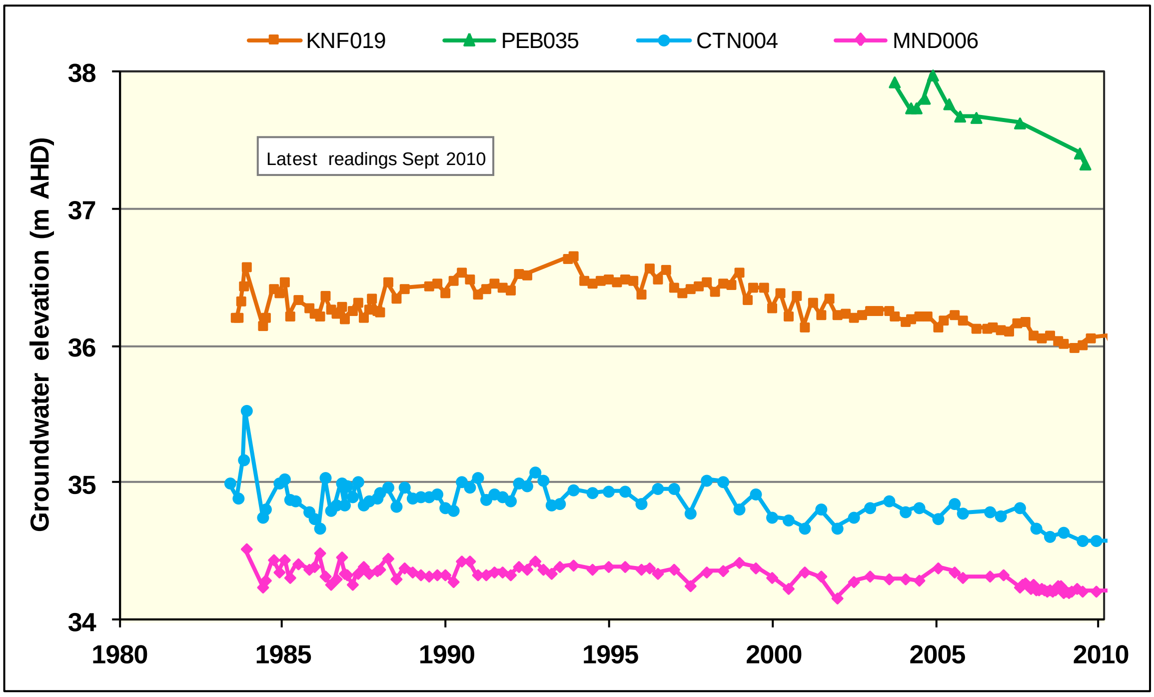

Figure 15. Groundwater levels in the Renmark Group confined aquifer of the Mallee PWA

GROUNDWATER SALINITY TRENDS

As groundwater is an important source of water in the Mallee PWA, increases in salinity represent the greatest risk to the resource. Potential sources of salinity increases are discussed in a salinity risk assessment, which can be downloaded at:

http://www.waterconnect.sa.gov.au/BusinessUnits/InformationUnit/Technical%20Publications/ki_dwlbc_tech_note_2007_05.pdf

Salinity monitoring in the confined portion of the MGL aquifer where the majority of irrigation occurs has shown no significant changes over the past 20 to 30 years (Fig. 16).

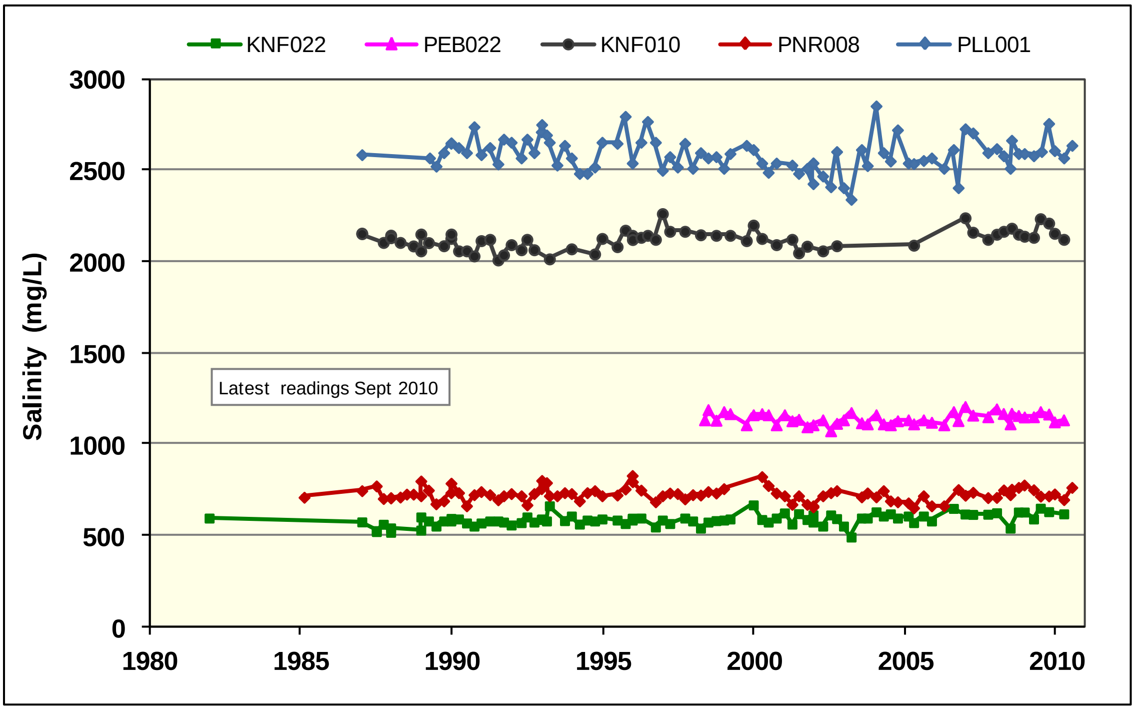

Figure 16. Groundwater salinity trends for the confined limestone aquifer in the Mallee PWA

In the unconfined portion of the MGL aquifer, salinity monitoring in the Wanbi – Mindarie area since 2007 has shown steady increases of up to 100 mg/L per year in shallow stock and domestic wells (Fig. 17). This increase in salinity is caused by the flushing of salt in the unsaturated zone down into the aquifer by the increased recharge following the clearance of native vegetation. This process was first predicted and then documented by CSIRO[1].

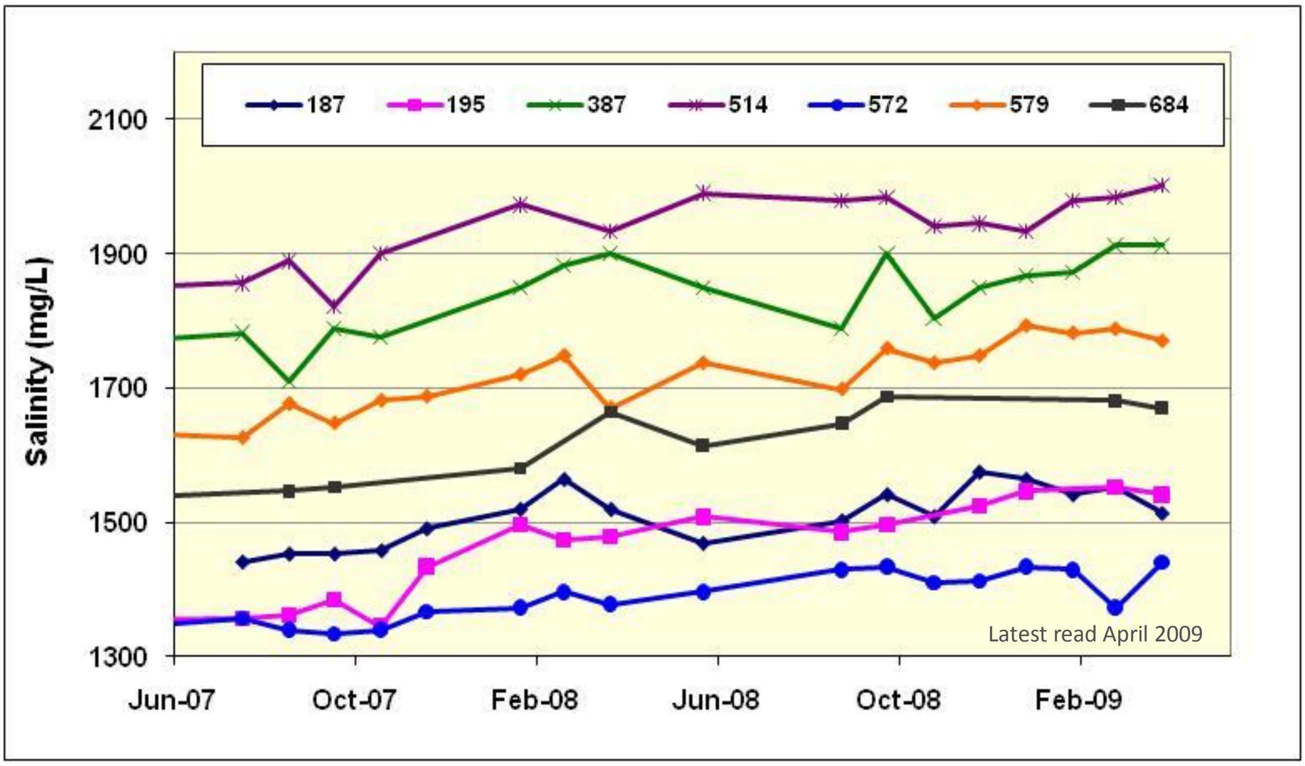

Figure 17[2]. Groundwater salinity trends for the unconfined limestone aquifer in the Mallee PWA

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[1] Allison GB, Cook PG, Barnett SR, Walker GR, Jolly ID and Hughes MW 1990, 'Land clearance and river salinisation in the western Murray Basin, Australia', in Journal of Hydrology, 119, pp. 1-20

[2] Figure 17 displays salinity graphs from stock and domestic wells. As these wells are not part of the State's Observation Well Network the numbers displayed that identify the wells are not typical of those displayed in other Groundwater Level and Salinity Status Reports.