TECHNICAL NOTE 2013/02

Department of Environment, Water and Natural Resources

CAPACITY OF THE GROUNDWATER RESOURCE OF THE KANGAROO FLAT AREA OF THE NORTHERN ADELAIDE PLAINS PWA

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May, 2013

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INTRODUCTION

A Notice of Restriction was first introduced over the groundwater resources in the Kangaroo Flat area in March 2000 in response to concerns about the impacts of a significant increase in groundwater pumping in the area. Extractions from the T2 aquifer increased from 330 ML/y in 1997 to over 1000 ML/y in 1998 (Gerges, 2000). The Kangaroo Flat area was subsequently incorporated into the Northern Adelaide Plains Prescribed Wells Area (PWA) by the *Water Resources (Northern Adelaide Plains Prescribed Wells Area) Regulations*, made under the *Water Resources Act 1997* on 22 July 2004.

Following an earlier assessment of the groundwater resources (Barnett, 2010), this report provides an updated assessment of the capacity of the groundwater resources to help determine whether water access entitlements of existing users should be reduced as required by Sec 164N of the Act. The social and economic impacts from such extractions are outside the scope of this report, and will be considered during the formulation of the Water Allocation Plan.

The Kangaroo Flat area is located about 42 km northeast of Adelaide and encompasses an area of 65 km^2 on the plains in the northeast corner of the Northern Adelaide Plains PWA (Fig. 1).

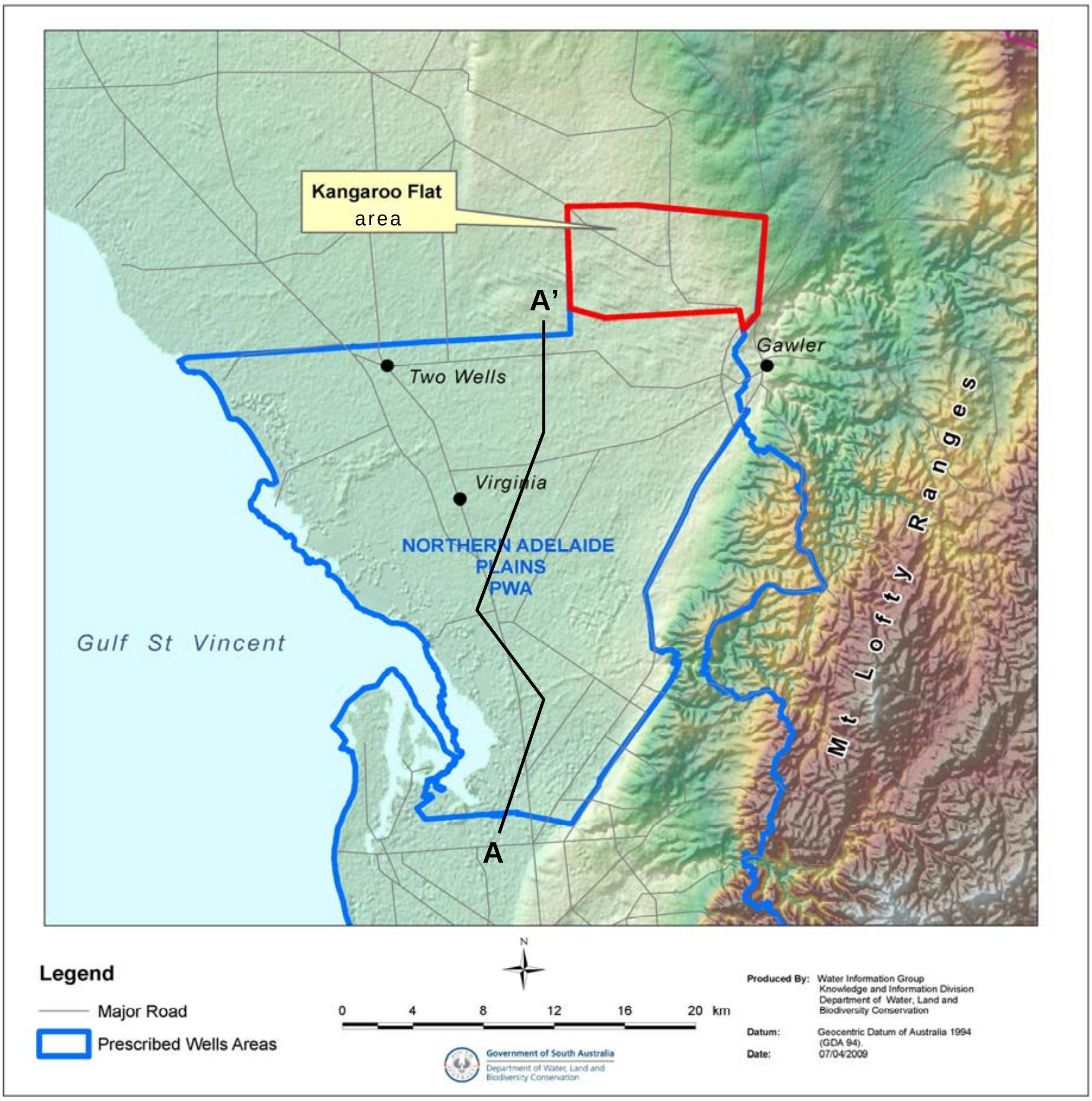

Figure 1. Location of Kangaroo Flat area

HYDROGEOLOGY

The stratigraphy within the study area has been well defined by numerous well logs (Gerges 2001). The sedimentary sequence includes Quaternary and Tertiary sediments that extend to a depth of about 600 m below ground surface. These sediments can be broadly divided into five regional hydrogeologic units as shown in the geological cross section in Figure 2.

1. Hindmarsh Clay - has a thickness of 30–50 m and consists primarily of clays with layers of silt and sand which may be several metres thick and form minor aquifers. It acts as a confining layer.
2. Carisbrooke Sand (Q4) aquifer - comprises very fine grained, poorly consolidated sands about 10 m in thickness. Scattered information suggests the salinity ranges between 3000–5000 mg/L.
3. Semi-confining layer - consists of a thin layer of clayey weathered Quaternary-Tertiary sediments.
4. T2 Tertiary confined aquifer - consists of limestones and sands from the Lower Port Willunga Formation. It is the only aquifer developed in the Kangaroo Flat area.
5. T3 Tertiary confined aquifer - comprises fine sands with carbonaceous material overlain by about 5 m of clayey sand (from geophysical log).

Groundwater salinity in the T2 aquifer varies between 1200–2300 mg/L, increasing toward the north and northwest as shown in Figure 3. The exact northern boundary between low salinity and saline groundwater is not well known (Gerges, 2001). Groundwater recharge to the T2 aquifer is believed to occur by lateral inflow from fractured aquifers of the Mount Lofty Ranges at the eastern boundary of the study area. Groundwater outflow from the aquifer system occurs through extraction and discharge beneath Gulf St Vincent.

The large groundwater volumes extracted in the study area have significantly altered the groundwater flow regime, with most of the groundwater movement now towards pumping wells and the associated cone of depression in the T2 aquifer centred on Virginia (Fig. 3). The increased head difference between the T2 aquifer and the overlying Quaternary aquifers in the study area may lead to increased downward leakage into the T2 aquifer of more saline groundwater as the semi-confining bed separating these aquifers is quite thin (Osei-Bonsu, 2002).

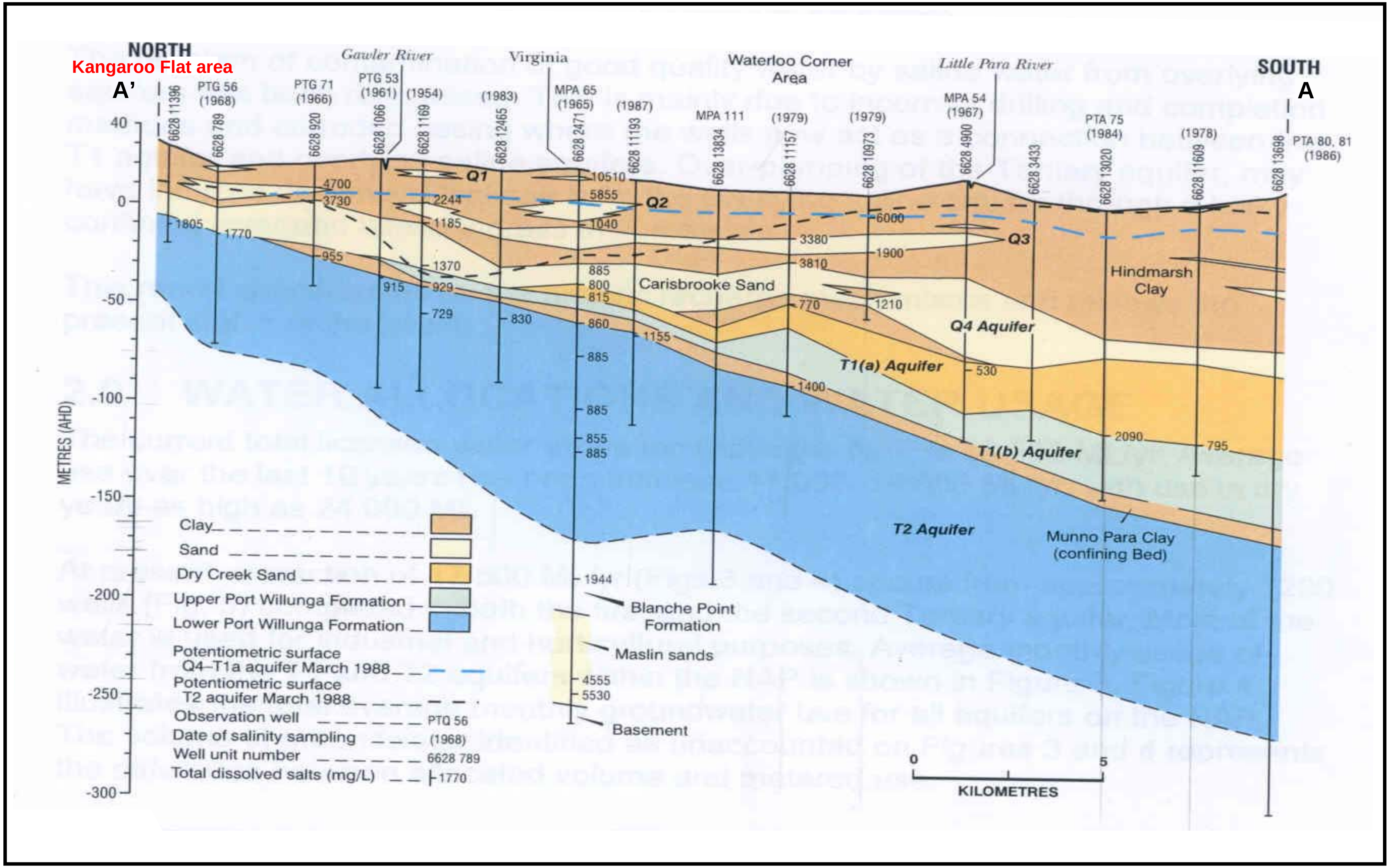

Figure 2. Diagrammatic north-south cross-section of the Northern Adelaide Plains (after Gerges, 2001)

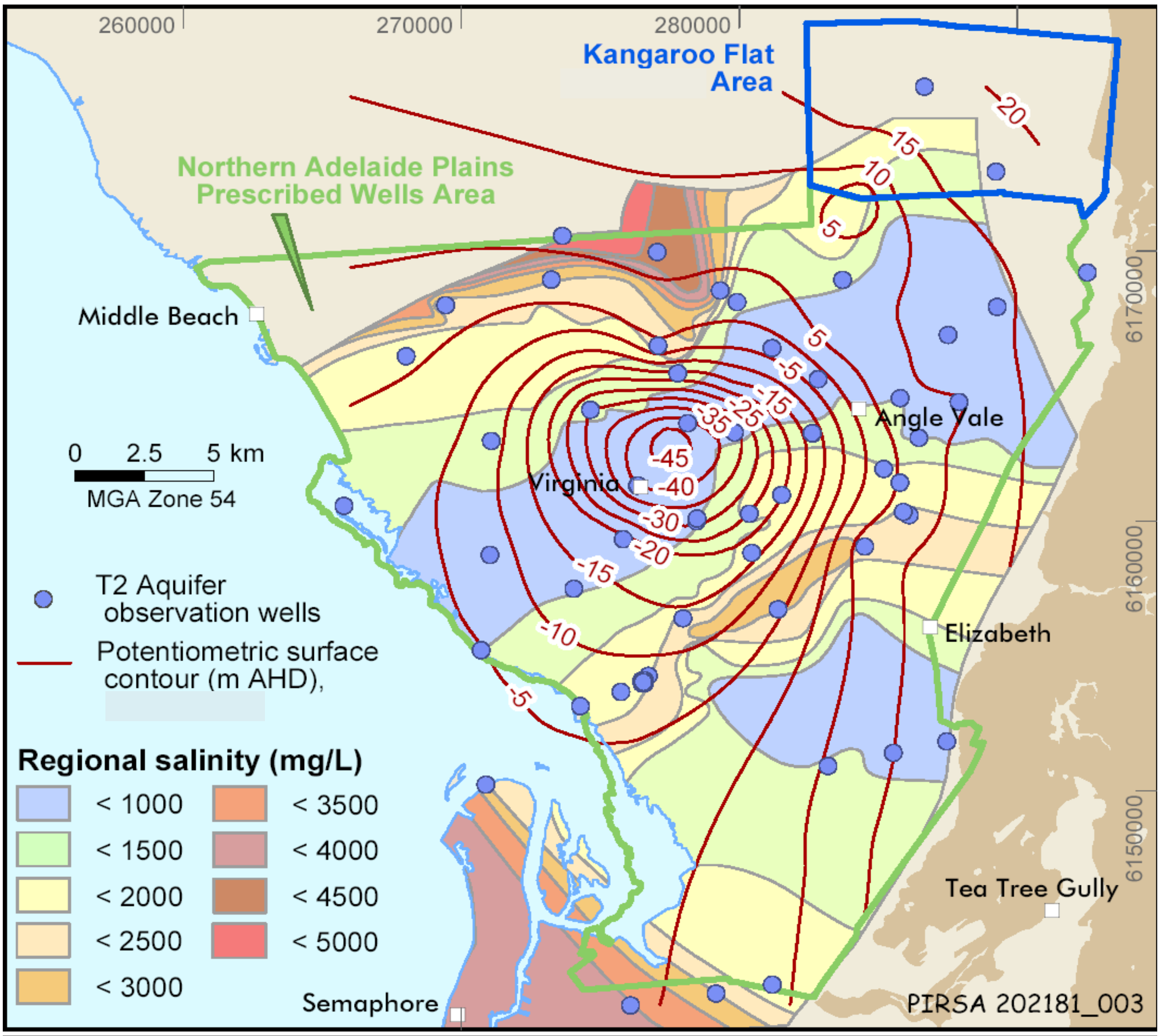

Figure 3. Potentiometric surface and salinity distribution for the T2 aquifer

PREVIOUS WORK

A preliminary assessment of the impacts of groundwater extractions in the Kangaroo Flat area was carried out by Gerges (2000). This was initiated by the increase in drilling activity between 1996 and 1999, and increasing extractions which led to concerns that the resource may become overdeveloped. The assessment was mainly a groundwater modelling exercise using a five layer model incorporating extractions from the neighbouring Northern Adelaide Plains PWA. The model accuracy was limited by the lack of monitoring data and hydraulic conductivity values for the T2 aquifer in the area of interest. The predictions assumed a total extraction of 5530 ML/y from the Kangaroo Flat area, which is considerably higher than current levels.

Further investigations were subsequently carried out following recommendations from Gerges (2000). Three new T2 observation wells were drilled in late 2000 (James-Smith and Gerges, 2001), and an aquifer test was carried out using four production wells and a disused well for observation purposes (James-Smith and Osei-Bonsu, 2001). The results found high potential for downward leakage of poor quality water in the overlying Carisbrooke Sands Q4 aquifer to move down through the semi-confining layer into the T2 aquifer.

A preliminary assessment of the resource capacity was carried out by Barnett (2010) which utilised a simple groundwater flow modelling exercise and also an interpretation of groundwater level and salinity monitoring trends. A significant increase in salinity of just over 130 mg/L/y from 2008 to 2010 was recorded in five irrigation wells when a change in pumping regime appears to have occurred. An interim limit of 1500 ML/y was recommended for allocations until more monitoring and drilling information became available.

In order to confirm the process of inter-aquifer leakage as the source of the widespread salinity increases in the T2 aquifer, additional observation wells were drilled into the overlying Q4 aquifer and the underlying T3 aquifer (Williams, 2011).

GROUNDWATER EXTRACTIONS

Metered extraction data from the T2 aquifer (from which all licensed extractions occur) is available since the 1999–2000 irrigation season as presented in Figure 4. Prior to that, estimates were used based on the area irrigated. The Notice of Restriction expired in June 2004. There was a steady increase in extraction up to almost 2000 ML/y in 2008–09, apart from the significant increase to over 2500 ML due to drought in 2006–07. Since 2008–09 however, there has been a marked decrease in extraction of 50% to only 1000 ML in 2010–11 in response to above average rainfall in recent years. There was an increase to 1323 ML in 2011–12.

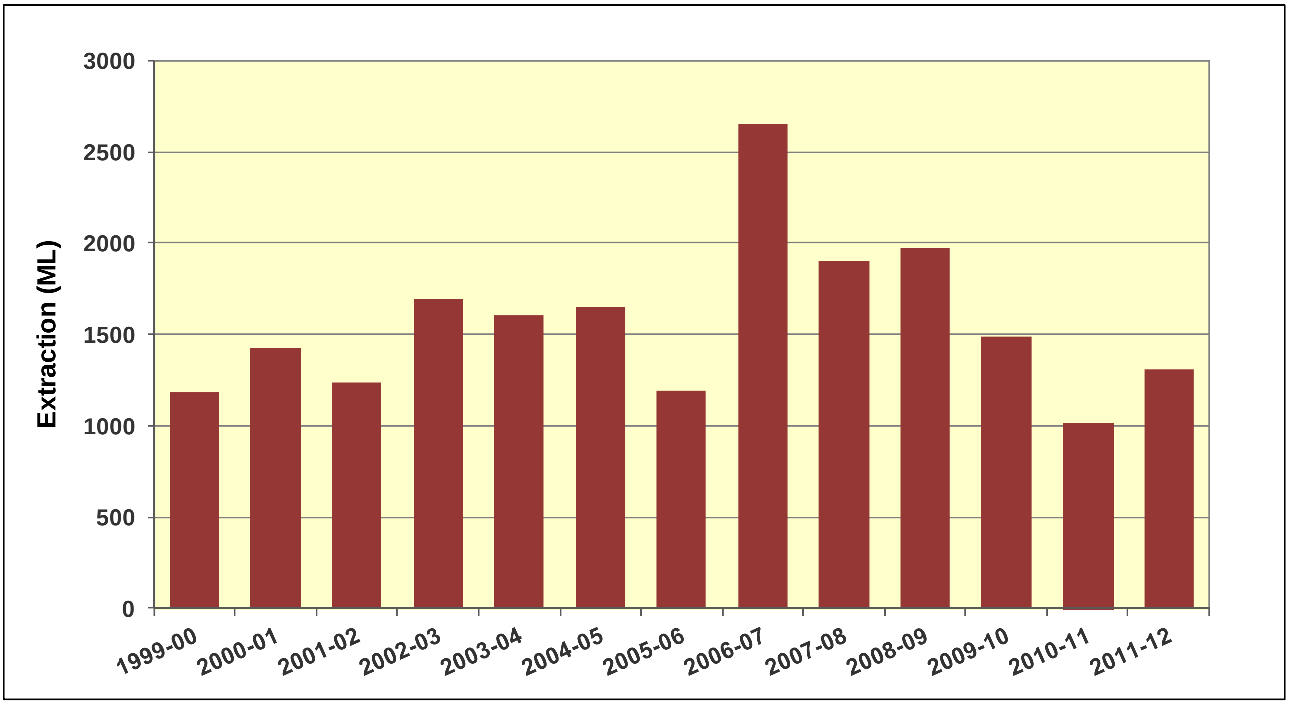

Figure 4. Groundwater extraction in the Kangaroo Flat area

Due to the presence of mains water and highly variable groundwater salinities, stock and domestic extractions are thought to be very minimal, if not non-existent. Only three wells have been drilled for stock purposes since 1976 when Well Construction Permits were first introduced. No domestic wells have been drilled over this period.

GROUNDWATER MONITORING

The main causes of changes in groundwater level or salinity are variations of inputs to the groundwater system (recharge), and also changes in outputs (extraction, natural discharge). Successful management of the groundwater resource requires identification of the causes of any observed changes.

Although groundwater water level monitoring in the Northern Adelaide Plains PWA had been carried out since the mid 1970s, none of the observation wells were located in the Kangaroo Flat area. Water level monitoring of three newly drilled observation wells completed in the T2 aquifer commenced in 2001, while the additional wells in the overlying Q4 aquifer and the underlying T3 aquifer have been monitored since 2010. The locations of these observation wells are shown in Figure 5, with completion details tabulated in Table 1.

Table 1. Observation well completion details

Obs well number	Aquifer	Completion interval (m)
MUW029	T2	46 - 54
MUW030	T2	46 - 51
MUW031	T2	48 - 55
MUW035	Q4	27 - 36
MUW036	Q4	32 - 38
MUW038	T3	74 - 80

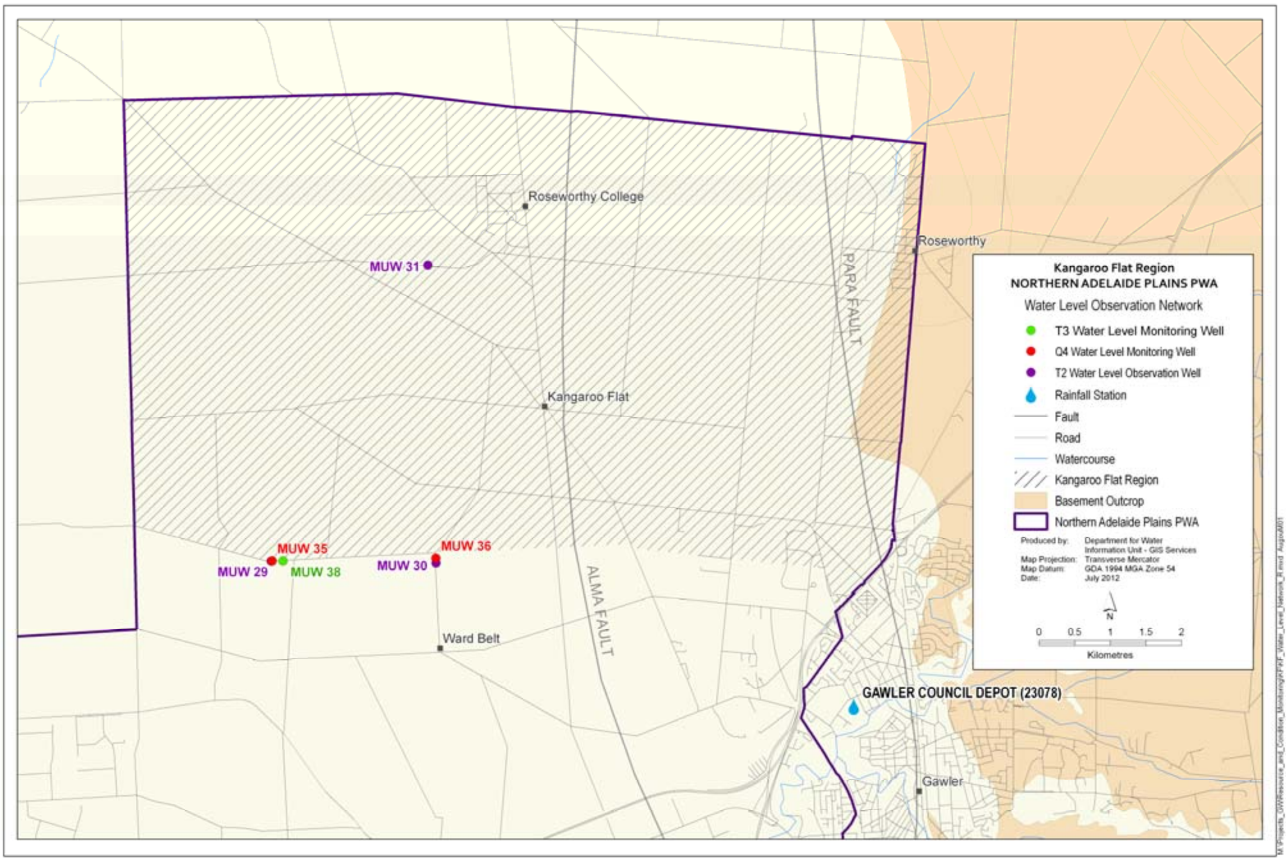

Figure 5. Location of water level observation wells

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Until recently, there has been no regular salinity monitoring carried out in the Kangaroo Flat area. However since February 2008, most extraction wells have been sampled at regular intervals (Fig. 6).

All observation well water level data for the Kangaroo Flat area can be obtained from the OBSWELL database via the web at this address; http://www.waterconnect.sa.gov.au/gd/

The network name of NAP-S should be entered to examine or download observation well data.

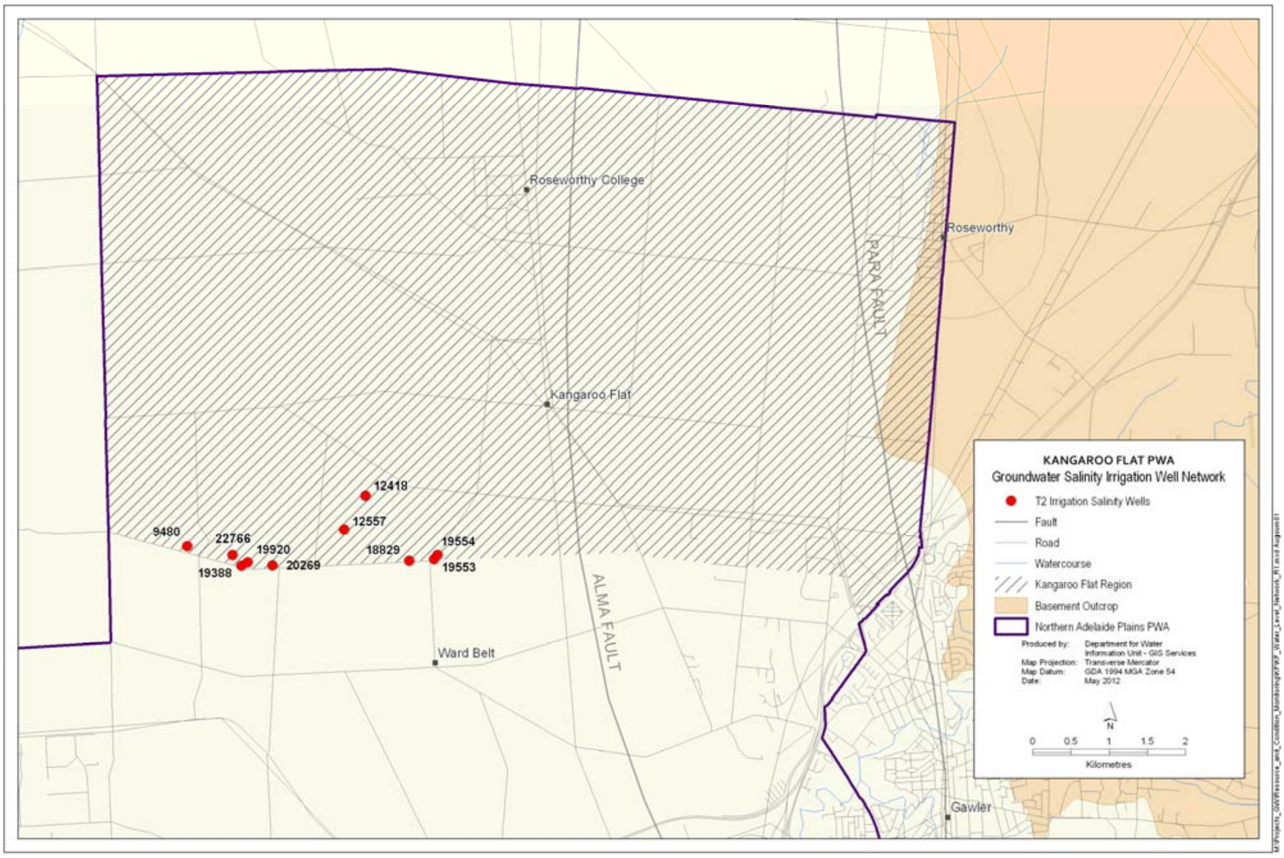

Figure 6. Location of salinity observation wells

WATER LEVELS

Hydrographs from within (or close to) the Kangaroo Flat area are shown in Figure 7. The new wells MUW 29, 30 and 31, were completed in the T2 aquifer after the increase in irrigation occurred in 1998. Well MUW 29 is located within 250 m of three production wells and not surprisingly, has recorded the greatest seasonal drawdown of 15–20 m. Well MUW 30 is located within 450 m of four production wells and has displayed a maximum seasonal drawdown of 10–15 m.

Up until about 2007, these wells indicate a form of equilibrium being reached, but they are more likely to reflect the magnitude and timing of local pumping, rather than regional trends. However between 2007 and 2010, a change in pumping regime (whereby most extractions occurred early in irrigation season to fill surface storages) reduced the maximum level of recovery, even though the seasonal drawdown was reducing. Since 2010, reduced extractions have led to reduced seasonal drawdowns during the irrigation season and a rise in the maximum recovered level of up to several metres.

Well MUW 31 is located three kilometres from the nearest production well and displays small seasonal variations and a gradual decline of about 0.15 m/y up until 2010, indicating that the cone of depression was still slowly widening even though it appears reasonably stable or even decreasing slightly, at the centre where most extractions occur. Since 2010, the trend has stabilised in response to reduced extraction.

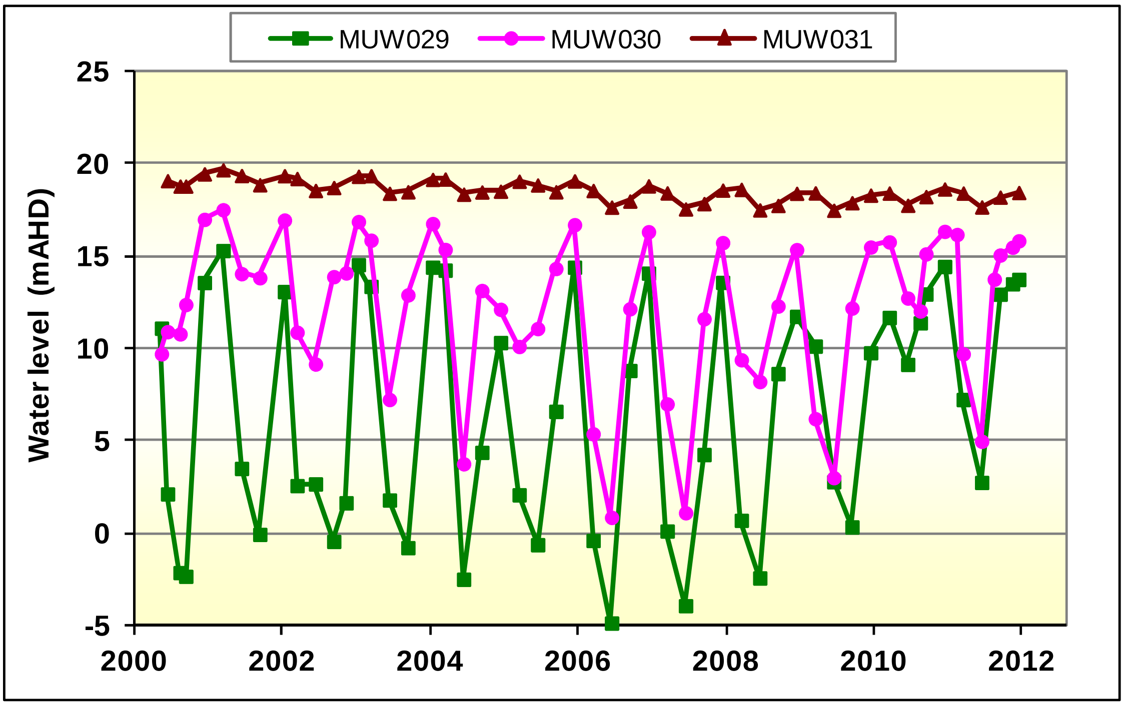

Figure 7. Kangaroo Flat area T2 aquifer hydrographs

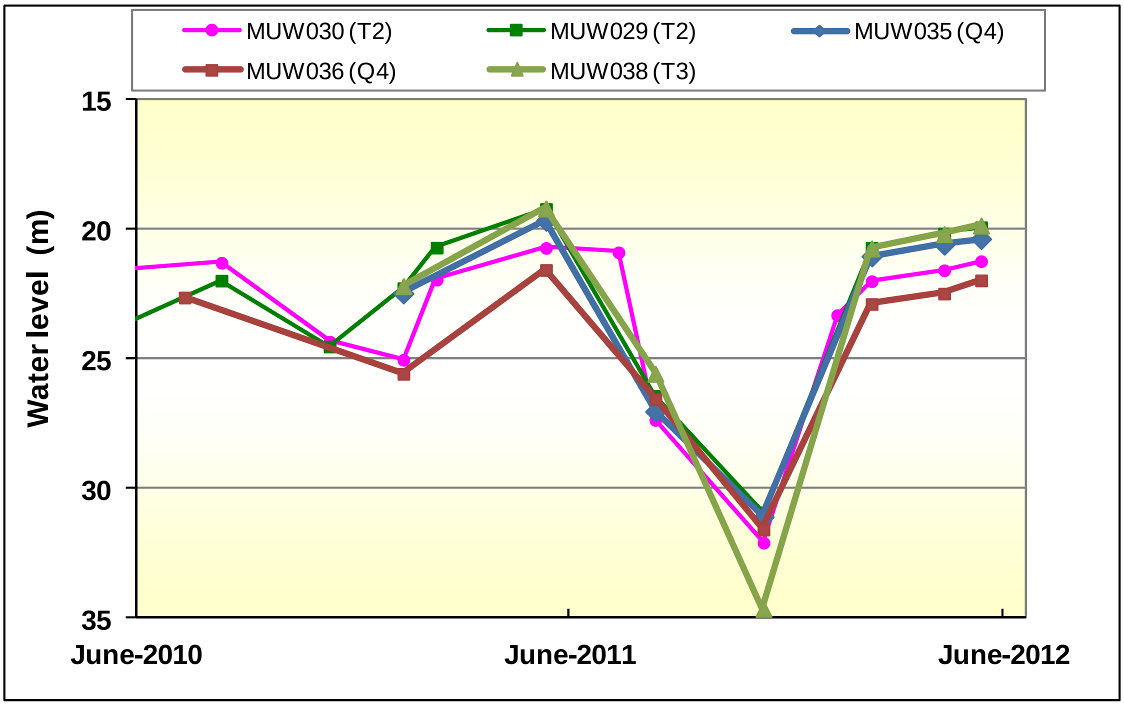

Figure 8. Kangaroo Flat area hydrographs for all aquifers

Figure 8 presents recent water levels from observation wells completed in all three aquifers. Significantly, the trends and magnitude of drawdown is almost identical in all three aquifers which indicates a very high degree of connectivity between them.

SALINITY

Figure 9 shows salinity trends for those irrigation wells completed in the T2 aquifer that have multiple salinity readings over a period of over 20 years. A steady increase can be seen in all wells sampled, with rates of increase varying from 5 to 25 mg/L/y.

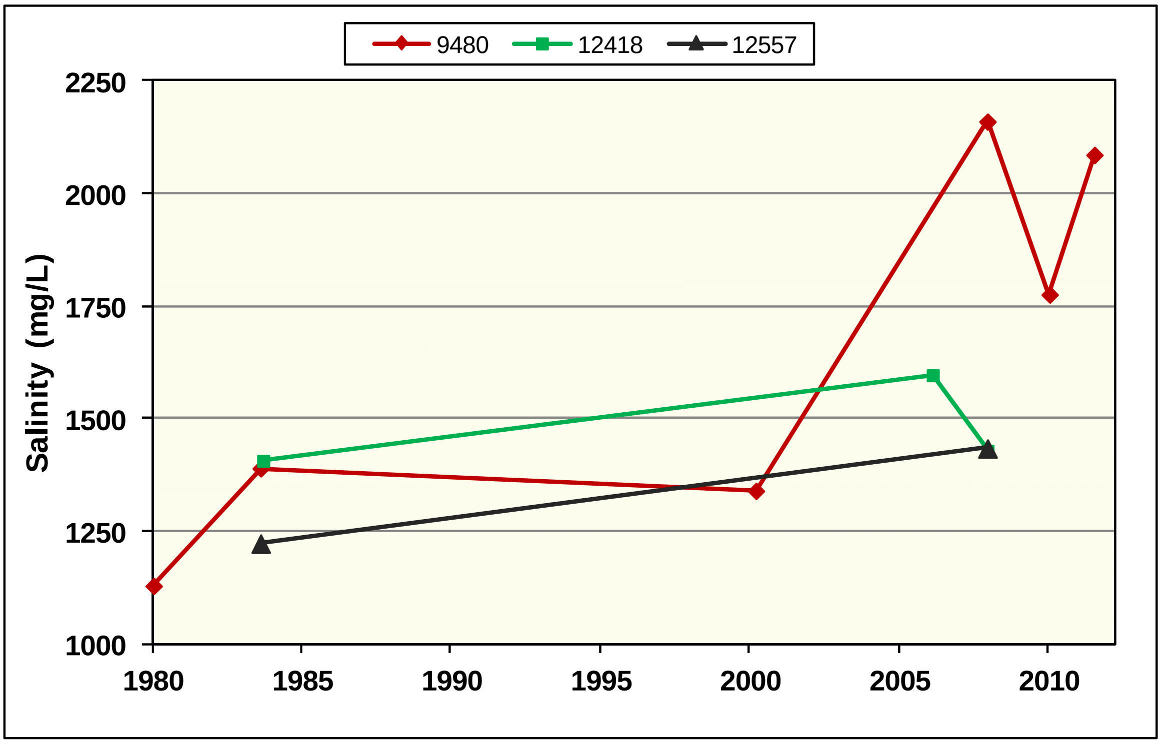

Figure 9. Kangaroo Flat salinity trends over 20 years

Figure 10 displays the more recent trends since 1998. Up until 2008, the rising trend reached a maximum of 40 mg/L/y, but over the last two years when the pumping regime appears to have changed as discussed previously, the trend from five irrigation wells has increased dramatically to just over 130 mg/L/y up until the end of the 2009–10 irrigation season.

The reduction in extractions over the last few years (Fig. 4) have resulted in a significant reduction in salinity in all of the eastern-most irrigation wells (wells 18829, 19553, 19554, see Fig. 6), but in only one of three wells sampled in the southwest corner of the area (well 19920).

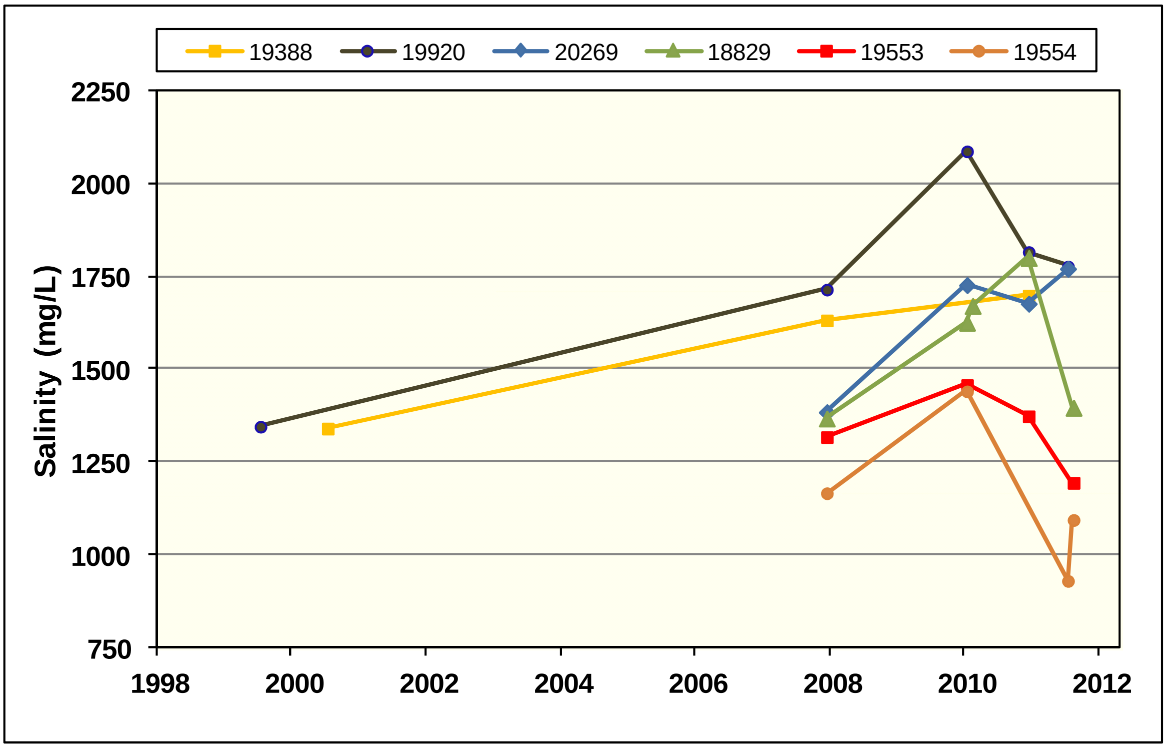

Figure 10. Kangaroo Flat salinity trends since 1998

Figure 11 displays the March 2010 salinity values which are the highest recorded in the region, the rate of salinity increase and the seasonal drawdown contours. It can be seen that the highest rates of salinity increase and the highest salinity values are associated with two areas of largest seasonal drawdowns (the change in water level from winter to summer) associated with two concentrations of extraction (east and west). These salinity values have already exceeded the maximum limits for vegetable irrigation which generally accepted to be around 1500 mg/L.

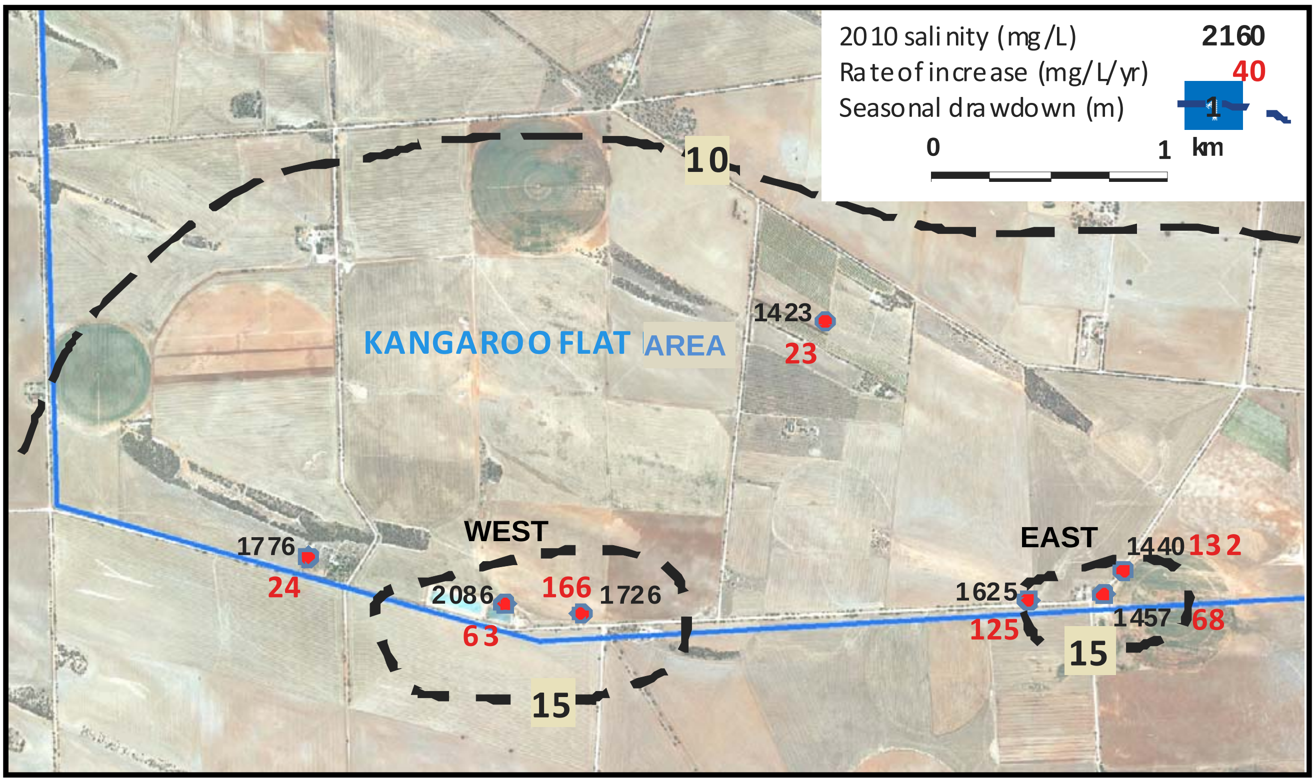

Figure 11. Kangaroo Flat drawdown and salinity trends

SUSTAINABILITY ISSUES

In the Kangaroo Flat area, the main sustainability issues that should be considered when determining the resource capacity are the lateral movement of saline groundwater from the northeast, and downward leakage of saline groundwater from the overlying Quaternary aquifers.

Salinity increases due to lateral inflows of more saline groundwater from the northeast are a potential problem over the long term, but due to the generally slow rate of groundwater movement, the salinity risk from downward leakage is considered greater and more immediate.

The monitoring data indicates a strong relationship between irrigation extraction, drawdown and salinity increases. The reductions in extractions since 2008-09 to below 1500 ML (Fig. 4) have led to a reduction in seasonal drawdown and a rise in the maximum recovered water level (Fig. 7) and a reduction in salinity in four of the six monitored irrigation wells in the two areas of concentration of extraction.

However some irrigation wells are showing an ongoing rising trend with half of those sampled still recording values over 1500 mg/L.

CONCLUSIONS

The additional monitoring carried out since the last assessment confirms 1500 ML/y as an initial limit for allocations. Ongoing monitoring may indicate the need for further reductions in allocations in the future.

The very high degree of connectivity between the three main aquifers is demonstrated by the observed stratigraphy and the almost identical drawdown response to extraction from the T2 aquifer. Determination of separate resource capacities for the Q4 and T3 aquifers is therefore not necessary given the lack of information and this high connectivity.

Salinity monitoring of all licensed wells should be carried out at six monthly intervals to gain a better understanding of salinity trends. Water users in the Kangaroo Flat area should be encouraged to develop extraction regimes that maximise the recovery of drawdowns in their extraction wells during the winter and spring period.

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