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Department of Water, Land and Biodiversity Conservation

GROUNDWATER RESOURCE ASSESSMENT OF THE KANGAROO FLAT PRESCRIBED WELLS AREA

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INTRODUCTION

A Notice of Prohibition 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/yr in 1997 to over 1000 ML/yr in 1998 (Gerges, 2000). The area was subsequently prescribed as the Kangaroo Flat Prescribed Wells Area (PWA) under the *Natural Resources Management Act 2004* (the Act) on 19 June 2008.

This report provides an assessment of the capacity of the groundwater resources to help determine the amount of groundwater that can be allocated (as required by Sec 155 of the Act). The social and economic impacts from such extractions (as required by Sec 76 of the Act) are outside the scope of this report, and will be considered during the formulation of the Water Allocation Plan.

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

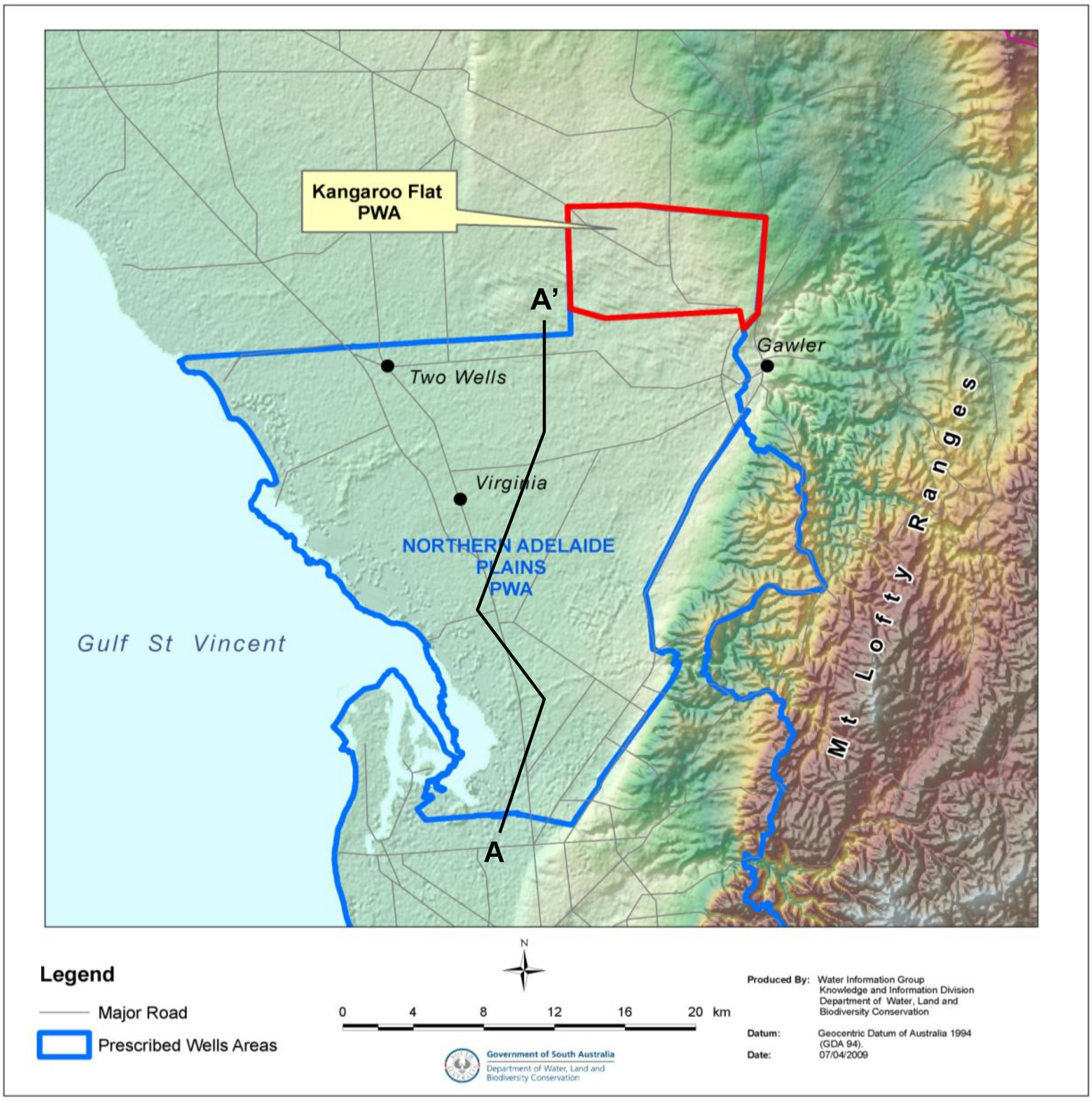

Figure 1. Location of Kangaroo Flat PWA

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 four 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 used in the Kangaroo Flat area.

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 fresh and saline groundwater is not well known (Gerges, 2001). Groundwater recharge to the T2 aquifer is thought to occur by lateral inflow from fractured aquifers of the Mt Lofty Ranges at the eastern boundary of the study area. Groundwater outflow from the aquifer system occurs through extraction from irrigation and domestic wells and discharge beneath St Vincent's Gulf.

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 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).

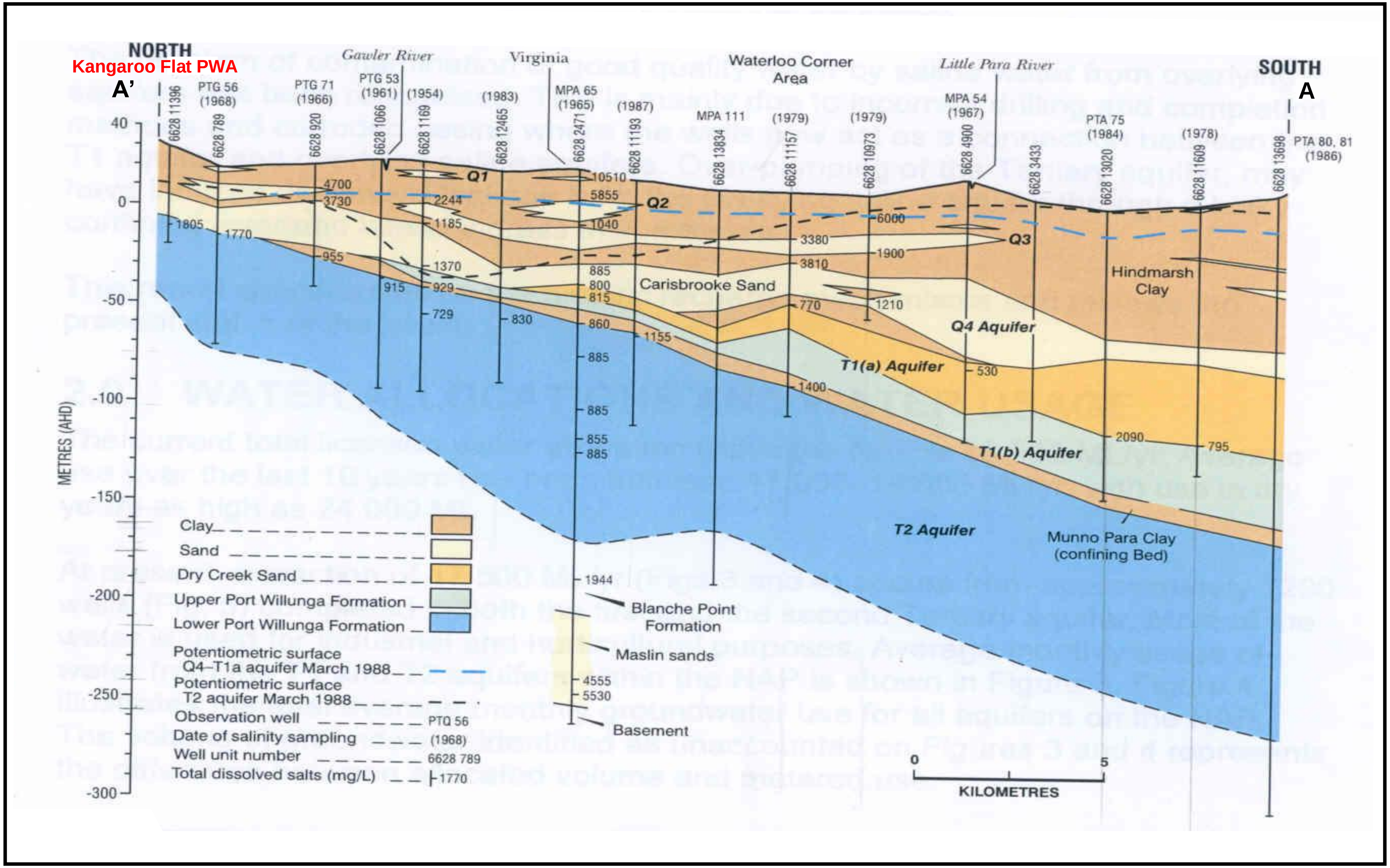

Figure 2. Diagrammatic north-south cross-section of the NAP (after Gerges, 2001)

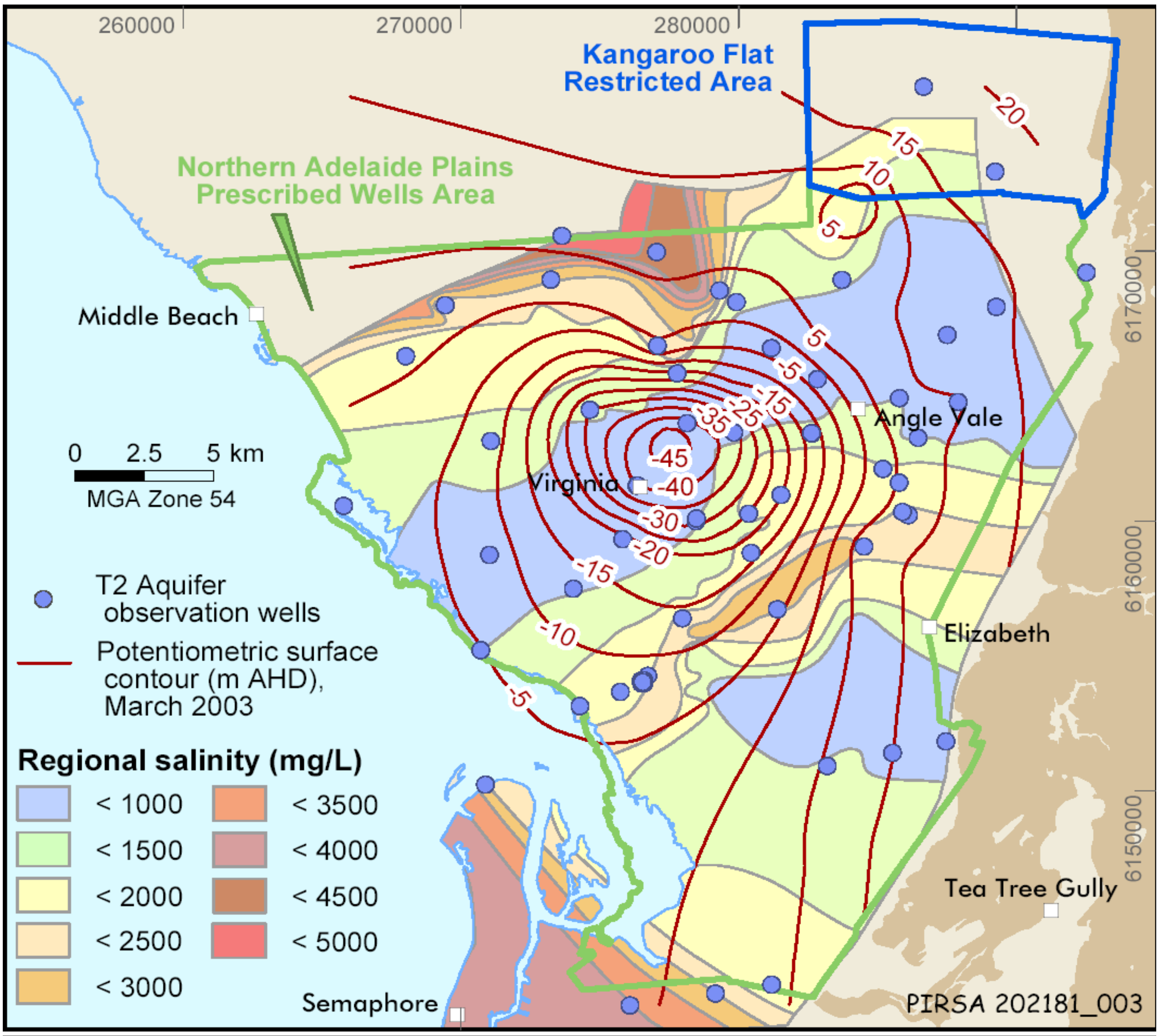

Figure 3. Potentiometric surface and salinity distribution for the T2 aquifer

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 be 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/yr from the Kangaroo Flat PWA, 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.

GROUNDWATER EXTRACTIONS

Metered extraction data from the T2 aquifer is available since the 1999/2000 irrigation season as presented in Figure 4. Prior to that, estimates were used based on the area irrigated. There appears to be steady increase in extraction over the last ten years. The Notice of Prohibition was lifted in June 2004. Due to the presence of mains water and highly variable groundwater salinities, stock and domestic extractions are thought to be minimal.

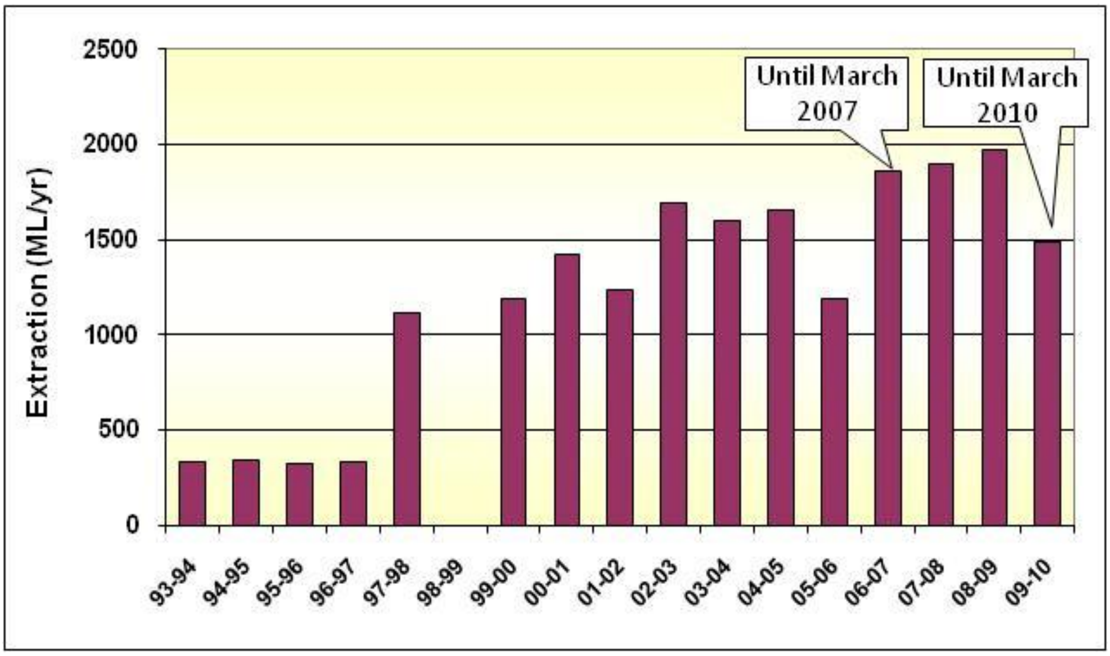

Figure 4. Groundwater extraction in the Kangaroo Flat PWA

Figure 5 shows the percentage of each authorisation developed, using the average annual metered use since 2001/02. There is a considerable variation, ranging from 0 to 104 %.

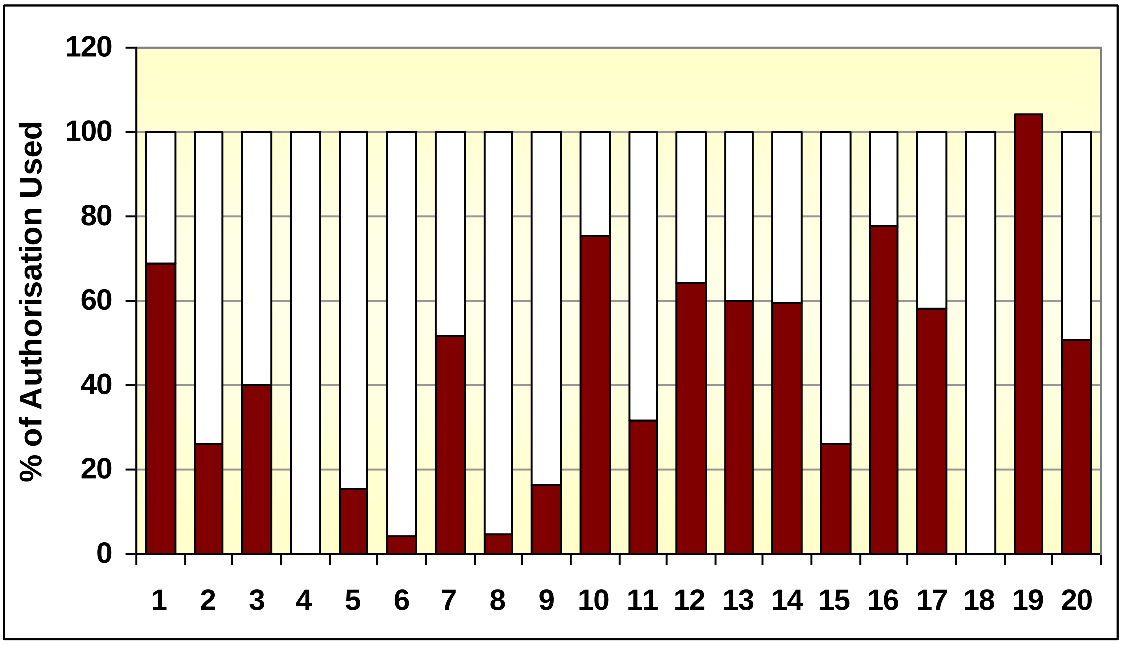

Figure 5. Percentage of authorisations used.

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 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. Following concerns about the increase in irrigation in the area, three new observation wells were drilled and completed in the T2 aquifer (James-Smith and Gerges, 2001). The location of these observation wells and others included in the discussion below, is shown in Figure 6.

All observation well data for the Kangaroo Flat PWA can be obtained from the OBSWELL database via the web at this address; https://obswell.pir.sa.gov.au/

The network name of NAP-S should be entered to examine or download observation well data (water levels and salinity).

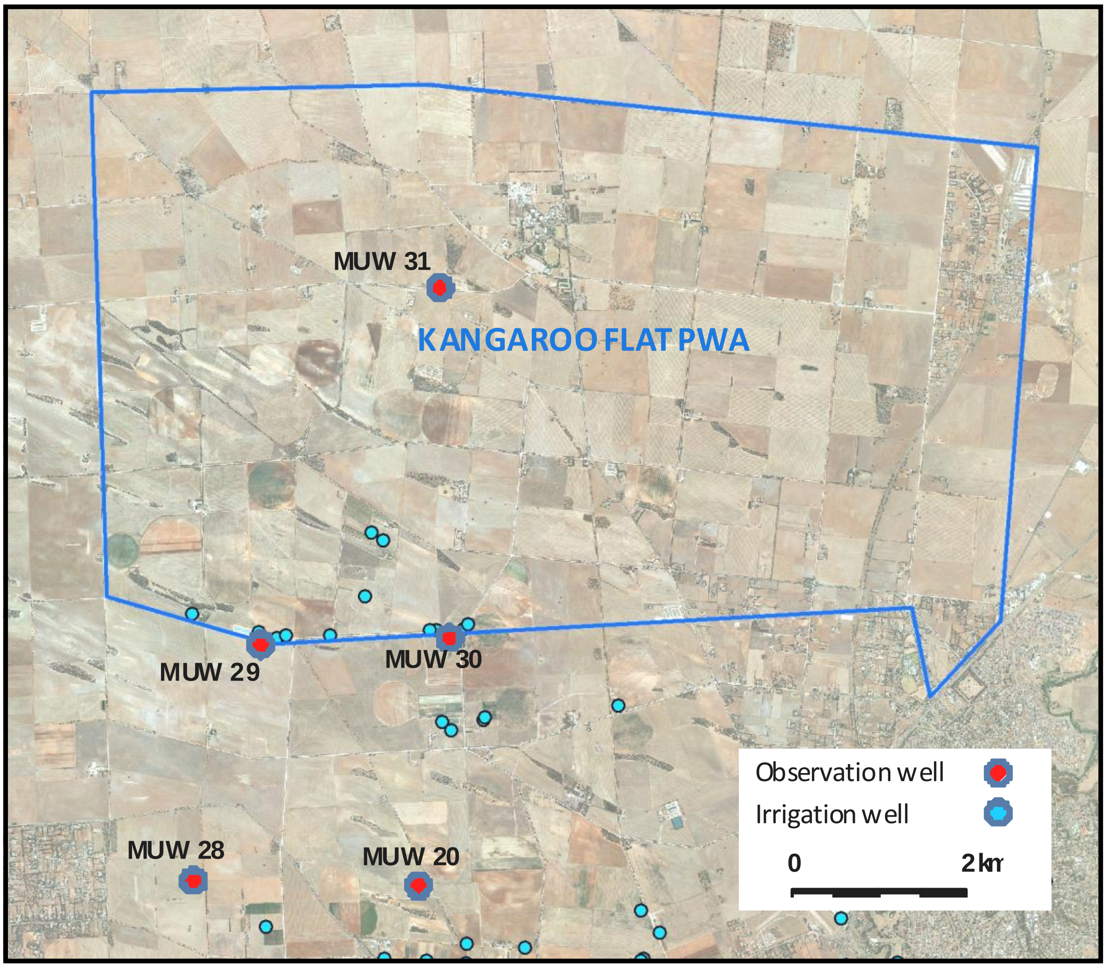

Figure 6. Location of observation wells

WATER LEVELS

Figure 7 shows water level hydrographs from observation wells in the T2 aquifer located to the south in the Northern Adelaide Plains PWA. Well MPA 111 is located near Waterloo Corner 20 km to the southwest of Kangaroo Flat, and displays the typical water level trend for the area, namely a recovery in levels from 2000 to 2004, with a decline until 2008. Well MUW 28 (and its replacement MUW 34) is located only 3 km southwest of Kangaroo Flat (Fig. 6). It mirrors the typical NAP trend until 1998, when extractions increased in the Kangaroo Flat area. Well MUW 20 is completed in the overlying Quaternary Q4 aquifer and shows a very gradual decline which could be contributed to decreasing recharge or downward leakage induced by irrigation drawdowns.

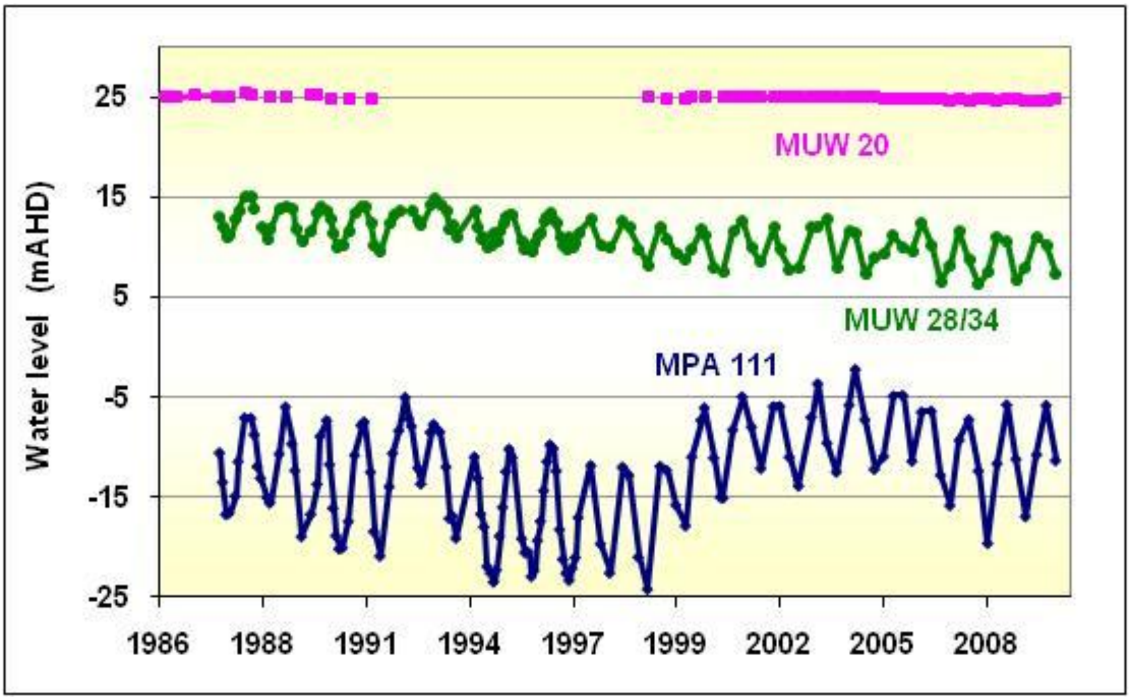

Figure 7. Hydrographs for wells in the Northern Adelaide Plains PWA

Hydrographs from within (or close to) the Kangaroo Flat PWA are shown in Figure 8. The new wells MUW 29, 30 and 31, were completed after the increase in irrigation occurred in 1998 (which can be seen as an increase in drawdown levels for MUW 28 at this time). Well MUW 29 is located within 250 m of three production wells and not surprisingly, shows the greatest seasonal drawdown of 15 – 20 m. Well MUW 30 is located within 450 m of four production wells and displays a seasonal drawdown of 10 – 15 m.

Up until about 2008, 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 after this time, a probable change in pumping regime to an earlier and more prolonged irrigation season is reducing the maximum level of recovery, even though the seasonal drawdown is reducing. The steady decline in the maximum recovered level in MUW 29 and 30 will have important salinity implications because the overall head difference between the T2 aquifer and the overlying more saline Q4 aquifer is increasing.

Well MUW 31 is located three kilometres from the nearest extraction well and displays small seasonal variations and a gradual decline of about 0.15 m/yr, indicating that the cone of depression is still slowly widening even though it appears reasonably stable or even decreasing slightly, at the centre where most extractions occur.

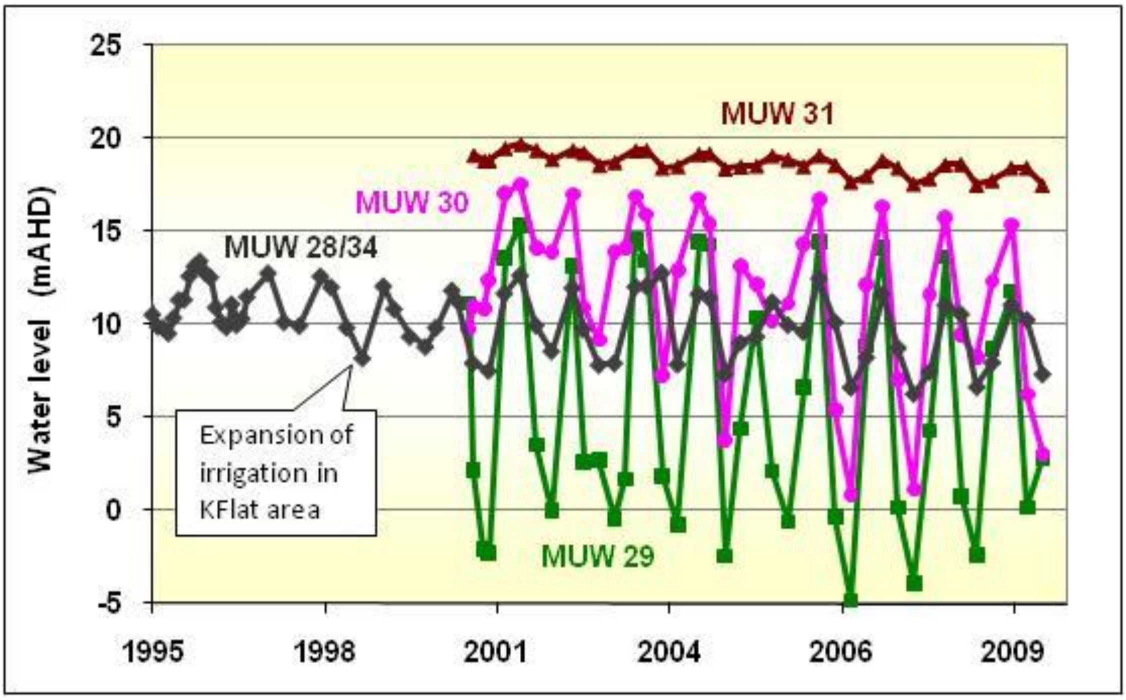

Figure 8. Kangaroo Flat hydrographs

SALINITY

Up until recently, there has been no regular salinity monitoring currently carried out in the Kangaroo Flat area. However in February 2008, most licensed extraction wells were sampled. Figure 9 shows salinity trends for those wells 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/yr.

Figure 10 displays the more recent trends since 1998. Up until 2008, the rising trend reached a maximum of 40 mg/L/yr, but over the last two years when the pumping regime appers to have changed, the trend from five irrigation wells has increased dramatically to just over 130 mg/L/yr.

Two irrigation wells one kilometer south of Kangaroo Flat have also recorded rises of 40 mg/L/yr over the last several years, suggesting that the problem with increasing salinities caused by downward leakage may be more widespread.

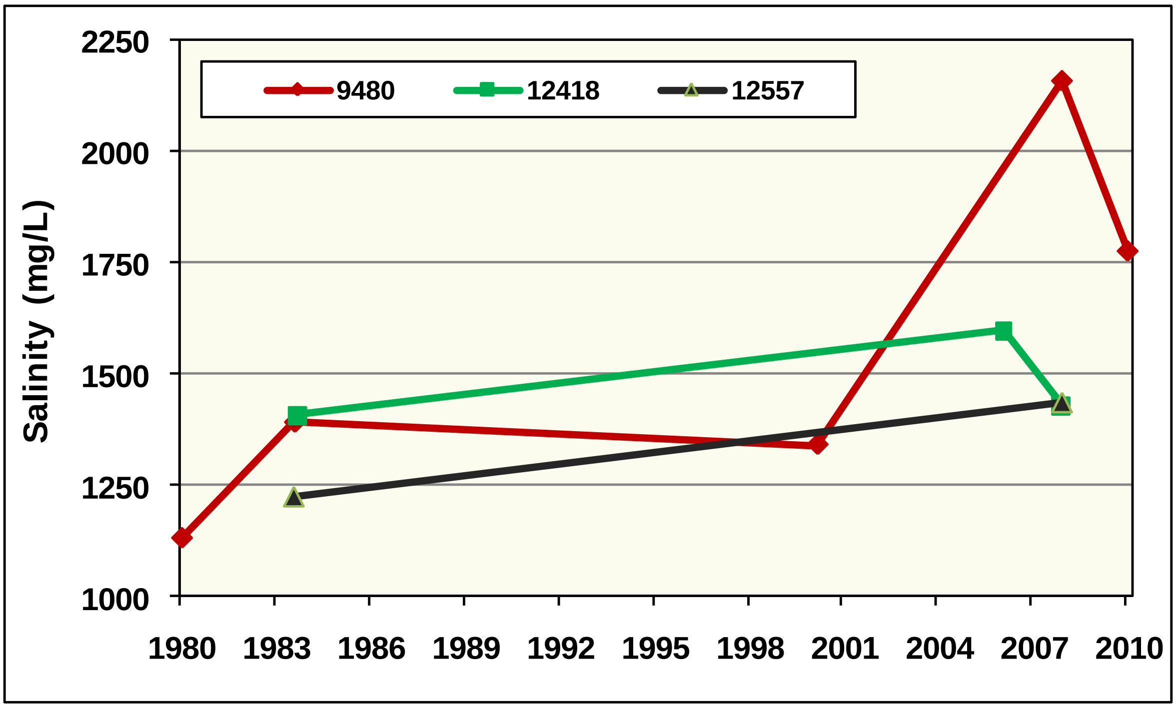

Figure 9. Kangaroo Flat salinity trends over 20 years

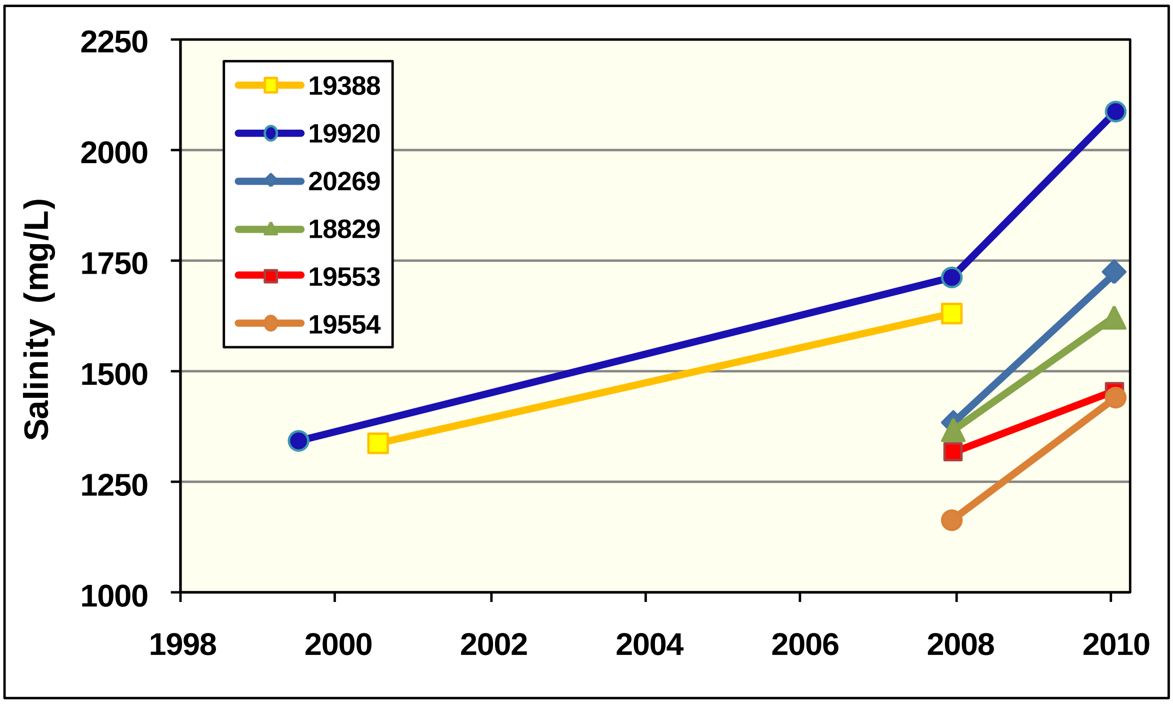

Figure 10. Kangaroo Flat salinity trends since 1998

Figure 11 displays the March 2010 salinity values, 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 the largest seasonal drawdowns (the change in water level from winter to summer). These salinity values have already exceeded the maximum limits for vegetable irrigation.

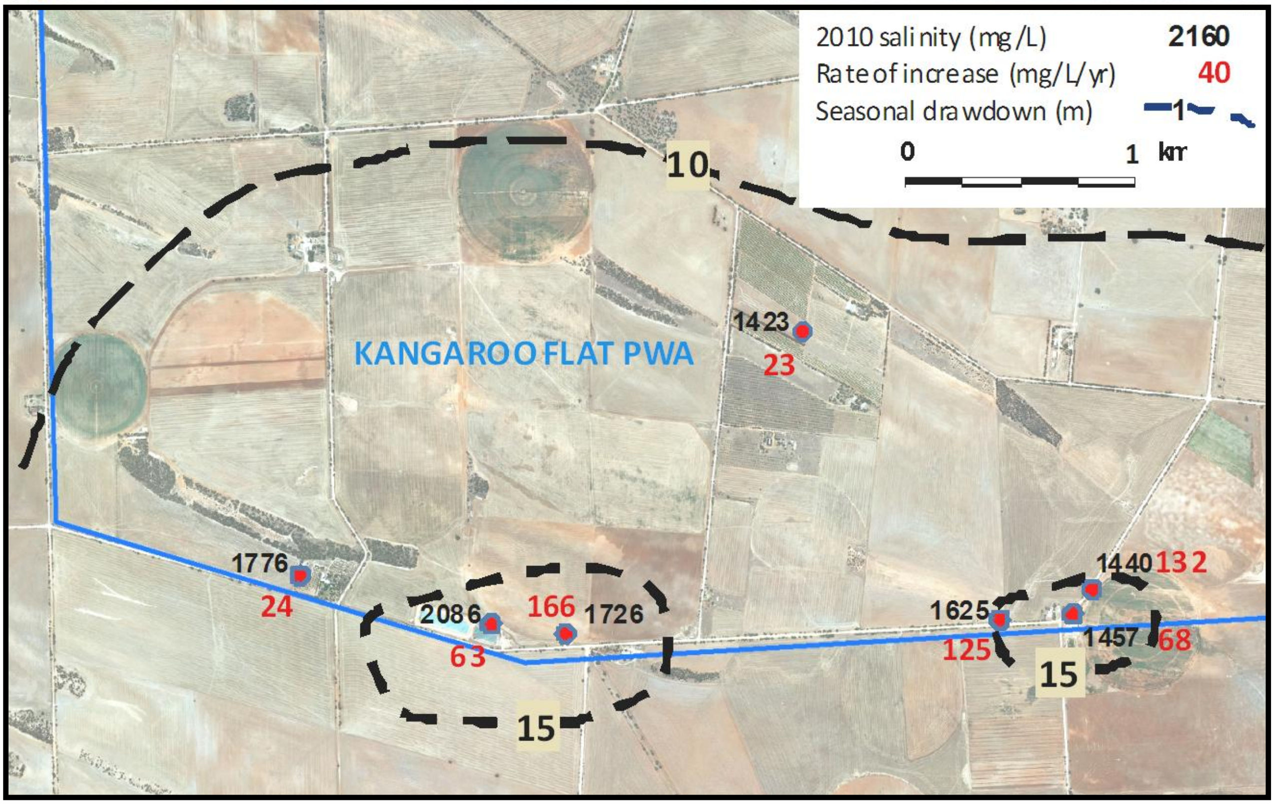

Figure 11. Kangaroo Flat salinity trends

SUSTAINABILITY ISSUES

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

In order to quantify these impacts, the groundwater model of the Northern Adelaide Plains PWA was updated and recalibrated using extraction and monitoring data up until 2008 in the Kangaroo Flat area (SKM, 2010). Several extraction scenarios were run at rates varying from 0 to 3000 ML/yr.

The model results show a typical confined aquifer drawdown response at an extraction rate of 1600 ML/yr that quickly reaches an equilibrium, and remains relatively unchanged into the future as shown in Figure 12. This is consistent with previous modelling results in the Kangaroo Flat area, and is also consistent with the response in other confined aquifers in SA. The impacts of pumping 3000 ML/yr in Kangaroo Flat on drawdowns in the NAP vary up to about 5 m just to the south of the Kangaroo Flat PWA. This should be compared to a seasonal drawdown of 15 m in this same area due to existing NAP pumping. These results show that the volume of extraction alone is not a major sustainability issue, assuming that groundwater is extracted during a conventional summer irrigation season.

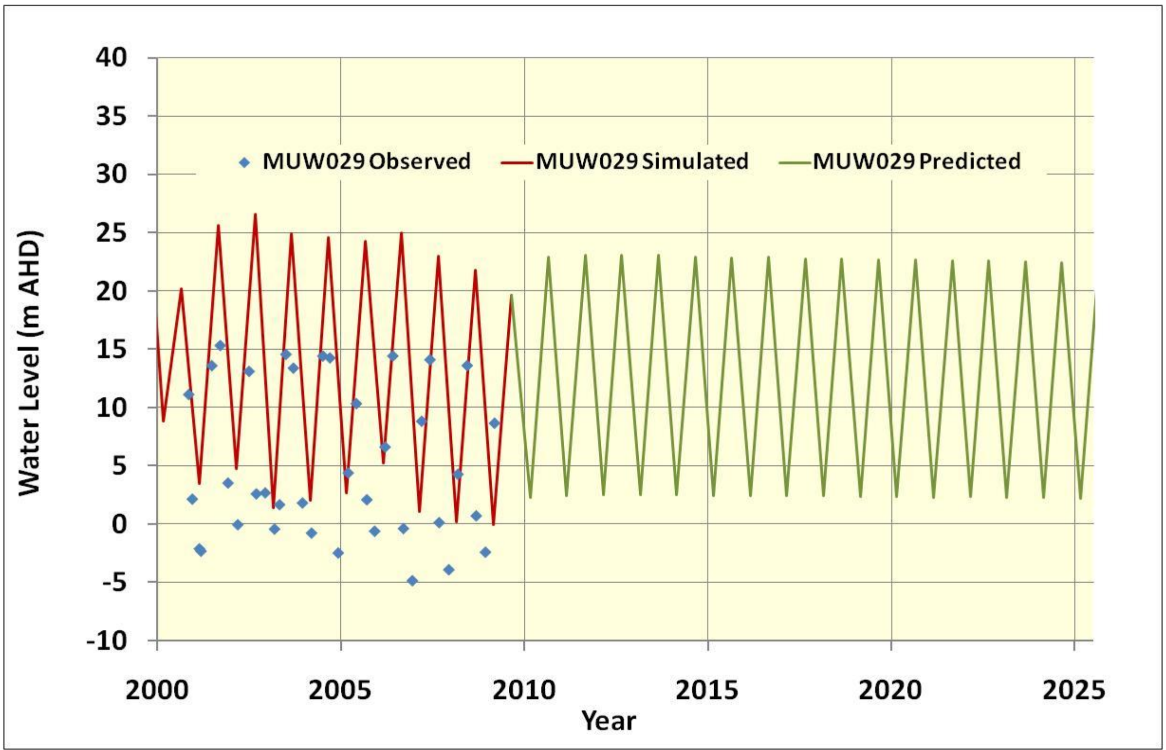

Figure 12. Modelled drawdown prediction at 1600 ML/yr

Of more concern are the salinity impacts of extraction in the Kangaroo Flat area. Calculations of volumes of downward leakage were made for the drawdowns resulting from the extraction scenarios, assuming a porosity of 0.15 and a mixing depth within the T2 aquifer of 20 m (SKM, 2010). Figure 13 displays the calculated range of increases in salinity in the area of intensive pumping at various extraction rates. The upper and lower bounds of the range assume a salinity in the overlying Quaternary aquifer of 10 000 and 3000 mg/L respectively.

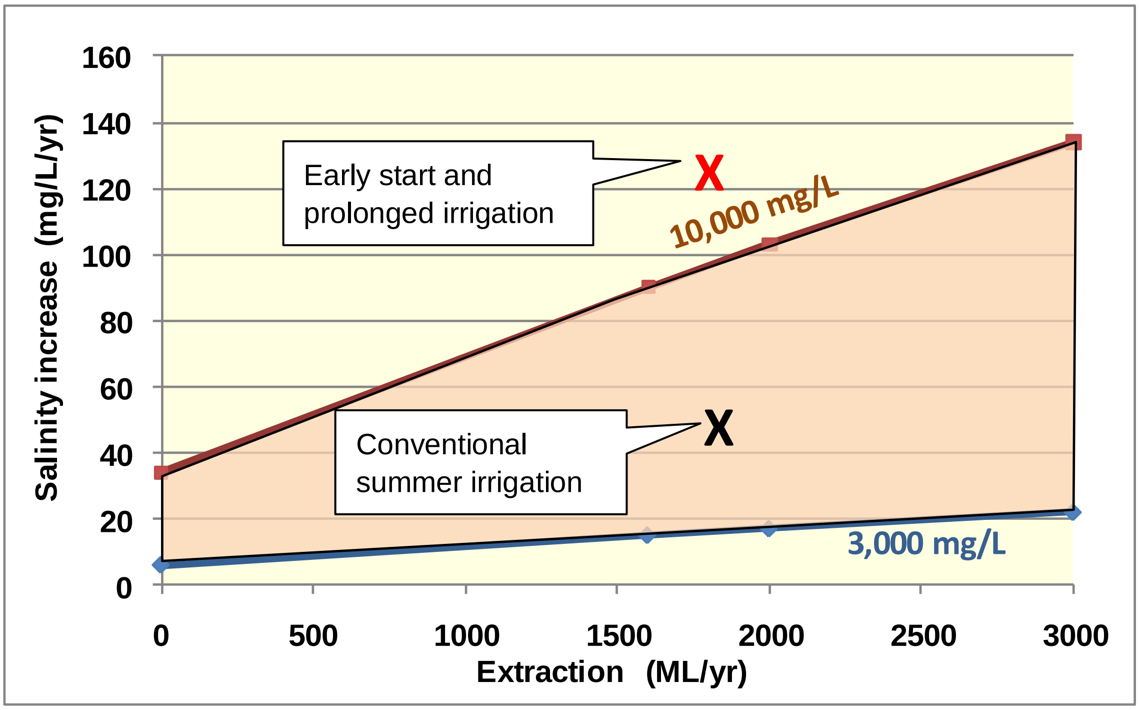

Figure 13. Kangaroo Flat calculated salinity increases due to downward leakage

The large black X indicates the maximum observed of salinity increase of 44 mg/L/yr in the area of maximum drawdown at an extraction rate of 1800 ML/yr in 2007/08. The red cross shows the measured increase of 130 mg/L/yr in the two years since, most likely due to the changed pumping regime from that observed previously which was used in the SKM modelling exercise. The salinity in the overlying Q4 aquifer may be higher than previous estimations from sparse data, with no values available for the Kangaroo Flat area. Metered data for 2009/10 (1,490 ML up to 25 March, 2010) does not show a significant increase over previous years (Fig. 4).

Salinity increases due to lateral inflows of more saline groundwater from the northeast are also 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.

CONCLUSIONS AND RECOMMENDATIONS

Due to the high salinity levels in irrigation wells, the increasing rate of rise in salinity and the very high risk of further increases, the current extraction regime in the Kangaroo Flat PWA is unsustainable. Unfortunately, the salinity data is not comprehensive, but the trend in irrigation well 6628-9480 in Figure 9 suggests that increases in salinity occurred after 2001 when extractions increased over 1,500 ML/yr (Fig. 4). It is therefore recommended that 1,500 ML be set as an interim limit for allocations until more monitoring and drilling information becomes available.

Salinity monitoring of all licensed wells should be carried out at six monthly intervals to gain a better understanding of salinity trends. Because of the lack of data on the overlying Q4 aquifer, two observation wells completed in this aquifer are recommended to be drilled adjacent to existing T2 observation wells MUW 29 and 30. Kangaroo Flat PWA Irrigators 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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