NORTHERN ADELAIDE PLAINS PWA

GROUNDWATER LEVEL AND SALINITY STATUS REPORT

2009–10

DEPARTMENT FOR WATER

Government of South Australia
Department for Water

SUMMARY 2009–10

The Northern Adelaide Plains Prescribed Wells Area (PWA) lies just to the north of the Adelaide Metropolitan Area and comprises Quaternary and Tertiary sedimentary aquifers of the St Vincent Basin. Groundwater extractions occur from Tertiary limestone aquifers. Metered extractions in 2009–10 totalled 14 713 ML, which represents a 2.4% increase from the previous water use year, however extraction is still well below the current allocation of 26 500 ML. A Water Allocation Plan provides for sustainable management of the water resources.

The Kangaroo Flat region of the Northern Adelaide Plains PWA has been assessed in a separate Status Report.

Groundwater extractions primarily occur from the T2 aquifer which provides 73% of the total volume, with the T1 aquifer being less developed (25%), and the Quaternary aquifers providing the remainder (2%).

Extractions from the T2 aquifer have created a long-standing cone of depression in groundwater pressure level contours centred on Virginia which has been relatively stable over the last 20 years or so. After a slight recovery in water levels from 2002 to 2006, below average rainfall since 2006 has led to increased extraction and a downward trend in water levels. This downward trend appears to be stabilising at levels higher than the lowest-ever-recorded levels observed in the late 1990s.

Similarly, T1 aquifer pumping has formed a long-standing cone of depression centred on Waterloo Corner which has also been relatively stable over the last 20 years. Similar trends to the T2 aquifer have been observed, but in the south of the Northern Adelaide Plains PWA, levels appear to still be declining, probably due to the influence of extractions in the neighbouring Central Adelaide PWA.

Groundwater level trends in the perched aquifer indicate a stable trend, while all the remaining four Quaternary aquifers show slight declines in water levels.

Salinity levels in the both the T1 and T2 aquifers are both characterised by reasonably stable trends over the past 10 years. However, the lateral inflow of more saline groundwater toward the cones of depression could be causing salinity increases in irrigation wells located close to the boundary of low salinity zones, assuming that no contamination due to corroded casing is occurring.

ASSESSMENT OF STATUS

The Northern Adelaide Plains PWA (excluding the Kangaroo Flat region) has been assigned a status of yellow "Adverse trends indicating low risk to the resource in the medium term" based on current trends. This status is supported by:

- a downward trend in groundwater levels in the T2 aquifer has been observed, as a result of increased extraction caused by below average rainfall since 2006. This downward trend appears to be stabilising at levels higher than the lowest ever recorded groundwater levels observed in the late 1990s.
- the T1 aquifer is displaying similar trends to the T2 aquifer, with ongoing declines only detected in the south of the Northern Adelaide Plains PWA, probably due to the influence of extractions in the neighbouring Central Adelaide PWA. These declines are not expected to affect access to the resource by groundwater users over the next 10–20 years.
- generally stable salinity levels in both the T1 and T2 aquifers over the past 10 years. However, the lateral inflow of more saline groundwater toward the cones of depression could be causing salinity increases in irrigation wells located close to the boundary of low salinity zones, assuming that the rises are not caused by contamination due to corroded well casing.

STATUS (2009–10)

No adverse trends, indicating a stable or improving situation

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

Adverse trends indicating low risk to the resource in the medium term

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.

Adverse trends indicating high risk to the resource eventuating in the short to medium term

Observed adverse trends are significant and if continued, will lead to a change in the current beneficial uses of the groundwater resource in about 10 years.

Degradation of the resource compromising present use within the short term

Trends indicate degradation of the resource is occurring, or will occur within 5 years. Degradation will result in a change in 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 Northern Adelaide Plains PWA is located immediately to the north of the Adelaide metropolitan area, extending from Salisbury to Two Wells and Gawler (Fig. 1). It is a regional-scale resource for which groundwater has been prescribed under South Australia's *Natural Resources Management Act 2004* since 1976. A Water Allocation Plan provides for sustainable management of the groundwater resource.

Monitoring data has recognised the Kangaroo Flat region of the Northern Adelaide Plains PWA (Fig. 4) as a region requiring specific attention and consequently, it has a separate Status Report.

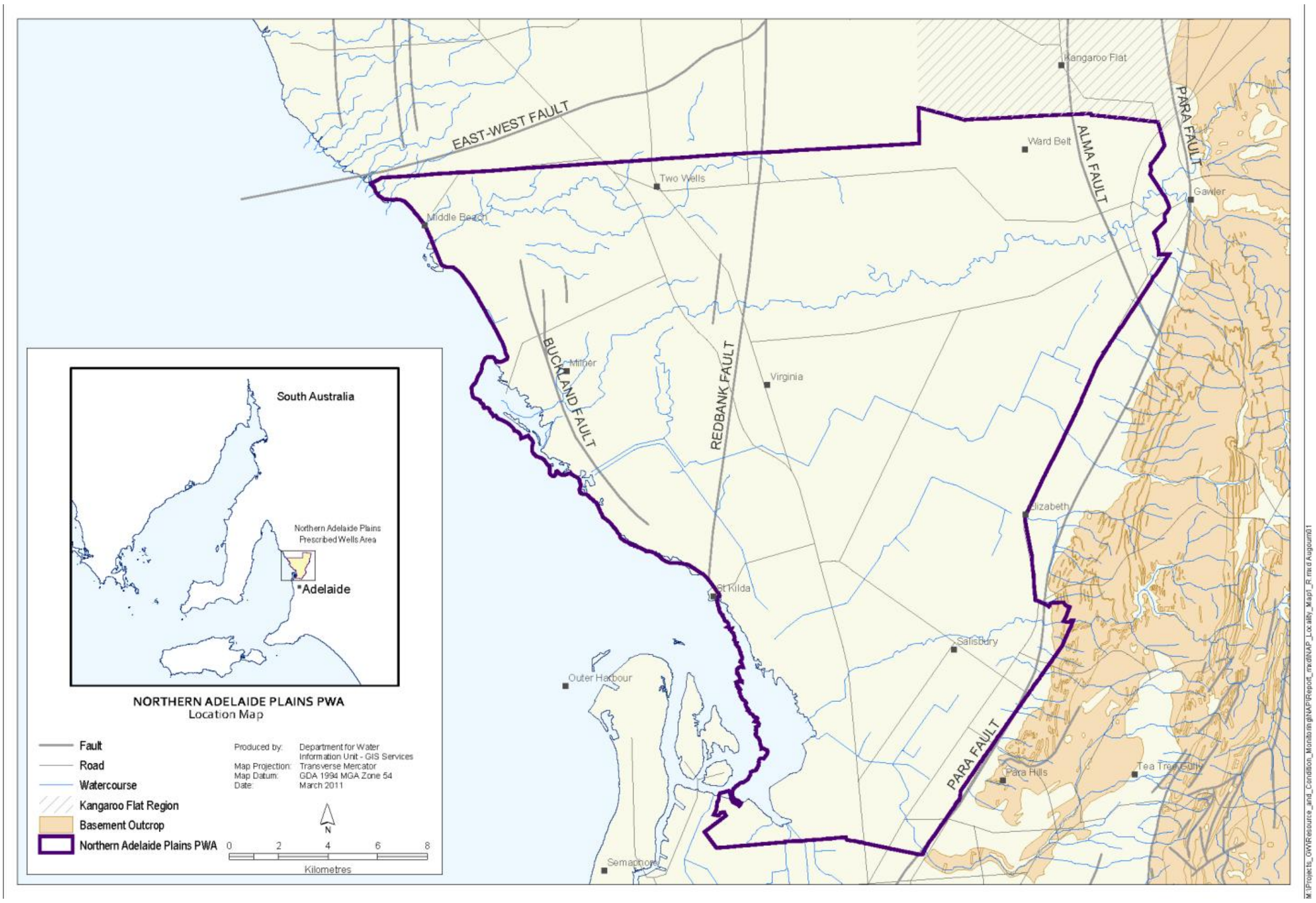

Figure 1. Location of Northern Adelaide Plains PWA

HYDROGEOLOGY

The Northern Adelaide Plains PWA lies just to the north of the Adelaide Metropolitan Area and comprises Quaternary and Tertiary sedimentary aquifers of the St Vincent Basin. There are mainly four Quaternary aquifers (although in some areas, up to six exist), while the Tertiary sediments contain up to four confined aquifers which exhibit large variations in thickness, lithology, salinity distribution and yield. Both the Quaternary and Tertiary Aquifers are categorised in order of increasing depth (Figs. 2 & 3).

Shallow Quaternary Aquifers

The Quaternary sediments (predominantly the Hindmarsh Clay) mainly consist of mottled clay and silt with interbedded sand and gravel layers which form aquifers. The shallowest aquifer is the Perched Aquifer, which is formed when infiltrating surface water is hindered by a low permeability layer. The distribution of this aquifer is not well known. Below this aquifer, there are generally up to three Quaternary Aquifers (Q1–Q3) over most of the PWA.

Q4 Aquifer

The Q4 Aquifer (also called Carisbrooke Sand Aquifer) directly underlies the Hindmarsh Clay and occurs over the whole area, except within 4–5 km of the coast. The aquifer consists of fine to medium-grained sand and silt, and in some areas, it may have direct hydraulic connection with the overlying Quaternary Q3 Aquifer or the underlying T1 Aquifer.

T1 Aquifer

The first Tertiary aquifer is the T1 Aquifer which overlies the Munno Para Clay confining layer and consists of two major sub-aquifers – the Hallett Cove Sandstone/Dry Creek Sand and limestones of the upper Port Willunga Formation. The T1 aquifer is absent in the northeast portion of the Northern Adelaide Plains.

T2 Aquifer

The second Tertiary aquifer comprises the T2 Aquifer which underlies the Munno Para Clay confining layer. It occurs throughout the entire Northern Adelaide Plains and consists of well-cemented limestone of the lower Port Willunga Formation.

T3 Aquifer

The distribution of the T3 Aquifer is not well known because of its depth and poor quality, but it is thought to occur in most of the NAP as a thin sandy layer with an average thickness of 5 m.

T4 Aquifer

The T4 Aquifer consists mainly of South Maslin Sand and occasionally North Maslin Sand which directly overlies the fractured rock aquifer which consists of Adelaidean basement rocks.

A summary of the hydrostratigraphy of the Northern Adelaide Plains PWA is presented in Table 1.

Table 1. Hydrostratigraphy of the Northern Adelaide Plains PWA

AGE		STRATIGRAPHY		HYDROSTRATIGRAPHY		
		Unit	**Lithology**	**Unit**		**Description**
Quaternary	Late to Early Pleistocene	Hindmarsh Clay	Fluviatile and alluvial clays and silts, with interbedded sands and gravels in outwash areas. Occurs over almost whole of PWA.	**Q1 Aquifer** **Q2 Aquifer** **Q3 Aquifer**		Up to three semi-confined aquifers. Relatively saline groundwater, except near streams, and low yields. Domestic and stock use.
	Pliocene/ Pleistocene	Carisbrooke Sand	Fluviatile, alluvial, multicoloured fine sands and silts with some clay and thin gravel beds in outwash areas. Occurs over whole area except within 4–5 km of the coast.	**Q4 Aquifer**		Confined aquifer; not widely developed because of low yields. Possible hydraulic connection with T1 Aquifer in some areas (near Little Para River).
Tertiary	Late Pliocene	Hallett Cove Sandstone – Dry Creek Sand	Limestone, calcareous sandstone and sands of marine deposition. Usually abundantly fossiliferous. Occurrence generally restricted to an area south of Two Wells.	**T1 Aquifer**	**T1a**	Confined aquifer; developed for irrigation stock and domestic purposes.
	Middle Miocene	Port Willunga Formation (upper part)	Fossiliferous sandy limestone, fine grained, occurring south of Two Wells.		**T1b**	Confined aquifer; developed mainly for irrigation. Salinity ranges between 500–3000 mg/L.
		Munno Para Clay	Blue-grey, sandy, shelly clay, missing in some coastal areas and north of Two Wells.	**Aquitard**		Confining bed for the T2 Aquifer.
	Early Miocene to Late Eocene	Port Willunga Formation (lower part)	Fossiliferous limestone with sands and sandstones, grading to a dense siliceous unit towards the base. Between Alma and Para faults, marginal marine white quartz sand and gravel in places with ferruginous matrix considered equivalents of Port Willunga Formation.	**T2 Aquifer**		Confined aquifer, salinity ranges between 500–2000 mg/L in the Gawler River area to >3000 mg/L to the north and south. Developed mainly for irrigation.
	Late Eocene	Chinaman Gully Formation	Dark-brown to black lignitic silt and clays, with sandy layers.	**Aquitard** **T3 Aquifer**		Lignitic clays Chinaman Gully Sands
		Blanche Point Formation	Marls, siltstone, limestone, fossiliferous and glauconitic.	**Aquitard**		Generally confining bed, but may be a low-grade aquifer in some areas.
	Middle Eocene	South Maslin Sand	Marginal marine sands, glauconitic and poorly fossiliferous.	**T4 Aquifer**		Confined aquifer, highly saline.
	Middle Eocene	Clinton Formation	Grey to blue clay, carbonaceous and silty.	**Aquitard**		Confining bed where present.
		North Maslin Sand	Pebbly quartz-sand, slightly clayey, pyritic, carbonaceous; fluviatile and estuarine deposition. Contains thin impure lignite in places.	**T4 Aquifer**		Confined aquifer, highly saline.
Proterozoic		Undifferentiated Adelaidean	Slates, quartzite, dolomites, tillites, shales and limestone.	**Fractured Rock Aquifer**		

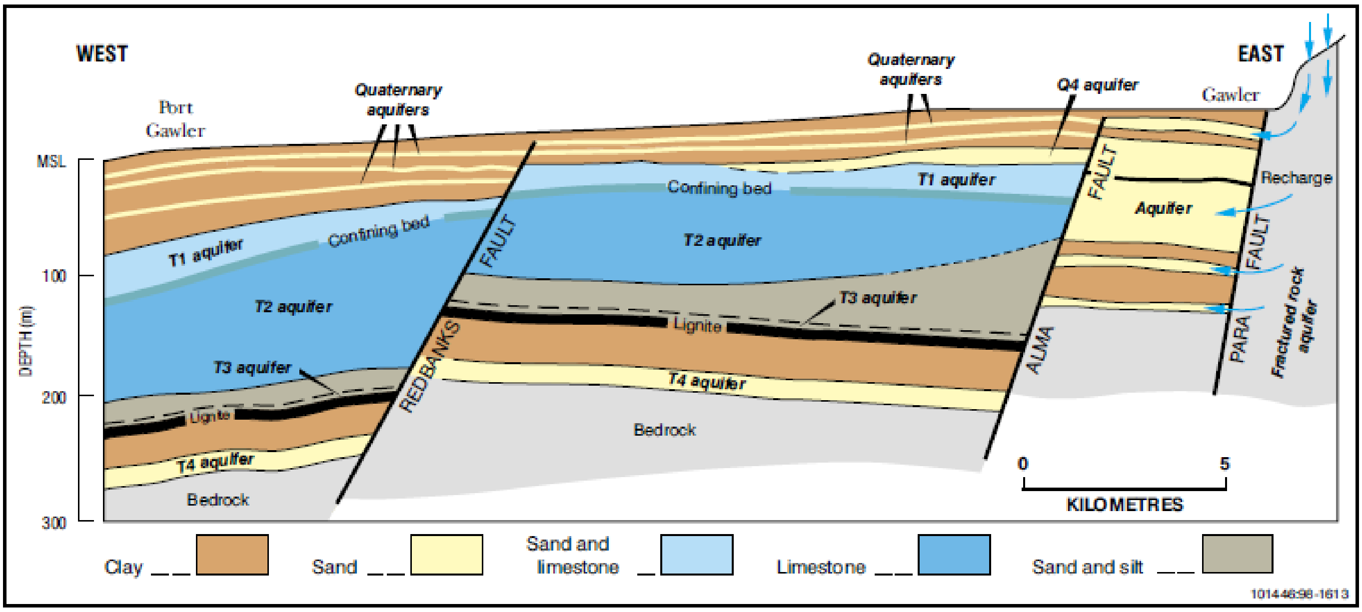

Figure 2. East-west hydrogeological cross-section along the Gawler River in the NAP PWA

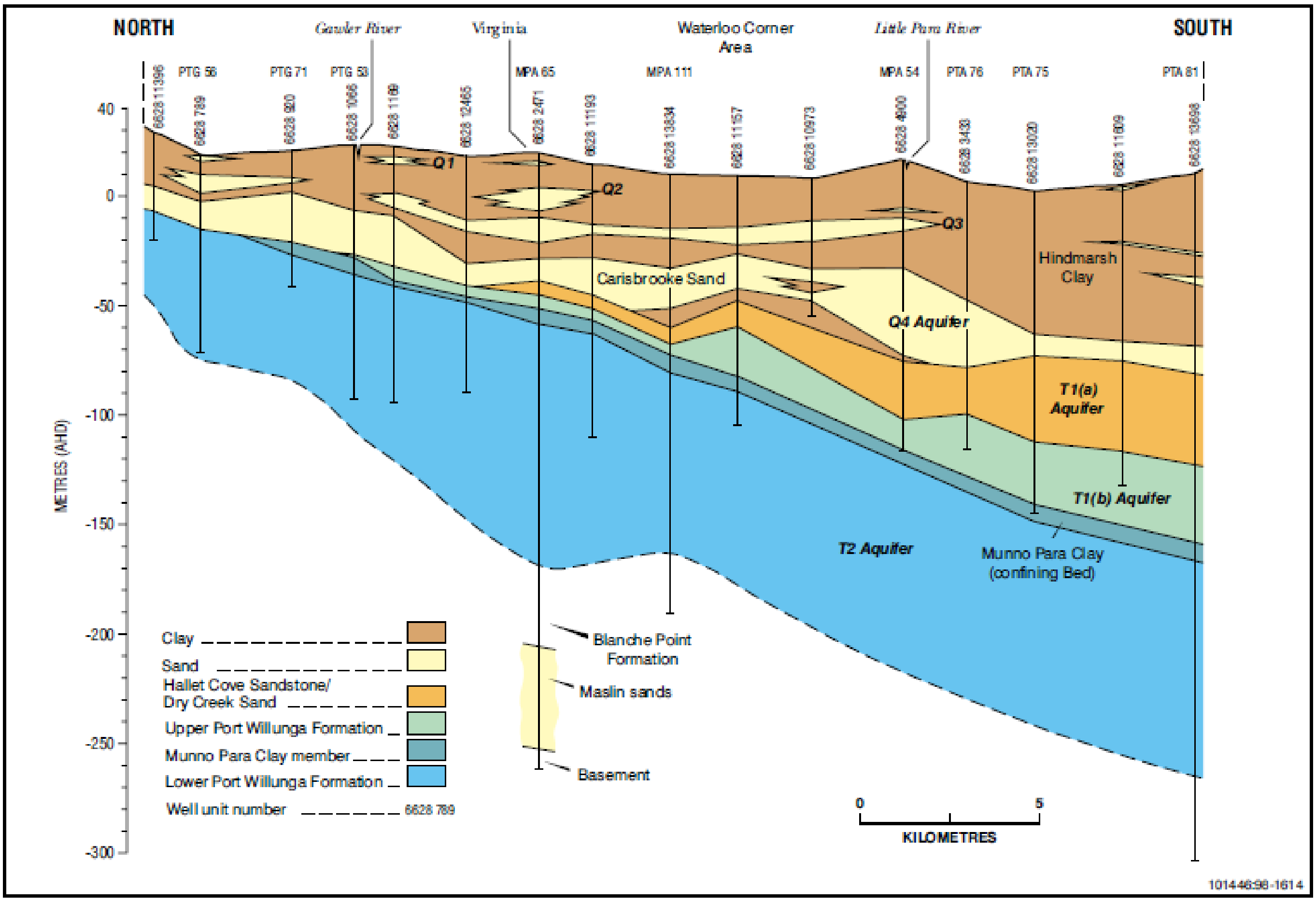

Figure 3. North-south hydrogeological cross-section through the NAP PWA

For further information on the hydrogeology of the Northern Adelaide Plains, see: http://www.waterforgood.sa.gov.au/wp-content/uploads/2010/06/Technical%20Reports/ki_report_2006_10_part1.pdf

To view the previous monitoring status report prepared in 2002, see: http://www.waterforgood.sa.gov.au/wp-content/uploads/2010/06/Technical%20Reports/nap_groundwater_2002_14.pdf

GROUNDWATER FLOW AND SALINITY

The groundwater flow directions and salinity distribution for the various Quaternary and Tertiary aquifers are discussed below.

Quaternary Aquifers

The groundwater flow direction in all Quaternary aquifers is generally westward from the Mount Lofty Ranges toward Gulf St Vincent (Fig. 4).

Groundwater salinities vary from 2000 to 13 000 mg/L within the Q1 and Q2 aquifers, 1500 to 3000 mg/L within the Q3 aquifer, and 400 to 1500 mg/L within the Q4 aquifer (Fig. 4). Groundwater salinity contours could not be produced for the Quaternary as a whole due to the presence of confining layers and the discontinuous nature of the shallow Quaternary aquifers.

These groundwater levels and salinities are not expected change significantly over time.

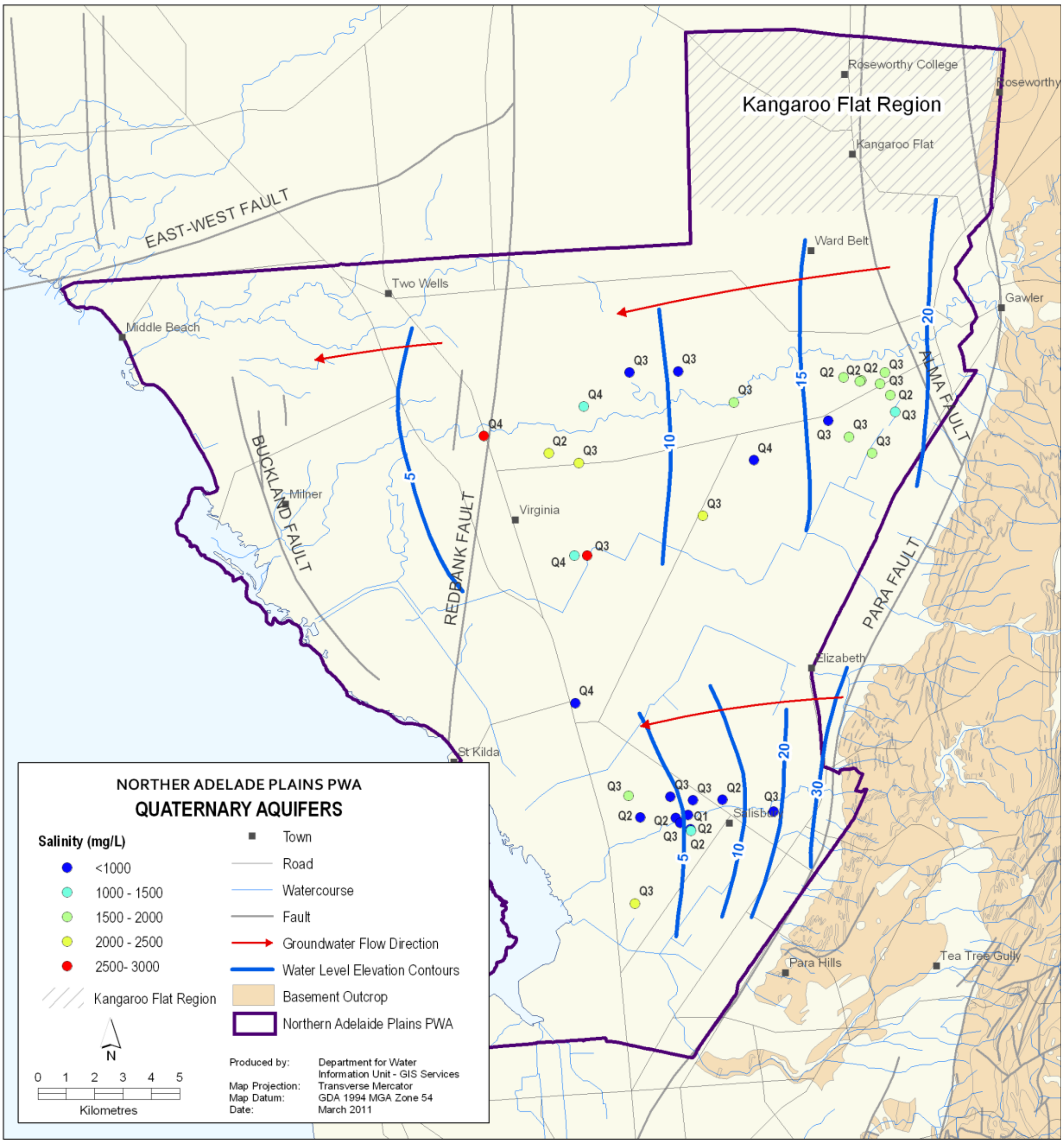

Figure 4. Groundwater flow direction and salinity distribution for the Quaternary aquifers in the NAP PWA (March 2010)

T1 Aquifer

The T1 Aquifer is the main source of irrigation extraction in the area south of Waterloo Corner. Groundwater salinity within the T1 aquifer is relatively fresh ranging from below 1000mg/L to 3000mg/L (Fig. 5). The salinity distribution appears to have little correlation with the groundwater level elevation contours, but higher salinity is evident in the Waterloo Corner and Angle Vale regions where groundwater is used for irrigation purposes.

The groundwater level contours show the pressure level surface for March 2010 and indicate that groundwater flow is from the Mount Lofty Ranges westward toward the coast (Fig. 5). A small cone of depression formed during the irrigation season can be seen in the Waterloo Corner area. A larger long-standing cone of depression is evident near the coast in the south-western corner of the PWA where significant industrial extraction occurs. The pressure level surface of the T1 aquifer has changed very little over the past 7 years, indicating the establishment of a new equilibrium.

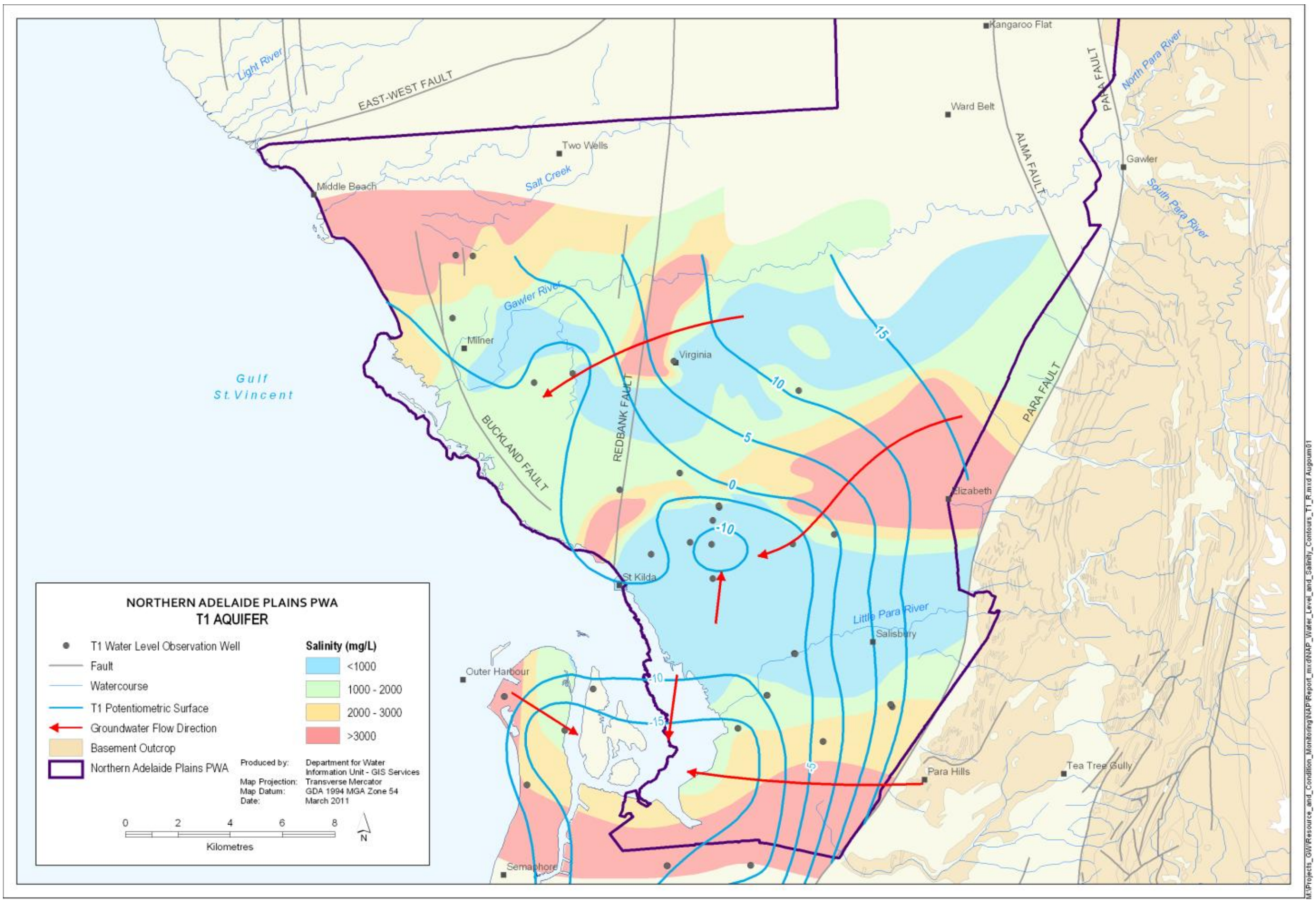

Figure 5. Groundwater-flow direction (March 2010) and salinity distribution for the T1 aquifer in the NAP PWA

WATER FOR GOOD

T2 Aquifer

Groundwater salinity levels in the T2 Aquifer increase from 600 mg/L in the Gawler River area, to over 3000 mg/L in both the north and south directions, reaching up to 5000 mg/L in the Two Wells area (Fig. 6).

The pressure surface indicates that groundwater within the T2 aquifer generally flows from the Mount Lofty Ranges westward to St Vincent Gulf (Fig. 6). However there are two cones of depression evident, a large cone located in the Virginia irrigation area and a smaller cone located at Osborne where large volumes of groundwater are extracted for industrial purposes.

The potentiometric surface of the T2 aquifer has changed very little over the recent years indicating the establishment of a new equilibrium.

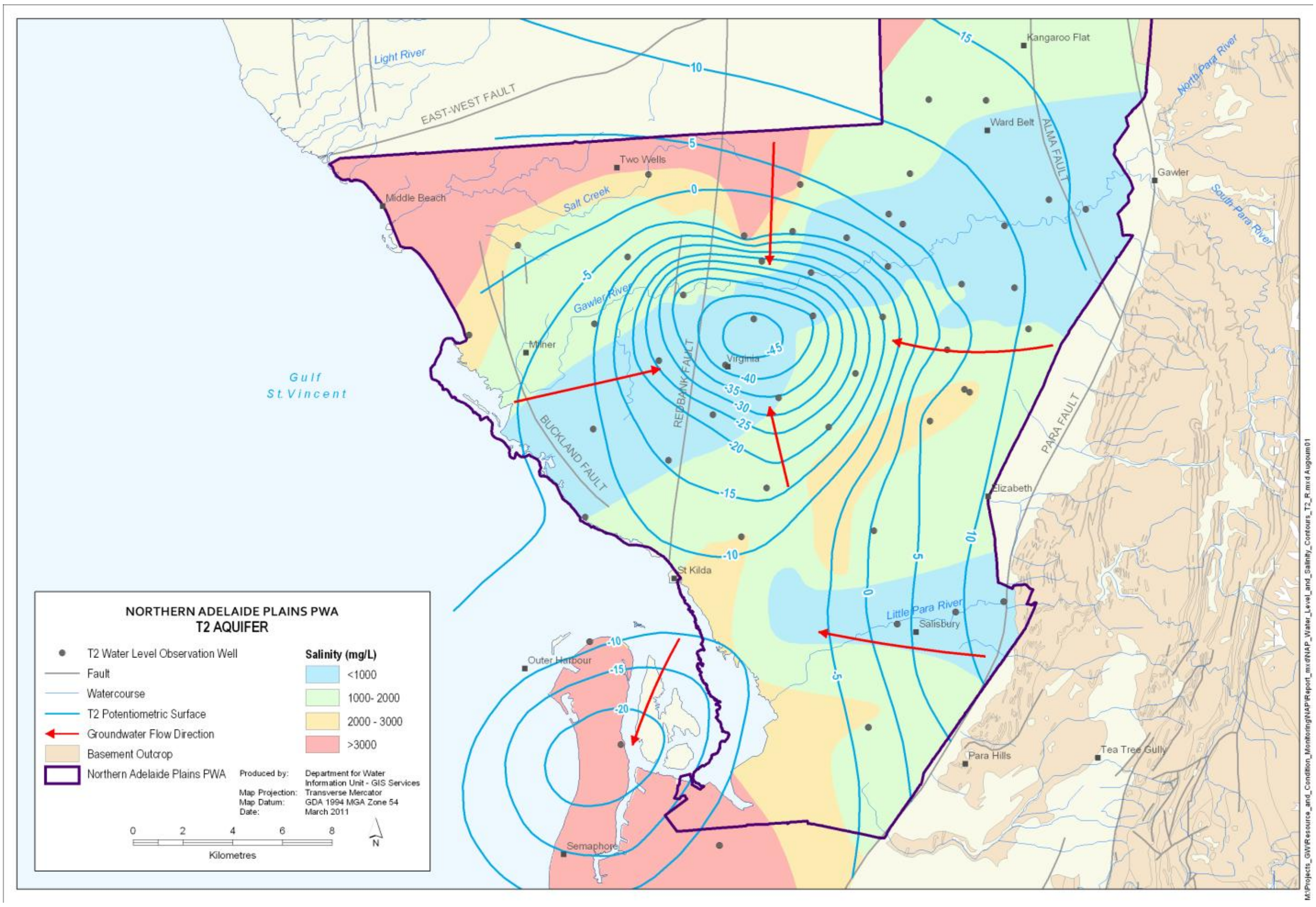

Figure 6. Groundwater flow direction and salinity distribution for the T2 aquifer in the NAP PWA (March 2010)

T3 and T4 Aquifers

The distribution of groundwater salinity within the two deep T3 and T4 Aquifers is not well known for most of the NAP area. Limited information available indicates that these aquifers contain groundwater of very high salinities of up to 80 000 mg/L, with groundwater flow thought to be from the Mount Lofty Ranges toward the coast.

GROUNDWATER DEPENDENT ECOSYSTEMS

Whilst groundwater dependent ecosystems (GDEs) have not been used in the assessment of the status of the groundwater resource, it is important to note the presence and ecological characteristics of the GDEs found in the Northern Adelaide Plains 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, either permanently, seasonally or intermittently. It is generally considered that shallow watertables, i.e. those 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 cracks and pools below the ground) which can be found at greater depths.

The Gawler and Little Para Rivers that flow through the Northern Adelaide Plains PWA appear to be losing watercourses, meaning surface flows recharge the groundwater system. However, mapping has indicated the presence of a number of persistent pools which may indicate isolated areas where the streambed intersects the Quaternary aquifer. Native diadromous (inland/marine) fish species are known to exist within the Gawler River catchment. These pools are likely to act as important ecological 'stepping stones' for migration to and from the lower reaches of the catchment.

Plants with a dependence on groundwater (Quaternary aquifer) have been mapped in the riparian zone and floodplains of both the Gawler and Little Para Rivers in the PWA, River Redgum (*Eucalyptus camaldulensis*) being the most notable species, but also consisting of other instream vegetation including Sedges (*Cyperus spp*), Rushes (*Juncus spp*), Common Reed (*Phragmites australis*) and Bulrush (*Typha domingensis*).

Other possible GDEs in the Northern Adelaide Plains PWA include stygofauna.

RAINFALL

Rainfall is a very important part of the groundwater balance because it is a source of replenishment or recharge to aquifers. This recharge is critical to the sustainability of mostly the unconfined aquifers, with the timing and magnitude of the recharge having a strong control over groundwater level trends, and in some cases, groundwater salinities.

Although there is no direct rainfall recharge to deep confined aquifers, there may be an indirect correlation between water levels and rainfall, because dry years 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.

The Northern Adelaide Plains PWA experiences a Mediterranean climate which is characterised by hot, dry summers and cool to cold winters. Two Bureau of Meteorology rainfall stations located in the Northern Adelaide Plains PWA, Two Wells (station 23028) and Bolivar (station 23081), were selected as representative of the rainfall pattern throughout the area (Fig. 11). Rainfall is winter dominant with annual average rainfalls of 399 and 424 mm, respectively.

The cumulative deviation from mean monthly rainfall identifies periods where rainfall trends are above or below average. An upward slope indicates a period where the rainfall is greater than the average, while a downward slope indicates a period where the rainfall is below the average.

The Two Wells and Bolivar stations show similar trends such as above-average rainfall during the 1973–75, 1978–80 and 1992–93 periods, and more importantly, significantly below-average rainfall since 2006 (Figs. 7 & 8).

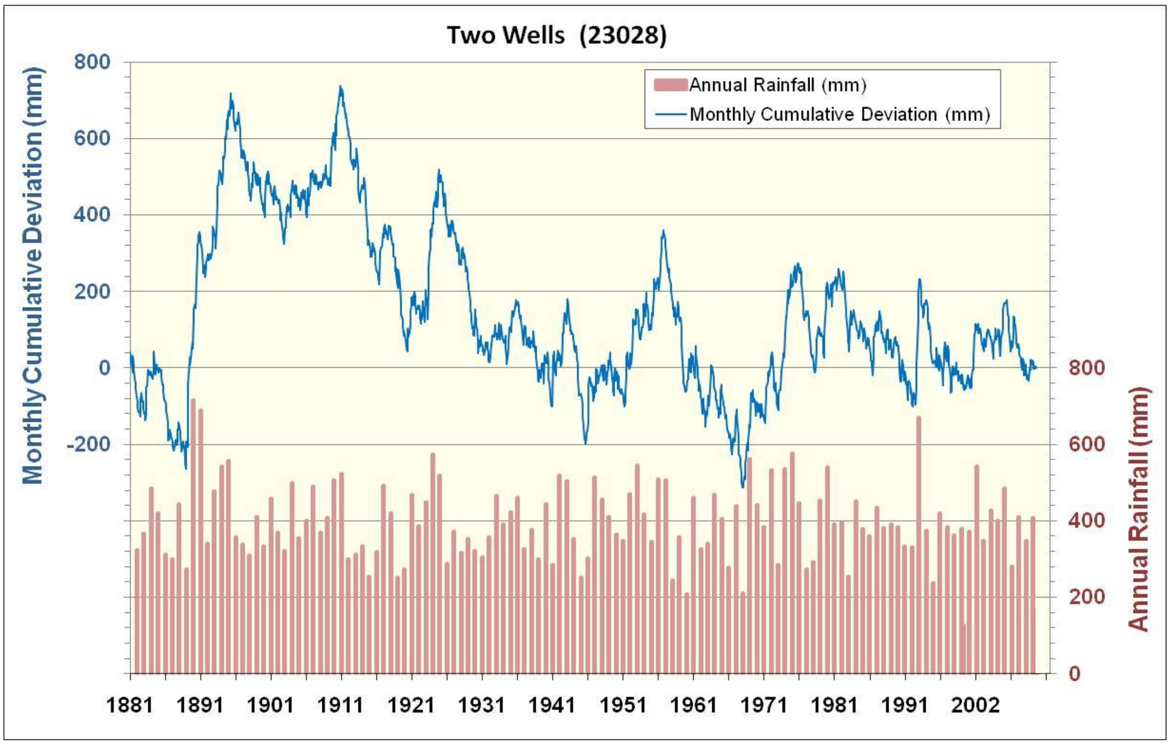

Figure 7. Annual rainfall and cumulative deviation for mean monthly rainfall for Two Wells

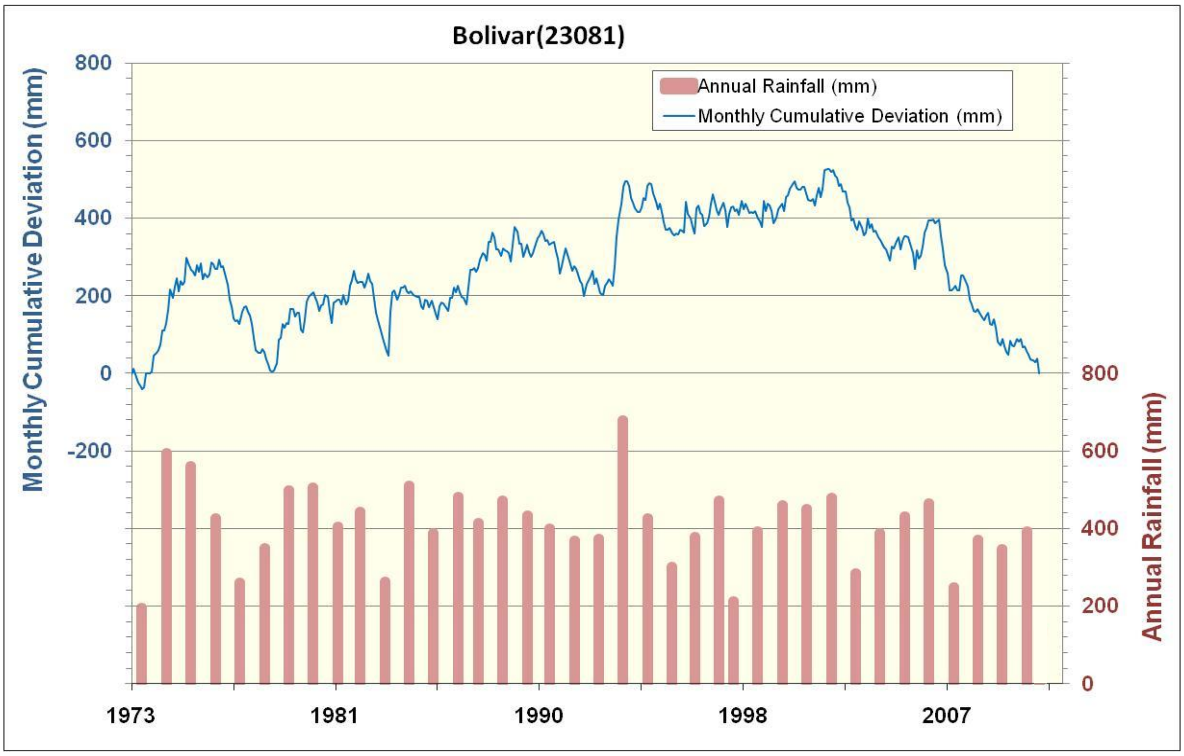

Figure 8. Annual rainfall and cumulative deviation for mean monthly rainfall for Bolivar

GROUNDWATER USE

Licensed groundwater extractions in the Northern Adelaide Plains PWA for 2009–10 totalled 14 713 ML, well below the current allocation of 26 500 ML. Extraction within the PWA has been generally stable for the past four irrigation seasons, with the exception of 2005–06 which was significantly lower due to above average rainfall (Fig. 9).

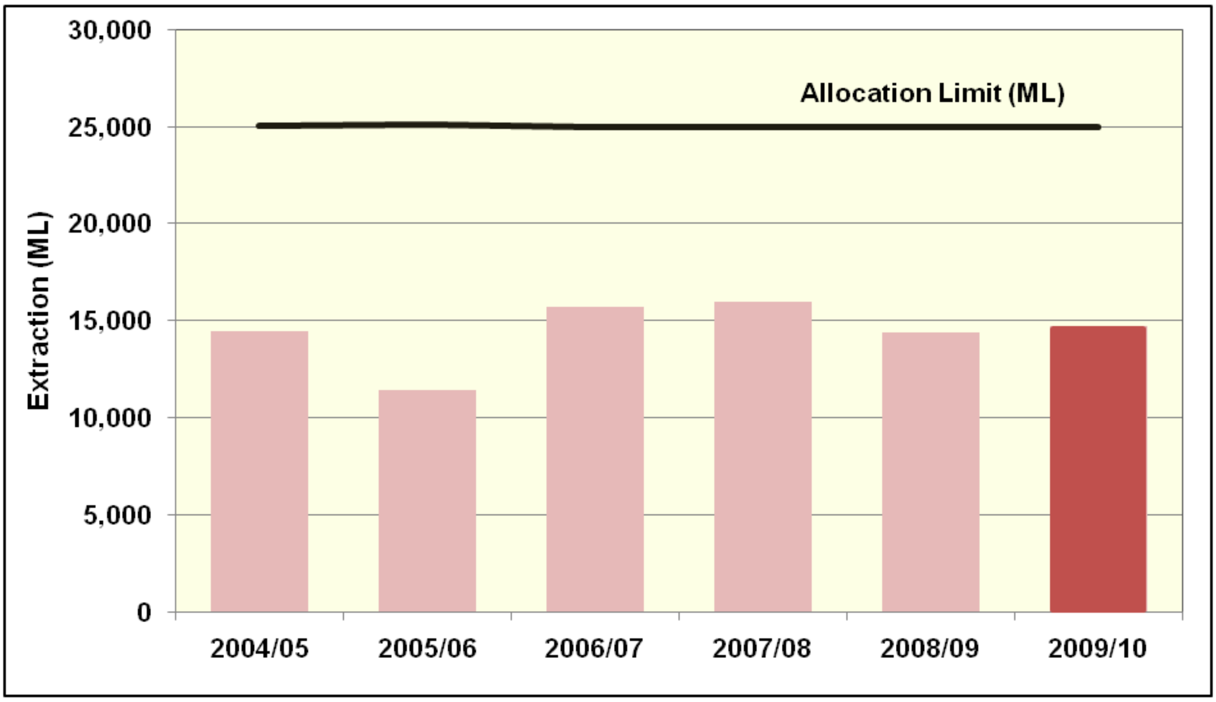

Figure 9. Historical licensed groundwater extraction in the NAP PWA

Figure 10 displays the 2009–10 percentage of extraction from each of the aquifers present in the Northern Adelaide Plains PWA. Groundwater extractions primarily occur from the T2 aquifer (72.5%), with the T1 aquifer being used to a lesser extent (24.7%) with all remaining extraction from the Quaternary aquifers.

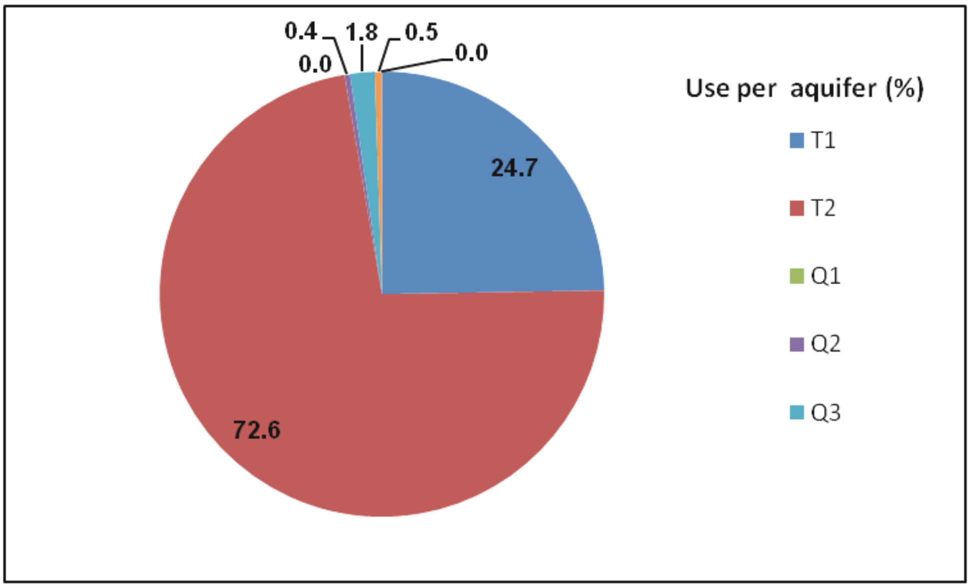

Figure 10. Groundwater extraction by aquifer type in the NAP PWA for the 2009–10 season

GROUNDWATER OBSERVATION NETWORKS

WATER LEVEL NETWORK

The groundwater level observation network for the Northern Adelaide Plains PWA consists of 153 observation wells monitored at quarterly intervals (Fig. 11). Sixty-one wells are within Quaternary aquifers and 82 are within Tertiary aquifers (Table 2).

Table 2. Groundwater level observation network

Aquifer		Number of wells
Quaternary	Perched	14
	Q1 aquifer	16
	Q2 aquifer	1
	Q3 aquifer	15
	Q4 aquifer	10
	Q3 and Q4 aquifer	5
Tertiary	T1 aquifer	32
	T2 aquifer	49
	T4 aquifer	1

SALINITY NETWORK

The groundwater salinity observation network for the Northern Adelaide Plains PWA consists of 40 observation wells monitored on an approximately annual basis (Fig. 12; Table 3). In addition to the Northern Adelaide Plains salinity observation network there is a licensed irrigator network which collects groundwater salinity samples annually from irrigation wells.

Table 3. Groundwater salinity observation network

Aquifer		Number of wells
Quaternary	Perched	4
	Q1 aquifer	10
	Q4 aquifer	1
Tertiary	T1 aquifer	8
	T2 aquifer	17

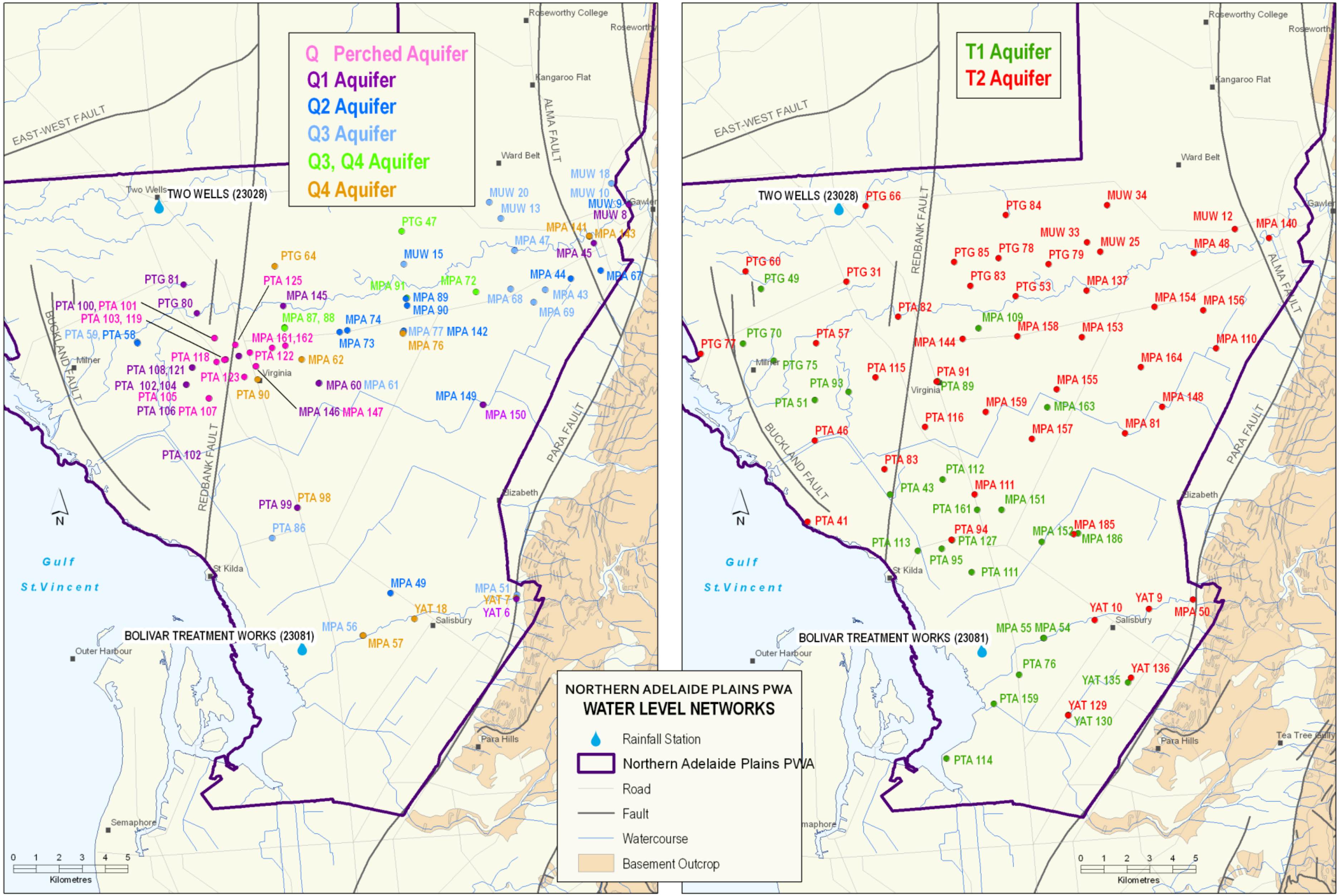

Figure 11. Location of groundwater level observation wells in the Northern Adelaide Plains PWA

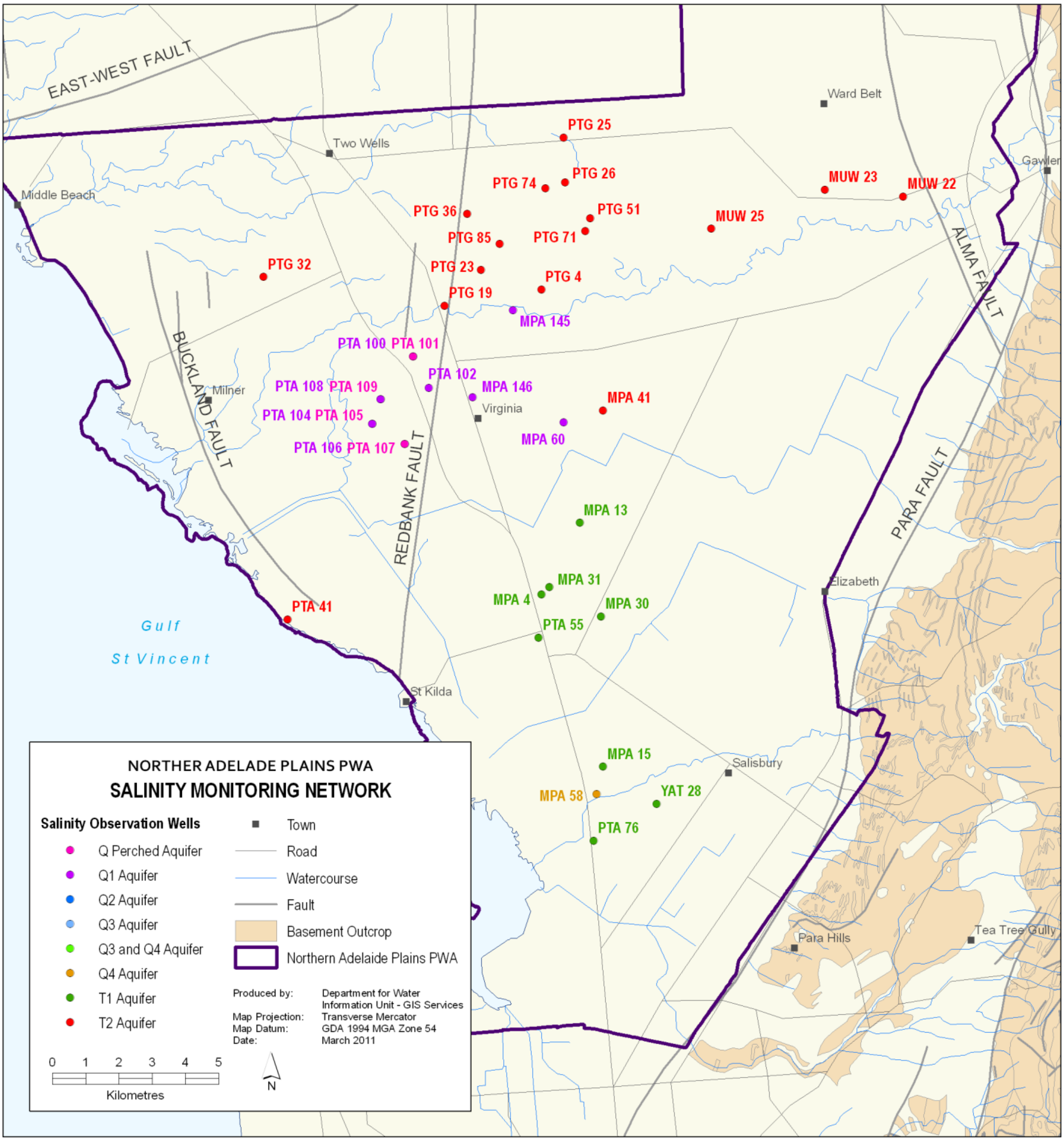

Figure 12. Location of groundwater salinity observation wells in the Northern Adelaide Plains PWA

QUATERNARY AQUIFERS

Long-term trends for representative observation wells in the various Quaternary aquifers generally indicate declining groundwater levels since 1981, which broadly corresponds to the periods of below-average rainfall recorded at Two Wells, as shown by the cumulative deviation from mean monthly rainfall (Fig. 13). Although there is some response to the wetter years of 1974, 1981, 1992 and 2005, an overall decline of 5–7 m has been observed over the past 30 years.

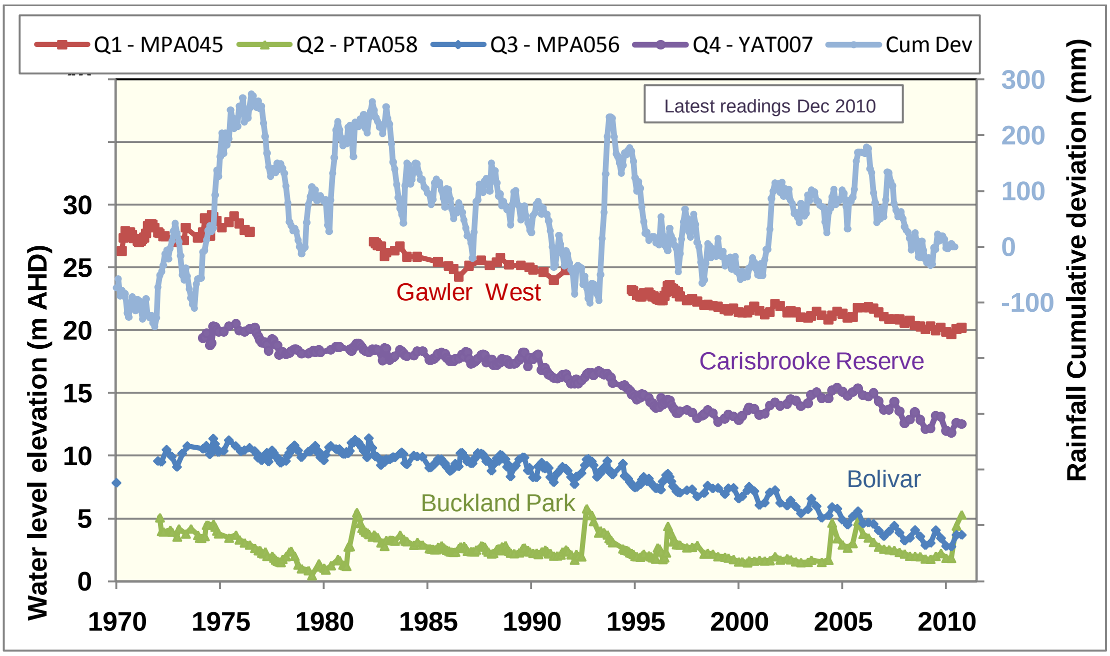

Figure 13. Groundwater level trends for the Quaternary Aquifers in the NAP PWA

The shallow perched aquifer is monitored because it presents a risk of waterlogging and land salinisation. Although a variety of trends were observed in the past, the groundwater levels have been fairly stable over the past 2–3 years (Fig. 14). The observed seasonal variations in groundwater levels indicate the highest levels responding to winter rainfall. If irrigation drainage was a significant influence, the highest levels would have occurred in summer.

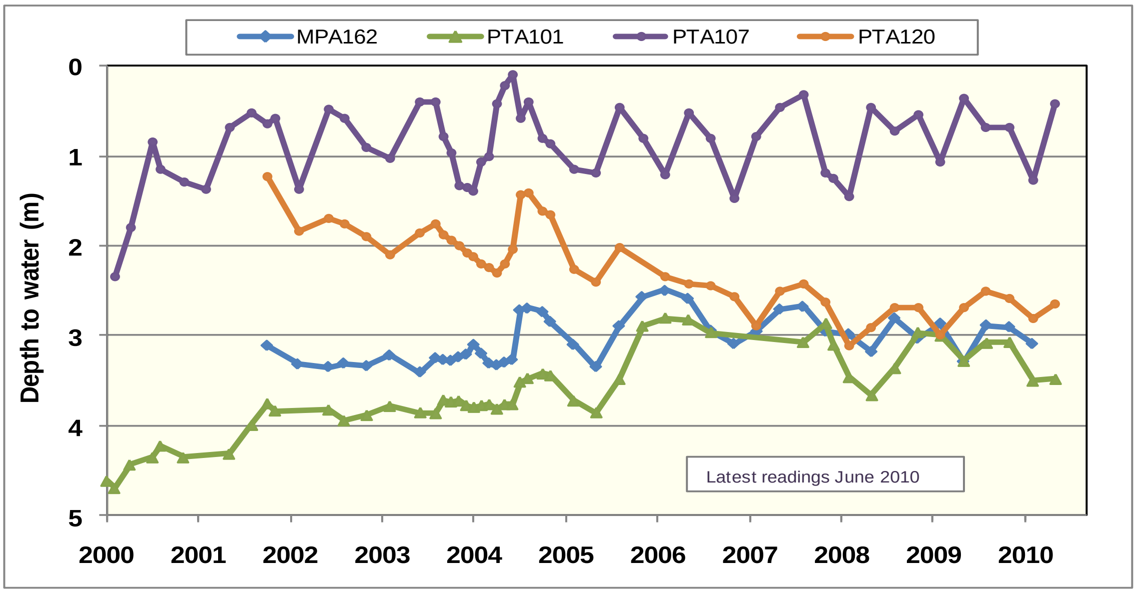

Figure 14. Groundwater level trends for the Perched Quaternary Aquifer in the NAP PWA

T1 AQUIFER

Hydrographs indicate that the area south of Waterloo Corner experiences seasonal fluctuations which are generally between 5 and 10 m due to high extractions during the summer period (MPA065; Fig 15). Following a general recovery in groundwater levels between 1993 and 2004, a decline in the level of maximum drawdown has been observed since 2006, probably as a result of increased extraction due to low rainfall. In the northern portion of the PWA where the T2 aquifer is the main source for groundwater extraction, the trend appears to have stabilised since 2005 (PTA089). However, to the south, the declining trend appears to be continuing (MPA055), possibly due to the influence of extractions to the south-west in the neighbouring Central Adelaide PWA.

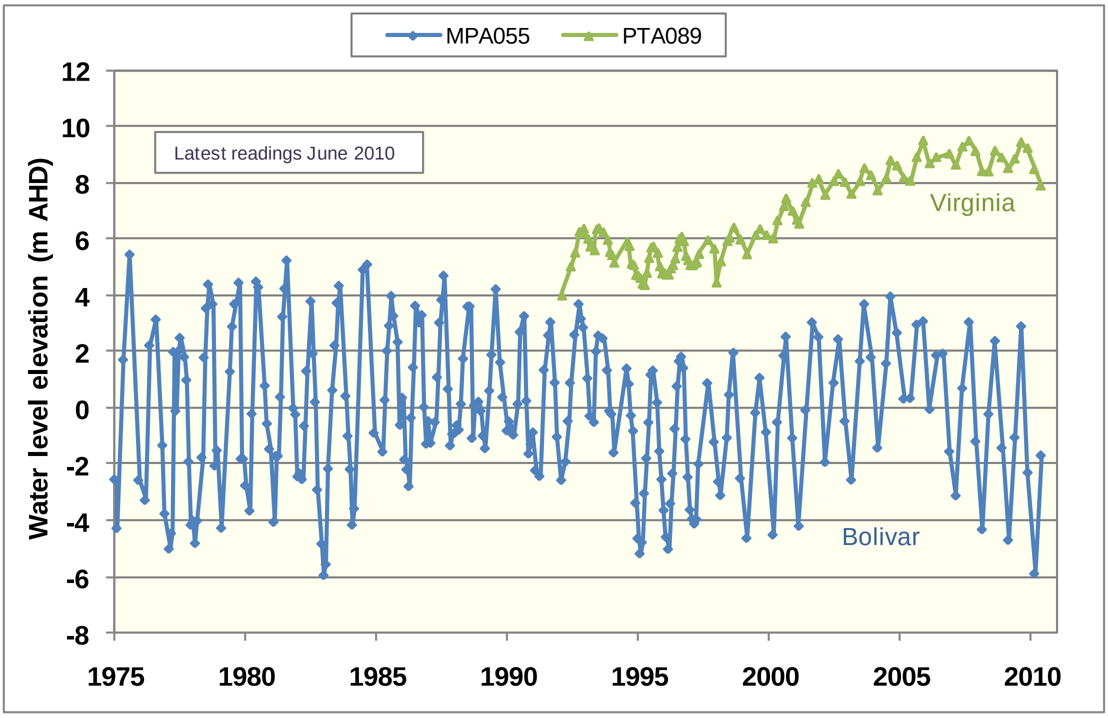

Figure 15. Groundwater level trends for the T1 Aquifer in the NAP PWA

T2 AQUIFER

The long-term groundwater level trends are essentially stable, with no significant changes in the extent of the main cone of depression centred near Virginia (Fig. 16). The T2 aquifer hydrographs indicate seasonal fluctuations due to extractions during the summer period, which are generally between 5 and 10 m but range up 30 m near the centre of the cone (MPA109). There has been a slight decline in groundwater levels since the 2006 drought which has been caused by an increase in extraction at that time (Fig. 9), although levels are still higher than the lowest level recorded in the late 1990s. The groundwater levels have almost stabilised in 2009–10 due to the reduction in extractions in recent years (in response to higher rainfall).

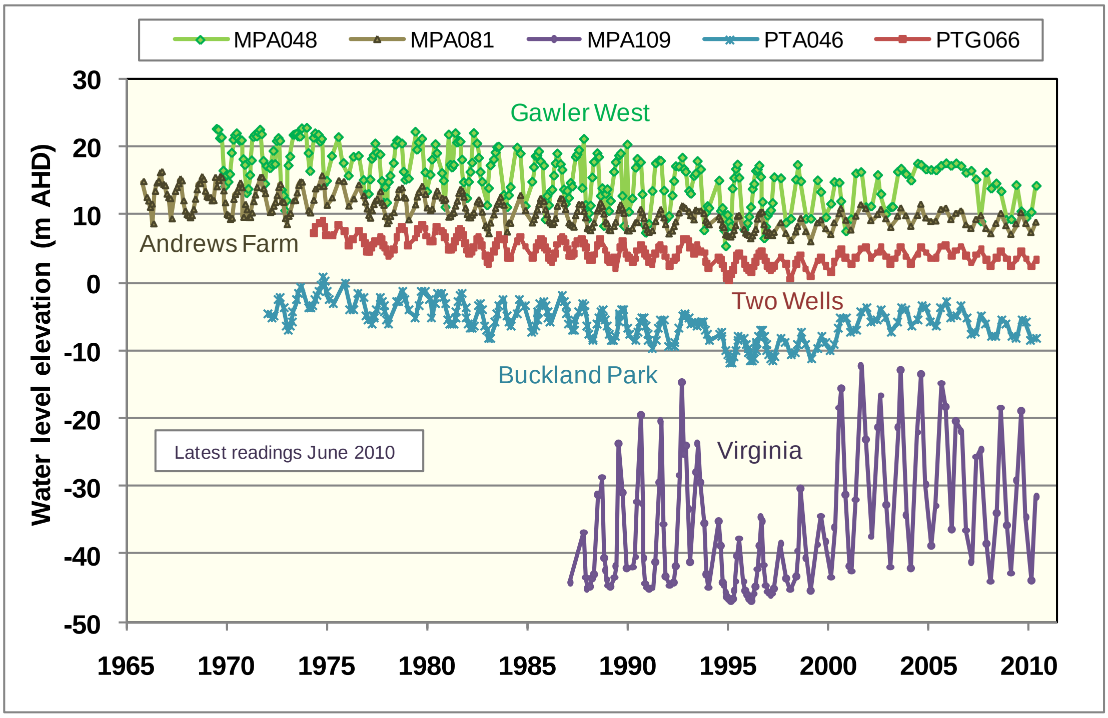

Figure 16. Groundwater level trends for the T2 Aquifer in the NAP PWA

GROUNDWATER SALINITY TRENDS

QUATERNARY AQUIFERS

In the Virginia area, groundwater salinity trends within the Q1 aquifer show a range of salinities and quite variable trends, which appear to have been stabilising since 2005 (Fig. 17).

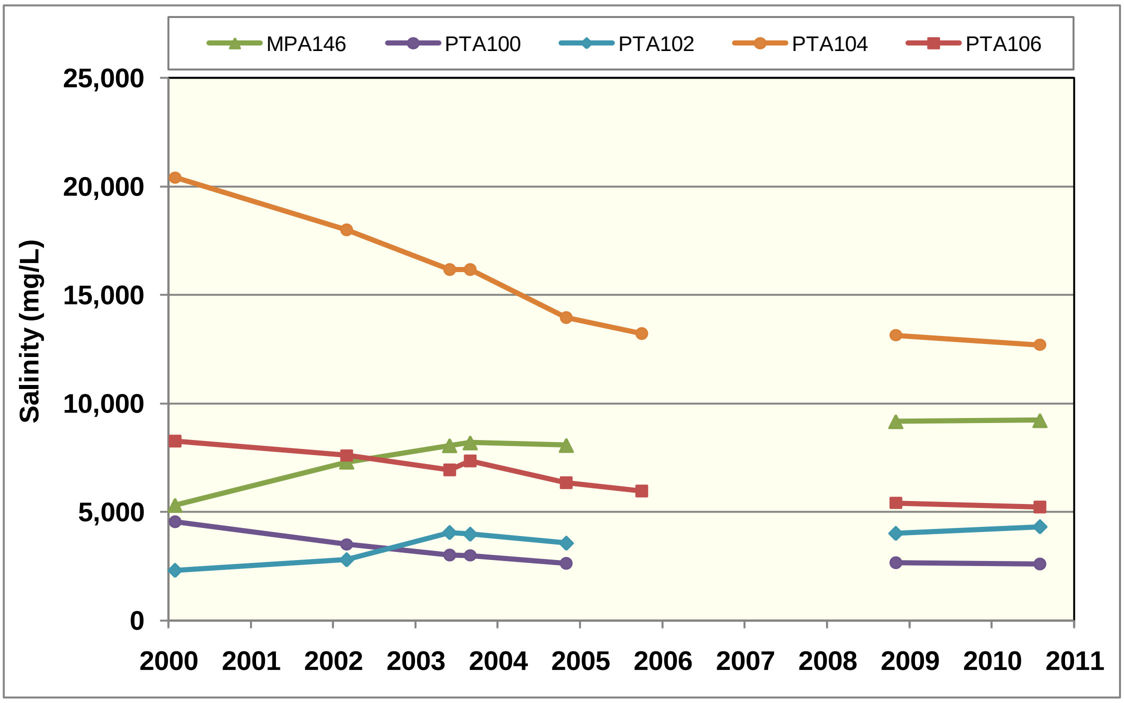

Figure 17. Groundwater salinity trends for the Q1 Aquifer in the NAP PWA

T1 AQUIFER

The groundwater salinity trends for the T1 aquifer are in general relatively stable (Fig. 18). However salinity rises are evident in observation wells MPA013 and MPA004 which are located near the boundary of the zone of low salinity groundwater in the T1 aquifer. While the trend in observation well MPA013 appears to be stabilising, the salinity in MAP004 is continuing to rise at 15 mg/L/yr, which could be the result of lateral inflows of more saline groundwater from the north-east toward the cone of depression centred on Waterloo Corner. Care should be taken to ensure that the recorded groundwater salinities are representative of the monitored aquifer and not affected by contamination by shallow, more saline groundwater through corroded well casings.

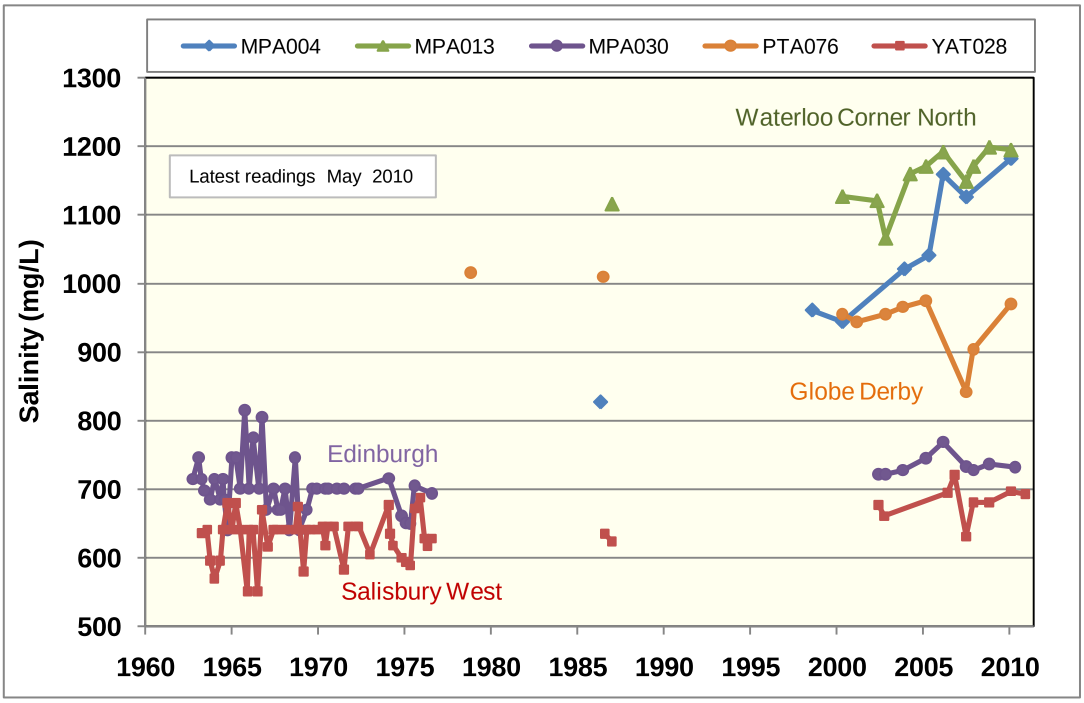

Figure 18. Groundwater salinity trends for the T1 Aquifer in the NAP PWA

T2 AQUIFER

In general, salinity within the T2 Aquifer has increased at rates varying up to 12 mg/L/yr over the last 40 years (Fig. 19), with the higher rates of increase found to the north of Virginia (observation well PTG036) where the regional salinity increases rapidly in a northerly direction (Fig. 6). The lateral inflow of more-saline groundwater from the north toward the cone of depression centred on Virginia is the probable cause of these increases, assuming that no contamination due to corroded well casings is occurring. Observation well PTA041 is located on the coast but shows no evidence of any groundwater salinity increases that could be caused by sea water intrusion.

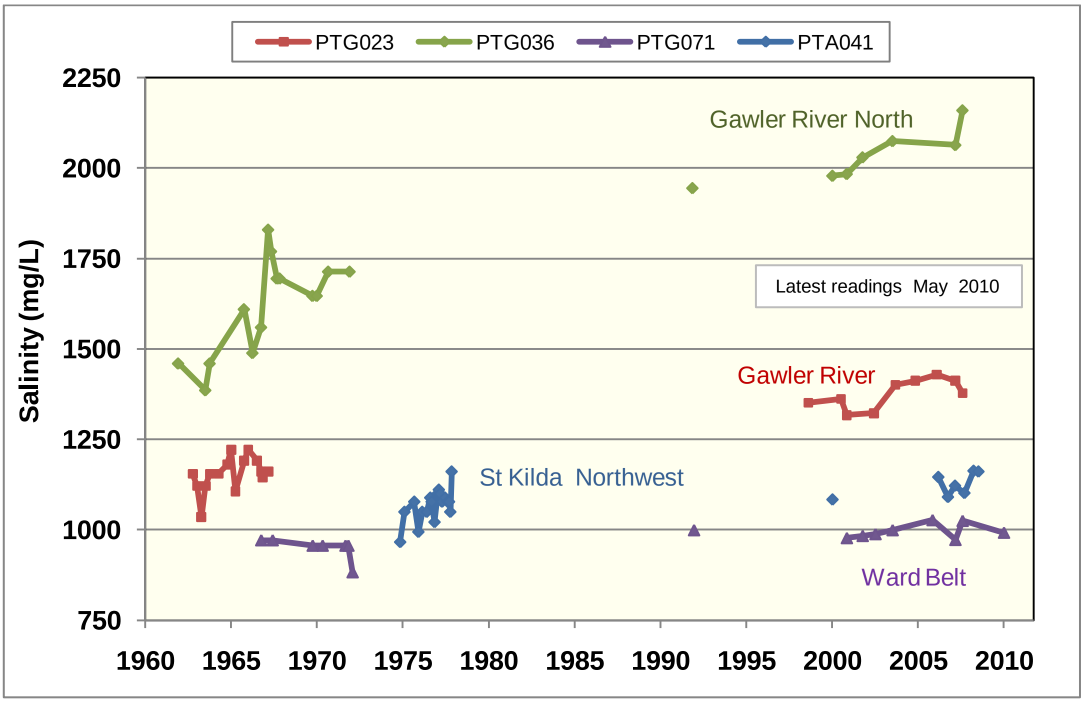

Figure 19. Groundwater salinity trends for the T2 Aquifer in the NAP PWA

Observation wells with a shorter, more recent period of record show reasonably stable trends, with observation well PTG004 showing an increasing trend that may be due to a corroded well casing (Fig. 20).

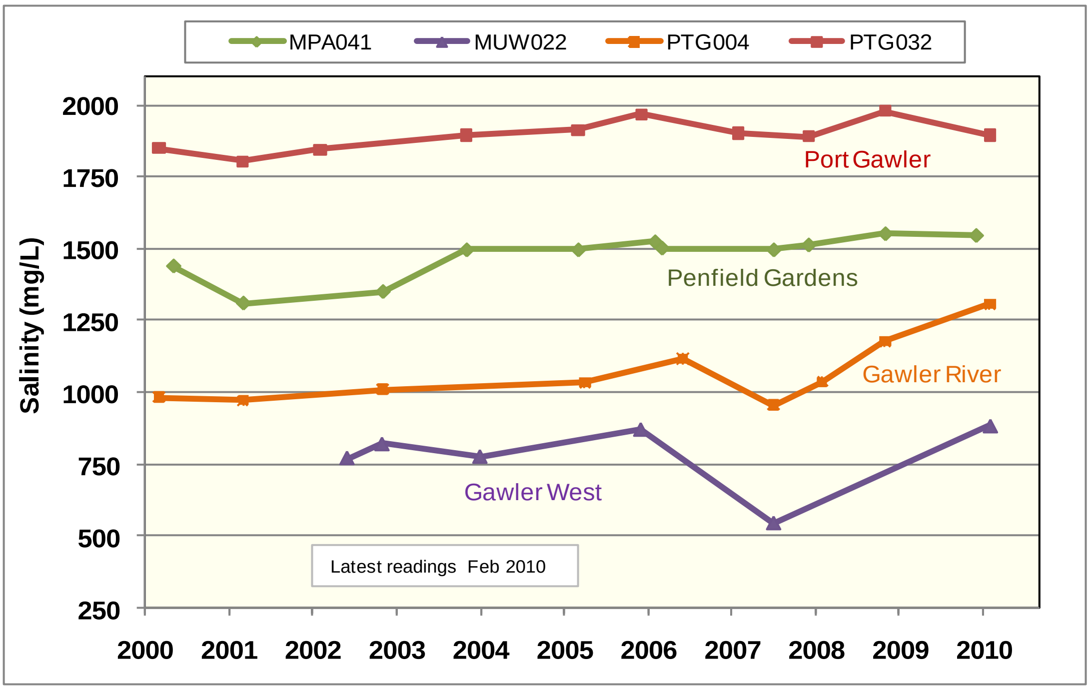

Figure 20. Recent groundwater salinity trends for the T2 Aquifer in the NAP PWA