The Department of Water, Land and Biodiversity Conservation



Northern Adelaide Plains Prescribed Wells Area Groundwater Monitoring Status Report 2003

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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 organisims 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 Division
Department of Water, Land and Biodiversity Conservation

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SI UNITS COMMONLY USED WITHIN TEXT

Name of unit	Symbol	Definition in terms of other metric units	
Millimetre	mm	10^{-3} m	length
Metre	m		length
Kilometre	km	10^{3} m	length
Hectare	ha	10^{4} m^2	area
Microlitre	µL	10^{-9} m^3	volume
Millilitre	mL	10^{-6} m^3	volume
Litre	L	10^{-3} m^3	volume
Kilolitre	kL	1 m^3	volume
Megalitre	ML	10^{3} m^3	volume
Gigalitres	GL	10^{6} m^3	volume
Microgram	µg	10^{-6} g	mass
Milligram	mg	10^{-3} g	mass
Gram	g		mass
Kilogram	kg	10^{3} g	Mass

Abbreviations Commonly Used Within Text

Abbreviation		Name	Units of measure
TDS	=	Total Dissolved Solids *(milligrams per litre)*	mg/L
EC	=	Electrical Conductivity *(micro Siemens per centimetre)*	µS/cm
PH	=	Acidity	
δD	=	Hydrogen isotope composition	$^{o}/_{oo}$
CFC	=	Chlorofluorocarbon *(parts per trillion volume)*	pptv
$\delta^{18}O$	=	Oxygen isotope composition	$^{o}/_{oo}$
^{14}C	=	Carbon-14 isotope *(percent modern Carbon)*	pmC
Ppm	=	Parts per million	
Ppb	=	Parts per billion	

1 INTRODUCTION

The Northern Adelaide Plains (NAP) Prescribed Wells Area (PWA) covers an area of approximately 800 km^2 centred 30 km north of Adelaide (Fig. 1). The area was proclaimed in 1976 in response to the intensive pumping during the 1960s, which formed the cones of depression in the main Tertiary aquifers. The region is comprised of fertile soils that overlie a series of sand, gravel and limestone aquifers inter-bedded with clay layers. These aquifers are the main source of water for irrigation in an area that is reliant on industry and horticultural crops.

The Tertiary and Quaternary sediments that constitute the area's aquifers are up to 600 m thick. The main source of recharge to the system is from the Mt Lofty Ranges, which lie to the east of the NAP PWA. Rainfall events in the ranges recharge the fractured rock system and in turn, the water filters down gradient towards the coast, recharging the aquifer system beneath the plains.

Two major problems are identified with the current level of groundwater use in the region. These are water level decline and an increase in groundwater salinity levels. The capacity of the groundwater resources is not sufficient to meet the current demands for water use in the area. The current level of groundwater use in the NAP PWA exceeds what is considered to be a sustainable yield from the aquifer system. A figure for an acceptable safe yield is hard to quantify due to the complexity of the aquifer system, however it is reliant on regular monitoring of groundwater levels, salinity trends and extraction rates. Therefore, regular monitoring reports are essential to advise of current trends in groundwater level, use and salinity, enabling steps to be taken that ensure the system does not become overstressed to the point of degradation.

The available data has been analysed and presented in this report as potentiometric surface and salinity maps for the most utilised T1 and T2 Aquifers, as well as representative hydrographs for all aquifers (Quaternary and Tertiary).

The Resource Allocation Division in DWLBC is currently finalising licensing and reporting requirements for establishing ASR wells in the Northern Adelaide Plains PWA. This is to be finalised for the beginning of the 2004–05 water use year and will enable reporting on volumes stored and recovered through ASR wells in subsequent groundwater monitoring reports.

At the time of preparing this report information concerning extraction demand for irrigation and industrial use was not available. Considerable work has been undertaken reconciling records within the Resource Allocation Division of groundwater use in the Northern Adelaide Plains PWA. This information will be available in the future reports providing a more comprehensive assessment of pumping impacts on the groundwater system.

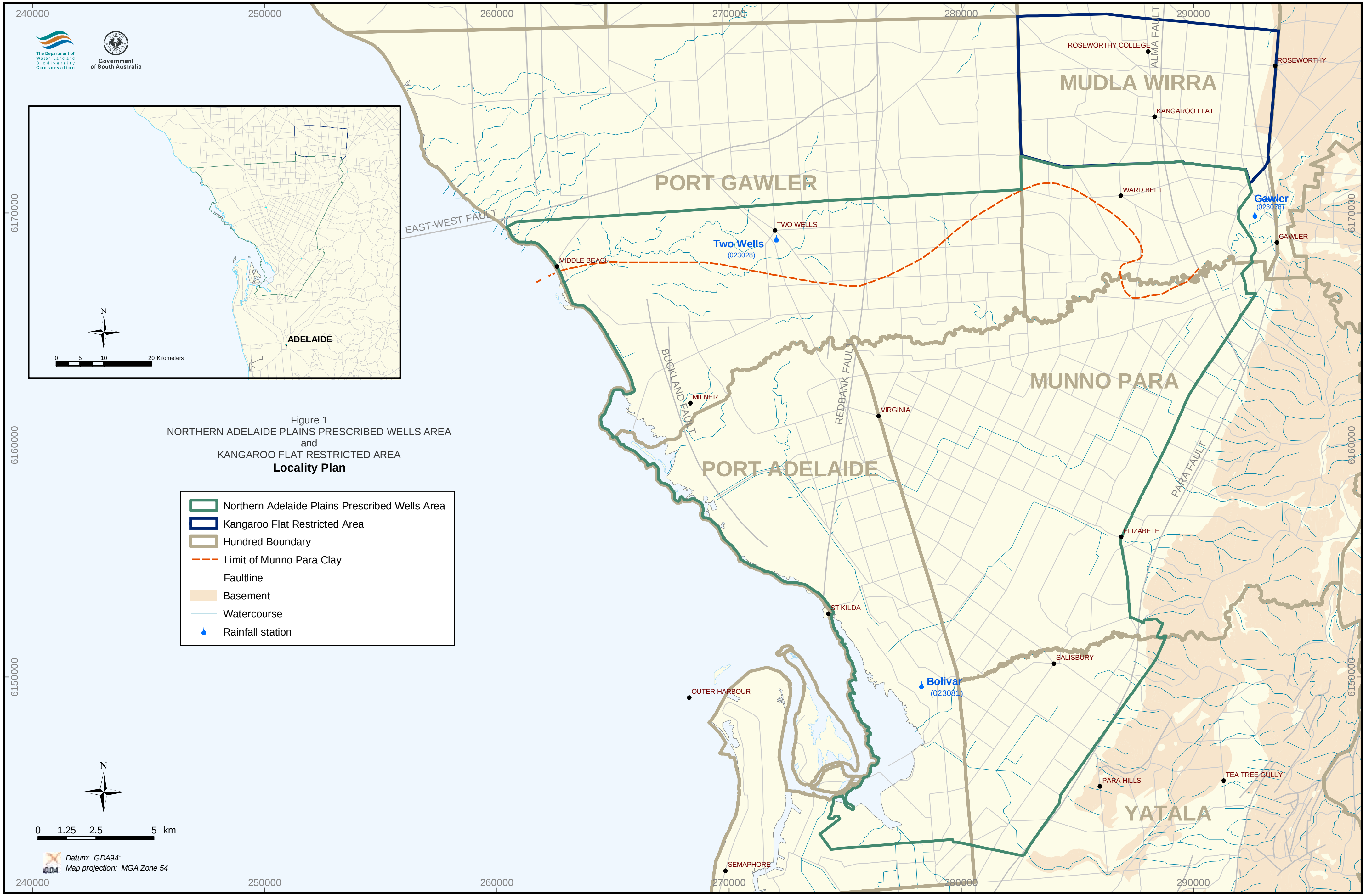


Figure 1
NORTHERN ADELAIDE PLAINS PRESCRIBED WELLS AREA
and
KANGAROO FLAT RESTRICTED AREA
Locality Plan

2 CLIMATE

The Mediterranean type of climate is characterised by winter dominant rainfall. Three rainfall stations were selected as representative of the rainfall pattern throughout the area: Two Wells (station 23028), Gawler (station 23078) and Bolivar (station 23081). Annual average rainfalls for selected stations are 400, 473 and 445 mm, respectively. The average monthly rainfall is shown in Table 1.

Table 1. Average monthly rainfall (mm)

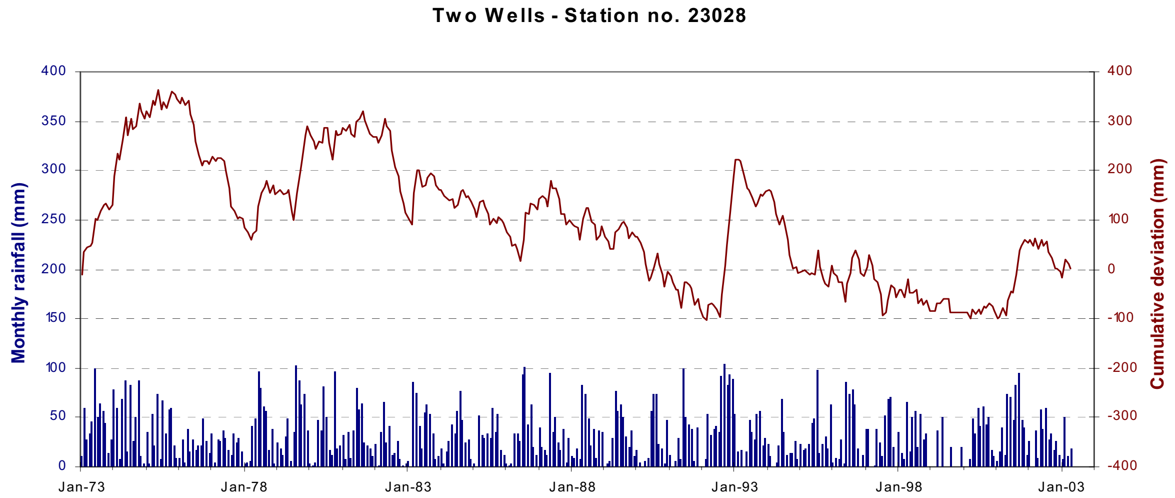
Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Two Wells	18	16	19	34	46	52	47	47	40	36	24	22
Gawler	18	16	24	40	55	62	56	56	52	43	27	23
Bolivar	21	15	27	31	45	56	57	51	46	47	23	23

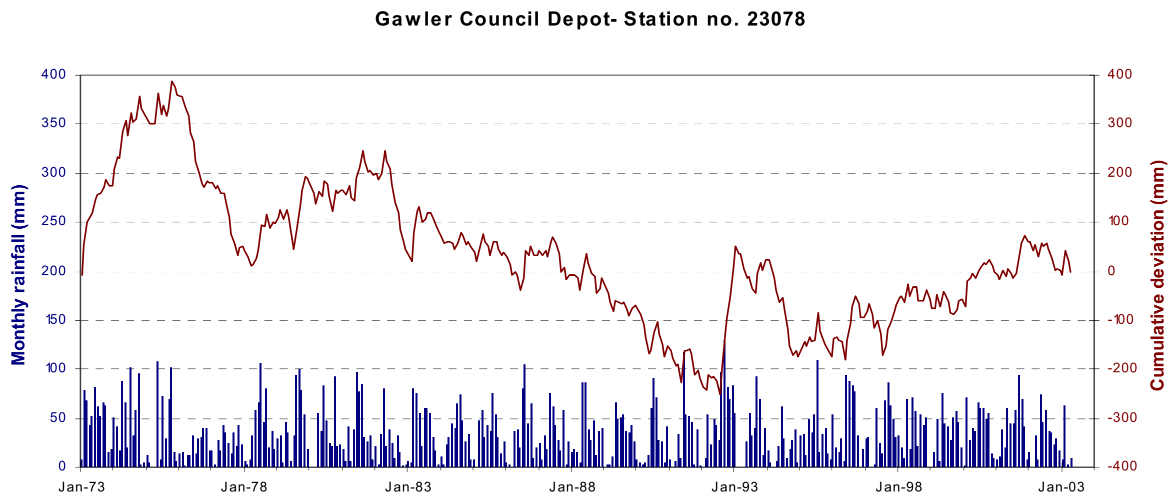
The rainfall records are available for a period of over 120 years for Two Wells station and 140 years for Gawler station; however, there is no data for this station between 1924 and 1969. For the Bolivar station, the recording of rainfall started in the early seventies. Figure 2 shows the monthly rainfall and cumulative deviation from each monthly mean obtained from these stations for the period 1973–2003.

All three stations show similar short-term trends such as above-average rainfall during the 1973–75, 1978–80 and 1992 periods and below-average rainfall during the 1976–77, 1982–1985 and 1990–92 periods (Fig. 2).

Over the sample period Two Wells has had generally below average rainfall. Gawler station has experienced generally below average rainfall until 1993 then a period of above average rainfall. The Bolivar station shows that over the sample period the rainfall has been generally average.

As the aquifer systems are not responsive to incident rainfall, this analysis may be a useful tool in analysing trends in groundwater extraction behaviour rather then recharge trends.





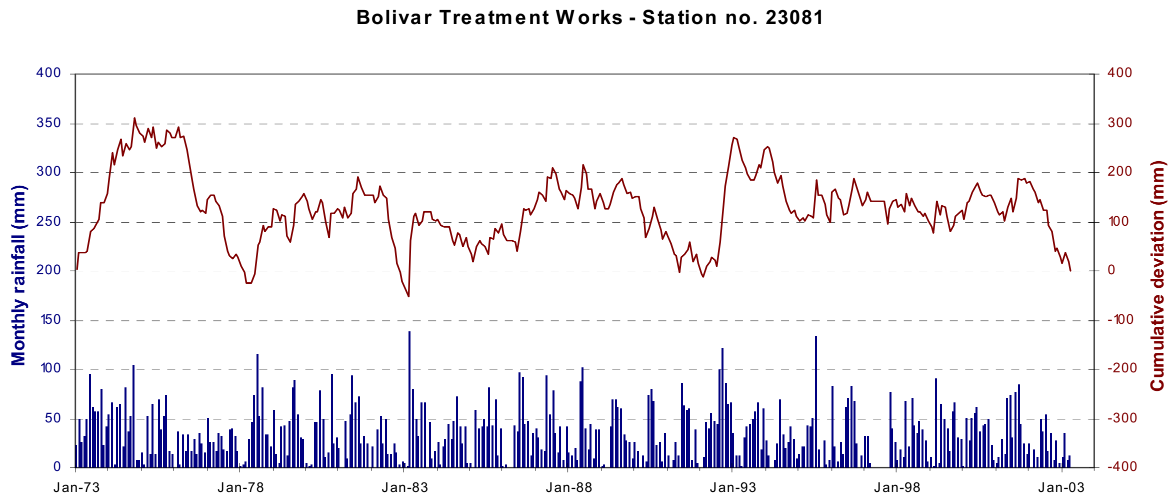


Figure 2. Monthly rainfall and cumulative deviation

3 SUMMARY OF AQUIFERS

The first major hydrogeological assessment of the NAP was undertaken by Shepherd, (1968 and 1975), who described it as a complex hydrogeological system. Since then the description of the hydrostratigraphy shown in Appendix A, has not considerably changed. Generally, two aquifer systems, Quaternary and Tertiary are recognised in the area.

Quaternary sediments containing mainly four, in some areas up to six, aquifers while the Tertiary Aquifers contain up to four aquifers (Gerges, 2001). Both the Quaternary and Tertiary Aquifers were designated identifiers in order of increasing depth.

3.1 Shallow Quaternary Aquifers

The main lithology of the Quaternary sediments is mottled clay and silt interbedded with sand, gravel and thin sandstone layers (Hindmarsh Clay). The shallowest Perched Aquifer is irregular in occurrence and exists because the infiltrating surface water is hindered by a confining layer. The distribution of this aquifer over the area is not well known. Underneath this aquifer there are mainly up to three Quaternary Aquifers (Q1–Q3) over most of the region and are represented by sands, gravels and sandstones. However, in the southern area five or six Quaternary Aquifers have been recognised. Below the shallow Quaternary Aquifers, the Hindmarsh Clay generally forms a confining layer to the underlaying lower Q4 Aquifer.

3.1.1 Q4 AQUIFER

The Q4 Aquifer, called the Carisbrooke Sand Aquifer, occurs over the whole area, except within 4–5 km of the coast. The Q4 Aquifer consists of multicoloured, poorly sorted, fine to medium-grained quartz sand and silt, with some clay and thin gravel beds. In some areas it is hydraulically connected to the overlaying Q3 Aquifer or to the underlying T1 Aquifer along the Little Para River.

3.2 Tertiary Aquifers

The Tertiary sediments contain several confined aquifer systems, each may comprise various sub-aquifers. These aquifers are designated T1, T2, T3 and T4 in order of increasing depth.

The aquifers exhibit large variations in thickness, lithology, salinity distribution and yield. The first and second Tertiary Aquifers (T1 and T2) are recognised as superior aquifers in terms of salinity and yield.

3.2.1 FIRST TERTIARY AQUIFER (T1)

The first Tertiary Aquifer (T1) is defined as the saturated and permeable Tertiary sediments intersected above the Munno Para Clay member. An exception is the area located a few kilometres north of Gawler River and west of Red Banks Fault, where the

Munno Para Clay is absent and the T1 Aquifer is directly overlying the T2 Aquifer, forming virtually one aquifer.

In the northeast of the NAP the T1 Aquifer is absent (Fig. 4).

The T1 Aquifer may consist of several stratigraphic units, varying in lithology and thickness. The first Tertiary Aquifer in the NAP area consists of two major sub-aquifers (Gerges, 1987):

- Sub-aquifer T1a — consists of Hallett Cove Sandstone and Dry Creek Sand, and permeable portions of the 'Croydon facies' and is hydraulically connected to the Carisbrooke Sand (Q4) Aquifer (along Little Para River area only).
- Sub-aquifer T1b — consists of limestone of the upper Port Willunga Formation.

A semi-confining bed comprising the remaining part of Croydon facies separates both Sub-aquifers but information about its extent is very limited. The T1a and T1b Aquifers are considered to be hydraulically connected and are therefore referred to as just the T1 Aquifer.

East of the Alma Fault the T1 Aquifer may be connected with the undifferentiated Tertiary sands; this hydraulic connectivity is considered to be minor.

3.2.2 SECOND TERTIARY AQUIFER (T2)

The second Tertiary Aquifer comprises saturated and permeable Tertiary sediments intersected below the Munno Para Clay member. The T2 Aquifer occurs throughout the entire NAP PWA. It consists of well-cemented limestone of lower Port Willunga Formation.

In the area north of the Gawler River and east of the Redbank Fault (Fig. 4), the Munno Para Clay and the T1 Aquifer are not present and the Q4 Aquifer overlies the T2 Aquifer.

In the area between the Alma Fault and Para Fault lithology suggests that this aquifer consists mostly of undifferentiated Tertiary quartz-sand and minor clay. Assuming hydraulic connectivity occurs across the Alma Fault it is considered that these sediments are the continuation of the T2 Aquifer. A better understanding of this portion of the Tertiary Aquifer system will occur as further investigation are undertaken.

3.2.3 THIRD TERTIARY AQUIFER (T3)

The distribution of the T3 Aquifer is not well known, but it is considered to occur over most of the NAP as a thin sandy layer with an average thickness of 5 m (Gerges, 2001). Few records relating to the T3 Aquifer are available from drillholes in the Port Gawler and Virginia areas. At the old Virginia Primary School site, the T3 Aquifer consisting of Aldinga Member and Chinaman Gully Formation sands was intersected at 215 m and the water level rose to 5 m above ground level (PTA 88, unit number 6628–15843 – backfilled in June 2003).

3.2.4 FOURTH TERTIARY AQUIFER (T4)

The fourth Tertiary Aquifer consists mainly of South Maslin Sand and occasionally North Maslin Sand.

4 MONITORING NETWORKS

The groundwater monitoring well network for the Northern Adelaide Plains (NAP) Prescribed Wells Area (PWA) was established in the early 1960s, in order to monitor groundwater levels and salinity. The purpose of the monitoring network is to observe the aquifer's responses to groundwater extraction and identify areas that may be under stress due to over-pumping of groundwater or areas that may be at risk of salinisation. From analysis of the monitoring data, steps can be taken to ensure the groundwater resource is not overstressed to the point of irreversible degradation.

The number of wells monitoring water levels, particularly in the Tertiary Aquifers (T1 and T2) has been increasing in response to groundwater extraction for irrigation purposes. Between 2000 and 2002 the monitoring network was upgraded with 20 new and two replacement monitoring wells. In 2003 the monitoring network was upgraded with five replacement monitoring wells completed in the T1 and T2 Aquifers, while two wells in the T1 Aquifer were rehabilitated. Seven wells were backfilled in the T1, T2 and T3-T4 aquifers, five of which were replaced.

Currently there are a total of 163 monitoring wells throughout the NAP PWA and Kangaroo Flat Restricted Area that monitor groundwater levels. The Groundwater Group within the Department of Water, Land and Biodiversity Conservation (DWLBC) carries out the monitoring on a three-monthly basis.
The number of monitoring wells monitoring each aquifer is presented in Table 2.

Table 2. Current monitoring wells

AQUIFER		Government owned wells	Privately owned wells	TOTAL
Quaternary	Perched	19	–	19
	Q1	17	–	17
	Q2	12	–	12
	Q3	16	–	16
	Q3 + Q4	4	–	4
	Q4	10	–	10
Tertiary	T1	22	8	30
	T2	45	6	51
	T3–T4	4	–	4
Total		**149**	**14**	**163**

The locations of current water level monitoring wells for all Quaternary and Tertiary Aquifers are presented in Figures 3 and 4 respectively.

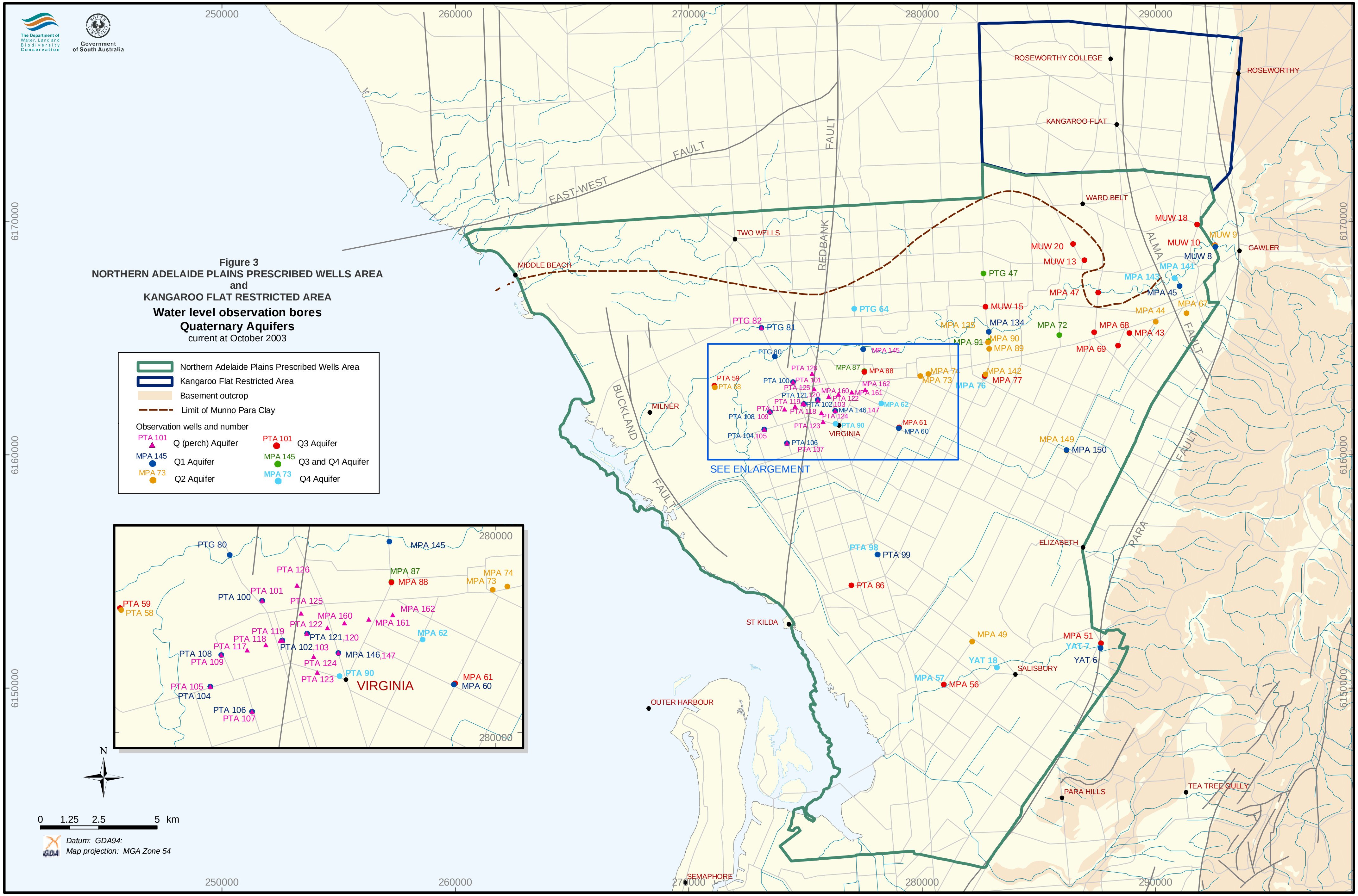


Figure 3
NORTHERN ADELAIDE PLAINS PRESCRIBED WELLS AREA
and
KANGAROO FLAT RESTRICTED AREA
Water level observation bores
Quaternary Aquifers
current at October 2003

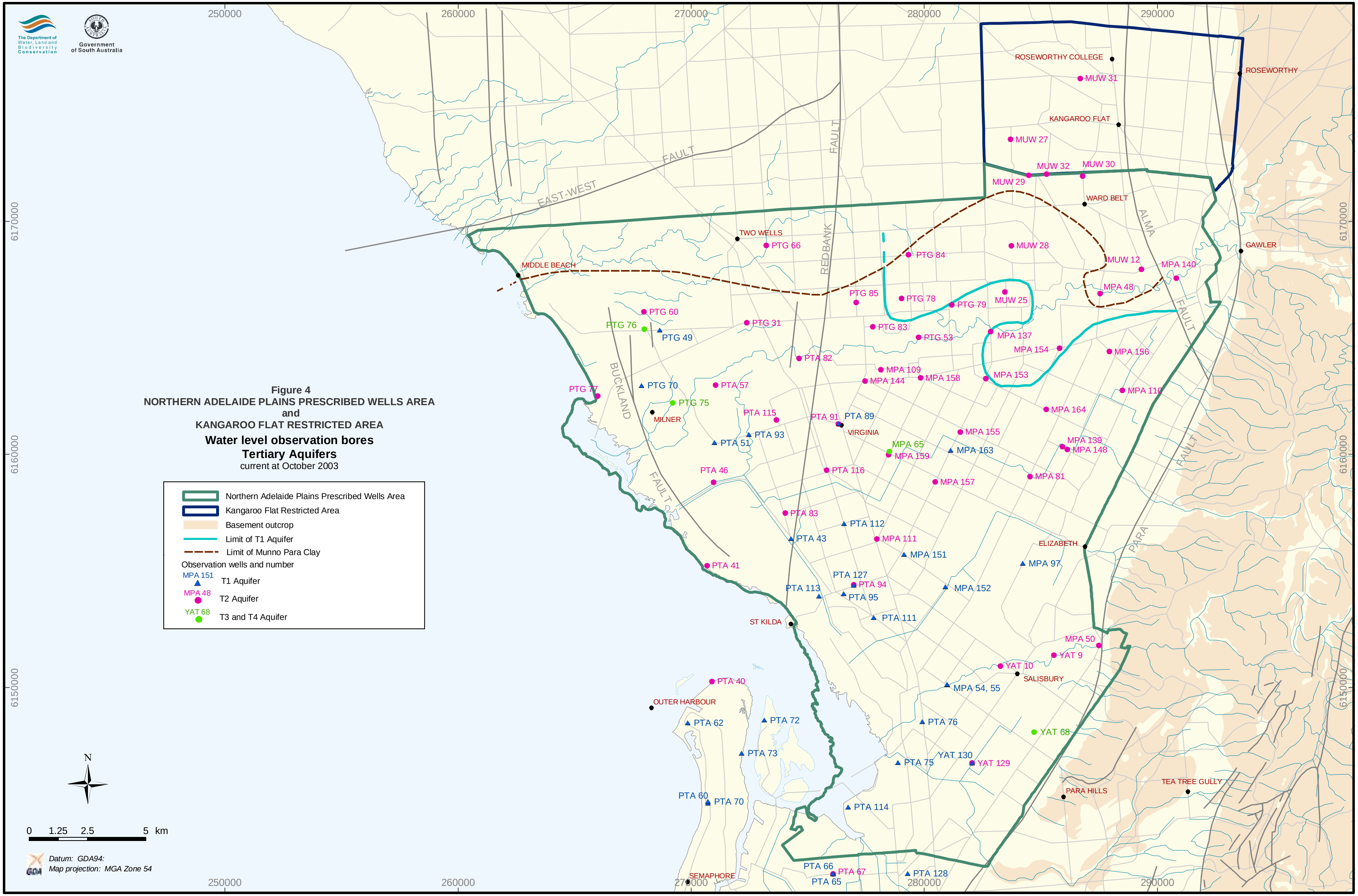


Figure 4
NORTHERN ADELAIDE PLAINS PRESCRIBED WELLS AREA
and
KANGAROO FLAT RESTRICTED AREA
Water level observation bores
Tertiary Aquifers
current at October 2003

5 WATER LEVEL ANALYSIS

The 2002 monitoring status report analyses in detail long and short term water level trends for all Quaternary and the T1 and T2 Aquifers. This report only highlighted changes in water levels during the last year. Representative hydrographs for all aquifers are presented in Appendix B. Water level trends for the T1 and T2 Aquifers have also been analysed by constructing residual maps that is subtracting seasonal potentiometric surfaces September 01 from September 02 and March 02 from March 03 (Figs 8 and 11).

5.1 Quaternary Aquifers

The locations of current water level monitoring wells for all Quaternary Aquifers are presented in Figure 3.

There are a total of 78 wells monitoring the Quaternary Aquifers. The Perched (watertable) Aquifer is being monitored by 19 wells, Q1 Aquifer by 17 wells, Q2 Aquifer by 12 wells, Q3 Aquifer by 16 wells and Q4 Aquifer (Carisbrooke Sand Aquifer) by 10 wells. Four wells are completed in both Q3 and Q4 Aquifers.

In the last year (September 2001-02 and March 2002-03) water level data shows that the water level trends declined in a number of the monitoring wells in all Quaternary aquifers (Tables 3, 4, 5, 6 and 7). There are a number of potential causes for this decline but a lack of detailed supporting groundwater use information across the NAP makes it difficult to identify the primary cause.

When water trends are analysed for the period 1999 to 2002 a rise in order of 0.3-0.6 m/y was observed in the Perched, Q1 and Q4 Aquifers recorded declining water level trends (Zulfic, 2002).

However, water level data recorded during the last year shows that all six wells analysed for the period September 2001-02 and six out of 16 for the March 2002-03 period in the Perched Aquifer recorded an average decline in water level of 0.14 and 0.03 m/y respectively (Table 3, App. B).

For the same period the majority of monitoring wells completed in the Q1 Aquifer (12 out of 14 and 9 out of 15 respectively), recorded a decline in water level, with average decline of 0.31 and 0.14 m/y respectively (Table 4).

During the last year the majority of the monitoring wells completed in the Q2 and Q3 Aquifers recorded a decline in water levels (Tables 5 and 6). Calculated average decline for September 2001-02 was 0.18 and 0.32 m/y respectively, while for March 2002-03 it was 0.28 and 0.36 m/y respectively.

In the Q4 Aquifer (Carisbrooke Sand Aquifer) 3 out of 8 analysed monitoring wells showed a decline in water level with an average rise of 0.01 m/y for the period September 2001-02, and an average decline of 0.02 m/y for March 02-03 (Table 7).

Table 3. Perched Aquifer: groundwater level trend

Aquifer	Observation Well No.	Unit No.	September 01 September 02	March 02 March 03	Comments
Perched	MPA 147*	6628-20002	-0.14	0.08	
Perched	MPA 160*	6628-20752	-	-	Not all SWL readings available
Perched	MPA 161*	6628-20753	-	-0.49	
Perched	MPA 162*	6628-20754	-	0.14	
Perched	PTA 101	6628-19992	-0.02	0.09	
Perched	PTA 103	6628-19998	-0.12	-0.35	
Perched	PTA 105	6628-20000	-0.48	0.14	
Perched	PTA 107	6628-20004	-0.02	0.16	
Perched	PTA 109	6628-20006	-0.05	0.19	
Perched	PTA 117*	6628-20746	-	0.24	
Perched	PTA 118*	6628-20747	-	0.14	
Perched	PTA 119*	6628-20748	-	-0.16	
Perched	PTA 120*	6628-20749	-	-0.25	
Perched	PTA 122*	6628-20751	-	-0.27	
Perched	PTA 123*	6628-20755	-	0.37	
Perched	PTA 124*	6628-20756	-	0.26	
Perched	PTA 125*	6628-20757	-	-0.74	
Average groundwater trend (m/yr)			**-0.14**	**-0.03**	

Negative values mean groundwater level is declining

Positive values mean groundwater level is rising

* Wells drilled in November 2001

Table 4. Q1 Aquifer: groundwater level trend

Aquifer	Observation Well No.	Unit No.	September 01 September 02	March 02 March 03	Comments
Q1	MPA 45	6628-1951	-0.51	-0.73	
Q1	MPA 60	6628-2515	0.21	0.18	
Q1	MPA 145	6628-19994	-0.87	-0.44	
Q1	MPA 146	6628-20001	-0.27	0.24	
Q1	MPA 150	6628-20170	-0.21	-0.01	
Q1	MUW 8	6628-1734	-	-	Missing SWL readings
Q1	PTA 99	6628-19657	-0.09	-0.11	
Q1	PTA 100	6628-19991	0.06	0.08	
Q1	PTA 102	6628-19997	-0.19	-0.18	
Q1	PTA 104	6628-19999	-0.59	-0.54	
Q1	PTA 106	6628-20003	-0.29	0.06	
Q1	PTA 108	6628-20005	-0.06	0.12	
Q1	PTA 121*	6628-20750	-	-0.24	
Q1	PTG 80	6628-19993	-1.24	-0.49	
Q1	PTG 81	6628-19995	-0.10	-0.21	
Q1	YAT 6	6628-5143	-0.19	0.22	
Average groundwater trend (m/yr)			**-0.31**	**-0.14**	

Negative values mean groundwater level is declining

Positive values mean groundwater level is rising

* Wells drilled in November 2001

Table 5. Q2 Aquifer: groundwater level trend

Aquifer	Observation Well No.	Unit No.	September 01 September 02	March 02 March 03	Comments
Q2	MPA 44	6628-1937	-0.03	-1.17	
Q2	MPA 49	6628-4911	-1.00	-0.60	
Q2	MPA 67	6628-2039	-0.07	-0.36	
Q2	MPA 73	6628-1143	0.29	0.01	
Q2	MPA 74	6628-1521	0.24	-0.05	
Q2	MPA 89	6628-1501	0.26	-0.05	
Q2	MPA 90	6628-1472	0.32	-	Missing SWL readings
Q2	MPA 142	6628-15492	0.31	0.06	
Q2	MPA 149	6628-16439	-0.42	-0.19	
Q2	MUW 9	6628-1735	-1.91	-0.21	
Q2	PTA 58	6628-2219	0.06	-0.26	
Average groundwater trend (m/yr)			**-0.18**	**-0.28**	

Negative values mean groundwater level is declining

Positive values mean groundwater level is rising

Table 6. Q3 Aquifer: groundwater level trend

Aquifer	Observation Well No.	Unit No.	September 01 September 02	March 01 March 03	Comments
Q3	MPA 43	6628-1403	-0.03	-0.33	
Q3	MPA 47	6628-1372	-0.29	-0.19	
Q3	MPA 51	6628-4998	-2.61	0.04	
Q3	MPA 56	6628-4902	-1.00	-0.41	
Q3	MPA 61	6628-2516	0.23	0.37	
Q3	MPA 68	6628-1408	0.02	-0.02	
Q3	MPA 69	6628-1422	-0.04	-0.07	
Q3	MPA 77	6628-1556	0.37	0.28	
Q3	MPA 88	6628-1161	0.13	0.61	
Q3	MUW 10	6628-1736	-0.15	-0.11	
Q3	MUW 13	6628-1336	-0.29	-0.25	
Q3	MUW 15	6628-1346	0.06	-0.03	
Q3	MUW 18	6628-1595	-0.28	-0.08	
Q3	MUW 20	6628-846	-0.05	-0.22	
Q3	PTA 59	6628-2220	-1.77	-0.17	
Q3	PTA 86	6628-15847	0.54	0.51	
Average groundwater trend (m/yr)			**-0.32**	**0.00**	

Negative values mean groundwater level is declining

Positive values mean groundwater level is rising

Table 7. Q4 Aquifer: groundwater level trend

Aquifer	Observation Well No.	Unit No.	September 01 September 02	March 02 March 03	Comments
Q4	MPA 57	6628-4903	0.21	0.12	
Q4	MPA 62	6628-2517	-1.02	1.48	
Q4	MPA 76	6628-2721	0.22	0.04	
Q4	MPA 141	6628-16714	-0.38	-0.65	
Q4	MPA 143	6628-19219	-0.40	-0.64	The same site as MPA 141-not calculated for average trend
Q4	PTA 90	6628-15841	0.19	0.11	
Q4	PTA 98	6628-19656	0.96	-1.06	
Q4	YAT 7	6628-7010	0.34	0.07	
Q4	YAT 18	6628-5050	-0.43	-0.3	
Average groundwater trend (m/yr)			**0.01**	**-0.02**	

Negative values mean groundwater level is declining

Positive values mean groundwater level is rising

5.2 T1 Aquifer

In the Hallett Cove Sandstone – Dry Creek Sand (T1a Aquifer) and upper Port Willunga Formation (T1b Aquifer) there is a total of 30 observation wells. Twenty one wells are located inside the NAP PWA, while nine wells are part of both the NAP and Metropolitan Adelaide observation networks (Fig. 4). Potentiometric surface contour maps of the first Tertiary Aquifer (T1) for September 2002 and March 2003 have been considered representative of the winter and summer potentiometric surface and are presented in Figures 5 and 6 respectively.

Extractions from T1 Aquifer occur from three distinctive areas: the Little Para River, Penrice (ICI) – SAMCOR and Waterloo Corner area, creating two cones of depression during summer (Fig. 6) in the Penrice and Waterloo Corner areas. The cone of depression in the Penrice area is permanent, while the potentiometric surface in the Waterloo Corner area recovers to near its pre-pumping level during winter. This has changed the local flow pattern from a general west direction to a radial flow toward the centre of the cone.

Analysed hydrographs from the heavy pumping areas where long-term records exist (App. B) show fluctuations from seasonal extraction and an overall decline in potentiometric surface (aquifer pressure).

The residual map of potentiometric surfaces September 2002/2001 (Fig. 7) shows that the potentiometric surface in September 2002 has declined in most of the area extracting from the T1 Aquifer. The largest decline, about 5 m, was recorded in the area of the Penrice cone of depression, in the vicinity of the monitoring well PTA 75. In the Waterloo Corner area, the potentiometric surface declined more than 2 m in the centre of the cone of depression. This suggests that due to continuation of pumping during the winter of 2002, the summer (2002) cone of depression did not recover to the level recorded in September 2001.

The residual map of potentiometric surfaces March 2003/2002 (Fig. 8) shows that the potentiometric surface rose about 2 m in the area of the Waterloo Corner cone of depression, while it declined about 3 m in the area of the Penrice cone of depression . A slight decline in the potentiometric surface is present northwest of the Waterloo Corner area.

5.3 T2 Aquifer

The T2 Aquifer (lower Port Willunga Formation) is monitored by a total of 51 wells, four of which are completed in the undifferentiated Tertiary sediments. Forty-six monitoring wells are located within the NAP PWA, 3 wells are in the Kangaroo Flat Restricted Area and two wells are part of both the NAP and Metropolitan Adelaide monitoring networks (Fig. 4).

The T2 Aquifer occurs throughout the entire prescribed wells area. The latest potentiometric surface maps for September 2002 and March 2003 (Figs 9 and 10) show a regional cone of depression formed in the Virginia – Angle Vale area. Generally, during the winter season, the T2 Aquifer recovers but does not reach the pre-development groundwater level. Until March 1999 the centre of the cone of depression was close to

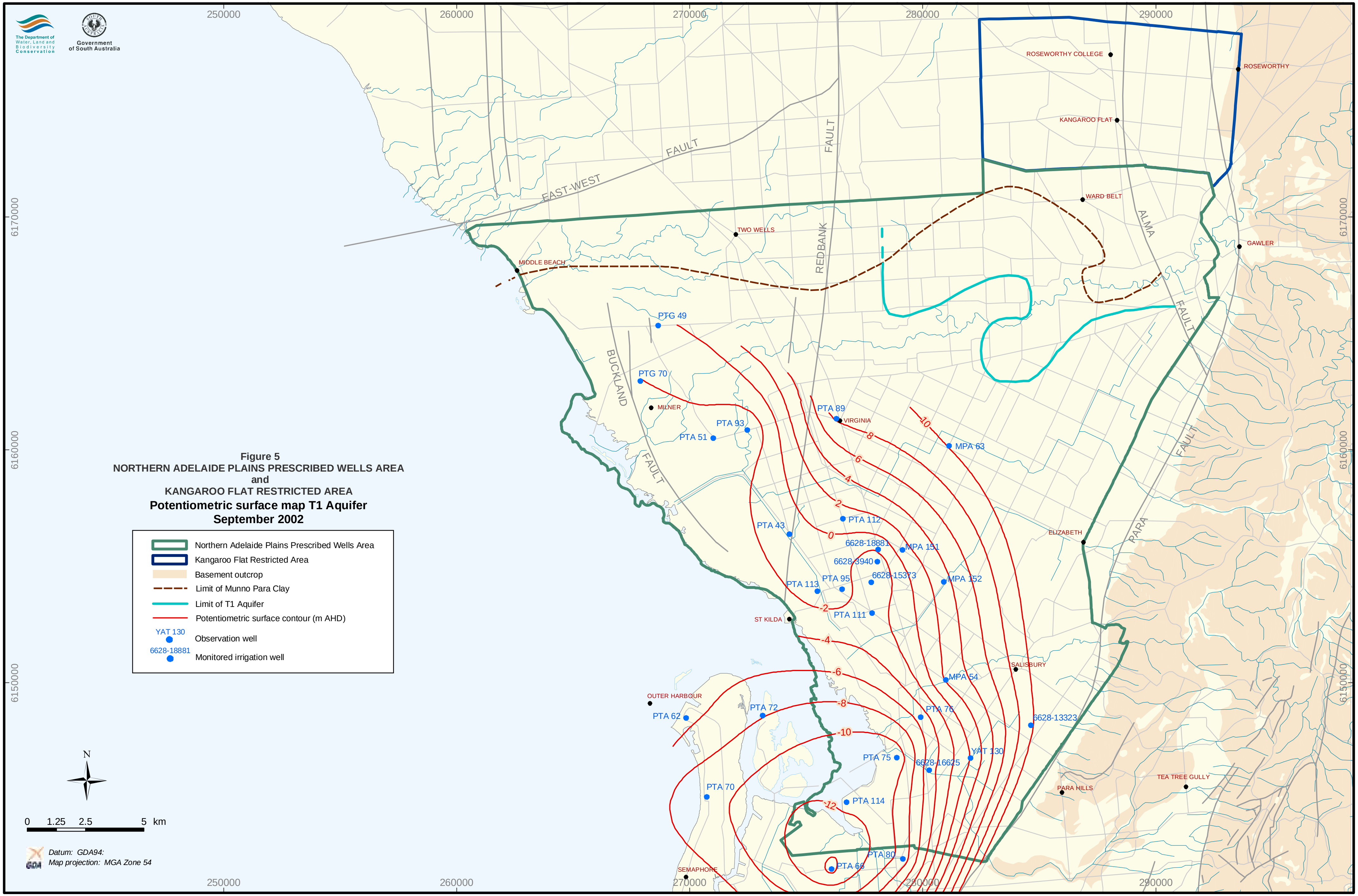


Figure 5
NORTHERN ADELAIDE PLAINS PRESCRIBED WELLS AREA
and
KANGAROO FLAT RESTRICTED AREA
Potentiometric surface map T1 Aquifer
September 2002

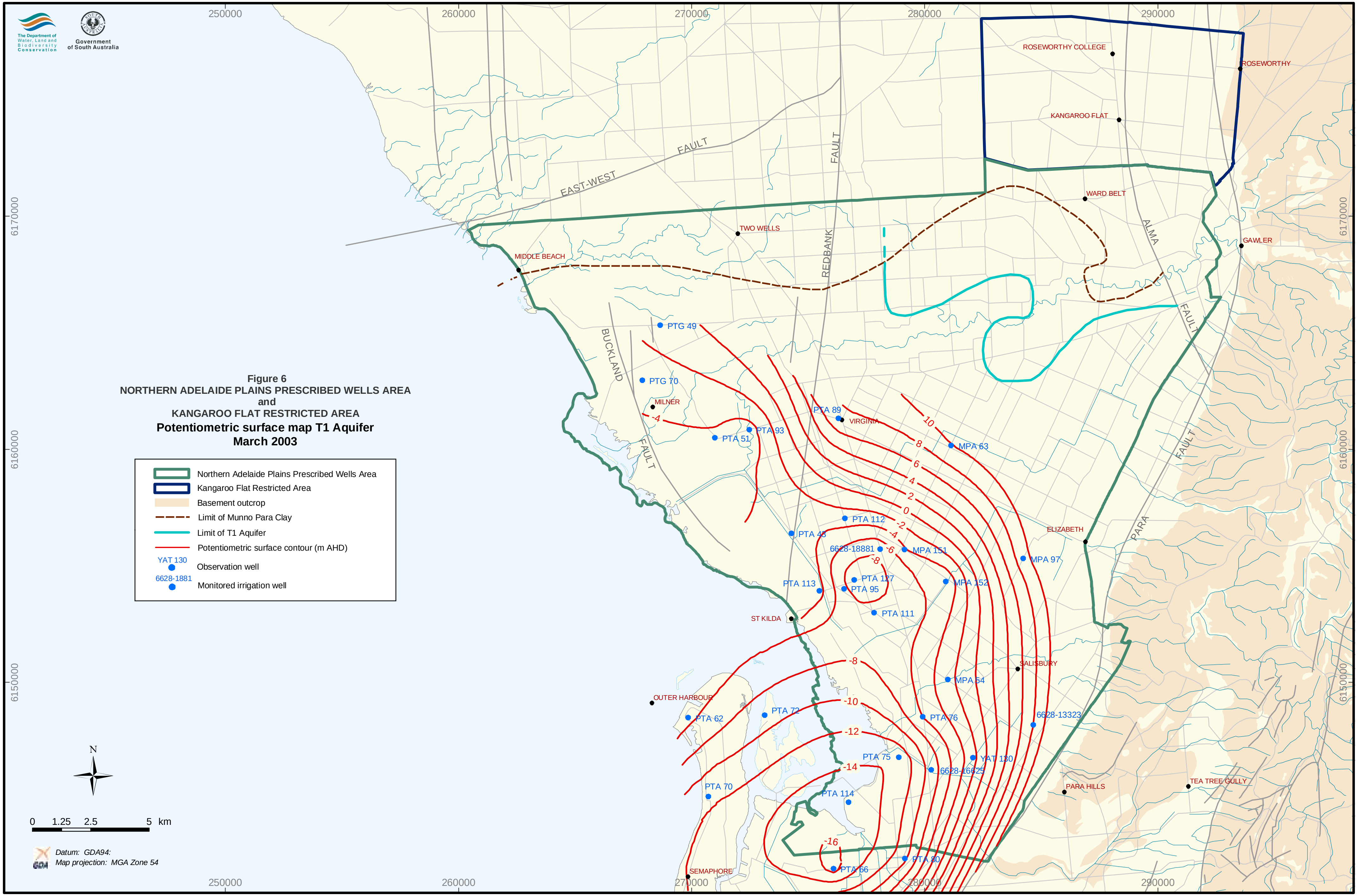


Figure 6
NORTHERN ADELAIDE PLAINS PRESCRIBED WELLS AREA and KANGAROO FLAT RESTRICTED AREA
Potentiometric surface map T1 Aquifer
March 2003

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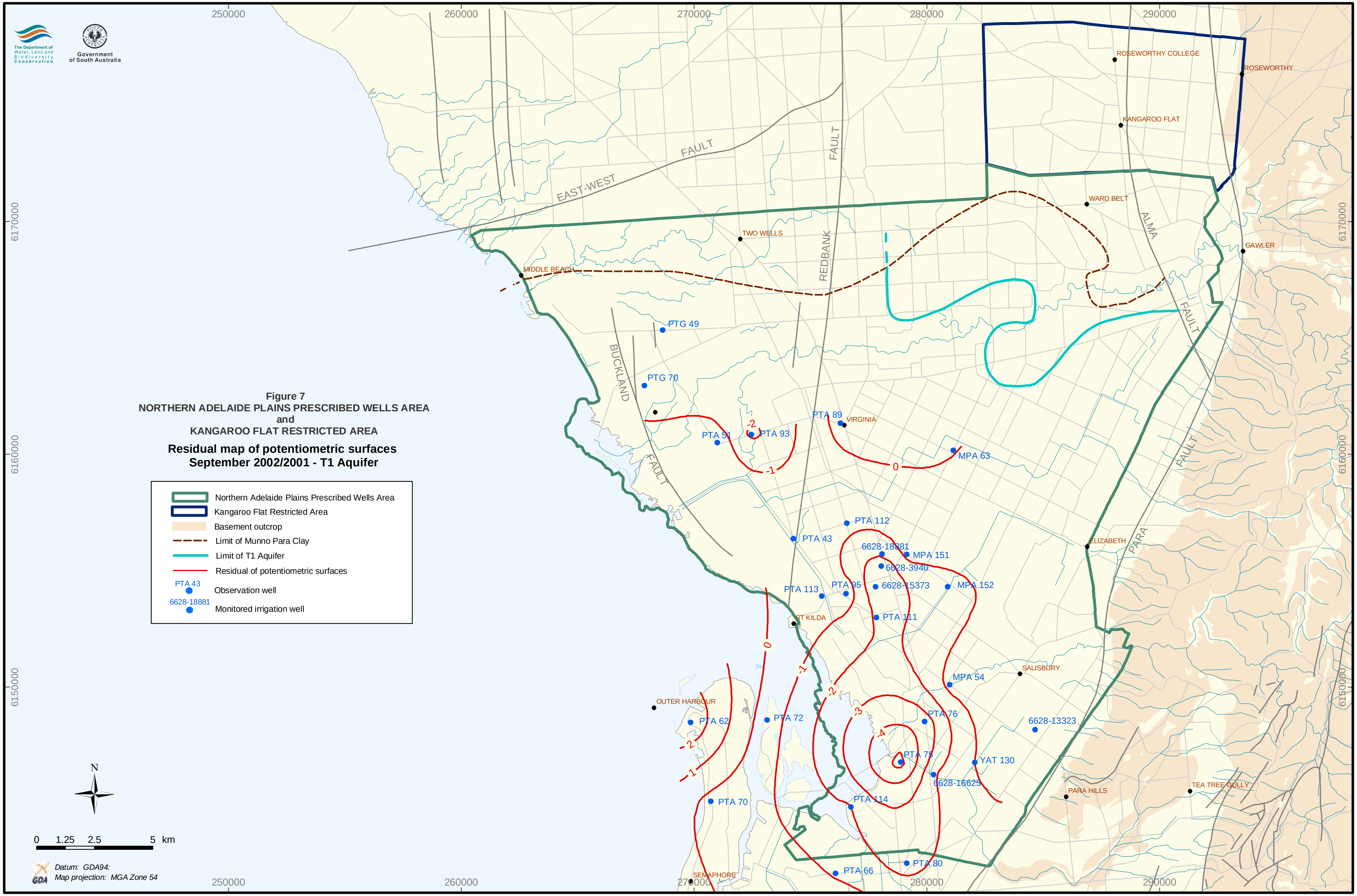

Figure 7
NORTHERN ADELAIDE PLAINS PRESCRIBED WELLS AREA
and
KANGAROO FLAT RESTRICTED AREA

Residual map of potentiometric surfaces
September 2002/2001 - T1 Aquifer

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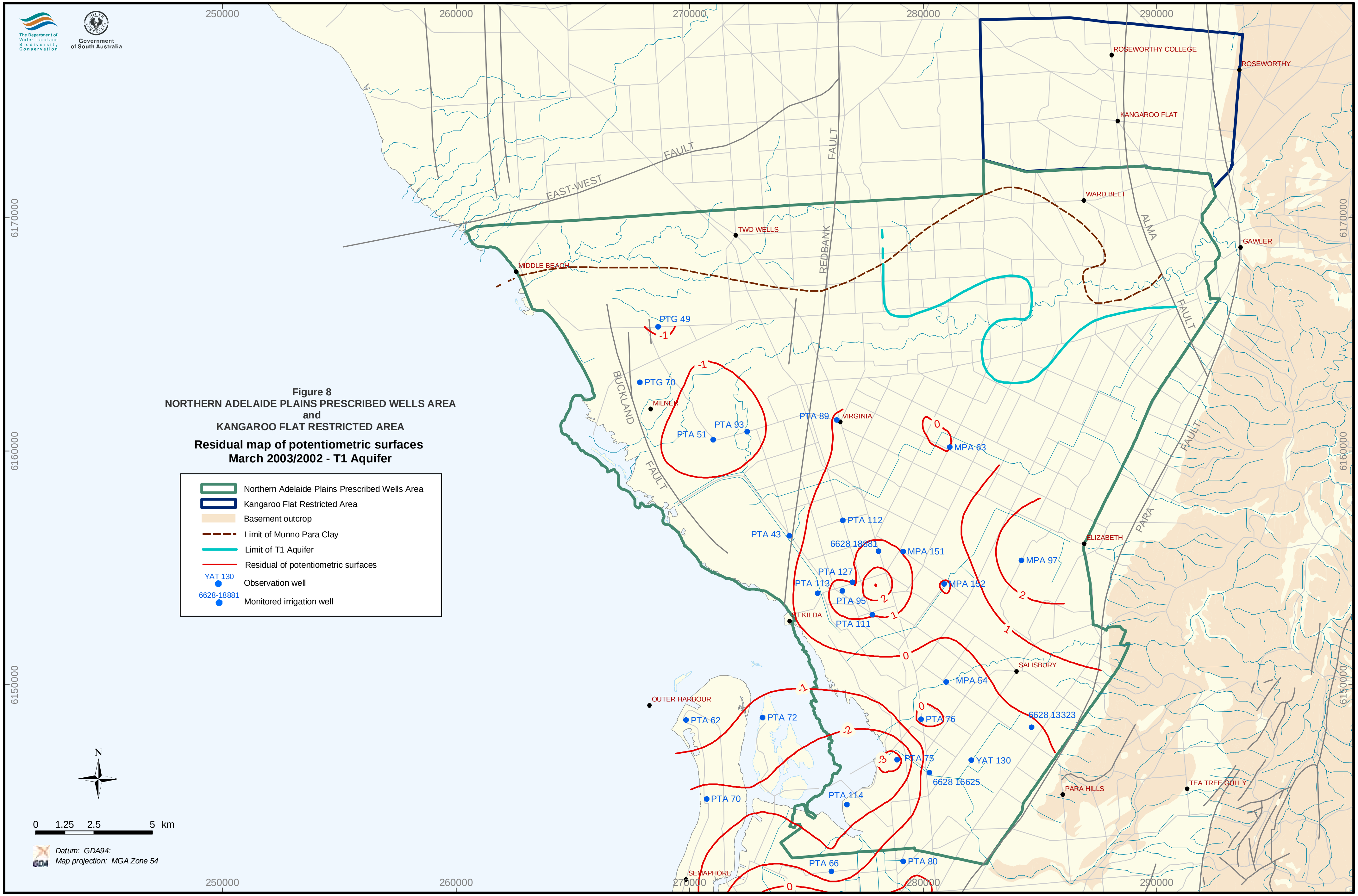

Figure 8
NORTHERN ADELAIDE PLAINS PRESCRIBED WELLS AREA and KANGAROO FLAT RESTRICTED AREA

Residual map of potentiometric surfaces March 2003/2002 - T1 Aquifer

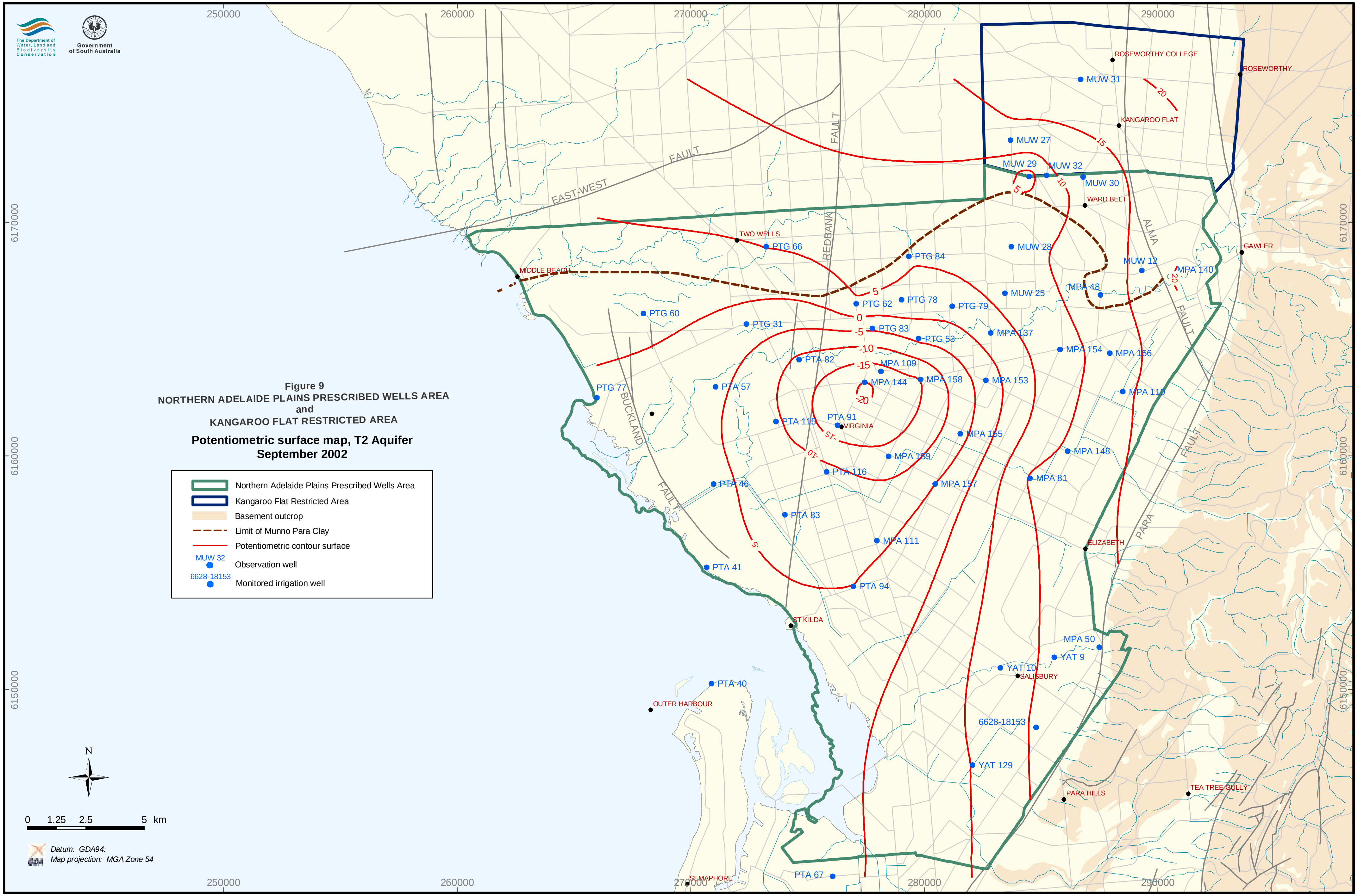
Figure 9
NORTHERN ADELAIDE PLAINS PRESCRIBED WELLS AREA
and
KANGAROO FLAT RESTRICTED AREA
Potentiometric surface map, T2 Aquifer
September 2002
Northern Adelaide Plains Prescribed Wells Area
Kangaroo Flat Restricted Area
Basement outcrop
Limit of Munno Para Clay
Potentiometric contour surface
MUW 32
Observation well
6628-18153
Monitored irrigation well
The Department of Water, Land and Biodiversity Conservation
Government of South Australia
250000
260000
270000
280000
290000
6170000
6160000
6150000
N
0 1.25 2.5 5 km
Datum: GDA94:
Map projection: MGA Zone 54
ROSEWORTHY COLLEGE
ROSEWORTHY
KANGAROO FLAT
WARD BELT
GAWLER
TWO WELLS
MIDDLE BEACH
VIRGINIA
ELIZABETH
ST KILDA
SALISBURY
OUTER HARBOUR
PARA HILLS
TEA TREE GULLY
SEMAPHORE
EAST-WEST FAULT
REDBANK FAULT
BUCKLAND FAULT
ALMA FAULT
PARA FAULT
MUW 31
MUW 27
MUW 29
MUW 32
MUW 30
MUW 28
MUW 12
MUW 25
MPA 140
MPA 48
PTG 66
PTG 84
PTG 62
PTG 78
PTG 79
PTG 60
PTG 31
PTG 83
PTG 53
MPA 137
MPA 154
MPA 156
PTA 82
MPA 109
MPA 144
MPA 158
MPA 153
MPA 110
PTG 77
PTA 57
PTA 115
PTA 91
MPA 155
MPA 148
MPA 159
PTA 116
MPA 157
MPA 81
PTA 46
PTA 83
MPA 111
PTA 41
PTA 94
MPA 50
YAT 9
YAT 10
PTA 40
6628-18153
YAT 129
PTA 67
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-20
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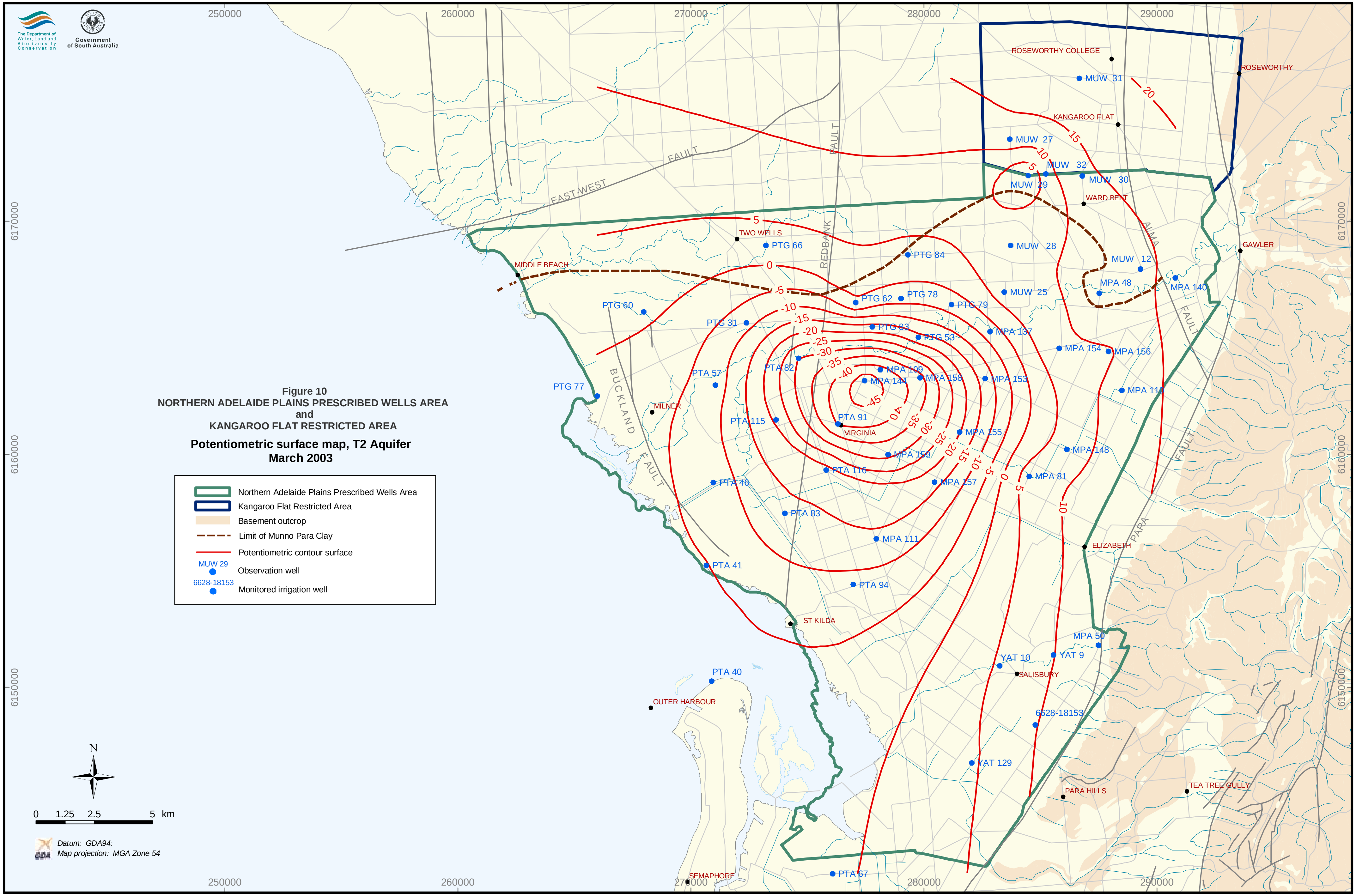

Figure 10
NORTHERN ADELAIDE PLAINS PRESCRIBED WELLS AREA
and
KANGAROO FLAT RESTRICTED AREA
Potentiometric surface map, T2 Aquifer
March 2003
Northern Adelaide Plains Prescribed Wells Area
Kangaroo Flat Restricted Area
Basement outcrop
Limit of Munno Para Clay
Potentiometric contour surface
MUW 29
Observation well
6628-18153
Monitored irrigation well
The Department of Water, Land and Biodiversity Conservation
Government of South Australia
Datum: GDA94:
Map projection: MGA Zone 54
0 1.25 2.5 5 km
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Virginia and the monitoring well PTA 91. Since then, the centre of the cone has moved about 2 km northeast and it is now in the vicinity of the monitoring well MPA 144.

The cone of depression formed in the Kangaroo Flat area during the summer irrigation season highlights another distinctive groundwater extraction area. This cone of depression was observed for the first time in March 2001 but was not present during winter until September 2002 (Fig. 9). The data used for generating the potentiometric surface map September 2002 and the residual map September 2002/2001 (Fig. 11), shows that the potentiometric surface declined over most of the area extracting from the T2 Aquifer (up to 6 m in the centre of the main cone of depression, in the vicinity of monitoring wells MPA 144 and MPA 158). However, the largest decline of 12.7 m was observed in the Kangaroo Flat area (monitoring well MUW 29). The overall decline suggests an increase in pumping during the winter of 2002 over most of the area extracting from the T2 Aquifer, particularly in the Kangaroo Flat area. Continuation of such a rate of pumping during the winter in the Kangaroo Flat area may cause this seasonal cone of depression to become permanent.

The residual map of potentiometric surfaces March 2003/2002 (Fig. 12) was generated and it shows that the potentiometric surface declined over most of the area extracting from the T2 Aquifer. The decline of the potentiometric surface in the centre of the cone was just under 5 m, but the highest decline of 7 m was recorded about 2.5 km east of the centre of the cone of depression in the vicinity of the recently constructed monitoring well MPA 158. A decline of the potentiometric surface (about 3 m) was recorded in the Bolivar area in the vicinity of the monitoring well PTA 94.

Care should be taken in the interpretation of the “bull’s eyes” (aquifer pressure raised) around the monitoring well PTA 116 on both residual maps. This is a newly constructed monitoring well and water levels were recorded and used for the first time for generating potentiometric surface maps September 2002 and March 2003.

Selected T2 hydrographs with the longest period of records (App. B) generally show the overall decline of potentiometric surface.

5.4 T3 and T4 Aquifers

A total of four wells monitor the T3 and T4 Aquifers (Fig. 4). Two of these monitoring wells (PTG 75 and PTG 76) are artesian while the other two monitoring wells (MPA 65 and YAT 68) have a potentiometric surface below ground level.

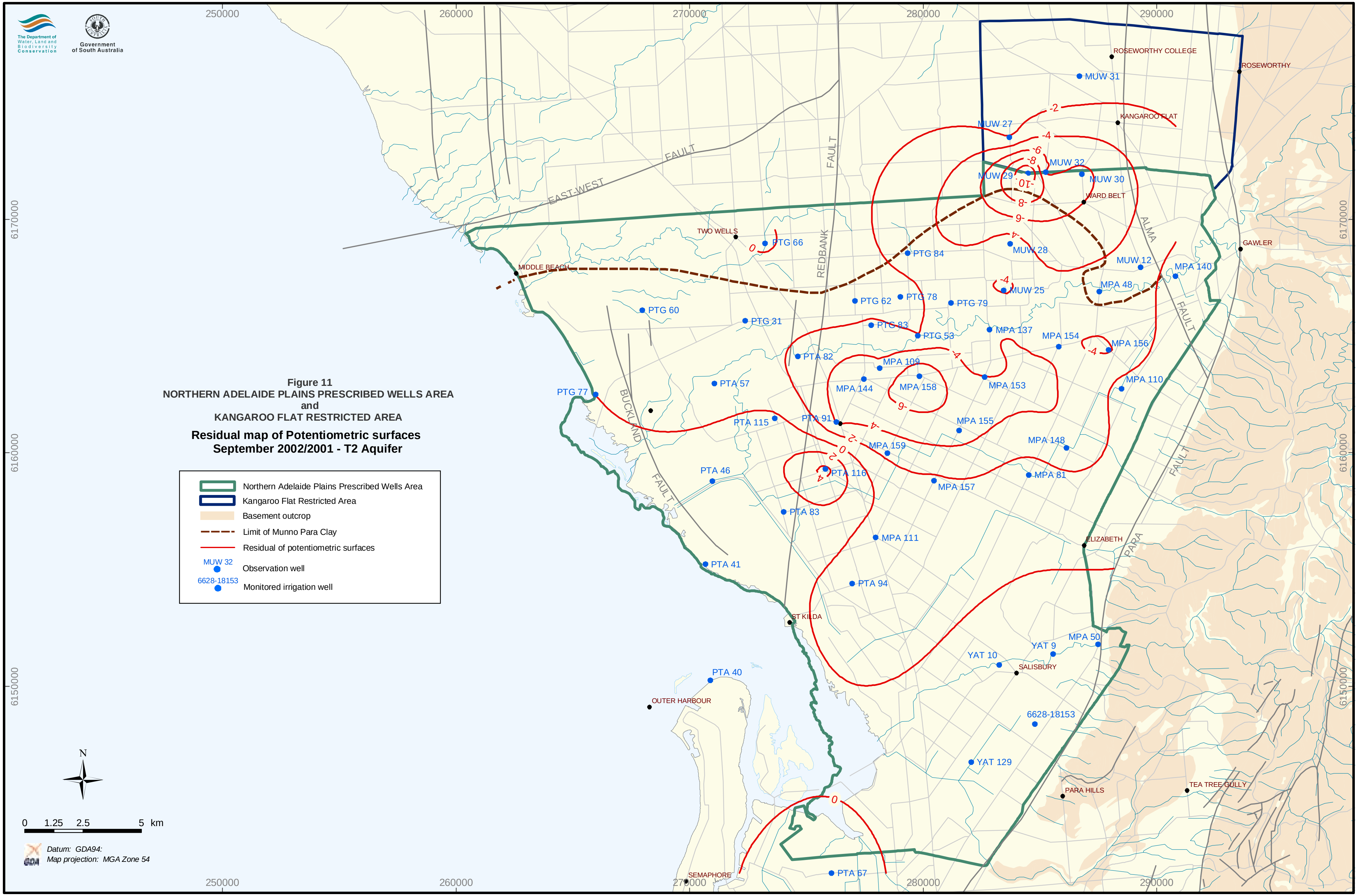

Figure 11
NORTHERN ADELAIDE PLAINS PRESCRIBED WELLS AREA
and
KANGAROO FLAT RESTRICTED AREA
Residual map of Potentiometric surfaces
September 2002/2001 - T2 Aquifer
Northern Adelaide Plains Prescribed Wells Area
Kangaroo Flat Restricted Area
Basement outcrop
Limit of Munno Para Clay
Residual of potentiometric surfaces
MUW 32
Observation well
6628-18153
Monitored irrigation well
The Department of Water, Land and Biodiversity Conservation
Government of South Australia
N
0 1.25 2.5 5 km
Datum: GDA94;
Map projection: MGA Zone 54
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250000
260000
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6150000
ROSEWORTHY COLLEGE
ROSEWORTHY
KANGAROO FLAT
WARD BELT
GAWLER
TWO WELLS
MIDDLE BEACH
ELIZABETH
ST KILDA
SALISBURY
OUTER HARBOUR
PARA HILLS
TEA TREE GULLY
SEMAPHORE
EAST-WEST FAULT
REDBANK FAULT
BUCKLAND FAULT
ALMA FAULT
PARA FAULT
MUW 31
MUW 27
MUW 32
MUW 29
MUW 30
MUW 28
MUW 25
MUW 12
MPA 140
MPA 48
MPA 156
MPA 154
MPA 137
MPA 110
MPA 109
MPA 144
MPA 158
MPA 153
MPA 155
MPA 148
MPA 159
MPA 81
MPA 157
MPA 111
MPA 50
PTG 66
PTG 84
PTG 62
PTG 78
PTG 79
PTG 60
PTG 31
PTG 83
PTG 53
PTG 77
PTA 82
PTA 57
PTA 115
PTA 91
PTA 116
PTA 46
PTA 83
PTA 41
PTA 94
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YAT 10
YAT 129
6628-18153
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-8
-10
0
2
4

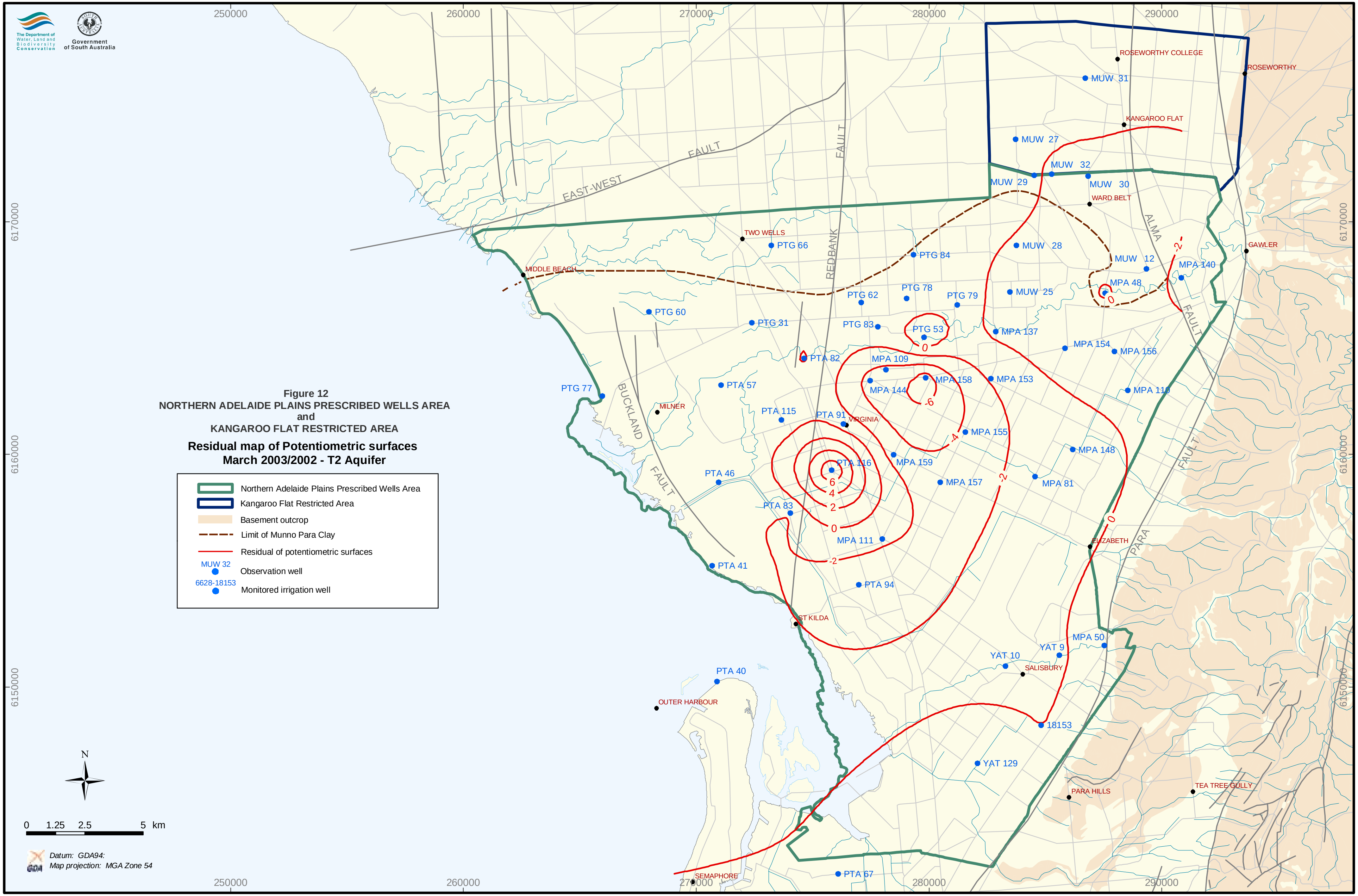

Figure 12
NORTHERN ADELAIDE PLAINS PRESCRIBED WELLS AREA
and
KANGAROO FLAT RESTRICTED AREA

Residual map of Potentiometric surfaces
March 2003/2002 - T2 Aquifer

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6 SALINITY ANALYSIS

A network consisting of Quaternary and Tertiary monitoring wells was established in the early 1960s for salinity monitoring in the area. Mainly production (equipped) wells have been selected for water sampling and salinity examination. The network was monitored regularly until the mid–late 1970s, but since then no regular sampling has been conducted in the area. At present, under regulation of the Water Allocation Plan (section 8, principle 4) all water licensees are required to submit an annual water sample from equipped production wells. Since June 1998 the number of sampled irrigation wells has been increasing each year. This should provide better data enabling a more comprehensive analysis of salinity trends in the area. Also, at the end of the irrigation season 2002/03, Groundwater Group of DWLBC has conducted water sampling of most of the Q4, T1, T2 and T3 – T4 SWL observation wells for full chemical analyses.

Latest available salinity records from January 1999 to June 2003 for monitoring and irrigation wells have been used to generate salinity distribution maps for the T1 and T2 aquifers.

6.1 Quaternary Aquifers

The salinity levels in the uppermost Quaternary Aquifers (Perched, Q1, Q2) are generally high and variable. Salinity varies from 2000 to 18 000 mg/L as you move towards the coast. Salinity decreases with depth and in the Q3 Aquifer ranges between 1500 and 3000 mg/L, with only few above that range and one extremely high (12 200 mg/L) in the Waterloo Corner area. However, in some areas, such as in the vicinity of the Gawler and Little Para Revers, the shallow Quaternary Aquifers (Q1–Q3) have low salinity in the range 400–1500 mg/L. In the perched watertable only four monitoring wells have salinity <2000 mg/L, while the rest of the records show much higher salinity of up to 14 000 mg/L. Monitoring of the perched watertable has been established recently (January 2000) in the area northwest of Virginia. The lower Quaternary Aquifer, Carisbrooke Sand Aquifer (Q4), is present over most of the region. Groundwater salinity within the Q4 Aquifer ranges from 400–1500 mg/L and is occasionally up to 3000–7500 mg/L (Two Wells and Waterloo Corner Area).

6.2 Tertiary Aquifers

The underlying Tertiary sediments contain several aquifer systems that exhibit significant variations in thickness, lithology, salinity distribution and yield. There are two main deep aquifers, the T1 and T2 Aquifers, which act as a primary source of irrigation water in the region.

6.2.1 T1 AQUIFER

The T1 Aquifer is the main source of irrigation water in the area south of Waterloo Corner. In 1999 salinity was analysed for a representative group of 37 T1 Aquifer irrigation wells (Schuster and Gerges, 1999; Gerges, 2001). The outcome of this analysis shows that generally average water salinity in the T1 Aquifer has increased by between 200–800 mg/L, and occasionally up to 6000 mg/L over the last 30 years, particularly near Waterloo Corner.

Latest groundwater salinities obtained from sampling done between 1999 and 2003 for 274 monitoring and irrigation wells have been used to generate a salinity distribution map (Fig. 13). Salinity ranges from ~500–2000 mg/L. Of the 273 sampled wells, 256 wells have salinity less than 2000 mg/L and 225 wells (82%) have salinity less than 1500 mg/L. Seventeen wells that have salinity >2000 and up to 5611 mg/L are located in the vicinity of Waterloo Corner. Corroded casing and leakage of shallow saline groundwater to the T1 Aquifer could be responsible, directly or indirectly, for the wells with highly saline groundwater.

6.2.2 T2 AQUIFER

Salinity levels range from 600 mg/L in the Gawler River area to >3000 mg/L to the north and south. In 1999, salinity was analysed for a representative group of 162 T2 Aquifer irrigation wells (Schuster and Gerges, 1999; Gerges, 2001). The outcome of this analysis shows that, generally, the average water salinity in the T2 Aquifer has increased by 200 mg/L during last 30 years of pumping along some areas of the Gawler River. However, evidence suggests that in some areas negligible salinity increase has occurred (Gerges, 2001).

The salinity distribution map for the T2 Aquifer (Fig. 14) was generated using the latest groundwater salinities collected between 1999 and 2003. Salinities range mostly from ~500–2000 mg/L. Of the 713 sampled wells, 657 wells have salinity less than 2000 mg/L and 559 wells (78%) have salinity less than 1500 mg/L. Only 56 wells have salinity greater than 2000 mg/L, which is less than 8%.

6.2.3 T3 AND T4 AQUIFERS

Distribution of groundwater salinity within the two deep Tertiary Aquifers, known as T3 and T4, is not well known for most of the NAP area. Information available indicates that those Tertiary Aquifers contain groundwater of very high salinity of up to 80 000 mg/L, which is unsuitable for any irrigation purpose.

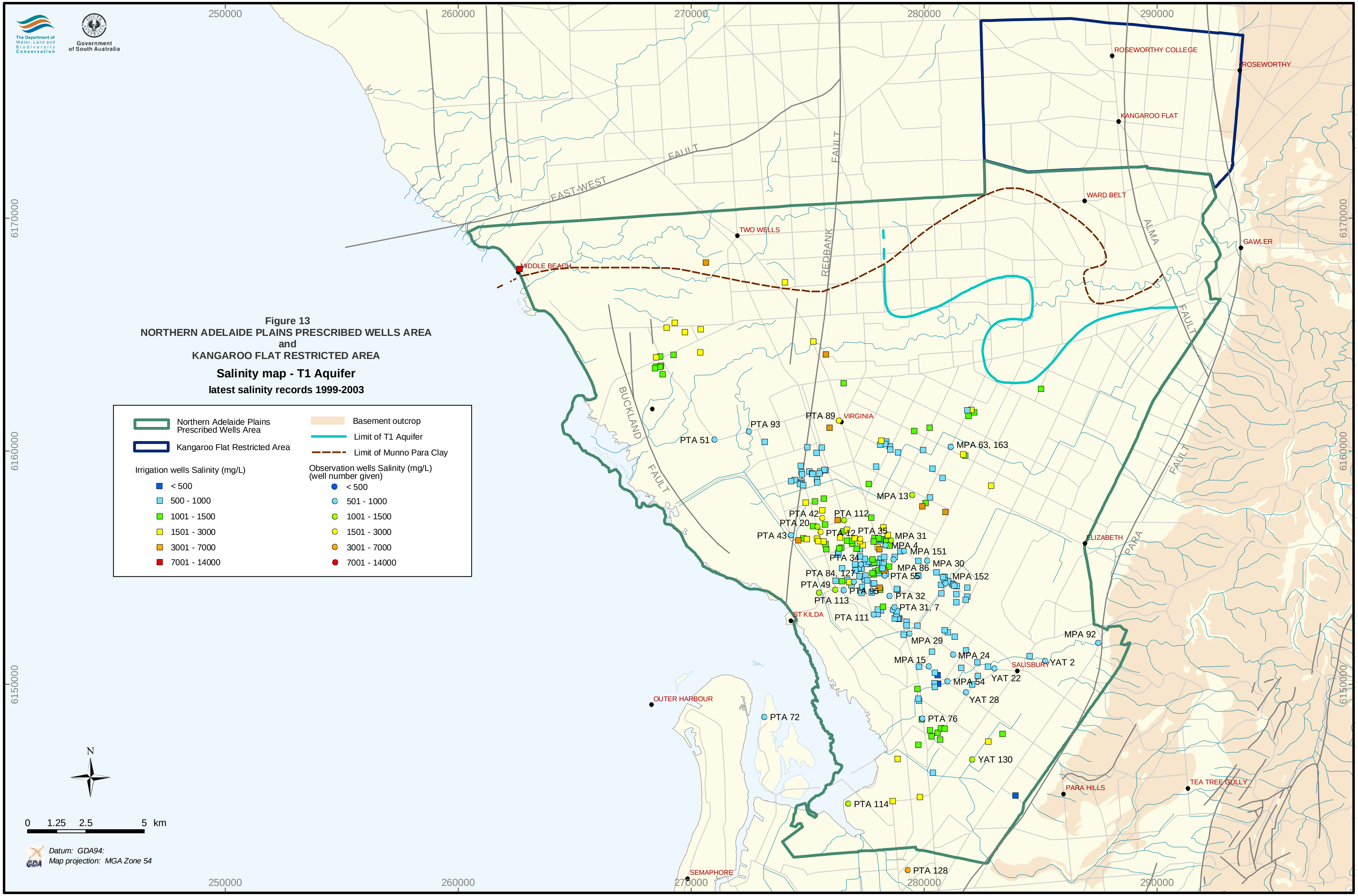

Figure 13
NORTHERN ADELAIDE PLAINS PRESCRIBED WELLS AREA
and
KANGAROO FLAT RESTRICTED AREA
Salinity map - T1 Aquifer
latest salinity records 1999-2003

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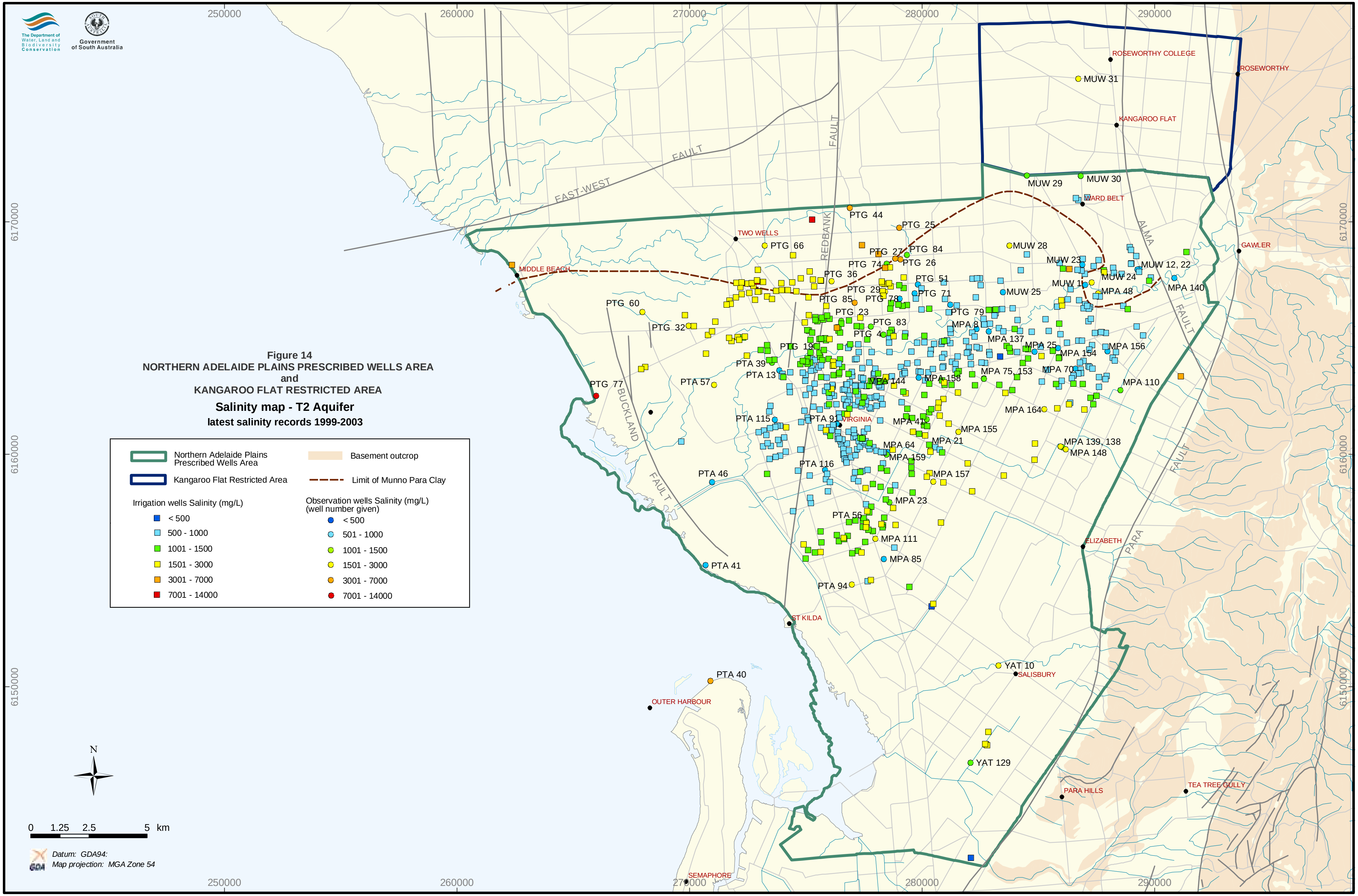

Figure 14
NORTHERN ADELAIDE PLAINS PRESCRIBED WELLS AREA
and
KANGAROO FLAT RESTRICTED AREA
Salinity map - T2 Aquifer
latest salinity records 1999-2003

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7 CONCLUSIONS

Most of the monitoring wells in the Quaternary and Tertiary Aquifers exhibited a decline in water levels after the 2001-02 irrigation season.

Analyses of the monitoring data over the period September 2001-02 show that the average decline in water levels was 0.14, 0.31, 0.18 and 0.32 m/y for the perched, Q1, Q2 and Q3 aquifers respectively. Only Carisbrooke Sand Aquifer (Q4) recorded a rise in water level over the same period, on average 0.01 m/y. However, during the period March 2002-03, an even larger number of monitoring wells in all Quaternary Aquifers recorded a decline in water levels with an average decline of 0.03, 0.14, 0.28, 0.36 and 0.02 m/y for the perched and Q1-Q4 aquifers respectively.

The residual maps of potentiometric surfaces September 2002/01 show that the potentiometric surfaces in September 2002 have declined in most of the area where there is extraction from the T1 and T2 Aquifers. However, the largest decline was recorded in the Kangaroo Flat area (extracting from the T2 Aquifer), forming for the first time a distinctive cone of depression during the winter season.

The residual maps of potentiometric surfaces March 2003/02 show that the potentiometric surfaces in March 2003 have declined in most of the area where there is extraction from the two most utilised Tertiary aquifers. However, the potentiometric surface recorded a recovery of about 2m in the area of the Waterloo Corner cone of depression where groundwater is being extracted from the T1 aquifer.

Analysis of salinity trends could not be done for this report as no regular groundwater sampling was conducted since mid-late 1970s. Since June 1998, the number of sampled irrigation wells has been increasing each year. This should provide better data enabling a more comprehensive analysis of salinity trends in the area that will be presented in the future reports.

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9 APPENDIX A

STRATIGRAPHY AND HYDROSTRATIGRAPHY

Stratigraphy and hydrostratigraphy of the Northern Adelaide Plains

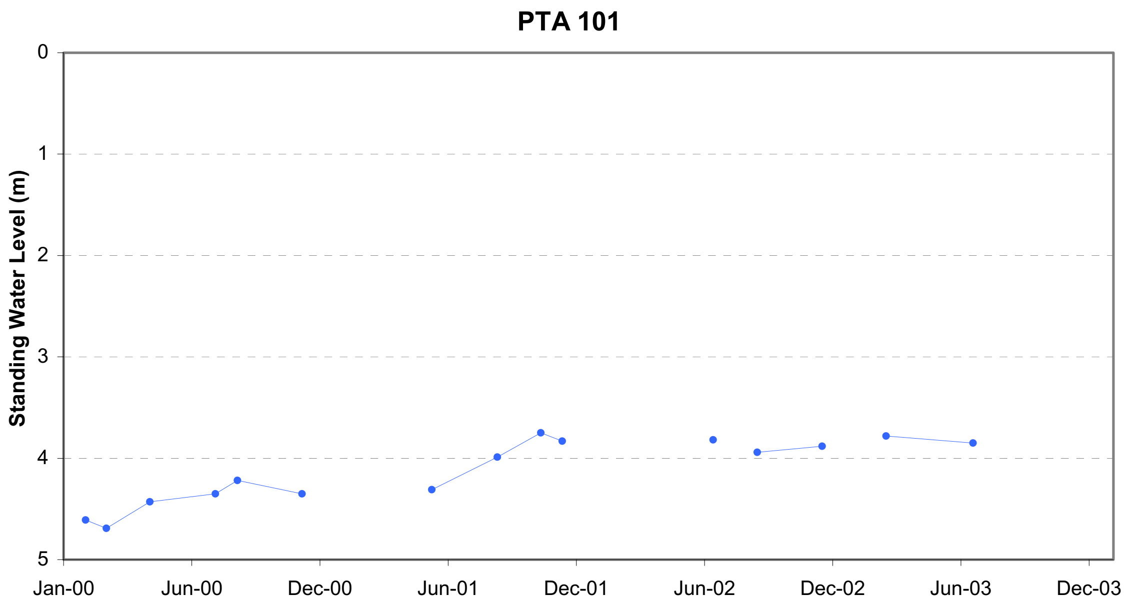
AGE		STRATIGRAPHY			HYDROSTRATIGRAPHY		
		Unit		Lithology	Unit		Description
Quaternary	Holocene	St Kilda Formation		Shallow marine deposits including shell beds, sands and clay (coastal areas).	**Unconfined Aquifer**		**Unconfined aquifer;** groundwater salinity at least equal to seawater.
	Late Pleistocene	Pooraka Clay		Alluvial clays, silts and sands.	**Aquitard**		Confining bed.
		Glanville Formation		Shallow marine deposits including sand and shell beds (adjacent to coast).	**Aquifer**		Contains highly saline groundwater.
	Late to Early Pleistocene	Hindmarsh Clay		Fluviatile and alluvial clays, silts, sands and gravels in outwash areas. Occurs over almost whole of basin.	**Aquitard** **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.
	Early Pliocene	Croydon facies (member)		Silt, bryozoal and glauconitic		**Aquitard**	Semi-confining aquitard where present
	Middle Miocene	Port Willunga Formation (upper part)	Undifferentiated Tertiary Sediments	Fossiliferous sandy limestone, fine grained, occurring south of Two Wells.		**T1b**	Confined aquifer; developed mainly for irrigation. Salinity ranges between 500–2000 mg/L.
		Munno Para Clay (member)		Blue-grey, sandy, shelly clay, missing in some coastal areas and north of Two Wells.	**Aquitard**		Confining bed to the T2 Aquifer.
	Early Miocene to Late Eocene	Port Willunga Formation (lower part)		Undifferentiated Tertiary sediments, mainly continental. White quartz sand and gravel in places with ferruginous matrix. Fluvial and alluvial. – Marginal marine influence. Between Alma and Para fault. Port Willunga Formation equivalent.	**T2 Aquifer**		Confined aquifer. Considered as continuation of the T2 Aquifer.
				Fossiliferous limestone with sands and sandstones, grading to a dense siliceous unit towards the base.			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 clay.	**Aquitard** **T3 Aquifer**		**Aquitard;** Confining bed; Chinaman Gully sands–aquifer.
		Blanche Point Formation		Marls, siltstone, limestone, fossiliferous and glauconitic.	**Aquitard**		Generally confining bed, but may be a low-grade aquifer in some areas.
	Late to 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**		

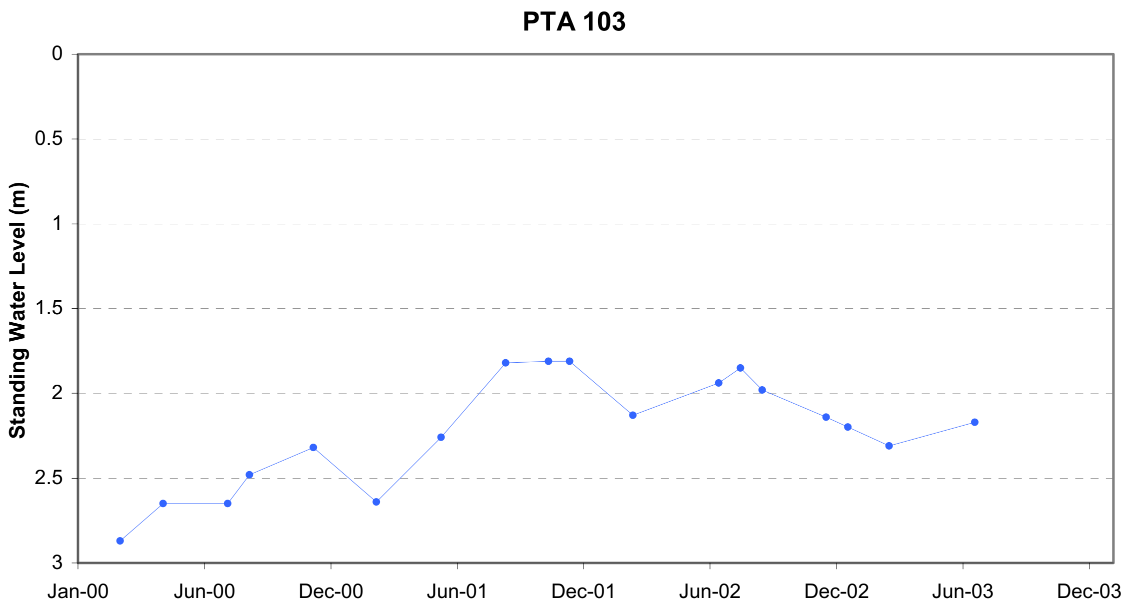
10 APPENDIX B

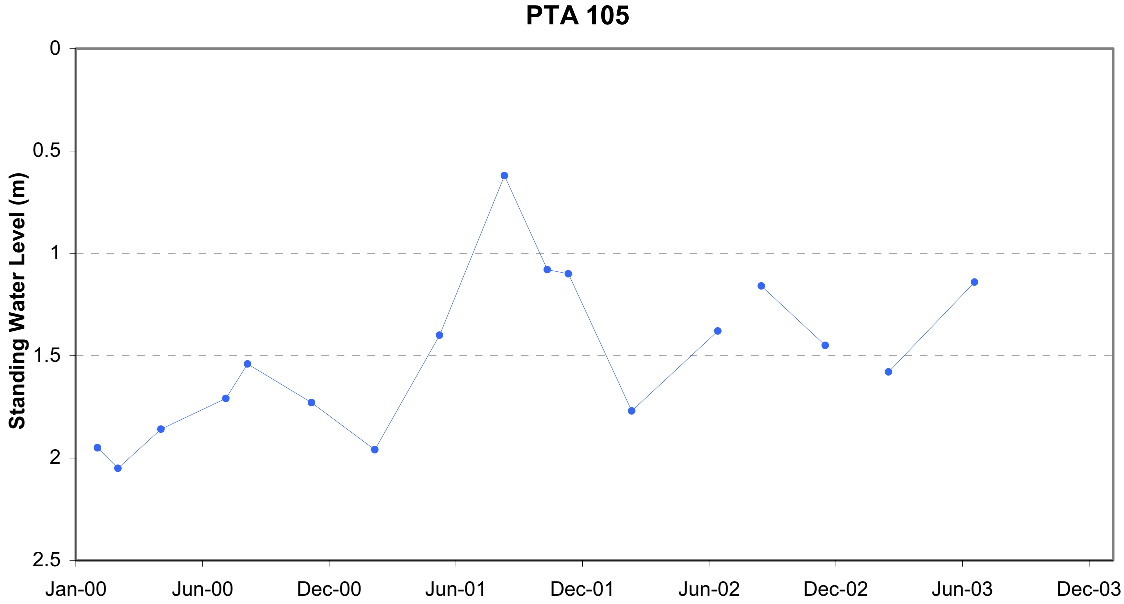


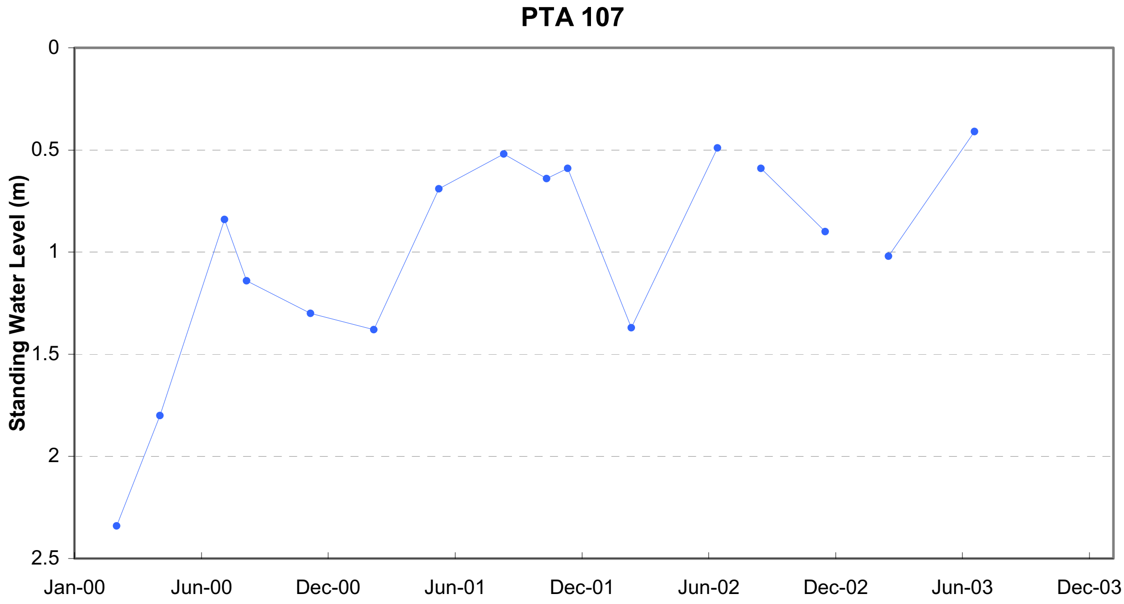
GROUNDWATER HYDROGRAPHS

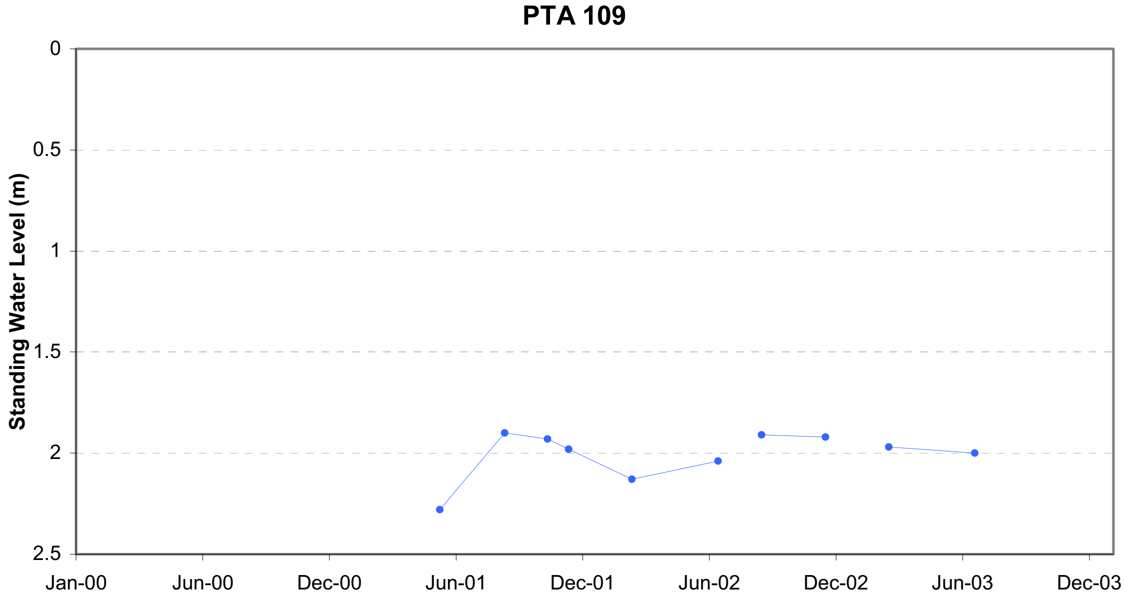
Perched Aquifer hydrographs



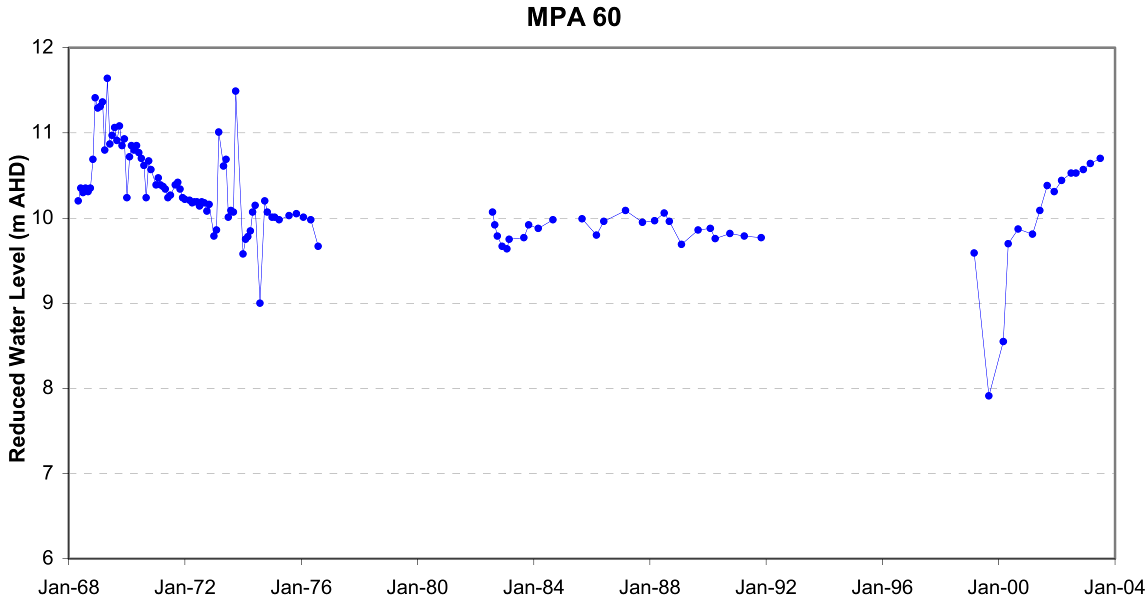


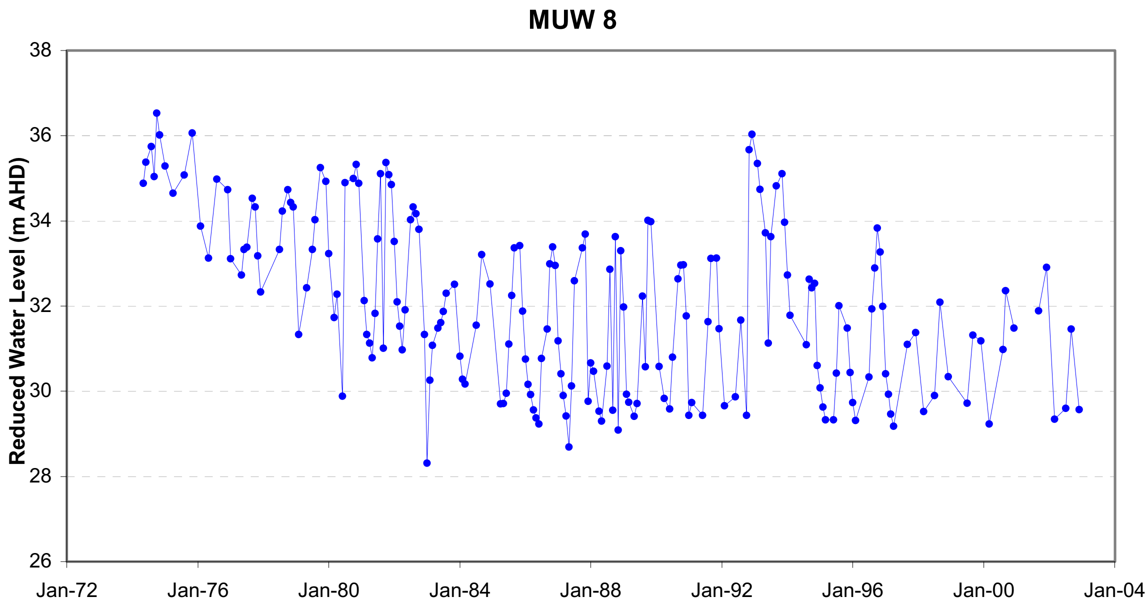

PTA 105
Standing Water Level (m)
0
0.5
1
1.5
2
2.5
Jan-00
Jun-00
Dec-00
Jun-01
Dec-01
Jun-02
Dec-02
Jun-03
Dec-03

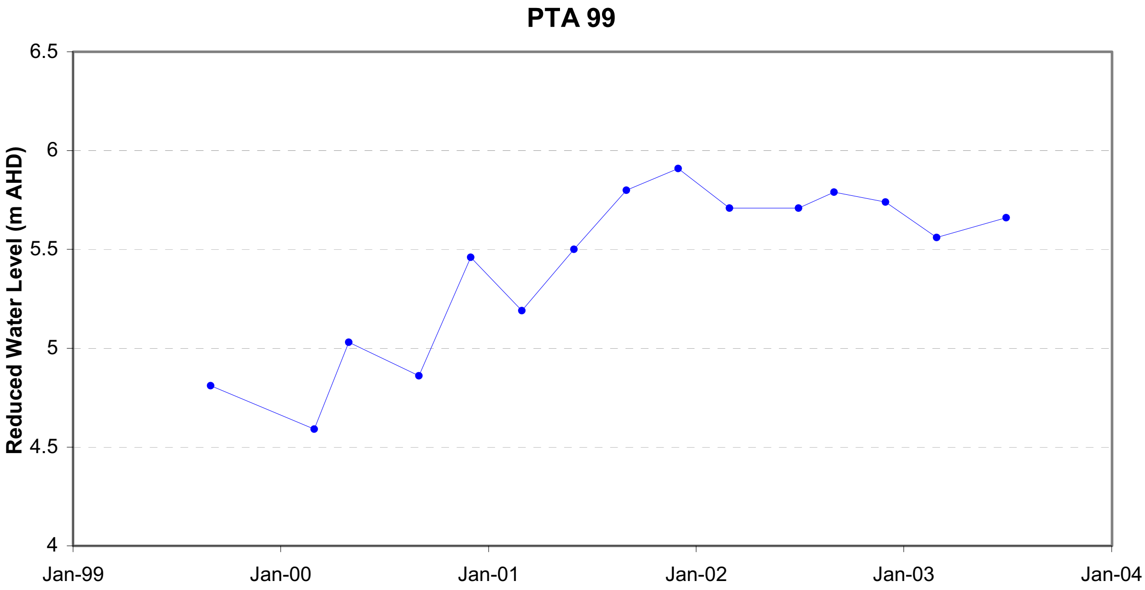

PTA 107
Standing Water Level (m)
0
0.5
1
1.5
2
2.5
Jan-00
Jun-00
Dec-00
Jun-01
Dec-01
Jun-02
Dec-02
Jun-03
Dec-03

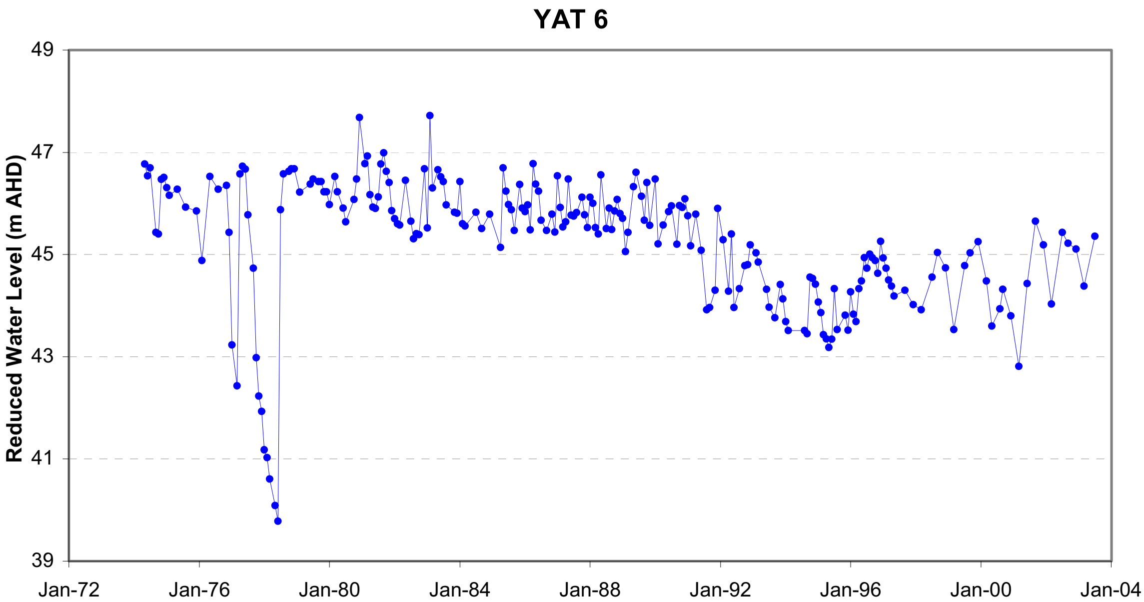

PTA 109
Standing Water Level (m)
0
0.5
1
1.5
2
2.5
Jan-00
Jun-00
Dec-00
Jun-01
Dec-01
Jun-02
Dec-02
Jun-03
Dec-03

Q1 Aquifer hydrographs

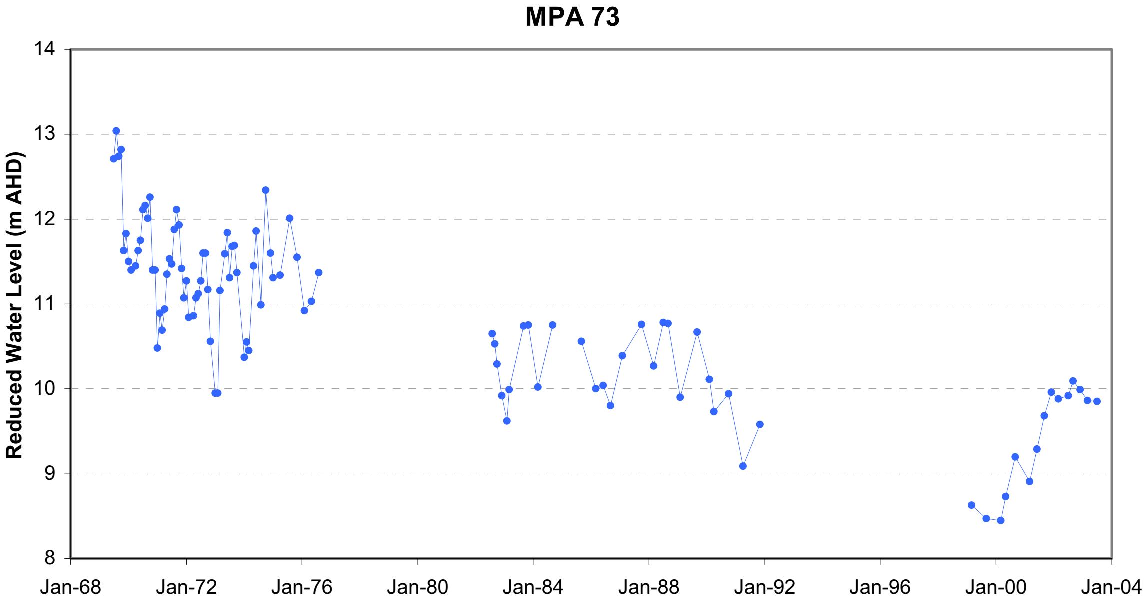


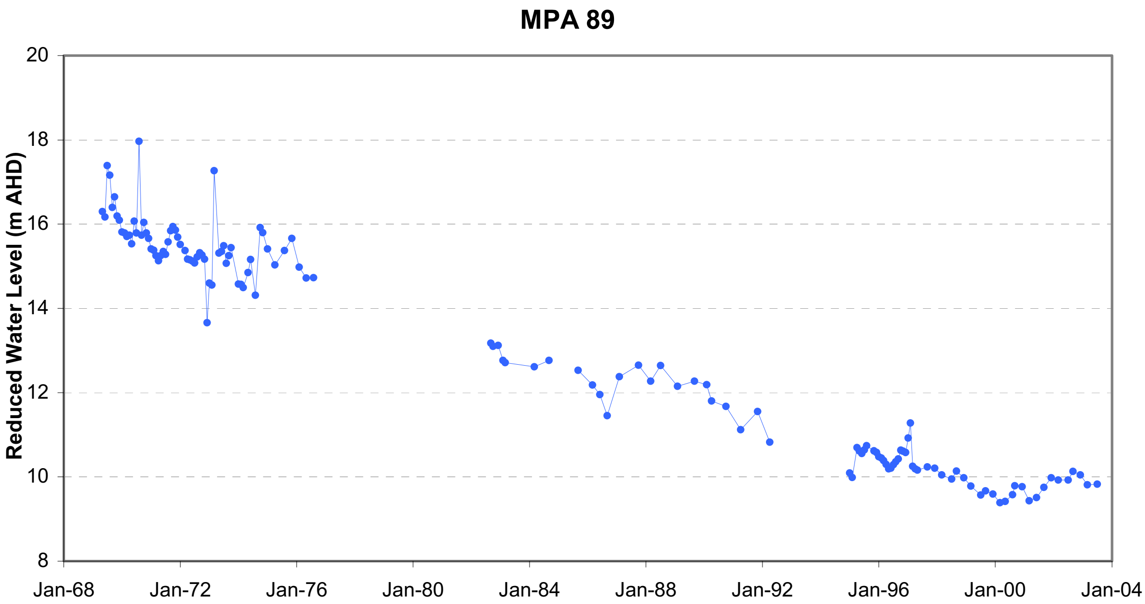


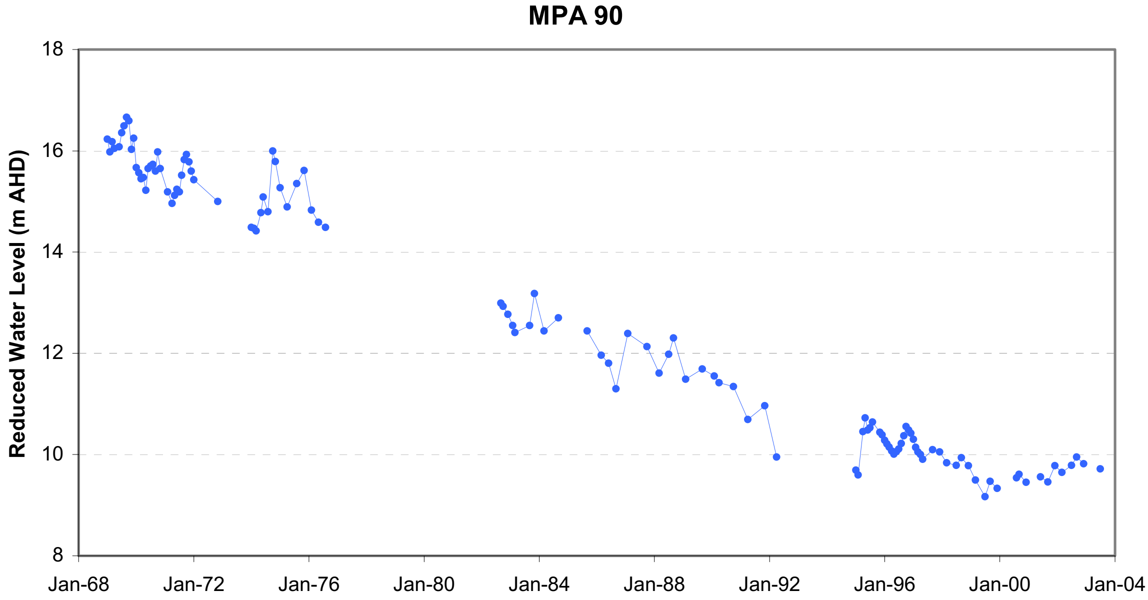

PTA 99
Reduced Water Level (m AHD)
6.5
6
5.5
5
4.5
4
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04

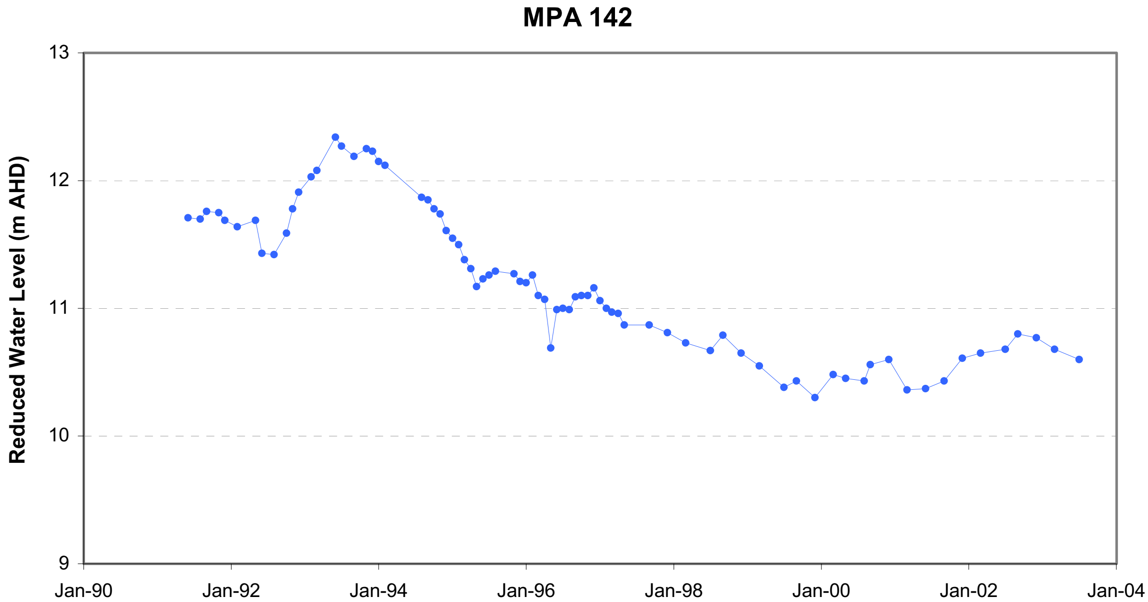

YAT 6
Reduced Water Level (m AHD)
49
47
45
43
41
39
Jan-72
Jan-76
Jan-80
Jan-84
Jan-88
Jan-92
Jan-96
Jan-00
Jan-04

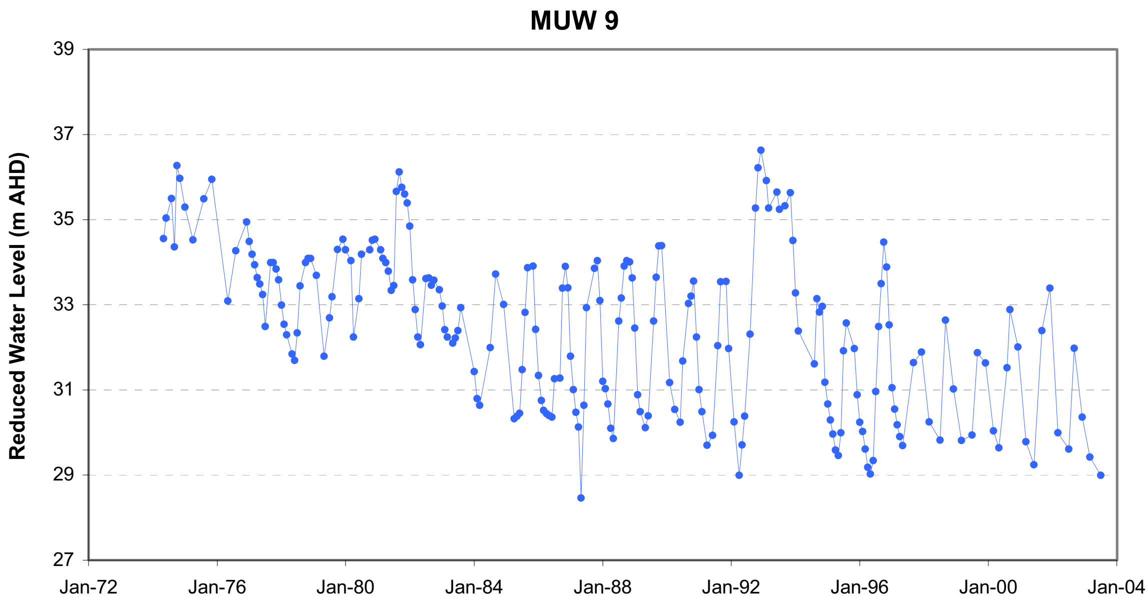
Q2 Aquifer hydrographs

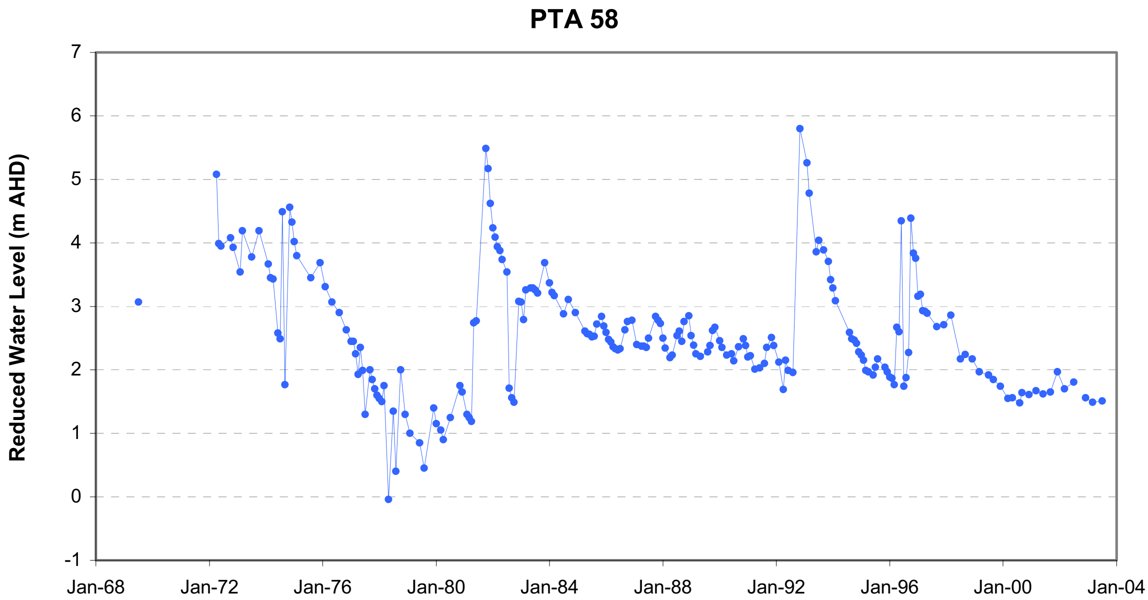




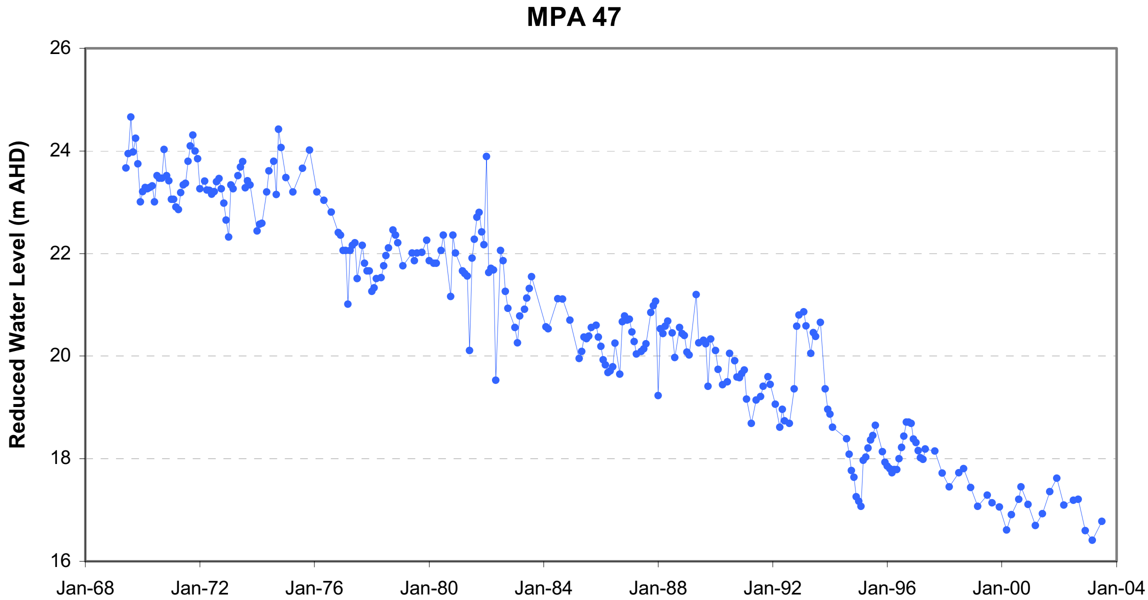

MPA 90
Reduced Water Level (m AHD)
18
16
14
12
10
8
Jan-68
Jan-72
Jan-76
Jan-80
Jan-84
Jan-88
Jan-92
Jan-96
Jan-00
Jan-04

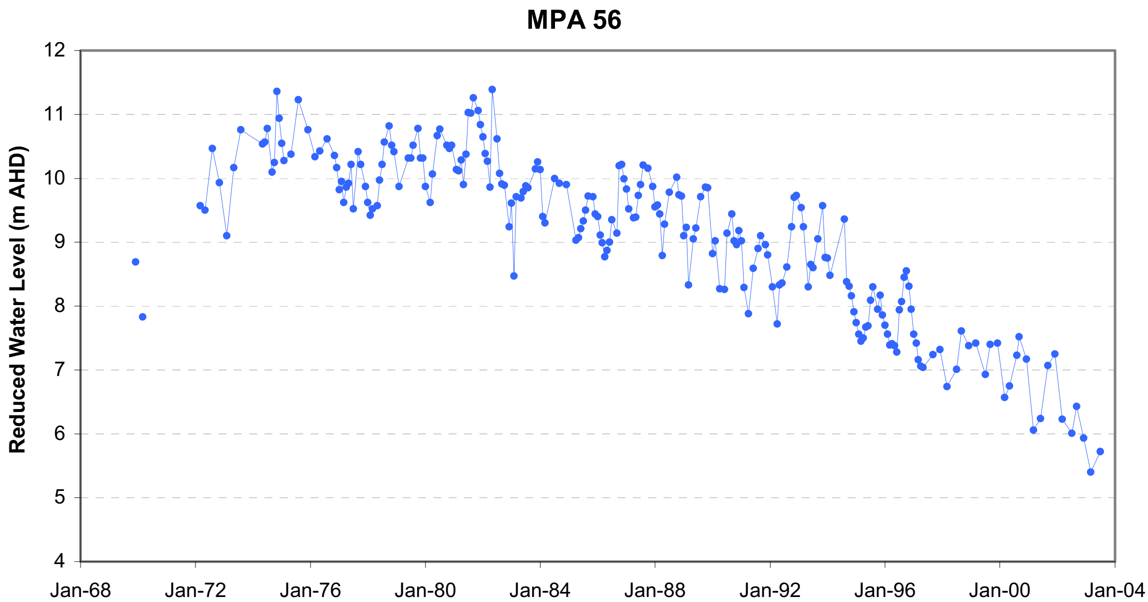

MPA 142
Reduced Water Level (m AHD)
13
12
11
10
9
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Jan-00
Jan-02
Jan-04

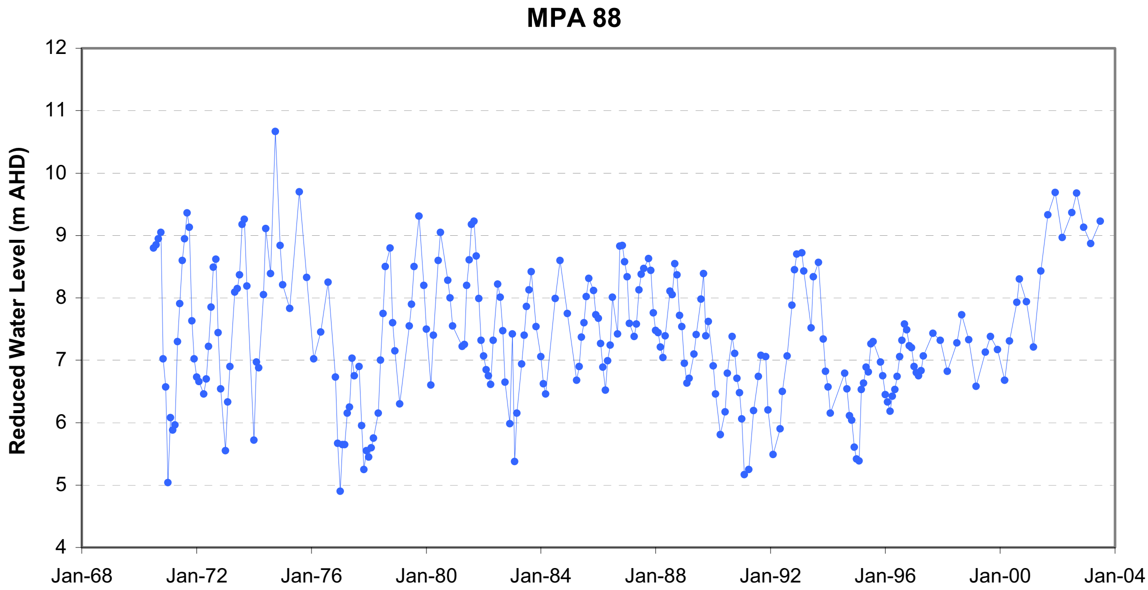

MUW 9
Reduced Water Level (m AHD)
39
37
35
33
31
29
27
Jan-72
Jan-76
Jan-80
Jan-84
Jan-88
Jan-92
Jan-96
Jan-00
Jan-04

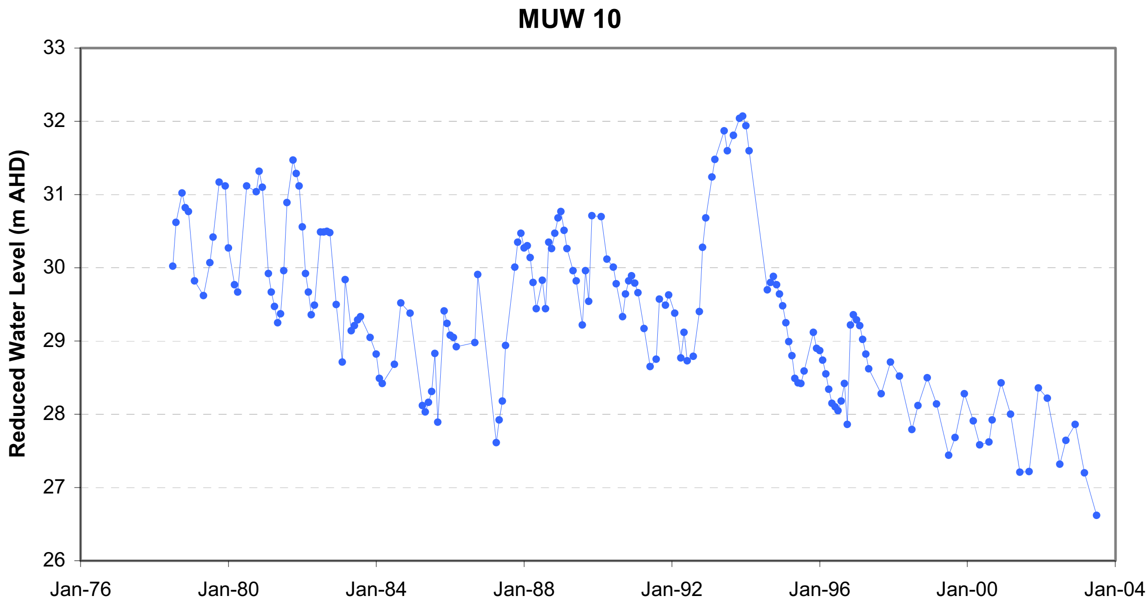

PTA 58
Reduced Water Level (m AHD)
7
6
5
4
3
2
1
0
-1
Jan-68
Jan-72
Jan-76
Jan-80
Jan-84
Jan-88
Jan-92
Jan-96
Jan-00
Jan-04

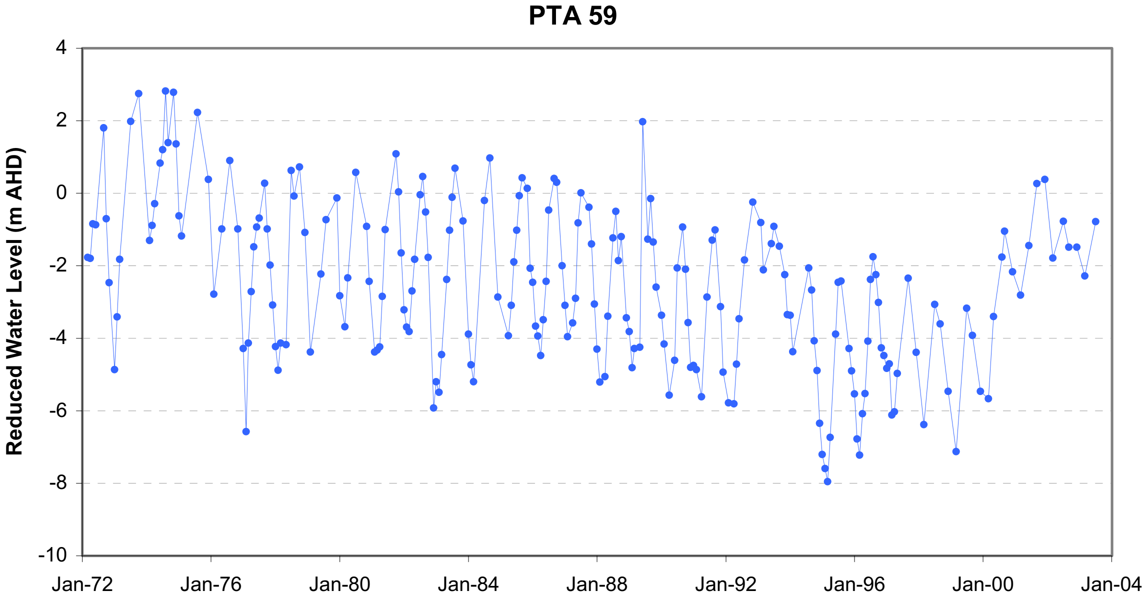
Q3 Aquifer hydrographs



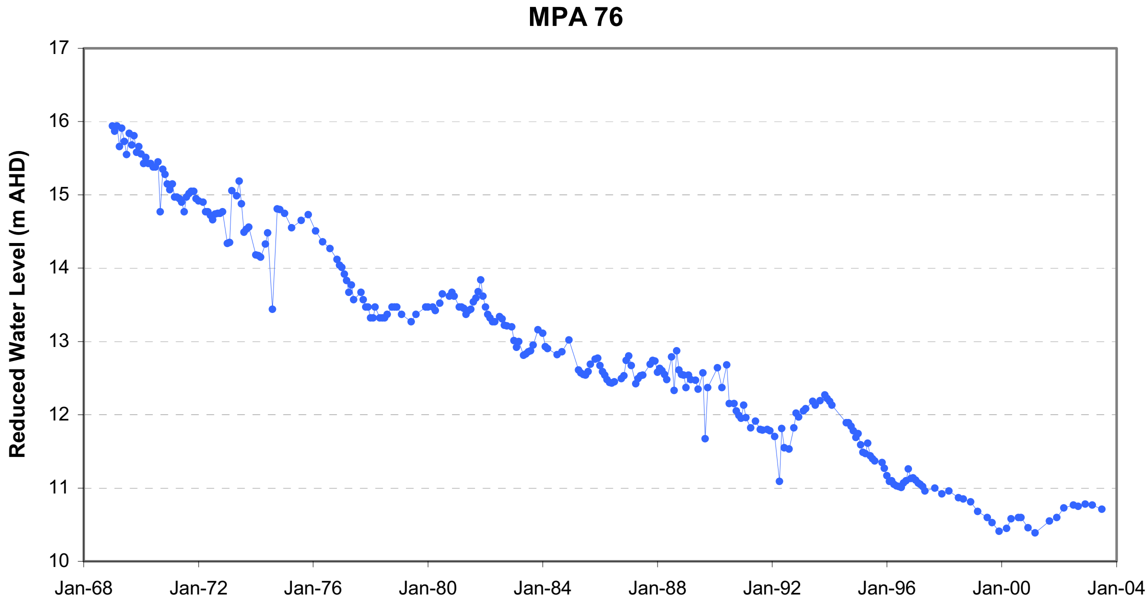


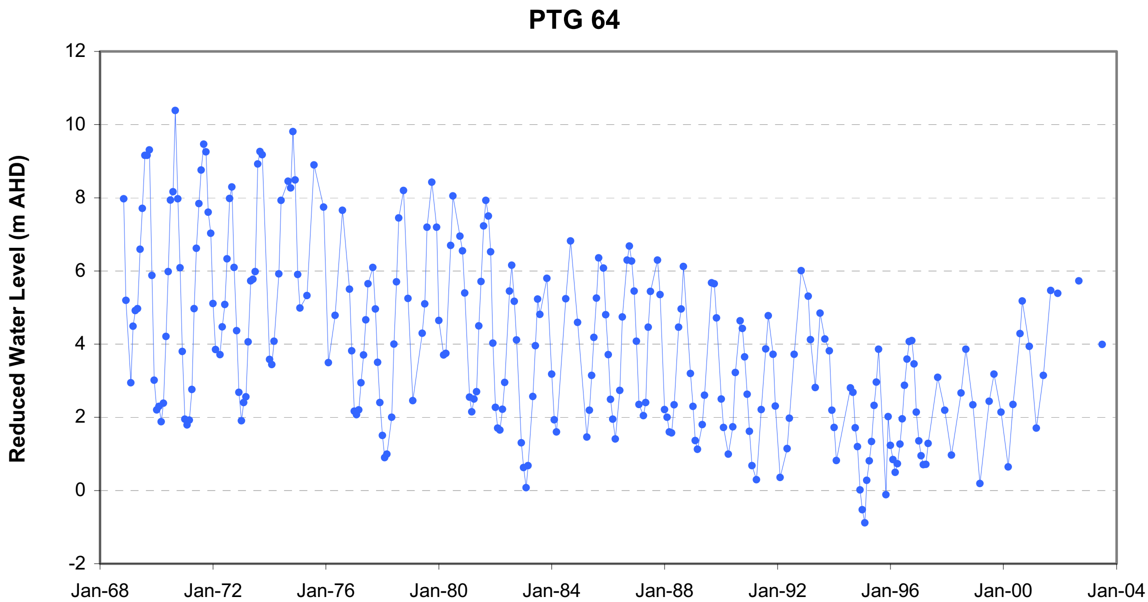

MPA 88
Reduced Water Level (m AHD)
12
11
10
9
8
7
6
5
4
Jan-68
Jan-72
Jan-76
Jan-80
Jan-84
Jan-88
Jan-92
Jan-96
Jan-00
Jan-04

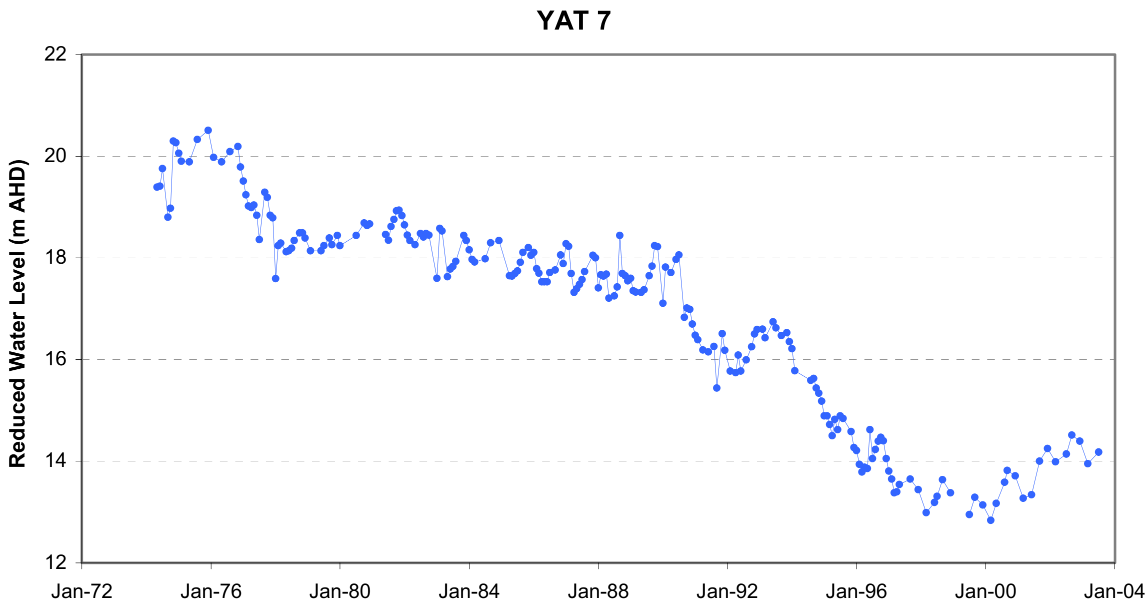

MUW 10
Reduced Water Level (m AHD)
33
32
31
30
29
28
27
26
Jan-76
Jan-80
Jan-84
Jan-88
Jan-92
Jan-96
Jan-00
Jan-04


PTA 59
Reduced Water Level (m AHD)
4
2
0
-2
-4
-6
-8
-10
Jan-72
Jan-76
Jan-80
Jan-84
Jan-88
Jan-92
Jan-96
Jan-00
Jan-04

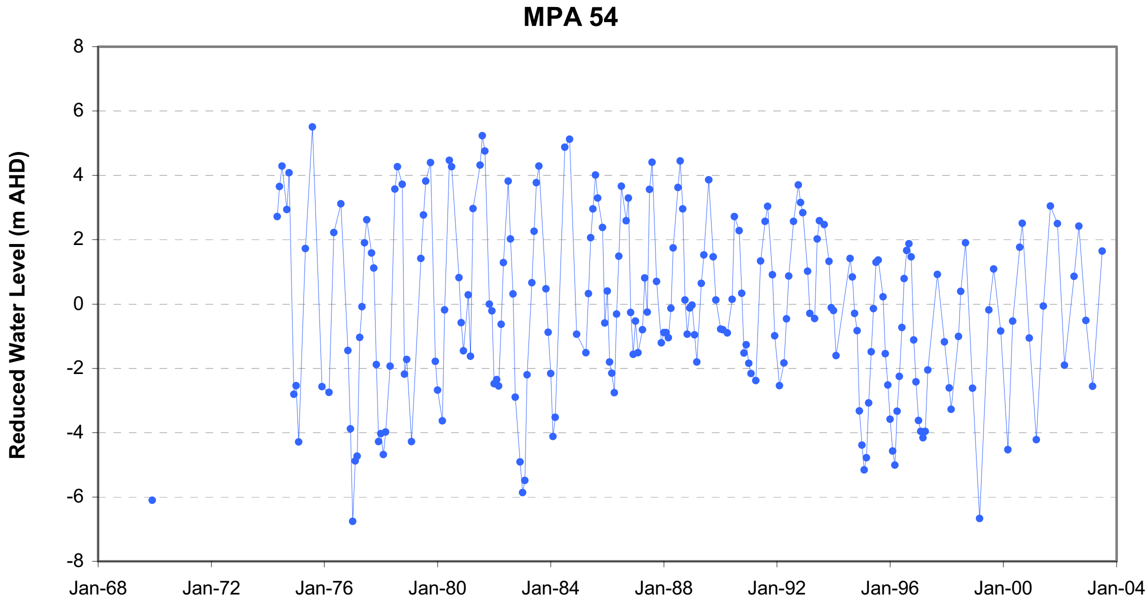
Q4 Aquifer hydrographs

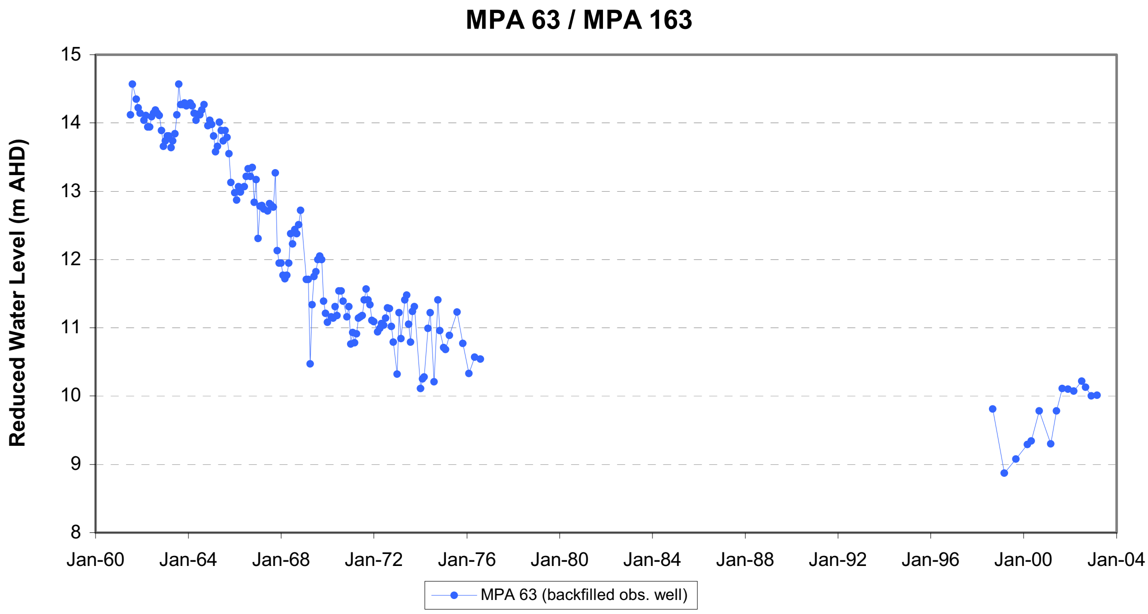


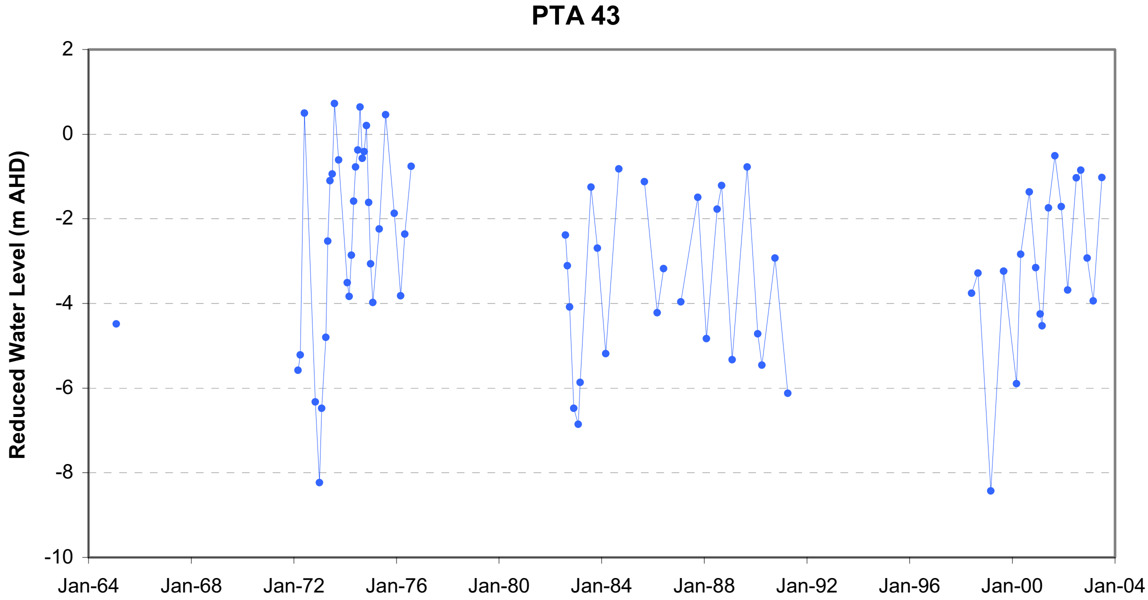


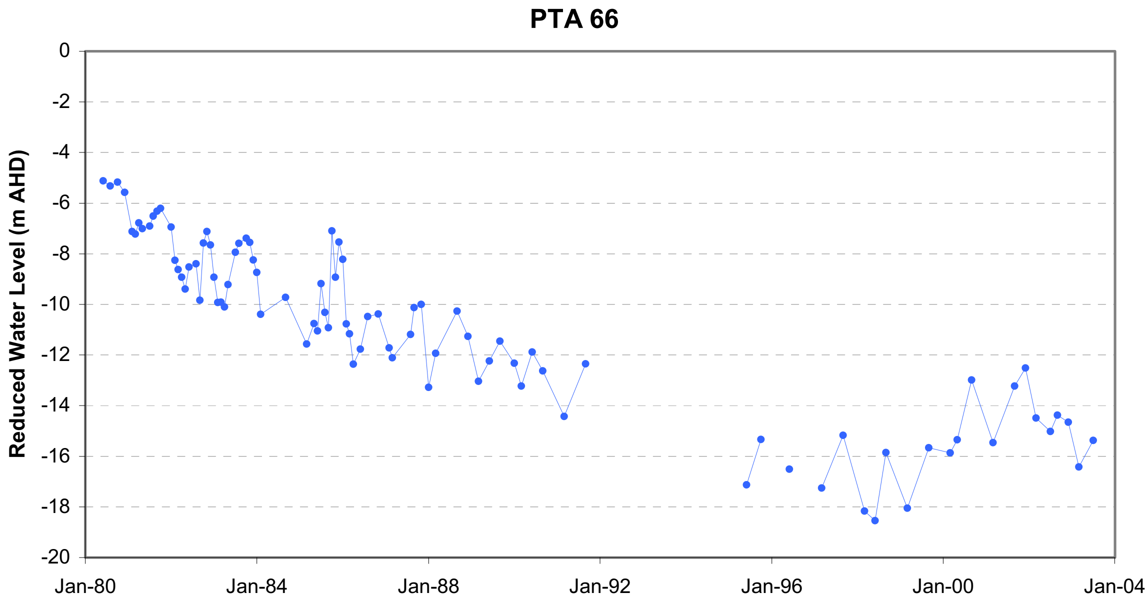

YAT 7
Reduced Water Level (m AHD)
22
20
18
16
14
12
Jan-72
Jan-76
Jan-80
Jan-84
Jan-88
Jan-92
Jan-96
Jan-00
Jan-04

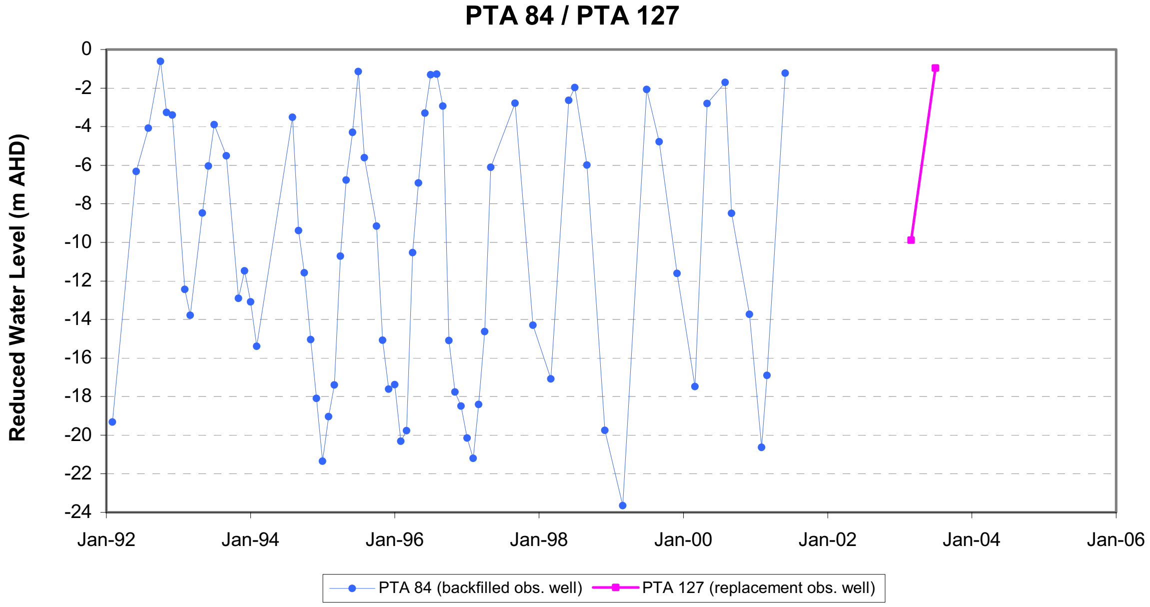
T1 Aquifer hydrographs



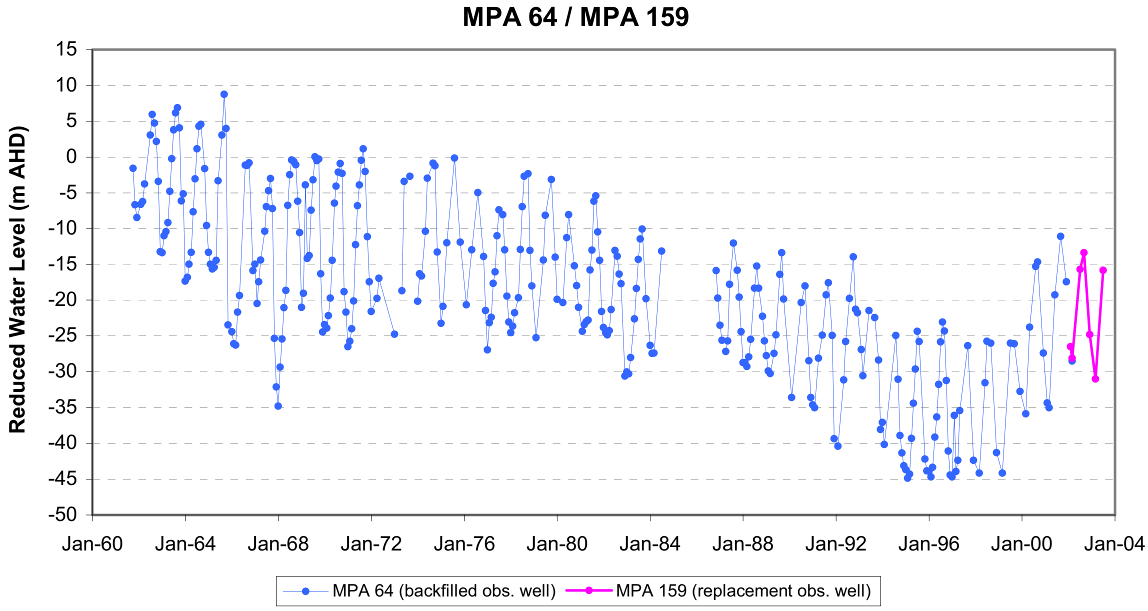


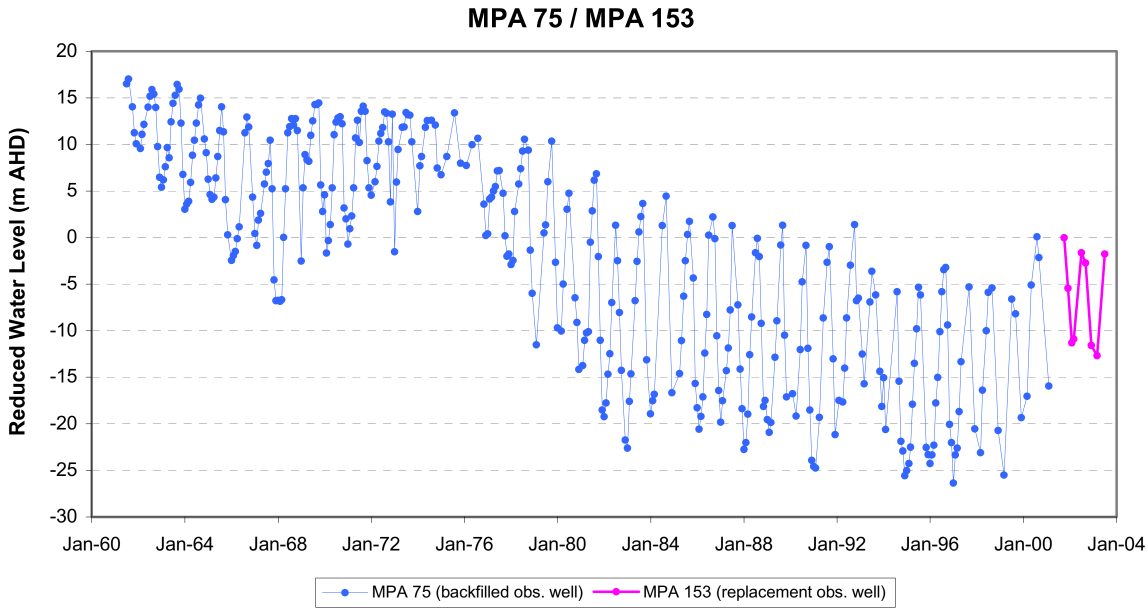

PTA 43
Reduced Water Level (m AHD)
2
0
-2
-4
-6
-8
-10
Jan-64
Jan-68
Jan-72
Jan-76
Jan-80
Jan-84
Jan-88
Jan-92
Jan-96
Jan-00
Jan-04

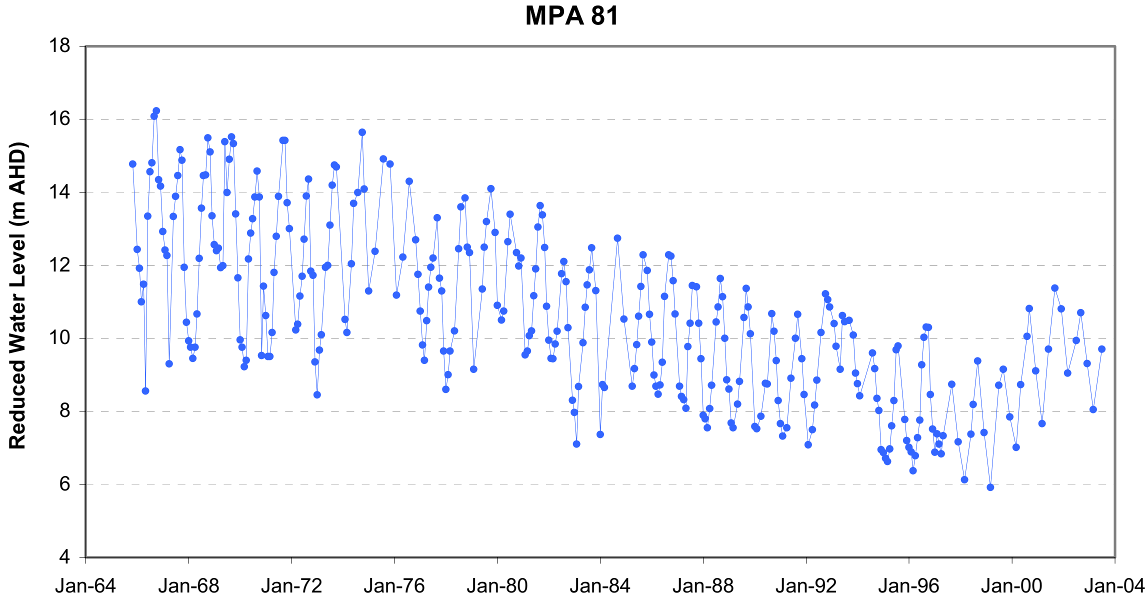

PTA 66
Reduced Water Level (m AHD)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
Jan-80
Jan-84
Jan-88
Jan-92
Jan-96
Jan-00
Jan-04


PTA 84 / PTA 127
Reduced Water Level (m AHD)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
-24
Jan-92
Jan-94
Jan-96
Jan-98
Jan-00
Jan-02
Jan-04
Jan-06
PTA 84 (backfilled obs. well)
PTA 127 (replacement obs. well)

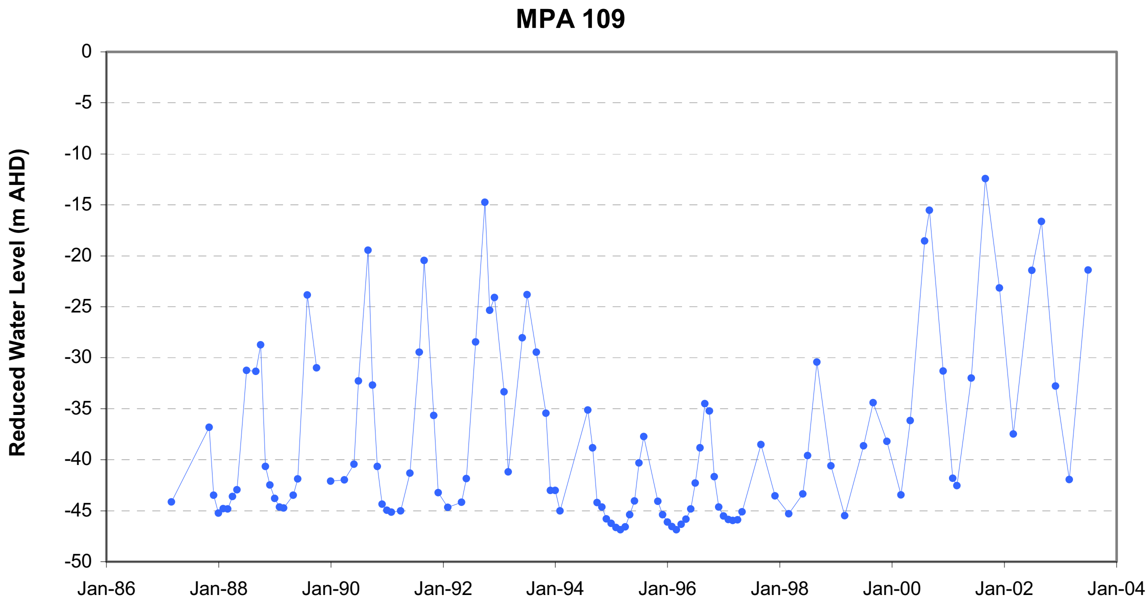
T2 Aquifer hydrographs



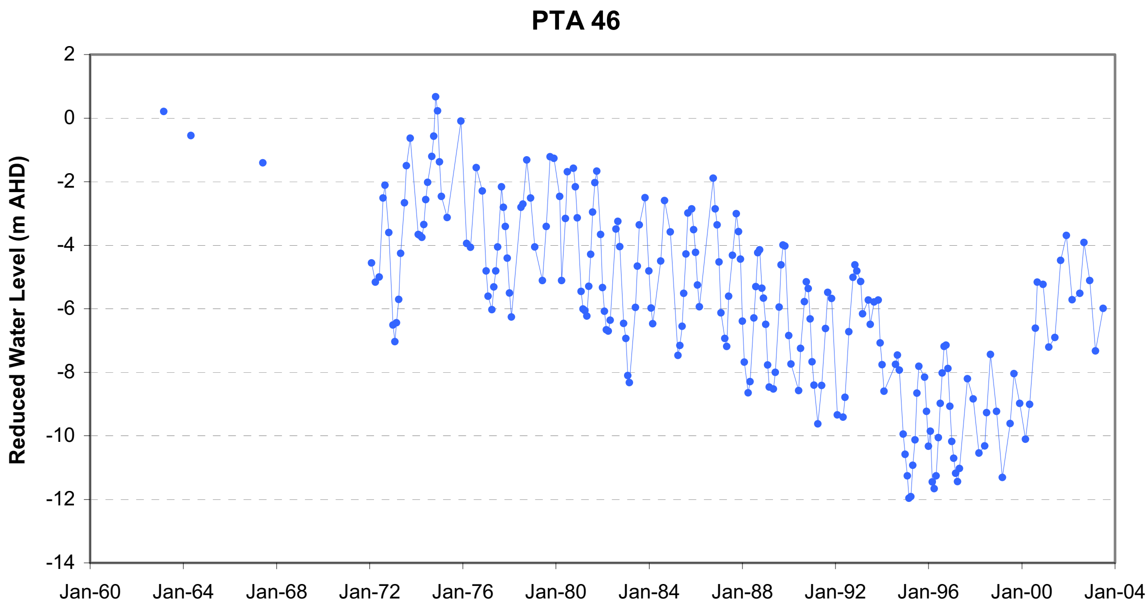


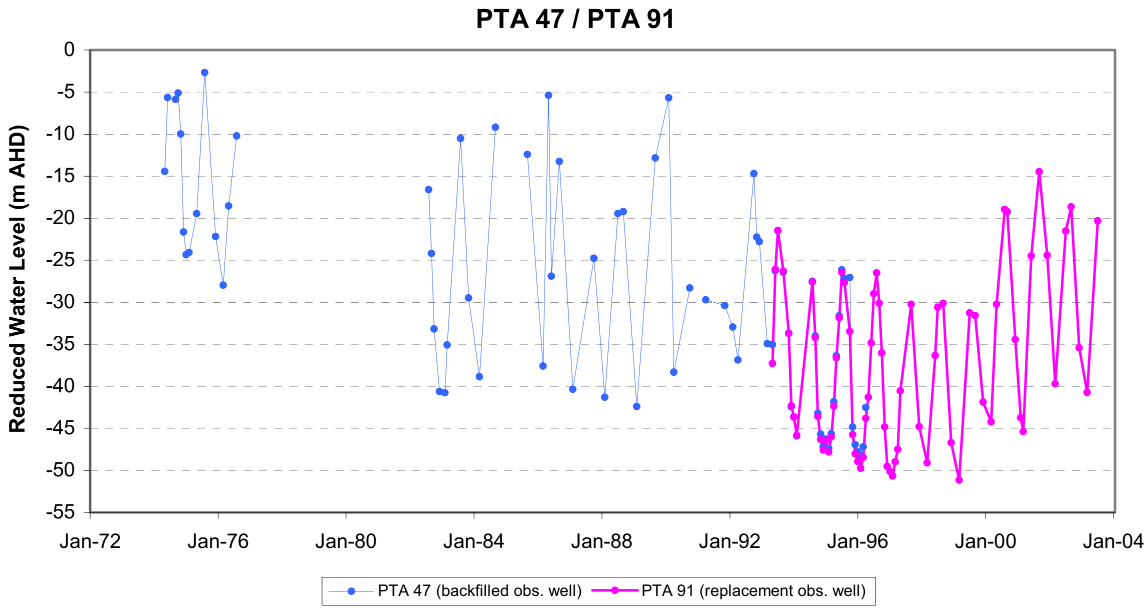


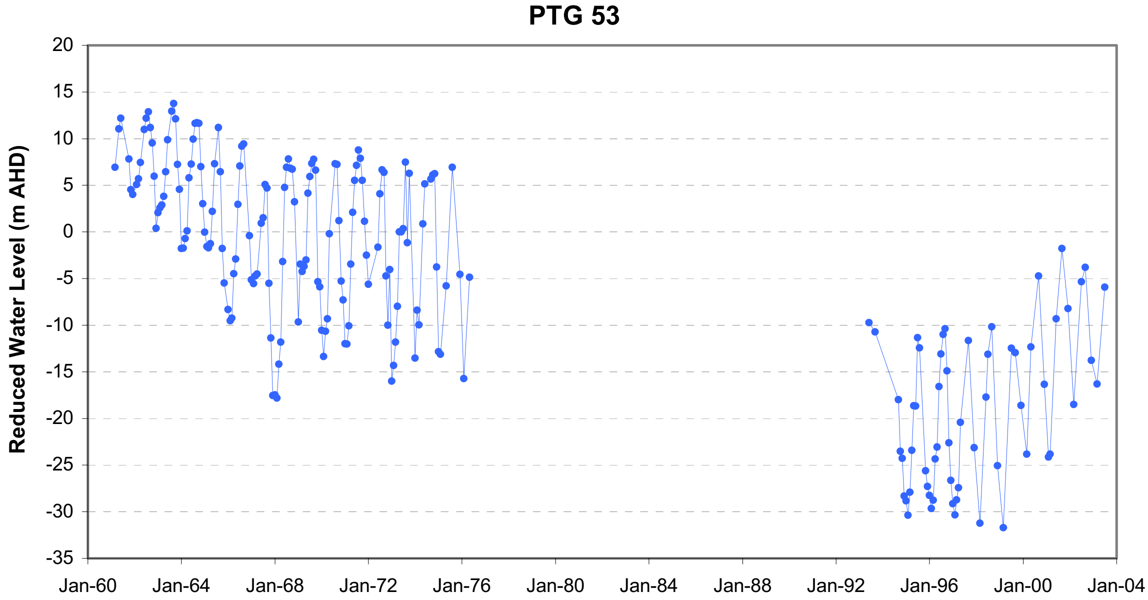
MPA 81
Reduced Water Level (m AHD)
18
16
14
12
10
8
6
4
Jan-64
Jan-68
Jan-72
Jan-76
Jan-80
Jan-84
Jan-88
Jan-92
Jan-96
Jan-00
Jan-04

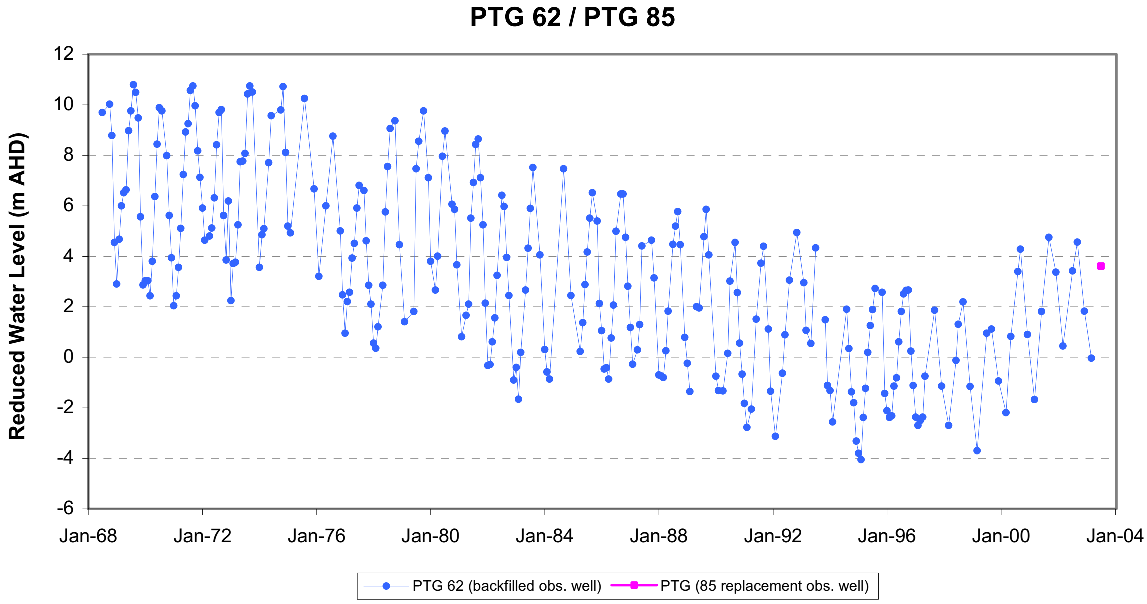


MPA 109
Reduced Water Level (m AHD)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Jan-00
Jan-02
Jan-04


PTA 46
Reduced Water Level (m AHD)
2
0
-2
-4
-6
-8
-10
-12
-14
Jan-60
Jan-64
Jan-68
Jan-72
Jan-76
Jan-80
Jan-84
Jan-88
Jan-92
Jan-96
Jan-00
Jan-04


PTA 47 / PTA 91
Reduced Water Level (m AHD)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
Jan-72
Jan-76
Jan-80
Jan-84
Jan-88
Jan-92
Jan-96
Jan-00
Jan-04
PTA 47 (backfilled obs. well)
PTA 91 (replacement obs. well)


PTG 53
Reduced Water Level (m AHD)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
Jan-60
Jan-64
Jan-68
Jan-72
Jan-76
Jan-80
Jan-84
Jan-88
Jan-92
Jan-96
Jan-00
Jan-04


PTG 62 / PTG 85
Reduced Water Level (m AHD)
12
10
8
6
4
2
0
-2
-4
-6
Jan-68
Jan-72
Jan-76
Jan-80
Jan-84
Jan-88
Jan-92
Jan-96
Jan-00
Jan-04
PTG 62 (backfilled obs. well)
PTG (85 replacement obs. well)