KANGAROO FLAT PWA GROUNDWATER FLOW MODEL

DWLBC
Report

2002/33

The Department of
Water, Land and
Biodiversity
Conservation

Government
of South Australia

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Kwadwo Osei-Bonsu

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Knowledge and Information Division
Department of Water, Land and Biodiversity Conservation
Grenfell Centre, 25 Grenfell Street, Adelaide
GPO Box 2834, Adelaide SA 5001

Telephone	+61 8 8463 6949
Fax	+61 8 8463 6999
Website	www.dwlbc.sa.gov.au

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FOREWORD

South Australia's natural resources are fundamental to the economic and social wellbeing of the State. One of the State's most precious natural resources, water is a basic requirement of all living organisms 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 a 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 viable 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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EXECUTIVE SUMMARY

A numerical groundwater flow model was developed and calibrated for the T2 aquifer in the North Adelaide Plains and the Kangaroo Flat Prescribed Wells Areas. The steady-state predevelopment (1969) and transient-state (1969-2002) conditions were modelled. Although the model was well calibrated with good matches between simulated water levels and observed water levels at most observation wells, there are no recorded water levels for the pre-development conditions and therefore the steady state model has uncertain reliability. Results of sensitivity analyses showed that the simulated heads were most sensitive to changes in the horizontal hydraulic conductivity of the T2 aquifer.

The calibrated model was used to evaluate the response of the T2 aquifer to pumping at current 2002 extraction rates over a 25 year period to 2027. The projected maximum seasonal drawdown after 25 years of pumping at current rates will be about 12 m in the southwest corner of Kangaroo Flat PWA where most extraction occurs. The T2 aquifer would attain a dynamic equilibrium if extraction were maintained at current rate with little change in trends from current conditions. The direction of groundwater flow across the Kangaroo Flat PWA is controlled by extractions from the adjacent Northern Adelaide Plains PWA, and is toward the southwest in both the irrigation (summer) and non-pumping (winter) seasons.

1. INTRODUCTION

The Kangaroo Flat area is underlain by good quality groundwater in the Tertiary T2 aquifer that is extensively developed in the Northern Adelaide Plains Prescribed Wells Area (PWA) which lies immediately to the southwest. Concerns about increasing extractions led to a Notice of Restriction being placed on the Kangaroo Flat area in March 2000.

An earlier modelling exercise (Gerges, 2000) was hampered by a lack of monitoring data and hydraulic conductivity values for the Kangaroo Flat area. The drilling of three new T2 observation wells (James-Smith and Gerges, 2001), and aquifer testing (James-Smith and Osei-Bonsu, 2001), has greatly improved the understanding of the hydrogeology of the area.

This report presents the results of development and calibration of a new numerical groundwater flow model of the T2 aquifer underlying the North Adelaide Plains PWA and the Kangaroo Flat PWA. The model was used to evaluate the long-term impacts resulting from current and future pumping from the T2 aquifer.

The location of the Northern Adelaide Plains PWA and Kangaroo Flat PWA are shown in Figure 1.

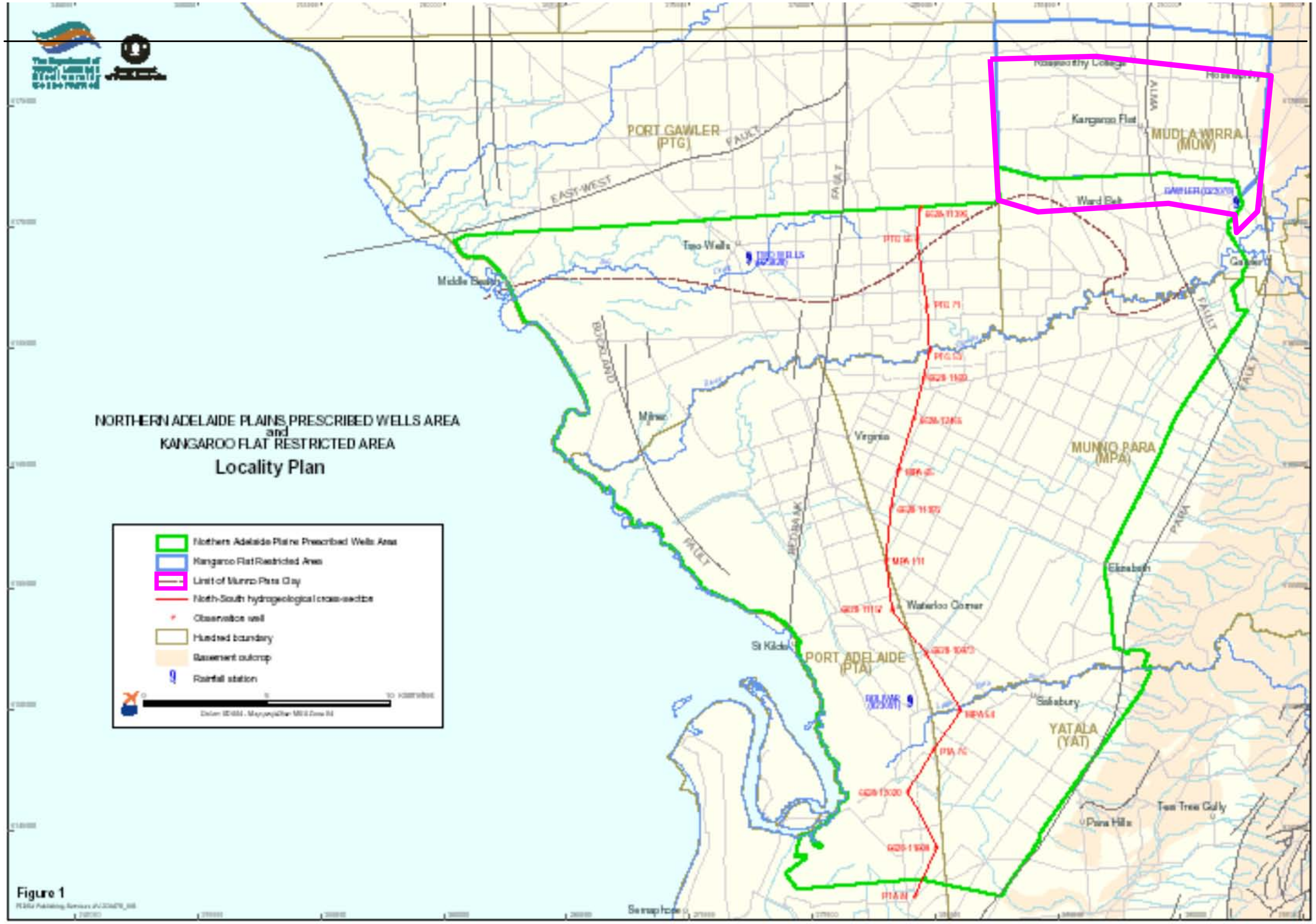

Figure 1. Locality plan for Northern Adelaide Plains PWA and Kangaroo Flat PWA

2. HYDROGEOLOGY

The stratigraphy within the study area has been well defined by numerous well logs (Gerges 2001, and Evans 1990). 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 north-south cross section in Figure 2.

1. Hindmarsh Clay - interbedded sand and gravel lenses that form Quaternary aquifers,
2. T1 Tertiary aquifer - comprises layers of limestone (upper Port Willunga Formation), sandstone (Hallett Cove Sandstone), and sand (Dry Creek sand). This aquifer pinches out in the northern part of the study area.
3. Munno Para Clay confining layer - separates the T1 aquifer from the underlying T2 aquifer. It ranges up to 10 m in thickness, except in the north where it is absent.
4. T2 Tertiary aquifer - consists of limestone and sand from the lower Port Willunga Formation. It is directly overlain by the Hindmarsh Clay in the northern part of the area.

The lateral extent of the Munno Para Clay confining layer is shown in Figure 1. Figure 3 shows an east-west cross-section along the Gawler River which lies just to the south of the

Water level trends from observation wells in the NAP and Kangaroo Flat Restricted Area indicate that aquifers in the aquifers are generally confined. However within the T2 aquifer, groundwater can occur under unconfined conditions during periods of heavy extraction in the Virginia area.

Groundwater recharge to the T1 and T2 aquifers is thought to occur by lateral inflow from fractured aquifers of the Mt Lofty Ranges at the eastern boundary of the study area (Fig. 3). Groundwater outflow from the aquifer system occurs through extraction from irrigation and domestic wells and discharge beneath St Vincent's Gulf.

Before development it is understood that groundwater moved laterally from the recharge area along the eastern region of the study area, to the west where it discharges. 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. 4). The increased head difference between the T2 aquifer and the overlying T1 and Quaternary Aquifers may lead to increased downward leakage into the T2 aquifer.

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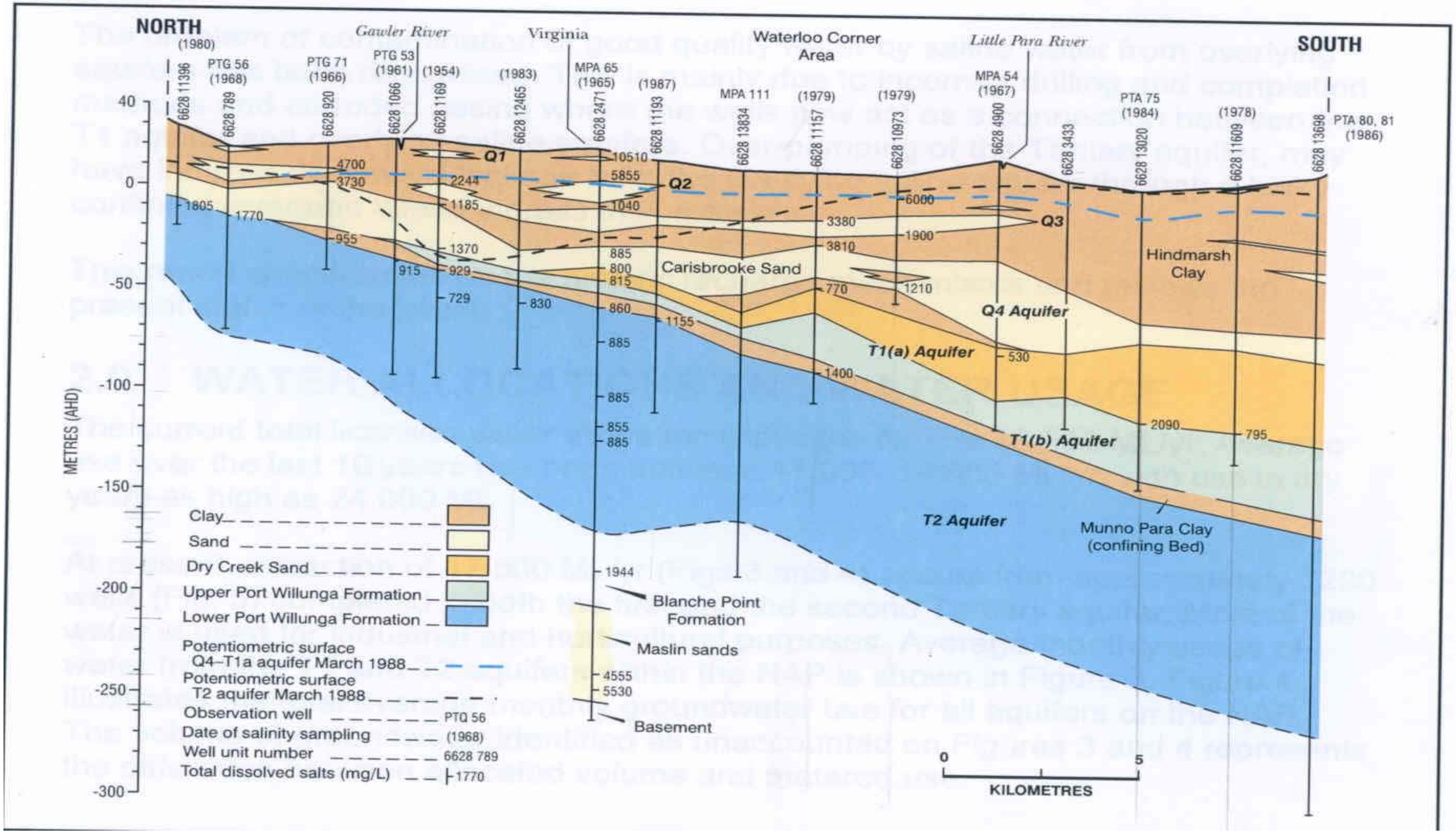


Figure 2. Diagrammatic north-south cross-section of the NAP (after Gerges, 2001)

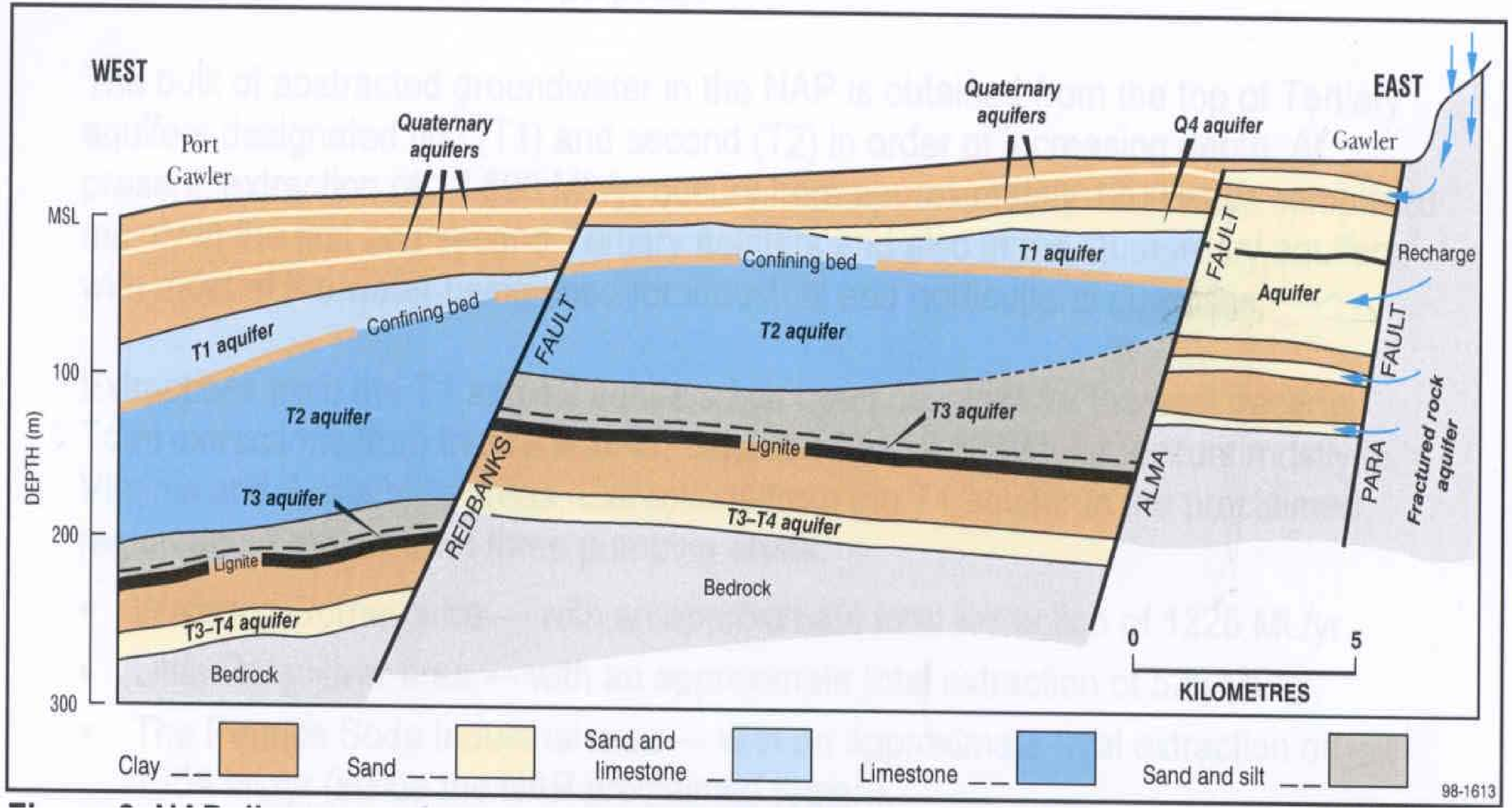


Figure 3. Diagrammatic east-west section along Gawler River (after Gerges 2001)

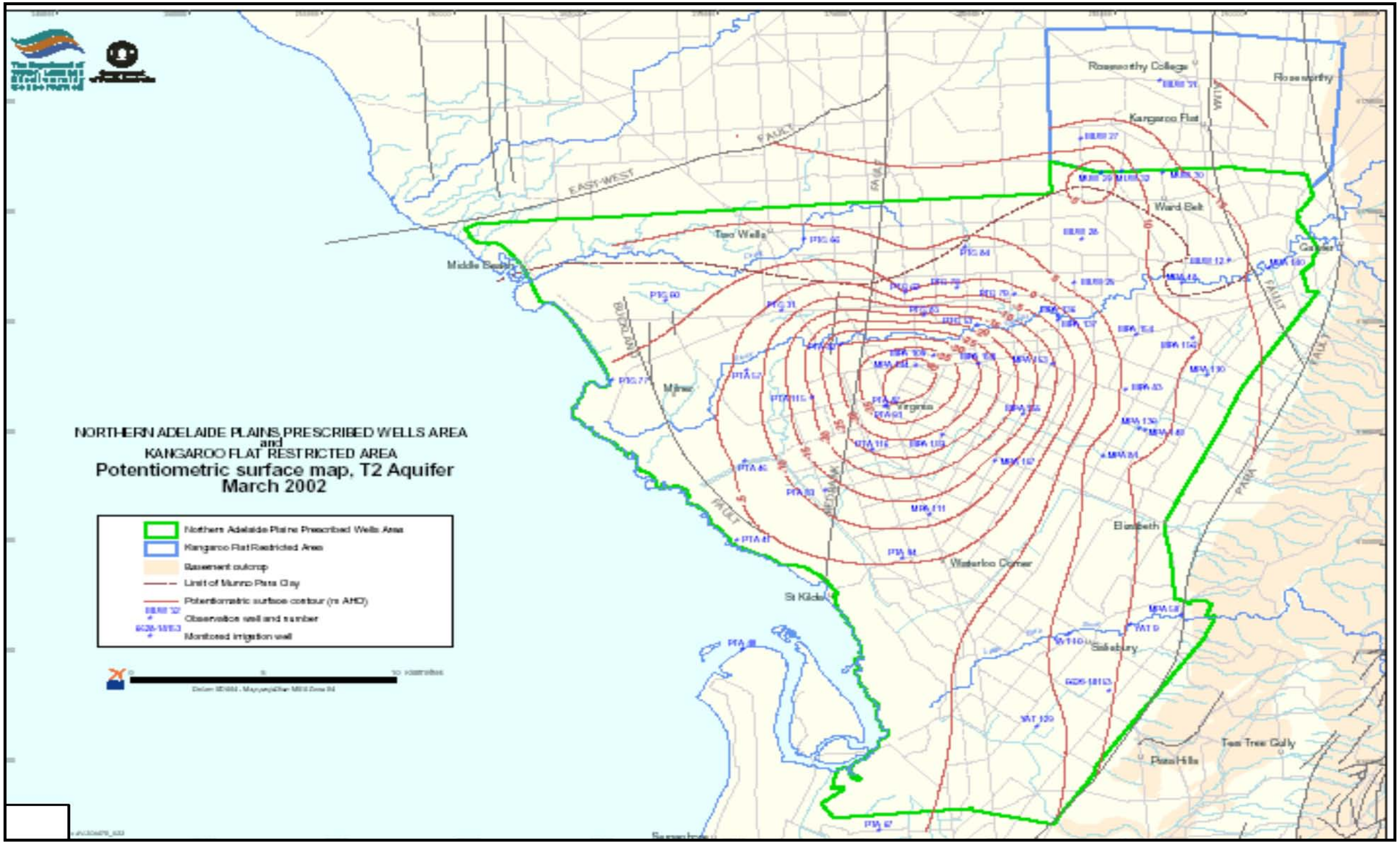


Figure 4. Current extent of cone of depression in T2 aquifer in the Virginia area

3. MODEL CONSTRUCTION

3.1 EXTENT

Modelling was accomplished by using the three-dimensional finite difference model called MODFLOW (McDonald and Harbaugh, 1988). In any groundwater flow modelling exercise, the extent of the model domain should be selected so that grid boundaries correspond to various natural boundaries of the aquifer. The eastern model boundary was selected as the Para Fault where the Quaternary and Tertiary sediments abut the fractured rock aquifers of the Mt Lofty Ranges (Fig. 1). The northwest boundary was aligned with the East-West Fault, and to the west, the modelled domain was extended beyond the boundary of NAP PWA to account for the discharge from the Tertiary sediments that extend beneath the Gulf.

The model was constructed using a rectangular finite-difference grid consisting of 120 rows and 120 columns with a cell size of 300 x 300 m. The origin of the grid (upper left corner) is located at E 260519 and N 6179819.

The aquifer system was vertically discretized into 4 layers, each containing 8965 active cells.

- Layer 1 - Hindmarsh Clay
- Layer 2 - T1 Tertiary aquifer
- Layer 3 - Munno Para Clay confining layer
- Layer 4 - T2 Tertiary aquifer

Water within the aquifer system is assumed to only flow horizontally in the aquifers, and predominantly vertically through the confining layers.

3.2 BOUNDARY CONDITIONS

The lateral boundaries of the model were defined as constant head and no-flow boundaries. The no-flow boundaries dictate that there is no exchange of water between the model cell and the area outside the model. The lateral boundaries, which were selected to match the groundwater flow regime in the study area, were located at the contact between the consolidated/unconsolidated sediments and the fractured rock aquifers or the natural faults. The constant head cells were used in the model to control the hydraulic gradient - and thus the inflow and outflow – near the limits of the simulated area. The constant heads were used where the limits of the modelled area could not be aligned perpendicular to equipotential lines on the potentiometric surfaces and where it is unrealistic and/or impractical to truncate the simulation with no-flow boundaries.

The northeastern corner, the southern boundary and part of the western boundary of the study area are approximately aligned with groundwater flow lines and were treated as no-flow boundaries. The bottom of the T2 aquifer (the lower boundary of the model) is bounded by no-flow boundaries.

3.3 AQUIFER HYDRAULIC PROPERTIES

Aquifer properties, such as hydraulic conductivity, specific yield and specific storage control respectively, the rate at which water moves through an aquifer, the volume of water in storage and the rate and areal extent of water-level decline caused by groundwater development. Various aquifer tests (step-drawdown and constant rate test) and laboratory tests have been performed to determine the hydraulic properties of the T2 aquifer. Figure 5 shows the location of sites where the tests were conducted and Table 1 is a summary of hydraulic properties of the T2 aquifer determined from these tests.

Table 1 T2 aquifer test results

Location	Well Number	Type of test	Transmissivity m^2/day	Storage Coefficient
Andrews Farm	6628-19960	Step-drawdown Constant rate discharge	180	1.9 to 5.6 x 10^{-4}
Bolivar	6628-18777	Step drawdown, Constant rate discharge	180	4.27 x 10^{-4}
Kangaroo Flat	6628-19388	Constant rate discharge	252 192	0.001 0.0015
Parafield Airport	6628-20328	Step drawdown, Constant rate discharge	177 180	1.9 to 5.6 x 10^{-4}

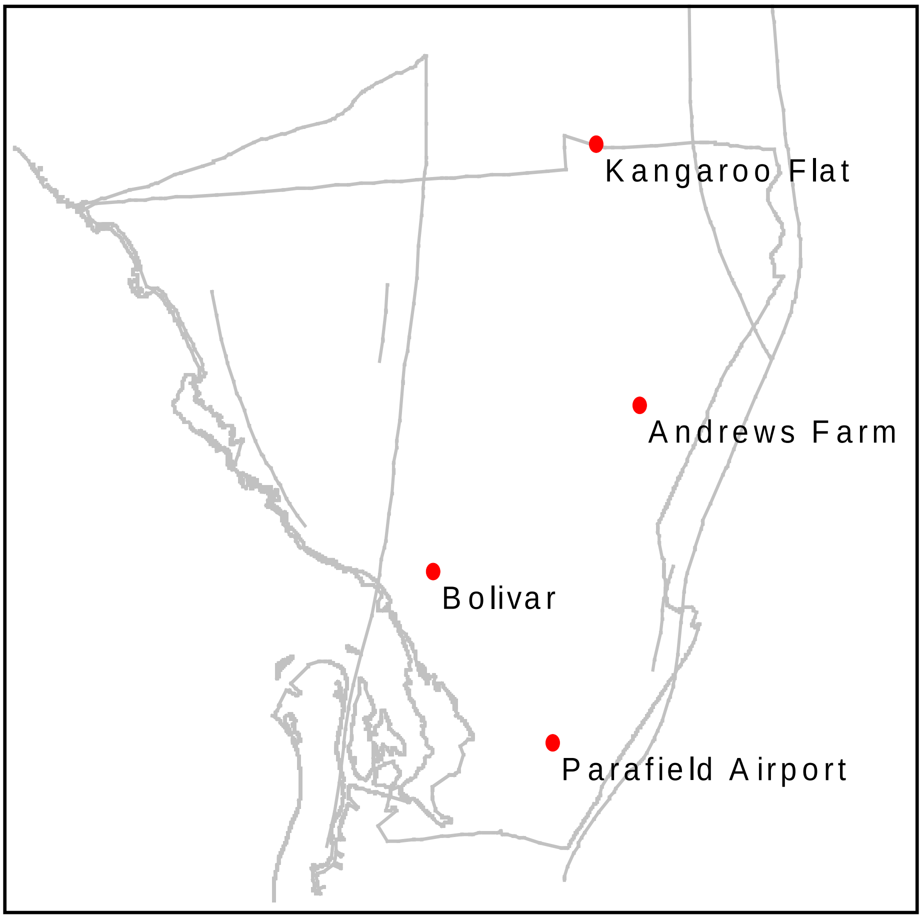


Figure 5. Location of T2 aquifer tests

4. MODEL CALIBRATION

Groundwater flow model calibration is an attempt to achieve a close match between model results and measured data by adjusting model input parameters. The flow model was calibrated using a trial-and-error method in adjusting aquifer properties and model boundary conditions to obtain a best match between simulated hydraulic heads and measured water levels. The initial estimates for the aquifer properties were based on pumping test results and reported values.

During the calibration process both steady-state and transient-state simulations were used. One of the problems encountered in this study was simulation of a steady-state model for an aquifer system that is not in equilibrium. This was overcome by the identification of a period in the past during which the aquifer system was in semi-equilibrium ie when the response to pumping was consistent over several years.

Any changes made during transient-state simulation were re-incorporated into the steady state simulation and the steady state simulation was rerun to ensure that the changes made during the transient-state simulation produced reasonable results for steady-state conditions.

4.1 STEADY-STATE CALIBRATION

Between 1967 and 1969, the groundwater conditions are assumed to be in a dynamic steady state representing “predevelopment” conditions (no actual predevelopment potentiometric levels for the Aquifer T2 are available). The steady-state model calibration involved trial-and-error adjustment of hydraulic conductivity values and boundary conditions in order to match the simulated hydraulic heads with water levels measured in August/September of 1967 to 1969 from 11 selected T2 aquifer observation wells. These wells were selected on the basis of the length of water level records and the spatial distribution of the wells.

A comparison of simulated hydraulic heads with water levels measured in August/September 1967 – 1969 is shown in Figure 6. The calculated water level elevations at each of the 11 observation wells for the calibrated steady-state model are shown with the measured values in Table 2. Measured water levels and simulated hydraulic heads for August/September months during 1967 – 1969 are plotted along 1:1 correlation line in Figure 7. After calibration, the simulated head were within 0.02 to 2.5 m of measured water levels with root-mean-square error of 1.21 m and mean error of 0.67 m.

The steady-state simulation was used to provide initial conditions for transient-state simulation.

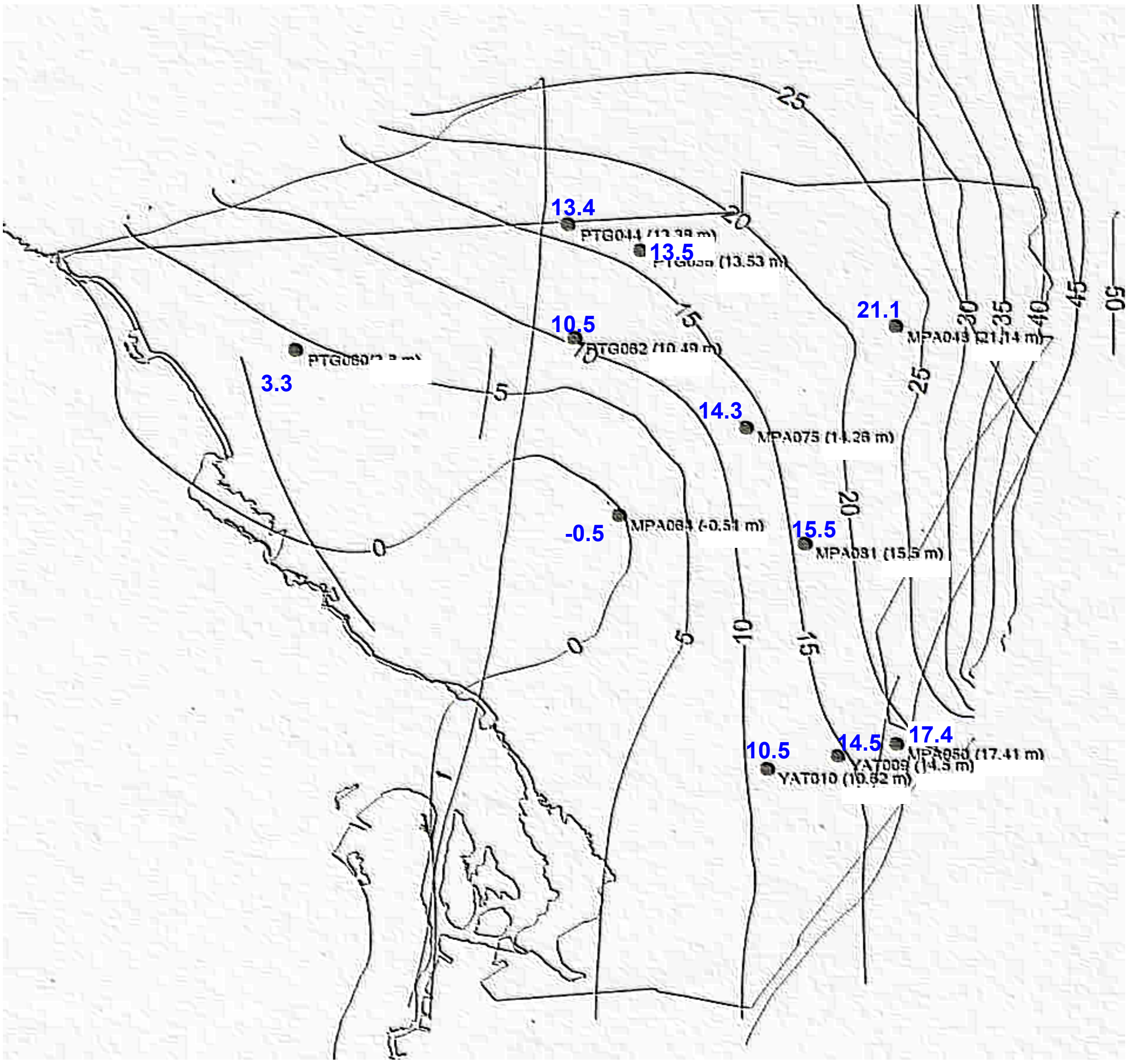


Figure 6. Steady state calibration - simulated T2 r head contours versus measured water levels

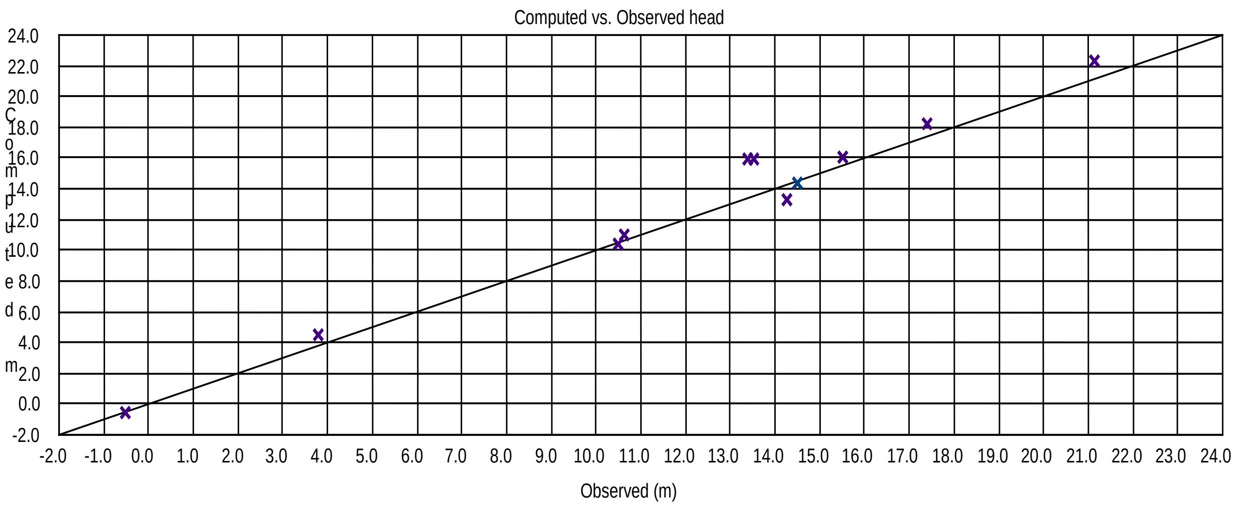


Figure 7. Steady state calibration - computed versus measured water levels

Table 2 Steady state calibration - measured and calculated water-level elevations

Observation well	Calculated head (mAHD)	Measured head (mAHD)	Difference
MPA048	22.35	21.14	1.21
MPA050	18.27	17.41	0.86
MPA064	-0.49	-0.51	0.02
MPA075	13.30	14.26	-0.96
MPA081	16.06	15.50	0.56
PTG044	15.91	13.38	2.53
PTG056	15.92	13.53	2.39
PTG060	4.45	3.80	0.65
PTG062	10.40	10.49	-0.09
YAT009	14.33	14.50	-0.17
YAT010	10.98	10.62	0.36

The final hydraulic conductivity values used in the model to achieve the steady state calibration are presented in Table 3.

Table 3 Hydraulic conductivity values

Layer	Unit	Horizontal (m/day)	Vertical (m/day)
Layer 1	Hindmarsh Clay	0.5	0.05
Layer 2	T1 aquifer	0.5	0.05
Layer 3	Munno Para Clay	0.00001 – 0.00005	
Layer 4	T2 aquifer	0.5 – 4.3	

The distribution of hydraulic conductivity zones in the T2 aquifer is shown in Figure 8.

4.2 TRANSIENT MODEL CALIBRATION

After achieving a satisfactory steady-state calibration, transient groundwater conditions were modelled for a 33-year period between 1969 and 2002. Each year was divided into two stress periods representing summer and winter. The summer stress period, which begins in September, is made up of 210 days. The winter stress period begins from April and last for 155 days.

Reported groundwater extractions from the T2 aquifer are shown in Figure 9. The annual withdrawals do not include withdrawals for 1988/89 and 1989/90 seasons. Extraction volumes from 1970/71 through 1987/88 represent withdrawals from both T1 and T2 aquifers, with an estimated 77% withdrawn from the T2 aquifer (Evans, 1990). Locations of extraction points are shown in Figure 10.

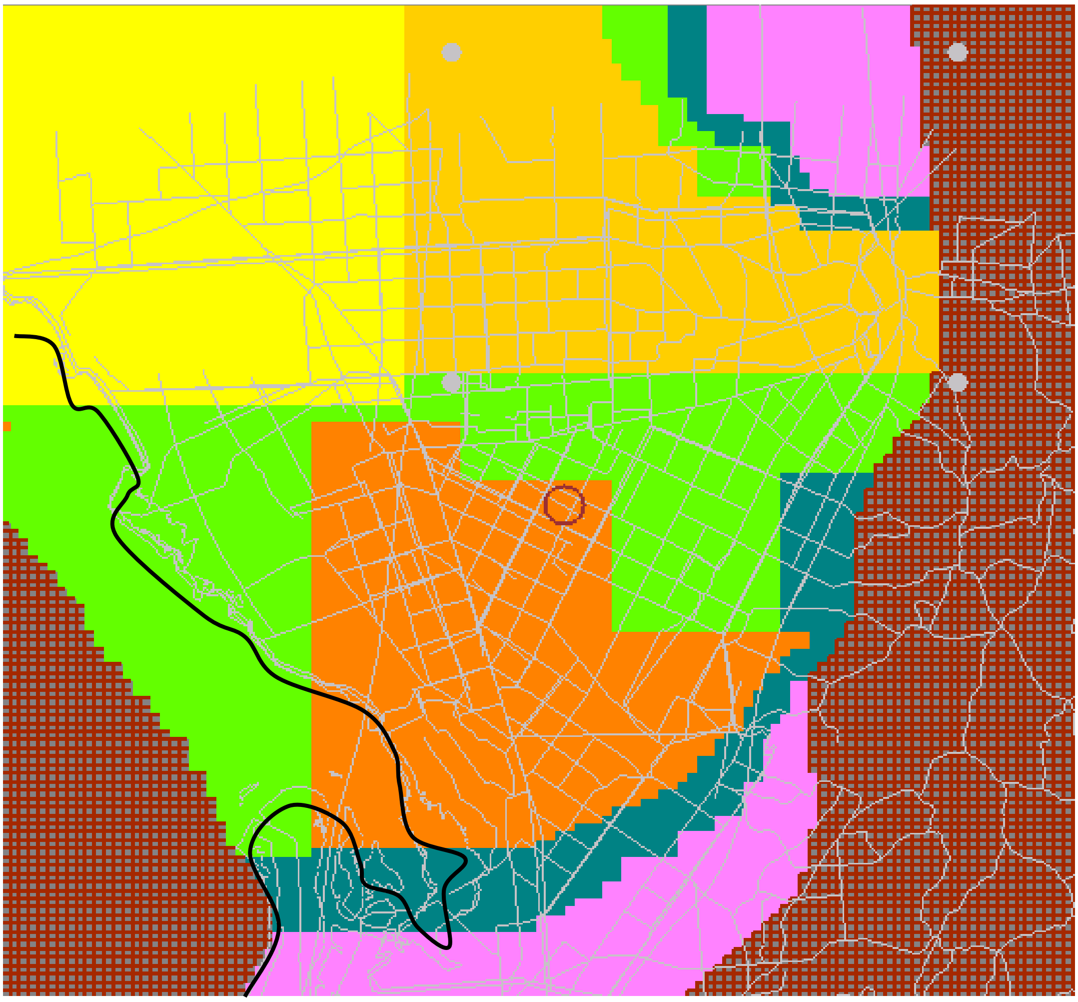


Figure 8. Hydraulic conductivity zones in the T2 aquifer

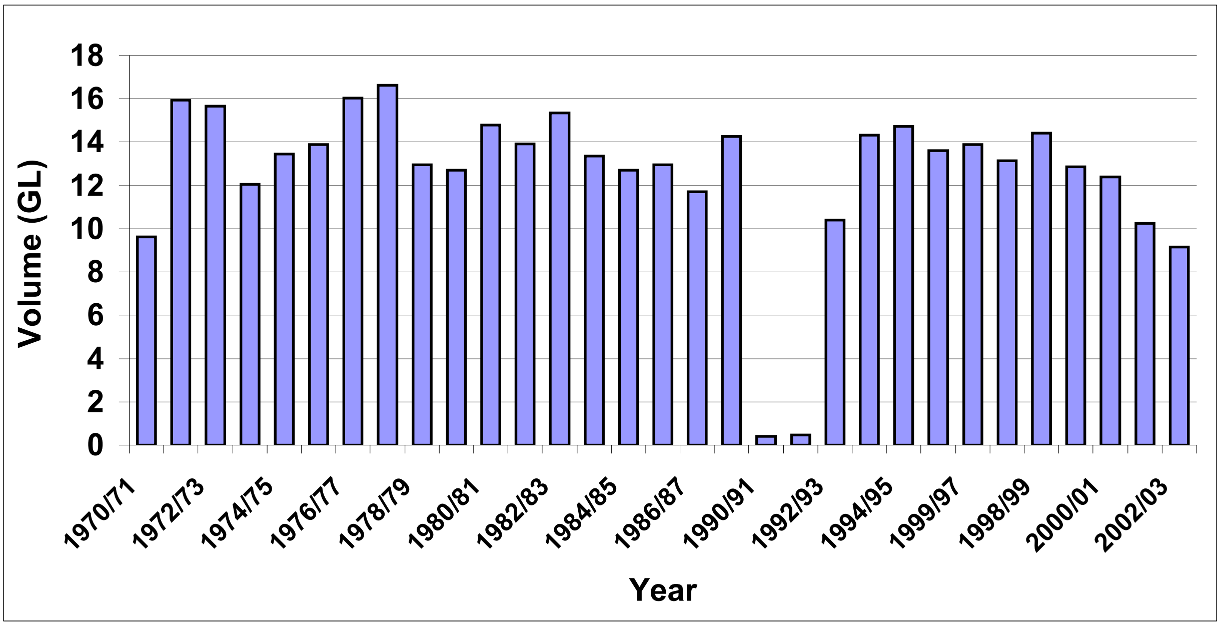


Figure 9. Annual extractions from the T2 aquifer

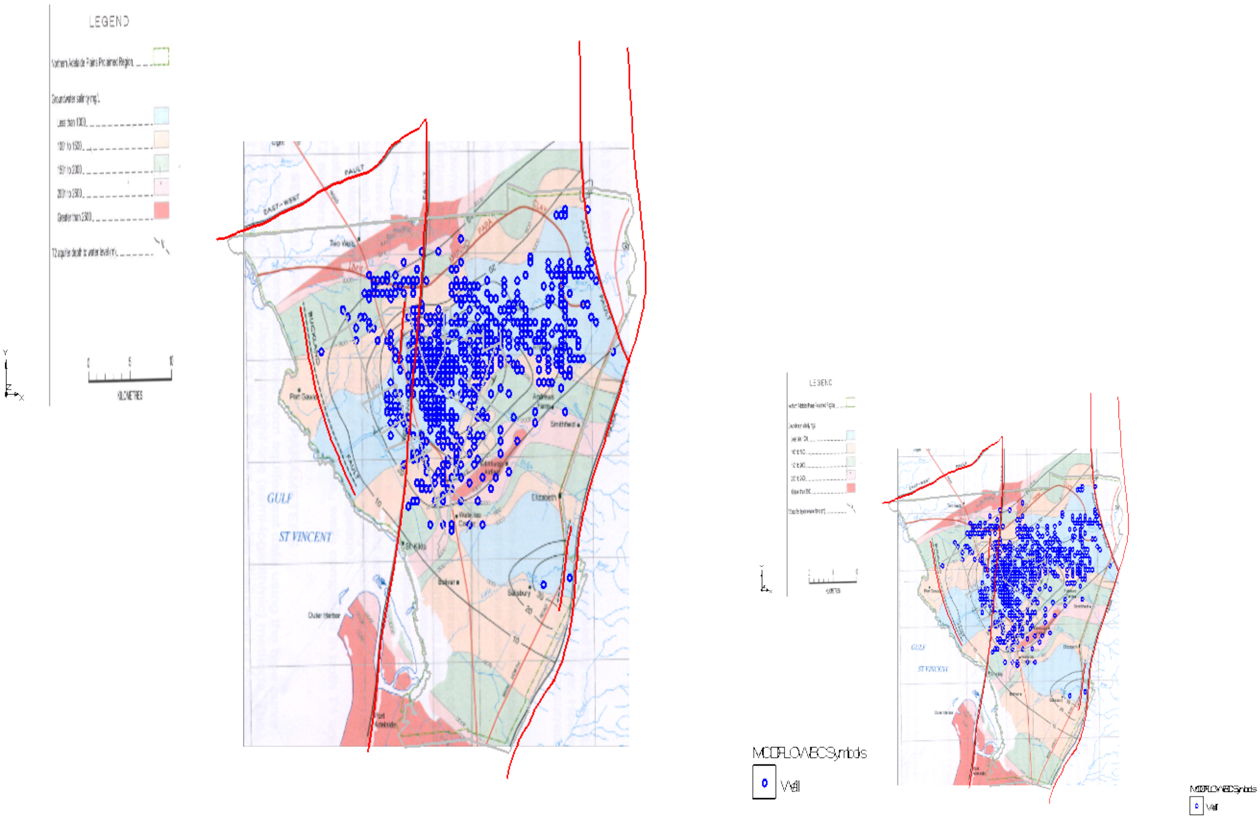


Figure 10. Location of extraction points from the T2 aquifer

The transient model was calibrated using available water level data from 26 observation wells. During the history matching process, values for horizontal hydraulic conductivity and specific storage were varied within acceptable limits.

The transient model was assumed calibrated when simulated water levels matched the general magnitude and trend of measured water levels and the model parameters were within reasonable limits supported by available data. Measured water levels and simulated hydraulic heads for September 2002 are plotted along 1:1 correlation line in Figure 11. A root-mean-square error of 2.1 m and a mean error of 0.53 m were obtained after calibration.

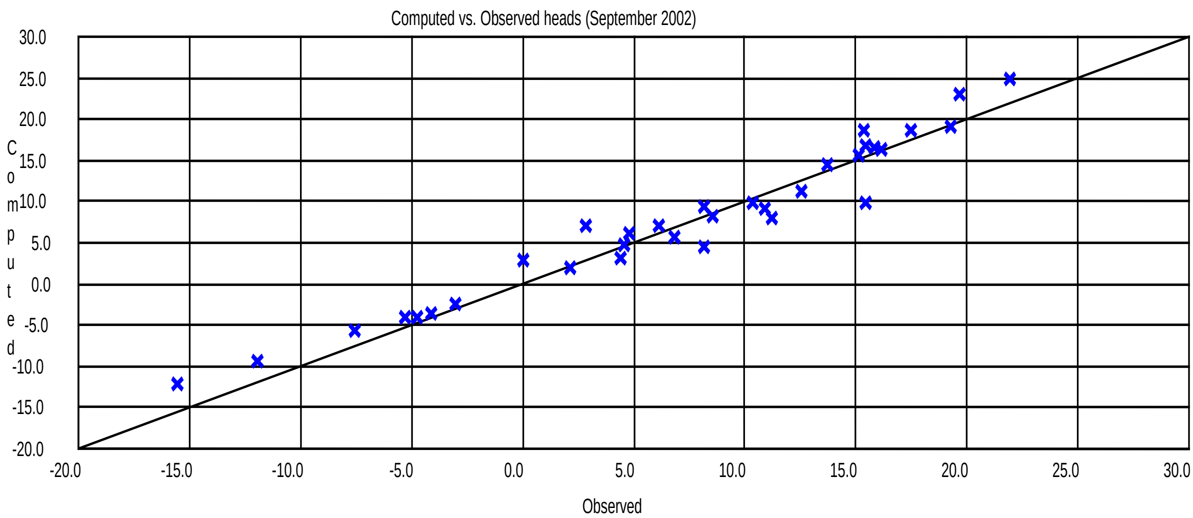


Figure 11. Transient-state simulation calibration: Computed versus measured heads

The hydrographs presented in Appendix A show the transient-state model reasonably simulates the long term water level changes in the T2 aquifer that have resulted from pumping. Figure 12 presents the transient calibration for MPA 64 as an example.

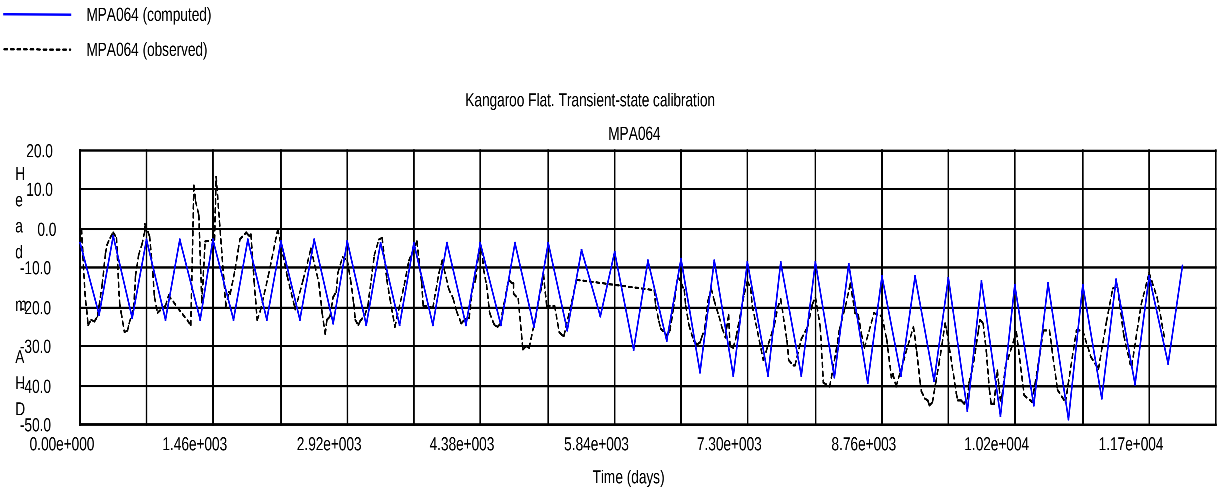


Figure 12. Hydrographs for wells unaffected by irrigation

The measured 2002 water levels were used to qualitatively evaluate the transient-state simulation result, with contours of the simulated and measured potentiometric surface elevations for March 2002 in the T2 aquifer shown in Figure 13. The model provides a good match with the observed cone of depression centred on Virginia, an area of intensive extraction.

The final specific storage values used in the model to achieve the transient calibration are presented in Table 4.

Table 4 Specific storage values

Layer	Unit	Specific yield	Storage coefficient
Layer 1	Hindmarsh Clay		0.00012 – 0.000013
Layer 2	T1 aquifer		0.00011 – 0.0000001
Layer 3	Munno Para Clay		0.000045 – 0.0000001
Layer 4	T2 aquifer	0.1	0.0039 - .00021

The distribution of hydraulic conductivity zones in the T2 aquifer is shown in Figure 14.

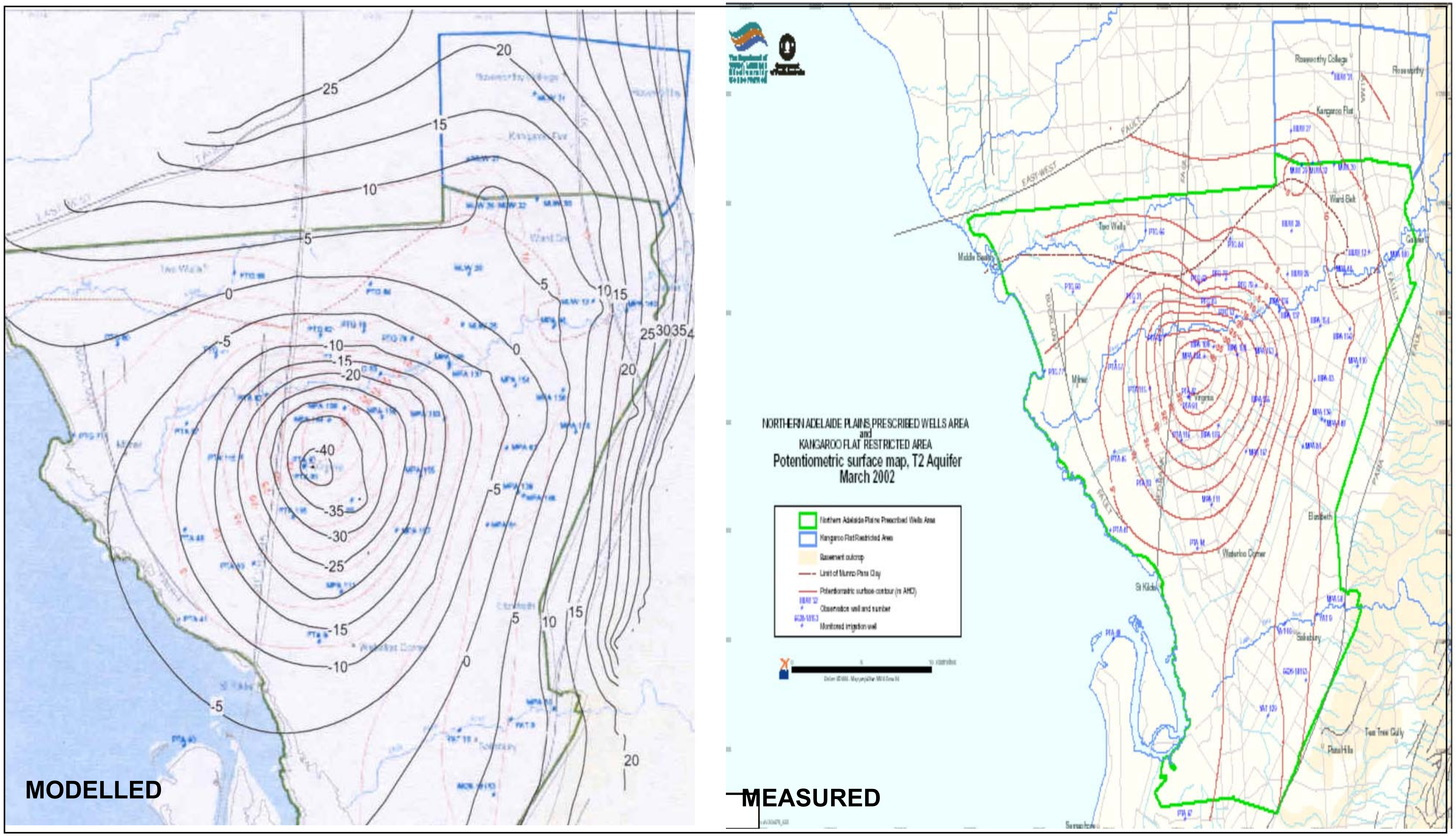


Figure 13. Comparison of modelled and measured potentiometric surface contours – March 2002

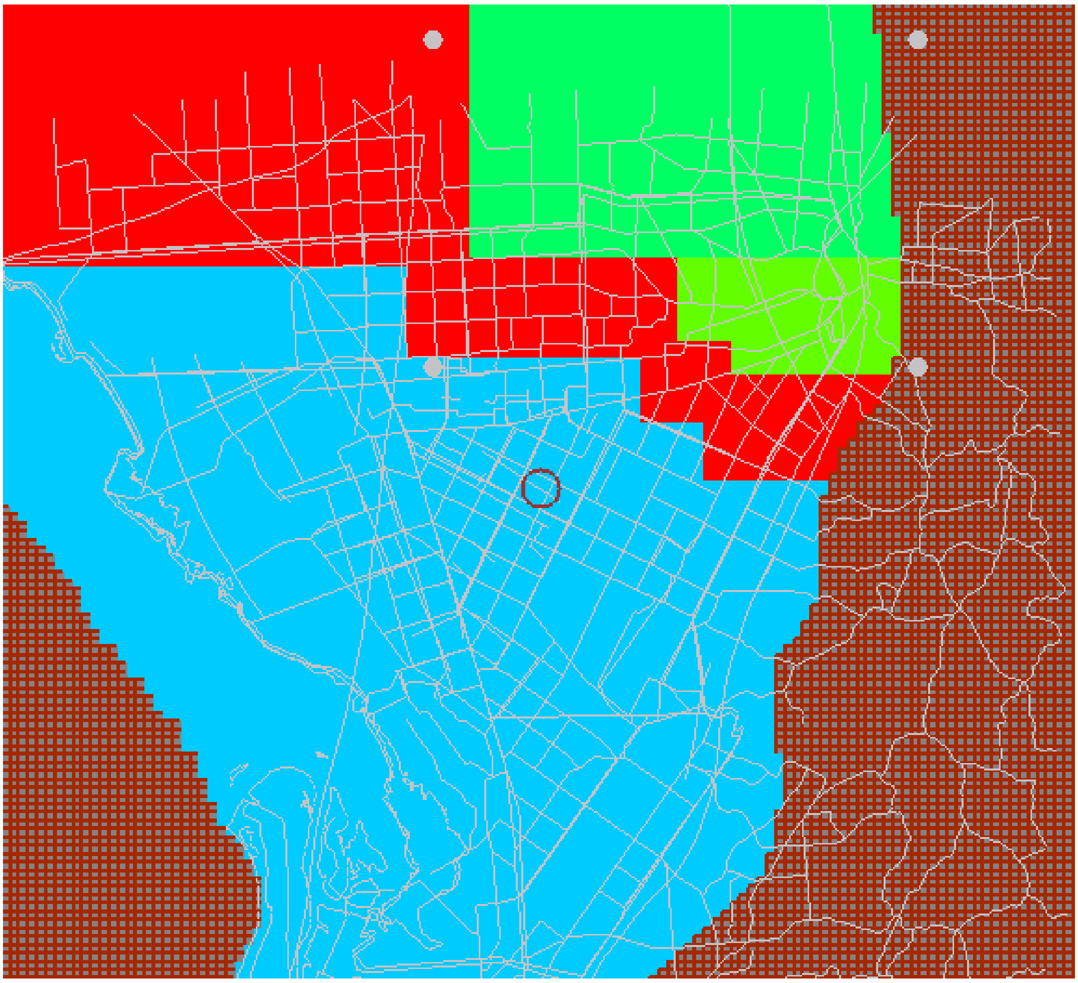


Figure 14. Specific storage values in the T2 aquifer

4.3 SENSITIVITY ANALYSIS

A sensitivity analysis was performed to evaluate the response of the model to changes in input parameters and to gain understanding of how much error could result by overestimating or underestimating input parameter values. Each parameter was adjusted uniformly over the entire model area while all other variables were kept constant. For each sensitivity run, only the examined parameter is adjusted from the value used in the calibrated model.

The results of the sensitivity analysis were evaluated by calculating the root-mean-square deviation between measured and simulated heads. The root-mean-square error in water levels was plotted with change factor for horizontal hydraulic conductivity, specific storage, and vertical hydraulic conductivity of the Munno Para Clay confining layer. A change factor of 1 represents the value of aquifer and confining layer properties used in the calibrated model and the corresponding root-mean-square difference. The greater the deviation of the water level from its original value at a change factor of 1, the greater the sensitivity of the model to an increase (a change factor greater than 1) or decrease (a change factor less than 1) for the aquifer or confining layer property.

The effects of varying the T2 aquifer hydraulic conductivity were evaluated by using the steady-state model. The sensitivity of the model in transient mode was determined for simulations representing April 2002 and September 2002 by adjusting the calibrated specific storage values of the T2 aquifer.

Simulated hydraulic heads are very sensitive to changes in the T2 aquifer horizontal hydraulic conductivity, and reasonably sensitive to an increase in the vertical hydraulic conductivity of the Munno Para Clay confining layer (Fig. 15). The simulated heads are also sensitive to decreases in specific storage (Fig. 16).

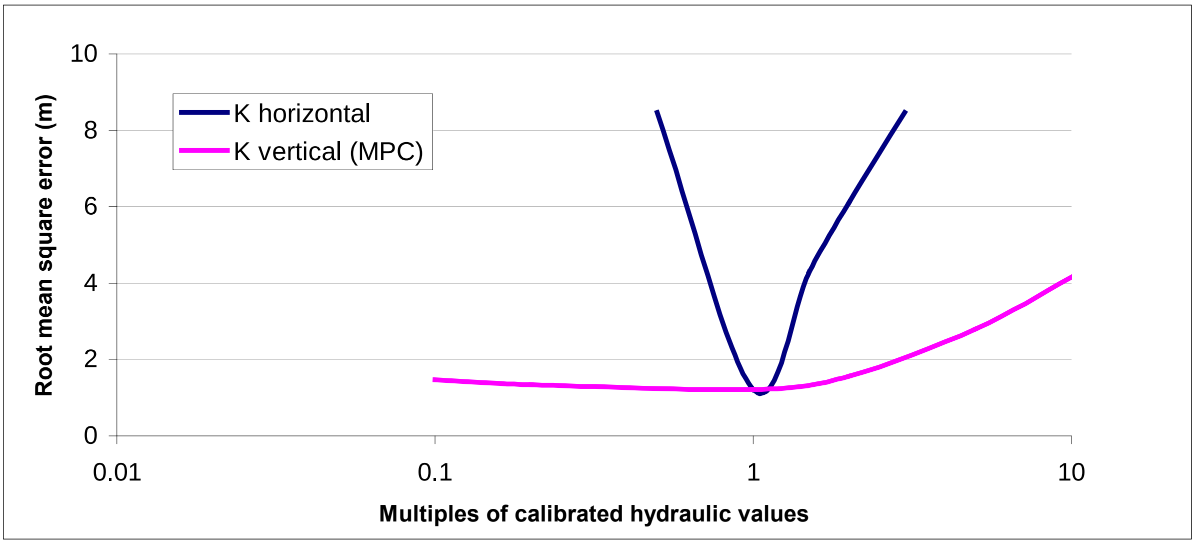


Figure 15. Unconfined aquifer observation network

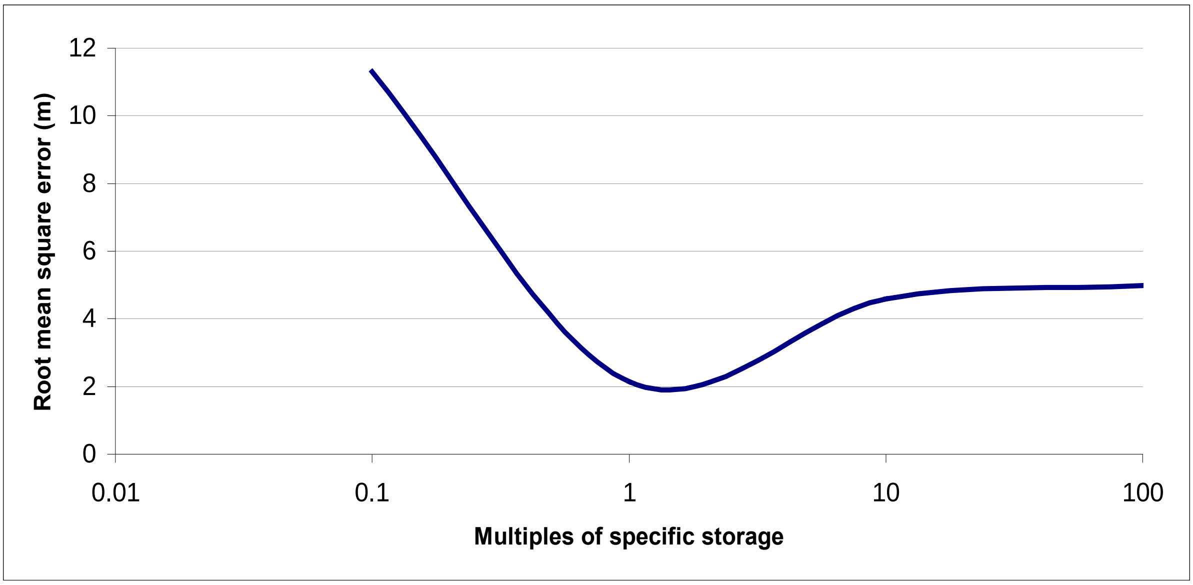


Figure 16. Unconfined aquifer observation network

5. PREDICTION RUN

A simulation of future groundwater flow conditions for the T2 aquifer for the 25 year period between 2002 and 2027 was made using the calibrated transient-state model, and the current 2002 extraction rates and production well locations.

The predicted maximum seasonal drawdown for the T2 aquifer after 25 years of pumping at current rates will be about 12 m at the southwest corner of Kangaroo Flat Restricted Area, as shown in Figure 17.

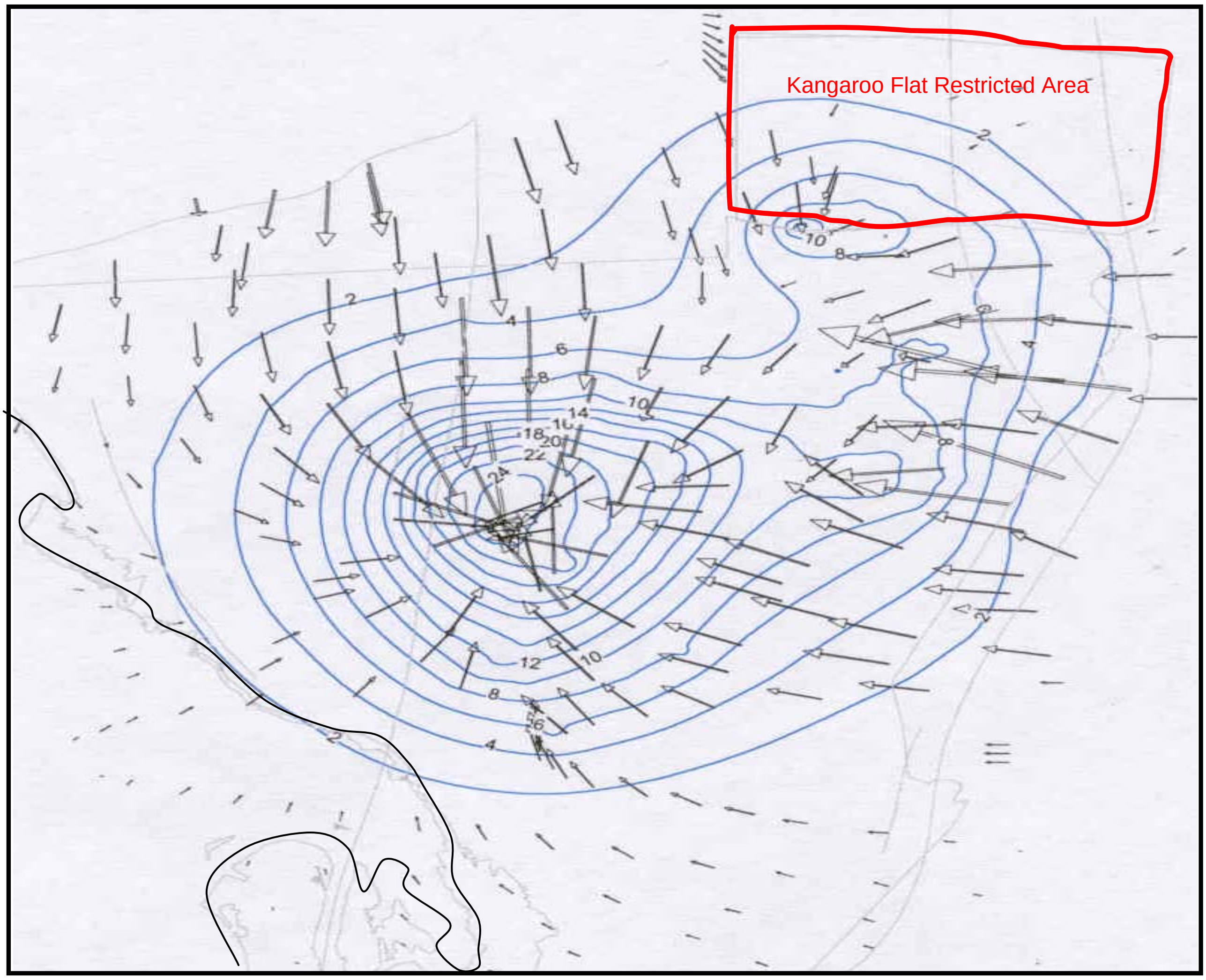


Figure 17. Predicted seasonal drawdown in T2 aquifer after 25 years at current (2002) extraction rates

The result of the predictive simulation in (Figs.18, 19) shows that if current extraction rates are projected over the next 25 years, the simulated water level trends will attain a dynamic equilibrium with little change in trends from current conditions.

The direction of groundwater flow across the Kangaroo Flat PWA (Fig. 19) is controlled by extractions from the adjacent Northern Adelaide Plains PWA, and is toward the southwest in both the irrigation (summer) and non-pumping (winter) seasons.

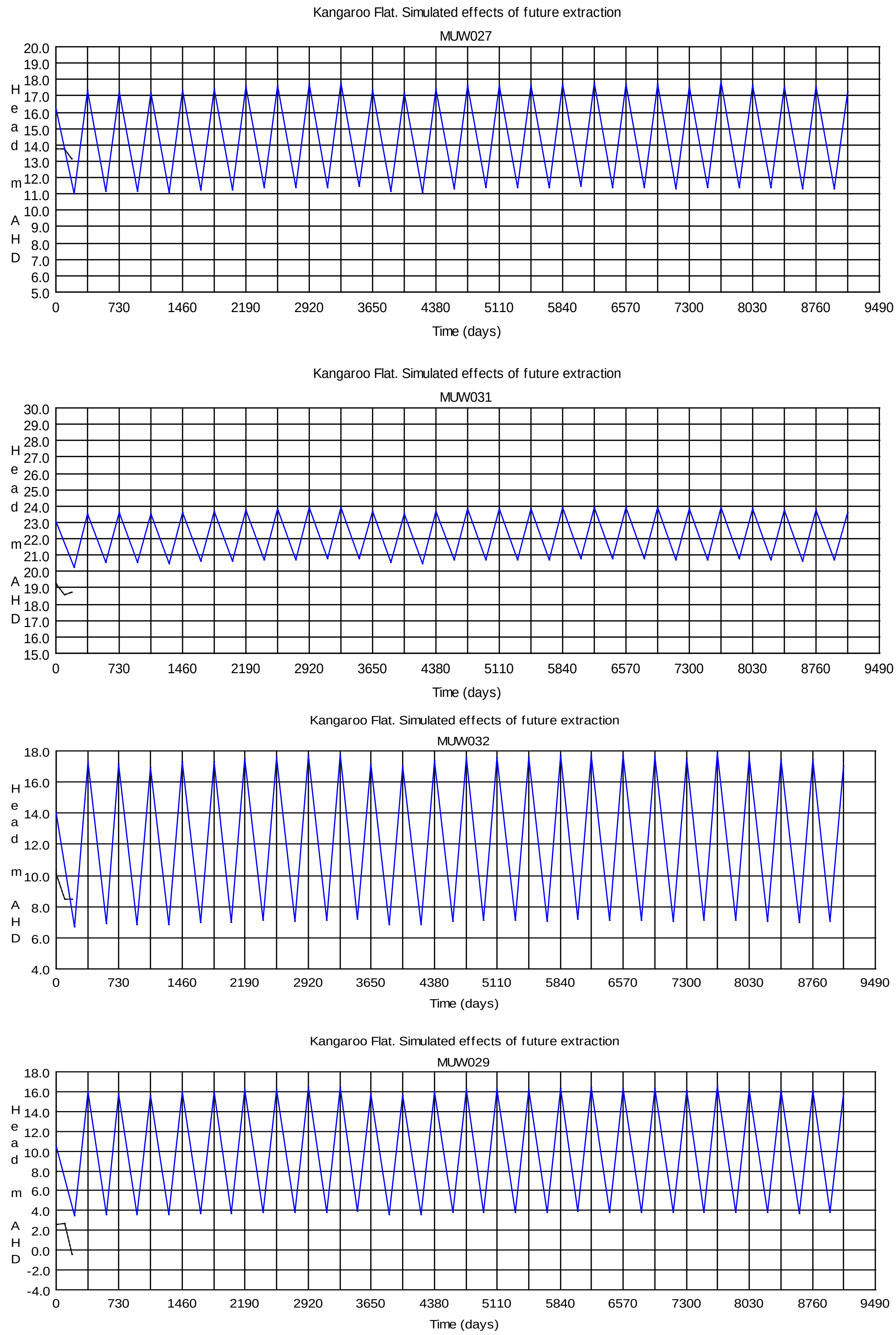


Figure 18. Predicted water level (head) from 2002 to 2027

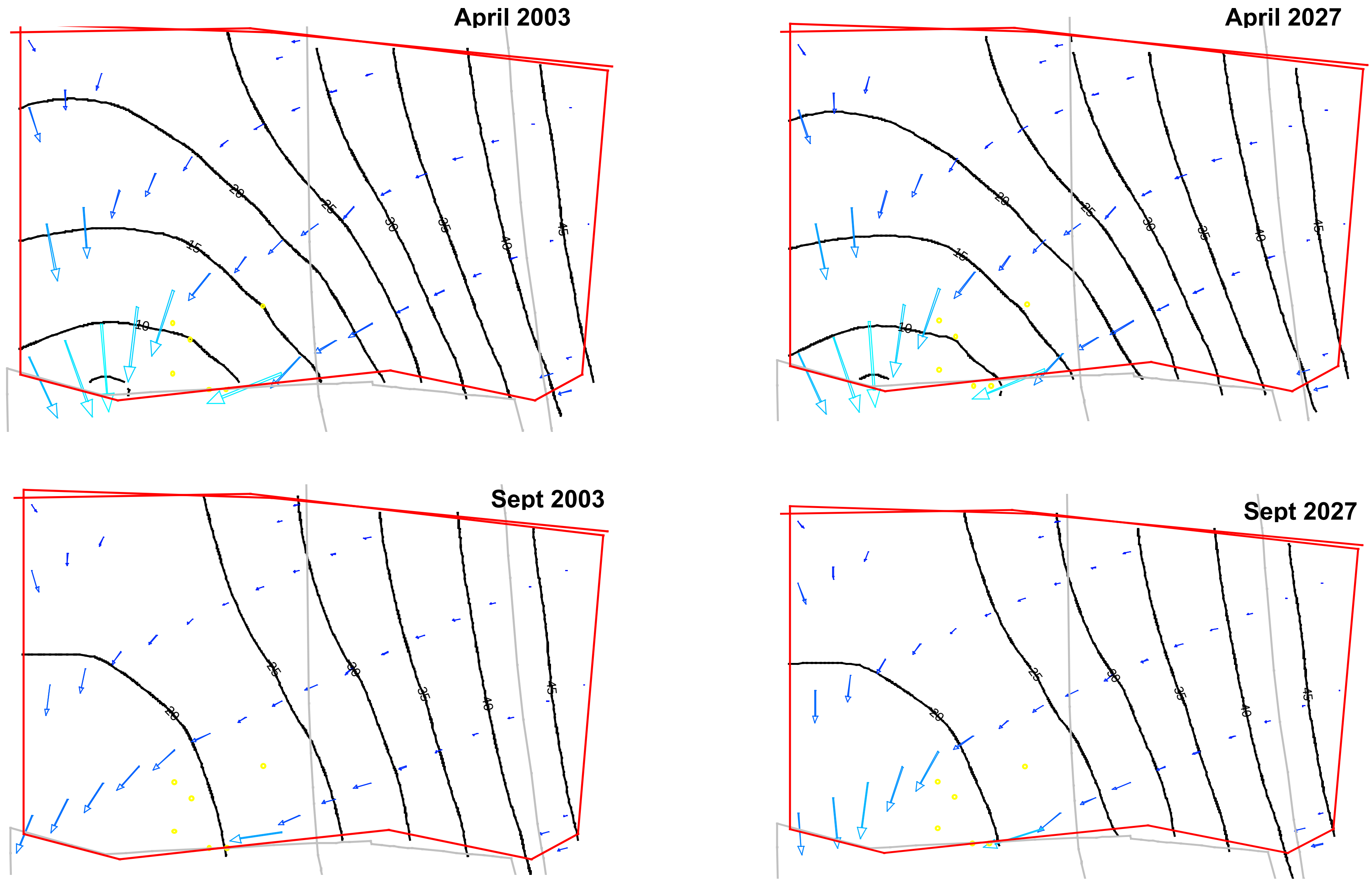


Figure 19. Predicted head and groundwater flow direction in Kangaroo Flat PWA

6. CONCLUSIONS

Steady-state and transient numerical models were developed to simulate groundwater flow in the T2 aquifer in the Northern Adelaide Plains and Kangaroo Flat PWAs. It was assumed that prior to 1970, there was little groundwater development in the study area and that the groundwater system was in dynamic equilibrium. The steady-state model, which was developed to provide initial conditions for the transient-state simulation, simulates the 1967 – 1969 August/September conditions. Data from 11 observation wells were used to compare measured and simulated water levels during the steady-state calibration. Since there were no observed water levels data prior to groundwater development in the study area, the calibrated steady-state model has uncertain reliability.

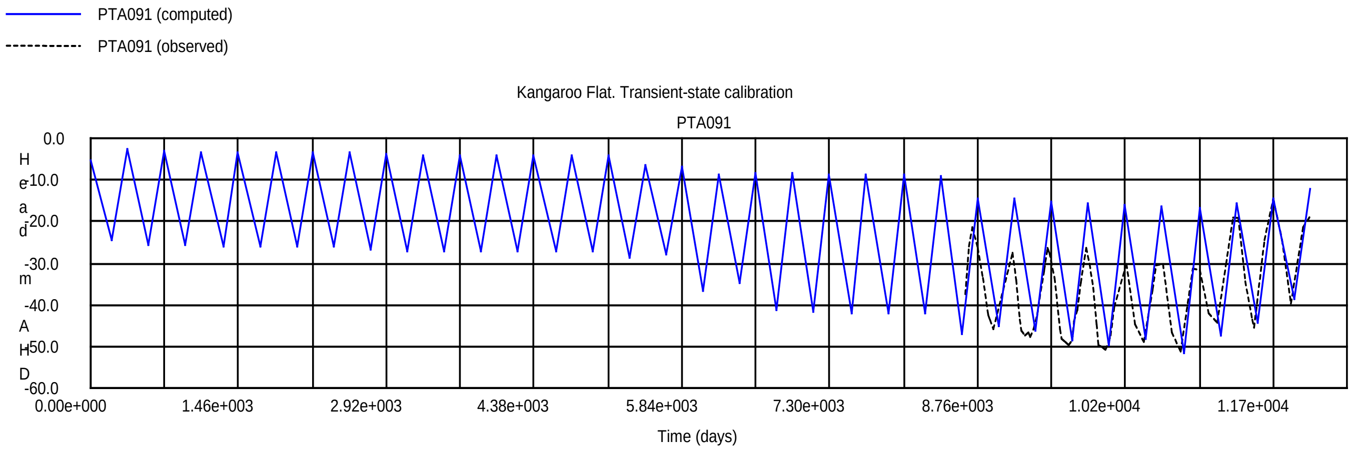
The transient-state model was calibrated using water level data from 33 observation wells over the period 1969 – 2002. The seasonal fluctuations of the simulated hydrographs are similar to the measured hydrographs, reaching a maximum water level elevation during August/September and a minimum during March/April.

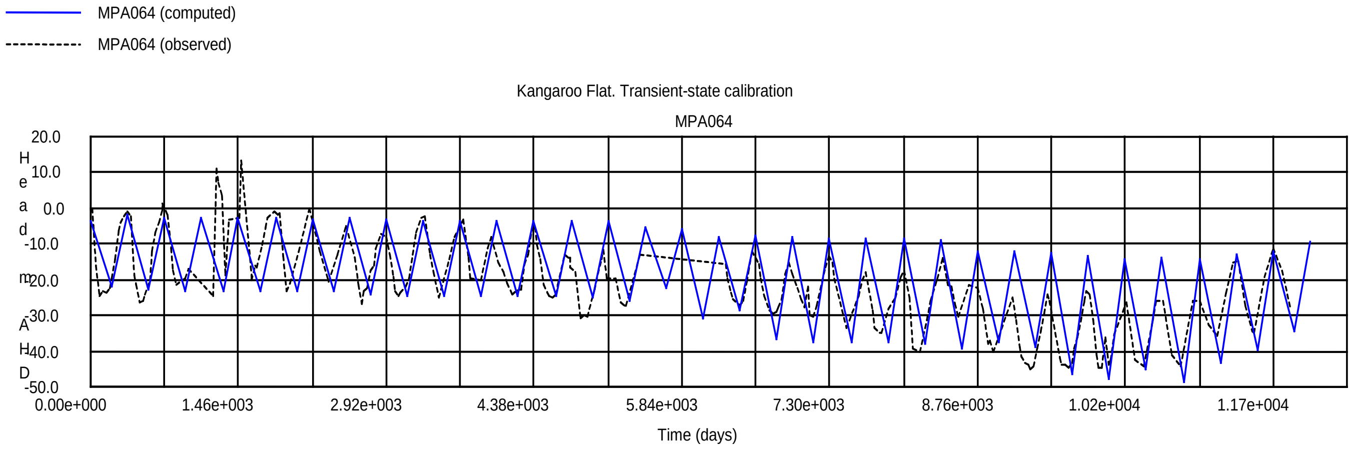
Results of sensitivity analyses indicate that calculated heads are most sensitive to variations in the horizontal hydraulic conductivity values for the T2 aquifer, and least sensitive to specific storage values and the vertical hydraulic conductivity of the Munno Para Clay confining layer.

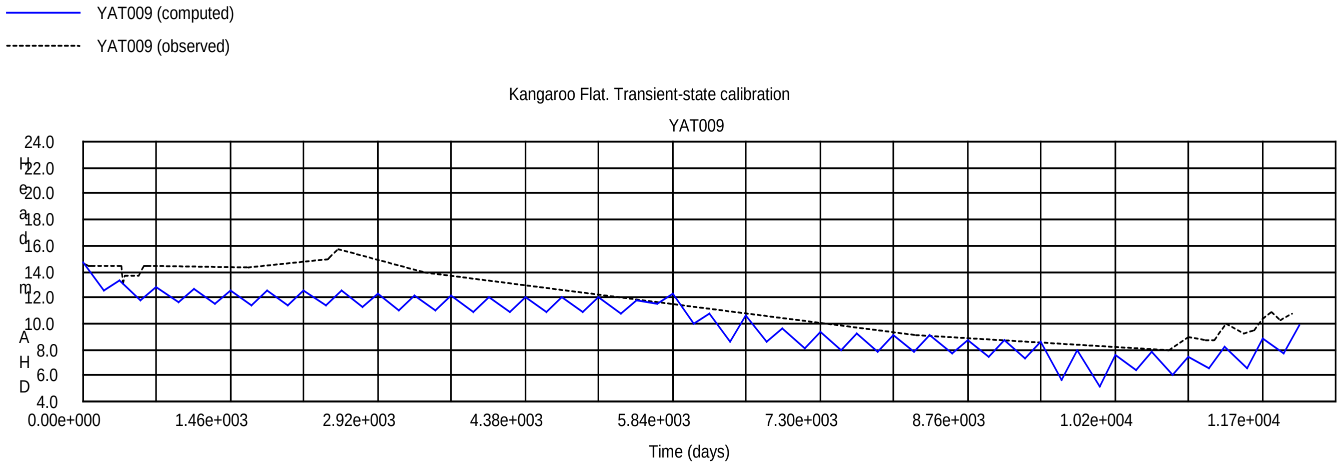
The calibrated model was used to predict the effects of pumping from the T2 aquifer over a 25 year period from 2002. The current (2002) pumping well locations and extraction rates were maintained for this period. The simulated water level trends showed that a dynamic equilibrium will be attained with little change in trends from current conditions. The projected maximum seasonal drawdown after 25 years of pumping at current rates will be about 12 m in the southwest corner of Kangaroo Flat PWA where most extraction occurs. The direction of groundwater flow across the Kangaroo Flat PWA is controlled by extractions from the adjacent Northern Adelaide Plains PWA, and is toward the southwest in both the irrigation (summer) and non-pumping (winter) seasons.

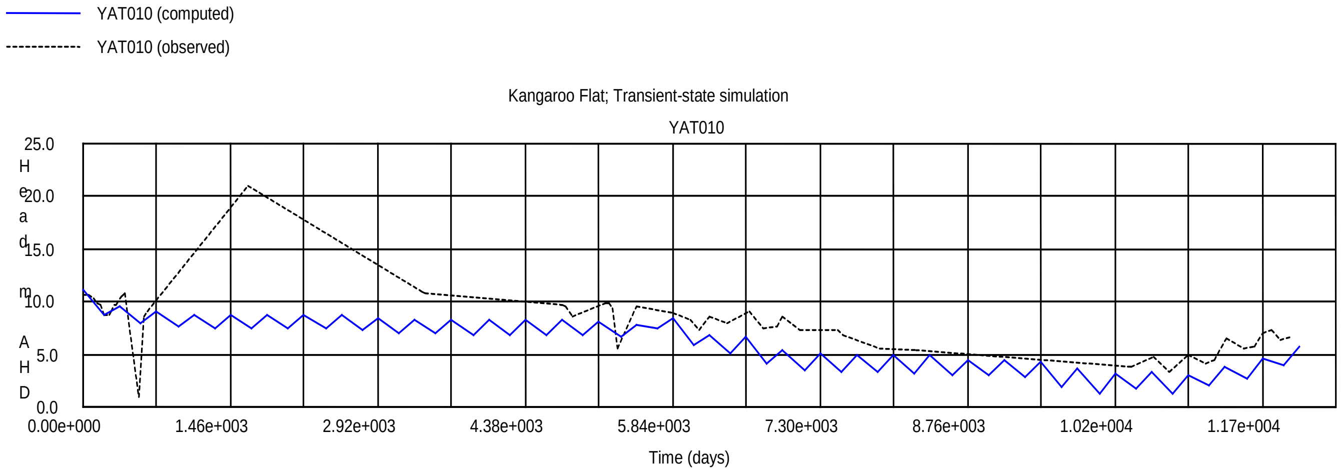
APPENDICES

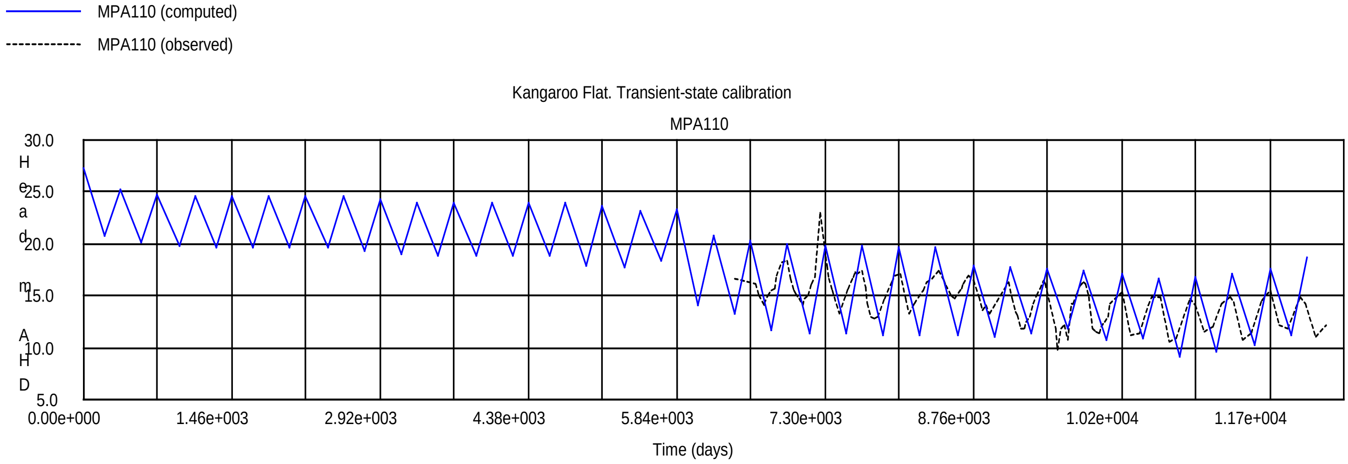
A. TRANIENT CALIBRATION RESULTS

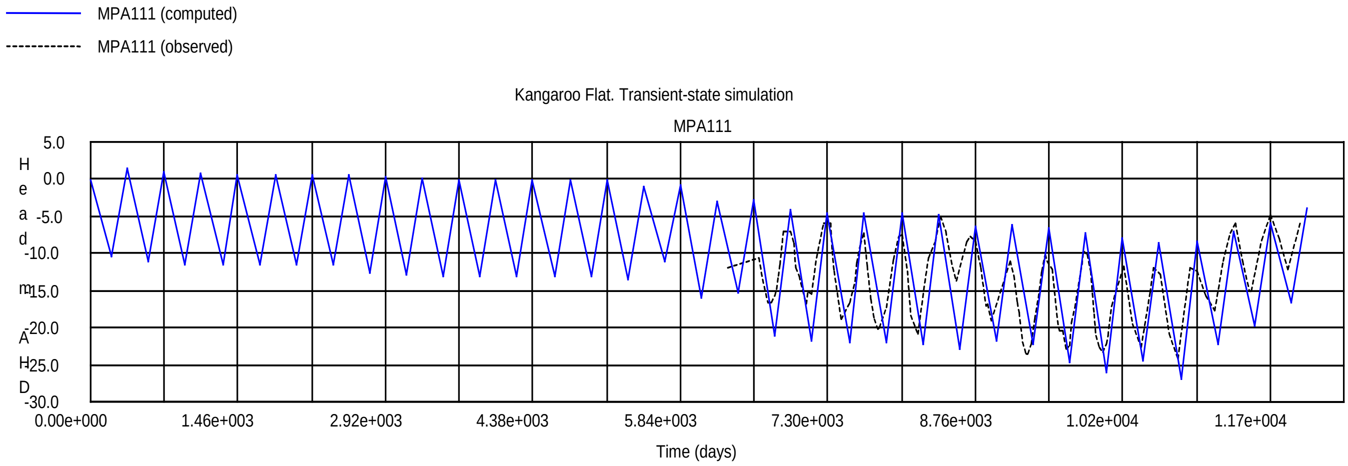







YAT010 (computed)
YAT010 (observed)
Kangaroo Flat; Transient-state simulation
YAT010
Head m AHD
25.0
20.0
15.0
10.0
5.0
0.0
0.00e+000
1.46e+003
2.92e+003
4.38e+003
5.84e+003
7.30e+003
8.76e+003
1.02e+004
1.17e+004
Time (days)


MPA110 (computed)
MPA110 (observed)
Kangaroo Flat. Transient-state calibration
MPA110
Head m AHD
30.0
25.0
20.0
15.0
10.0
5.0
0.00e+000
1.46e+003
2.92e+003
4.38e+003
5.84e+003
7.30e+003
8.76e+003
1.02e+004
1.17e+004
Time (days)


MPA111 (computed)
MPA111 (observed)
Kangaroo Flat. Transient-state simulation
MPA111
Head m AHD
5.0
0.0
-5.0
-10.0
-15.0
-20.0
-25.0
-30.0
0.00e+000
1.46e+003
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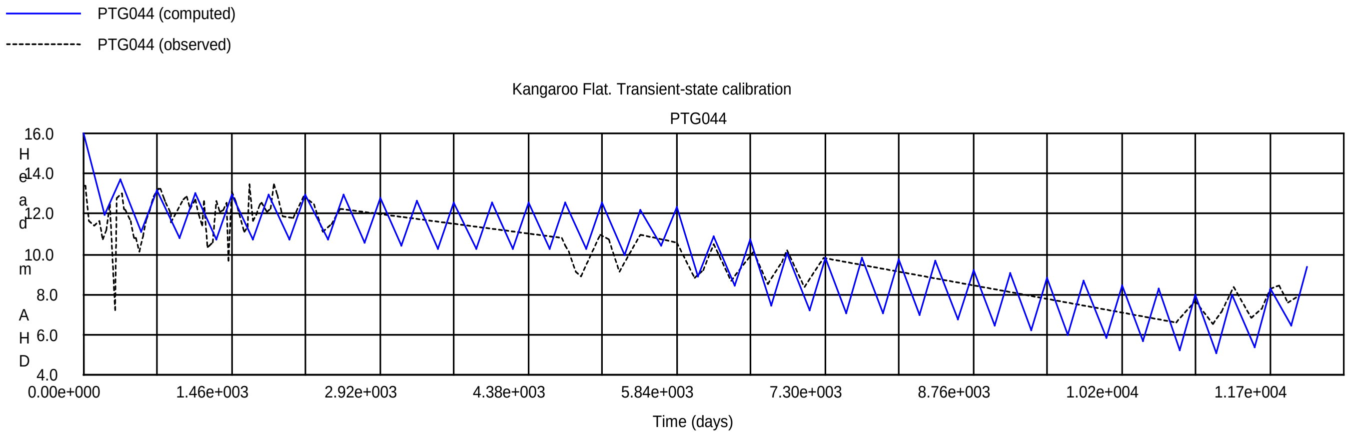
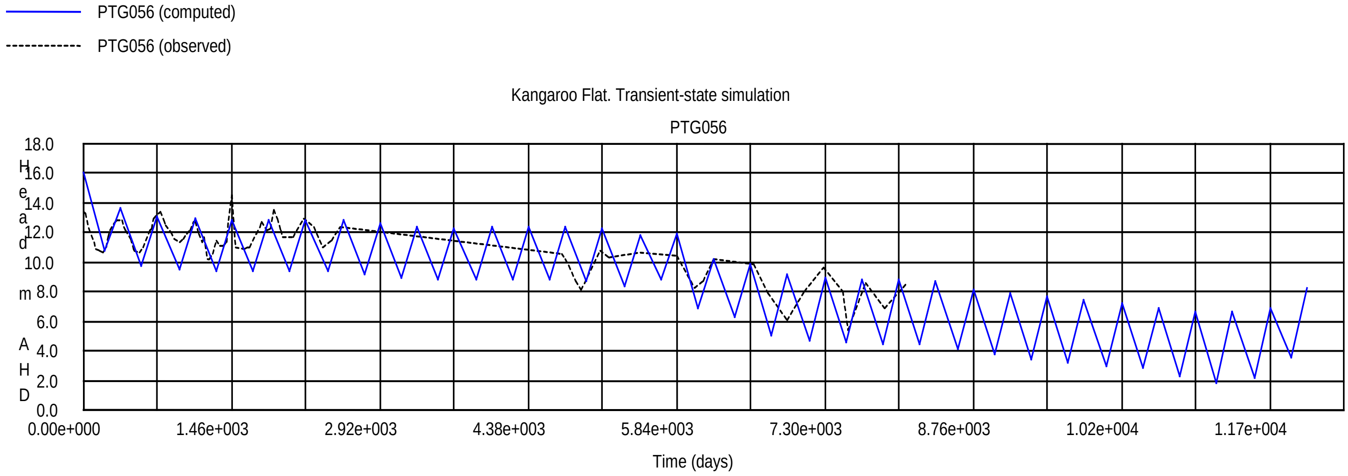
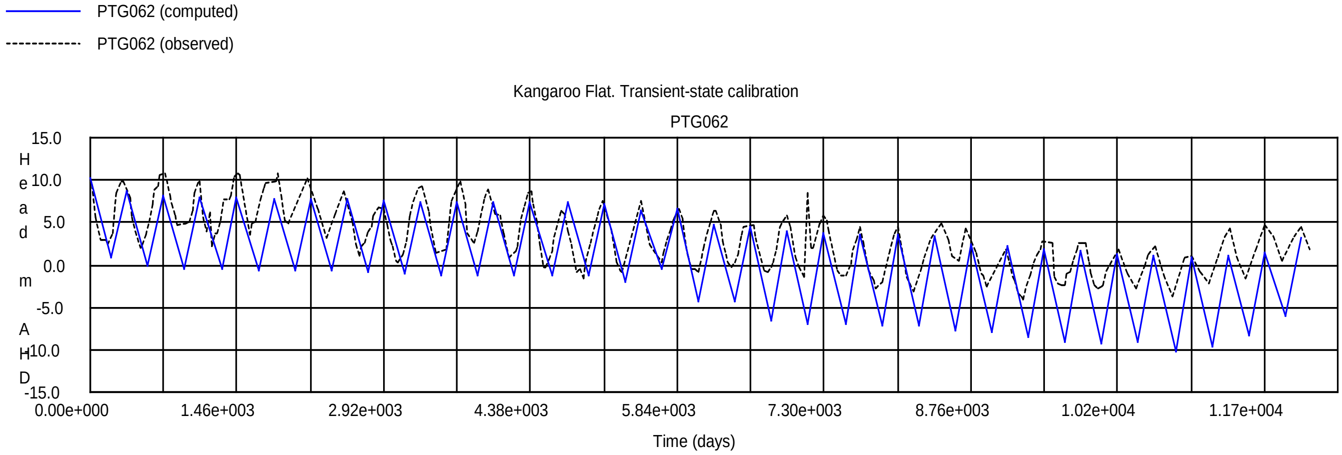
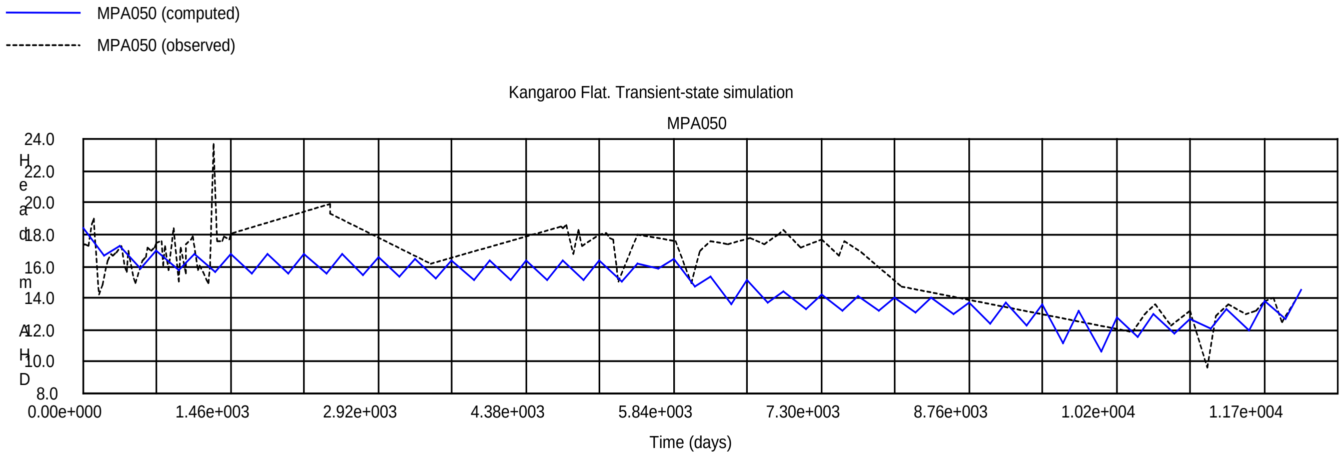
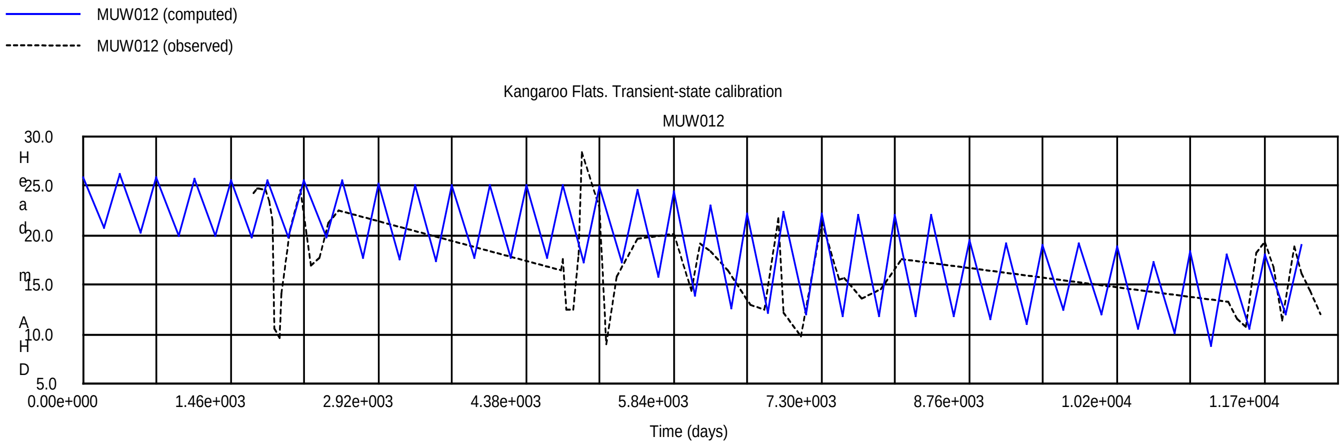
8.76e+003
1.02e+004
1.17e+004
Time (days)

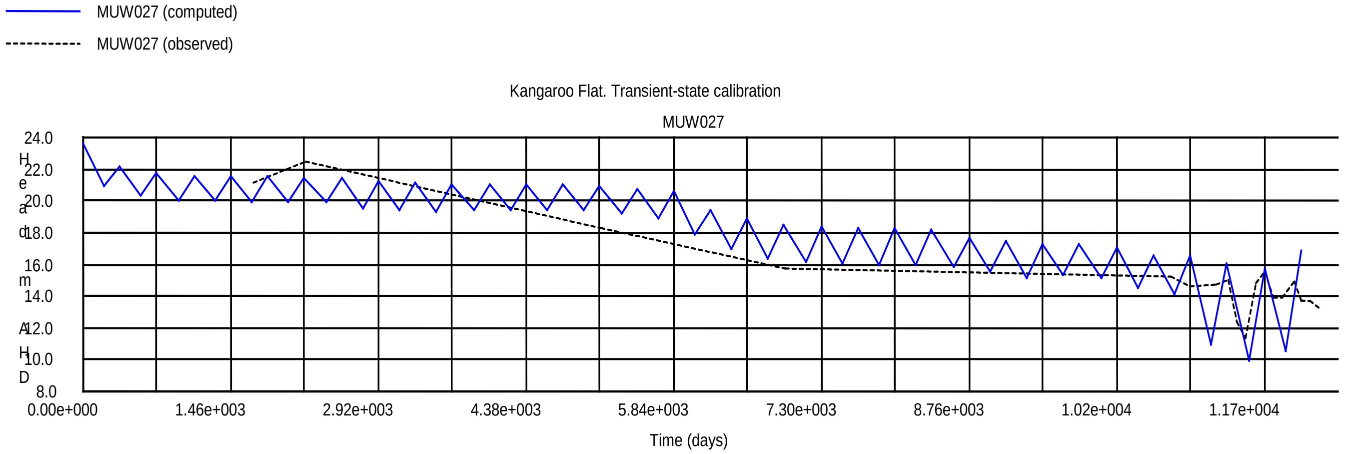

PTG044 (computed)
PTG044 (observed)
Kangaroo Flat. Transient-state calibration
PTG044
Head m AHD
16.0
14.0
12.0
10.0
8.0
6.0
4.0
0.00e+000
1.46e+003
2.92e+003
4.38e+003
5.84e+003
7.30e+003
8.76e+003
1.02e+004
1.17e+004
Time (days)

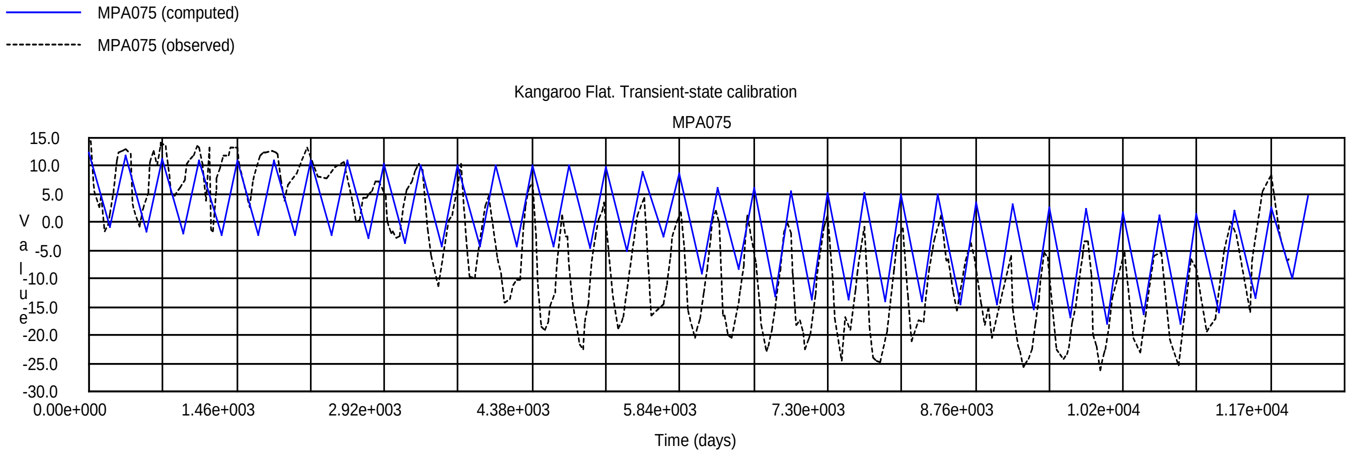

PTG056 (computed)
PTG056 (observed)
Kangaroo Flat. Transient-state simulation
PTG056
Head m AHD
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0.00e+000
1.46e+003
2.92e+003
4.38e+003
5.84e+003
7.30e+003
8.76e+003
1.02e+004
1.17e+004
Time (days)

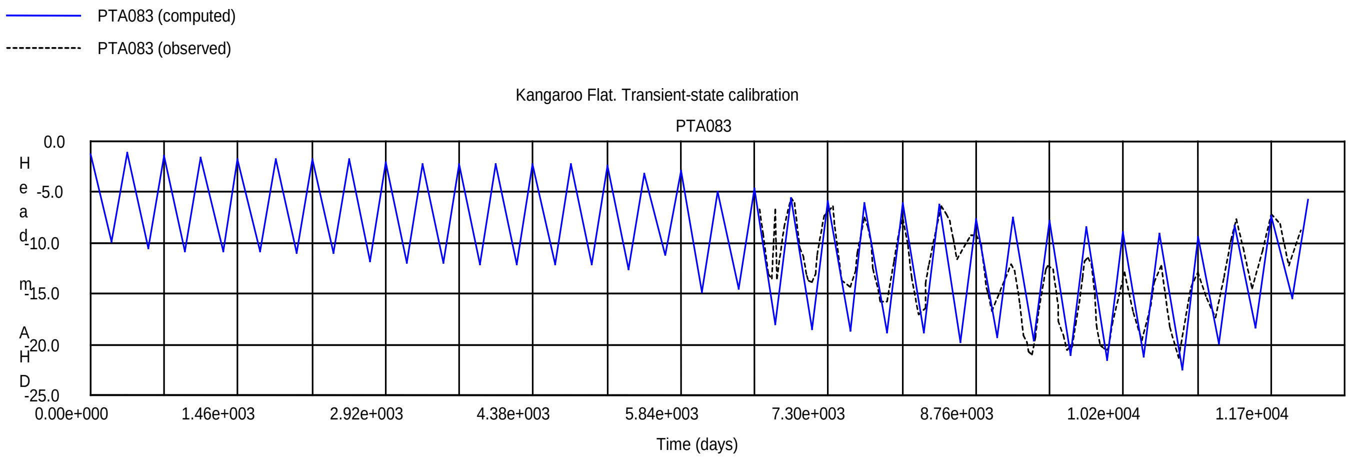

PTG062 (computed)
PTG062 (observed)
Kangaroo Flat. Transient-state calibration
PTG062
Head m AHD
15.0
10.0
5.0
0.0
-5.0
-10.0
-15.0
0.00e+000
1.46e+003
2.92e+003
4.38e+003
5.84e+003
7.30e+003
8.76e+003
1.02e+004
1.17e+004
Time (days)

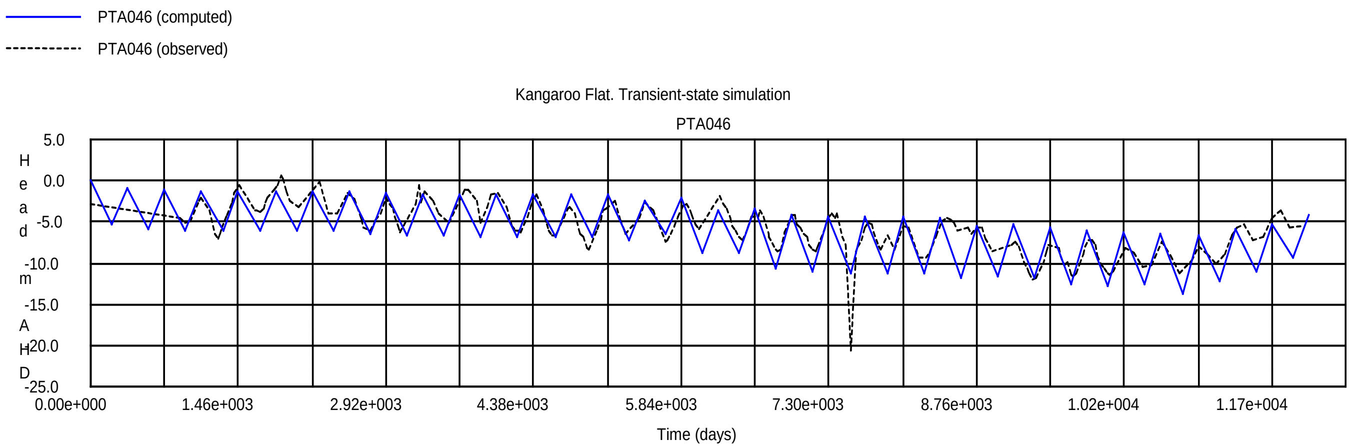

MPA050 (computed)
MPA050 (observed)
Kangaroo Flat. Transient-state simulation
MPA050
Head m AHD
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
0.00e+000
1.46e+003
2.92e+003
4.38e+003
5.84e+003
7.30e+003
8.76e+003
1.02e+004
1.17e+004
Time (days)

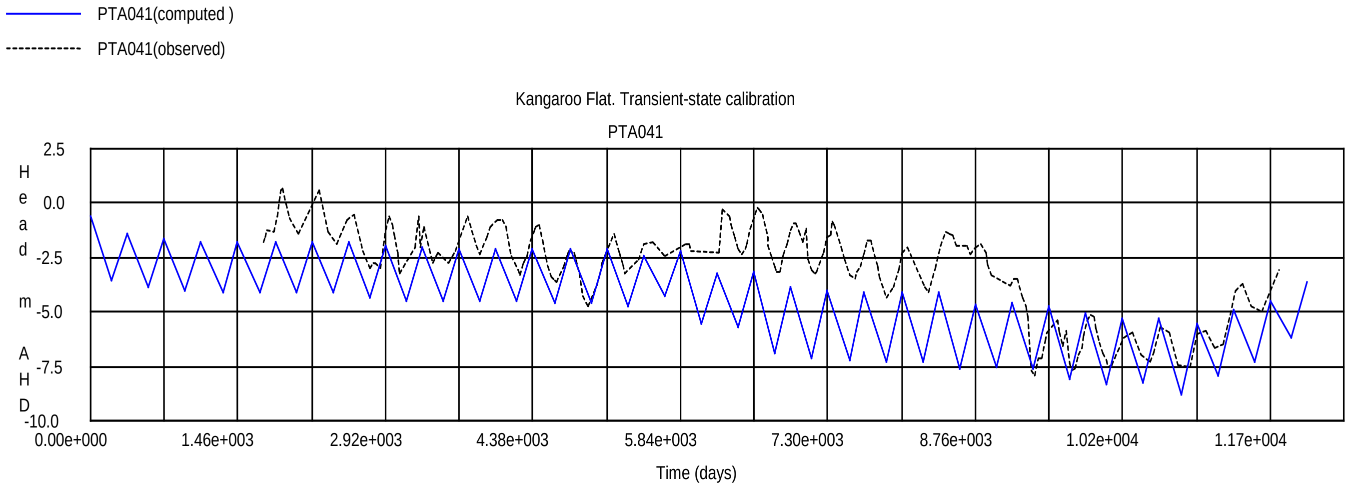

MUW012 (computed)
MUW012 (observed)
Kangaroo Flats. Transient-state calibration
MUW012
Head m AHD
30.0
25.0
20.0
15.0
10.0
5.0
0.00e+000
1.46e+003
2.92e+003
4.38e+003
5.84e+003
7.30e+003
8.76e+003
1.02e+004
1.17e+004
Time (days)

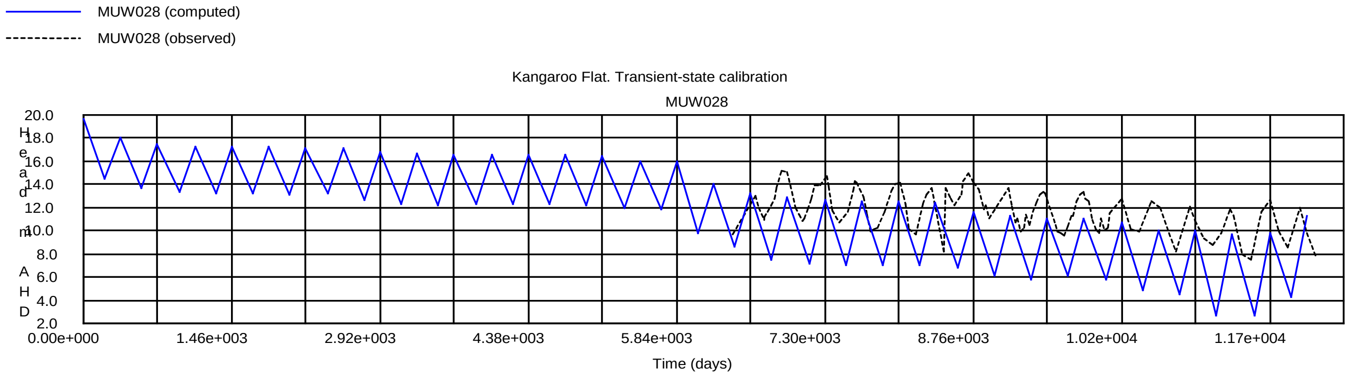

MUW027 (computed)
MUW027 (observed)
Kangaroo Flat. Transient-state calibration
MUW027
Head m AHD
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
0.00e+000
1.46e+003
2.92e+003
4.38e+003
5.84e+003
7.30e+003
8.76e+003
1.02e+004
1.17e+004
Time (days)

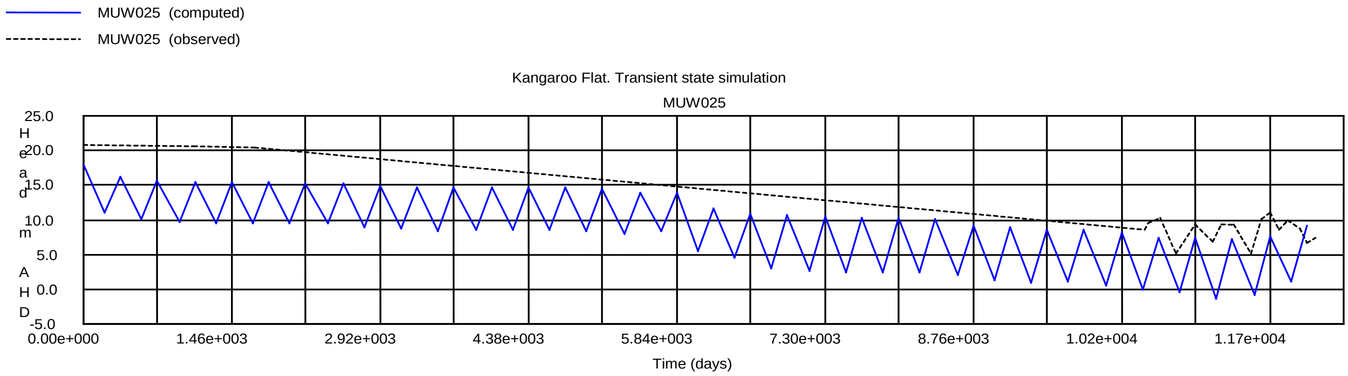

MPA075 (computed)
MPA075 (observed)
Kangaroo Flat. Transient-state calibration
MPA075
Value
15.0
10.0
5.0
0.0
-5.0
-10.0
-15.0
-20.0
-25.0
-30.0
0.00e+000
1.46e+003
2.92e+003
4.38e+003
5.84e+003
7.30e+003
8.76e+003
1.02e+004
1.17e+004
Time (days)

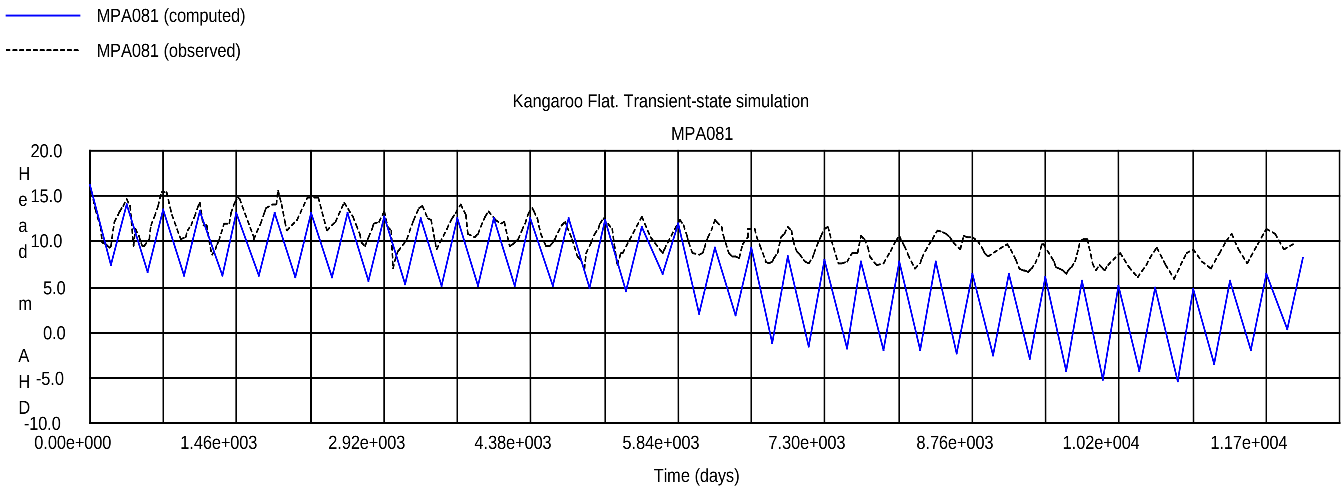

PTA083 (computed)
PTA083 (observed)
Kangaroo Flat. Transient-state calibration
PTA083
Head m AHD
0.0
-5.0
-10.0
-15.0
-20.0
-25.0
0.00e+000
1.46e+003
2.92e+003
4.38e+003
5.84e+003
7.30e+003
8.76e+003
1.02e+004
1.17e+004
Time (days)


PTA046 (computed)
PTA046 (observed)
Kangaroo Flat. Transient-state simulation
PTA046
Head m AHD
5.0
0.0
-5.0
-10.0
-15.0
-20.0
-25.0
0.00e+000
1.46e+003
2.92e+003
4.38e+003
5.84e+003
7.30e+003
8.76e+003
1.02e+004
1.17e+004
Time (days)


PTA041(computed)
PTA041(observed)
Kangaroo Flat. Transient-state calibration
PTA041
Head m AHD
2.5
0.0
-2.5
-5.0
-7.5
-10.0
0.00e+000
1.46e+003
2.92e+003
4.38e+003
5.84e+003
7.30e+003
8.76e+003
1.02e+004
1.17e+004
Time (days)


MUW028 (computed)
MUW028 (observed)
Kangaroo Flat. Transient-state calibration
MUW028
Head m AHD
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.00e+000
1.46e+003
2.92e+003
4.38e+003
5.84e+003
7.30e+003
8.76e+003
1.02e+004
1.17e+004
Time (days)


MUW025 (computed)
MUW025 (observed)
Kangaroo Flat. Transient state simulation
MUW025
Head m AHD
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
0.00e+000
1.46e+003
2.92e+003
4.38e+003
5.84e+003
7.30e+003
8.76e+003
1.02e+004
1.17e+004
Time (days)


MPA081 (computed)
MPA081 (observed)
Kangaroo Flat. Transient-state simulation
MPA081
Head m AHD
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
0.00e+000
1.46e+003
2.92e+003
4.38e+003
5.84e+003
7.30e+003
8.76e+003
1.02e+004
1.17e+004
Time (days)

GLOSSARY

Act (the) — In this document, refers to the *Natural Resources Management Act* (SA) *2004*.

Aquifer — An underground layer of rock or sediment that holds water and allows water to percolate through.

Aquifer, confined — Aquifer in which the upper surface is impervious and the water is held at greater than atmospheric pressure. Water in a penetrating well will rise above the surface of the aquifer.

Aquifer test — A hydrological test performed on a well, aimed to increase the understanding of the aquifer properties, including any interference between wells, and to more accurately estimate the sustainable use of the water resource available for development from the well.

Aquifer, unconfined — Aquifer in which the upper surface has free connection to the ground surface and the water surface is at atmospheric pressure.

Aquitard — A layer in the geological profile that separates two aquifers and restricts the flow between them.

Bore — *See well.*

Cone of depression — An inverted cone-shaped space within an aquifer caused by a rate of groundwater extraction that exceeds the rate of recharge. Continuing extraction of water can extend the area and may affect the viability of adjacent wells, due to declining water levels or water quality.

DWLBC — Department of Water, Land and Biodiversity Conservation (Government of South Australia).

GL — Gigalitre. One thousand million litres (1 000 000 000).

Groundwater — *See underground water.*

Hydrogeology — The study of groundwater, which includes its occurrence, recharge and discharge processes, and the properties of aquifers. *(See hydrology.)*

Irrigation — Watering land by any means for the purpose of growing plants.

Irrigation season — The period in which major irrigation diversions occur, usually starting in August–September and ending in April–May.

ML — Megalitre**.** One million litres (1 000 000).

Model — A conceptual or mathematical means of understanding elements of the real world which allows for predictions of outcomes given certain conditions. Examples include estimating storm runoff, assessing the impacts of dams or predicting ecological response to environmental change.

Permeability — A measure of the ease with which water flows through an aquifer or aquitard. The unit is m^2/d.

Potentiometric head — The potentiometric head or surface is the level to which water rises in a well due to water pressure in the aquifer; the unit is metres (m).

PWA — Prescribed Wells Area.

Recharge area — The area of land from which water from the surface (rainfall, streamflow, irrigation, etc.) infiltrates into an aquifer. *(See artificial recharge, natural recharge.)*

Underground water (groundwater) — Water occurring naturally below ground level or water pumped, diverted or released into a well for storage underground.

Well — (a) an opening in the ground excavated for the purpose of obtaining access to underground water; (b) an opening in the ground excavated for some other purpose but that gives access to underground water; (c) a natural opening in the ground that gives access to underground water.

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