SA/VIC BORDER GROUNDWATER REVIEW COMMITTEE

FIVE YEAR TECHNICAL REVIEW 1996 - 2000

by

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1. INTRODUCTION

The Groundwater (Border Agreement) Act of 1985 provides the legislative framework for the joint management of the groundwater resources along the South Australia/Victoria State border. The Act established a 40 km wide Designated Area along the border with twenty two management zones, as shown on Figure 1.

A Border Groundwater Agreement Review Committee (BGARC), which is comprised of members of relevant water management authorities in South Australia and Victoria administers the Act. The Committee is required to undertake a review of the management arrangements, including Permissible Annual Volumes (PAVs), at least every five years. A Technical Working Group (TWG) directed by and reporting to the BGARC, conducts investigations of the groundwater resources in the Designated Area.

The purpose of this report is to provide technical information from the TWG to the BGARC to enable the mandatory review of the management arrangements in the Designated Area to be undertaken. The BGARC will present its determinations and recommendations to the respective State Ministers in early 2001.

This document:

- provides a consolidated report of studies undertaken since the last technical review (Bradley et al 1995), during the period 1996 to 2000;
- identifies the key issues facing groundwater management in the Designated Area; and
- recommends the key areas of investigation which need to be undertaken during the next five years as part of the 2001 to 2005 technical work program.

2. OVERVIEW OF THE PHYSICAL SYSTEM

2.1 Geology

The Designated Area occurs within two sedimentary basins: the Murray Basin to the north and the Otway Basin to the south. The basins are separated in the subsurface along a line between the Padthaway Ridge and the Dundas Plateau as shown in Figure 1.

The hydrostratigraphic relationship of the various geological units in the Otway and the Murray Basins is presented in Figure 2. A more detailed description of the geology for each basin can be found in Bradley et al (1995).

2.2 Hydrogeology

Within the Designated Area there are two main regional aquifer systems and a third more restricted aquifer, separated wholly or in part by aquitards.

The aquifers and aquitards are shown on Figure 2 and consist of:

- the **Tertiary Confined Sand Aquifer (TCSA)**, comprising mainly the Dilwyn Formation in the Otway Basin and the Renmark Group in the Murray Basin;
- the **Lower Tertiary Aquitard** consisting of marl and clay;
- the **Tertiary Limestone Aquifer (TLA)**, consisting of the Gambier Limestone (and overlying limestone units) in the Otway Basin, and the Murray Group Limestone in the Murray Basin;
- the **Upper Tertiary Aquitard**, consisting of the Bookpurnong Beds, restricted largely to the north and north eastern parts of the Murray Basin in the Designated Area; and
- the **Pliocene Sands Aquifer (PSA)** which is found in the northern part of the Designated Area and locally north of the Dundas Plateau in Victoria. The PSA directly overlies the TLA in limited areas.

Two east–west cross sections which illustrate the inter-relationships of the regional aquifers and aquitards are shown in Figure 3. Cross Section A-A is located in the Murrayville/Pinnaroo area and Section B-B to the north of Naracoorte and Edenhope, as shown in Figure 4.

2.2.1 Tertiary Confined Sand Aquifer

The TCSA consists mainly of interbedded quartz sand, finer grained sediment and clay horizons. The TCSA is separated from the Tertiary Limestone Aquifer in the Designated Area by the Lower Tertiary Aquitard.

Groundwater flow in the TCSA is radially away from the Dundas Plateau in a southerly, westerly, and northerly direction as shown in Figure 5. Groundwater salinity is generally less than about 2000 ECU, however it increases to in excess of 10 000 ECU in the north of the Designated Area as shown in Figure 6.

The TCSA is not greatly utilised in the Designated Area due to the availability of good quality water in the overlying TLA, where pumping and drilling costs are lower. The use of the TCSA in the Designated Area is mainly limited to town water supply.

2.2.2 Tertiary Limestone Aquifer

The TLA consists mainly of cemented limestone that is karstic in places. In the Designated Area, the TLA has been subdivided into three hydrogeological provinces as shown in Figure 4.

<u>Province 1</u> occurs largely in the Otway Basin and is characterised by Quaternary limestone overlying the Gambier Limestone forming one unconfined aquifer system.

<u>Province 2</u> is located in the Murray Basin where the Murray Group Limestone is unconfined and either outcrops at the surface, or is overlain directly by the PSA.

<u>Province 3</u> is in an area of the Murray Basin where the Murray Group Limestone is confined by the Upper Tertiary Aquitard.

Groundwater flow is generally from Victoria to South Australia across the State Border. The direction of flow is north east to south west in the southern part of the Designated Area, east to west in the central part, and south east to north west in the northern part, as shown in Figure 7. Groundwater salinity is mostly less than 3000 ECU in the Designated Area except in the far north where it exceeds 30 000 ECU as shown in Figure 8.

The TLA is the principal source of groundwater for existing users in the Designated Area. The TLA is extensively used for stock and domestic and irrigation, and to a lesser extent for industrial, recreation and town supply purposes.

2.2.3 Pliocene Sands Aquifer

The PSA is generally unconfined over the Designated Area and consists mainly of the Loxton-Parilla Sands. The Loxton-Parilla Sands are however unsaturated in places and do not form an aquifer. This occurs notably south of Pinnaroo in South Australia, and in Victoria, in areas west and north west of Edenhope and Kaniva.

The groundwater flow direction in the PSA is generally northwards towards the Murray River where it discharges. Salinity in the PSA ranges from less than 1000 to greater than 35 000 mg/L TDS in the north of the Designated Area, however it is mostly greater than 3000 mg/L. It is not used extensively due to better water quality and yield in the underlying TLA. Some old stock and domestic bores north of Pinnaroo have utilised the PSA where the salinity was found to be suitable. Figure 9 shows the PSA salinity in the Mallee. This data was recently collected to better understand the risk of saline flow from the PSA to the TLA as a result of large scale pumping from the TLA.

2.3 Climate

The Designated Area has a Mediterranean type climate, characterised by warm to hot and dry summers and cool to cold and wet winters. The average annual rainfall varies from 750 mm per year in Mount Gambier to 350 mm per year in Pinnaroo. Over most of the Designated Area rainfall has been below average since 1996, except in the far north, where above average rainfall was recorded in 1998 and 1999.

Plots showing five-year moving average annual rainfall (January to December) and cumulative deviation from mean, for stations at Mt Gambier, Naracoorte, Bordertown and Pinnaroo, are contained in Appendix A. This data shows the general deficit in rainfall over the last five years.

The rainfall deficit would be expected to result in reduced vertical recharge to groundwater. This is discussed further in an analysis of groundwater level trends in the Designated Area, in Section 4 of this report.

3. SUMMARY OF TECHNICAL WORK UNDERTAKEN 1996 – 2000

3.1 Work Recommended In Previous 5 Year Review

In its 1995 review (Bradley et al,1995), the TWG recommended to the Border Groundwater Agreement Review Committee that the following technical work be undertaken.

3.1.1 Assessment of Groundwater Quantity

- the groundwater resources of the TCSA should be fully evaluated and PAVs determined;
- assessment of inter-aquifer leakage between the three regional aquifers should be undertaken;
- assessment of recharge to the Pliocene Sand Aquifer should be undertaken to determine recharge rates and interaction with the TLA;
- groundwater flow in the TLA should be modelled;
- investigations should be undertaken to obtain better estimates of the variation of transmissivity and storage coefficient in the TLA, especially in Hydrogeological Provinces 1 and 2;
- an investigation should be undertaken to assess the direct use of groundwater from the TLA by softwood plantations.

3.1.2 Assessment of Groundwater Quality

- predictive groundwater salinity modelling should be undertaken for the TLA;
- a detailed hydro-chemical investigation of groundwater in the TLA should be undertaken,
- studies to examine effects of afforestation on groundwater quality should be undertaken to determine whether contamination is occurring.

3.1.3 Monitoring and Data Compilation

- states should continue their respective groundwater level and groundwater quality monitoring programs;
- the planned 1996 water sampling and full chemical analysis should be undertaken;
- a consistent sampling approach should be undertaken in Victoria to obtain reliable salinity monitoring data;
- sampling of newly drilled irrigation bores in Victoria should be undertaken to obtain some background salinity data;
- total groundwater use from the TLA and TCSA should be determined in SA and Vic;
- both States should improve their estimates of licensed groundwater use;
- states should compile plans of the distribution of irrigated areas to assist in the assessment of changes in groundwater level and quality; and
- a geographic information system should be used for data in the Designated Area.

3.2 Additional Technical Issues

The following technical issues arose during the five year period since the previous review.

- the need to refine the areal extent of confinement of the TLA to improve the assessment of recharge to the TLA
- the need to determine a hydrogeological basis for interstate transfer of groundwater entitlements

- the need to assess the effects of intensive local extraction in Neuarpurr and Murrayville in Victoria,
- the need to install additional monitoring bores in Victoria in areas of high groundwater allocation
- the need to re-assess recharge rates to the TLA in the southern part of the Designated Area, as a result of additional information on the aquifer Specific Yield, and changes in the area of afforestation.

3.3 Investigations Undertaken

The following work has been undertaken either directly by the TWG for the BGARC or, by other bodies to the benefit of the Border Zone technical work program. A brief synopsis of reports undertaken by the TWG for the BGARC is provided in Appendix B. The reports undertaken for the BGARC are identified as such, below.

3.3.1 Assessment of Groundwater Quantity

- A groundwater flow net of the TCSA was constructed where salinity is less than 3000 mg/L TDS, and management areas and options developed to apportion the available flow to the management areas. TWG report to BGARC (SKM 1998f).

- A groundwater flow model of the TCSA was constructed to examine the effects of groundwater pumping from the TCSA under various allocation scenarios within separate management areas in order to determine PAVs for this aquifer. The model also examined leakage between the TCSA and the TLA. TWG report to BGARC (Brown 2000).

- A groundwater flow model was constructed to examine the effects of existing and future pumping on the TLA in the Mallee. The model examined leakage from the underlying TCSA to the TLA and the overlying PSA to the TLA, and also lateral inflow to pumping centres from areas of poor quality groundwater (Barnett and Yan 2000).

- A groundwater flow model was constructed to examine the long term effects of existing and future pumping on the TLA within Zones 5A/5B, 6A/6B in the Designated Area. (Calibration report and scenario modelling in progress).

- The areal extent of the Upper Tertiary Aquitard in Zones 5B to 8B of the Designated Area was reviewed, and recharge re-assessed in areas found to be unconfined. TWG report to BGARC (SKM 1997b).

- A review of available transmissivity and storage coefficient data was conducted on the Victorian side of the Designated Area, and the reliability of the data assessed. TWG report to BGARC (SKM 1998d).

- A pumping test in the Neuarpurr /Minimay area in Victoria was undertaken to determine aquifer transmissivity and storage coefficient values in the TLA. A number of monitoring bores were also installed in the area (SKM 1997c).

- The effect of intensive pumping on TLA water levels in the Murrayville area in Victoria was assessed (SKM 1998b).

- A prediction of the effects of pumping in the Murrayville area on the potentiometric surface in the TLA was undertaken by using a simple spreadsheet model (SKM 1998e).

- Groundwater modelling was undertaken in the area south of Mount Gambier to examine the potential for increasing the PAVs of the TLA beyond the levels of vertical recharge, that is, using a proportion of the lateral throughflow (Stadter and Yan 2000).

- Recent changes in afforestation in the southern part of the Designated Area of South Australia have been mapped to help assess the impact of forestry on groundwater recharge to the TLA.

- A three layer model was constructed of the Tintinara-Coonalpyn Moratorium Area, Zones 8 and 9 and the Telopea Downs GMA. Pumping scenarios were run to predict drawdowns in both the TLA and the TCSA. (report in preparation by SA Department for Water Resources)

- A groundwater management strategy for the West Wimmera was developed. (SKM 2000).

- A program to study the feasibility of undertaking an artificial recharge assessment in Zones 5B and 6B was developed. TWG report to BGARC (SKM 1998g).

- Investigations were undertaken by the SA Department for Water Resources at two sites within Zone 2A to determine the recharge to the TCSA (report in preparation).

3.3.2 Assessment of Groundwater Quality

- A one dimensional hydraulic soil column model was developed to investigate the effects on groundwater salinity of irrigation recycling. TWG report to BGARC (SKM 1997d).

- The origin of fresh groundwater in the Mallee region of the Designated Area and the potential for salinisation of the TLA following tree clearing and irrigation has been investigated by the CSIRO (Leaney and Herczeg 1999).

- A salinity risk assessment project was commenced to map the risk of salinisation of low salinity groundwater in the Designated Area, due to land use changes and pumping. (In progress)

- An assessment of chemical analysis data from monitoring bores in the Designated Area was undertaken which identified the chemical characteristics of groundwater in the Designated Area and areas of increasing salinity. TWG report to BGARC (Brown & SKM 1998).

3.3.3 Monitoring and Data Compilation

- A review of the need for additional groundwater monitoring bores in the Victorian Wimmera and Mallee was conducted (SKM 1998c).

- Ongoing monitoring of water levels and salinity was undertaken as described below in Section 3.4.

- A full chemical analysis from bores in the Designated area was undertaken in 1996. TWG report to BGARC, DWR & SKM (1998).

- Additional monitoring bores have been installed in high allocation areas in the TLA in the Murrayville, Telopea Downs, and Neuarpur areas in the Victorian portion of the Designated Area. Additional bores have also been installed in the PSA in the Murrayville area.

- Trends in groundwater use in Victoria were investigated. TWG report to BGARC (SKM 1996b).

- A bore metering program was instituted in high allocation areas in Victoria, as described below in Section 3.5. In addition, a metering trial was initiated in the Mallee PWA.

- A geographic information system is in use which includes part of the data available in the Designated Area

- A hydrogeological basis for interstate transfer of groundwater entitlements was developed.

3.4 Bore Monitoring Program

The bore monitoring program undertaken at the direction of the BGARC in the Designated Area consists of monitoring water levels and water quality.

3.4.1 Water Level Monitoring

Water level monitoring is aimed at the three main aquifer systems, the TCSA, TLA and PSA. In a number of cases more than one aquifer is monitored at the same nested site. The water level monitoring consists of:

- Taking readings from the bores listed in Table 1 in Appendix C for SA, and Table 2 in Appendix C for Victoria, where "water level" is indicated in the tables as a "parameter measured";
- Reading levels four times a year in: March, June, September and December;
- Recording water levels on State-wide computer data bases: the Water Management System in Victoria and the SA_GEODATA corporate database in South Australia, which will have a website interface to examine the observation well data.

The bores in Tables 1 and 2 shown in Appendix C have been sorted into the aquifer system monitored, and include bores current as of June 2000. The locations of: the TCSA water level monitoring bores are shown in Figure 10, TLA water level monitoring bores in Figures 11(a), 11(b) and 11(c), and PSA water level monitoring bores in Figure 12.
It should be noted that a number of the bores in Tables 1 and 2, may be read more frequently than quarterly by local water authorities or States, in relation to local investigations and issues. This additional data is normally incorporated into the respective State groundwater data bases.

3.4.2 Water Quality Monitoring

Water quality monitoring is mainly undertaken for the TLA. Monitoring generally consists of determining salinity as an electrical conductivity (EC) reading.

Salinity readings are taken from private bores that are being actively pumped at the time of sampling, or by pumping other bores to obtain samples. As the private bores have permanent pumps fitted, they often do not allow water levels to be read, with the result that the salinity monitoring bores are a substantially different set to the water level bores.

The salinity monitoring consists of:

- Taking readings from bores identified as having “salinity” as a “parameter measured” in Tables 1 and 2 in Appendix C. These bores are almost all developed in the TLA.
- Taking samples for salinity measurement four times a year: in March, June, September and December.
- Recording salinity readings on the Water Management System (Vic) and the SA_GEODATA database (SA).

The locations of the TLA salinity monitoring bores are shown in Figures 13a and 13b.

In addition to the EC monitoring, water chemistry monitoring is undertaken. In the past this occurred annually between 1998 and 1990, and on a three yearly basis in 1993 and 1996. It is intended to continue this monitoring six yearly, with the next monitoring scheduled for 2002. The chemistry monitoring consists of taking pumped samples from TLA bores and analysing for major cations, anions and nutrients. The results of previous monitoring are described in a combined report by SA and Victoria (Brown & SKM 1998).

3.4.3 New Monitoring Bores

In Victoria, twenty new monitoring bores have been installed in the Designated Area since the last 5 Year Review. These bores have all been installed in areas of intensive groundwater allocation and use, near Murrayville, Neuarpurr and Telopea Downs. The aquifers monitored are the TLA and the PSA as shown in Table 1 below. These bores were installed under a Victorian State Groundwater Initiative in relation to the development of Groundwater Management Areas (as described in Section 6.5). The need for a number of the bores is discussed in SKM (1998c). The bores are now included in the monitoring network of the Designated Area.

In the Neuarpurr area an additional ten private bores were monitored for water levels for a short period of time. In Murrayville three abandoned stock and domestic bores and one State owned monitoring bore, have continuous water level recorders installed. The PSA bores at Murrayville have been read for salinity (EC), however this is not expected to be done regularly.

In South Australia, in Zones 9, 10 and 11, 30 additional bores in the concentrated irrigation area are being read to define the extent and magnitude of drawdown from irrigation pumping, in addition to those already in the monitoring network in the Designated Area. These 30 bores are being read more frequently than three monthly. Six of the additional bores are monitoring the PSA to investigate the possibility of downward leakage from the PSA to the TLA.

3.5 Bore Metering Program

In Victoria, flow meters have been fitted to irrigation bores in areas of high use in the Designated Area. The private irrigation bores which have had meters fitted to date occur in the Neuarpur and Murrayville areas. Sixteen meters have been fitted in the Neuarpur area and twelve meters in the Murrayville area. The bores currently with meters are listed in Table 1 in Appendix D. The meters are read by Wimmera Mallee Water not less than twice yearly in October and April. Metered data is recorded by Wimmera Mallee Water on a data base, and reported to DNRE on an annual basis.

Table 1: New Victorian Monitoring Bores

Area	Bore Number	Aquifer Monitored	
		TLA	PSA
Neuarpurr	129744	✔	
	129745	✔	
	129746	✔	
	129751	✔	
	129752	✔	
Telopea Downs	138351	✔	
	138352	✔	
	138353	✔	
Murrayville	137190		✔
	137191		✔
	137194	✔	
	137195	✔	
	137196		✔
	137197		✔
	137198	✔	
	137199		✔
	137200	✔	
	137201		✔
	137294		✔

In SA, meters are not widespread. In the Mallee portion of the Designated Area, only six bores have been metered until a recent metering trial (initiated by the Mallee Water Resources Planning Committee), where a further seven bores were metered to test the suitability of various types of meters for the irrigation installations common in the area (Appendix D). Two of these have meters attached to the pivot intake rather than the bore due to pipework constraints.

4. TRENDS IN GROUNDWATER USE, WATER LEVELS AND QUALITY

4.1 Groundwater Use

Groundwater is relied on in the Designated Area as a water supply due to the general absence of large scale surface water resources. The majority of groundwater is sourced from the Tertiary Limestone Aquifer.

With the exception of stock and domestic supplies any person wishing to take and use groundwater is required to obtain a groundwater licence. In Victoria licences are issued by volume. In SA they are issued on the basis of irrigated area, however conversion to volumetric allocations is being undertaken in the Mallee PWA (Zones 10A and 11A).

Groundwater licenses set out the maximum amount of groundwater that can be used as an entitlement. The full amount of the entitlement is not necessarily used, and as noted in the previous section of this report, there is limited accurate data on usage. Metering is generally accepted as the most reliable way of obtaining information on use.

As States have only recently initiated metering programs, metered data have not been collated for this report. To estimate use in SA, aerial photography and land use surveys are utilised. For modelling undertaken in the Mallee PWA, each irrigator was interviewed to obtain an estimate of pumping hours and the extraction rate to determine total groundwater use.

Licence allocation is indicative however of the level of groundwater use. It provides information on the demand for groundwater resources, and the uses to which it is being put. The amount of allocation also points to possible impacts of extraction, locally or regionally.

Most licensed allocation is for irrigation. A number of towns use groundwater within the Designated Area for urban supply as listed below in Table 2. Urban supplies are from the TCSA and the TLA.

Table 2: Towns Using Groundwater from the Designated Area

South Australia	Zone	TCSA	TLA	Victoria	Zone	TLA
Pinnaroo	Zone 10A		✔	Murrayville	Zone 10B	✔
Naracoorte	Zone 5A	✔		Serviceton	Zone 7B	✔
Mt Gambier	Zone 1A	✔	✔	Apsley	Zone 5B	✔
Penola	Zone 3A		✔	Lillimur	Zone 7B	✔
Tarpeena	Zone 2A	✔				
Nangwarry	Zone 2A	✔	✔			

The level of allocation in each Zone in the Designated Area is shown below in Table 3. A total of about 200,000 ML has been allocated in the Designated Area as at June 2000. This represents an increase of nearly 43,000 ML since 1995. Slightly more water has been allocated since 1995 in SA (nearly 25,000 ML) than in Victoria (about 18,000 ML).

Seventy five percent of the total allocation has been made in SA. Five Zones in the Designated Area are now fully allocated. Four of these occur in South Australia.

4.2 Water Level Trends

Trends in water levels have been assessed as part of this report, for the water level monitoring bores contained in Tables 1 and 2 of Appendix C.

Many of the monitoring bores have records extending over 15 or more years. In assessing water level trends it was noted that there were commonly trends developing in the last five years, which were different to longer term trends. As a result, the analysis of trends presented here has been restricted to the recent trends, calculated from data collected between June 1995 to June 2000.

4.2.1 Tertiary Confined Sand Aquifer

The water level trends over the June 1995 to June 2000 period are shown in Figure 14 and indicate that there are two separate regions of trend patterns in the Designated Area. North of Zones 6A and 6B, water levels are stable with virtually a flat trend observed over the past five years. From Zones 6A and 6B south to the coast, water levels have been declining, with the greatest decline of around 20 to 30 cm/year occurring in a north east - south west band between Mount Gambier and Edenhope.

Table 3: Allocation History 1996 - 2000

ZONE	Allocation (ML/a)					PAV (ML/a)
	October 1996	June 1997	June 1998	June 1999	June 2000	June 2000
11A	6137	6647	6862	6862	6861	12000
11B	0	0	0	0	Nil	12000
10A	8988	8988	9000	9000	9000	9400
10B	848	3663	3663	3663	3663	6000
9A	1699	2333	3977	3840	5285	11600
9B	192	192	192	165	1500	6000
8A	2568	3447	4738	4780	6317	7700
8B	155	155	605	2210	2210	3500
7A	7500	7500	7500	7500	7500	7500
7B	424	424	2021	1170	1541	7000
6A	8500	8850	8850	8850	8850	8850
6B	9868	9958	9958	9718	9718	10000
5A	18500	18500	18500	18500	18500	18500
5B	6045	11264	11824	12040	12040	12000
4A	20000	20000	20000	20000	20000	20000
4B	403	476	537	777	779	14000
3A	24000	24000	24000	24000	23763	24000
3B	65	100	70	95	95	16500
2A	12959	15885	18873	20818	20141	25000
2B	12627	13696	14031	17256	17282	25000
1A	16855	21444	28181	25377	26136	30900
1B	900	823	1100	898	898	71000
Totals	159233	178345	194482	197519	202079	

Note: Allocation Data Sourced from Border Zone Annual Reports

The reason for the decline is not entirely clear. Pumping in this part of the TCSA in the Designated Area is limited to moderately small volumes for urban supply as listed above in Table 2 at Naracoorte, Mount Gambier, Nangwarry, and Tarpeena. Whilst pumping may have some effect on water levels, the region of greatest drawdown between Mt Gambier and Edenhope coincides with an area where the TCSA is draped over the structural high which separates the Otway and Murray Basins, between the Padthaway Ridge and the Dundas Plateau.

In the area of this structural high, the TCSA occurs at relatively shallow depths. It is therefore possible that the falling trends may be related to a reduction in recharge in this region due to the recent reduction in rainfall. Reduced recharge may derive from reduced vertical leakage from the overlying TLA, as water levels in the TLA have also fallen by a similar amount in this region over the same period. In addition, there may be areas where the TCSA outcrops or subcrops and is unconfined, with the reduction in rainfall affecting direct recharge to the TCSA. The declines lessen away from the structural high to the north and south. To the north of Zones 6A and 6B, the declines reduce to zero where the TCSA is generally deeper and strongly confined.

To the east of Zones 2B and 3B, the TCSA outcrops against the Dundas Plateau. Recharge in this area may be affected by afforestation, contributing possibly to the decline in water levels further to the west.

Another possible cause, is that the decline may be due at least in part to a reduction in hydrostatic loading caused by reduced groundwater storage in the TLA.

The assessment of trends in TCSA water levels is summarised in Table 4 below. Figure 15 presents two hydrographs illustrating the above trends in groundwater levels for the northern (Bore 756690) and southern (Bore PEN025) areas.

Table 4: Groundwater Level Trends for the Tertiary Confined Sand Aquifer

Area	Area description	Water level trend from 1995 to 2000	Range m/yr	Likely cause
North	North of Zones 6A and 6B	Stable levels	0	
South	From Zones 6A and 6 B, south to the coast	Declining levels	0 to – 0.30	Reduced rainfall recharge

The reason for the decline in the southern part of the Designated Area needs to be investigated further. In the short term the water levels should be regularly reviewed, to determine whether there is a reversal in the declining trend with a return of higher rainfall conditions.

4.2.2 Tertiary Limestone Aquifer

Water level trend data for the period June 1995 to June 2000 from the TLA is shown in Figures 16(a) and 16(b). Four areas with different trend patterns have been discerned from the trend data. These four areas are listed in Table 5 below, with a description of the nature and the likely cause of the trend.

Figure 17 contains hydrographs illustrating the trends in three of the areas as described in Table 5. Bore 110746 in the southern area, Bore GGL2 in the central area and Bore PEB12 in the northern area.

Table 5: Groundwater Level Trends for the Tertiary Limestone Aquifer

Area	Area description	Water level trend from 1995 to 2000	Range M/yr	Likely cause
Far North	North and central part of 11A and 11B	Rising and falling levels	-0.17 to +0.15	Unknown, possibly change in hydrostatic loading for rises
North	From the southern part of 11A & B to southern part of 10A & 10B	Declining water levels	- 0.02 to –1.04	Irrigation extraction
Central	From central 9A and 9B to southern part of 6A & 6B	Rising levels and stable levels	- 0.01 to +0.08	Vegetation clearance
South	From southern part of 6A & 6 B to the coast	Declining water levels	0 to – 0.46	Largely climatic – reduced rainfall over last few years

4.2.3 Pliocene Sands Aquifer

There is insufficient water level monitoring data from the PSA to establish any meaningful water level trends at this point in time.

4.3 Water Quality Trends

The analysis of water quality trends in the Designated Area is restricted to salinity data collected from the monitoring bores listed in Tables 1 and 2 in Appendix C. In contrast to the water level trends determined above, it was considered that salinity is unlikely to be as responsive in the short term to climatic or other effects, therefore the long term trend of the available data has been determined.

4.3.1 Tertiary Confined Sand Aquifer

Salinity is not regularly monitored in the TCSA observation bores. The ECU data shown in Figure 6 varies in relation to the time it was recorded. In most cases, the ECU values were taken when the bore was installed.

4.3.2 Tertiary Limestone Aquifer

The long term trends determined from the EC data for the TLA monitoring bores are plotted in Figure 18.

Figure 18 indicates that to the north of Zones 2A and 2B, there are increasing EC trends. These increases are of concern and should be further investigated. The EC increases are likely to be due to irrigation and/or vegetation clearance with re-mobilising of existing salt in the soil profile by increased vertical recharge or excess irrigation application.

It is possible that salinity processes differ between this northern region and the southern part of the Designated Area. In Zones 1A/1B, 2A/2B, and also 3A/3B, rainfall is relatively high and the unsaturated zone is likely to be flushed of salt. In this southern region irrigation recycling may therefore be a more significant process in relation to salinity increase than remobilisation of salt.

Examples of EC graphs for two Tertiary Limestone Aquifer monitoring bores (Bores GGL8 and CMM83) with an increasing trend in salinity are presented in Figure 19.

4.3.3 Pliocene Sand aquifer

There is no long term salinity monitoring in the PSA. The recent drilling of six bores in the PSA in the northern Mallee in Victoria, and the conversion of four TLA bores to PSA monitoring bores in SA, has enabled the distribution of salinity in the region to be better defined (as shown in Figure 9). This work has indicated that the salinity in the PSA in the Mallee is not as high as previously thought.

5. NEW UNDERSTANDINGS AND PERSPECTIVES

Since the last 5 year review there have been new understandings gained of the groundwater resources in the three main aquifer systems, and also of the way the aquifers interact with each other. This has largely come about from groundwater flow modelling, as well as other investigations outlined in Section 3 of this report.

The new understandings mainly relate to three different combinations of aquifer system and hydrogeological province. These are: the TLA in Province 3 where it is it is confined; the TLA in Provinces 1 and 2 where it is unconfined; and the TCSA over the whole of the Designated Area. Of particular importance, the study undertaken by the CSIRO (Leaney and Herczeg (1999)), which looked at the origin of the fresh groundwater in the TLA in the Mallee, has provided a new perspective of that particular resource. The new understandings and perspectives are highlighted briefly below. Comment has also been provided on additional work required to substantiate these findings.

5.1 The Tertiary Limestone Aquifer in Province 3

1. Nature and extent of the confining aquitard

    (a) Extensive drawdown cones observed in the TLA in the Mallee have reinforced the view that the TLA is a strongly confined aquifer.

    (b) Knowledge of the extent of the Upper Tertiary Aquitard has been improved using recent drilling information.

    (c) Drawdowns predicted by modelling will need to be verified by monitoring water levels.

2. Interaction between the TLA and the TCSA

    (a) Modelling and observed head differences have suggested that there is significant leakage from the TCSA to the TLA.

    (b) This leakage needs to be verified by further field studies and monitoring.

3. Interaction between the PSA and the TLA

(a) There is potential for remobilisation of salt in the soil profile from land clearing and irrigation, however the impact on the TLA may be limited by the Upper Tertiary Aquitard.

(b) The Mallee Model (Barnett and Yan (2000)) has indicated very minor vertical leakage from the PSA to the TLA through the Upper Tertiary Aquitard

(c) The extent of low salinity groundwater in the PSA in Victoria has been found to be greater than previously thought, which has lowered the perceived salinisation risk to the TLA.

(d) Flows between the PSA and TLA need to be further assessed in the field by monitoring water levels in both the TLA and the PSA, and by undertaking additional one dimensional modelling of salinisation, incorporating the Upper Tertiary Aquitard as an intervening layer.

4. Non-renewable Nature of the TLA Resource

(e) Rates of vertical infiltration in the Mallee have been found to be very low, and fresh groundwater in the TLA has been found to be very old (in excess of 20,000 years as described in Leaney and Herczeg 1999), when it infiltrated under a considerably wetter climatic regime. As a result the fresh groundwater in the TLA in the Mallee is considered to be ancient and not being renewed.

5.2 The Tertiary Limestone Aquifer in Provinces 1 & 2

1. Salinisation of the TLA

(a) Monitoring data has revealed deteriorating groundwater quality and increased post-vegetation clearance recharge rates. It is difficult however to distinguish the significance of the processes causing the changes, that is as a result of irrigation return flows; clearance of native vegetation; or salt mobilisation due to rising water levels.

(b) Additional field work and risk assessment is required to determine the nature and the degree of threat of salinisation.

2. Reduced Recharge in the South of the Designated Area

(a) Water levels have been observed to be declining in the southern part of the Designated Area in the TLA.

(b) Declines in water level are likely to be due to the reduced rainfall in recent years. In addition, some declines are considered to be due to afforestation. It is difficult to distinguish between the two processes.

(c) With a return to more average rainfall conditions it is expected that water levels will recover away from areas of afforestation, whereas in areas of afforestation they may not.

(d) Mapping of areas of afforestation and land use change needs to be continued to be able to better interpret groundwater monitoring data in terms of the significance of the effect of afforestation on recharge.

3. Assessment of Recharge Volumes

(a) Modelling in the south of the Designated Area in South Australia has found that the Specific Yield of the TLA is not as high as previously thought.

(b) A pumping test conducted to determine the Specific Yield of the TLA in Victoria was inconclusive, because the test was not long enough.

(c) A model is being used to predict water level changes and assess recharge in Province 2. This work has not yet been completed.

(d) It is considered that additional field testing of recharge rates and the Specific Yield of the TLA needs to be conducted for input to modelling and to analyse recharge from water level data. Pumping tests need to be undertaken of sufficient duration. The modelling in Province 2 needs to be completed.

5.3 The Tertiary Confined Sand Aquifer in Provinces 1, 2 & 3

1. Modelling Results

(a) Modelling was conducted of the TCSA in the central and southern parts of the Designated Area. The effectiveness of the modelling has been limited by the fact that the TCSA is not being stressed by extraction in the Designated Area, making it difficult to calibrate leakage and aquifer parameters with a high degree of confidence.

(b) Modelling has however suggested that volumes available for sustainable extraction are relatively low from the TCSA. The modelling also indicated there may be substantial leakage between the TLA and the TCSA. These results are considered to be able to be extrapolated to the northern part of the Designated Area, which was not a part of the model.

(c) Additional work needs to be undertaken to examine leakage between the TCSA and the TLA.

2. Trend analysis

(a) The water level trend analysis undertaken in this report (Section 4.2), has indicated that water levels in the TCSA have declined substantially recently in the southern part of the Designated Area. The declines appear greatest where the TCSA is relatively shallow, to the north and north east of Mt Gambier. This area coincides with the structural high separating the Murray and Otway Basins. The decline may be due to a reduction in vertical recharge or reduced hydraulic loading in the overlying TLA, resulting from the dry conditions.

(b) Work needs to be undertaken to determine the reasons for the decline in water levels in the south of the Designated Area, particularly in relation to better defining the nature and extent of the Lower Tertiary Aquitard east and south east of the Padthaway Ridge towards the Dundas Plateau.

6. REVIEW OF MANAGEMENT CRITERIA

6.1 Permissible Annual Volumes of Groundwater Extraction

During the period since the last 5 year review the PAVs in the Designated Area have been subjected to review and alteration. The purpose of this section of the report is to present the PAVs in each Zone in terms of the technical (or other) basis for the determination of the existing PAV, to indicate where PAVs are currently under review, or indicate where review is considered necessary.

PAVs are discussed below for Zones in the TLA which are firstly confined and secondly unconfined, and new PAVs are presented for the TCSA.

6.1.1 PAVs for the Confined TLA in Zones 11A, 11 B, 10A, 10B, 9A, 9B and 8B

The existing PAVs in Zones 11A, 11B, 10A,10B, 9A, 9B and 8B are contained in Table 6 below. As can be seen from Figure 20, the confined/unconfined boundary as presently known passes through the southern parts of Zones 9A and 9B and through the north eastern and eastern part of Zone 8B. The confined/unconfined boundary in Figure 20 has been modified since the last 5 year report (Bradley et al, 1995), by an examination of drilling information in Zones 9A and 9B and by adopting the boundary determined in SKM (2000) in Zone 8B. Whilst there are areas where the TLA is unconfined in Zones 9A, 9B and 8B, the full PAV for these zones have been discussed here.

Table 6: Existing PAVs in the Confined TLA

Existing PAV (ML/a)	Zone	Zone	Existing PAV (ML/a)
12,000	11A	11B	12,000
9,400	10A	10B	6,000
11,600	9A	9B	6,000
		8B	3,500

The technical basis for the determination of the existing PAVs in the confined TLA in Table 6 was to include the vertical recharge, a proportion of throughflow, and a small amount of water from storage, as described in Bradley et al (1995).

With the current recognition however that groundwater in the confined area of the TLA is an ancient resource (as described in Section 5.1 of this report) with no direct vertical recharge, it has been considered necessary to alter the basis for the determination of the PAV and undertake new PAV calculations. The following principles and methodology have been developed to determine PAVs for the confined TLA. Proposed PAVs as listed below in Table 7 have been submitted from the TWG to the BGARC with the recommendation that they be adopted.

The principles relating to the calculation of PAVs for the TLA where it is confined in the Mallee are:

- As the resource is not being renewed, removal of water from storage is permitted.

- The rate of removal of water from storage is limited to 0.05 m of annual water level decline, assuming the TLA behaves as an unconfined aquifer and has a Specific Yield of 0.15.

- Removal of water from storage should not occur extensively under parks. It is recognised however that a bore immediately outside the park boundary would create a drawdown cone approximately 3km into a park. Consequently the area under which removal of water from storage is permitted is calculated as extending 3 km into parks within the Designated Area. It should be noted that with Zone 11A, a 3 km extension into parkland is able to occur across the border into parkland in Victoria.

- The PAVs within zones should be subdivided on the basis of water quality. The quality boundary chosen was 3000 mg/L TDS.

- The formula for calculating the PAVs in this confined region (for separate sub-zones with groundwater less than 3000 mg/L TDS and greater than 3000 mg/L TDS) is therefore:

$$PAV\ (ML/year) = \{Area\ of\ Zone + area\ extending\ 3\ km\ into\ adjoining\ parkland (km^2)\}\ \mathbf{X}\ 0.15\ \mathbf{X}\ 0.05\ m/year\ \mathbf{X}\ 1000$$

On this basis, proposed PAVs have been calculated for sub zones of the Zones in the confined part of the TLA in the Mallee region as indicated in Table 7 below. The Sub-Zones are shown in Figure 20.

A spreadsheet showing the calculations for the proposed PAVs is contained in Appendix E.

6.1.2 PAVs for the Unconfined TLA in the Remainder of the Zones

The PAVs for the TLA in hydrogeological provinces 1 and 2, where it is unconfined, were originally based on an adopted uniform vertical recharge rate for each Zone, excluding forested and native vegetation areas. In the last 5 year technical review (Bradley et al, 1995), a more detailed assessment of the vertical recharge was made for each of these Zones by considering the hydrographic response of the aquifer in relation to the spatial variation in vegetation type, land use, depth to water table and soil type.

The PAVs for some Zones (Zones 6A, 8A) were increased subsequently in the 1996 Management Review (BGARC 1996) to reflect these assessments. For other Zones (Zones 2A, 2B, 3A, 3B, 4A, 4B, 5A and 7A) the pre-existing PAVs were retained however at this time due to concerns regarding some increasing groundwater salinity trends, even though higher vertical recharge volumes had been determined in Bradley (op cit). For Zones 1A and 1B the existing PAVs were also retained, despite them being higher than the vertical recharge volumes assessed in Bradley (op cit).

The reason for retaining the pre-existing PAVs in Zones 1A and 1B was that it was considered that the specific yield of 0.1 used for the recharge determinations in Bradley (op cit) was thought to have been too low, due to the very karstic nature of the aquifer in these areas. It was recommended at this time that studies be undertaken to define the specific yield more accurately. In 2000, the PAV for Zone 1A was reduced to 30900 ML, following an assessment of vertical recharge undertaken by PIRSA in 1999. This assessment was undertaken because groundwater levels were continuing to decline in the area, and modelling south of Mount Gambier (Stadter and Yan, 2000) indicated that a specific yield of 0.1 was in fact likely to be representative of the aquifer.

Table 7: Proposed PAVs for the Confined Tertiary Limestone Aquifer

Sub – Zone	Proposed PAV (ML/year)	Description of land in Sub-Zone
Zone 11A North	11,932	consisting of land outside of parkland, greater than 3000 mg/L TDS, and extending 3km into parkland in Victoria
Zone 11A South	5,632	consisting of land outside of parkland, less than 3000 mg/L TDS, and extending 3km into parkland in Victoria
Zone 11B North	1,914	consisting of a small area in the north of Zone 11B, outside of parkland, greater than 3000 mg/L TDS, and extending 3km into parkland
Zone 11B North East	1,814	consisting of a small area of land outside of parkland in the north eastern part of Zone 11B, greater than 3000 mg/L TDS, and extending 3km into parkland
Zone 11B South	1,823	consisting of land outside of parkland, less than 3000 mg/L TDS, and extending 3km into parkland (truncated by 3000 mg/L limit)
Zone 10A	7,844	consisting of land outside of parkland, less than 3000 mg/L TDS, and extending 3km into parkland
Zone 10B	6,721	consisting of land outside of parkland, less than 3000 mg/L TDS, and extending 3km into parkland
Zone 9A North	470	consisting of a small area in the north west of Zone 9A outside of parkland, less than 3000 mg/L TDS, and extending 3km into parkland
Zone 9A South	6,496	consisting of land where the TLA is both confined and unconfined, less than 3000 mg/L TDS. For the part of this area where the TLA is confined, a 3km extension into the parkland has been included. For the area where the TLA is unconfined, a vertical recharge rate of 15 mm has been adopted for the determination of the proposed PAV.
Zone 9B South	2,539	consisting of land where the TLA is both confined and unconfined, less than 3000 mg/L TDS. For the part of this area where the TLA is confined, a 3km extension into the parkland has been included. For the area where the TLA is unconfined, a vertical recharge rate of 15 mm has been adopted for the determination of the proposed PAV.
Zone 8B	6,761	consisting of land where the TLA is both confined and unconfined, less than 3000 mg/L TDS. For the area where the TLA is unconfined, vertical recharge rates of 15 mm and 12 mm/yr have been adopted for the determination of the proposed PAV.

In 1997, the confined / unconfined TLA boundary determined in the 1995 technical review (Bradley op cit) was re-assessed (SKM report 1997(b)) and it was concluded in the SKM report that the TLA was unconfined throughout Zones 5B and 6B. The recharge for these zones, which was therefore predominantly vertical, was re-calculated in the SKM report. The PAVs for Zones 5B and 6B, were however not altered to the revised recharge, rather they were altered to match groundwater allocation in each of the Zones.

The current PAVs for the unconfined TLA in the various Zones together with the assessed 1995, 1997 or 1999 vertical recharge calculations (as described above) are provided in Table 8 below. This table also summarises the basis of the PAV determination and reasons where relevant for not adopting the vertical recharge volumes from the 1996, 1997 and 1999 assessments, as the PAV.

6.1.3 Review of the Existing TLA PAVs

PAVs are required to be reviewed by the TWG for the five year management review. The following therefore summarises the preceding material on PAVs for the TLA and recommends new PAVs or where further review of existing PAVs should be undertaken.

- **Zones 1A, 2A, 2B, 3A, 3B, 4A, 4B, 5A, 6A, 7A, 7B and 8A**

  At present it is considered that there is no need to change the PAV in each of these Zones.

  The PAV for Zone 1A was reduced in 2000 due to a decline in water levels in the Mount Gambier area and indications from the computer modelling that the specific yield of the TLA was likely to be 0.1. Field investigations should be undertaken to validate the conclusion on the specific yield from the modelling.

  For the remainder of the Zones, there is concern about the increasing salinity trend obvious in some monitoring bores. The cause of this salinity change could be due to irrigation recycling, or to remobilisation of salt to the TLA following vegetation clearance and irrigation. Field investigations need to be undertaken to define the salt accession mechanisms, quantify the likely groundwater salinity change, and identify the areas at risk of groundwater salinisation.

  A review of the groundwater quality monitoring network is required once the areas at risk of groundwater salinisation have been defined. Some current monitoring bores may not be adequately located to assess the different land use impacts, particularly in relation to irrigation recycling which is likely to be more site specific than remobilisation of salt from vegetation clearing.

  Whilst the increasing salinity trend for some monitoring bores is not as high as reported in the last 5 year technical review, the lower rainfall in the last few years may have reduced salt accessions to the TLA. This however may result in greater salinity increase in the future because the increased accumulation of salt in the profile above the water table, may move downwards as a saline slug with a return to higher rainfall.

  It is recommended that the PAVs for these Zones not be increased until salinity investigations as described above are undertaken.

Table 8: Unconfined Tertiary Limestone Aquifer PAVs and Basis of Determination

Zone	Current PAV (ML/year)	Assessed Annual Vertical Recharge Volume (ML) + Bradley et al (1995) * SKM (1997b) # PIRSA 1999	Method of PAV Determination	
			Primary Method	Reason for not adopting the vertical recharge as the PAV
8A	7700	7720+	Vertical recharge	
7A	7500	8070+	Vertical recharge	Modified by Quality Concerns
7B	7000	6600*	Vertical Recharge	
6A	8850	10760+	Vertical recharge	Clay spreading in the area was likely to reduce the vertical recharge, and a lower PAV was adopted
6B	10000	3700*	Vertical recharge	Existing allocation used as the PAV
5A	18500	19980+	Vertical recharge	Modified by Quality Concerns
5B	12000	10700*	Vertical recharge	Existing allocation used as the PAV
4A	20000	33580+	Vertical recharge	Modified by Quality Concerns
4B	14000	17350+	Vertical recharge	Modified by Quality Concerns
3A	24000	45600+	Vertical recharge	Modified by Quality Concerns
3B	16500	20630+	Vertical recharge	Modified by Quality Concerns
2A	25000	36390+	Vertical recharge	Modified by Quality Concerns
2B	25000	41900+	Vertical recharge	Modified by Quality Concerns
1A	30900	30090#	Vertical recharge	
1B	71000	45720+	Vertical recharge	

NOTE: The modification for quality concern was not a fixed %, but consisted generally of leaving the PAV at its lower pre-existing value.

- **Zone 1B**

  The recent groundwater modelling in part of Zone 1A (Stadter and Wan, 2000) indicates that the specific yield of the TLA in this general area may be 0.1. Given this, and the high level of softwood afforestation in the Zone, it is recommended that the vertical recharge in the Zone be re-assessed and the PAV reviewed as a matter of priority.

- **Zones 5B and 6B**

  The PAV exceeds the assessed vertical recharge for each of these Zones as determined in the 1997 review of the confined / unconfined TLA boundary in this area (SKM 1997 (b)).
  The high level of groundwater allocation and use in these Zones, particularly Zone 6B, is of some concern and it is recommended that the groundwater modelling commenced for this area be completed as a matter of priority, and that the PAVs be reviewed once the modelling results are available.

- **Zones 8B, 9A, 9B, 10A, 10B, 11A and 11B**

  Proposed PAVs have been determined for these Zones, as shown in Table 7, based on a new management prescription that the TLA is confined in all or parts of these Zones and that extraction volumes may be derived from storage in the confined areas.

  The individual Zones have been sub-divided into sub-Zones based on consideration of groundwater quality in the TLA and the presence of parkland where extraction is not likely to occur.

6.1.4 Tertiary Confined Sand Aquifer PAVs

In relation to the Tertiary Confined Sand Aquifer, the TWG has determined proposed PAVs as shown in Table 9 below, which are currently being considered by the BGARC.

Table 9: Proposed Tertiary Confined Sand Aquifer PAVs

South Australian Zone	Proposed PAV (ML/Year)	Victorian Zone	Proposed PAV (ML/Year)
1A	9200	1B	14500
2A	2900	2B	5100
3A	1900	3B	1100
4A	710	4B	300
5A	540	5B	570
6A	360	6B	360
7A	350	7B	350
8A	340	8B	330
9A	570	9B	630
10A	320	10B	560
11A	0	11B	0

The proposed PAVs have been determined by a reasonably complex process which consisted of:

- Initially assessing throughflow volumes for each Zone based on a flow net analysis of the TCSA and the apportionment of flow along flow paths (SKM, 1998(f)).

- Including the volumes derived from throughflow into a groundwater model and adjusting the volumes downwards to reach an acceptable level of aquifer drawdown under the scenario of maximum PAV use which was generally 75% of the throughflow volumes (Brown, 2000).

- The model suggested that vertical leakage from the TLA may be a large component of the volume extracted and that extraction from the TCSA may need to be further reduced to limit any impact on the TLA resource as a result of pumping from the TLA. On this basis, the thickness of aquitard between the TLA and the TCSA was taken as an indicator of the risk of leakage between the TLA and the TCSA. Consequently the reduced values of the available resource derived from the modelling were further reduced on the basis of whether the aquitard was thin or not. Where the aquitard was regarded as thin, an additional reduction of 50% was made.

- Discussions between the BGARC and the South East Catchment Water Management Board resulted in further caution towards the adoption of PAVs for the TCSA, whereby the above 50% reduction was adopted for all zones except 3B and 4B, as shown below. In zones 3B and 4B the management prescription of 25% of throughflow is due to the proximity of these Zones to the Dundas Highland and the likelihood of excessive local groundwater level drawdown.

  The management prescription therefore recommended for the PAVs of the TCSA for the Zones in the Designated Area is as follows:

Zones 1A to 11A	)	
Zones 1B and 2B	)	PAV = 50 % x (0.75 x Throughflow Volumes)
Zones 5B to 11B	)	
Zones 3B and 4B		PAV = (0.25 x Throughflow Volumes)

6.1.5 Separation of the TLA from the TCSA

The TWG has proposed that the TCSA should be separated from TLA on the basis of the hydrostratigraphy shown in Figure 2.

The TLA would be taken as comprising aquifers in the Murray Group, Heytesbury Group, Coomandook Formation, Bridgewater Formation and Padthaway Formation, called collectively the Tertiary Limestone Aquifer, the base of which is identified as marl or black carbonaceous silt, sand or clay.

The TCSA would comprise the Wangerrip Group and Renmark Group, below the Tertiary Limestone Aquifer.

6.2 Permissible Distance from the South Australia Victorian Border

The Permissible Distance from the South Australia / Victoria border relates to a requirement under the Groundwater (Border Agreement) Act, that the BGARC must consider and approve all applications for well construction and groundwater extractions within the Permissible Distance.

The purpose of the Permissible Distance in the Designated Area, is to ensure that where a bore may be installed close to the border, problems of interference can be effectively addressed on the other side of the border.

The existing Permissible Distance is 1km. This distance was determined however with unconfined aquifer conditions in mind. Due to the presence of confined aquifer conditions in the TLA in Province 3 and in the TCSA over the whole of the Designated Area, it is necessary to reconsider the Permissible Distance for these areas because of the greater drawdown per unit volume extracted under confined aquifer conditions.

To determine a suitable Permissible Distance for the confined TLA, a drawdown distance calculation was undertaken for a typical hydrogeological and pumping scenario along the border in Province 3. This consisted of assuming: a pumping rate of 5000 m^3/d over a 100 day period, TLA thickness of 100 m, Transmissivity of 500 m^2/d, Storage Coefficient of 1×10^{-4}, and a potentiometric surface above the top of the TLA of 20 m. Under this scenario there would be a drawdown of approximately 20% of the potentiometric surface above the top of the TLA, at 3 km distance from the pumping bore. A reduction of up to 20% available drawdown is generally regarded as acceptable. On the basis that conversely, a bore located within 3 km would be regarded as unacceptable, 3 km can be considered as a suitable Permissible Distance for Province 3.

This distance would also appear reasonable throughout the whole of the Designated Area in relation to extraction from the TCSA.

On this basis the Permissible Distance should:
- remain as 1 km for the TLA in Provinces 1 & 2,
- be altered to 3km for the TLA in Province 3.
- be taken as 3km in the TCSA in Provinces 1, 2 & 3.

6.3 Permissible Rate of Potentiometric Surface Lowering

The Permissible Rate of Potentiometric Surface Lowering refers to a maximum rate of water level decline that is permitted in all Zones in the Designated Area. The Permissible Rate of Potentiometric Surface Lowering is specified in the Groundwater (Border Agreement) Act. It is currently set at 0.05 metres per annum.

The Permissible Rate of Potentiometric Surface Lowering represents a difficult limit to adhere to in practice. Rates of potentiometric surface lowering as a result of pumping, well in excess of 0.05 m per year are currently being experienced in Zones 10 and 11 in the TLA where it is confined. In addition, current declines in the south of the Designated Area of up to 0.45m per year in the TLA as shown in Table 5 in Section 4.2, have been attributed to climatic effects, and afforestation which are not related to groundwater extraction.

From a conceptual point of view however a maximum limit of 0.05 m of unconfined aquifer drawdown across a Zone with unconfined aquifer conditions, may have some merit as a maximum limit on the resource. With respect to confined aquifer conditions, however, 0.05 m/yr is not acceptable. The TWG is presently assessing the observed and predicted (modelled) drawdown in the TLA in an attempt to determine a realistic rate of potentiometric surface decline under confined conditions. Based on this, it is hoped to be able to recommend a rate of decline for the confined aquifer, and a method by which it can be applied.

Despite the above, the TWG considers that the Permissible Rate of Potentiometric Surface Lowering as currently contained in the Act needs to be examined more closely in terms of what it is attempting to achieve and how it can be practically applied. These matters should be addressed and clarified in any future amendment to the Act.

6.4 Permissible Levels of Groundwater Salinity

The Permissible Level of Salinity refers to a maximum level of salinity expressed in EC units that may be agreed upon for any Zone in the Designated Area, under the Groundwater (Border Agreement) Act.

To date, maximum salinity levels for Zones have not been invoked, however salinity increase in the unconfined aquifers in the Designated Area represents a major risk to the groundwater resource. Some aspects of the risk of salinisation are controllable, whilst with others there is a limited ability to control them. The investigation of salinisation needs to be a major thrust of future investigations in the Designated Area, which may ultimately lead to the introduction of Permissible Levels of Groundwater Salinity.

The concept of setting a maximum salinity should however be carefully considered as this may condone large salinity increases up to the set limit in Zones where there is a large spatial variability in groundwater salinity. A specified rate or amount of salinity change would be a better management approach.

6.5 Relationship of Zones to Other Management Areas in Victoria and South Australia

The Designated Area covers regions of intensive and less intensive groundwater use. The zones of intensive use also extend beyond the limit of the 40 km wide Designated Area into adjoining areas in each State.

There are a number of groundwater management areas within South Australia, referred to as Prescribed Wells Areas, which are adjacent to or incorporate parts of the Designated Area. These Prescribed Wells Areas in South Australia adjacent to the Designated Area are shown in Figure 21.

In Victoria, high use areas are covered by Groundwater Management Areas, or declared Groundwater Supply Protection Areas. The locations of existing Groundwater Management Areas and Groundwater Supply Protection Areas in Victoria are also shown in Figure 21.

7. KEY TECHNICAL ISSUES

The studies undertaken during the last five years by the BGARC and other groups have increased the technical understanding of the groundwater resources within the Designated Area.

These investigations have, however, raised other technical issues important for sound groundwater resource management. The need to address presently unresolved key technical issues is discussed below.

7.1 Risk of Salinisation of the Groundwater Resources in the Tertiary Limestone Aquifer in Provinces 1 & 2

The monitoring of groundwater quality in the TLA has shown some longer term increasing salinity trends particularly in Provinces 1 and 2.

It has not been possible at this stage to differentiate the cause of such water quality changes, with the increases being due to either irrigation recycling or the effects of vegetation clearance and irrigation accession. Recent investigations by the CSIRO in the Tintinara area have shown that there is a significant salt accumulation in the unsaturated profile above the TLA which can be mobilised by increases in the vertical recharge from clearing and by excess irrigation water return flow to the aquifer.

Within Zones 1A, 1B, 2A, 3A and 3B, there may be a greater risk from irrigation recycling than from remobilisation of salt. In these zones, the locations of the existing regional salinity monitoring bores may not be adequately detecting salinity increase at such irrigation sites.

Field investigations over the next three years are planned within the southern part of the Designated Area by the SA Department for Water Resources to gain a better understanding of the potential for salinity increase from irrigation activity. This should include targeting salinity monitoring towards irrigation bores where salinity increase through recycling may be occurring

The results of these investigations will indicate whether a management approach in Provinces 1 and 2 in the Designated Area of solely determining PAVs based on the level of vertical recharge to the TLA is appropriate.

An assessment of the salinity risk for the groundwater resources in the TLA has been commenced and should be completed as a priority. Once this risk assessment is completed, the adequacy of the current TLA groundwater quality monitoring network in each State should also be evaluated.

7.2 The Confined Tertiary Limestone Aquifer in the Mallee Region in Province 3

The response to extraction from the confined TLA in the Mallee region has been modelled and calibrated against available groundwater level monitoring data.

The observed decline in water levels evident in this area needs to be monitored in the longer term and compared with modelled predictions. Where the observed water levels vary from the predicted levels, the model should be revised accordingly.

The response in the lower TCSA to these extractions needs to be evaluated to determine the degree of upward leakage from the TCSA to the TLA. This is considered important for assessing the appropriateness of the PAVs for the TLA and the TCSA in this region.

The response of the irrigation activity on the saturated and unsaturated PSA needs to be assessed in order to determine the degree of downward leakage from it and the resultant risk of salt accession to the TLA.

7.3 The Tertiary Confined Sand Aquifer

Initial PAVs for the TCSA have been determined on the basis of groundwater throughflow calculations and modelling.

With the limited use of the TCSA groundwater resources in the Designated Area, the appropriateness of these PAVs needs to be continually re-assessed as development of this resource increases. A suitable groundwater monitoring network is required for such an assessment and the current network in each State should be reviewed and expanded where necessary.

The modelling highlighted that the vertical leakage between the TLA and the TCSA is important in relation to the management of the groundwater resources in both aquifers. The key issues identified were:

- there could be a substantial increase in the leakage from the TLA with increased extractions from the TCSA. This has the potential to cause some change in the water balance of the TLA which could result in a head decline in this aquifer.
- there is a potential for head reversal in the potentiometric levels between the TLA and the TCSA, which could result in more saline water from the TLA impacting on the water quality in the TCSA through downward leakage.
- the increased use of groundwater from the TCSA for irrigation purposes also has the potential to increase the salt accessions to the TLA which could result in adverse water quality deterioration in this aquifer.

Investigations are therefore required to assess the degree of leakage in various parts of the Designated Area.

The water level decline in the TCSA over the last few years in the southern part of the Designated Area should also be investigated to determine whether the decline is related to climatic conditions or other processes.

7.4 Vertical Recharge to the Tertiary Limestone Aquifer in Provinces 1 and 2

Vertical recharge to the TLA is important as it is used as a basis of determining the PAVs for this aquifer in Provinces 1 and 2.

Further investigations are required to more accurately assess the recharge to the TLA, particularly determining the spatial variability of Specific Yield of the aquifer which is a key parameter for such recharge determinations.

A significant issue which has arisen over the last few years is the change in land use to forestry in the southern part of the Designated Area. This has the potential to significantly change the vertical recharge to the TLA and therefore the PAVs in this area. A review of changes in land use and their impact on recharge is considered necessary.

The decline in groundwater levels over the last few years, considered to be due to a series of relatively low rainfall years should be regularly reviewed, as rainfall returns to higher levels.

8. CONCLUSIONS

Technical investigations since the last five year review in 1995 have been directed largely towards determining the sustainable yield of the groundwater resources in three separate aquifer/hydrogeological provinces in the Designated Area - the unconfined TLA, the confined TLA, and the TCSA.

With regard to the unconfined TLA, the main objective has been to refine existing PAVs by better quantifying vertical recharge and the extent to which vertical recharge needs to be qualified by the potential impact of salinity on water quality. With the confined TLA, now considered an ancient non-renewable groundwater resource, the main objective has been to determine PAVs based on an acceptable rate of extraction of groundwater from storage. With the TCSA, the objective has been to establish initial PAVs.

The work program undertaken has consisted of monitoring, some field investigations, and desk studies with a strong emphasis on groundwater modelling.

Groundwater monitoring has focused mainly on water levels and salinity in the TLA, and on water levels in the TCSA. Water chemistry was also monitored on one occasion from the TLA. Monitoring of use by metering has commenced in some areas of intensive extraction, and a number of new monitoring bores were installed in areas of intensive use in the TLA, and also in the PSA in the Mallee region.

Analysis of water level and salinity monitoring data has revealed the following trends within the Designated Area:

- declining water levels of up to 1.04 m/yr in the TLA in Zones 11A/11B and 10A/10B, due to irrigation extraction
- rising water levels in the TLA in Zones 9A/9B to 6A/6B, due to vegetation clearance and subsequent increased vertical recharge rates to the aquifer
- declining water levels of up to 0.46 m/yr in the TLA from Zones 5A/5B to the coast, thought to be mainly due to recent low rainfall years and corresponding reduced vertical recharge to the aquifer
- rising EC levels in the TLA in Province 1 & 2 north of Zones 2A/2B, thought to be due to vegetation clearance and irrigation accession leading to the remobilisation of salt in the unsaturated zone
- declining levels of up to 0.3 m/yr in the TCSA between Zones 6A/6B and the coast, possibly due to reduced recharge or the effect of reduced hydraulic loading because of lower water levels in the overlying TLA.

Field investigations undertaken have been somewhat limited, consisting of a pumping test from the TLA at Neuarpurr to determine aquifer hydraulic parameters, and studies at two sites in Zone 2A to determine recharge rates to the TCSA.

The main desk studies undertaken have consisted of:

- flow modelling of the TLA in the Mallee, Zones 5A/5B, 6A/6B, and south of Mt Gambier
- flow modelling of the TLA and TCSA in the Tintinara-Coonalpyn Moratorium Area, Zones 8A/8B and 9A/9B in the Telopea Downs GMA region
- flow modelling of the TCSA in the southern part of the Designated Area and south east South Australia
- one dimensional salinity modelling at Keith
- assessment of groundwater flow in the TCSA by use of flow net analysis

- assessment of the extent of the Upper Tertiary Aquitard, and available aquifer hydraulic parameters in Victoria
- assessment of chemical analysis data to identify chemical characteristics and areas of increasing salinity
- commencement of risk assessment to map areas of low salinity groundwater at risk to salinisation.

The major outcomes of the overall technical work program have been:

- The determination of proposed PAVs for sub-zones in the confined TLA in the Mallee as listed in Table 7 of this report, to replace existing PAVs
- The determination of proposed PAVs for the TCSA as listed in Table 9 of this report as initial PAVs for the TCSA
- Review of the PAVs in the unconfined TLA.

The review of the existing PAVs in the unconfined TLA indicated that in the case of Zones 1A, 2A, 2B, 3A, 3B, 4A, 4B, 5A, 6A, 7A, 7B and 8A there is no need at present to alter the PAVs. In these zones, with the exception of Zones 8A, 7B and 1A, the existing PAVs are less than the calculated vertical recharge in the zones. These PAVs have not been increased to the level of vertical recharge because of concerns over salinisation, and it is considered that they not be increased until adequate investigations of salinity impacts are undertaken. In respect of Zones 1A, 7B and 8A; Zone 1A is equivalent to the vertical recharge rate, Zone 8A is roughly equivalent, and Zone 7B is marginally above.

In the case of Zone 1B in the unconfined TLA, it is considered necessary that the PAV be re-assessed based on findings from within Zone 1A, that the Specific Yield value used in the existing PAV calculation may be too high, and that changes in forestation need to be taken into account in relation to their impact on vertical recharge.

With the remaining two zones in the unconfined TLA, Zones 5B and 6B, the existing PAVs exceed the vertical recharge, which has resulted from the adoption of the allocation in these zones as the PAV rather than the assessed vertical recharge volume.

In addition a review was undertaken of the Permissible Rate of Potentiometric Surface Lowering, the Permissible Distance from the South Australia Victorian Border, and Permissible Levels of Groundwater Salinity.

In relation to the Permissible Rate of Potentiometric Surface Lowering, it has been recognised that the existing permissible rate of 0.05m/yr specified in the Act, is not appropriate to manage the effects of pumping under confined aquifer conditions where drawdown relative to pumping rate is much higher than for unconfined aquifer conditions. The Technical Working Group has examined this issue and is currently developing an appropriate rate for the confined aquifer in the TLA and the TCSA.

The difference in confined aquifer behaviour also creates a difficulty with the Permissible Distance of 1 km specified in the Act, due to the greater drawdown under confined aquifer conditions. This matter has also been examined by the TWG who have determined that a distance of 3 km is more appropriate for the Permissible distance in the confined portion of the TLA and the TCSA.

The provision for setting a Permissible Level of groundwater salinity in the Act has not been invoked as yet, however the TWG has suggested that if it were to be invoked, care needs to be taken in the way it is used to ensure it is not interpreted as sanctioning widespread salinity increase.

The key technical issues which need to be addressed in the future have been identified in Section 7 of this report. In summary they are:

- The threat of salinisation of the unconfined TLA from remobilisation of salt in the unsaturated zone and irrigation recycling
- The need to substantiate the understanding of the confined TLA in the Mallee in response to future development as predicted by modelling
- The need to substantiate PAVs developed for the TCSA largely based on modelling
- The need to further investigate and assess vertical recharge to the unconfined TLA particularly in relation to determining reliable Specific Yield values and in being able to separate the effects of afforestation and climate on recharge

In relation to the threat of salinisation and the determination of recharge to the unconfined TLA, it is considered imperative that work commenced on flow modelling of the TLA in Zones 5A/5B and 6A/6B, and the salinity risk assessment be completed as soon as possible. A further comment is that in future work programs, there may need to be a change of emphasis form desk based studies to field investigations to provide much needed field data for modelling and other more theoretical assessments. In addition the TWG consider that greater emphasis will need to be placed on the assessment of salinity impacts on the TLA in the future as it currently represents possibly the least well addressed aspect of technical understanding in the Designated Area.

9. RECOMMENDATIONS

9.1 Permissible Annual Volumes of Groundwater Extraction

1. In Zones 1A, 2A, 2B, 3A, 3B, 4A, 4B, 5A, 6A, 7A, 7B and 8A, PAVs for the unconfined TLA should not be increased until a satisfactory assessment of the risk of salinisation is undertaken.

2. The PAVs for Zones 5B and Zone 6B for the unconfined TLA are of concern as they exceed the calculated recharge. As such the groundwater modelling commenced in this area should be completed as a matter of priority, and the PAVs should be reviewed once modelling results become available.

3. The vertical recharge in Zone 1B for the unconfined TLA should be re-assessed particularly with reference to the Specific Yield and changes in forestry.

4. The Proposed PAVs developed for the confined TLA as listed in Table 7 of this report and previously recommended to the BGARC be adopted.

5. The Proposed PAVs developed for the TCSA as listed in Table 9 of this report and previously recommended to the BGARC to be adopted.

6. In relation to the above Proposed PAVs for the TCSA, the appropriateness of the PAVs should be closely examined as development from the aquifer proceeds, due to the limited experience of the effect of pumping on the aquifer within the Designated Area.

9.2 Permissible Distance from the South Australia Victoria Border

The Permissible Distance from the border should:

- remain as 1 km for the TLA in Provinces 1 & 2,

- be altered to 3km for the TLA in Province 3.
- be taken as 3km in the TCSA in Provinces 1, 2 & 3.

9.3 Other Recommendations

- Additional field work should be undertaken to determine the nature and the degree of threat of salinisation to the unconfined TLA. This should include studies to distinguish between the various processes affecting salinity as well as their regional significance. The results of field investigations should be incorporated into one dimensional quality modelling to predict salinisation impacts.

- The risk assessment of salinity to the unconfined TLA which has been commenced, should be completed as a priority. Once the risk assessment is completed, the adequacy of the current TLA groundwater quality monitoring network in each State should be reviewed and if necessary new monitoring bores should be included to target areas or sites where a high salinity risk has been identified

- Additional field testing of recharge rates and the Specific Yield of the unconfined TLA should be undertaken for input to groundwater flow models, and to determine recharge rates from water level data. Any pumping tests need to be of sufficient duration to determine the Specific Yield.

- Investigation of the effects of afforestation, other land use change, and climate on recharge to the unconfined TLA should be undertaken to better understand the effect of each phenomena on recharge. Water level monitoring may need to be targeted to forested areas which are present lightly monitored.

- Drawdowns predicted by modelling in the confined TLA should be verified by monitoring water levels, and the model revised if there is a disparity between predicted and observed levels.

- Flow between the PSA and TLA in the area of the confined TLA should be further assessed by monitoring water levels in both the TLA and the PSA, and by undertaking additional one dimensional modelling of salinisation which incorporates the Upper Tertiary Aquitard as a retarding layer. The response of irrigation activity on the saturated and unsaturated PSA also should be assessed to determine the risk of salt accession to the TLA.

- The leakage response predicted from modelling between the TCSA and the TLA in the confined area of the TLA should be verified by monitoring water levels in the TCSA beneath areas of high extraction from the TLA. This needs to be done to be able to soundly apportion groundwater between the TCSA and TLA in setting PAVs.

- Additional investigation should also be undertaken to determine the leakage between the TCSA and the TLA in the area of the unconfined TLA in relation to setting PAVs for the TCSA.

- Declines in water levels the TCSA in the southern part of the Designated Area should be investigated, as they are presently not well understood. This should include better defining the nature and extent of the Lower Tertiary Aquitard, east and south east of the Padthaway Ridge.

- The monitoring network for the TCSA should be reviewed in relation to the adequacy of existing bores, and new bores should be installed where necessary.

9.4 2001 – 2005 Technical Work Program

For Province 3:

- Determine the extent and distribution of the Upper Tertiary Aquitard layer
- Verify the TLA modelling predictions on drawdown, inter-aquifer flows by field studies.
- Predict the potential for salinisation taking account of the confining layer

For Province 1 & 2

- Field work and risk assessment is required to determine the nature and threat of salinisation processes
- Verify the expectation of groundwater level recovery by observing monitoring levels on annual basis.
- Undertake field tests to determine specific yield.
- Complete the water level modelling prediction work.
- Correlation studies between forestry/land use, groundwater level and climate data. (Need for field studies of recharge?)

For the Tertiary Confined Sand Aquifer

- Establish a groundwater level monitoring program,
- Determine extent and configuration of the overlying aquitard east and south east of the Padthaway ridge and the aquifer east to the Dundas Plateau.

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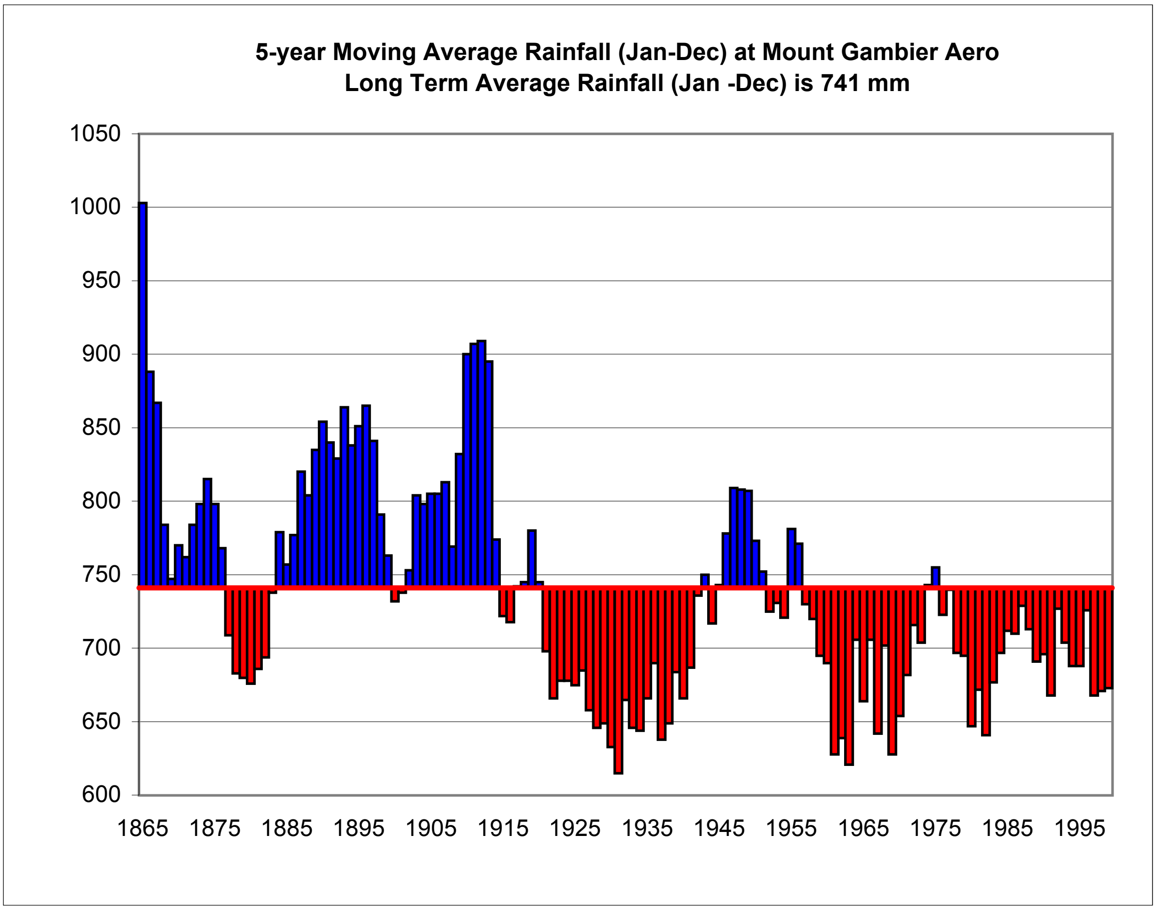
APPENDIX A

Rainfall Data Analysis



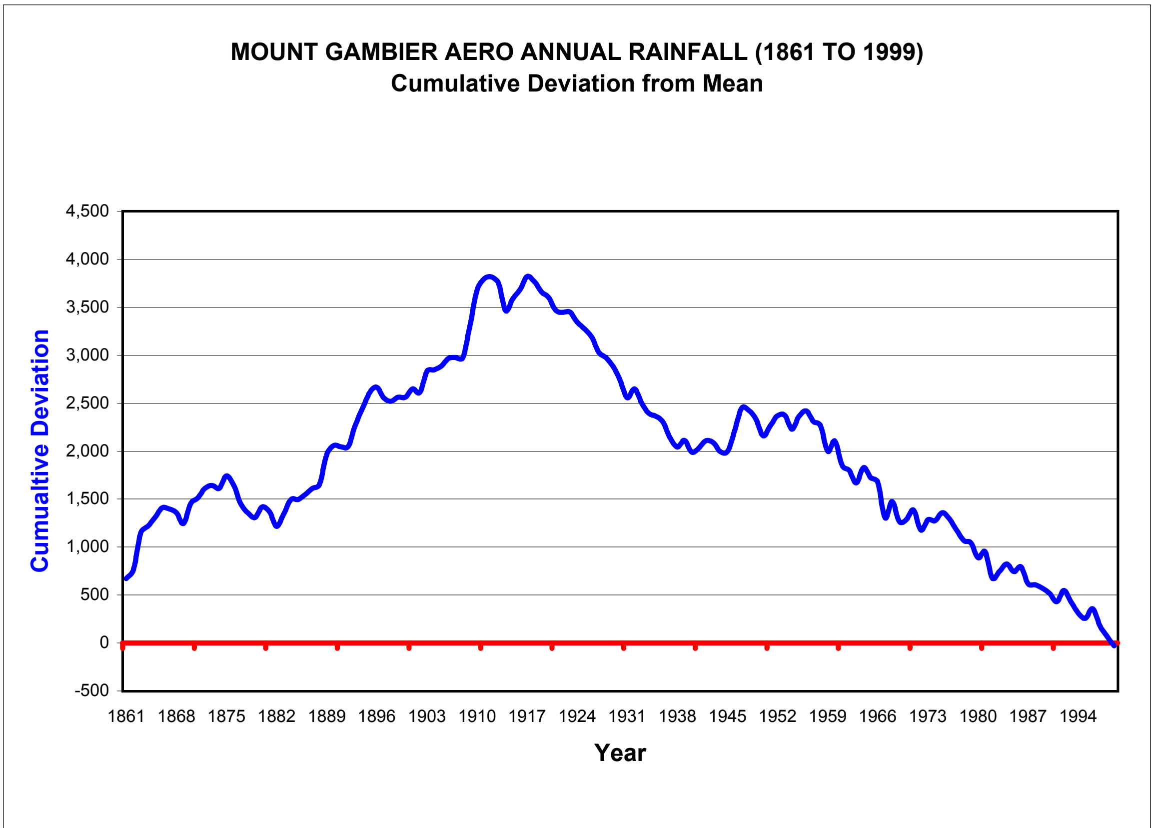
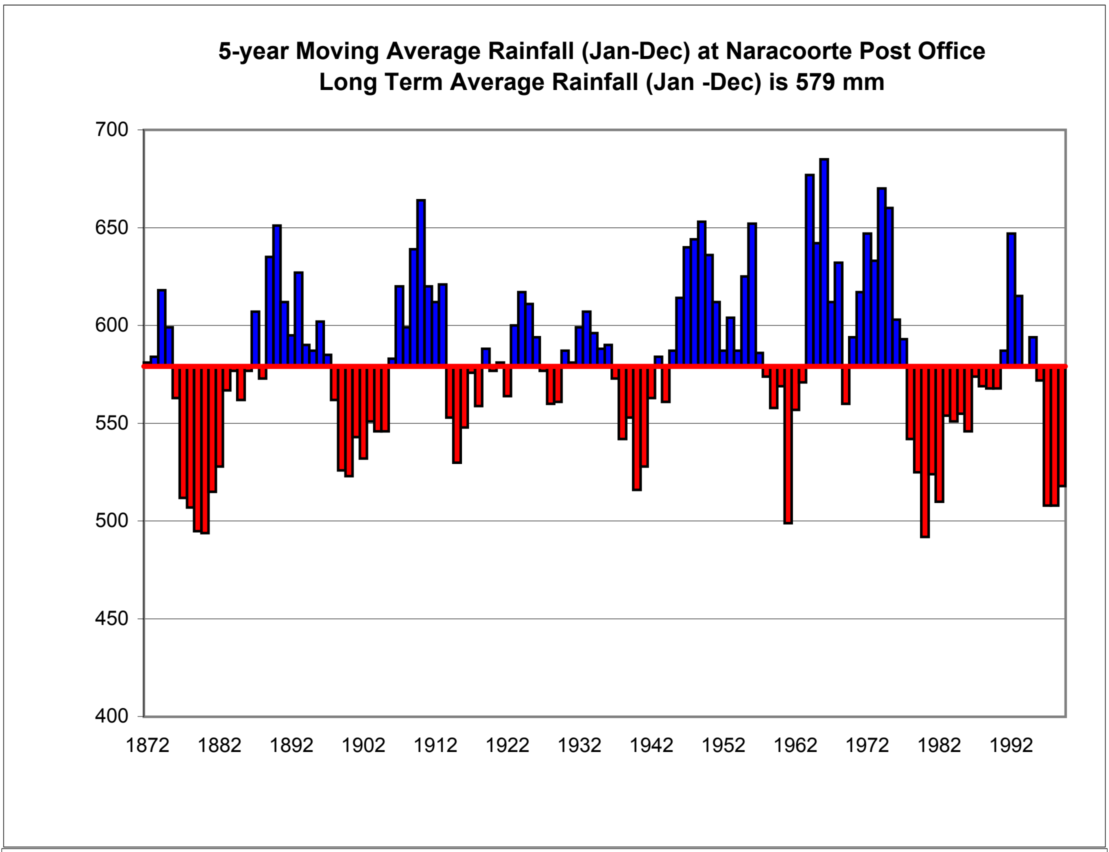


FIGURE A1 RAINFALL DATA ANALYSES FOR MOUNT GAMBIER



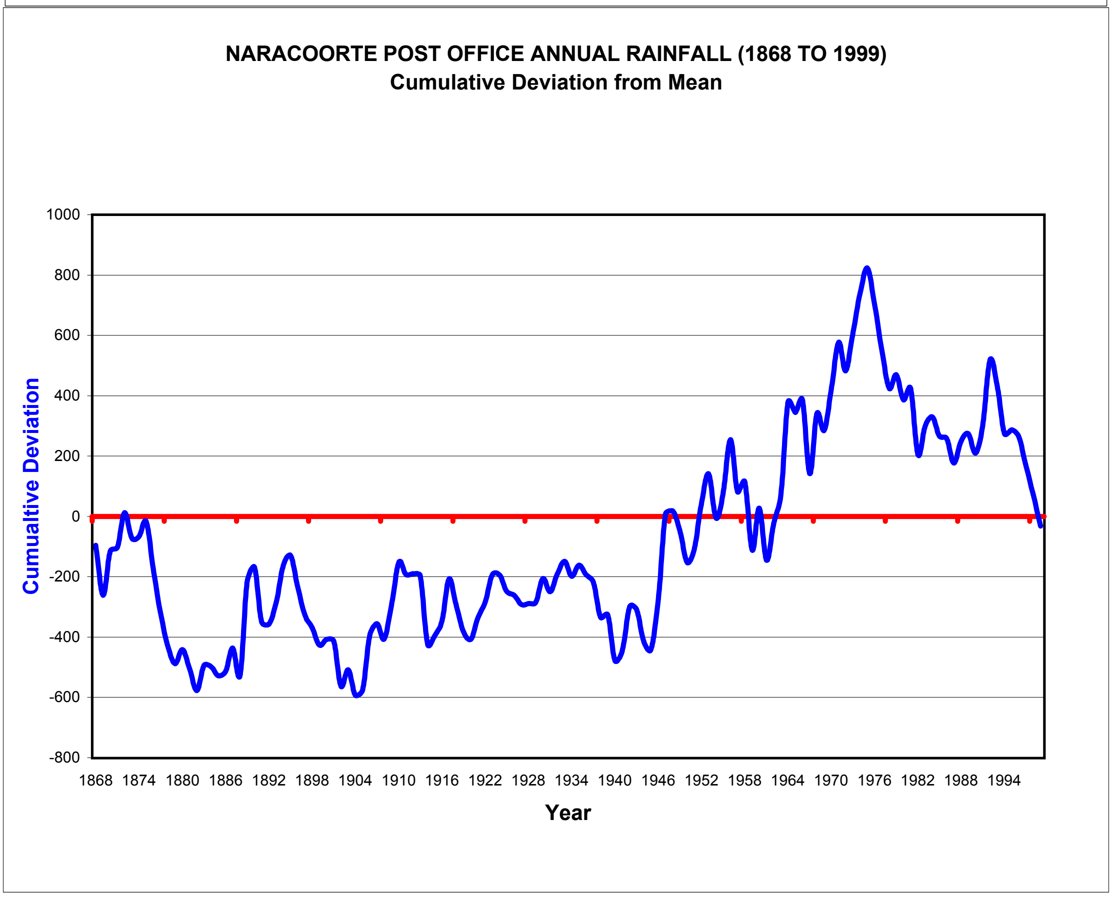
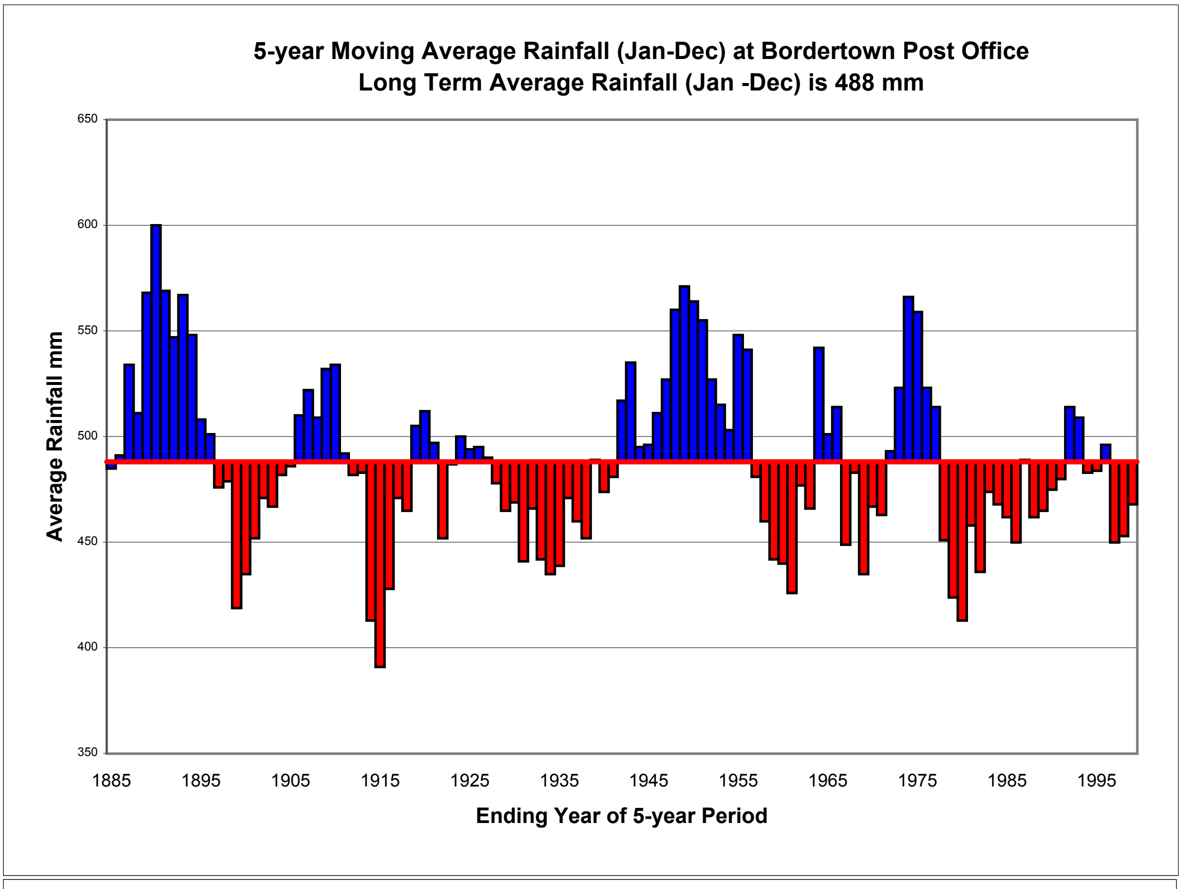


FIGURE A2 RAINFALL DATA ANLAYSES FOR NARACOORTE



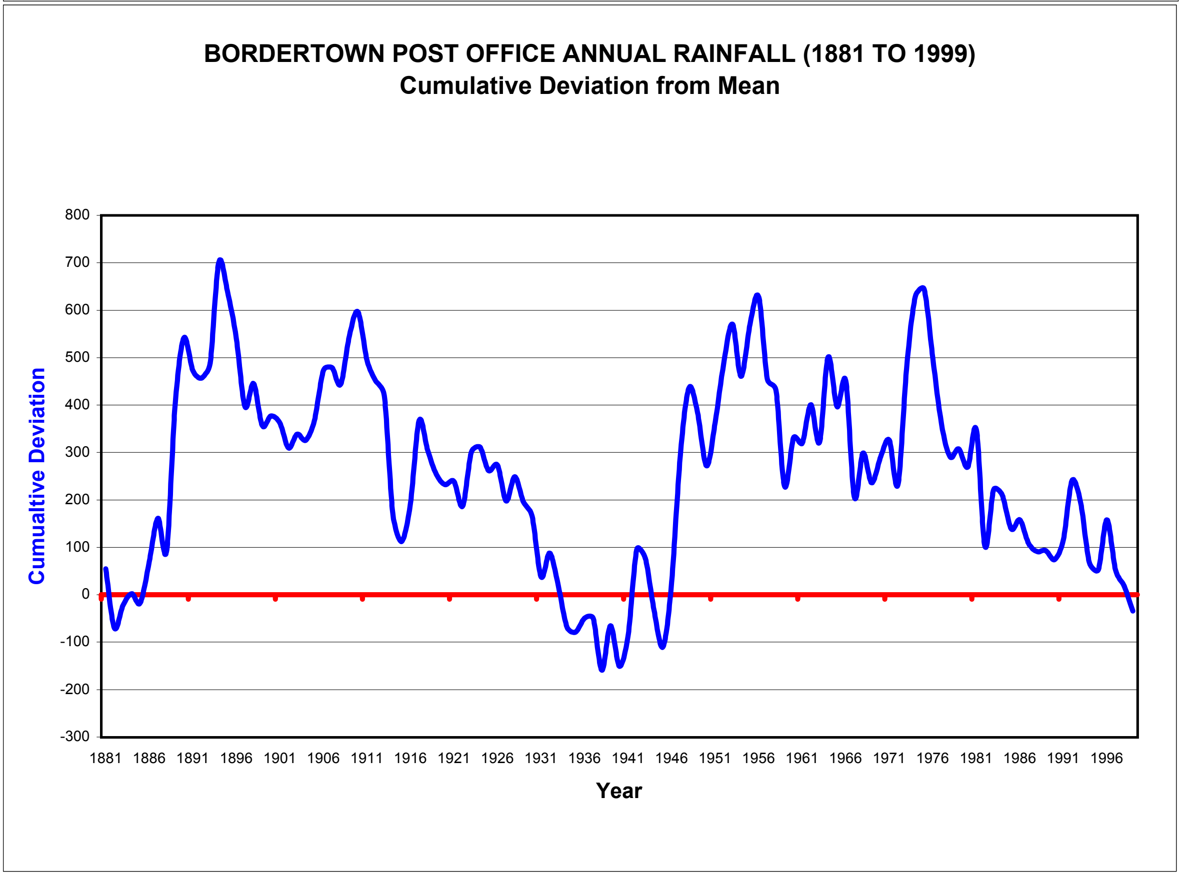
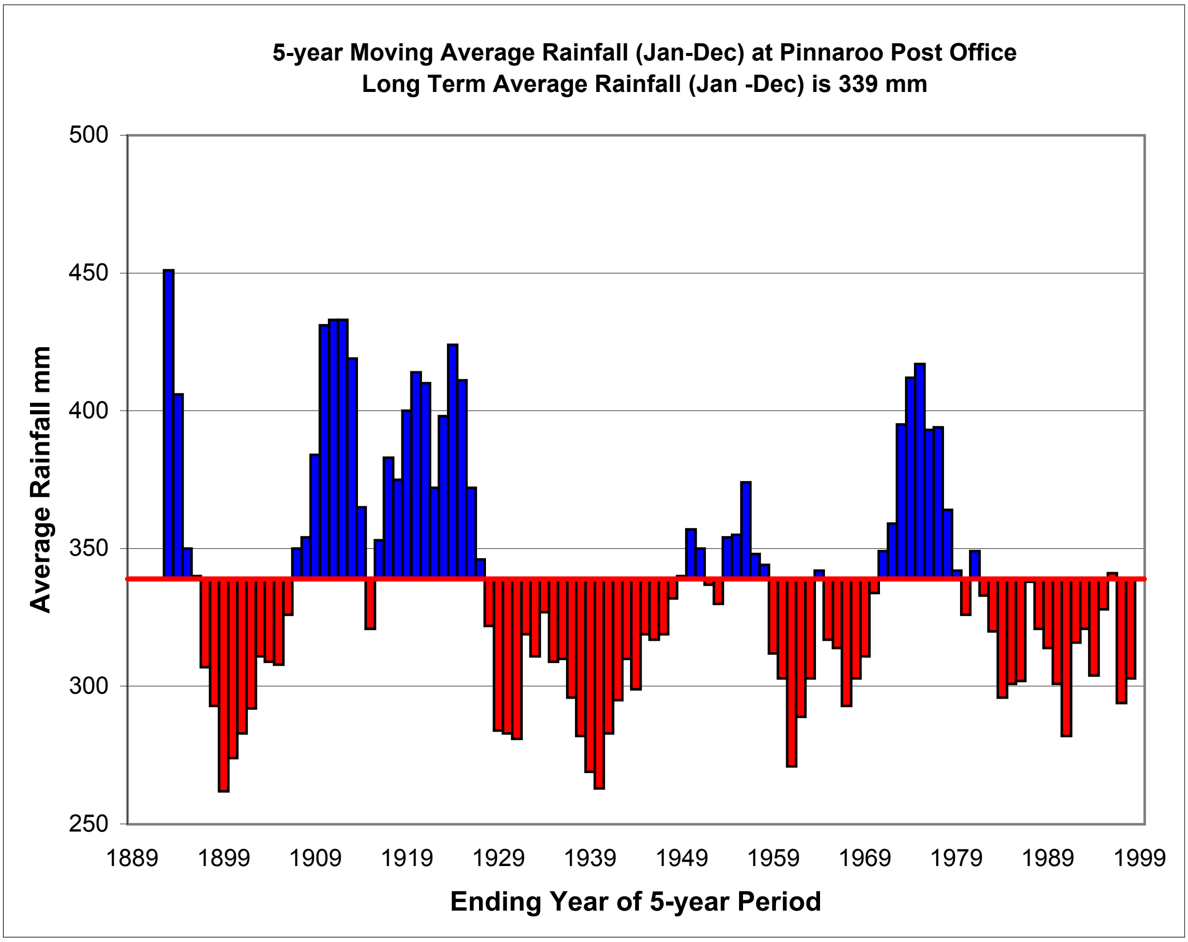


FIGURE A3 RAINFALL DATA ANALYSES FOR BORDERTOWN



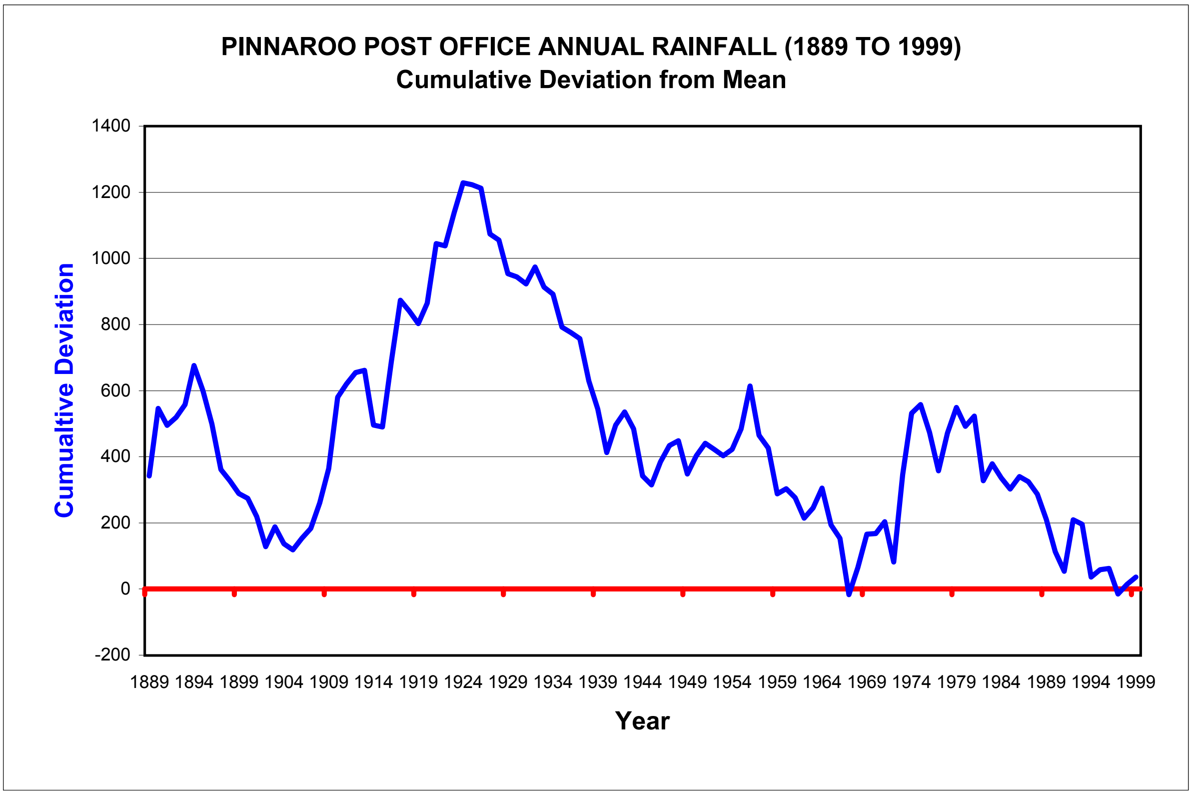


FIGURE A4 RAINFALL DATA ANALYSES FOR PINNAROO

APPENDIX B

Brief Synopsis of Investigation Reports to BGARC

Report Title	**Border Zone Groundwater Monitoring Review, February 1996. Report to Victorian Department of Natural Resources and Environment by Sinclair Knight Merz.**
Area	Victorian segment of Border Zone Designated Area.
Aim/objectives	Review hydrographs to ensure data is complete and bores are functioning correctly
Methodology	Hydrographs of 99 bores plotted and checked: 69 TLA monitoring bores, 23 TCSA and 7 PCA bores
Key Outcomes	Data found to be complete. One bore recommended to be further investigated as suspected of malfunctioning, a number of data entry errors detected and corrected on the Groundwater Data Base.
Report Title	**Review of Upper Tertiary Aquitard Distribution for Designated Zones 5B to 8 B, November 1997. Report to DNRE by Sinclair Knight Merz.**
Area	Designated Zones 5B to 8B and immediate environs.
Aim/objectives	Review the mapped extent of the aquitard overlying the TLA Recalculate recharge rates where necessary Review PAVs where recharge rates have changed. Review monitoring bore water level trends in Zones 5A/B and 6A/B. Review adequacy of monitoring in 5B/6B
Methodology	The extent of the upper Tertiary aquitard (Bookpurnong Beds and Winnambool Formation) was remapped based mainly on interpretation of drillers logs. Vertical recharge was recalculated by examining bore hydrograph fluctuations, assuming a Specific Yield of the aquifer of 0.1, and extrapolating results to other like land units (soil type and land use).
Key Outcomes	The upper Tertiary aquitard was found to be absent over most of Zones 5B to 8B. The aquitard was found to be present in the northern part of Zone 8B. Recalculated recharge was greater than previously reported, possible PAVs were calculated based on the new recharge figures. Water levels were generally found to have flat trends apart from near the SA bore BIN007, and the Victorian Bore 85628 where levels were declining at 1cm/yr and 5 cm/yr respectively. Additional monitoring bores were considered to be required near the boundary of Zones 5B/6B near Minimay/Neuarpur
Report Title	**Investigation of the recent groundwater level decline in the Murrayville area, April 1998. Report to Wimmera Mallee Water by Sinclair Knight Merz.**
Area	Zone 10B of Designated Area
Aim/objectives	To determine the extent of groundwater level declines, develop appropriate management response to the declines and examine the PAV methodology.
Methodology	Examine water levels in available private and government monitoring bores in Murrayville area, consisting of 3 bores in immediate extraction area and 8 bores outside of extraction area.
Key Outcomes	Seasonal fluctuations in bores to a maximum of 8 m identified. Insufficient length of data available to determine long term trends.

Report Title	**Predictions of Potentiometric Surface Drawdown in the Murrayville area for the 1998/99 irrigation season, October 1998. Report to Wimmera Mallee Water by Sinclair Knight Merz.**
Area	Zone 10B of the Designated Area
Aim/objectives	Provide an estimation of drawdown in the main extraction area in 1998/99 using a simple spread sheet model, and examine effects on drawdown of reducing extraction by 20%.
Methodology	The pre pumping groundwater level was determined from available data, and the maximum cone of depression in the potentiometric surface determined from bore data during the 1997/98 pumping season. The expected cone of depression for eth 1998/99 season was estimated using a simple spread sheet based on the Theis equation and incorporating anticipated pumping volumes.
Key Outcomes	No long term decline in water levels was predicted by the model, also there was almost no benefit of reducing extraction by 20% both across the board or in individual bores.
Report Title	**Review of transmissivity and Storage Coefficient Values from pumping test data for the Victorian portion of the Border Designated area, November 1998. Report to Victorian Department of Natural Resources and Environment by Sinclair Knight Merz.**
Area	Victorian Segment of Border Zone Designated Area
Aim/objectives	Collate and critically assess available Transmissivity and Storativity data obtained from pumping tests, and review adequacy of spatial distribution of available data.
Methodology	From collated pumping test information rate the reliability of the T & S data from the tests based on criteria of: Nature and duration of test, number of observation bores used, calculation method, conformation with analytical type curves. Plot data on maps and identify data gaps.
Key Outcomes	For the TLA there are 40 T values, all of which are to the south of Zone 8B. Four of these T values were considered to have high reliability, 4 moderate reliability and 32 low reliability. There were 4 S values, 3 of which were high reliability and 1 moderate reliability. There were no T or S values for the TCSA It was considered there was a need for TCSA pumping tests, and TLA pumping tests in Zone 1B and 2B, and additional long term testing in the unconfined area of the TLA.
Report Title	**South Australian/Victorian Border Groundwater Agreement – Assessment of Groundwater Throughflow for the Tertiary Confined Sand Aquifer , December 1998. Report to Victorian Department of Natural Resources and Environment by Sinclair Knight Merz.**
Area	The region of the combined Murray Basin and Otway Basin in Western Victoria and SE South Australia where the salinity of the TCSA is less than 3000 mg/L TDS. This covered the Border Zones from Zone 8 southwards to the coast.
Aim/objectives	Determine preliminary groundwater throughflow volumes for the TCSA as a first step towards defining PAVs for the TCSA. Determine appropriate management areas.
Methodology	Prepare potentiometric surface and flow map for TCSA and calculate

	throughflow volumes. Three methods to apportioning throughflow were used: 1. Calculate through flow at eastern boundary of Designated Zones and apportion across zones. 2. Divide area into sub areas based on flow tubes and apportion throughflow equally along flow tubes 3. Use the results from 2 above to calculate throughflow per unit area and apportion to Designated Zones and to remaining areas of flow tubes outside of Zones
Key Outcomes	Through flow volumes were found to be relatively small in the TCSA. More data on hydraulic conductivity should be obtained to improve the estimate of throughflow. The throughflow values should be used in the groundwater flow model being developed by PIRSA in SA to investigate PAVs for the TCSA.
Report Title	**Border Groundwater Agreement – The development and application of a one dimensional soil column model (SUS1D) November 1997. Report to Victorian Department of Natural Resources and Environment by Sinclair Knight Merz.**
Area	General Application, Case study conducted at Keith South Australia.
Aim/objectives	To develop an interactive model to predict the impact on groundwater salinity from pumping and recycling irrigation back to the groundwater at the same site.
Methodology	Develop model consisting of one dimensional saturated unsaturated flow model incorporating conservative solute transport, evapotranspiration, exfiltration, subsurface lateral flow and coupling to deep groundwater saturated zone. Applied in case study at Keith, where long term salinity trends observed and where the dominant process of salinity increase in groundwater is considered to be a result of groundwater recycling.
Key Outcomes	Model successfully constructed and used to simulate groundwater salinity increase at Keith. Model would be improved with a variable saturated unsaturated boundary to enable calibration with groundwater hydrographs.

Report Title	**The Hydrochemistry of Groundwaters in the South Australian – Victorian Designated Area. Groundwater Border Agreement Act. Joint Report by PIRSA and Sinclair Knight Merz. Report Book 98/00025 PIRSA.**
Area	Designated Area
Aim/objectives	To examine the chemistry of the groundwater resources occurring within the Designated Area
Methodology	Review and interpretation of the full chemical analysis data for monitoring bores in the Designated Area.
Key Outcomes	Groundwater types vary through the Designated Area, with sodium chloride type water in the northern Zones compared to calcium bicarbonate type water in the southern Zones. The majority of TLA monitoring bores indicated negligible change in groundwater salinity, but a number of bores showed some significant salinity increase attributed either to impacts of vegetation clearance or irrigation activity. The frequency of the full chemical analysis monitoring be extended to six yearly. The water quality monitoring networks be reviewed to better identify the causes of increased groundwater salinity.
Report Title	**A Groundwater Flow Model of the Tertiary Confined Sand Aquifer in South East South Australia and South West Victoria. Report Book 2000/00016 Primary Industries and Resources SA.**
Area	Southern part of the Designated Area and adjoining areas in South Australia and Victoria.
Aim/objectives	To determine potential PAVs for the Tertiary Confined Sand Aquifer
Methodology	A groundwater flow model was constructed for the Tertiary Confined Sand Aquifer. Various extraction scenarios were modelled to examine the longer term change in aquifer pressure and changes in leakage between the TLA and the TCSA.
Key Outcomes	The model established that there was a reasonable match between modelled inflows to the TCSA under current extraction conditions and the throughflows calculated from the flow net analysis, and that the throughflow volumes could therefore be used as a starting point for modelling future extraction scenarios. Increased extractions from the TCSA would result in a significant longer term decline in potentiometric head in the TCSA. The main limitations with the modelling were recognised to be the uncertainty in the levels of extraction from the aquifer, particularly in the artesian area in the South East of South Australia, and a lower level of reliability of the model results in the areas where there was limited current extraction from the TCSA which made calibration of the model difficult in these areas.

Report Title	**Mallee Region Groundwater Modelling Report No1. Report Book 2000/00004, Primary Industry and Resources SA, February 2000.**
Area	The Mallee region in the northern part of the Designated Area.
Aim/objectives	To examine the impacts of groundwater extraction from the confined part of the Tertiary Limestone Aquifer.
Methodology	A five layer groundwater flow model was constructed and various extraction scenarios were modelled to examine longer term changes in potentiometric head in the Tertiary Limestone Aquifer.
Key Outcomes	Large longer term decline in potentiometric head in the Tertiary Limestone Aquifer was predicted from the modelling results, with depressurisation of the aquifer in the centres of the cones of depression. There were, however, significant areas within the Designated Area where the drawdown did not exceed the permissible rate of drawdown of 0.05 m/year.
Report Title	**Assessment of the Potential Use of the Groundwater Resources in the area south of Mount Gambier. Report book 2000/00040 Primary Industries and Resources SA.**
Area	Part of Zone 1A and the coastal area south of Mount Gambier.
Aim/objectives	To examine the potential of increasing the PAV in the area south of Mount Gambier beyond the level of the assessed vertical recharge to the Tertiary Limestone Aquifer.
Methodology	A three layer groundwater flow model was constructed and various extraction scenarios were modelled to examine longer term changes in potentiometric head in the Tertiary Limestone Aquifer.
Key Outcomes	Increasing the extractions from the Tertiary Limestone Aquifer above the assessed level of vertical recharge resulted in adverse water level decline, decreases in discharge from the coastal springs, potential for raising the salt-water interface near the coast and potential to exacerbate the water level decline in the Mount Gambier region. A specific yield of 0.1 for the Tertiary Limestone Aquifer was considered to produce the most appropriate model calibration. It was recommended that the PAVs not be increased beyond the assessed vertical recharge to the Tertiary Limestone Aquifer.

APPENDIX C

Bore Monitoring Networks

TABLE 1 Monitoring Bore Network South Australia
TABLE 2 Monitoring Bore Network Victoria

TABLE 1 Monitoring Bore Network South Australia

Obs Number	Bore Location (GDA Coordinates)		Bore Elevation (mAHD at reference point)	Aquifer	Parameters Measured	
	Easting	Northing			Water Level	Salinity
BIN 11	496551	5932065	102.67	TLA	✓	
BIN 13	486706	5927654	91.11	TLA	✓	
BIN 14	491695	5927675	93.61	TLA	✓	
BIN 15	496595	5927177	98.32	TLA	✓	
BIN 20	482047	5917310	75.15	TLA	✓	
BIN 24	493057	5919461	89.88	TLA	✓	
BIN 26	488862	5937987	NA	TLA		✓
BIN 28	487444	5927826	NA	TLA		✓
BIN 29	486923	5927603	NA	TLA		✓
BIN 32	490839	5934101	101.35	TLA	✓	
BIN 34	492772	5933423	NA	TLA		✓
BIN 35	485155	5922657	NA	TLA		✓
BIN 36	493824	5918390	NA	TLA		✓
BIN 37	493297	5923828	NA	TLA		✓
BIN 38	492736	5923984	NA	TLA		✓
BIN 39	492637	5923116	NA	TLA		✓
BIN 40	492867	5922788	NA	TLA		✓
BIN 41	492722	5922678	NA	TLA		✓
BIN 42	491522	5923566	NA	TLA		✓
BIN 43	492092	5923698	NA	TLA		✓
BIN 44	494242	5922718	NA	TLA		✓
BIN 45	495042	5922958	NA	TLA		✓
BIN 46	492022	5925238	NA	TLA		✓
BIN 47	496433	5937002	NA	TLA		✓
BIN 48	494232	5927938	NA	TLA		✓
BIN 5	486522	5937344	95.78	TLA	✓	
BIN 7	496550	5936947	103.21	TLA	✓	
BKP 14	489084	6177568	48	TLA	✓	
BKP 15	475547	6177921	39.29	TLA	✓	
BKP 19	489189	6171489	29.14	TLA	✓	
BLA 100	470402	5816759	46.29	TLA	✓	
BLA 102	470424	5814448	47.15	TLA	✓	
BLA 114	478569	5810987	46.78	TLA	✓	
BLA 121	481067	5811418	99.58	TLA	✓	
BLA 134	479263	5810916	53.76	TLA	✓	
BLA 135	480917	5810586	67.79	TLA	✓	
BLA 136	479088	5810441	46.49	TLA	✓	
BLA 137	478436	5810350	59	TLA	✓	
BLA 138	478643	5810827	44.16	TLA	✓	
BLA 144	478792	5811177	58.89	TLA	✓	
BLA 145	479612	5810891	56.44	TLA	✓	
BLA 146	480616	5811488	90.93	TLA	✓	
BLA 148	480640	5811501	91.21	TLA	✓	
BLA 149	478652	5810902	50.26	TLA	✓	
BLA 150	478262	5811257	52.17	TLA	✓	
BLA 151	478762	5811137	53.55	TLA	✓	
BLA 152	482002	5812312	41.26	TLA	✓	
BLA 154	482012	5812307	41.04	TLA	✓	
BLA 156	481582	5812568	41.29	TLA	✓	
BLA 160	481627	5811973	46.96	TLA	✓	
BLA 162	481612	5811993	46.9	TLA	✓	
BLA 163	477769	5814933	41.6	TLA	✓	
BLA 164	478075	5814258	41.48	TLA	✓	
BLA 165	481077	5812702	40.71	TLA	✓	
BLA 17	479996	5814024	41.5	TLA	✓	
BLA 18	480055	5812673	45.5	TLA	✓	
BLA 2	481258	5820267	53.64	TLA	✓	

	Bore Location (GDA Coordinates)				Parameters Measured	
BLA 20	480257	5809929	44.71	TLA	✓	
BLA 21	480231	5807613	39.6	TLA	✓	
BLA 22	481765	5806772	71.39	TLA	✓	
BLA 29	478494	5811356	66.8	TLA	✓	
BLA 30	478511	5809680	53.87	TLA	✓	
BLA 34	476204	5820861	55.2	TLA	✓	
BLA 38	476864	5814443	38.6	TLA	✓	
BLA 39	476648	5812914	40.69	TLA	✓	
BLA 40	476844	5811640	52.69	TLA	✓	
BLA 41	476910	5810161	38.04	TLA	✓	
BLA 42	481608	5812548	41.07	TLA	✓	
BLA 5	481149	5814652	40.35	TLA	✓	
BLA 50	475263	5814105	38.27	TLA	✓	
BLA 56	473304	5820612	67.5	TLA	✓	
BLA 6	481690	5813308	46.98	TLA	✓	
BLA 65	473600	5807531	28.96	TLA	✓	
BLA 68	480196	5806385	36.51	TLA	✓	✓
BLA 69	471869	5820063	57.84	TLA	✓	
BLA 71	471578	5816632	69.94	TLA	✓	
BLA 72	472010	5815378	52.54	TLA	✓	
BLA 76	480970	5816252	56.93	TLA	✓	
BLA 77	478855	5814242	40.9	TLA	✓	
BLA 8	481739	5810278	47.23	TLA	✓	
BLA 81	475259	5812234	41	TLA	✓	
BLA 82	479050	5813355	43.75	TLA	✓	
BLA 84	474184	5819997	48.11	TLA	✓	
BLA 85	469393	5820727	53.37	TLA	✓	
BLA 95	471575	5810399	36.5	TLA	✓	
BMA 10	472475	5960078	82.34	TLA	✓	
BMA 11	480545	5959368	96.17	TLA	✓	✓
BMA 13	477780	5954851	NA	TLA		✓
BMA 14	467036	5955591	NA	TLA		✓
BMA 6	470031	5947096	81.99	TLA	✓	
BMA 8	480299	5950657	90.45	TLA	✓	
BMA 9	471921	5955082	82.36	TLA	✓	
CAN 101	471730	5994494	NA	TLA		✓
CAN 102	467163	6003126	NA	TLA		✓
CAN 103	468104	6007691	82.68	TLA	✓	
CAN 104	471416	6001077	81.85	TLA	✓	✓
CAN 11	471722	5994663	75.75	TLA	✓	
CAN 12	466765	6000013	69.91	TLA	✓	
CAN 13	478249	5996508	105.37	TLA	✓	
CAN 14	475761	5993111	93.72	TLA	✓	
CAN 16	475801	6008503	107.77	TLA	✓	
CAN 20	480730	6003854	NA	TLA		✓
CAR 1	482151	5794508	23.06	TLA	✓	
CAR 10	483118	5788829	2.64	TLA	✓	
CAR 11	495248	5788954	3.81	TLA	✓	
CAR 19	496646	5801548	35.15	TLA	✓	
CAR 20	485786	5796657	18.57	TLA	✓	
CAR 22	497057	5796632	21.78	TLA	✓	
CAR 39	490088	5792462	13.76	TLA	✓	✓
CAR 4	484080	5792195	8.71	TLA	✓	
CAR 40	489131	5795118	28.98	TLA	✓	
CAR 41	497110	5799623	41.61	TLA	✓	
CAR 42	492205	5802916	36.64	TLA	✓	
CAR 43	489204	5802732	33.15	TLA	✓	
CAR 48	486931	5800967	31.3	TLA	✓	
CAR 53	490435	5797902	NA	TLA	✓	
CAR 55	491942	5800677	NA	TLA		✓
CAR 6	483077	5789091	2.74	TLA	✓	
CAR 9	487278	5796320	27.93	TLA	✓	
CMM 10	485867	5871943	58.63	TLA	✓	✓
CMM 19	485848	5883440	56.58	TLA	✓	

	Bore Location (GDA Coordinates)				Parameters Measured	
CMM 20	490730	5884243	82.63	TLA	✔	
CMM 21	482299	5877611	54.96	TLA	✔	
CMM 22	486727	5879023	58.21	TLA	✔	
CMM 23	491645	5879965	70.61	TLA	✔	
CMM 25	482001	5873484	56.06	TLA	✔	
CMM 26	490777	5873683	63.51	TLA	✔	
CMM 79	483517	5874662	55.42	TLA	✔	✔
CMM 8	485694	5878171	56.62	TLA		✔
CMM 81	485694	5878171	56.62	TLA	✔	✔
CMM 82	486823	5869704	NA	TLA		✔
CMM 83	490609	5872588	NA	TLA		✔
CMM 84	486823	5869704	NA	TLA	✔	✔
CMM 85	486612	5869693	NA	TLA		✔
CMM 86	486597	5869683	60.986	TLA	✔	✔
CMM 87	486612	5869693	60.719	TLA	✔	
CMM 88	486637	5869688	60.236	TLA	✔	
GAM 113	485039	5819330	61.09	TLA	✔	
GAM 12	481833	5809030	38.57	TLA	✔	
GAM 18	484682	5812158	50.71	TLA	✔	
GAM 20	485133	5809283	35.91	TLA	✔	
GAM 21	484978	5807626	36.14	TLA	✔	
GAM 22	485097	5806043	35.93	TLA	✔	
GAM 223	483440	5805496	65.66	TLA	✔	
GAM 228	482676	5816666	NA	TLA		✔
GAM 250	482202	5812167	40.75	TLA	✔	
GAM 252	482182	5812117	40.4	TLA	✔	
GAM 253	482502	5811243	NA	TLA	✔	
GAM 255	494180	5817114	64.82	TLA	✔	
GAM 28	486946	5813825	57.63	TLA	✔	
GAM 29	486649	5812800	42.45	TLA	✔	
GAM 3	482842	5818420	54.83	TLA	✔	
GAM 37	488101	5817137	65.7	TLA	✔	
GAM 46	489586	5819652	65.54	TLA	✔	
GAM 52	489964	5810667	42.63	TLA	✔	
GAM 60	484977	5810777	37.73	TLA	✔	
GAM 62	492047	5820216	68.25	TLA	✔	
GAM 7	483432	5812157	38.54	TLA	✔	
GAM 70	496814	5811719	57.61	TLA	✔	
GAM 71	496659	5814438	64.08	TLA	✔	
GAM 72	491694	5816415	62.81	TLA	✔	
GAM 75	485040	5819436	62.63	TLA	✔	
GAM 78	493181	5805671	38.01	TLA	✔	
GAM 79	493873	5811024	43.68	TLA	✔	
GAM 8	483082	5811060	40.45	TLA	✔	
GAM 80	494405	5814749	60.65	TLA	✔	✔
GAM 81	497258	5808899	48.05	TLA	✔	✔
GAM 9	483537	5809309	37.23	TLA	✔	
GGL 10	496007	5946929	106.3	TLA		✔
GGL 2	487285	5962017	97.93	TLA	✔	
GGL 4	489198	5954569	94.16	TLA	✔	✔
GGL 7	494259	5951798	104.32	TLA	✔	
GGL 8	481454	5946884	92	TLA	✔	✔
GGL 9	489968	5947951	106.53	TLA	✔	
GRY 15	477656	5838311	NA	TLA	✔	✔
GRY 17	477416	5840477	71.2	TLA	✔	
GRY 19	480838	5841421	72.03	TLA		✔
GRY 20	480638	5841813	70.45	TLA		✔
GRY 3	477253	5848607	66	TLA	✔	
GRY 6	471903	5844722	68.67	TLA	✔	
GRY 9	471485	5839919	69.51	TLA	✔	
HYN 1	470725	5941430	73.57	TLA	✔	
HYN 14	467657	5917637	45.5	TLA	✔	
HYN 15	472299	5917245	46.46	TLA	✔	
HYN 17	481425	5921868	82.99	TLA	✔	

	Bore Location (GDA Coordinates)				Parameters Measured	
HYN 18	468092	5930240	53.62	TLA	✔	
HYN 20	466561	5918060	NA	TLA		✔
HYN 21	479130	5921800	NA	TLA		✔
HYN 25	478424	5937770	85.82	TLA		✔
HYN 26	480951	5925311	NA	TLA		✔
HYN 27	471694	5919980	NA	TLA		✔
HYN 28	469439	5927550	NA	TLA		✔
HYN 29	470662	5941315	NA	TLA		✔
HYN 30	480957	5924671	NA	TLA		✔
HYN 31	481288	5924632	NA	TLA		✔
HYN 32	478732	5925608	NA	TLA		✔
HYN 7	476032	5930522	84.7	TLA	✔	
HYN 9	470423	5926030	72.69	TLA	✔	
JES 4	491942	5909438	93.65	TLA	✔	✔
JES 5	496098	5912410	103.83	TLA	✔	
JES 50	484075	5911927	87.06	TLA	✔	✔
JES 54	488622	5902345	NA	TLA		✔
JES 55	493145	5901922	NA	TLA		✔
JES 56	486794	5906941	NA	TLA		✔
JES 58	488496	5908941	NA	TLA		✔
JES 59	481870	5914996	NA	TLA		✔
JES 60	482575	5914793	NA	TLA		✔
JES 61	481884	5906068	NA	TLA		✔
JES 7	496242	5907356	96.7	TLA	✔	
JOA 10	496491	5887690	121.44	TLA	✔	
JOA 12	495460	5887465	NA	TLA		✔
JOA 13	495923	5895389	NA	TLA	✔	✔
JOA 14	485006	5898972	NA	TLA		✔
JOA 17	495397	5890667	108.91	TLA		✔
JOA 18	487889	5894065	NA	TLA		*
JOA 4	496158	5898127	103.33	TLA	✔	
JOA 5	488192	5891752	77.67	TLA	✔	
JOA 8	481749	5888633	54.34	TLA	✔	✔
KKW 1	475291	6158064	55.44	TLA	✔	
KLN 11	479422	5882706	53.8	TLA	✔	✔
KLN 2	471167	5883284	51.9	TLA	✔	
KLN 5	472564	5878359	52.47	TLA	✔	✔
KNF 10	472827	6136721	86.7	TLA		✔
KNF 22	469194	6115735	90.24	TLA		✔
KNF 23	472744	6136347	72.83	TLA	✔	
MAC 10	480986	5800528	26.91	TLA	✔	
MAC 13	475225	5801386	17.84	TLA	✔	
MAC 16	473998	5799667	21.13	TLA	✔	
MAC 19	478476	5798756	14.5	TLA	✔	
MAC 2	474105	5805257	29.9	TLA	✔	
MAC 27	477051	5791003	6.45	TLA	✔	
MAC 3	478019	5803960	26.12	TLA	✔	
MAC 34	479150	5804010	30.2	TLA	✔	
MAC 35	476283	5798940	14.82	TLA	✔	
MAC 39	467049	5795459	14.63	TLA	✔	
MAC 4	475174	5804384	33.78	TLA	✔	
MAC 42	481725	5795939	18.96	TLA	✔	
MAC 44	471858	5790837	7.04	TLA	✔	
MAC 45	479735	5791715	7.71	TLA	✔	
MAC 46	471503	5802080	15.14	TLA	✔	
MAC 47	477669	5794884	9.4	TLA	✔	✔
MAC 54	471823	5788298	3.57	TLA	✔	
MAC 56	467093	5801477	24.87	TLA	✔	
MAC 6	475845	5802760	20.85	TLA	✔	
MAC 61	476742	5801626	22.91	TLA	✔	
MAC 9	480084	5802969	29.07	TLA	✔	
MCA 2	465160	6022155	90.94	TLA		✔
MCG 1	494900	6155059	62.22	TLA	✔	
MCG 2	493055	6142304	NA	TLA	✔	

	Bore Location (GDA Coordinates)				Parameters Measured	
MCG 4	495185	6146399	NA	TLA	✔	
MCG 5	495194	6146402	NA	TLA	✔	
MCG 6	492285	6149874	NA	TLA	✔	
MCG 7	492298	6149880	NA	TLA	✔	
MIN 15	495636	5824529	70.33	TLA	✔	
MIN 16	491771	5835754	70.4	TLA	✔	
MIN 18	492017	5829457	69.14	TLA	✔	✔
MIN 19	486493	5834496	71.14	TLA	✔	
MIN 20	486228	5825942	70.37	TLA	✔	
MIN 23	482797	5824355	NA	TLA		✔
MIN 25	496934	5834505	NA	TLA	✔	✔
MIN 7	489487	5823280	68.71	TLA	✔	✔
MIN 9	496220	5834477	69.73	TLA	✔	
MKN 2	463045	6019060	97.71	TLA		✔
MON 14	477328	5855585	63.2	TLA	✔	
MON 17	472762	5869303	55.58	TLA	✔	
MON 18	472292	5863062	56.371	TLA	✔	
MON 22	479270	5860868	NA	TLA		✔
MON 4	481034	5869282	55.66	TLA	✔	
MON 8	467897	5858595	57.5	TLA	✔	
NAN 11	495667	5839198	66.3	TLA	✔	
NAN 12	488560	5845877	71.36	TLA	✔	
NAN 13	484493	5846865	68.46	TLA		✔
NAN 15	494762	5844345	70.43	TLA		✔
NAN 19	491790	5844228	72.46	TLA	✔	
NAN 20	496474	5843821	71.24	TLA	✔	✔
NAN 21	493276	5841034	NA	TLA	✔	✔
NAN 29	495037	5842580	68.47	TLA		✔
NAN 3	494427	5848152	70.36	TLA	✔	
NAN 31	484420	5853371	NA	TLA		✔
NAN 33	484007	5853140	64.11	TLA	✔	
NAN 38	487096	5843493	70.52	TLA		✔
NAN 39	487456	5843483	70.56	TLA		✔
NAN 4	483583	5845657	70.5	TLA	✔	
NAN 40	485656	5846674	69.48	TLA		✔
NAN 41	486041	5846158	70.15	TLA		✔
NAN 9	485711	5840293	70.11	TLA	✔	✔
NAR 8	467017	5902330	46.49	TLA		✔
NAR 1	468251	5912945	44.94	TLA	✔	
NAR 10	477707	5902731	50.17	TLA	✔	
NAR 2	472638	5911803	48.94	TLA	✔	
NAR 46	477456	5907836	83.48	TLA	✔	
NAR 48	474221	5909080	49.103	TLA	✔	✔
NAR 49	467137	5906180	44.886	TLA	✔	
NAR 5	472334	5907671	48.65	TLA	✔	
NAR 50	474286	5906830	NA	TLA		✔
NAR 51	473964	5905916	NA	TLA		✔
NAR 52	473132	5903568	NA	TLA		✔
NAR 53	473314	5903495	NA	TLA		✔
NAR 54	476469	5905012	NA	TLA		✔
NAR 55	475167	5905686	NA	TLA		✔
NAR 56	477531	5902319	NA	TLA		✔
NAR 57	475263	5901542	NA	TLA		✔
NAR 58	476142	5901946	NA	TLA		✔
NAR 59	480882	5915752	NA	TLA		✔
NAR 6	476592	5907661	52.07	TLA	✔	
NAR 60	478566	5912543	NA	TLA		✔
NAR 61	475475	5909475	NA	TLA		✔
NAR 63	474627	5901921	49.19	TLA	✔	
NAR 64	475352	5913330	NA	TLA		✔
NAR 8	467017	5902330	46.49	TLA	✔	
NAR 9	471491	5903356	49.65	TLA	✔	
PEB 1	490968	6121141	NA	TLA		✔
PEB 11	484257	6131873	69.032	TLA	✔	

	Bore Location (GDA Coordinates)				Parameters Measured	
PEB 12	485630	6128611	75.923	TLA	✔	
PEB 13	490669	6125964	71.408	TLA	✔	
PEB 15	491842	6129628	60.941	TLA	✔	
PEB 16	491446	6131728	NA	TLA	✔	✔
PEB 17	489233	6132631	NA	TLA	✔	
PEB 19	494515	6140073	NA	TLA	✔	
PEB 20	488548	6134428	NA	TLA	✔	
PEB 22	491893	6134748	NA	TLA	✔	✔
PEB 23	485102	6133103	NA	TLA	✔	
PEB 24	494063	6118621	NA	TLA	✔	✔
PEB 25	494494	6140056	NA	TLA	✔	✔
PEB 26	485154	6140046	NA	TLA	✔	
PEB 27	482803	6138323	NA	TLA	✔	
PEB 28	493302	6138128	NA	TLA	✔	
PEB 29	493537	6135529	NA	TLA	✔	
PEB 3	494091	6118573	81.02	TLA	✔	
PEB 30	495415	6132770	NA	TLA	✔	
PEB 31	496102	6125464	NA	TLA	✔	
PEB 33	495925	6122808	NA	TLA	✔	
PEB 4	493938	6115230	89.32	TLA	✔	
PEB 6	492202	6139858	48.59	TLA	✔	
PEB 7	491688	6139914	47.93	TLA	✔	
PEB 8	485808	6134346	61.462	TLA	✔	
PEN 11	495619	5854291	65.62	TLA	✔	
PEN 15	485398	5868673	59.13	TLA	✔	
PEN 2	497533	5869149	77.98	TLA	✔	
PEN 27	491432	5865159	64.75	TLA	✔	
PEN 28	495792	5854627	NA	TLA		✔
PEN 3	482219	5864320	58.23	TLA	✔	
PEN 30	494514	5866829	NA	TLA		✔
PEN 6	486133	5858753	63.38	TLA	✔	✔
PEN 8	494860	5859974	70.56	TLA	✔	
PLL 1	480203	6111530	NA	TLA		✔
PLL 13	475828	6094059	87.491	TLA	✔	
PLL 14	469778	6094076	102.48	TLA	✔	
PLL 2	479701	6111555	96.599	TLA	✔	
PLL 24	476571	6097501	NA	TLA		✔
PLL 28	479357	6093945	NA	TLA	✔	
PNN 1	479935	6055937	NA	TLA		✔
PNN 3	478839	6061133	115.54	TLA	✔	
PNR 1	495969	6096569	101.79	TLA	✔	
PNR 14	493617	6113301	NA	TLA	✔	
PNR 15	494496	6111280	NA	TLA	✔	
PNR 16	495822	6107888	NA	TLA	✔	
PNR 17	494998	6103452	NA	TLA	✔	
PNR 18	487357	6114554	NA	TLA	✔	
PNR 5	491040	6083028	118.69	TLA	✔	
PNR 6	487879	6082771	NA	TLA		✔
PNR 7	493636	6106683	100.78	TLA	✔	
PNR 8	492542	6098592	NA	TLA		✔
QRK 1	477619	6070635	119.12	TLA		✔
ROB 1	467105	5897603	48.17	TLA	✔	
ROB 10	476971	5888070	51.44	TLA	✔	
ROB 13	474267	5889402	NA	TLA		✔
ROB 2	471560	5897849	48.99	TLA	✔	✔
ROB 4	466663	5892895	49.7	TLA		✔
ROB 6	476787	5893560	55.53	TLA	✔	
ROB 8	467392	5888508	50.68	TLA	✔	
ROB 9	471656	5888577	51.34	TLA	✔	
SEN 12	485518	6007346	115.2	TLA	✔	
SEN 13	480930	6000262	107.02	TLA	✔	
SEN 14	488803	6004202	116.14	TLA	✔	
SEN 15	480902	6005590	112.24	TLA	✔	
SEN 16	492459	5994511	NA	TLA		✔

	Bore Location (GDA Coordinates)				Parameters Measured	
SEN 17	481985	5995175	NA	TLA		✔
SEN 18	491391	6006292	NA	TLA		✔
SEN 2	488671	5998414	113.85	TLA	✔	
SEN 3	488197	5993861	104.53	TLA	✔	
SEN 4	487586	5988218	96.06	TLA	✔	
SEN 5	496779	6004142	130.3	TLA	✔	
SEN 6	492382	5990022	109.03	TLA	✔	
SEN 8	480903	5996169	103.01	TLA	✔	
SEN 9	492078	5994889	106.34	TLA	✔	
SHG 2	494652	6017926	129.14	TLA	✔	
SHG 4	480426	6020142	115.49	TLA		✔
SHG 5	479081	6017465	114.07	TLA	✔	
SHG 6	481559	6036219	125.1	TLA	✔	
SHG 7	481559	6036215	125.04	TLA	✔	
TAT 10	480505	5975782	83.82	TLA	✔	
TAT 101	491224	5965724	NA	TLA		✔
TAT 102	494771	5981607	NA	TLA		✔
TAT 104	475376	5980095	NA	TLA		✔
TAT 106	496863	5978485	NA	TLA	✔	✔
TAT 107	488294	5979479	98.63	TLA	✔	✔
TAT 108	477657	5967930	89.99	TLA	✔	✔
TAT 109	488294	5979480	NA	TLA		✔
TAT 110	491140	5968156	NA	TLA	✔	✔
TAT 18	475671	5985380	79.61	TLA	✔	
TAT 20	494810	5967646	110.34	TLA	✔	
TAT 23	495027	5976868	113.22	TLA	✔	
TAT 24	485339	5966328	95.66	TLA	✔	
TAT 25	489987	5985427	107.37	TLA	✔	
TAT 26	475988	5972701	85.03	TLA	✔	
TAT 4	475492	5980189	75.46	TLA	✔	
TAT 9	475761	5976345	72.5	TLA	✔	
WRG 111	473119	5984605	NA	TLA	✔	
WRG 116	467319	5972525	NA	TLA	✔	
WRG 18	470997	5967175	81.14	TLA	✔	
WRG 23	470788	5975519	83.2	TLA	✔	
YOU 10	470322	5821432	61.3	TLA	✔	
YOU 12	473076	5837274	69.74	TLA	✔	
YOU 14	481251	5835660	71.3	TLA	✔	
YOU 16	471655	5831356	72.29	TLA	✔	
YOU 21	477047	5825474	64.19	TLA	✔	
YOU 23	469784	5823529	68.59	TLA	✔	
YOU 26	469225	5826973	72.56	TLA	✔	
YOU 28	476205	5829198	70.77	TLA	✔	
YOU 29	478086	5836000	74.36	TLA	✔	
YOU 3	473016	5823067	60.67	TLA	✔	
YOU 30	471353	5835726	72.213	TLA	✔	
YOU 32	471243	5835812	72.330	TLA	✔	
YOU 33	481354	5830904	NA	TLA	✔	✔
YOU 4	474646	5822844	57.49	TLA	✔	
WRG 25	472227	5976323	74.38	TCSA	✔	
TAT 27	490933	5974763	110.57	TCSA	✔	
HYN 19	466498	5922293	43.030	TCSA	✔	
SPE 12	462606	5911964	42.09	TCSA	✔	
NAR 45	468507	5906645	46.21	TCSA	✔	
ROB 11	466965	5892888	49.82	TCSA	✔	
JOA 11	483086	5889931	55.38	TCSA	✔	
CMM 82	491773	5880003	70.080	TCSA	✔	
KLN 10	474863	5876225	53.88	TCSA	✔	
MON 19	472294	5863062	57.3	TCSA	✔	
PEN 25	494746	5860092	71.78	TCSA	✔	
NAN 43	495122	5844052	70.76	TCSA	✔	
GRY 16	473960	5842286	69.35	TCSA	✔	
GRY 21	474022	5838427	NA	TCSA	✔	
NAN 42	487472	5838138	69.75	TCSA	✔	

	Bore Location (GDA Coordinates)				Parameters Measured	
YOU 24	478086	5836000	74.28	TCSA	✔	
MIN 21	491794	5835786	70.4	TCSA	✔	
MIN 17	492018	5829575	69.02	TCSA	✔	
YOU 27	476206	5829198	70.59	TCSA	✔	
YOU 25	469225	5826973	72.44	TCSA	✔	
MIN 22	488037	5822446	72.17	TCSA	✔	
GAM 75	485040	5819436	62.63	TCSA	✔	
BLA 88	478356	5814323	40.39	TCSA	✔	
MAC 57	467059	5801533	25.52	TCSA	✔	
MAC 77	473579	5788386	2.07	TCSA	✔	✔

TABLE 2: Monitoring Bore Network Victoria

Obs Number	Bore Location		Aquifer	Parameters	
	GDA Co-ordinates		Monitored	Measured	
	Easting	Northing		Water Level	Salinity
46217	497400	5818600	TCSA	✔	
48554	526500	5946300	TLA	✔	
48559	526500	5946400	TCSA	✔	
49426	503311	5916753	TLA		✔
49676	502750	6135800	TCSA	✔	
49677	502800	6135800	TLA	✔	✔
49678	503794	6139795	TLA	✔	
49679	504030	6130645	TLA		✔
49950	528600	6069500	TLA	✔	
49951	533600	6044500	TLA	✔	✔
49952	528847	6069365	TLA		✔
50946	513600	5929600	TLA		✔
51844	518040	5914143	TLA	✔	
51845	516034	5918369	TLA	✔	
51846	517196	5915291	TLA	✔	✔
54274	508350	5854600	TLA	✔	
54612	498669	6099863	TLA	✔	
54613	497715	6095184	TLA	✔	
54636	499800	6095350	TLA		✔
54642	503728	6100298	TLA		✔
58079	526300	6009400	TLA	✔	
58111	526600	6009400	TCSA	✔	
58587	523140	5803414	TLA	✔	
60436	506500	5946900	TLA	✔	✔
60450	506500	5987200	TLA	✔	✔
60475	506600	5987200	TCSA	✔	
60610	530500	5926450	TLA	✔	
60623	530500	5926400	TCSA	✔	
60988	525343	5795095	TLA	✔	
61571	519442	6110062	TLA	✔	
61572	522264	6113021	TLA	✔	
61573	526400	6107050	TLA	✔	
61922	523550	5886000	TLA	✔	
61923	523550	5886000	PSA	✔	
61930	516100	5896200	TLA	✔	
64361	505400	6159700	PSA	✔	
64362	505400	6159700	TLA	✔	
64363	506000	6161000	TLA	✔	
64364	506000	6161000	TCSA	✔	
65058	508050	5787450	TLA	✔	
65070	504300	5789500	TLA		✔
65745	514606	6116484	TLA		✔
65758	514350	6016150	TLA	✔	
66475	522304	6091890	TLA	✔	
66476	517410	6091690	TCSA	✔	
66477	517410	6091690	TLA	✔	✔
67829	527250	5907150	TLA	✔	
67847	527300	5907000	TCSA	✔	
69120	505800	5869600	TLA	✔	
69961	522130	5786399	TLA	✔	
69962	524969	5780187	TCSA	✔	
69963	524900	5776000	TLA	✔	
70857	516650	5794650	TLA		✔
71062	539600	6112700	TLA	✔	
74255	500692	5883493	TLA	✔	
75333	498459	5974195	TLA	✔	
75351	500390	5974947	TLA		✔

75365	498300	5976950	TLA	✔	
75651	506600	5967100	TLA	✔	✔
75669	506600	5967100	TCSA	✔	
76898	506600	5886450	TLA	✔	✔
76914	511400	5878000	TLA	✔	
76919	512050	5886500	TLA	✔	
76977	498900	5809600	TCSA	✔	
76986	502411	5810118	TLA	✔	
77199	503142	6120819	TLA		✔
77850	503200	5895350	TLA	✔	✔
79530	514637	5937252	TLA		✔
79655	525600	5987300	TLA	✔	
81832	515000	6194600	TCSA	✔	
81833	515000	6194600	TLA	✔	
81834	515000	6194600	PSA	✔	
82220	506150	6106760	TLA	✔	✔
82344	518105	5814245	TLA	✔	
82347	506945	5814153	TCSA	✔	
82350	506700	5805900	TLA	✔	
82778	506250	5907150	TLA	✔	
82796	506300	5907100	TCSA	✔	
83446	506350	5844700	TCSA	✔	
83447	506350	5844700	TLA	✔	
83459	502000	5836700	TLA		✔
83726	519927	5839473	TLA	✔	
83729	525500	5847250	TLA	✔	
84741	520562	5953870	TLA	✔	✔
85568	505000	6178000	PSA	✔	
85570	505000	6178000	TLA	✔	✔
85628	500656	5934213	TLA	✔	✔
85806	506200	6087600	TLA	✔	
85815	513286	6093817	TLA	✔	
86774	498050	6231500	TCSA	✔	
86775	498050	6231500	TLA	✔	
86776	498050	6231500	PSA	✔	
87527	497300	5796800	TCSA	✔	
87529	497000	5796250	PSA	✔	
87530	503000	5806150	TLA		✔
87537	504248	5798667	TLA		✔
89851	511000	5865000	TLA	✔	✔
92808	506900	5927100	TLA	✔	✔
97046	506700	5838700	TLA		✔
98254	507200	6025350	TLA	✔	✔
98290	507250	6025300	TCSA	✔	
98297	497700	6020000	TLA	✔	
100515	510900	5802600	TLA		✔
100533	506112	5795435	TLA	✔	
101238	510083	5787088	TLA	✔	
101239	509565	5787397	TCSA	✔	
101241	514400	5785600	TLA		✔
101246	516900	5781850	TLA	✔	
102621	508000	5825450	TLA	✔	
103113	513700	5831200	TLA		✔
103354	530600	6026400	TLA	✔	
103369	536265	6020008	TLA		✔
104800	530600	6208100	TCSA	✔	
104801	530650	6208100	PSA	✔	
105672	500565	5896608	TLA	✔	
107455	526200	5966800	TLA	✔	
108158	509600	6007100	TLA	✔	✔
110716	507000	5908000	TLA	✔	
110717	513000	5930000	TLA	✔	
110745	523099	5803423	TCSA	✔	
110746	505300	5831000	TLA	✔	
110747	519354	5853598	TLA	✔	
110748	515050	5793550	TLA	✔	
111321	505200	5898800	TLA		✔

113473	501700	5820000	TLA		✔
113474	507200	5814150	TLA		✔
113475	500800	5855400	TLA		✔
114849	539600	6112700	TLA	✔	
114850	539600	6112700	TLA	✔	
129744	503380	5933090	TLA	✔	
129745	503380	5933140	TLA	✔	
129746	502080	5938920	TLA	✔	
129751	505100	5930500	TLA	✔	
129752	505000	5936000	TLA	✔	
137190	506825	6118475	PSA	✔	
137191	511800	6117140	PSA	✔	
137193			PSA		
137194	503044	6121080	TLA	✔	
137195	501493	6127899	TLA	✔	
137196	501495	6127900	PSA	✔	
137197			PSA		
137198	513550	6098080	TLA	✔	
137199	513550	6098084	PSA	✔	
137200	513290	6087402	TLA	✔	
137201	513292	6087405	PSA	✔	
137294	502010	6135800	TLA		✔
137294	502010	6135800	PSA	✔	✔
138351	502318	6013376	TLA	✔	
138352	515560	6012822	TLA	✔	
138353	502010	6003032	TLA	✔	

APPENDIX D

Bore Metering Network

Table 1	**SA Metered Bores**
Table 2	**Victorian Metered Bores**

Table 1 SA Metered Bores

Identification Number	Licence Number	Bore Location (AMG Coordinates)		Meter no	Open Interval (metres below ground surface) From - To	Extraction from
		Easting	Northing			
Mallee						TLA
7028-472	8024	487730	6127700		101 – 168	TLA
7028-474	8024	486400	6129030		103 – 174	TLA
7028-475	8024	487910	6129043		100 – 162	TLA
7028-471	8038	487650	6130400		100 – 161	TLA
7028-473	8038	489080	6130480		100 – 174	TLA
7027-620	8024	487200	6126500		73 – 160	TLA
7028-591	8108	495888	6131512	Attached to pivot	71 – 150	TLA
7027-746	8058	479748	6096970		83 - 185	TLA
7027-562	8049	486360	6137640	Attached to pivot	75 - 170	TLA
7027-737	8116	495130	6117375		83 - 186	TLA
7027-668	8048	492000	6113775		83 - 183	TLA
7027-649	8028	494280	6120215		73 - 160	TLA
7027-724	8028	493335	6122070		79 - 168	TLA

TABLE 2: Victorian Metered Bores

Identification Number	Lic Number	Bore Location (AMG Coordinates)		Meter no	Geologic formation extracting from
		Easting	Northing		
Neuarpur					
133285					
125936					
127717					
133287					
133288					
133286					
128094					
127722					
125451					
60429					
60610		530500	5926450		
127172					
85640					
98853					
92912					
125934					
92906					
Murrayville					
128128		497834	6104102	23783-9	
128127		498950	6111700	23783-12	
128129		498035	6112060	23783-8	
128132				23783-10	
132242		501362	6116541	23783-7	
132243		501004	6115215	23035-17	
132244		501813	6115629	22669-4	
128126		498147	6115142	23035-13	
139055		498647	6113428	NRZR 8148	
138349		511780	6113825	NRZR 2968	
139053		511770	6087690	NRZR 8147	
112601		516000	6097200		

APPENDIX E

Calculations of Proposed PAVs for the TLA in Province 3

Zones and Sub - Zones	Sub-Areas of Zones and Sub-Zones	Sub-Zone Area <3000 mg/L km^2	Sub-Zone Area >3000 mg/L km^2	Area 3km Into Park km^2	Total Area km^2	Current Zone PAV ML/yr	Confined Volume of Sub-Zone Sy = 0.15 ML/yr	Confined Volume 3km into Park Sy = 0.15 ML/yr	Total Confined Volume ML/yr	Unconfined Recharge Rate mm/yr	Unconfined Volume ML/yr	Total Zone/ Sub-Zone Volume ML/yr
Zone 11A					2146.00	12000						
Sub-Zone 11A North			1421.70	169.25	1590.95		10662.75	1269.38	11932.13			**11932**
Sub-Zone 11A South		707.60		43.30	750.90		5307.00	324.75	5631.75			**5632**
Zone 11B					2115.00	12000						
Sub-Zone 11B North			163.72	91.42	255.14		1227.90	685.65	1913.55			**1914**
Sub-Zone 11B North-East			102.43	139.39	241.82		768.23	1045.43	1813.65			**1814**
Sub-Zone 11B South		168.79		74.30	243.09		1265.93	557.25	1823.18			**1823**
Zone 10A					1110.00	9400						
Sub-Zone 10A		986.73		59.10	1045.83		7400.48	443.25	7843.73			**7844**
Zone 10B					1110.00	6000						
Sub-Zone 10B		789.20		106.90	896.10		5919.00	801.75	6720.75			**6721**
Zone 9A					1110.00	11600						
Sub-Zone 9A North		24.85		37.80	62.65		186.38	283.50	469.88			**470**
Sub-Zone 9A South	9A South (Confined)	89.97		136.93	226.90		674.78	1026.98	1701.75			
	9A South (Unconfined)	319.60			319.60					15	4794	**6496**
Zone 9B					1110.00	6000						
Sub-Zone 9B South	9B South (Confined)	221.24		68.75	289.99		1659.30	515.63	2174.93			
	9B South (Unconfined)	24.30			24.30					15	364.5	**2539**
Zone 8B					555.00	3500						
	8B (Confined)	207.76			207.76		1558.20		1558.20			
	8B (Unconfined - 1)	334.83			334.83					15	5022.45	
	8B (Unconfined - 2)	12.00			12.00					12	180	**6761**

Notes:

Volume calculation (ML/yr) for confined areas is - Area (km^2) x 0.15 x 0.05 x1000

Volume calculation (ML/yr) for unconfined areas is - Area (km^2) x recharge rate in meters x1000

The two sub-areas of 8B (unconfined) relate to areas of different land use with different vertical recharge rates

FIGURES

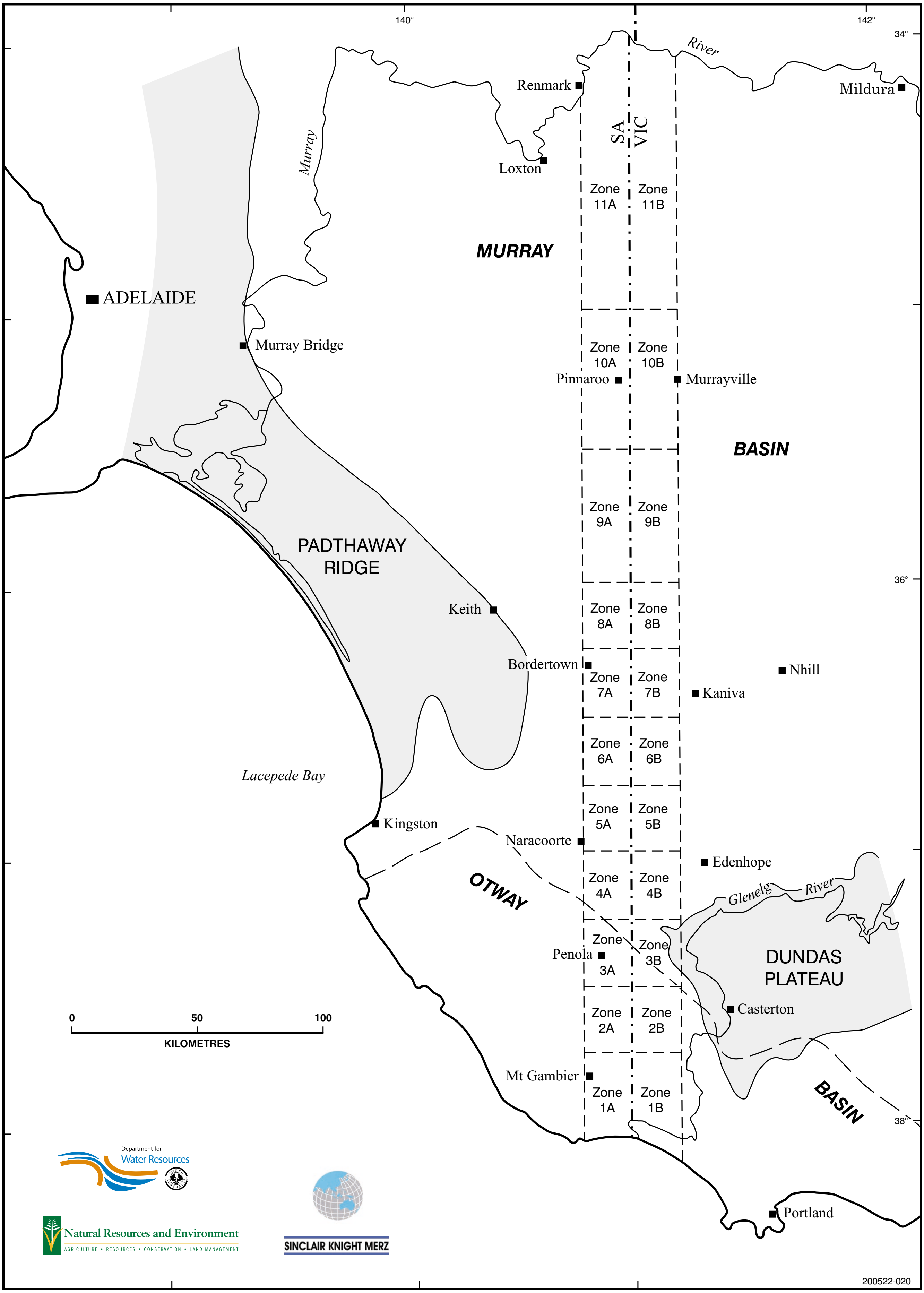


Figure 1 *Locality Plan.*

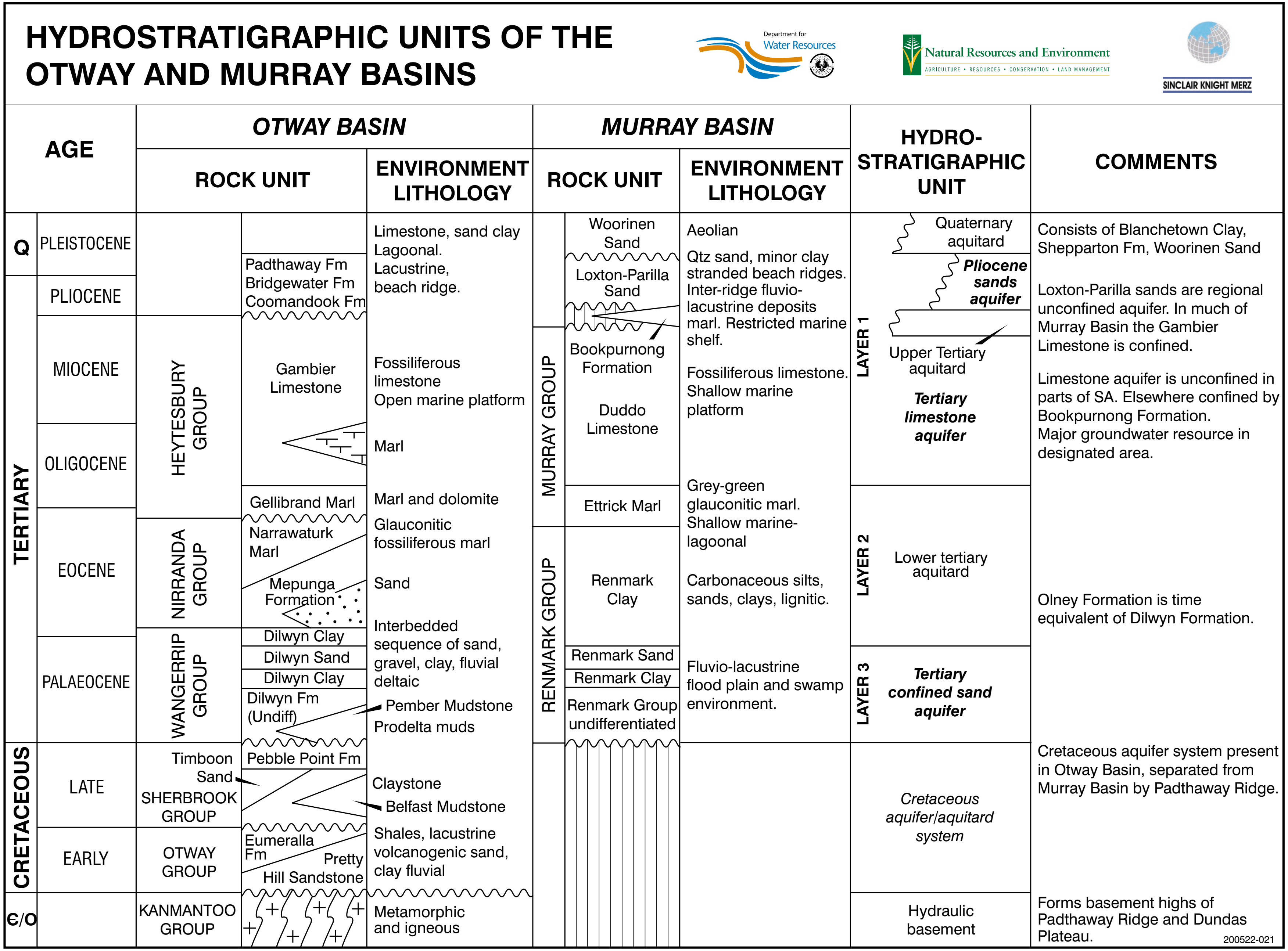


***Figure 2** Hydrostratigraphic units of the Otway and Murray Basins.*

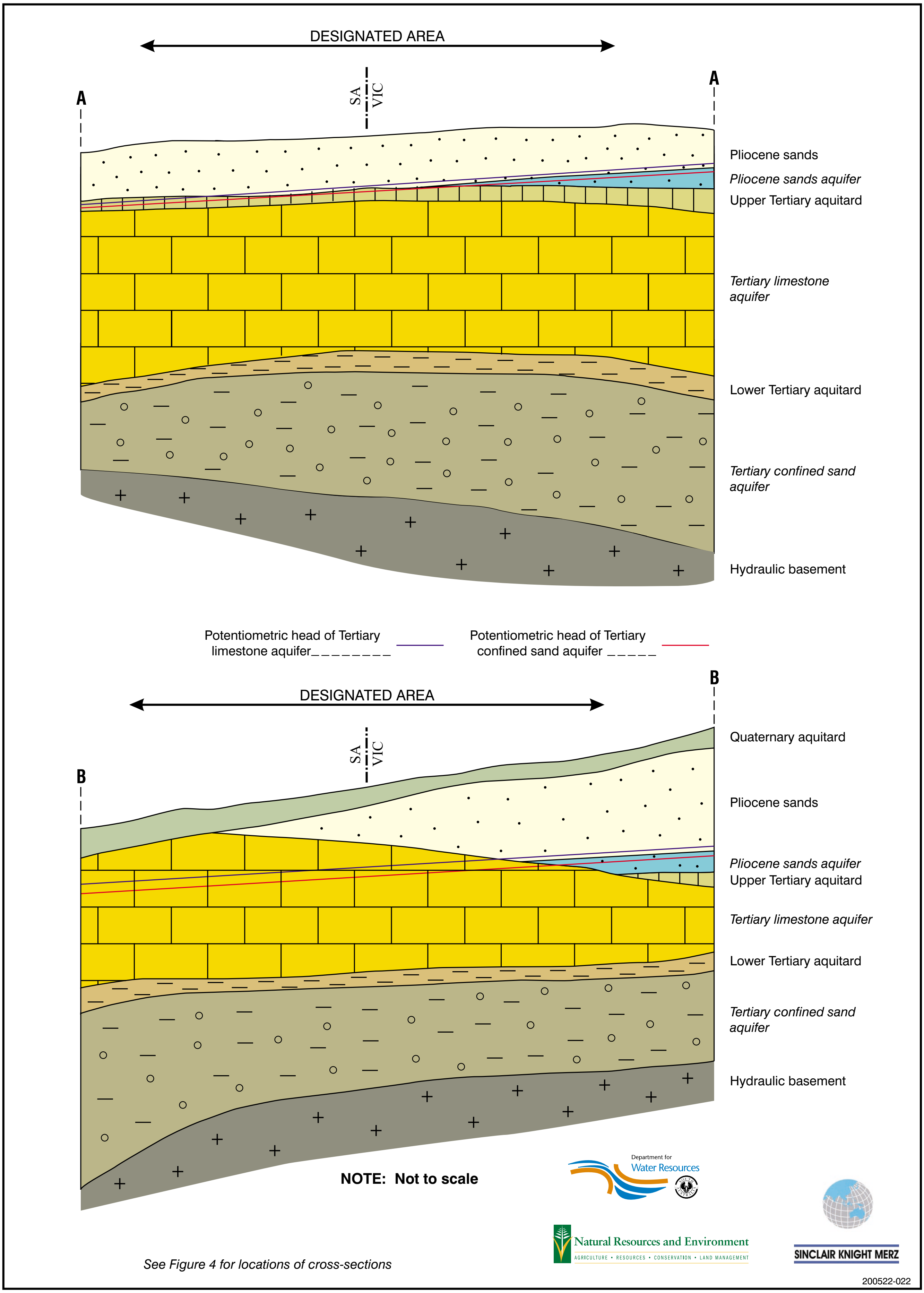


Figure 3 *Schematic hydrostratigraphic cross-sections through Designated Area.*

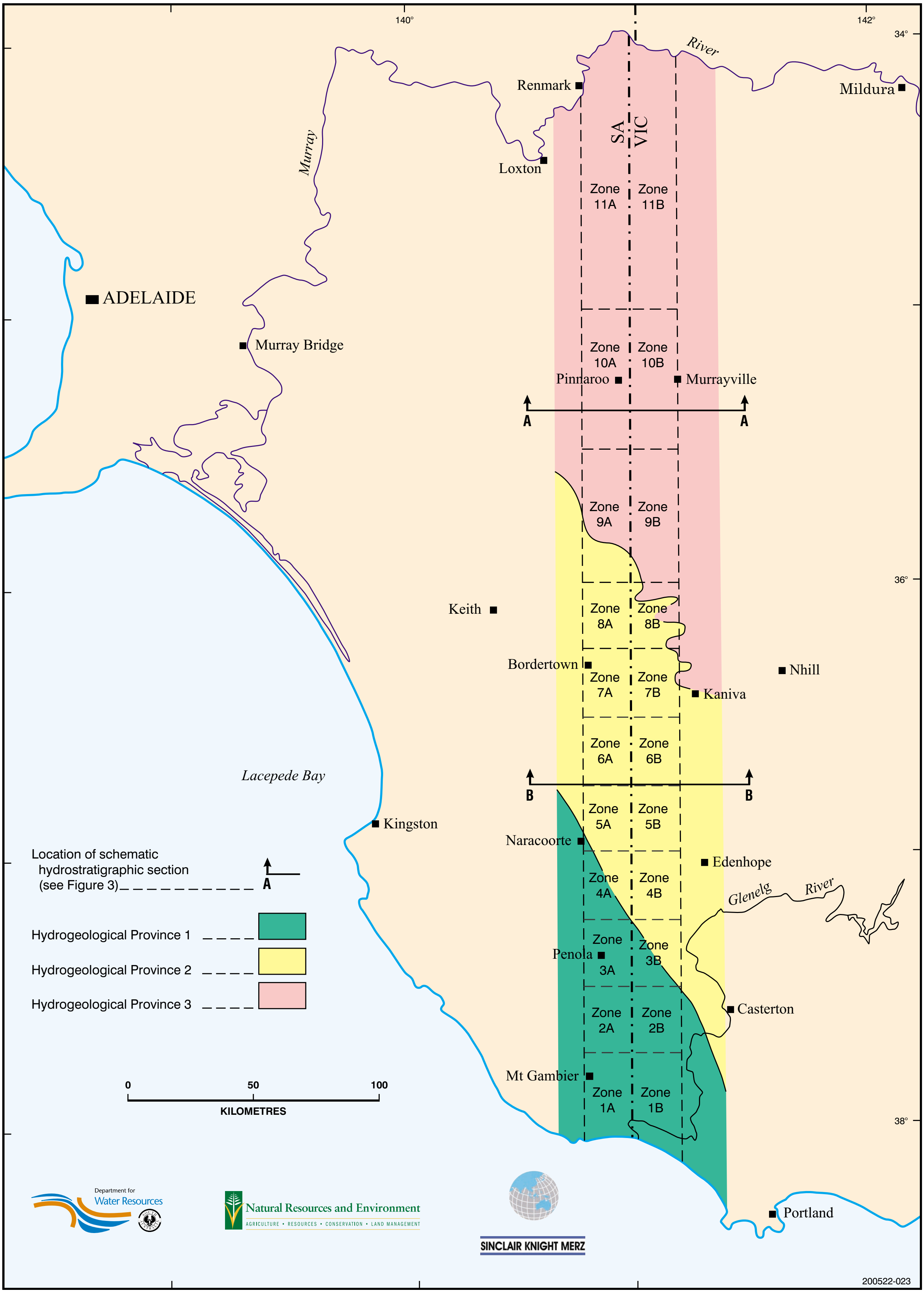
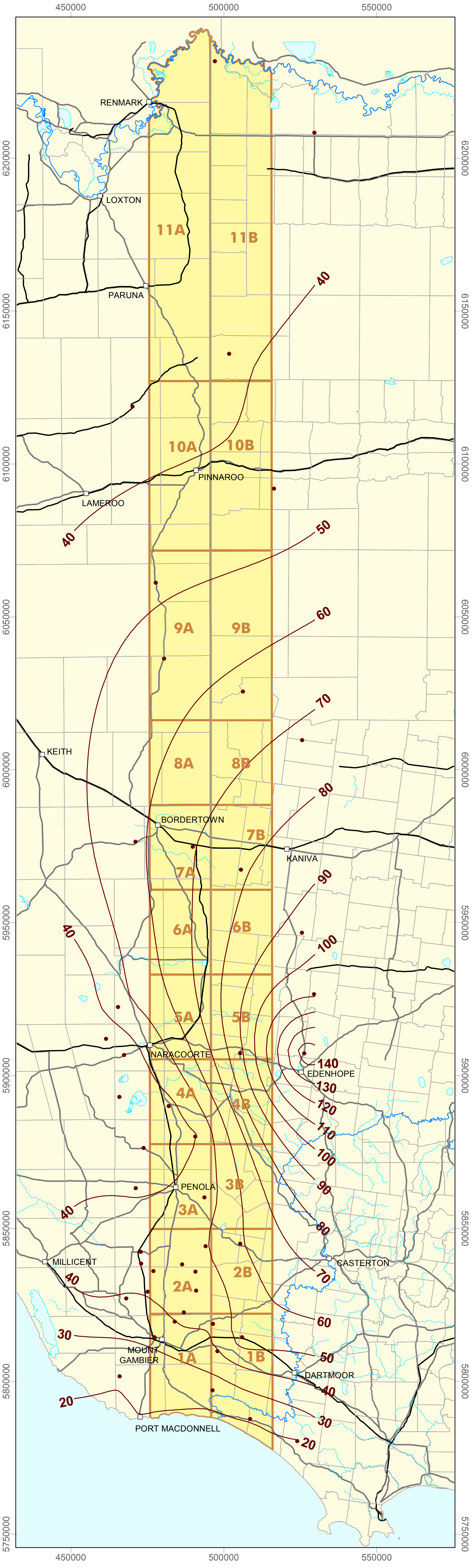


Figure 4 *Hydrogeological provinces of the Designated Area.*



- Water level monitoring bore
- 70 Potentiometric contour (metres AHD)
- Town
- Road
- Railway
- Hundreds/Parishes boundary
- Zone of Designated Area

0 25 50 75 100 Kilometers

Datum GDA94 - Projection UTM MGA Zone 54

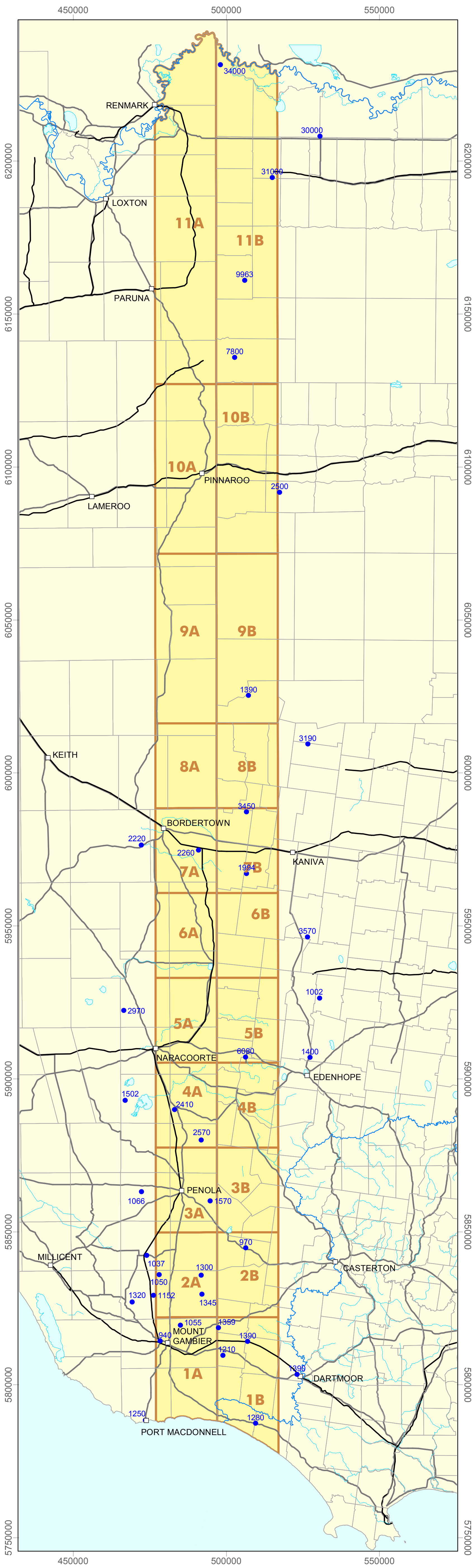
GROUNDWATER (BORDER AGREEMENT) ACT
FIVE YEAR TECHNICAL REPORT 1996-2000

TERTIARY CONFINED SAND AQUIFER

Potentiometric Contours September 1999

AV : 200522_011
PIRSA Publications and Displays

Figure 5



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SINCLAIR KNIGHT MERZ

- Salinity monitoring bore
- 1066 Salinity value (Electrical Conductivity Units)
- Town
- Road
- Railway
- Hundreds/Parishes boundary
- Zone of Designated Area

0 25 50 75 100 Kilometers

Datum GDA94 - Projection UTM MGA Zone 54

GROUNDWATER (BORDER AGREEMENT) ACT
FIVE YEAR TECHNICAL REPORT 1996-2000

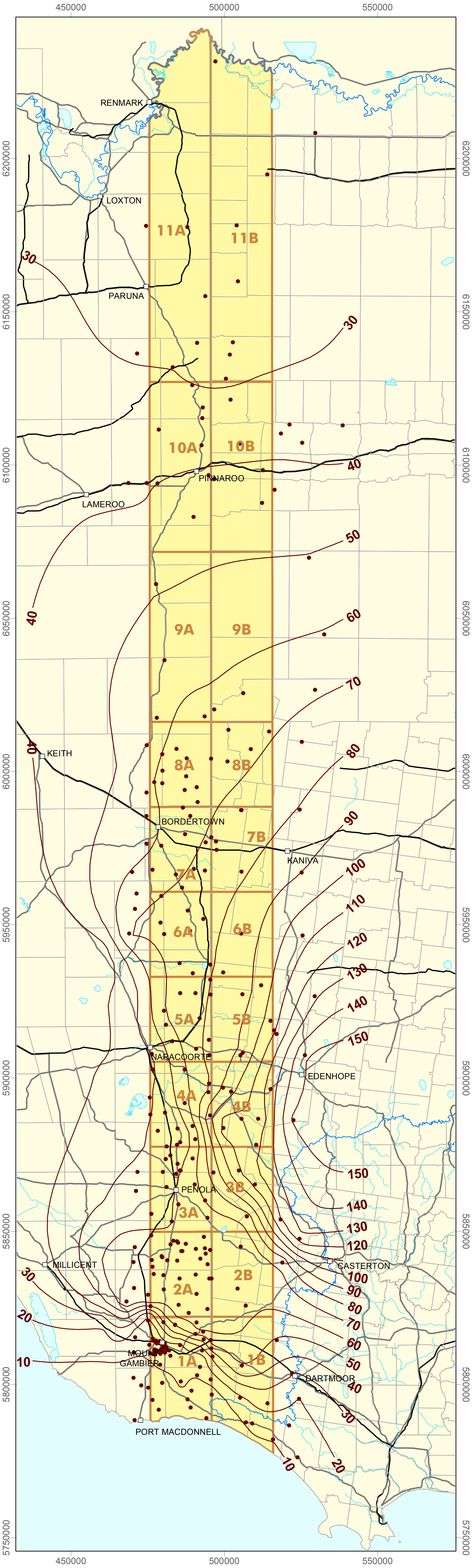
TERTIARY CONFINED SAND AQUIFER

Groundwater Salinity

AV : 200522_015
PIRSA Publications and Displays

GDA

Figure 6



Department for Water Resources

Natural Resources and Environment

SINCLAIR KNIGHT MERZ

Water level monitoring bore

70 Potentiometric contour (metres AHD)

Town

Road

Railway

Hundreds/Parishes boundary

Zone of Designated Area

0 25 50 75 100 Kilometers

Datum GDA94 - Projection UTM MGA Zone 54

GROUNDWATER (BORDER AGREEMENT) ACT
FIVE YEAR TECHNICAL REPORT 1996-2000

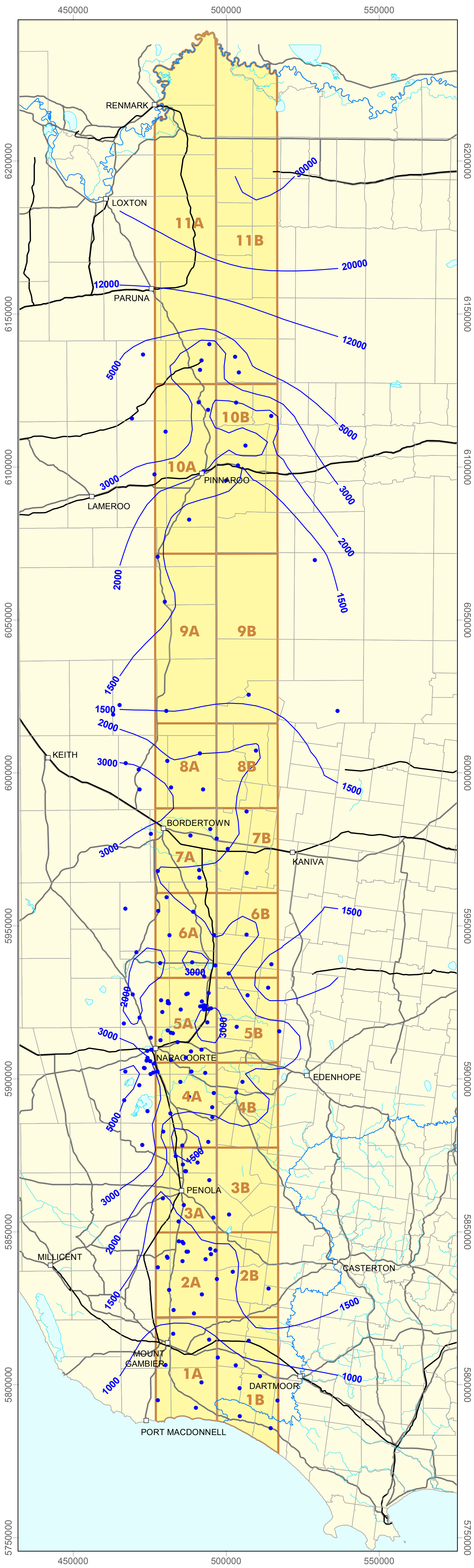
TERTIARY LIMESTONE AQUIFER

Potentiometric Contours
September 1999

AV : 200522_008
PIRSA Publications and Displays

GDA

Figure 7



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SINCLAIR KNIGHT MERZ

Salinity monitoring bore

1000 Salinity contour (Electrical Conductivity Units)

Town

Road

Railway

Hundreds/Parishes boundary

Zone of Designated Area

0 25 50 75 100 Kilometers

Datum GDA94 - Projection UTM MGA Zone 54

GROUNDWATER (BORDER AGREEMENT) ACT
FIVE YEAR TECHNICAL REPORT 1996-2000

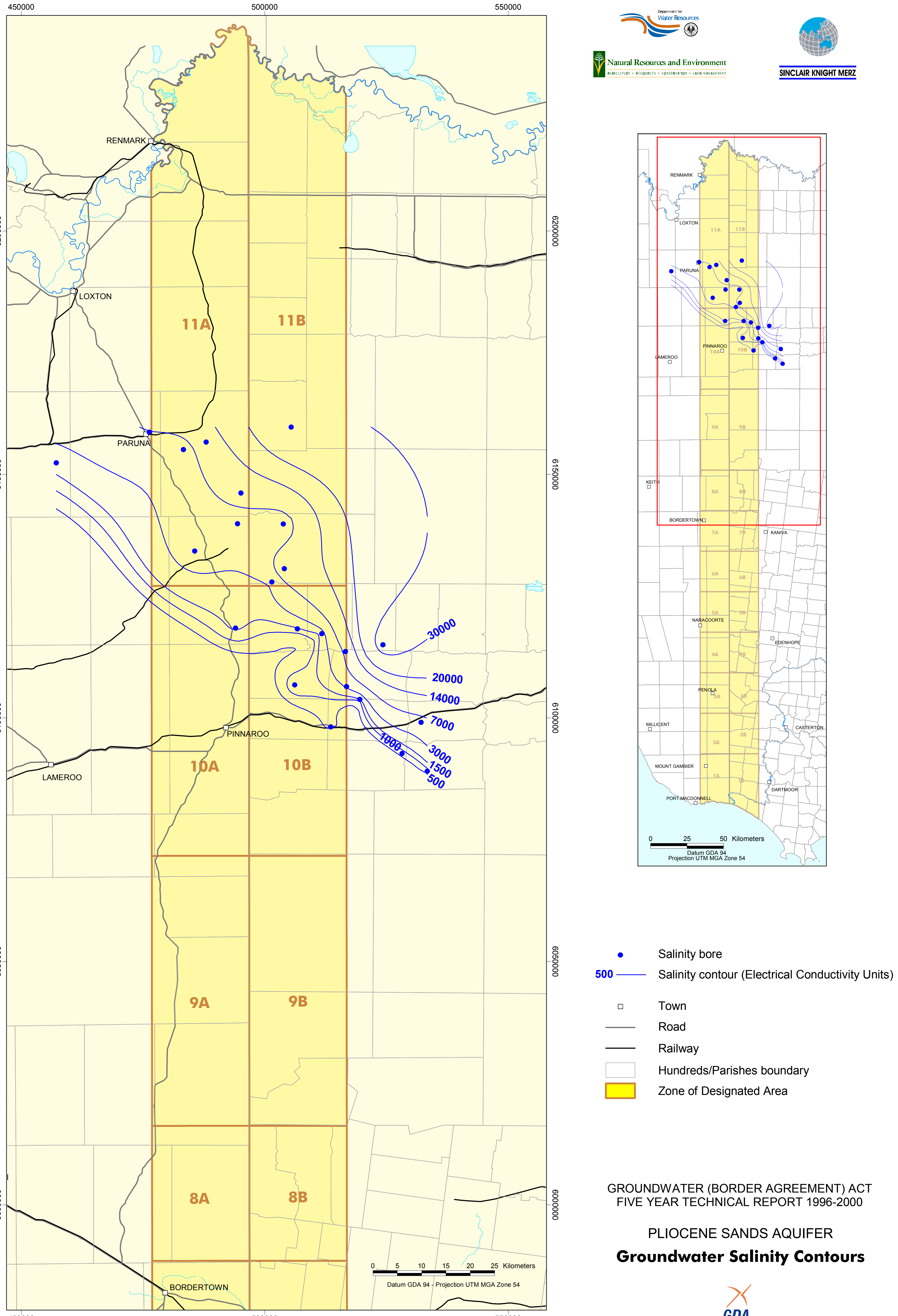
TERTIARY LIMESTONE AQUIFER

Groundwater Salinity Contours December 1999

AV : 200522_013
PIRSA Publications and Displays

GDA

Figure 8



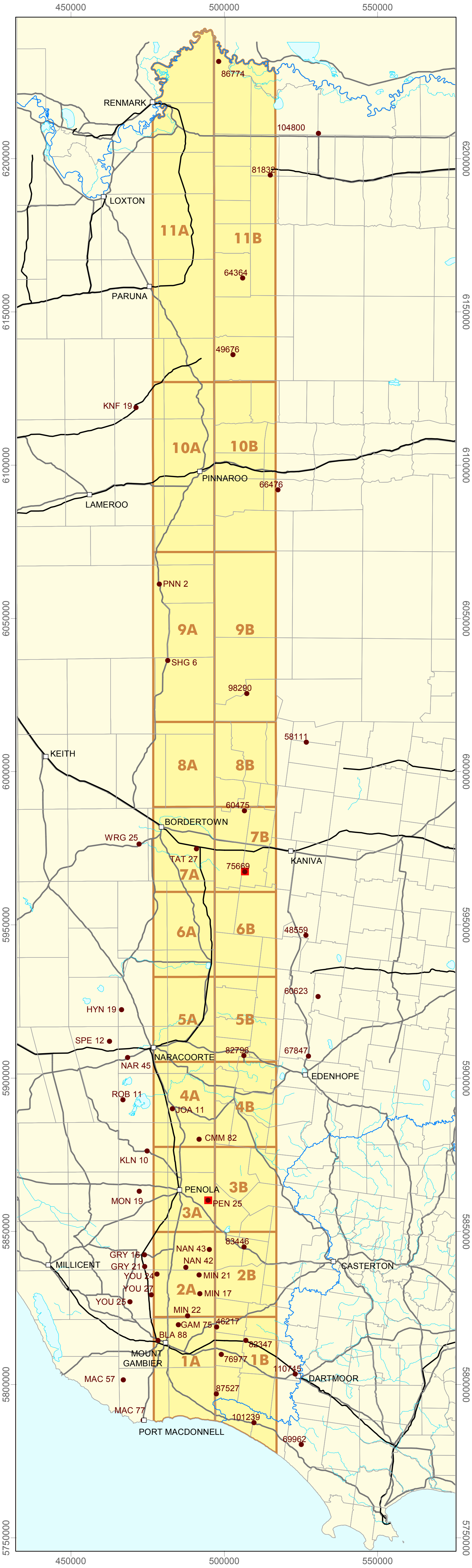
GROUNDWATER (BORDER AGREEMENT) ACT
FIVE YEAR TECHNICAL REPORT 1996-2000

PLIOCENE SANDS AQUIFER

Groundwater Salinity Contours

AV : 200522_019
PIRSA Publications and Displays

Figure 9



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SINCLAIR KNIGHT MERZ

67847 Water level monitoring bore and number

PEN 25 75669 Water level monitoring bore with hydrograph (see Fig 15)

Town

Road

Railway

Hundreds/Parishes boundary

Zone of Designated Area

0 25 50 75 100 Kilometers

Datum GDA94 - Projection UTM MGA Zone 54

GROUNDWATER (BORDER AGREEMENT) ACT
FIVE YEAR TECHNICAL REPORT 1996-2000

TERTIARY CONFINED SAND AQUIFER

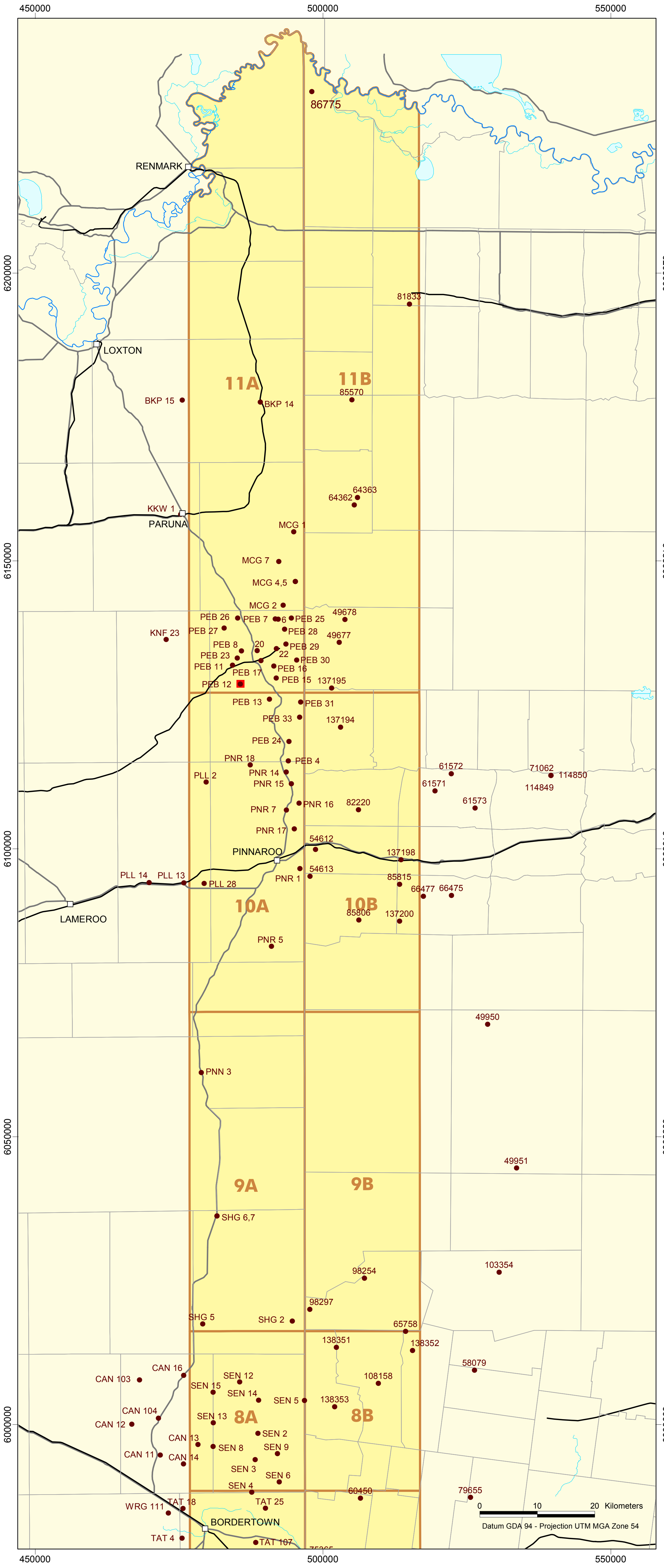
Water Level Monitoring Bores

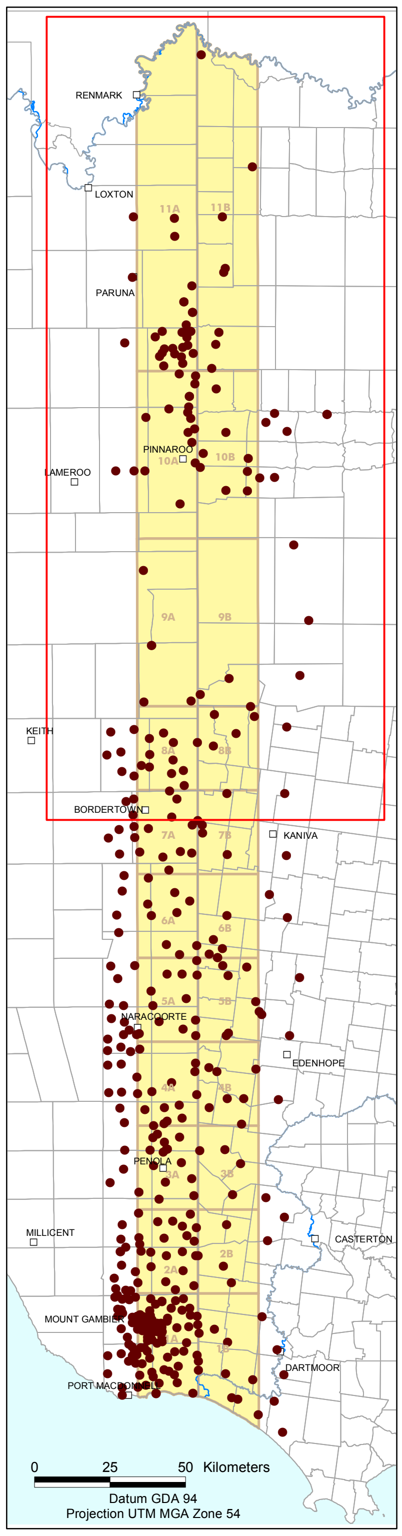
AV : 200522_004

PIRSA Publications and Displays

GDA

Figure 10





• SHG 5 Water level monitoring bore and number

■ PEB 12 Water level monitoring bore with hydrograph (see Fig 17)

□ Town

Road

Railway

Hundreds/Parishes boundary

Zone of Designated Area

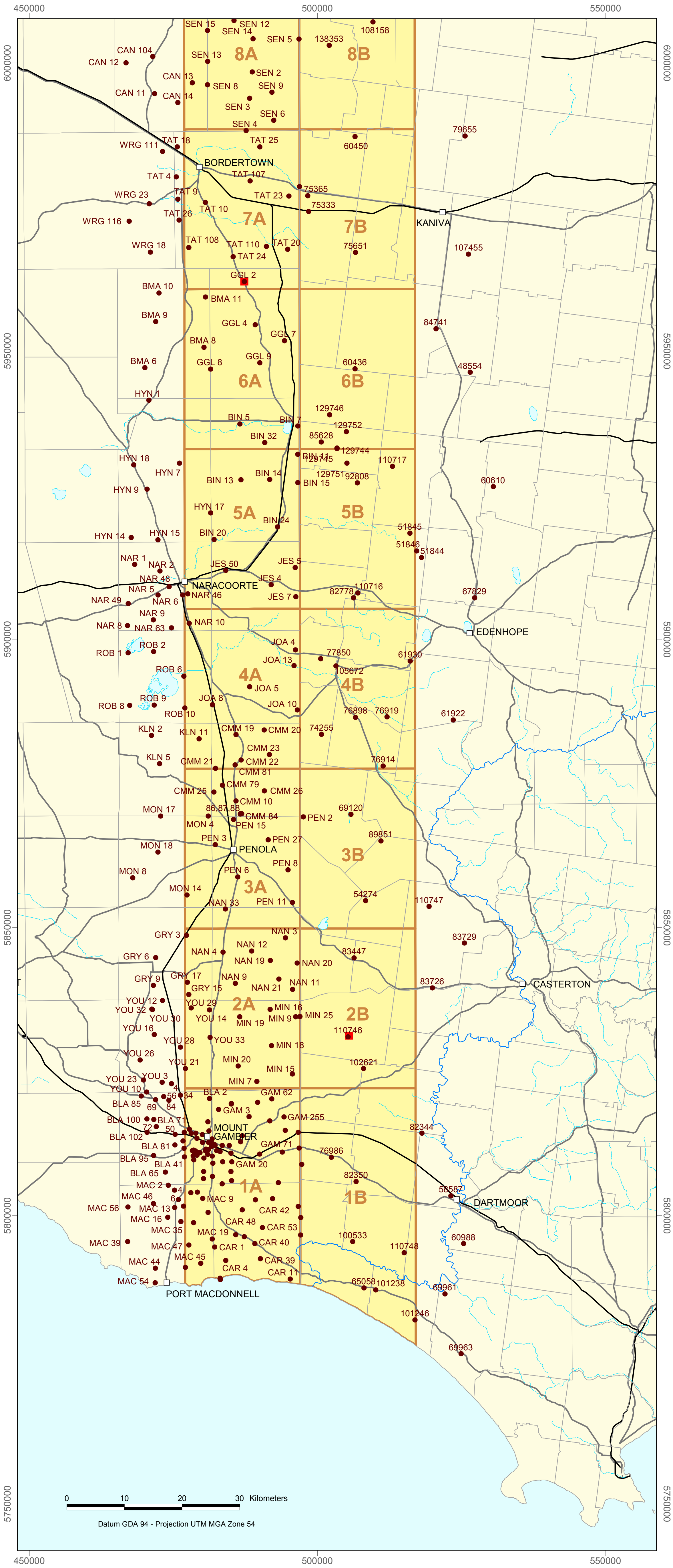
GROUNDWATER (BORDER AGREEMENT) ACT
FIVE YEAR TECHNICAL REPORT 1996-2000

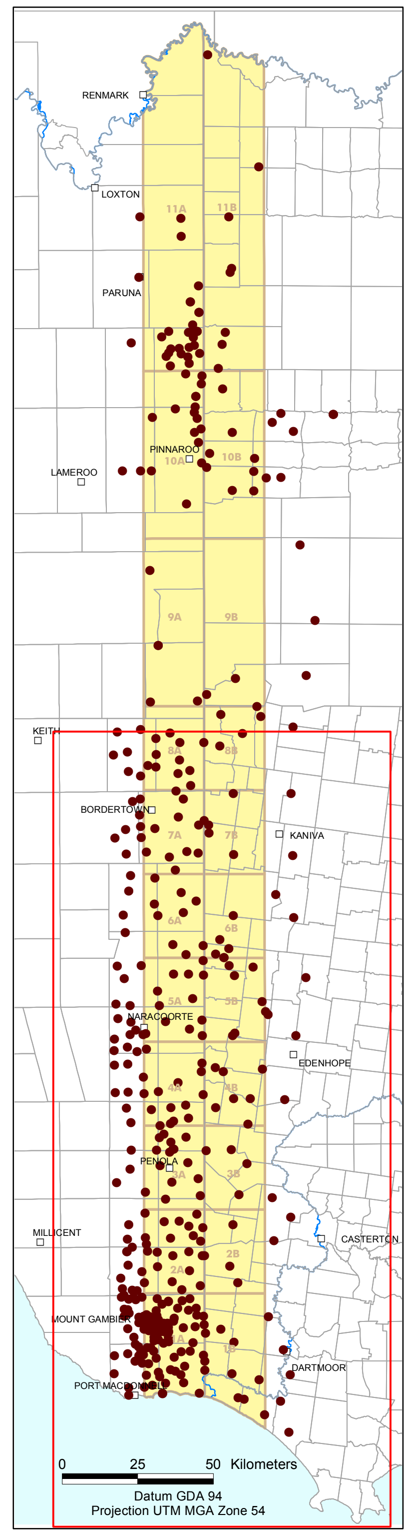
TERTIARY LIMESTONE AQUIFER

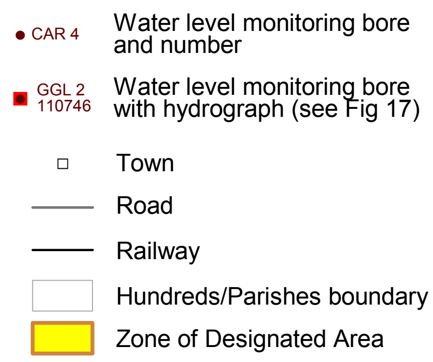
Water Level Monitoring Bores in Northern Part of the Designated Area

AV : 200522_001
PIRSA Publications and Displays

Figure 11a







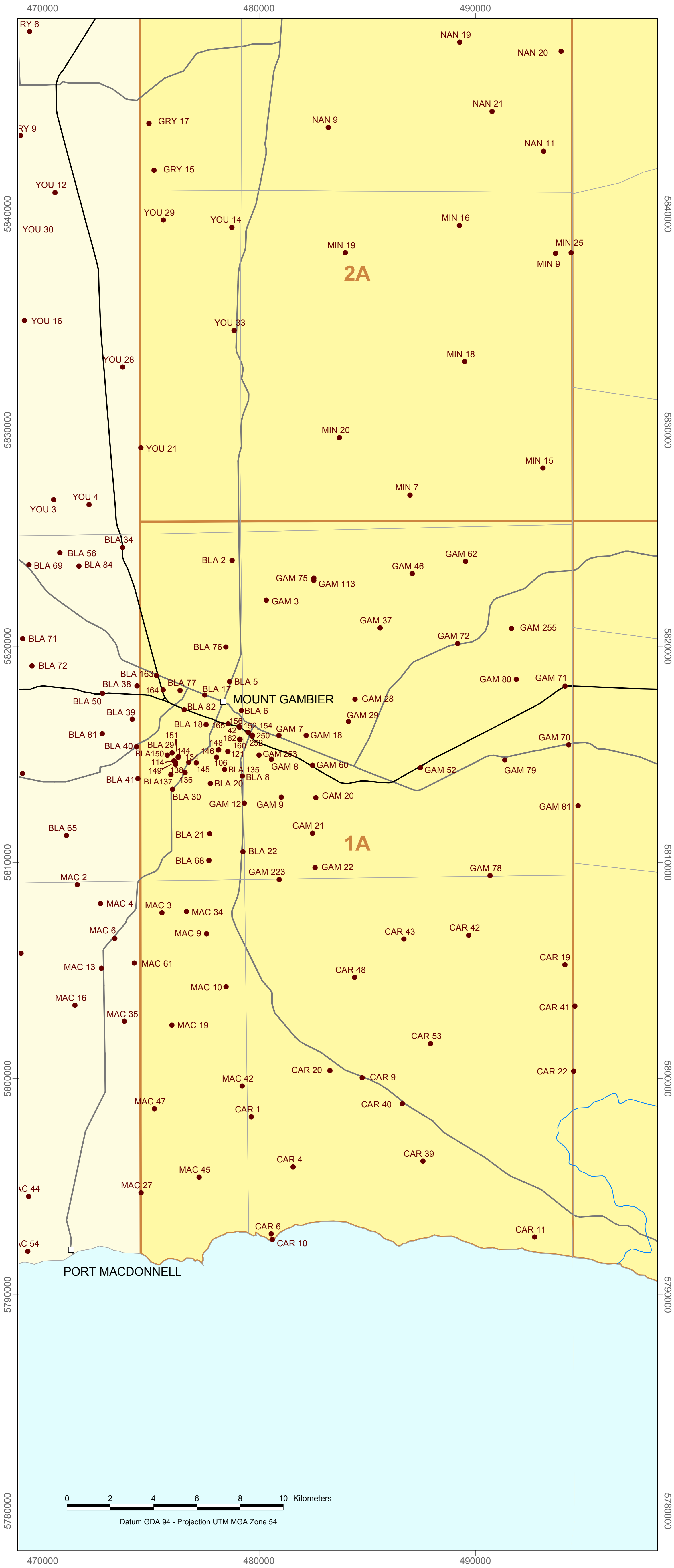
GROUNDWATER (BORDER AGREEMENT) ACT
FIVE YEAR TECHNICAL REPORT 1996-2000

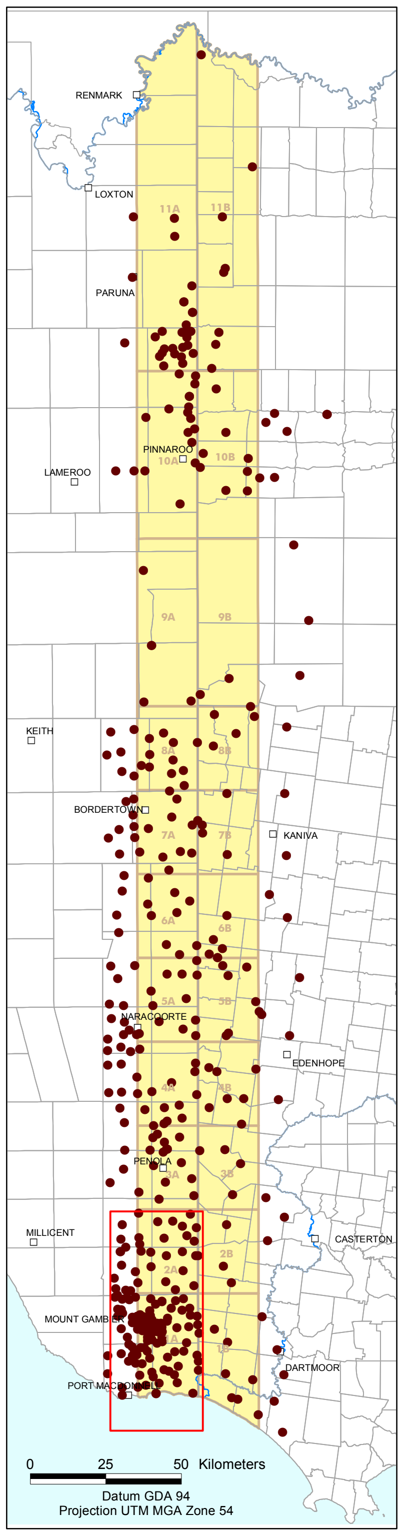
TERTIARY LIMESTONE AQUIFER

Water Level Monitoring Bores in Southern Part of the Designated Area

AV : 200522_002
PIRSA Publications and Displays

Figure 11b





SHG 5 Water level monitoring bore and number

Town

Road

Railway

Hundreds/Parishes boundary

Zone of Designated Area

GROUNDWATER (BORDER AGREEMENT) ACT
FIVE YEAR TECHNICAL REPORT 1996-2000

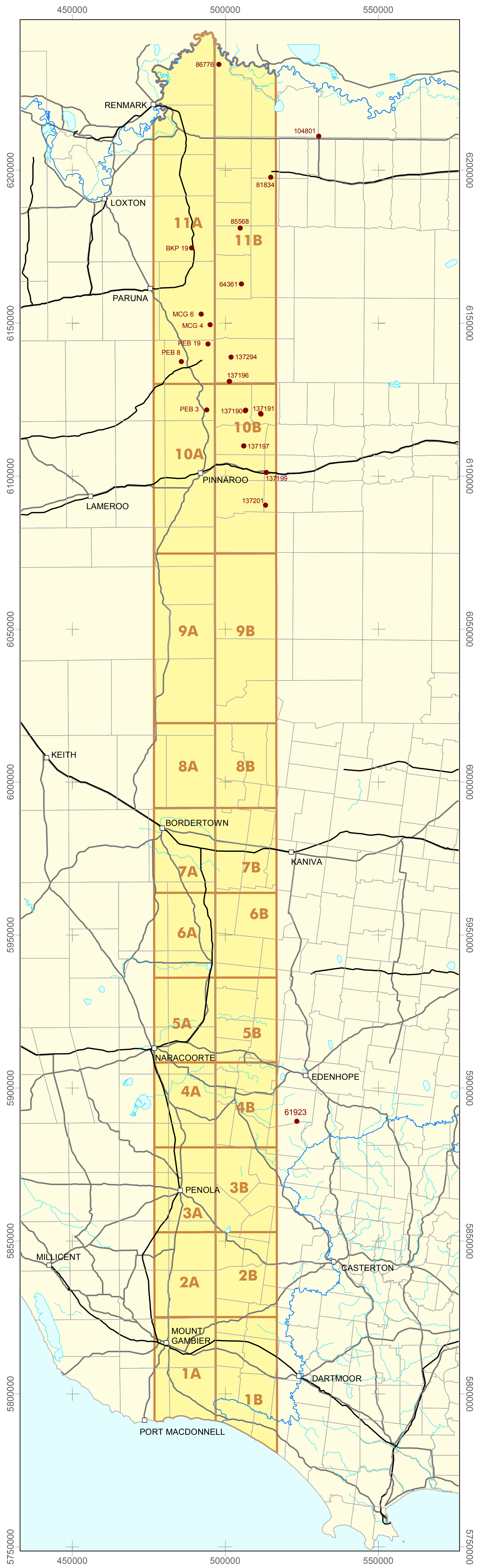
TERTIARY LIMESTONE AQUIFER

Water Level Monitoring Bores in Zone 1A

AV : 200522_003

PIRSA Publications and Displays

Figure 11c



Water level monitoring bore & number

Town

Road

Railway

Hundreds/Parishes boundary

Zone of Designated Area

0 25 50 75 100 Kilometers

Datum GDA94 - Projection UTM MGA Zone 54

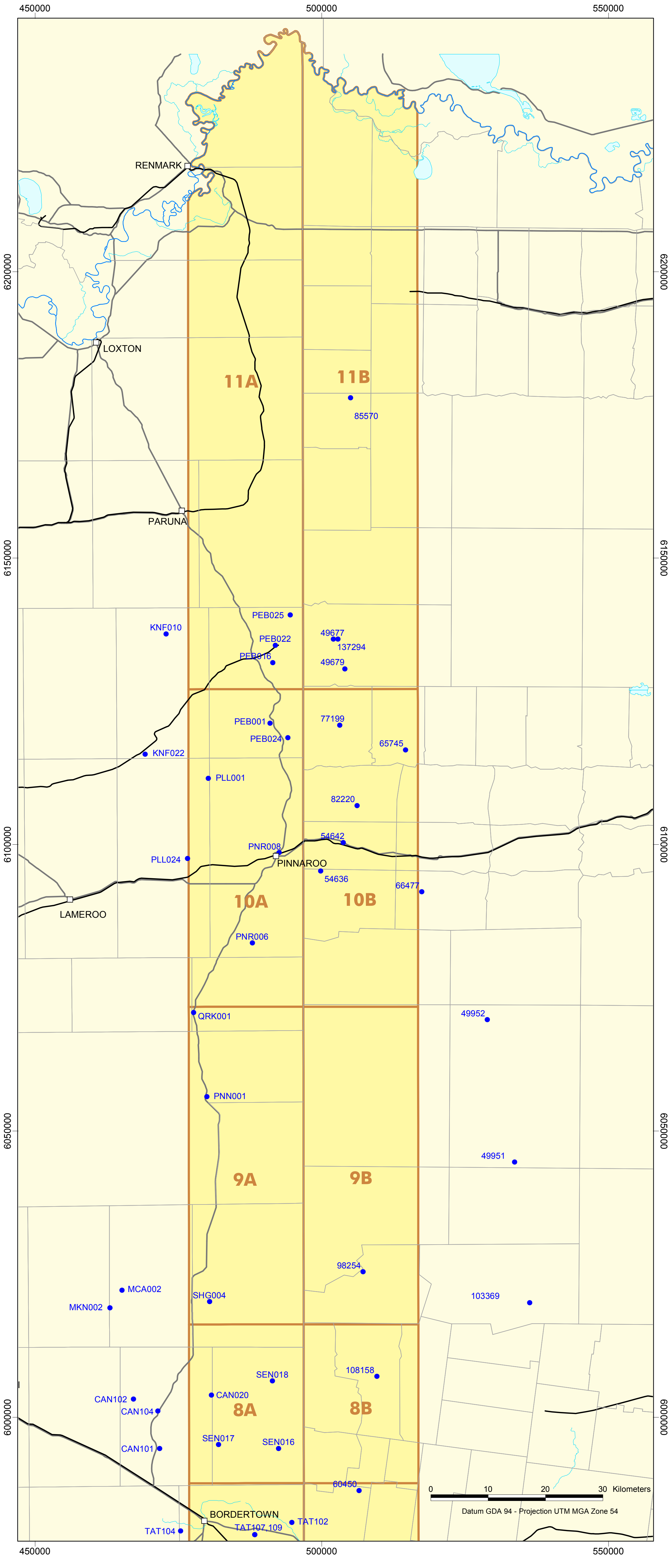
GROUNDWATER (BORDER AGREEMENT) ACT
FIVE YEAR TECHNICAL REPORT 1996-2000

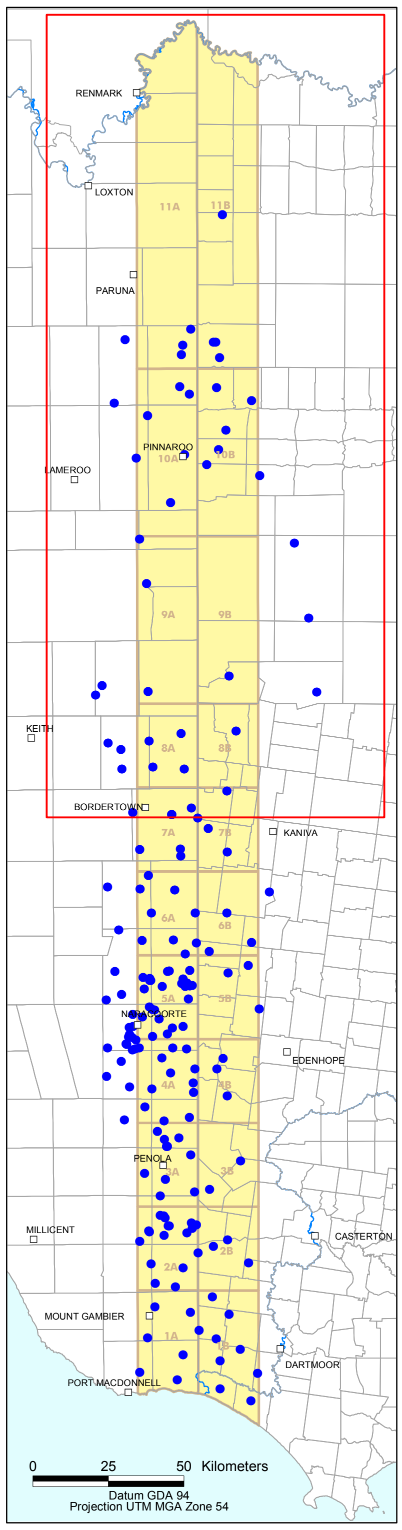
PLIOCENE SAND AQUIFER

Water Level Monitoring Bores

AV : 200522_005
PIRSA Publications and Displays

Figure 12





• 87537 Salinity monitoring bore and number

□ Town

Road

Railway

Hundreds/Parishes boundary

Zone of Designated Area

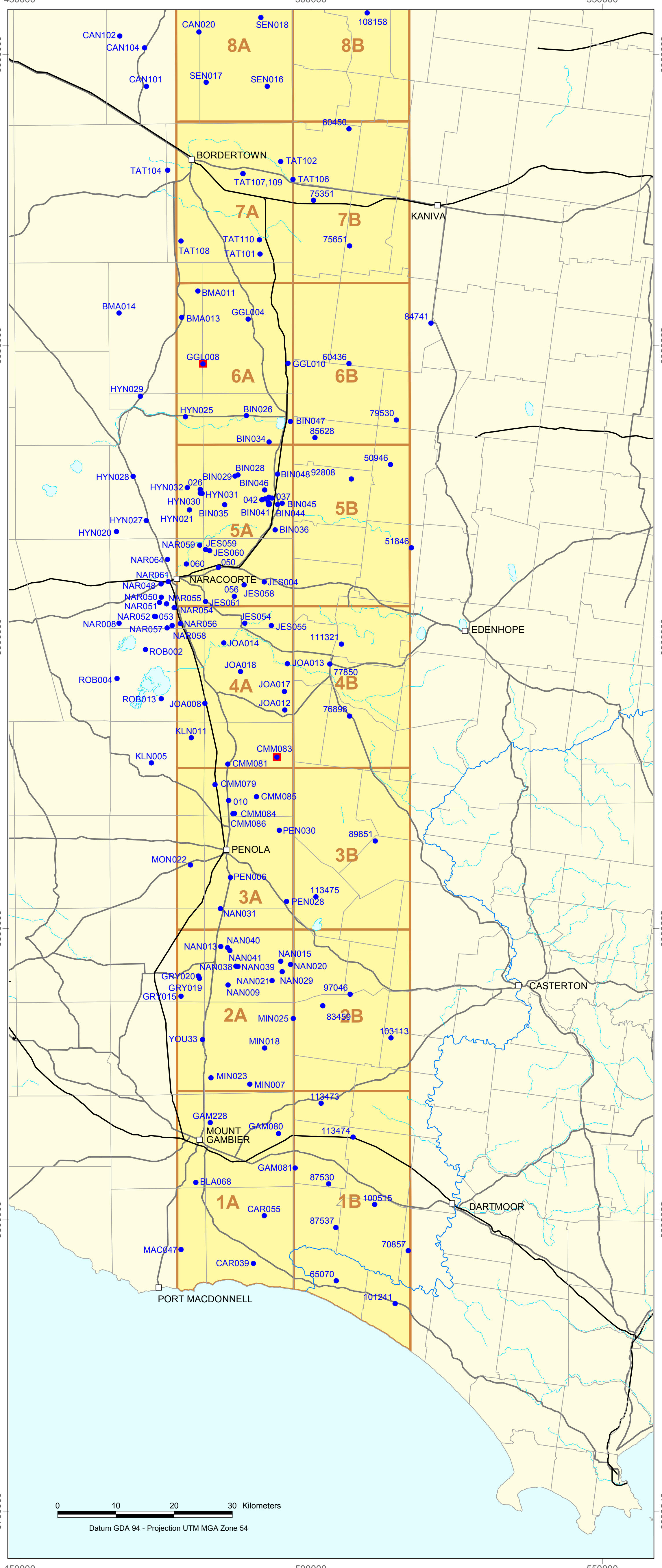
GROUNDWATER (BORDER AGREEMENT) ACT
FIVE YEAR TECHNICAL REPORT 1996-2000

TERTIARY LIMESTONE AQUIFER

Salinity Monitoring Bores in Northern Part of the Designated Area

AV : 200522_006
PIRSA Publications and Displays

Figure 13a



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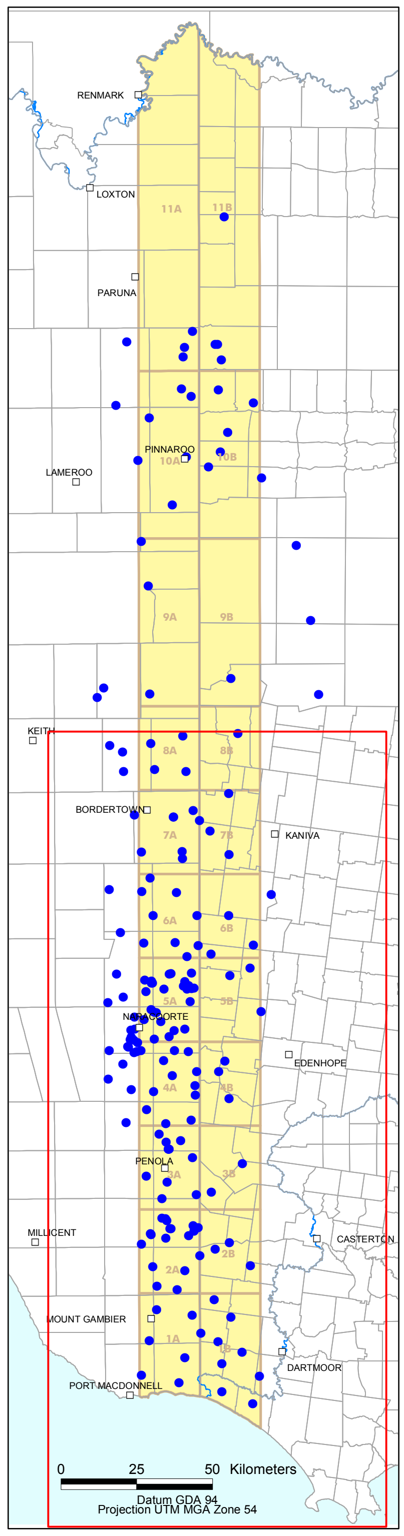


87537	Salinity monitoring bore and number
CMM083 GGL008	Salinity monitoring bore with graph (see Fig 19)
	Town
	Road
	Railway
	Hundreds/Parishes boundary
	Zone of Designated Area

GROUNDWATER (BORDER AGREEMENT) ACT
FIVE YEAR TECHNICAL REPORT 1996-2000

TERTIARY LIMESTONE AQUIFER

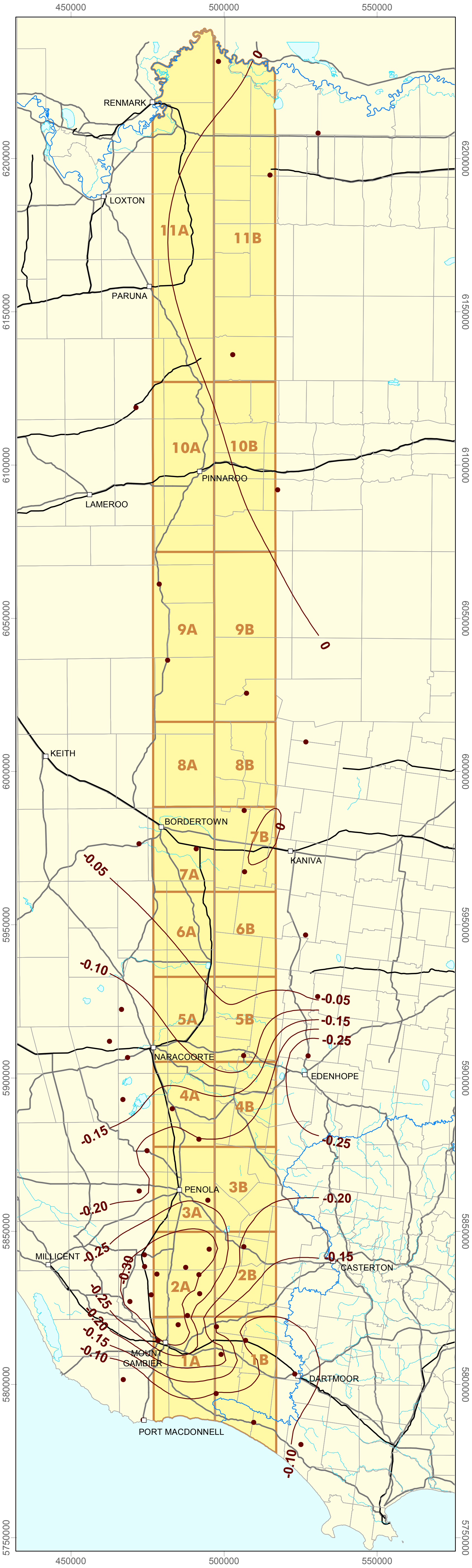
Salinity Monitoring Bores in Southern Part of the Designated Area

AV : 200522_007

PIRSA Publications and Displays

GDA

Figure 13b



Water level monitoring bore

-0.10 Water level trend (m/year)

Town

Road

Railway

Hundreds/Parishes boundary

Zone of Designated Area

0 25 50 75 100 Kilometers

Datum GDA94 - Projection UTM MGA Zone 54

GROUNDWATER (BORDER AGREEMENT) ACT
FIVE YEAR TECHNICAL REPORT 1996-2000

TERTIARY CONFINED SAND AQUIFER

Water Level Trends
June 1995 to June 2000

AV : 200522_012
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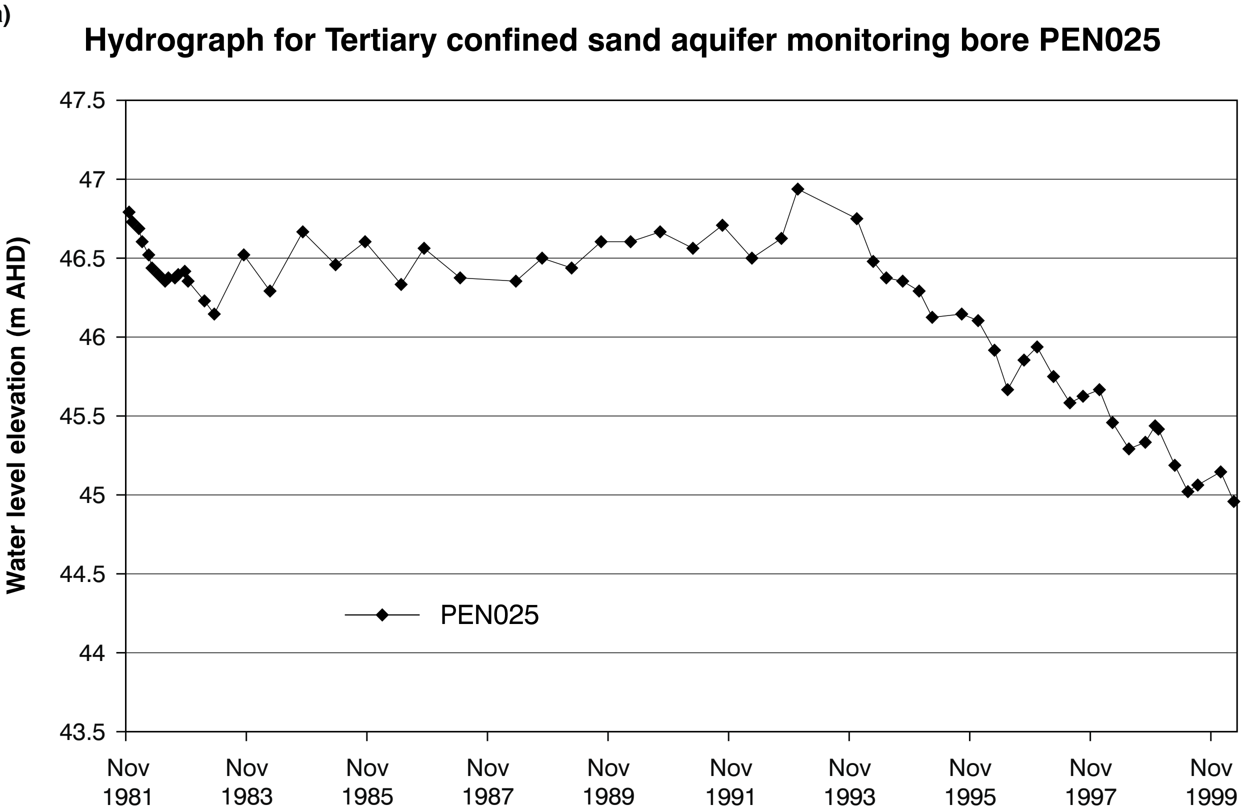
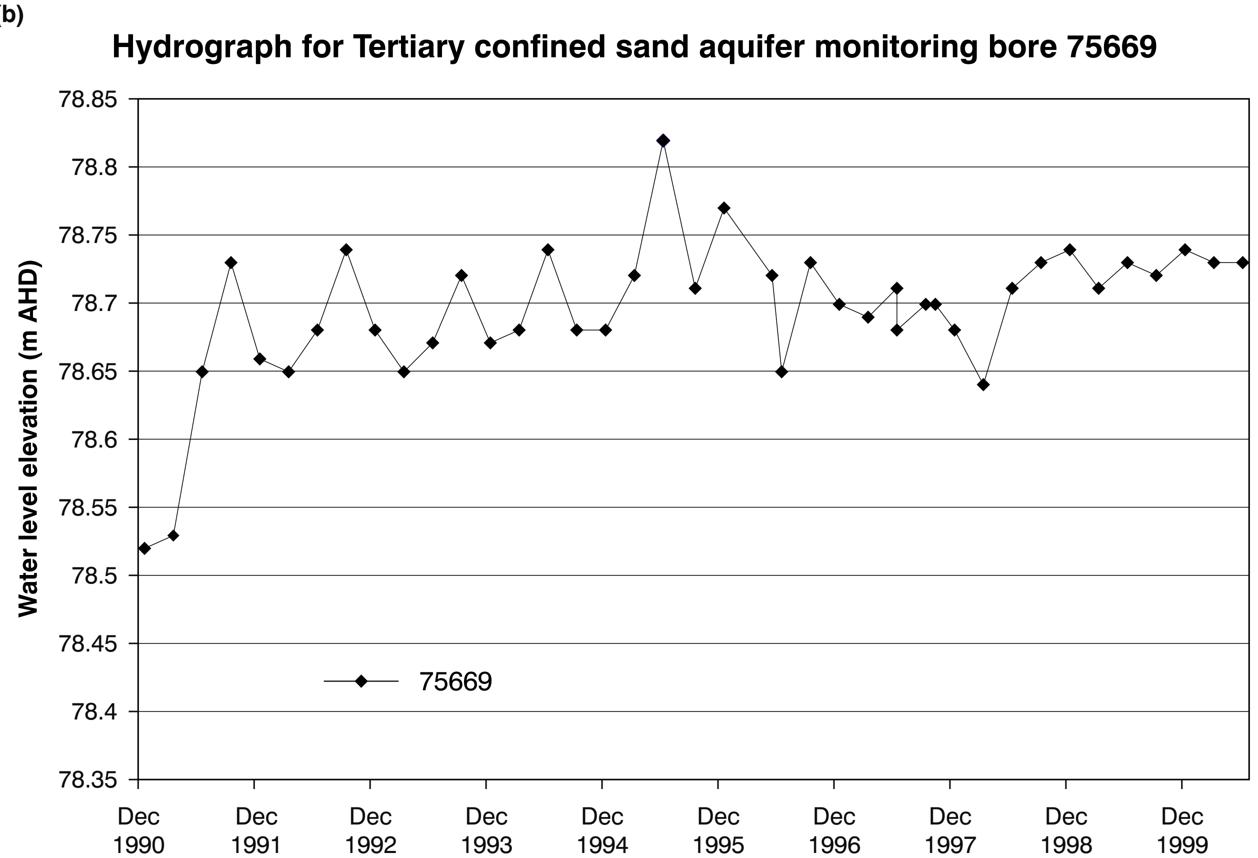
Figure 14

(a)



(b)



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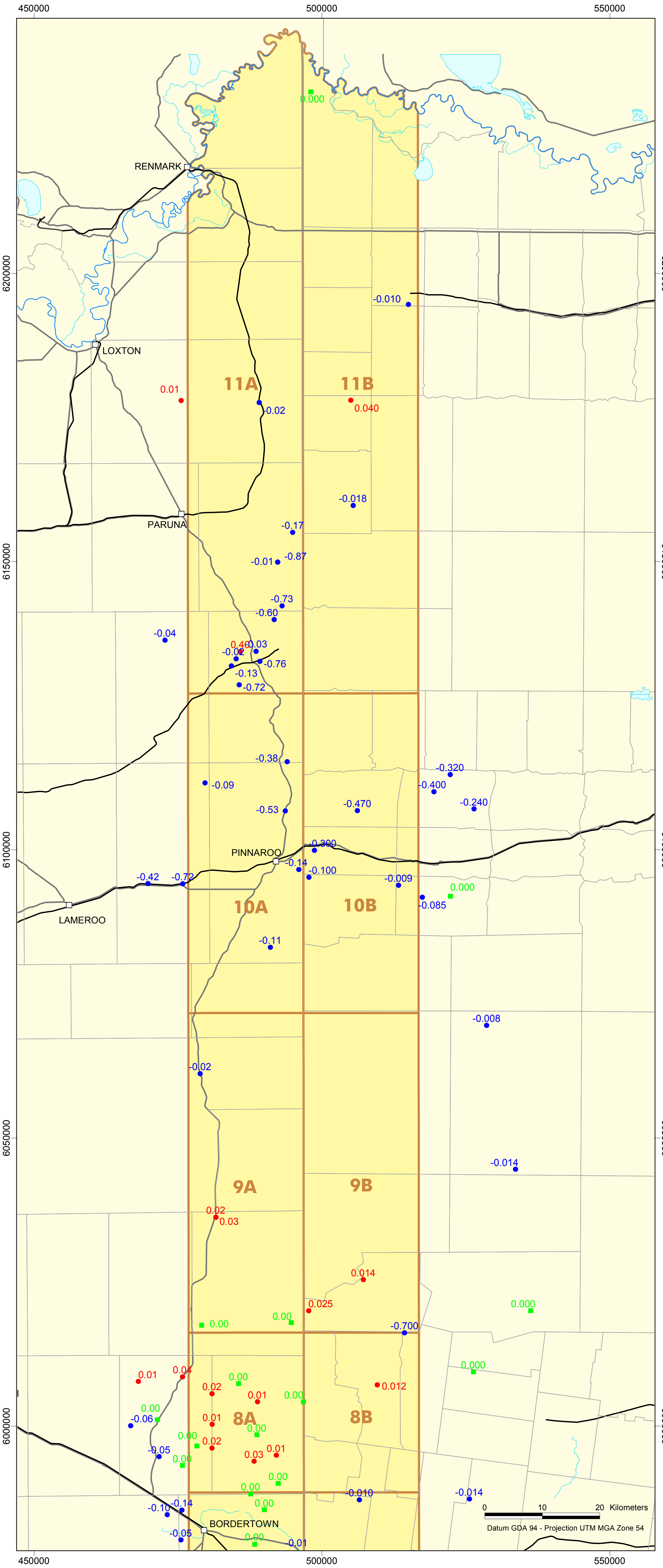
Note: See Figure 10 for bore locations

200522-017

Figure 15 *Hydrographs for Tertiary Confined Sand Aquifer monitoring bores.*



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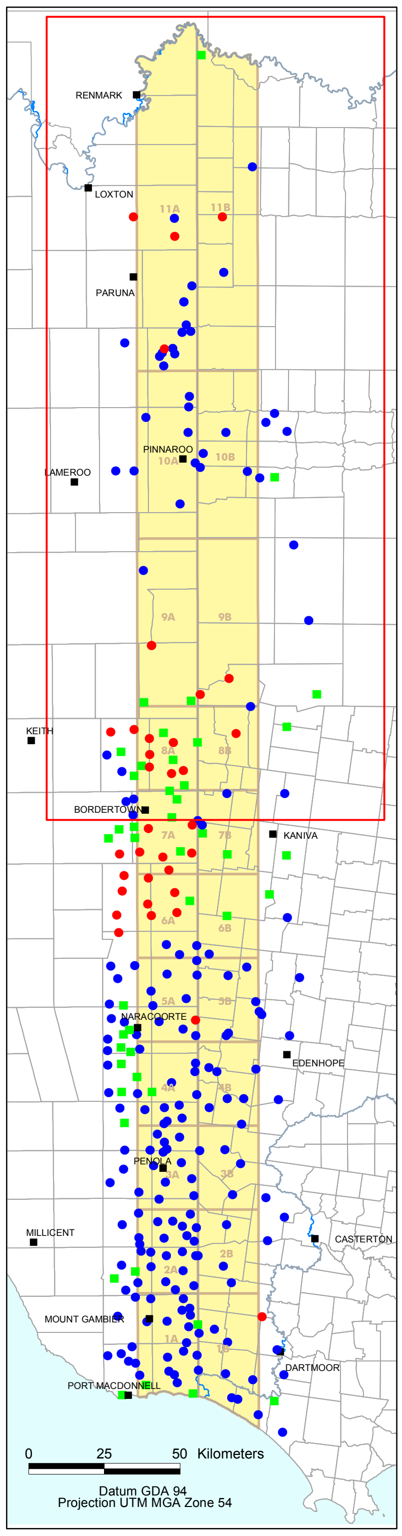

Monitoring bore and water level trend (m/year)

- Rising groundwater level trend
- Static groundwater level trend
- Falling groundwater level trend

- Town
- Road
- Railway
- Hundreds/Parishes boundary
- Zone of Designated Area

GROUNDWATER (BORDER AGREEMENT) ACT
FIVE YEAR TECHNICAL REPORT 1996-2000

TERTIARY LIMESTONE AQUIFER

Water Level Trends
June 1995 to June 2000
in Northern Part of the Designated Area

AV : 200522_009
PIRSA Publictions and Displays

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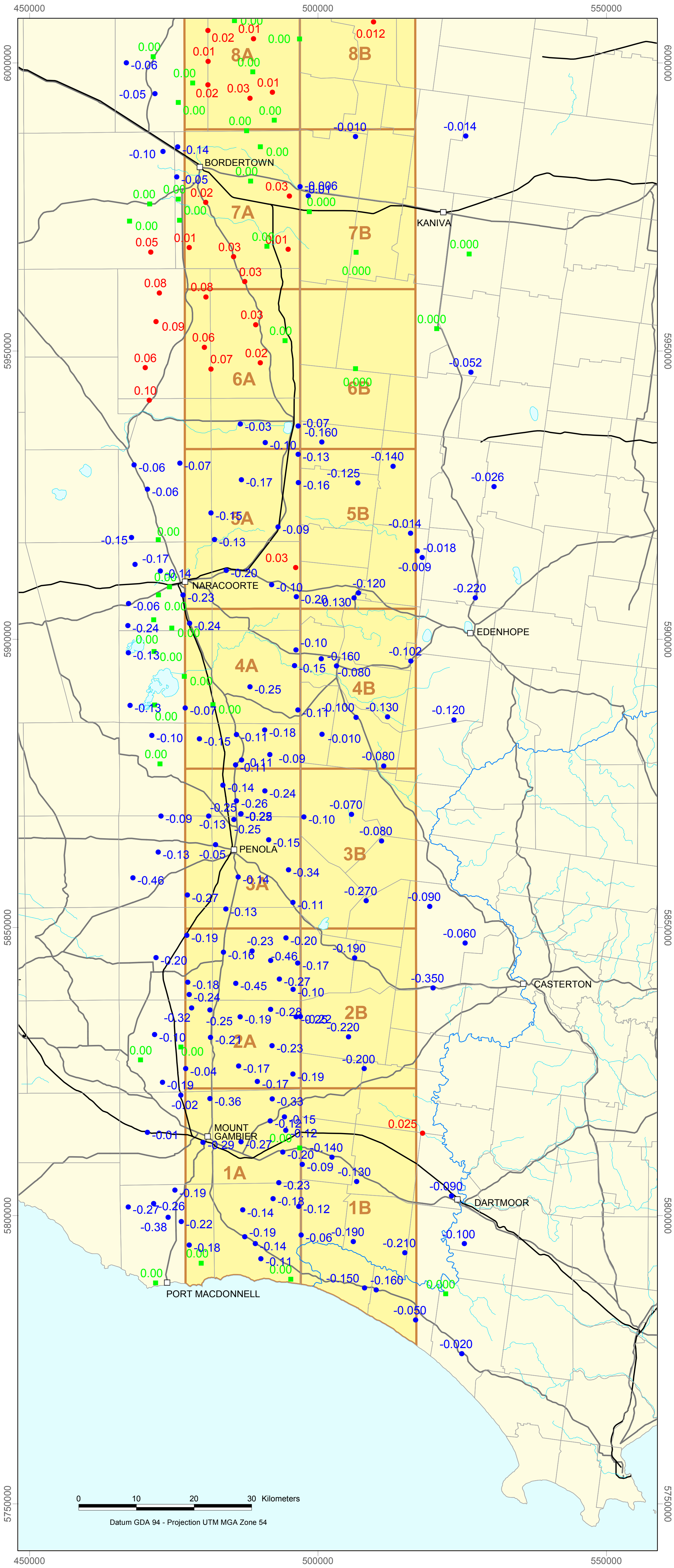
Figure 16a



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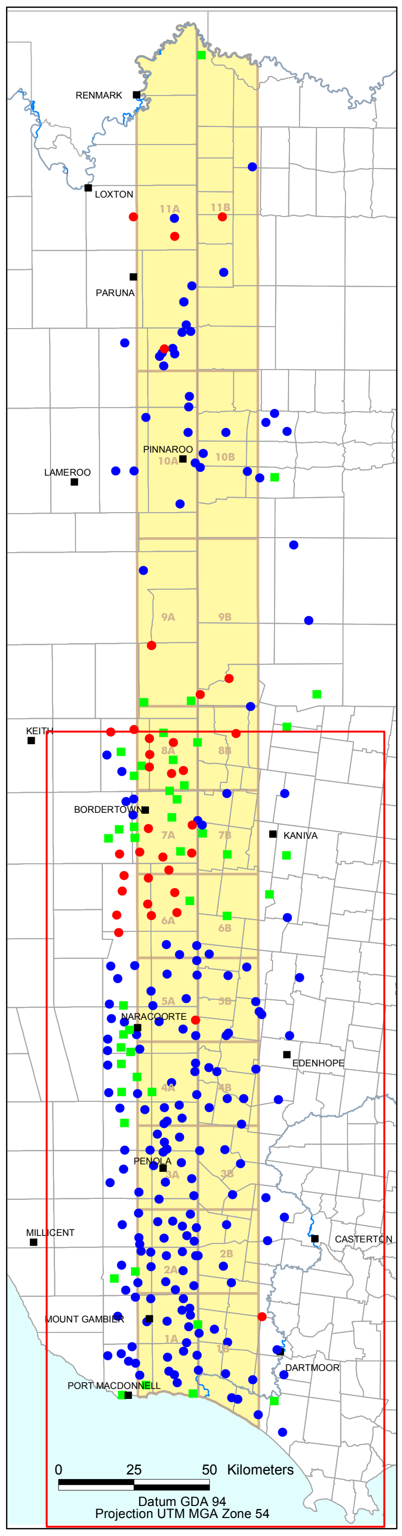

Monitoring bore and water level trend (m/year)

- Rising groundwater level trend
- Static groundwater level trend
- Falling groundwater level trend
- Town
- Road
- Railway
- Hundreds/Parishes boundary
- Zone of Designated Area

GROUNDWATER (BORDER AGREEMENT) ACT
FIVE YEAR TECHNICAL REPORT 1996-2000

TERTIARY LIMESTONE AQUIFER

Water Level Trends
June 1995 to June 2000
in Southern Part of the Designated Area

AV : 200522_010
PIRSA Publications and Displays

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Figure 16b

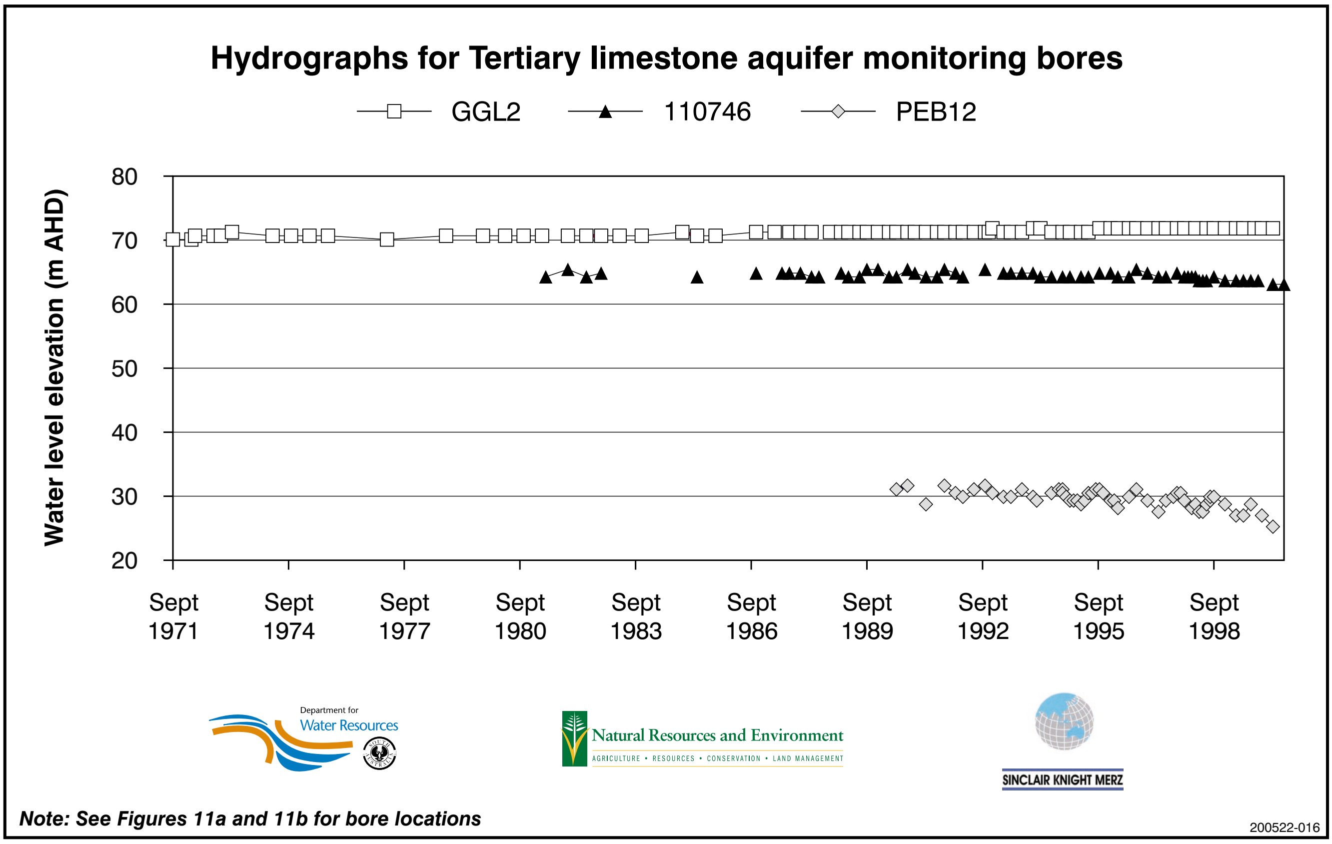
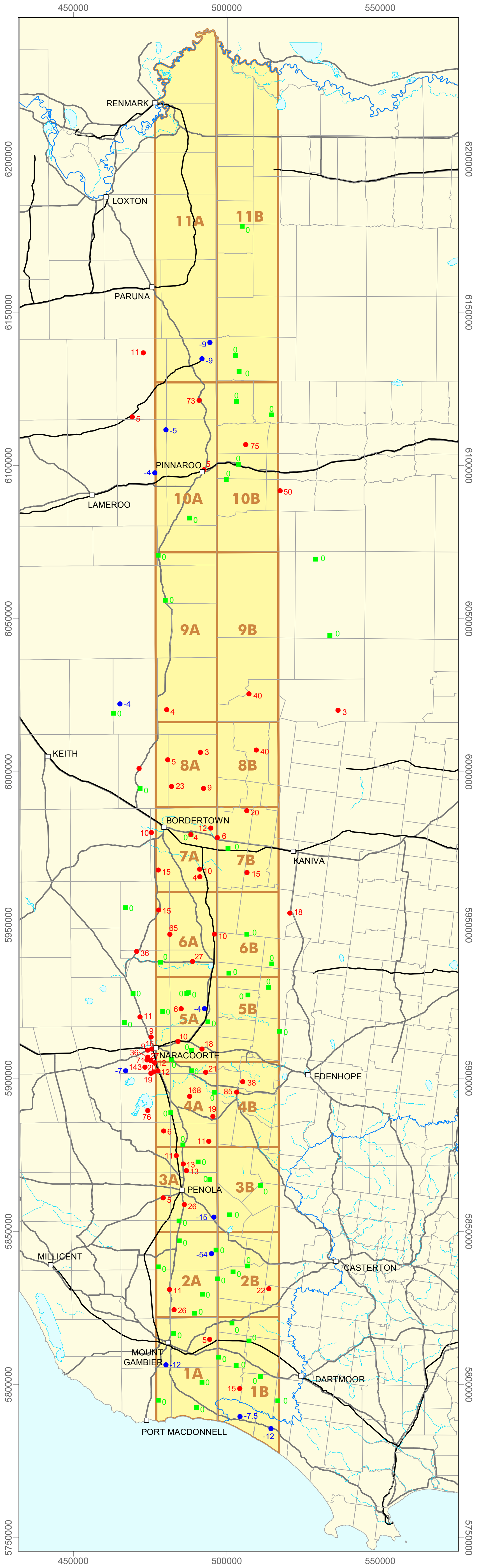


Figure 17 *Hydrographs for Tertiary Limestone Aquifer monitoring bores.*



Salinity trends (Electrical Conductivity Units/year)

- Less than 0
- 0
- Greater than 0

- Town
- Road
- Railway
- Hundreds/Parishes boundary
- Zone of Designated Area

0 25 50 75 100 Kilometers

Datum GDA94 - Projection UTM MGA Zone 54

GROUNDWATER (BORDER AGREEMENT) ACT
FIVE YEAR TECHNICAL REPORT 1996-2000

TERTIARY LIMESTONE AQUIFER

Salinity Trends
June 2000

AV : 200522_014
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Figure 18

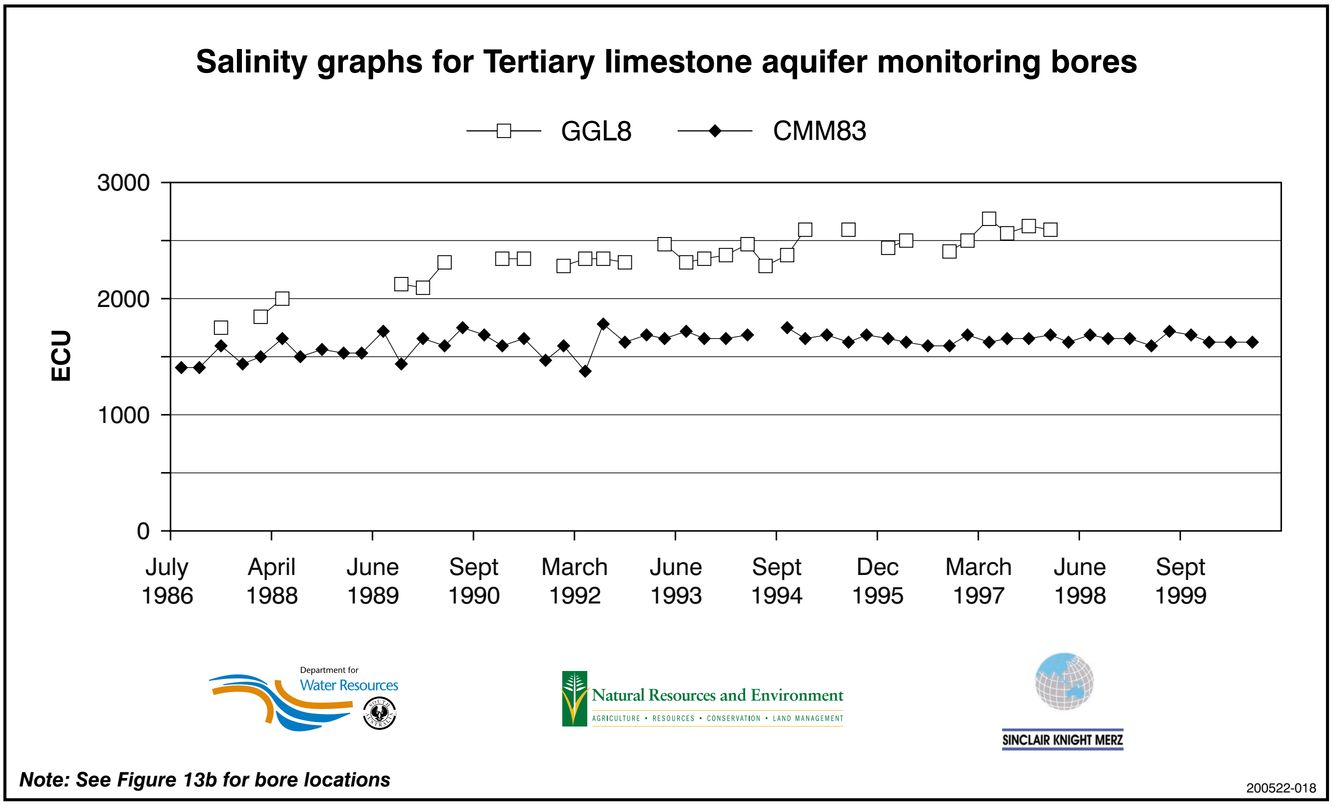
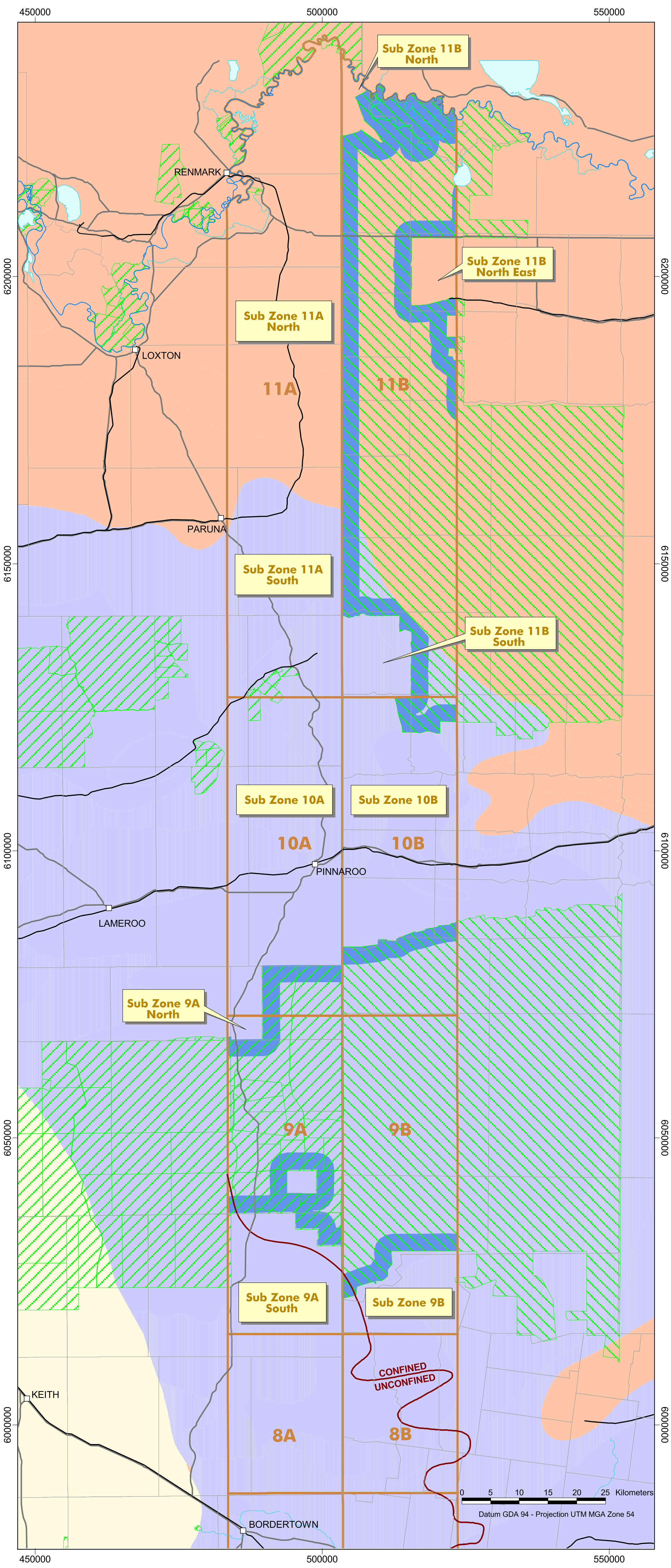
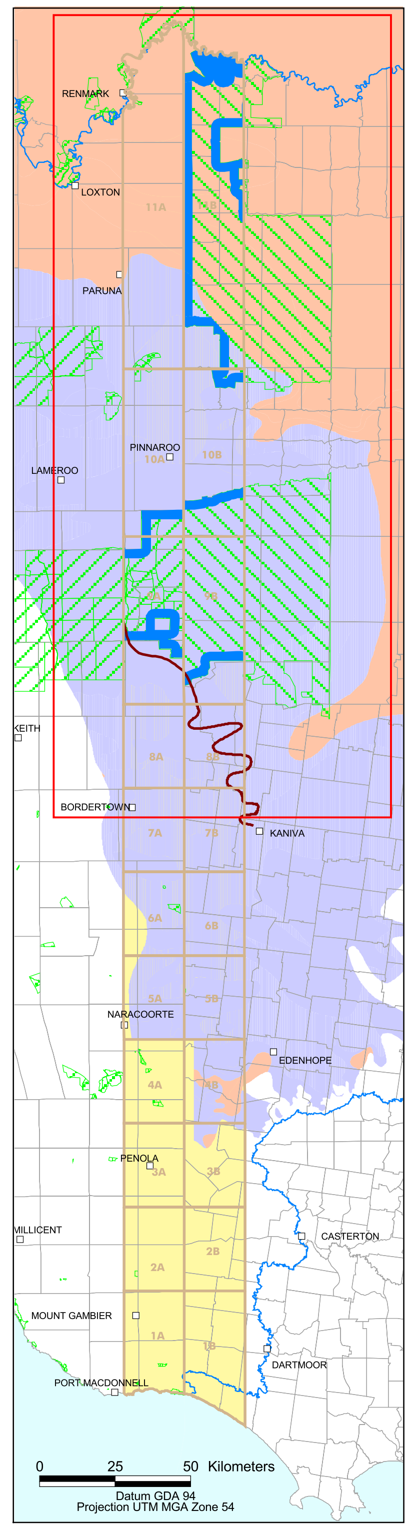


***Figure 19** Salinity graphs for Tertiary Limestone Aquifer monitoring bores.*





Limestone salinity (TDS/mg/L)

- Less than 3000
- Greater than 3000
- Three kilometre buffer area in vegetated areas
- South Australian National Parks
- Victorian Crown Land
- Confined/Unconfined boundary
- Town
- Road
- Railway
- Hundreds/Parishes boundary
- Zone of Designated Area

GROUNDWATER (BORDER AGREEMENT) ACT
FIVE YEAR TECHNICAL REPORT 1996-2000

Sub-Zones for the Confined Tertiary Limestone Aquifer

AV : 200522_025
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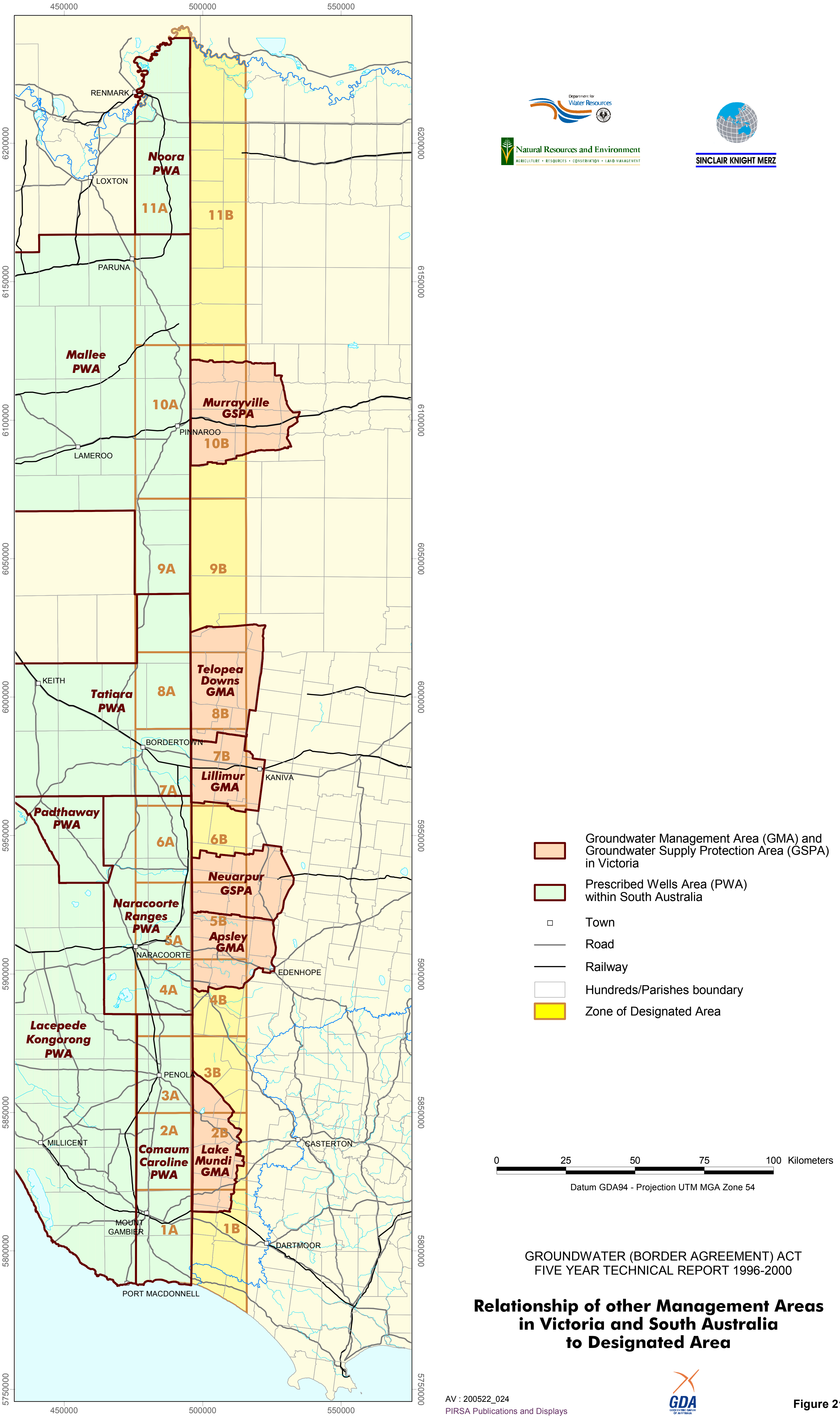
Figure 20



GROUNDWATER (BORDER AGREEMENT) ACT
FIVE YEAR TECHNICAL REPORT 1996-2000

Relationship of other Management Areas in Victoria and South Australia to Designated Area

AV : 200522_024

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Figure 21