Water Resource Assessment: Comaum–Caroline Prescribed Wells Area
for the
South East Catchment Water Management Board

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by

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WATER RESOURCE ASSESSMENT COMAUM–CAROLINE PRESCRIBED WELLS AREA FOR THE SOUTH EAST CATCHMENT WATER MANAGEMENT BOARD

By Michael Cobb and Keith Brown

EXECUTIVE SUMMARY

In the development of a Water Allocation Plan for the Comaum–Caroline PWA, the South East Catchment Water Management Board (SECWMB) appointed groundwater consultants Water Search Pty Ltd. and the Department for Water Resources (DWR) to assess the water resources of the area. The study was funded jointly by the SECWMB and the DWR. This study provides an overview of the current status of the water resources in the Comaum–Caroline PWA and where applicable makes recommendations for its future management.

The Comaum–Caroline PWA is located approximately 400 kilometres southeast of Adelaide and covers an area of ~1900 km^2. The PWA generally consists of a low-lying coastal plain which rises gently from the coast in the south to ~70 m above sea level in the far north of the area. In the far north-eastern portion of the PWA the Kanawinka Fault separates the coastal plain from the elevated Naracoorte Ranges.

Unconfined and confined aquifers are both present in the Comaum–Caroline PWA. The main water resource is the unconfined aquifer which predominantly consists of the Gambier Limestone Formation. The salinity of the aquifer ranges between 300 and 1000 mg/L.

The Comaum–Caroline PWA was proclaimed in 1986 following the passing of the *Groundwater Border Agreement Act (Governments of South Australia and Victoria) 1985*. There were originally five water management Sub-areas; Zone 1A, 2A, 3A and Glenroy and Comaum (both part Zone 4A) of the Designated Border Area. Zone 1A has recently been subdivided into Myora, Glenburnie and Donovans to help manage the decline in water level in the middle of the Zone.

The total water allocation for the Comaum–Caroline PWA for the 1998/99 year was 78 093 ML with an estimated water usage of 37 316 ML. Water usage is therefore about half the total allocation. The accuracy of this figure is debatable as water use is estimated from crop figures supplied by the irrigator and on the crop water use ratio system. Stock water use is considered to be only a minor contributor to the overall water budget (ie 1960 ML).

There are currently 104 unconfined aquifer wells measured quarterly in the water level monitoring network and 49 wells in the unconfined aquifer salinity monitoring network. There are ten confined aquifer water level and salinity monitoring wells. The networks have recently been increased and should meet the monitoring requirements for the PWA.

In the Comaum–Caroline PWA, the impact that taking or use of water from one resource may have on the quantity and quality of water of another resource was considered in the following situations:

- the impact of using surface water to artificially replenish the groundwater system.
- the impact taking of groundwater from the unconfined aquifer may have on the confined aquifer.
- the impact taking of groundwater from the confined aquifer may have on the unconfined aquifer.

In the first scenario there is the potential for groundwater contamination to occur to the unconfined aquifer as a result of applying animal bi-products, agricultural chemicals and fertilisers in the southern portion of the PWA.

The second scenario was considered unlikely to occur in the Comaum-Caroline PWA, however in heavily forested areas, the rainfall recharge potential to the unconfined aquifer is low. Whilst forestry in the strict sense is not defined as a water use such land use does have an impact on the available water resource. This may ultimately impact on recharge to the confined aquifer.

The third scenario is considered to be of limited relevance in the Comaum–Caroline PWA.

INTRODUCTION

BACKGROUND

There are five water management zones, covering an area of almost 20 000 km^2, in the South East region of South Australia (Fig. 1). The South East Catchment Water Management Board (SECWMB) is in the process of preparing Water Allocation Plans for each of these five Prescribed Wells Areas (PWAs).

Under the *Water Resources Act (1997)* there is a requirement that in the preparation of each Water Allocation Plan, consideration must be given to Sections 101 (4) (b) and 101 (4) (e) of the Act. That is the Plan must:

- "*include an assessment as to whether the taking or use of water from the resource will have a detrimental effect on the quantity or quality of water that is available from any other resource*": and

- "*assess the capacity of the resource to meet the demands for water on a continuing basis and provide regular monitoring of the capacity of the resource to meet those demands*. "

In order to fulfil this requirement, the Department for Water Resources South Australia (DWR), and groundwater consultants Water Search Pty. Ltd. have been jointly appointed by the SECWMB to assess the water resources of each PWA in the context of the above sections of the Act. Funding of the project was undertaken jointly by the SECWMB and DWR.

NATURE AND SCOPE OF WORK

This report provides an overview of the water resources for the Comaum–Caroline PWA and applies specifically to the principal term of reference namely addressing Sections 101 (4) (b) and 101 (4) (e) of the Act.

To meet this commitment each PWA assessment includes:

- a general description of the groundwater resources for each of the aquifers in the PWA

- for both the unconfined and confined aquifers:

    - the management approach adopted for the sustainable use of the resource (generally referred to as Permissible Annual Volume) and a description of the manner in which the sustainable limits of use can be determined. Where separate management areas exist within the PWA, the adopted limits of sustainable groundwater use need to be tabulated. The assessment should identify any data deficiencies and requirements for future investigations.

    - the historical demand (in terms of use) and current demand (in terms of the level of allocations and use) in each of the management areas within the PWA, by major categories (irrigation, industrial, municipal, stock and domestic supplies).

    - the likely future demand for groundwater from this resource in the PWA, where possible differentiating between major use categories (irrigation, industrial, municipal, stock and domestic supplies).

    - an assessment of whether the taking or use from either aquifer will have a detrimental effect on the quantity or quality of water that is available from any other water resource, both within and outside of the PWA, including a description of the likely nature and extent of any detrimental effects.

    - an assessment of the current condition of the groundwater resources of both aquifers, taking into consideration available groundwater monitoring data to determine the capacity of both aquifers to meet the demands identified, on a continuing basis.

This is to include recommendations for management intervention in areas where it is considered that the resource may not have the capacity to meet future demands.

- an assessment of the adequacy of the current groundwater monitoring network undertaken in the PWA for monitoring the capacity of the resource to meet demands, including recommendations for any additional monitoring requirements.

The project brief does not include an environmental assessment of groundwater dependent ecosystems as this is being undertaken by a separate consultancy.

STUDY AREA

Regional Hydrogeology

Geologically the South East region lies mostly within the Gambier Embayment of the Otway Basin. With the exception of the Glenelg River, which lies predominantly over the State border in Victoria, there are no extensive supplies of good quality surface water flows in the South East. Groundwater, therefore, provides the main water resource for the region. While primarily used for irrigation, the groundwater is also used for industrial, recreational and stock use, and for supplying municipal water to a number of towns located in the area.

The South East region is characterised by several extensive low-lying flats interspersed with a series of north-west trending remnant sand dune ridges. Beyond the Kanawinka Fault (east of Naracoorte) the topography rises into higher inland plains that extend into western Victoria (maximum elevation of ~300 metres).

The groundwater flows through two major aquifer systems: a regionally unconfined limestone aquifer and an underlying confined quartz sand aquifer. The two aquifers are separated by a low permeability aquitard usually made up of dark brown carbonaceous clay. The aquifers are hydraulically connected, but the degree of inter-connectivity between them is poorly understood and is currently an area of active research.

The upper, unconfined aquifer is the most extensively used of the two aquifers. However the recent introduction of water management policies which effectively caps its use, coupled with poor groundwater quality in the aquifer in some areas, has resulted in increased interest in the confined aquifer as a water resource.

The regionally extensive unconfined aquifer consists mainly of calcareous sandstone and limestone deposited from the latter part of the Tertiary Period through to the Quaternary (~30 million years ago to present). It incorporates the Gambier Limestone, Coomandook, Bridgewater, and Padthaway Formations (Fig. 2).

Recharge to the confined aquifer relies on downward leakage from the overlying unconfined aquifer. This occurs in the eastern margin of the region where the water table in the unconfined aquifer is higher than the potentiometric head in the confined aquifer. To the west and south of the region the head distribution is reversed and there is the potential for upward leakage from the confined aquifer to the unconfined aquifer.

The confined aquifer consists of non-calcareous quartz sands, interbedded with dark brown carbonaceous clays. Together these units make up the Dilwyn Formation. Deposition occurred during the early part of the Tertiary Period (~50 million years ago).

The confined aquifer, for management purposes, is treated regionally as one aquifer, but it is in actuality a complex multi-aquifer groundwater system. Lack of data means there is little real understanding on the hydraulic interconnection between these sub-aquifers. The confined aquifer is very thin or absent over much of the northern margin of the South East region.

Groundwater flow, for both the unconfined and confined aquifer systems, originates from the topographic high of the Dundas Plateau located in western Victoria. From there, the groundwater flows radially westward and southward to the coast, and northwards to the Murray River. The rate the groundwater moves through each aquifer depends on their respective hydrogeological properties. Higher rates of groundwater flow are most evident in the upper unconfined aquifer where a secondary porosity has developed.

There are a number of major faults in the area. The two most prominent are the NW trending Kanawinka Fault and the W-NW trending Tartwaup Fault (Fig. 1). The Kanawinka Fault has a pronounced lineament and is downthrown to the south-west. The west-northwesterly trending Tartwaup Fault is expressed as a monoclinal structure. Downthrow is generally in a southerly direction. The potentiometric surface of both aquifers indicates a significant steepening of slope immediately up-gradient of each fault. While the effect faulting has had on groundwater flow can be inferred from the head gradients in both aquifers, the mechanisms responsible for this are poorly understood.

The salinity of the groundwater of the unconfined aquifer ranges from ~500 mg/L in the south, to more than 7000 mg/L in the north. Groundwater salinity in the confined aquifer system is typically less than 500 mg/L in the south, around Mount Gambier, but increases gradually northwards to over 10 000 mg/L as the aquifer thins north of Kingston.

The climate of the South East region is typified by hot, dry summers and cool wet winters. Annual rainfall ranges from more than 800 mm in the south to about 450 mm in the north. Potential evapotranspiration increases from about 1400 mm in the south to about 1800 mm in the north. Precipitation exceeds potential evapotranspiration usually from May to September. Recharge to the upper unconfined aquifer generally occurs during this period.

Groundwater Management Areas

The South East Catchment Water Management Board was established under the *Water Resources Act 1997*. The Board is responsible for the management of the water resources in the South East region. It is under the Act that the water resources of South Australia are prescribed. In total there are five Prescribed Wells Areas in the South East region. They include the established PWAs of Padthaway, Tatiara, Comaum-Caroline, and Naracoorte Ranges (these were proclaimed/prescribed under previous Water Resources Acts) and the recently prescribed Lacepede-Kongorong PWA. To allow for more effective management of each PWA, the PWAs have been subdivided into zones, and sometimes sub-zones.

The other piece of water resource legislation that is important to the region is the *Groundwater Border Agreement Act (Governments of South Australia and Victoria) 1985*. The Act covers the water resources of the 40 kilometre wide strip that is centred on the South Australian and Victorian border. The South Australian/Victorian Border Review Committee comprising representatives from both States is responsible for administering the water resources along the Border Zone.

Formal boundaries have yet to be established for the confined aquifer in the South East region. For this report the confined aquifer boundaries were assumed to be those proposed by the Border Technical Review Committee (Fig. 3).

GROUNDWATER ALLOCATION METHOD (LICENSING SYSTEM)

For the purposes of managing the unconfined aquifer, groundwater is allocated on the basis of the estimated average yearly vertical recharge to the water table. The underlying principle behind this approach is that lateral throughflow is maintained in the aquifer, thereby allowing any salts accumulated during recharge to be flushed down-gradient. Average rainfall, soil type (and its properties), land use (and vegetation cover) and water level changes (both seasonal and long-term) are taken into consideration in the vertical recharge calculation.

The sustainability of the resource is therefore defined as total vertical recharge to each PWA (ie, the Permissible Annual Volume (PAV)). Theoretically, licences would then be issued to take water up to the limit of the PAV. Allocation of a water licence is based on area and the irrigated crop water requirement relative to a reference crop (Crop Area Ratio system). The area based system does not take into account irrigation inefficiencies. It assumes any excess water pumped from the aquifer, and not used by the crop or lost to evaporation, percolates back down into the unconfined aquifer.

The current irrigation equivalents and crop area ratios (Desmier, 1990) were adopted in 1990 and are shown in Appendix A.

The same water allocation system is used for the confined aquifer. However the excess irrigation water does not return to the confined aquifer but to the unconfined aquifer. Therefore this method considerably under estimates water use from the aquifer.

As stated in the previous section, boundaries for the confined aquifer have yet to be formalised for the South East region. The areas adopted for this report are those recommended by the Technical Review Committee of the SA/Victoria Border Zone. PAVs have been calculated for each zone using a numerical flow model, Brown (2000) and are based on proportional throughflow as estimated by SKM (1998).

HYDROGEOLOGY OF THE COMAUM–CAROLINE PWA

GEOGRAPHICAL SETTING

The Comaum–Caroline PWA covers an area of approximately 1900 km^2 and includes the Hundreds of Comaum, Penola, Nangwarry, Mingbool, Gambier and Caroline and the eastern portion of the Hundreds of Killanoola, Monbulla, Grey, Young, Blanche and MacDonnell (Fig. 1). The PWA includes the Zones 1A, 2A, 3A and the southern part of Zone 4A of the Designated Border Area. The major population centre in the South East region is the city of Mount Gambier (population ~23 000). It is located in the southern portion of the Comaum–Caroline PWA.

GEOMORPHOLOGY

The Comaum–Caroline PWA generally consists of a low-lying coastal plain that gently rises from the coast in the south to ~70 m above sea level in the north of the area. In the north-eastern portion of the PWA the Kanawinka Fault separates the coastal plain from the elevated Naracoorte Ranges which rise 30 to 40 m above the elevation of the plain.

To the south east of Mount Gambier city is the topographic high of the Blue Lake and further south is Mount Schank which together are the two most prominent examples of the Mount Gambier Volcanic Complex in the area.

Land use in the Comaum–Caroline PWA is mainly open pastures and forestry plantations (softwood and blue gum). Irrigated crop types have generally remained unchanged since the mid-1980s (DENR, 1997). Major groundwater users include potato growing and dairying in the southern portion of the PWA and viticulture in the Coonawarra area (Zone 3A and Part Zone 4A).

RAINFALL

The climate in the Comaum–Caroline PWA is typical of the South East with hot dry summers and cool wet winters. The mean annual rainfall in Mount Gambier is 778 mm/a (Mount Gambier PO, 1860–1975). Mean annual rainfall decreases northwards to 658 mm/a at Penola (Penola PO, 1961 to present).

The annual potential evapotranspiration is approximately 1400 mm in the south of the PWA increasing to more than 1500 mm in the northern portion of the PWA (Stadter et al. 1995).

Rainfall recharge volumes to the unconfined aquifer in the Comaum–Caroline PWA were taken from Stadter et al. (1995). The method used to calculate rainfall recharge in the Border Zone was to delineate recharge zones classified according to soil type, morphology and hydrogeological characteristics. Each recharge zone was further subdivided to reflect depth characteristics of soil types, depth to water, vegetation cover and aquifer response (measured from well hydrographs and an assumed specific yield of 0.1).

SURFACE WATER

The Glenelg River, the only major surface flow in the region, crosses the State Border from Victoria in to the lower south eastern portion of Zone 1A for ~5 kilometres before recrossing the Border and outflowing to the sea at the small township of Nelson.

There are three other surface exposures of water, albeit groundwater, of significance in the PWA. The Blue Lake located in the volcanic crater south east of Mount Gambier City is its main water supply. South of the city, near the coast, Eight Mile Creek and Piccaninnie Ponds which are sourced from groundwater springs are large natural discharges from the unconfined aquifer.

LOCAL HYDROSTRATIGRAPHY

Unconfined Aquifer

Groundwater flow in both the unconfined and confined aquifers radiates out from the Nangwarry-Tarpeena area in a northerly, westerly and southerly direction in the Comaum–Caroline PWA. Generally, however, the flow is in a south to south-westerly direction. The unconfined aquifer is a multi-lithological system, which is hydraulically continuous throughout the PWA. Groundwater flow in the aquifer is mainly through the Gambier Limestone Formation in both the Naracoorte Ranges and coastal plain. On the plain significant groundwater flow occurs through the Padthaway and Bridgewater Formations where they are present.

The aquifer can be as little as ~10 m thick in the Nangwarry-Tarpeena area (Fig. 2), increasing to more than 300 m thick south of Mount Gambier (Waterhouse, 1977). The depth to water varies relative to topography. Generally the depth to water is less than 5 m on the plain and up to 20 m in the Ranges.

A well developed secondary porosity in the limestone in the southern portion of the PWA has resulted in the development of numerous karst (dissolution) features such as the Eight Mile Creek and the Piccaninnie Ponds.

Confined Aquifer

In the Comaum–Caroline PWA the unconfined and confined aquifers are separated by a low permeability clay aquitard and the depth to the confined aquifer is generally more than 75 metres. However in the Nangwarry-Tarpeena area the depth to the aquitard is relatively close to the ground surface (~10 metres) and it is thin (possibly absent in some areas.). The confined aquifer in the Nangwarry-Tarpeena area is effectively a dome structure which deepens rapidly away from this area most distinctly southwards towards the coast.

The confined aquifer in the South East region is essentially a 'hidden' aquifer, that is, there are very few locations where the aquifer outcrops at the surface. Recharge to the confined aquifer therefore relies on downward leakage from the overlying unconfined aquifer via the aquitard. This can occur at any point where the elevation of the water table in the unconfined aquifer is higher than the piezometric head of the confined aquifer. In the South East region, this hydraulic head distribution occurs over most of the north-eastern portion of the region.

The principal mechanism of vertical recharge was traditionally considered to be by diffuse percolation through the porous aquitard. A recent study by Brown et al. (in prep.) concluded that vertical recharge to the confined aquifer is more likely to occur by preferential flow paths such as faults, fracture zones or sinkholes (where the aquitard is absent). It further concluded that these recharge areas to the aquifer were relatively small and localised.

The Nangwarry-Tarpeena area has been identified as one of these confined aquifer recharge areas. The area is, however, extensively covered in radiata pine and blue gum forest plantations, which may preclude future recharge.

While it is well documented the effect forestry has had on reducing recharge to the unconfined aquifer (Holmes and Colville, 1970b; Colville and Holmes, 1972; Allison and Hughes, 1978), little consideration has been given to the impact forestry could have on recharge to the confined aquifer.

There are very few confined aquifer wells in the Comaum–Caroline PWA. The two main reasons for this are considered to be because of the availability of good supplies of quality water from the unconfined aquifer, and the prohibitive cost of drilling a well into the aquifer (especially in the southern portion of the PWA where the depth to the aquifer can be more than 300 metres).

GROUNDWATER MANAGEMENT APPROACH

HISTORY

The Comaum–Caroline PWA was proclaimed in 1986 following the passing of the *Groundwater Border Agreement Act (Governments of South Australia and Victoria) 1985*.

Border Zone 1A has recently been sub-divided into three separate sub-areas as part of a strategy to manage declining water levels in the aquifer around Mount Gambier.

MANAGEMENT ZONES

Unconfined Aquifer

The Comaum–Caroline PWA is divided in to 7 management sub-areas (Fig. 4). They are:

- **Sub-area Glenroy** – is the coastal plain portion of Zone 4A in the Comaum–Caroline PWA,
- **Sub-area Comaum** – is the Naracoorte Ranges portion of Zone 4A in the Comaum–Caroline PWA,
- **Sub-area Zone 3A** – is the Designated Border Zone 3A,
- **Sub-area Zone 2A** – is the Designated Border Zone 2A,
- **Sub-area Myora** – is that portion north of the 2 metre drawdown zone in Zone 1A,
- **Sub-area Glenburnie** – is that area delineating the 2 metre drawdown zone in Zone 1A and,
- **Sub-area Donovans** – is that portion south of the 2 metre drawdown zone in Zone 1A.

Confined Aquifer

Formal boundaries are yet to be established for the confined aquifer in the South East region however proposed boundaries have been recommended. In the Border strip zone boundaries have been maintained, hence for this assessment the boundaries were assumed to be the same as those of Zones 1A, 2A, 3A and the southern portion of Zone 4A (Fig. 3).

THE MONITORING NETWORK

The Department for Water Resources and its predecessors have undertaken regular water level monitoring of the water resources in the Comaum–Caroline PWA since the early 1970s. Included in the Comaum–Caroline network are a number of wells that are located on the Victorian side of the Border. The salinity monitoring network was established in the mid-1980s. A number of wells are also regularly sampled and analysed for major ion chemistry as part of the State’s commitment to the management of the Border Designated Area.

UNCONFINED AQUIFER

Water Level Monitoring Network

The water level monitoring network in the Comaum–Caroline PWA has been in operation for more than 30 years. Over this period, the network has been upgraded and expanded to match the agricultural development in the PWA. There are currently 104 wells in the water level monitoring network. The majority of these wells are measured quarterly (March, June, September and December) by the Department for Water Resources.

The locations of wells in the current water level monitoring network are shown on Figure 5. There is a fairly even distribution of observation wells over the PWA. The highest concentration of wells are centred around Mount Gambier City and is part of the water level and salinity monitoring program for the Blue Lake.

The current network fulfils groundwater monitoring requirements for the PWA. Those wells with more than 30 years of data are an important dataset, and a valuable asset which should be maintained. The network has recently been expanded in a number of areas. These include observation wells in and around blue gum developments, an investigation in to lateral groundwater inflow to the Blue Lake, and south of Mount Gambier additional wells in the intensely irrigated dairying area.

Salinity Monitoring Network

There are currently 49 wells in the Comaum–Caroline salinity monitoring network (Fig. 6). Sampling frequency is the same as the water level monitoring network. The network has recently been expanded to meet increased development in the area (see above section).

Based on recent improvements there are no specific recommendations for changes to the water level and salinity monitoring networks.

CONFINED AQUIFER

Water Level Monitoring Network

There are currently 10 confined aquifer water level monitoring wells in the Comaum–Caroline PWA (Fig. 5). All the wells are part of the network that monitors confined aquifer water levels in the Designated Border zone.

Salinity Monitoring Network

Salinity monitoring of the ten confined aquifer wells in the Comaum–Caroline PWA is undertaken every five years as part of the *Border Agreement Act*. None of the wells have sufficient record lengths to interpret trends.

CURRENT STATUS OF THE WATER RESOURCES

UNCONFINED AQUIFER

Groundwater Flow

The water table elevation zones for the unconfined aquifer are shown on Figure 7. The regional flow direction is generally east to west. North of the Nangwarry-Tarpeena high, groundwater flow is mainly in a north-westerly direction. South of the high, the flow direction is southward. The changes in hydraulic gradient as reflected in the spacing of the zones are inferred to represent changes in hydraulic conductivity. The close spacing of zones just north of Mount Gambier possibly reflect an area of low permeability related to the Tartwaup Fault.

Water Level Trends

Long term water level trends from hydrographs located in the Comaum–Caroline PWA are shown spatially on Figure 8. Only wells with more than five years of data and currently part of the monitoring network were included in the assessment.

Hydrographs from the majority of wells initially show little change in the water table elevation, followed by a more recent decline since the end of 1992. This is consistent with a period of below average annual rainfall over the same period.

There are however a number of hydrographs that do not follow this general pattern (see Appendix B – GAM078, GAM079 and GAM080). In the Glenburnie Sub-area, the decline is more long term and is consistent with the expansion of forestry in the area. Observation well NAN019 in Zone 2A shows a ~5 metre rise in the water table following the 1983 bushfire (Appendix B) reflecting an increase in rainfall recharge after that event.

Land use change particularly forestry is the major water management issue for the Comaum–Caroline PWA, particularly the expansion of blue gums. The effect plantations have on vertical recharge is well documented. Declining water levels in and around established plantations provide further evidence of their effect on recharge to the aquifer.

Salinity Distribution

The groundwater salinity distribution in June 2000 for the Comaum–Caroline PWA is shown in Figure 9. Generally the aquifer salinity is very good, ranging between 300 and 1000 mg/L.

Salinity Trends

Regular salinity monitoring began in 1986, which gives up to 14 years of monitoring record. Figure 10 shows the long-term salinity trends in mg/L/year from wells located in the area. Groundwater salinity has remained generally unchanged over the length of monitoring record. The two exceptions are increasing salinity trends in observation wells NAN009 (+25 mg/L/yr) and MIN023 (+13 mg/L/yr.). Both are probably related to the effects of the 1983 bushfire but a more thorough examination is required.

Groundwater contamination of the unconfined aquifer has been identified as a possible future water management issue for the Comaum–Caroline PWA (DENR, 1997). The aquifer is particularly vulnerable in the intensely irrigated dairy area south of Mount Gambier. Widespread applications of substances such as agricultural chemicals, fertilisers and animal bi-products all have the potential to contaminate the aquifer. To reduce the potential risk of contamination better codes of practice have been actively encouraged. The Department for Water Resources has also increased the number of observation wells in the area.

Waste from timber treatment plants and storm water drainage from Mount Gambier City also warrant further consideration.

CONFINED AQUIFER

Groundwater Flow

The groundwater flow pattern in the confined aquifer is similar to that of the unconfined aquifer. The potentiometric head decreases from a high of ~45 m in the Nangwarry-Tarpeena area in a north-westward direction north of the area, and a south-westward direction, south of the area. At the coast the potentiometric head is ~20 m above AHD.

Water Level Trends

Water level trends are similar to those of the unconfined aquifer. Generally heads remained stable up until the end of 1992, since then they have shown a steady decline (Appendix B). The decline in hydraulic head in the confined aquifer is probably related to a reduction in overburden pressure consistent with the decline in water level in the unconfined aquifer. It is unlikely to be a result of extraction as there is very little occurring from the confined aquifer in this area.

Salinity Distribution

The salinity of the groundwater in the confined aquifer ranges from ~500 mg/L to ~1400 mg/L. There is a general trend of increasing groundwater salinity northwards. The last major sampling occurred in 1996, however the groundwater salinity is not expected to change significantly over each five year sampling period.

The aquifer salinity is unlikely to change appreciably in those parts of the PWA where the confined hydraulic head is higher than the unconfined head. If there were an increase in groundwater salinity in the overlying unconfined aquifer (or some other form of contamination) the confined aquifer salinity will remain unchanged as there is no potential for downward movement of the groundwater.

In areas where the hydraulic head in the unconfined aquifer is higher than that of the confined aquifer there is the potential for downward leakage of groundwater to the confined aquifer. Usually the depth to the aquifer and thickness of the aquitard means that any change in groundwater quality in the unconfined aquifer would take a significant period of time to reach the confined aquifer. However, this assumes the recharge to the confined aquifer is via diffuse leakage through the aquitard.

If as suggested by Brown et al. (in print) the aquifer is receiving recharge via preferential flow paths, then any change in water quality in the unconfined aquifer may impact on the confined aquifer within a much shorter time period.

Salinity Trends

There are currently insufficient data to assess salinity trends in the confined aquifer.

WATER DEMAND

UNCONFINED AQUIFER

Historical Demand

The historical and current estimated crop water use data were obtained from the Department for Water Resources – Policy Division and is presented in Tables 2 and 3 respectively. The data as supplied by the Department is based on the original four water management areas. Since then Zone 1A has been further sub-divided in to Sub-areas Myora, Glenburnie and Donovans.

The changes in allocation volumes vary slightly from season to season due to adjustments in crop area ratios and increases in individual water licences following legal appeals (L. Schmidt, *pers. com.*, 2000).

The water usage volume is estimated from seasonal returns supplied by the water users. The estimation of the volume relies on the veracity of the water user and the irrigated crop water requirement method. In both instances, therefore, the figures should not be considered as a rigorous calculation.

Allocations have increased in Zone 1A from 8816 ML in the 1993/94 year to 25377 ML in 1998/99. Over the same period water use rose from 33 ML to 12161 ML, which is about half the allocation. A similar trend is evident in Zone 2A.

The total combined industrial and recreational allocation for the PWA is 1425 ML. There is however no recorded usage of the industrial and recreational allocation. Even though the allocations exist and some wells are equipped with meters, there is no regular meter reading program. Therefore there is no comprehensive database.

In Zone 3A the allocation increased steadily from 11468 ML in 1984/85 to 23579 ML in 1995/96 after which it has remained about stable. Similarly usage shows a steady increase before stabilising at about half the allocation volume.

Allocation in the Glenroy Sub-area, following a steady increase from 1984/85 to 1992/93 has since stabilised at ~5700 ML. Usage is now about a third of the total allocation. In Sub-area Comaum the allocation has increased steadily from 1539 ML in 1984/85 to 2227 ML in 1998/99. Again usage is about a third of the total allocation.

Annual water use from the Blue Lake for Mount Gambier City between 1991/92 and 1998/99 has remained fairly stable. The lowest recorded level of water use was 3077 ML in the 1992/93 season. The highest was 3589 ML in 1998/99.

Current Demand

The total annual groundwater allocation for 1998/99 was 78 093 ML. Total groundwater usage for the same period was estimated to be 37 316 ML, which represents about half the total allocation. Table 3 presents PAVs, allocation and usage for each water management sub-area. The PAV for sub-areas of Myora, Glenburnie, and Donovans in former Zone 1A was 71 000 ML. This value was calculated using a storage coefficient of 0.15. This has been reassessed using an Sy of 0.1 to a combined total for the 3 sub-areas of 30 900 ML of which ~25 377 ML is allocated. In Zone 2A ~4500 ML of groundwater remains unallocated. Those areas not fully allocated have been included in the pro-rata roll out. Existing allocations, stock and domestic use, expected plantation expansion and the environment were considered as part of the assessment (Table 4).

It is evident from the above table that the rainfall recharge is higher than the PAV in Zones 2A and 3A. It was decided not to increase the PAVs however to match the recharge values as a number of monitoring wells were showing a possible increase in groundwater salinity (Stadter et al, 1995).

Stock numbers for the 1996/97 season for the Comaum–Caroline PWA are presented in Table 5. The data were obtained from the Australian Bureau of Statistics, Hobart. Daily stock consumption figures are based on data supplied by the NSW Department of Agriculture (Appendix C). Stock water use estimates are to the nearest 5 ML. Total annual stock use was estimated to be 1960 ML.

Table 1 Comaum Caroline PWA annual groundwater allocations

Sub-areas	Irrigation Season (in ML)														
	84/85	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99
Zone 1A															
Irrigation	-	-	-	-	-	-	-	-	-	8692	10638	12953	15659	22338	24521
Industrial and Recreational	-	-	-	-	-	-	-	-	-	124	195	536	543	543	856
Sub-area Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**8816**	**10834**	**13488**	**16202**	**22881**	**25377**
Zone 2A															
Irrigation	22	22	-	-	-	-	-	239	586	9219	11840	13246	16940	19829	20790
Industrial and Recreational	-	-	-	-	-	-	-	-	-	17	24	28	28	28	28
Sub-area Total	**22**	**22**	**0**	**0**	**0**	**0**	**0**	**239**	**586**	**9236**	**11864**	**13274**	**16968**	**19857**	**20818**
Zone 3A															
Irrigation	11468	14156	14156	15541	16150	17471	18041	18965	18965	19747	22326	23194	23175	23517	23427
Industrial and Recreational	-	-	-	-	-	-	-	-	-	376	382	384	382	382	532
Sub-area Total	**11468**	**14156**	**14156**	**15541**	**16150**	**17471**	**18041**	**18965**	**18965**	**20123**	**22708**	**23579**	**23557**	**23899**	**23959**
Glenroy															
Irrigation	3594	3594	3594	3594	3594	4433	4433	5075	5087	5771	5747	5810	5810	5601	5711
Industrial and Recreational	-	-	-	-	-	-	-	-	-	1	1	1	1	1	1
Sub-area Total	**3594**	**3594**	**3594**	**3594**	**3594**	**4433**	**4433**	**5075**	**5087**	**5772**	**5748**	**5811**	**5811**	**5602**	**5712**
Comaum															
Irrigation	1539	1539	1539	1539	1539	1552	1552	1649	1649	1837	2123	2208	2208	2123	2219
Industrial and Recreational	-	-	-	-	-	-	-	-	-	8	8	8	8	8	8
Sub-area Total	**1539**	**1539**	**1539**	**1539**	**1539**	**1552**	**1552**	**1649**	**1649**	**1845**	**2131**	**2216**	**2216**	**2131**	**2227**
Annual Season Totals	**16623**	**19311**	**19289**	**20674**	**21283**	**23456**	**24026**	**25928**	**26287**	**45792**	**53285**	**58368**	**64754**	**74370**	**78093**

Table 2 *Comaum Caroline PWA annual groundwater usage*

Sub-areas	Irrigation Season (in ML)														
	84/85	**85/86**	**86/87**	**87/88**	**88/89**	**89/90**	**90/91**	**91/92**	**92/93**	**93/94**	**94/95**	**95/96**	**96/97**	**97/98**	**98/99**
Zone 1A															
Irrigation	-	-	-	-	-	-	-	-	-	0	33	6425	9055	9847	12161
Industrial and Recreational	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0
Sub-area Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**33**	**6425**	**9055**	**9847**	**12161**
Zone 2A															
Irrigation	0	0	-	-	-	-	-	0	0	121	226	4503	7092	9643	9744
Industrial and Recreational	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0
Sub-area Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**121**	**226**	**4503**	**7092**	**9643**	**9744**
Zone 3A															
Irrigation	0	5906	5834	6808	8033	8620	8434	9255	9154	10100	10468	11399	12425	11700	12556
Industrial and Recreational	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0
Sub-area Total	**0**	**5906**	**5834**	**6808**	**8033**	**8620**	**8434**	**9255**	**9154**	**10100**	**10468**	**11399**	**12425**	**11700**	**12556**
Glenroy															
Irrigation	0	843	325	1335	765	1619	1166	1196	1605	1527	2047	2620	2239	2004	2098
Industrial and Recreational	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0
Sub-area Total	**0**	**843**	**325**	**1335**	**765**	**1619**	**1166**	**1196**	**1605**	**1527**	**2047**	**2620**	**2239**	**2004**	**2098**
Comaum															
Irrigation	0	348	0	718	582	320	616	597	674	674	499	360	543	556	757
Industrial and Recreational	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0
Sub-area Total	**0**	**348**	**0**	**718**	**582**	**320**	**616**	**597**	**674**	**674**	**499**	**360**	**543**	**556**	**757**
Annual Season Totals	**0**	**7097**	**6159**	**8861**	**9380**	**10559**	**10216**	**11048**	**11433**	**12422**	**13273**	**25307**	**31354**	**33750**	**37316**

Table 3 Comaum–Caroline PWA current PAVs, allocation, usage and available allocation (all in ML)

Sub-area	PAV	Vertical Recharge[1]	Allocation (1998/99)	Use (1998/99)	% of Used Allocation	Available Allocation
Myora	6000					Available
Glenburnie	12300					Available
Donovans	12600	31090[2]	25377[2]	12161[2]	48	Available
Zone 2A	25000	36390	20818	9744	47	Available
Zone 3A	24000	45600	23959	12556	52	Closed
Glenroy	4500		5712	2098	37	Closed
Comaum	1750		2227	757	34	Closed
Total	86150		78093	37316	48	Closed

[1] from Stadter (1995). Data available only on zone basis.

[2]combined allocation for Myora, Glenburnie and Donovans (formerly Zone 1A).

The stock consumption figures (Table 5) used in this report are considered to be maximum values. There is a non-consistent variation in the stock use figures shown in Tables 4 and 5 caused by different methods of calculation. Table 4 is based on typical stocking rates expressed as dry sheep equivalents and per head consumption whilst Table 5 is based on actual stock figures for one year and average per head consumption data. The stock use figures are considered insignificant when compared to the total water use figures for the PWA.

Water supplied for Mount Gambier city from the Blue Lake from July 1998 to June 1999 was 3589 ML.

Future Demand

There is the potential to increase present water use in the PWA by approximately 100% before the groundwater allocation threshold is reached.

An increased demand for groundwater in the southern portion of the PWA for crop use is considered unlikely (DENR, 1997). However in dairying areas development may be restricted by the density of irrigation. The climate is generally unsuitable for grapes (and possibly other crop types).

Plantation expansion can potentially have a significant impact on future demand. If the area under plantation were to expand then rainfall recharge to the unconfined aquifer would effectively be reduced. The *pro-rata* roll out takes into account future plantation development in the Myora, Glenburnie and Donovans sub-areas, although this was considered nil as no further forestry commitment is known in these sub-areas. However if in the future there was a dramatic increase in forestry development then it becomes unclear how the PAV will be reduced to compensate for the reduction in rainfall recharge.

Annual fluctuations in stock and domestic use are anticipated to be small.

SA Water consider Mount Gambier's water use has stabilised, and predict a maximum annual usage of 4000 ML over the next five years.

CONFINED AQUIFER

Historical Demand

There are a number of town water supply wells that use the confined aquifer in the PWA. There are two confined aquifer wells at Tarpeena, one at Nangwarry, and two back-up wells that are used periodically for the Mount Gambier water supply. There possibly are a number of private wells that also utilise the aquifer but they have not been identified on the DWR database.

From 1991/92 to 1998/99 the total annual groundwater use for Tarpeena town water supply ranged between 31 and 37 ML/yr. The Nangwarry well is a recent addition to the town water supply network and therefore has no historical water use record. There is no recorded use for the two Mount Gambier town water supply wells.

Current Demand

Water use for the township of Tarpeena between July 1998 and June 1999 was 37 ML. Water use at Nangwarry for the same period was 22 ML.

At present there is no PAV for the confined aquifer in the Comaum–Caroline PWA. Proposed PAVs are discussed in the next section.

Table 4 *Pro-Rata determination for sub-areas in the Comaum–Caroline PWA*

Sub-area	Adopted 1996 PAV (ML)	Re-assessed PAV (2000) (ML)	Existing Allocation (ML) 1999/2000	Stock Use (ML)	Domestic Use (ML)	Town Use (ML)	Forestry Commitment (ML) (see Note 2)	Environmental Commitment (ML) (See Note 1)	Volume Available for Pro-rata Allocation (ML)
Zone 1A	71 000								
Myora		6000	2326	65	530		0	600	2479
Glenburnie		12 300	11 094	105	1300	4000	0	1230	-5429
Donovans		12 600	12 410	145	325		0	1260	-1540
Zone 2A	25 000	25 000	20 544	273. 4	307	80	0	2500	1295. 6

Note 1An allowance of 10% of the re-assessed PAV has been taken for environmental requirements

2No forestry commitment is known

Table 5 *Stock Use in the Comaum–Caroline PWA in 1996/97*

Sub-area	Estimated Stock Use (ML)	Approximate Stock Numbers			
		Sheep/Lambs	Dairy Cows	Meat Cattle	Pigs
Myora	195	9190	1960	5640	7540
Glenburnie	295	17 440	3270	8350	7560
Donovans	320	23 440	6130	6410	—
Zone 2A	550	82 170	3520	15 280	280
Zone 3A	505	77 780	1280	16 800	320
Glenroy	65	8770	210	2080	—
Comaum	30	1220	200	1470	—
Total	**1960**	**221 510**	**16 570**	**56 030**	**15 700**

Future Demand

SA Water considers water use to have stabilised in Tarpeena and Nangwarry, and predict a maximum annual usage of 50 ML/yr and 100 ML/yr (includes unconfined aquifer water use) respectively.

The proposed PAVs for the confined aquifer for both South Australia and Victoria are presented in Table 6. The management zones are shown on Figure 3. Tarpeena and Nangwarry town water supply wells would be part of the Zone 2A confined aquifer allocation. The Mount Gambier confined aquifer wells would be part of the Zone 1A confined aquifer PAV allocation.

The availability of an ample supply of good quality water in the unconfined aquifer has meant there has been little need to utilise groundwater from the confined aquifer. Even though the water quality in the confined aquifer is very good (generally less than 1000 mg/L) the cost/benefit of drilling to a greater depth, especially in the southern portion of the PWA is marginal. There may be future demand on the confined aquifer water resource in the southern dairy belt if there is no available allocation in the unconfined aquifer. If this were to happen, monitoring wells would have to be established, preferably before any extraction occurred.

WATER BALANCE

Groundwater flow in the unconfined aquifer is particularly complex in the Comaum–Caroline PWA. Flow-net analysis used in the Padthaway, Tatiara and Naracoorte Ranges PWA reports was considered too difficult for this area, so a simple steady state groundwater flow model using MODFLOW (McDonald and Harbaugh, 1988) was constructed and calibrated against observed water table contours. Vertical recharge rates were generalised from Stadter et al. (1995). (Caution should be exercised when using these results as time constraints limited a more thorough assessment of the aquifer characteristics.).

The preliminary water balance for the Comaum–Caroline PWA is presented in Table 7.

In its most general form the water balance for any closed basin may be expressed as follows:

$\sum$(inputs) - $\sum$(outputs) = (change in storage)

A tentative water balance for the Comaum–Caroline PWA (in ML) is therefore as follows:

(131 605 ML) - (178 410 ML) = (-46 805 ML)

The change in storage is consistent with a decline in water level in the PWA since 1993, and the more noticeable long term decline in the southern areas of the PWA.

Table 6 Proposed PAVs for the TCSA in South Australia and Victoria

South Australian Management Areas	Proposed PAV (ML/yr)	Victorian Management Areas	Proposed PAV (ML/yr)
1A	9200	1B	14 400
2A	2900	2B	5100
3A	1900	3B	1100
4A	690	4B	300
5A	550	5B	550
6A	350	6B	350
7A	350	7B	350
8A	340	8B	340
9A	570	9B	630
10A	320	10B	560
11A	0	11B	0
Copeville	940	Dartmoor	18 600
Karoonda	1500	Goroke	2200
Keith	2500	Kaniva	1000
Kingston	24 972	Little Desert	1100
Lameroo	1200	Nhill	1200
Millicent	12 000		
Mindarie	780		
Monbulla	4300		
Naracoorte	3900		
Wirrega	960		

1. where the volume is less than 1000 ML, the PAV has been rounded upwards to the nearest 10 ML.

Table 7 Water Balance for the Comaum–Caroline PWA (in ML)

	Sub-area				
Inputs	**1A**	**2A**	**3A**	**4A**	**Totals**
Inflow	10 490	3860	2460	2300	
Rainfall Recharge	31 055	33 860	40 460	7120	
Total In					**131 605**
Outputs					
Outflow	25 050	30 830	35 040	9390	
Extraction (1998/99)	25 380	20 820	23 960	7940	
Total Out					**178 410**
Change in Storage					**-46 805**

Note: the rainfall recharge figures differ slightly from the vertical recharge values as estimated by Stadter et al, (1995) (Table 3) mainly due to the approximation of the grid dimensions used in the model.

POTENTIAL IMPACTS THE USE OR TAKING OF WATER FROM ONE RESOURCE MAY HAVE ON ANOTHER RESOURCE

The potential detrimental impacts taking, or using, water from one resource may have on the quantity or quality of water of another resource in the Comaum–Caroline PWA were considered in the following situations:

- the impact of using surface water to artificially replenish the groundwater system.
- the impact taking groundwater from the unconfined aquifer may have on the confined aquifer.
- the impact taking groundwater from the confined aquifer may have on the unconfined aquifer.

In all three scenarios consideration was also given to the impacts extraction may have across management boundaries.

THE IMPACT OF USING SURFACE WATER TO ARTIFICIALLY REPLENISH THE GROUNDWATER SYSTEM

Vertical recharge to the unconfined aquifer is acquired mostly from diffuse percolation of rainfall through the soil profile and the unsaturated zone. During high rainfall events, however, surface water, in the form of run-off, can enter the aquifer directly via dissolution features in the limestone (eg. sinkholes) or man-made drainage wells. The man-made wells are usually located in local topographic depressions and are designed mainly to minimise surface flooding.

Herczeg et al. (1997) undertook a study of point source recharge at a number of sites in the South East region. Four of the five sites are located north of the Comaum–Caroline PWA, in the Naracoorte Ranges PWA. Results from their study concluded that recharge to the unconfined aquifer was only detectable on a local scale (less than 500 m) and that groundwater mounds arising from point source recharge dissipate within 2–4 months after the cessation of rainfall. They also showed that even though the salinity of the surface water entering the aquifer is very low, it does not affect the regional groundwater salinity to any large degree. Hence it is unlikely that point source recharge from surface flows would have any significant impact on the resources of the unconfined aquifer.

Surface flooding is prone to carry nutrients such as fertilisers or sewage that can flow directly into the aquifer. These nutrients include those ions or organic compounds containing nitrogen (NO_2^-, NO_3^-, NH_4^+) and phosphorus. However this type of contamination can also occur through diffuse recharge processes hence it would normally be difficult to pinpoint individual point source contamination. In the dairying belt located in the southern part of the PWA the application of animal bi-products, agricultural chemicals and fertilisers onto pastures has the potential to contaminate the unconfined aquifer.

As the area of influence of point source recharge is relatively small it is unlikely to have any impact across water management boundaries.

It is concluded therefore that the addition of surface water to artificially replenish the groundwater system would have only minimal effects on groundwater levels and salinity in the unconfined aquifer. However in the intensely irrigated dairying area there is the potential for aquifer contamination and hence the area should be monitored closely for degradation in water quality.

THE IMPACT TAKING OR USING GROUNDWATER FROM THE UNCONFINED AQUIFER MAY HAVE ON THE CONFINED AQUIFER AND ADJACENT PWAs

Generally the depth to the aquitard that separates the unconfined and confined aquifers is considerable (>250 m at the southern coast). The aquitard is also often more than 20 m thick and of very low permeability. It is therefore unlikely there would be any detrimental impact on the confined aquifer water resource caused by extraction in the unconfined aquifer. In the southern portion of the PWA the hydraulic head in the confined aquifer is higher than the unconfined aquifer. This means the vertical component of groundwater flow is upwards. There is therefore very little possibility of downward leakage of groundwater from the overlying unconfined aquifer to the confined aquifer.

In the Nangwarry-Tarpeena area the potential for recharge to the confined aquifer exists (ie. the head in the unconfined is higher than the potentiometric head in the confined aquifer). If, as suggested by Brown et al. (in prep.) point source recharge is the principal mechanism of recharge to the confined aquifer, then the possibility exists that water use in the unconfined aquifer may impact on the water resource of the confined aquifer. While not classified as a water user under the Water Resources Act, forestry does significantly impact on the water resource of the unconfined aquifer. In the Nangwarry-Tarpeena area forestry may potentially be impacting on recharge to the confined aquifer. Further drilling and sampling is required around this area to establish the hydrogeological relationships, particularly inter-aquifer leakage between the unconfined and confined aquifers.

As Sub-area Glenburnie delineates a two metre drawdown cone in Zone 1A then any increase or decrease in the size of the cone would impact on the adjacent management areas. This however is not considered a major concern. No other significant across management boundary impacts were identified for the unconfined aquifer in this PWA.

THE IMPACT TAKING OR USING GROUNDWATER FROM THE CONFINED AQUIFER MAY HAVE ON THE UNCONFINED AQUIFER AND ADJACENT PWAS

For the same reasons as outlined in the previous section there is little likelihood that extraction from the confined aquifer could impact on the unconfined aquifer water resource.

There is only a small possibility that if groundwater were taken from the confined aquifer and applied to the unconfined aquifer that an additional volumetric effect, due to the increased quantity of water applied to the unconfined aquifer, and possibly a quality effect due to the addition of salts would occur.

However the application of an additional volume of water is also unlikely to have any long-term effect on the unconfined aquifer in the Comaum–Caroline PWA. Studies have shown that there was only a minimal response in the aquifer when additional volumes of water were applied during point source recharge events. The salinity of the groundwater in the confined aquifer is generally very low hence it is unlikely that the addition of the additional salt load would significantly impact on the water quality of the unconfined aquifer.

On a regional basis with the exception of the Kingston sub-area, the proposed PAVs for the confined aquifer are relatively small compared to those of the unconfined aquifer. The approach to the management of the confined aquifer water resource is a conservative one. If these PAVs are adopted then this would minimise potential impacts across water management boundaries.

CONCLUSIONS

A preliminary water balance for the unconfined aquifer in the Comaum–Caroline PWA indicates that the aquifer is not in steady state. This is consistent with a general decline in the water table since the end of 1993 which is attributed to below average mean annual rainfall, and a more long term decline in the southern portion of the PWA, possibly due to the expansion of forestry in the area.

In the unconfined aquifer water level trends from well hydrographs in the Comaum–Caroline PWA generally show a stable water table followed by a period of decline post-1992. In the southern portion of the PWA, a more long term decline is evident and is consistent with the expansion of forestry in the area. The salinity of the groundwater in the aquifer is generally very good and with few exceptions there has been little change in the salinity since monitoring began about 15 years ago.

Water level trends in the confined aquifer are similar to those in the unconfined aquifer and are attributed to a reduction in hydrostatic pressure related to the decline in water level in the unconfined aquifer. There are no salinity trends available for the confined aquifer. The groundwater salinity in the aquifer ranges between ~500 mg/L in the south of the PWA and 1400 mg/L in the north.

The two major water resource issues in the Comaum–Caroline PWA are considered to be:

- The potential for groundwater contamination in the southern, intensely-irrigated dairy farming area from animal waste, agricultural chemicals and fertilisers.

- The effect land use change, particularly forestry may have on vertical recharge to the unconfined aquifer and also possibly on the confined aquifer.

The total annual groundwater allocation for 1998/99 was 78 093 ML, and groundwater usage was estimated to be 37 316 ML. There is therefore the potential to increase current water use by 100% before the allocation threshold is reached. An increase in the demand for groundwater for crop growing in the southern portion of the PWA is unlikely as the climate is generally unsuitable for most crops. However in high density irrigation dairying areas restrictions of water use in the unconfined aquifer may result in irrigators targetting the confined aquifer.

The recent expansion of the water level and salinity monitoring networks are considered adequate for the PWA.

The three scenarios that may potentially impact on the water resources in the Comaum–Caroline PWA were identified as follows:

- the impact of using surface water to artificially replenish the groundwater system.
- the impact taking groundwater from the unconfined aquifer may have on the confined aquifer.
- the impact taking groundwater from the confined aquifer may have on the unconfined aquifer.

There is the potential for groundwater contamination to occur to the unconfined aquifer as a result of applying animal bi-products, agricultural chemicals and fertilisers in the southern portion of the PWA. Waste from timber treatment plants and storm water drainage from Mount Gambier City also warrant further consideration.

In the Nangwarry-Tarpeena area recharge to the unconfined aquifer beneath forested areas is negligible. This may impact on the water resources of the confined aquifer.

RECOMMENDATIONS

The following recommendations are made:

- maintain the current groundwater monitoring networks,
- obtain accurate water extraction figures,
- an investigation into the potential impacts that plantations could be having on rainfall recharge to the unconfined and confined aquifers,
- on-going monitoring into the impacts farming practices may be having on groundwater quality in the unconfined aquifer,
- DWR database should be changed to include the latest sub-areas. The database should be accessible using a GIS system. This would enable easy extraction of relevant information,
- the introduction of an annual review of monitoring and licence data for each PWA.

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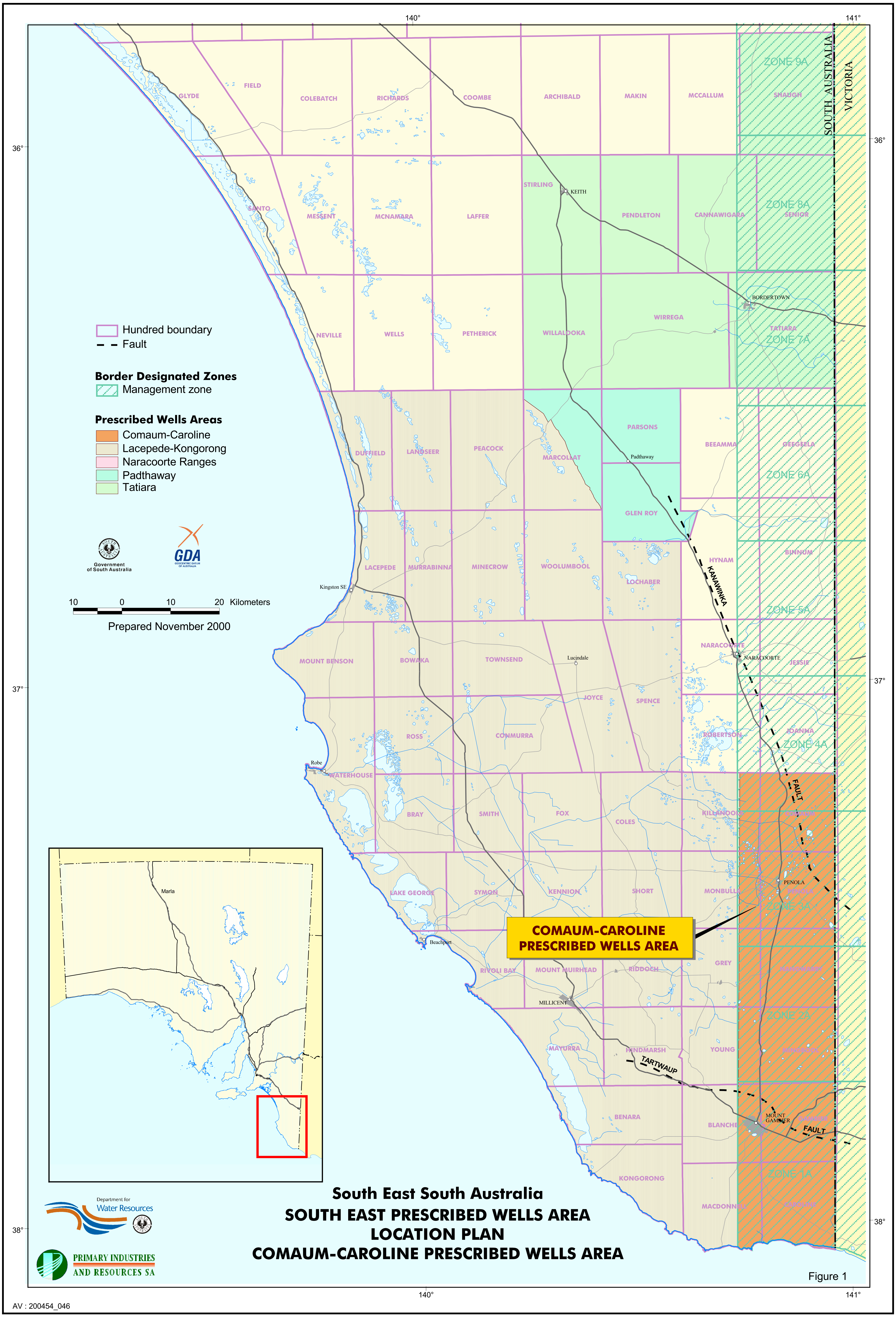
Figures



South East South Australia

SOUTH EAST PRESCRIBED WELLS AREA

LOCATION PLAN

COMAUM-CAROLINE PRESCRIBED WELLS AREA

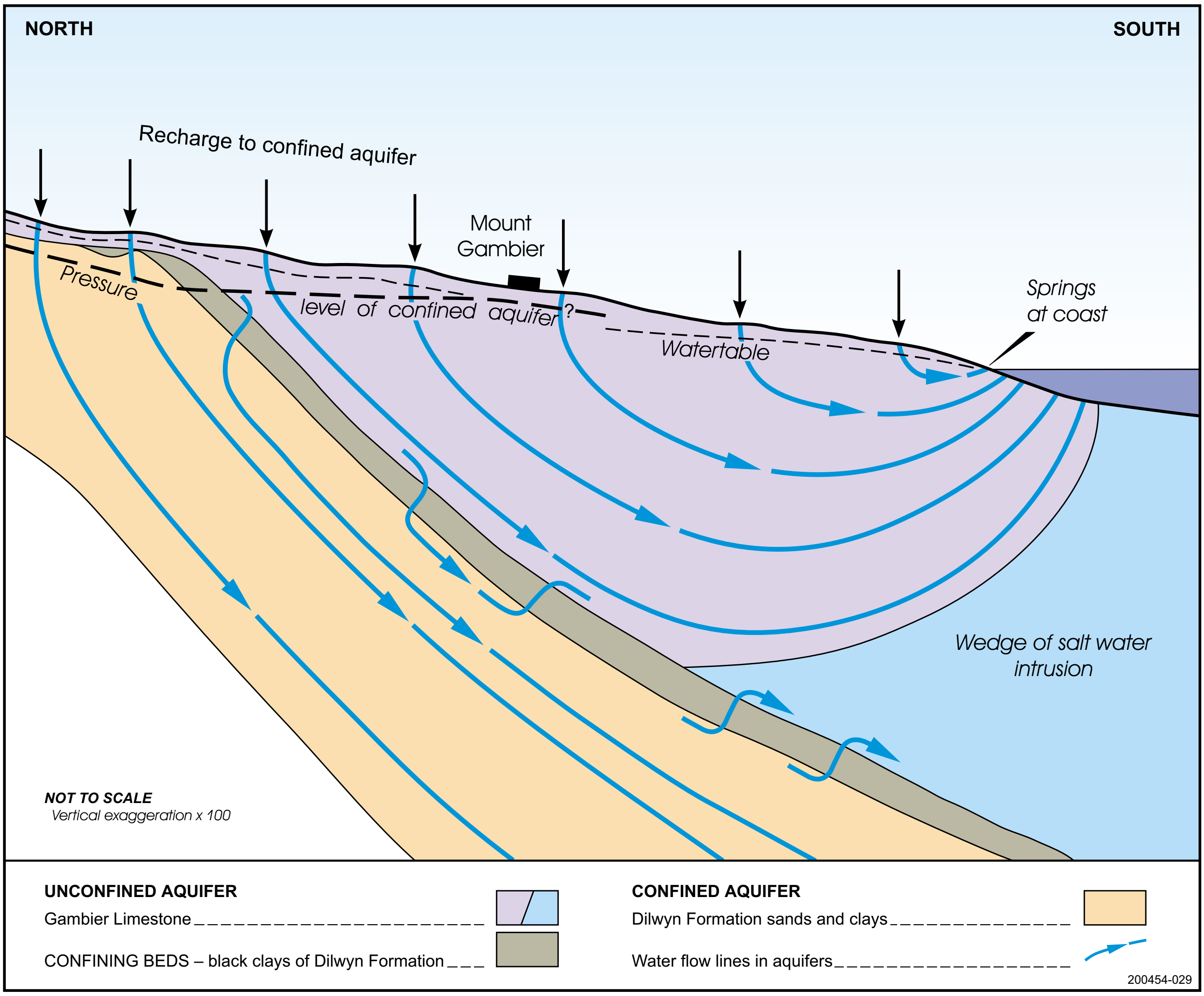
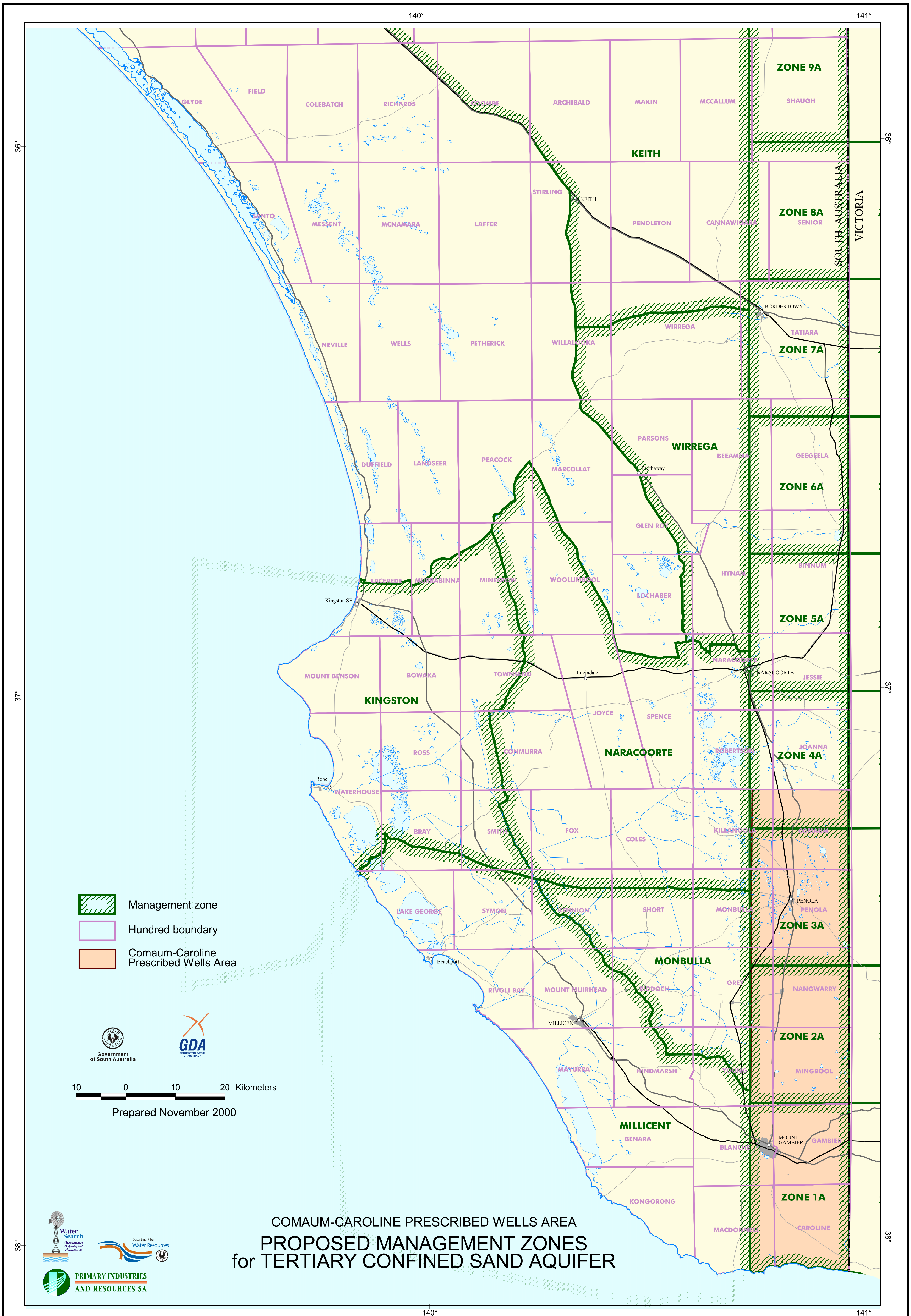


Figure 2 *Schematic north-south geological cross section of the Comaum-Caroline PWA.*

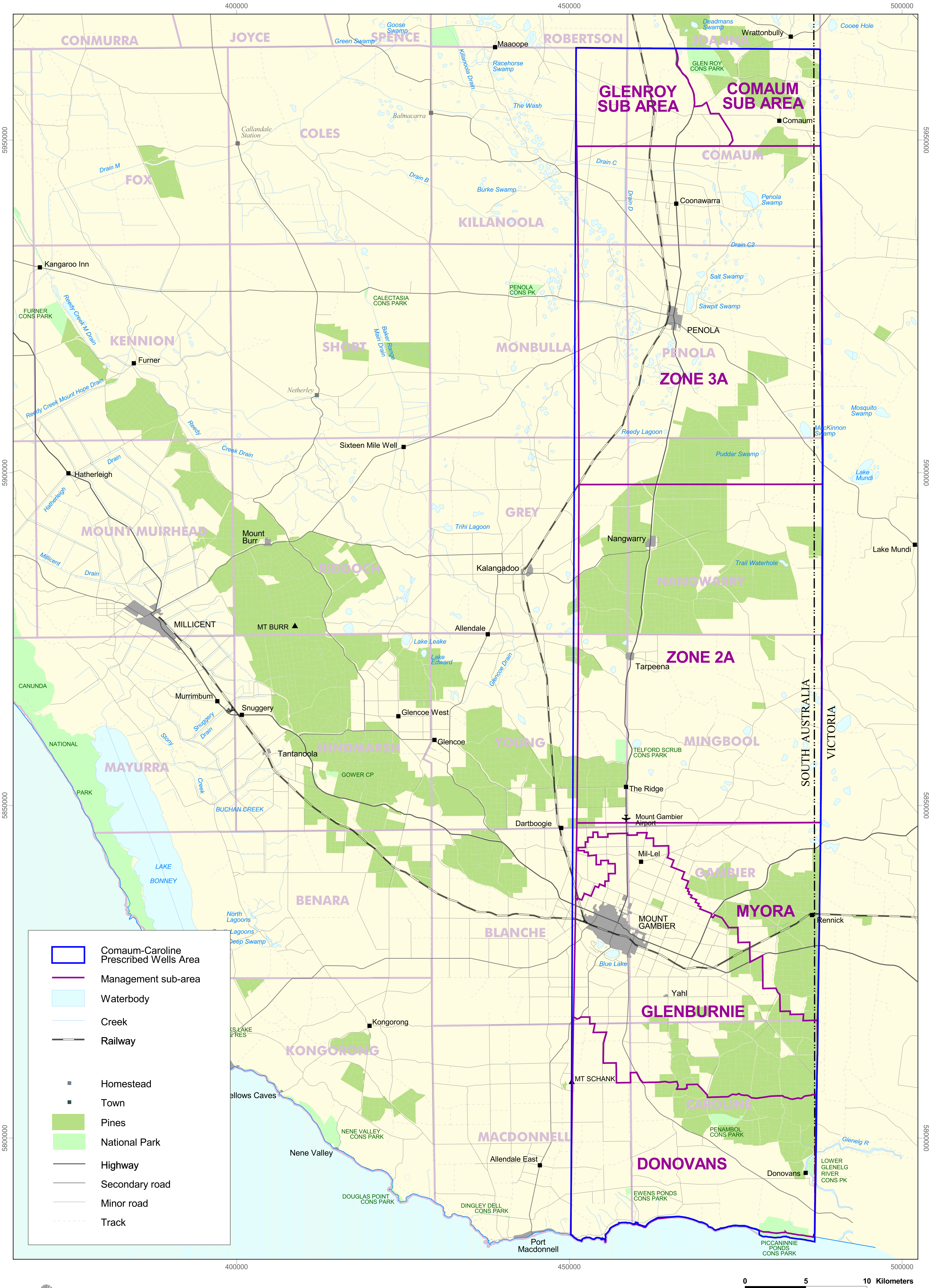


COMAUM-CAROLINE PRESCRIBED WELLS AREA

PROPOSED MANAGEMENT ZONES for TERTIARY CONFINED SAND AQUIFER

AV : 200454_047

Figure 3



COMAUM-CAROLINE PRESCRIBED WELLS AREA

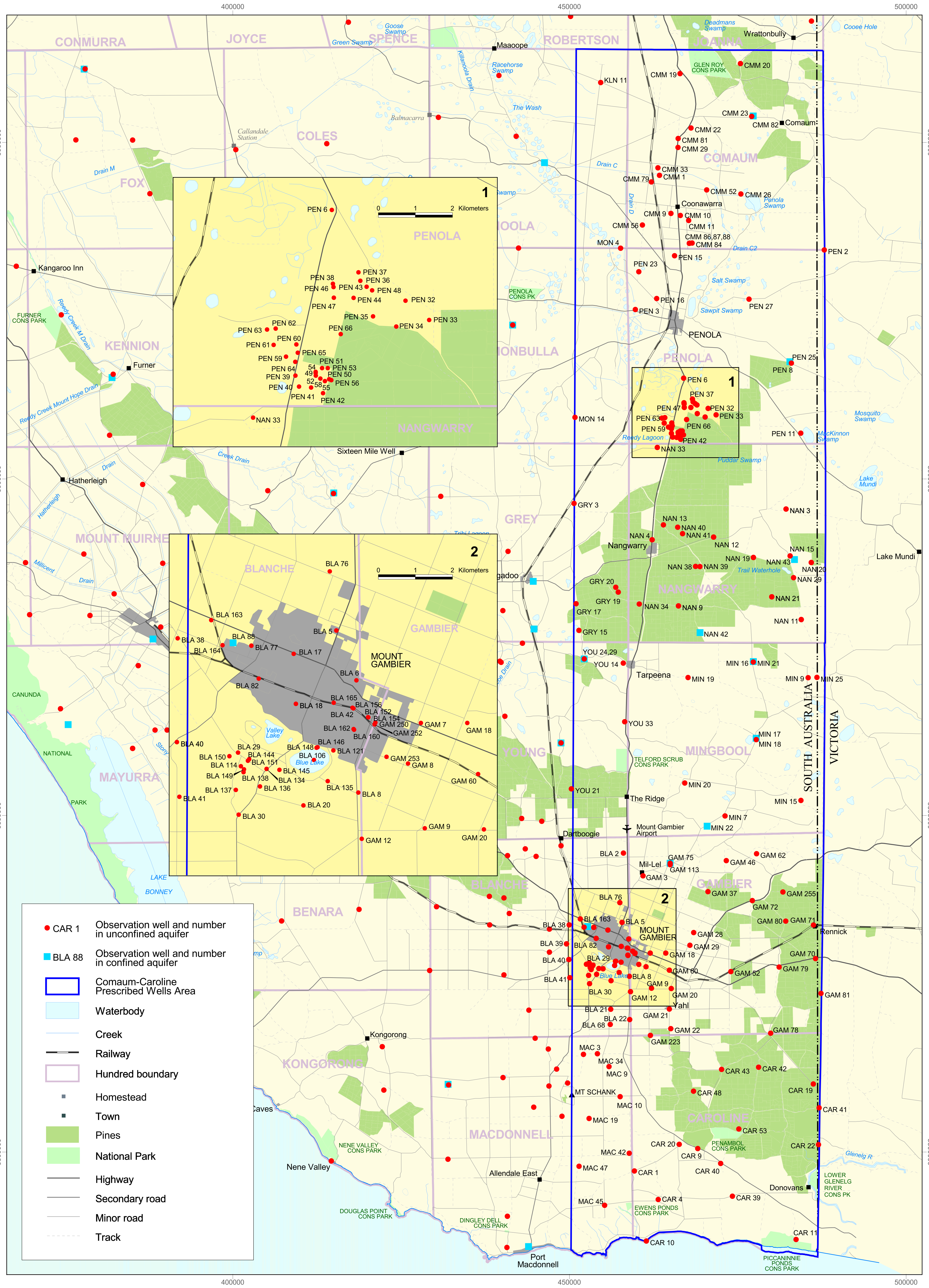
GROUNDWATER MANAGEMENT SUB AREAS for UNCONFINED AQUIFER

Datum GDA 94 - Projection UTM MGA Zone 54

Prepared November 2000

Figure 4

AV3: 200454_048



COMAUM-CAROLINE PRESCRIBED WELLS AREA

LOCATION of CURRENT MONITORING WELLS

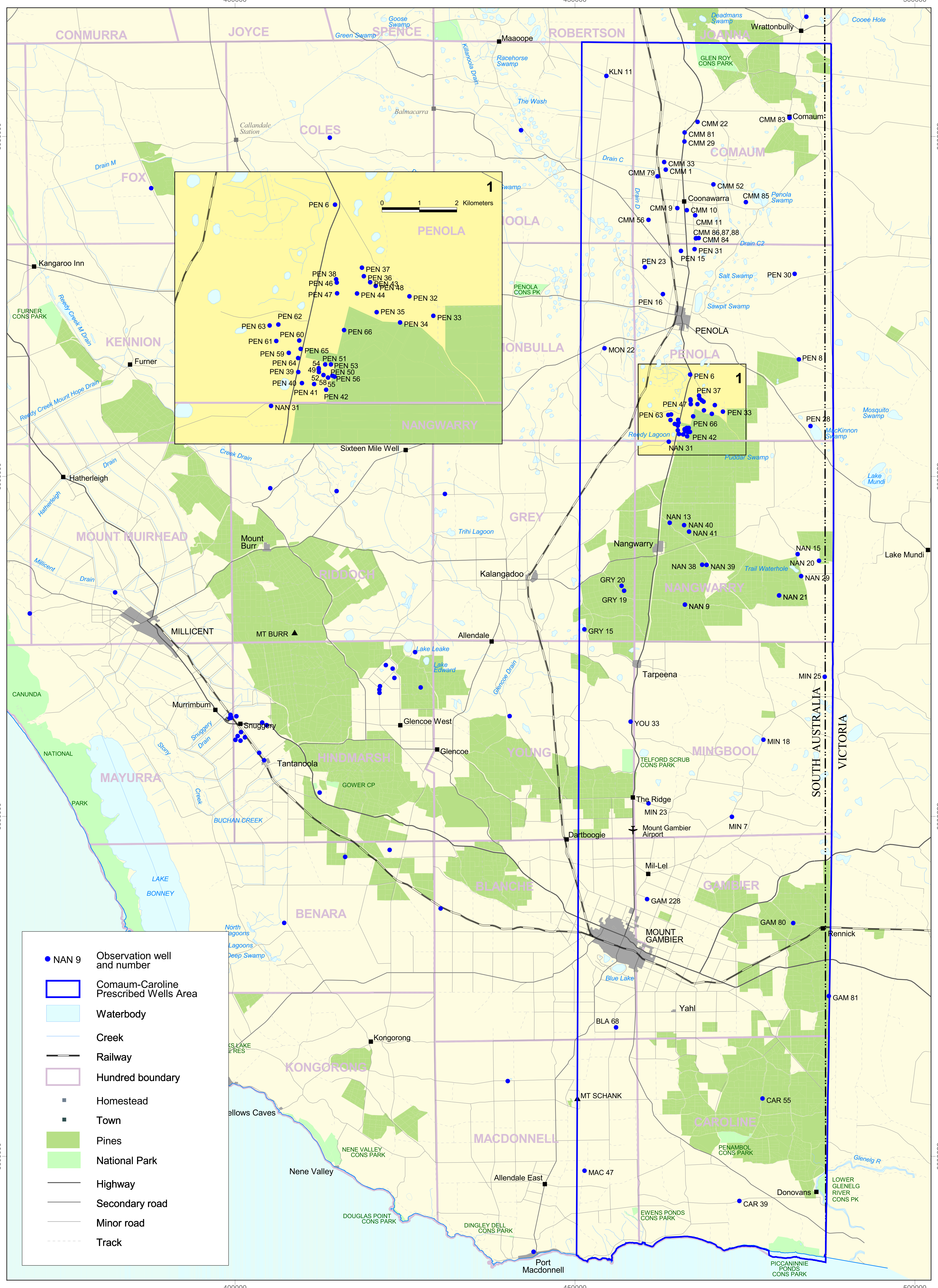
Prepared November 2000

PRIMARY INDUSTRIES AND RESOURCES SA

Government of South Australia

AV3: 200454_049

Figure 5



0 5 10 Kilometers

Datum GDA 94 - Projection UTM MGA Zone 54

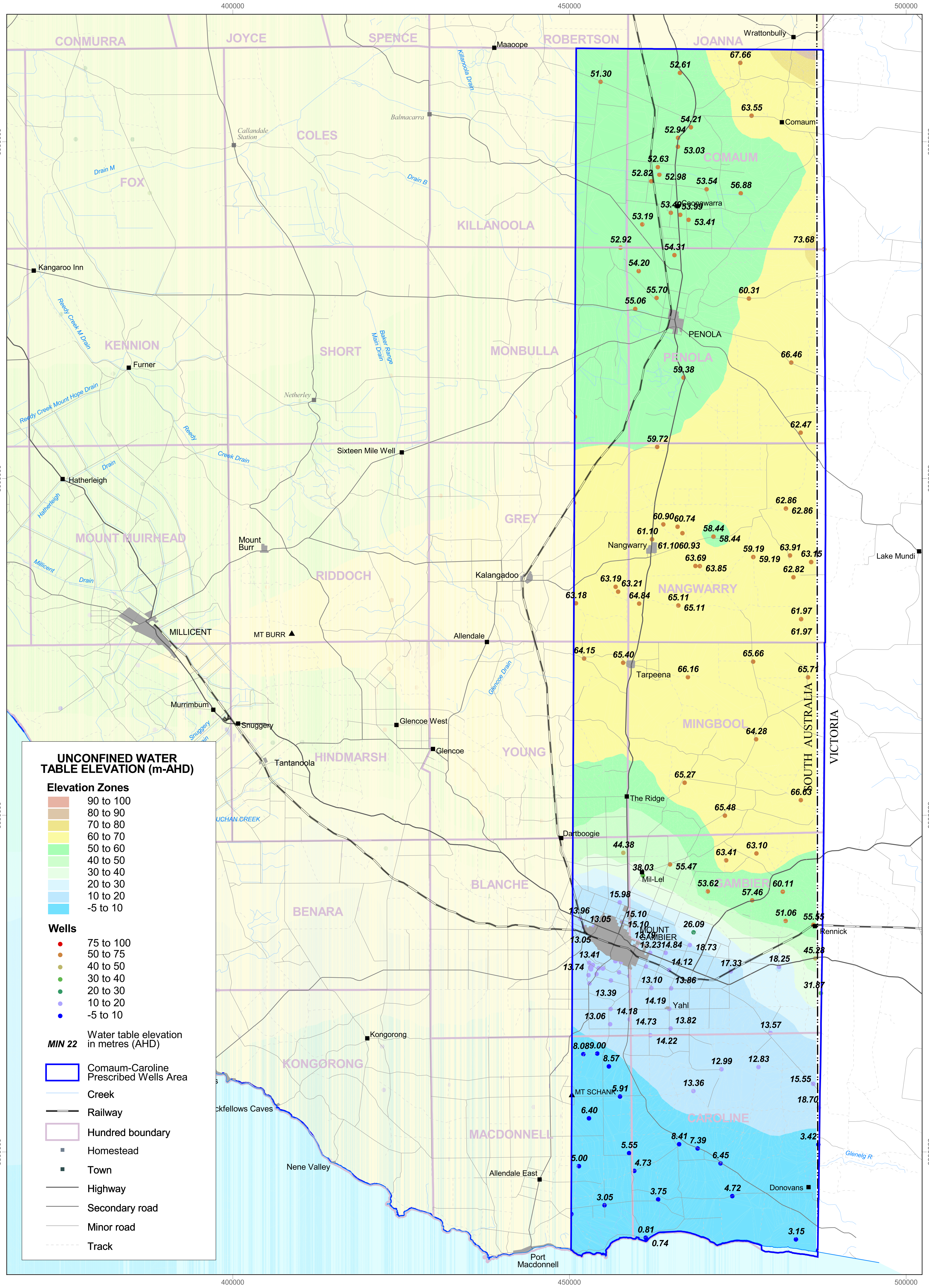
Prepared November 2000

COMAUM-CAROLINE PRESCRIBED WELLS AREA

LOCATION of CURRENT SALINITY MONITORING WELLS

Figure 6

AV3: 200454_050



0 5 10 Kilometers

Datum GDA 94 - Projection UTM MGA Zone 54

Prepared November 2000

COMAUM-CAROLINE PRESCRIBED WELLS AREA

GENERALISED WATER ELEVATION ZONES in UNCONFINED AQUIFER

Water Search

Department for Water Resources

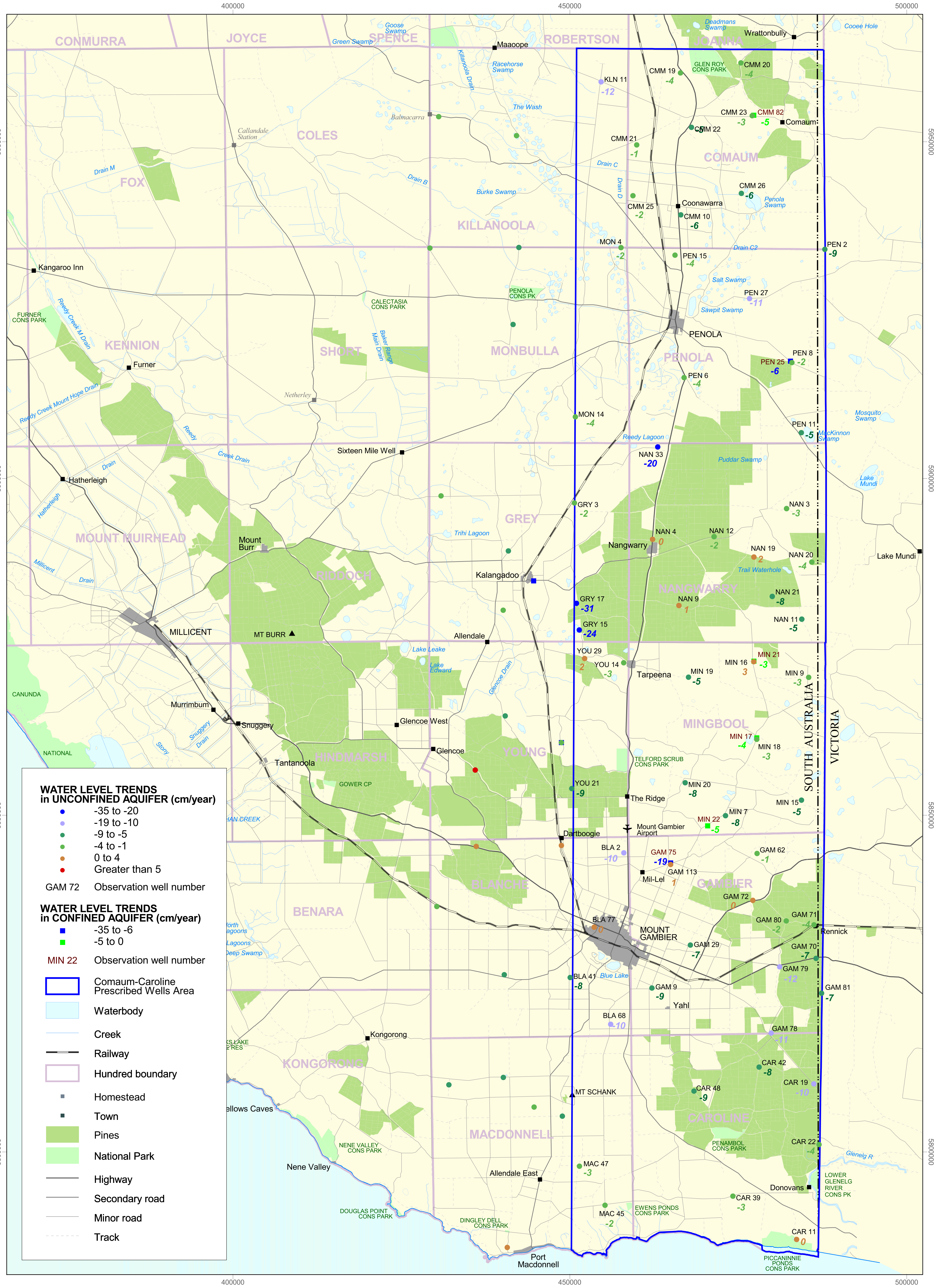
PRIMARY INDUSTRIES AND RESOURCES SA

GDA

Government of South Australia

AV3: 200454_051

Figure 7



Datum GDA 94 - Projection UTM MGA Zone 54

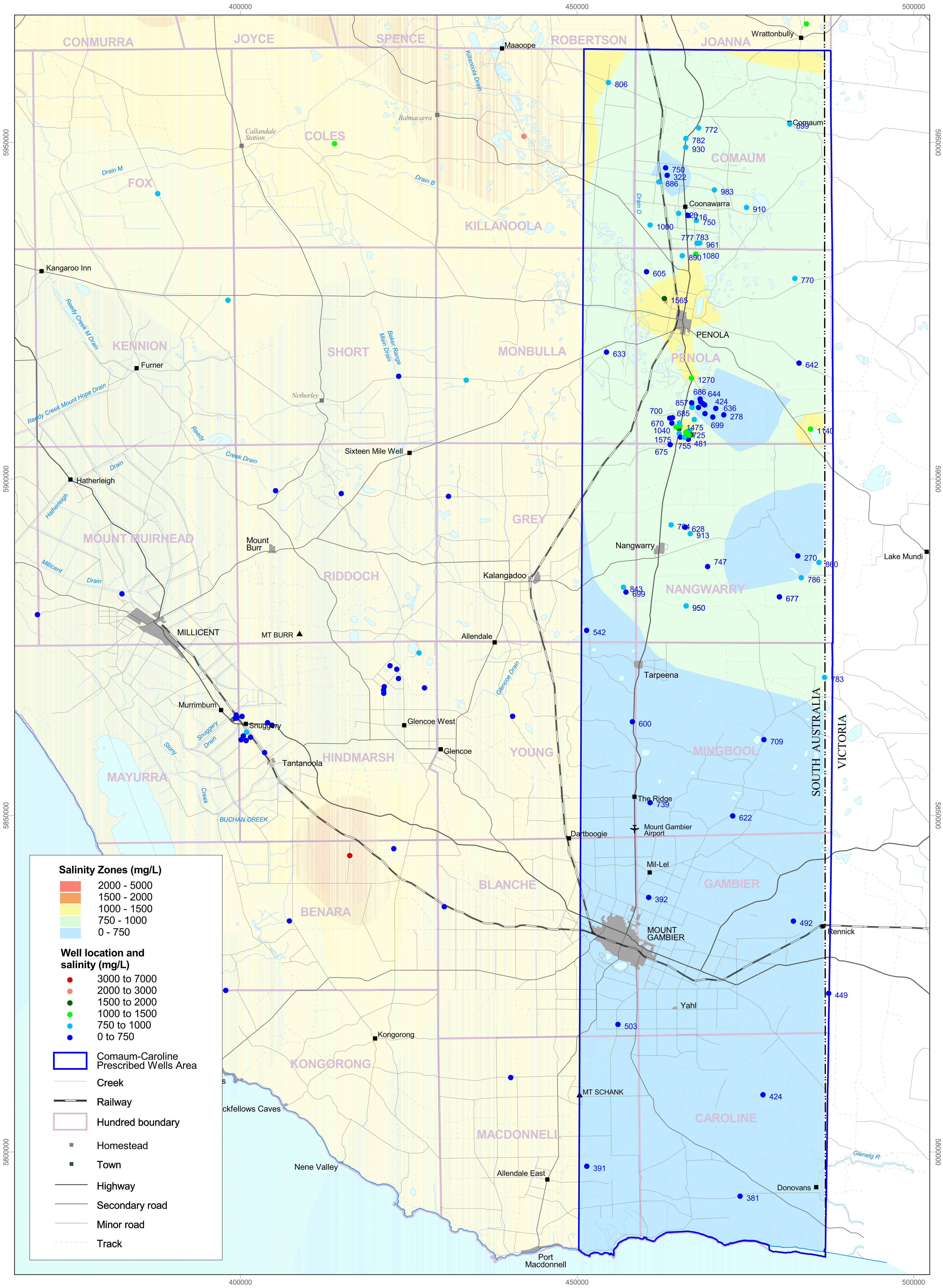
Prepared November 2000

COMAUM-CAROLINE PRESCRIBED WELLS AREA

WATER LEVEL TRENDS to JUNE 2000 in CONFINED and UNCONFINED AQUIFERS

Figure 8

AV3: 200454_052



0 5 10 Kilometers

COMAUM-CAROLINE PRESCRIBED WELLS AREA

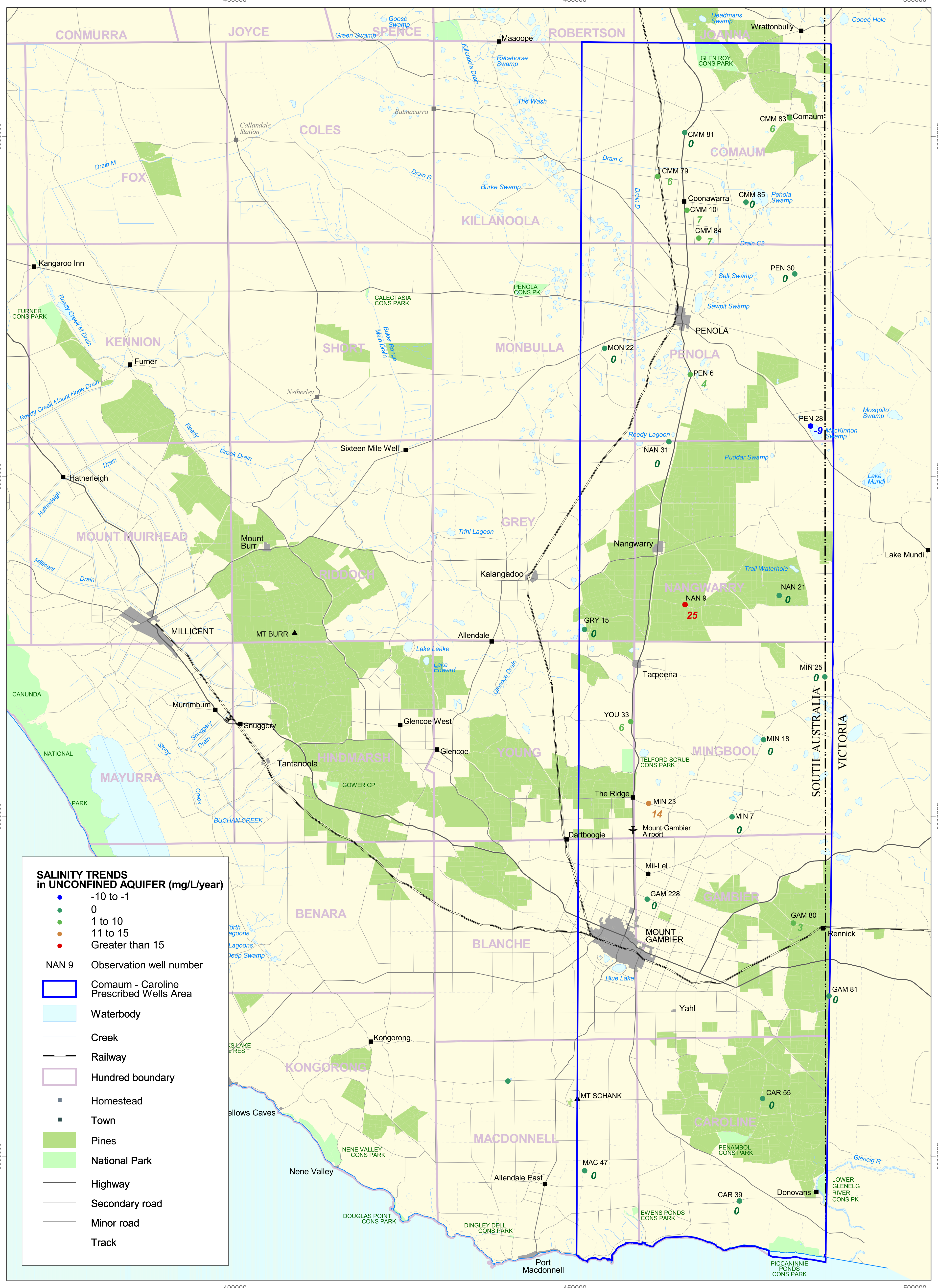
GENERALISED SALINITY DISTRIBUTION in the UNCONFINED AQUIFER

Datum GDA 94 - Projection UTM MGA Zone 54

Prepared November 2000

Figure 9

AV3: 200454_053



0 5 10 Kilometers

Datum GDA 94 - Projection UTM MGA Zone 54

Prepared November 2000

COMAUM - CAROLINE PRESCRIBED WELLS AREA

SALINITY TRENDS in UNCONFINED AQUIFER

Figure 10

AV3: 200454_054

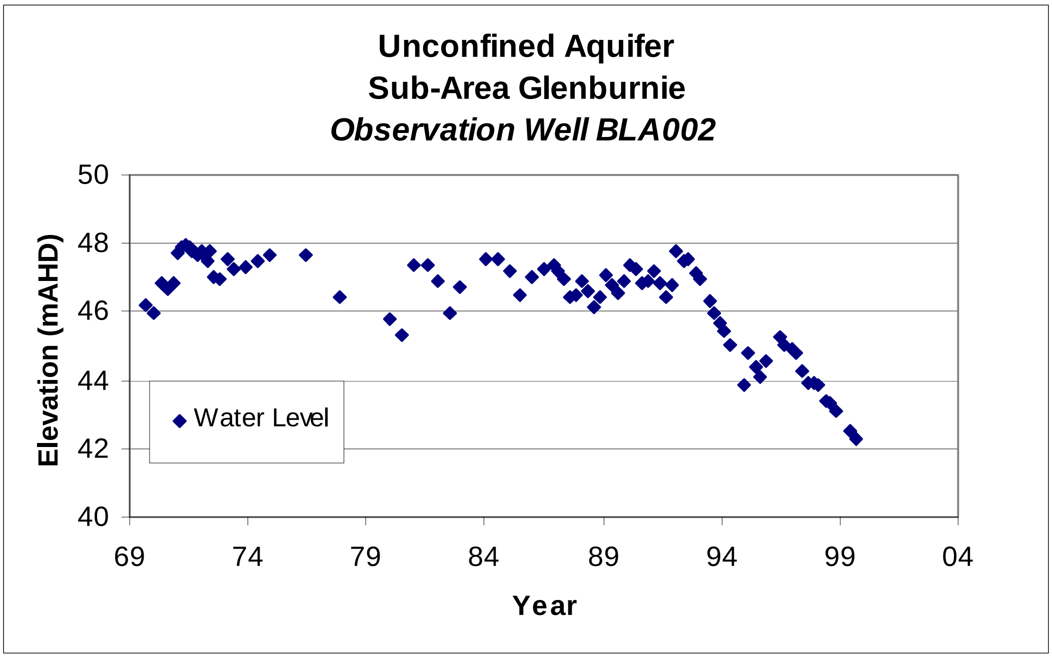
Appendix A

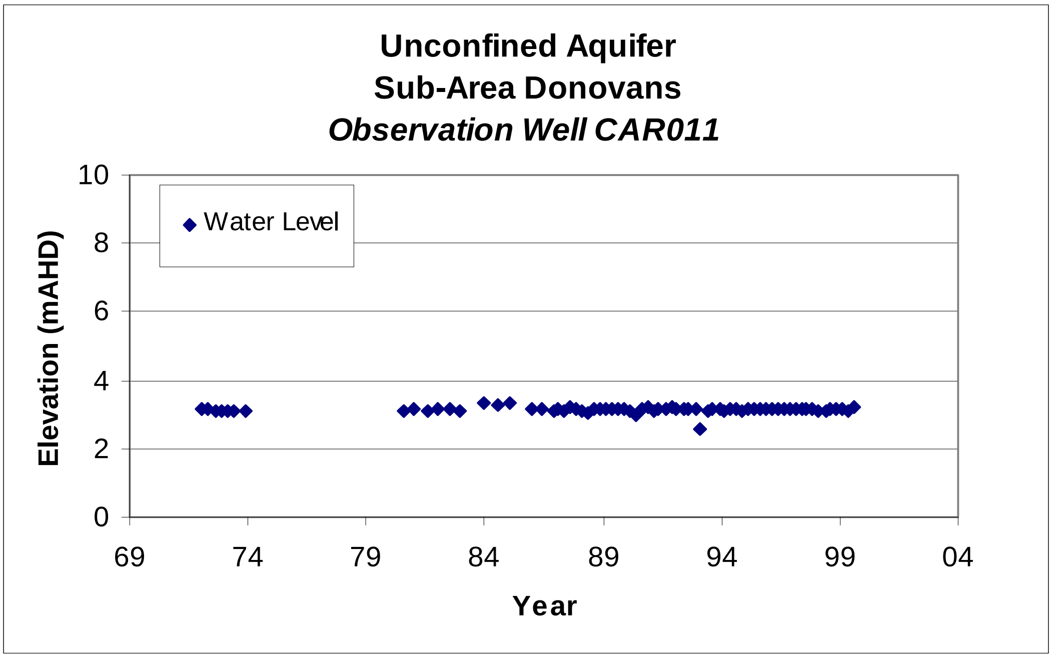
Estimated irrigation requirements and crop area ratios for the Comaum–Caroline Prescribed Wells Area

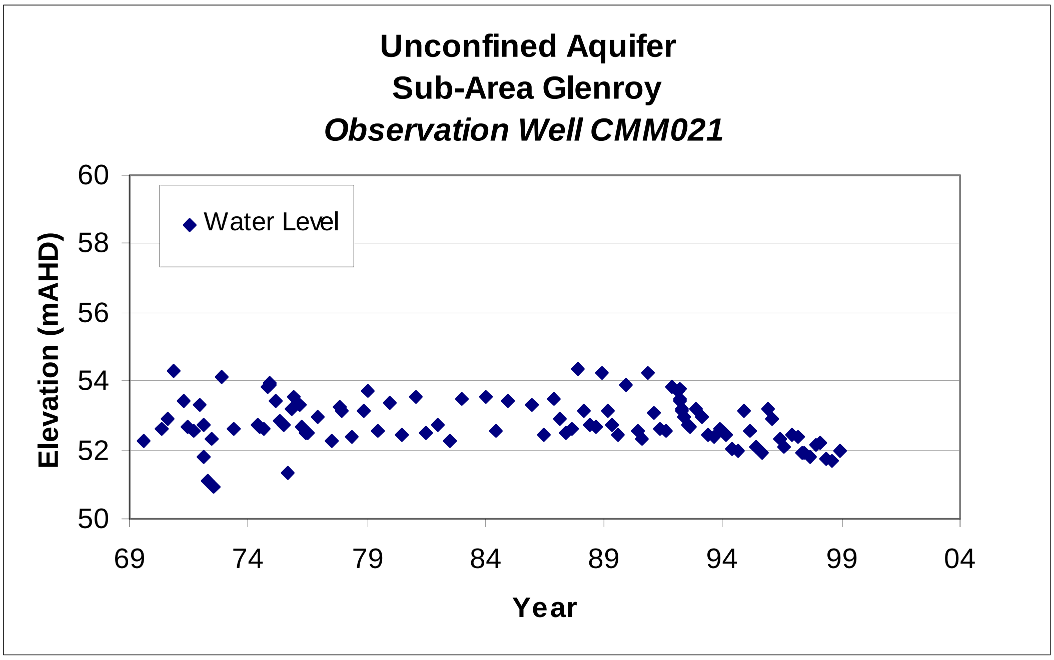
Crop	Irrigation Requirement (mm)				Crop Area Ratio
	Zones				
	1A	2A	3A	4A	
Reference crop	404	440	493	521	1
Annual clover seed	137	151	175	189	2. 9
Beans	81	93	112	124	4. 7
Canola seed	68	77	93	105	5. 6
Cereals	85	96	115	129	3. 7
Coriander seed	68	77	93	105	5. 6
Glasshouses	291	291	291	291	1. 5
Linseed	68	77	93	105	5. 6
Lucerne hay	280	315	363		1. 4
Lucerne seed	252	285	329	350	1. 5
Lupins	81	93	112	124	4. 7
Medic seed	197	215	246	261	2
Millet/Sudax	199	227	266	306	1. 9
Mustard seed	68	77	93	105	5. 6
Native flowers	70	70	70	70	5. 9
Nut trees	269	298	341		1. 5
Onions	319	348	387	496	1. 3
Pasture	404	440	493	521	1
Pasture starter	50	50	50		8. 9
Peas	81	93	112	124	4. 7
Perennial clover seed	261	289	335	359	1. 5
Primrose	68	77	93	105	5. 6
Potatoes	352	384	394	438	1. 2
Small horticultural holding	195	195	195		2. 3
Sunflower	238	262	296	313	1. 7
Vines			213	242	2. 3

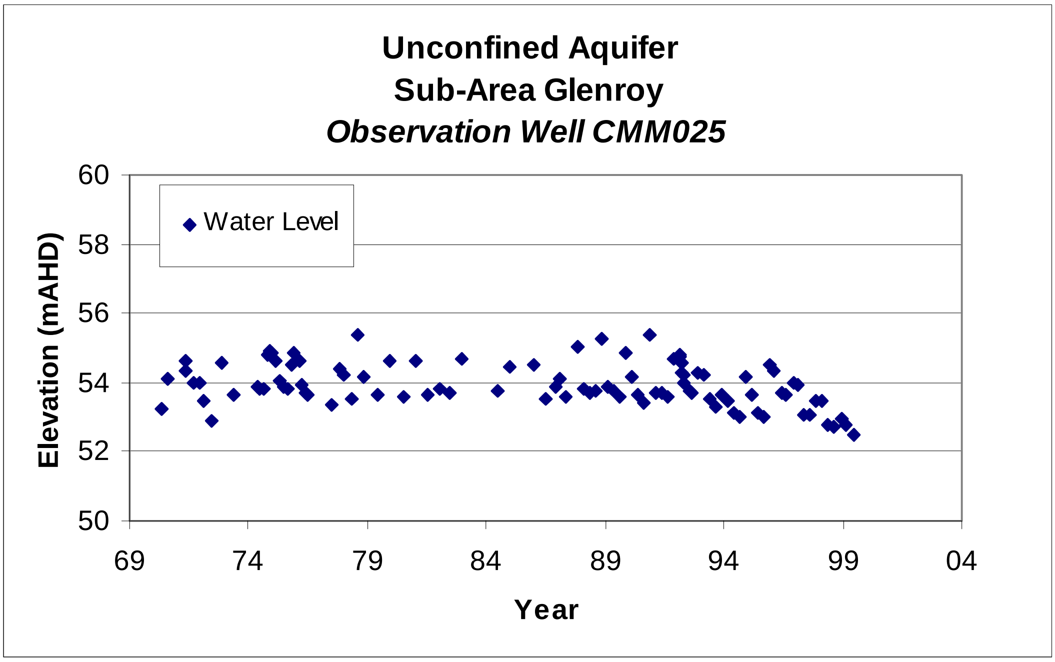
Appendix B

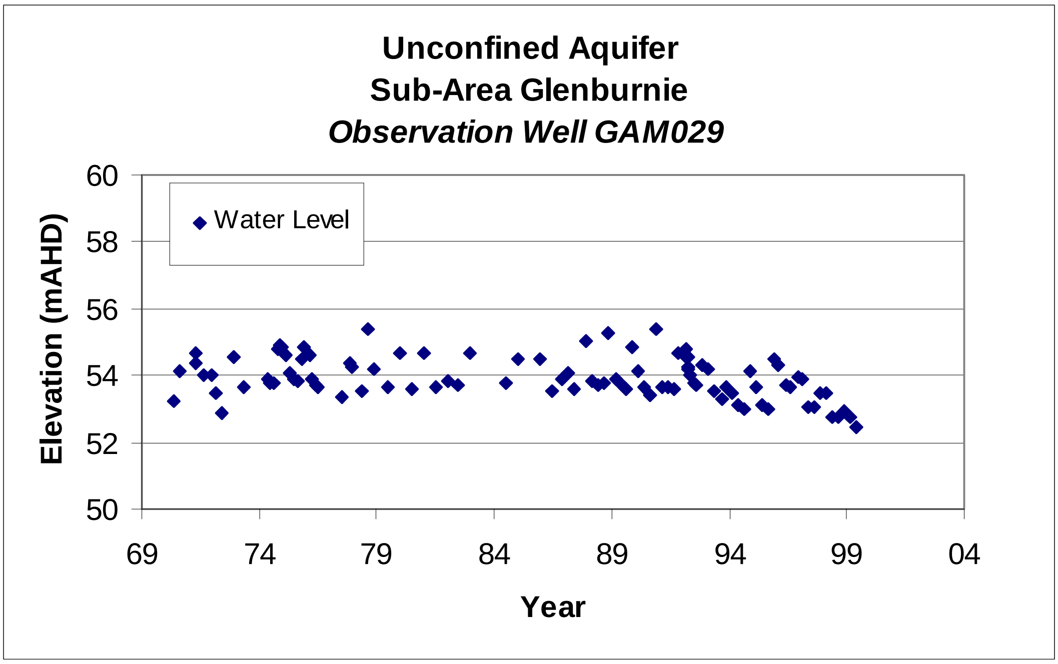
Bore hydrographs and salinity graphs

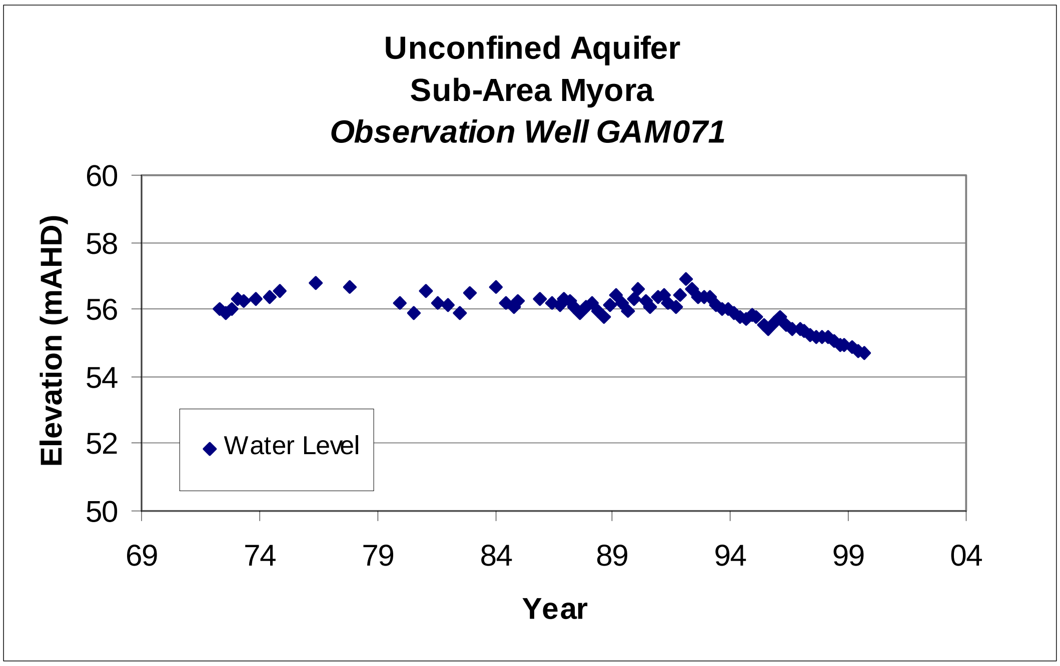

Unconfined Aquifer
Sub-Area Glenburnie
Observation Well BLA002
Elevation (mAHD)
50
48
46
44
42
40
Water Level
69
74
79
84
89
94
99
04
Year


Unconfined Aquifer
Sub-Area Donovans
Observation Well CAR011
Elevation (mAHD)
10
8
6
4
2
0
Water Level
69
74
79
84
89
94
99
04
Year


Unconfined Aquifer
Sub-Area Glenroy
Observation Well CMM021
Water Level
Elevation (mAHD)
60
58
56
54
52
50
69
74
79
84
89
94
99
04
Year


Unconfined Aquifer
Sub-Area Glenroy
Observation Well CMM025
Water Level
Elevation (mAHD)
60
58
56
54
52
50
69
74
79
84
89
94
99
04
Year


Unconfined Aquifer
Sub-Area Glenburnie
Observation Well GAM029
Water Level
Elevation (mAHD)
60
58
56
54
52
50
69
74
79
84
89
94
99
04
Year


Unconfined Aquifer
Sub-Area Myora
Observation Well GAM071
Water Level
Elevation (mAHD)
60
58
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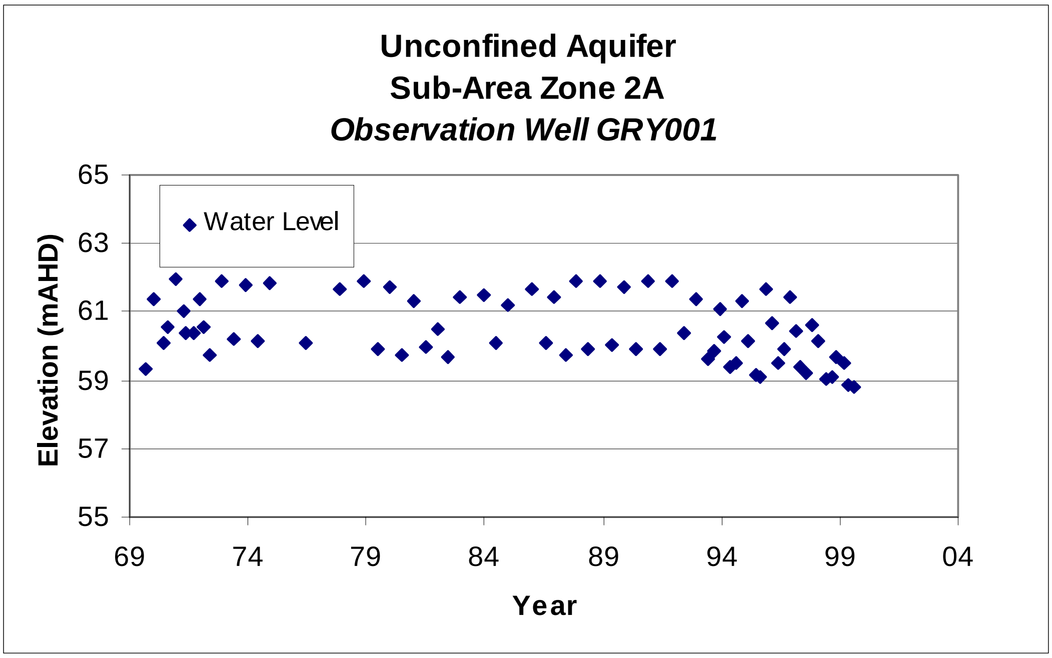
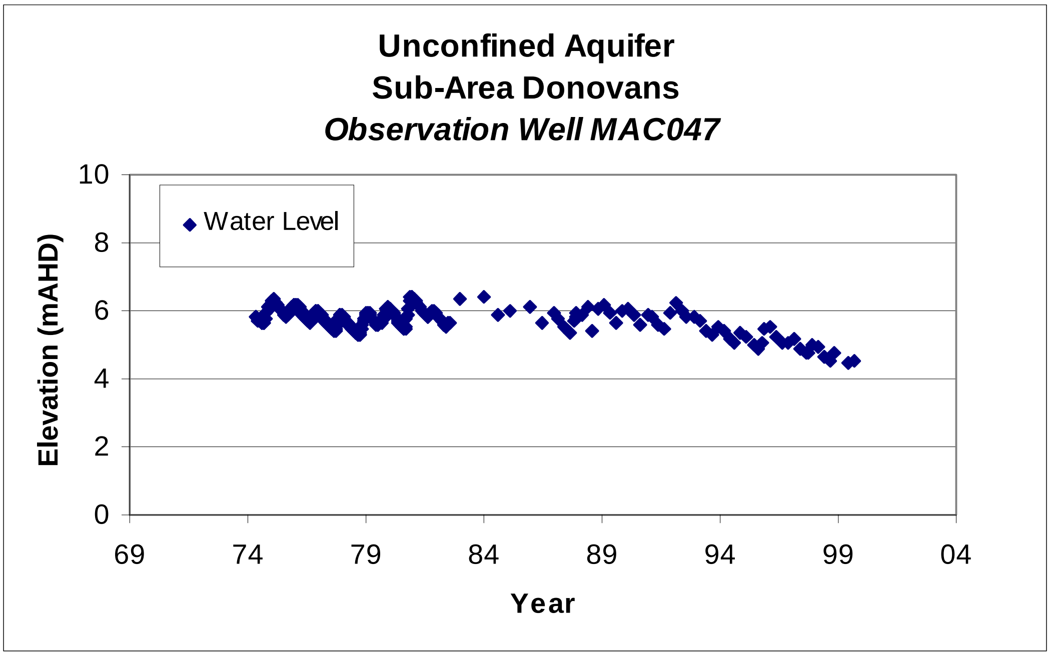
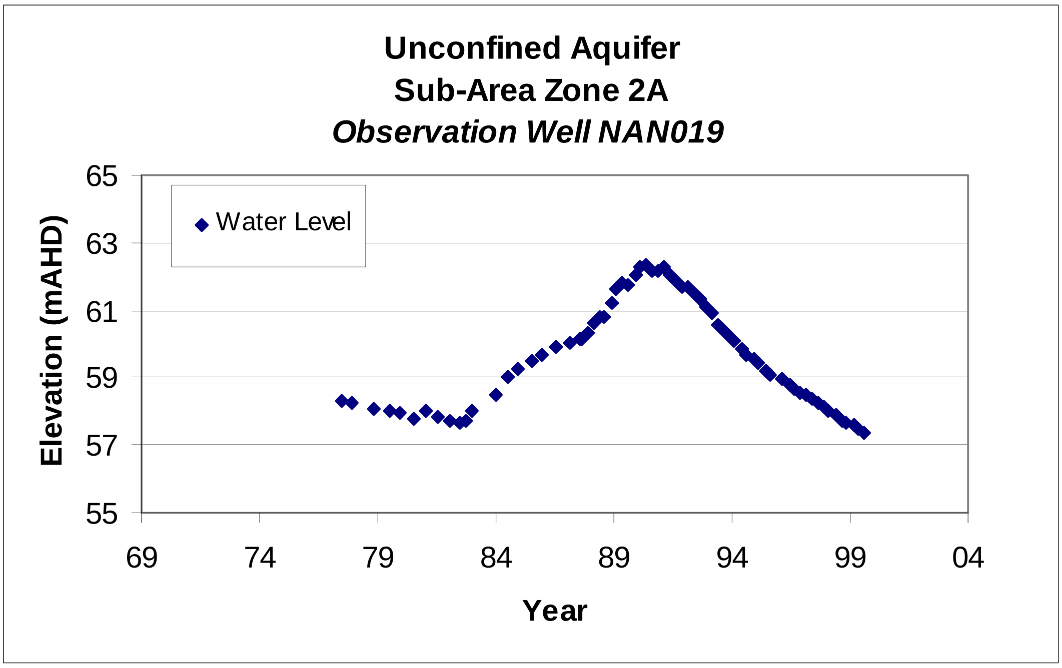
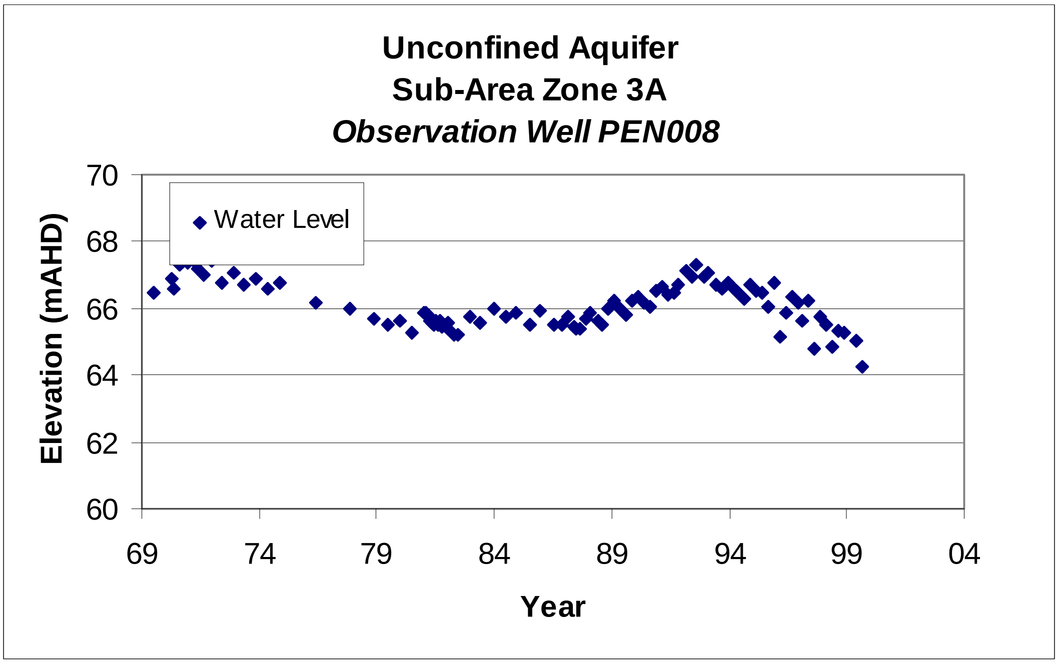
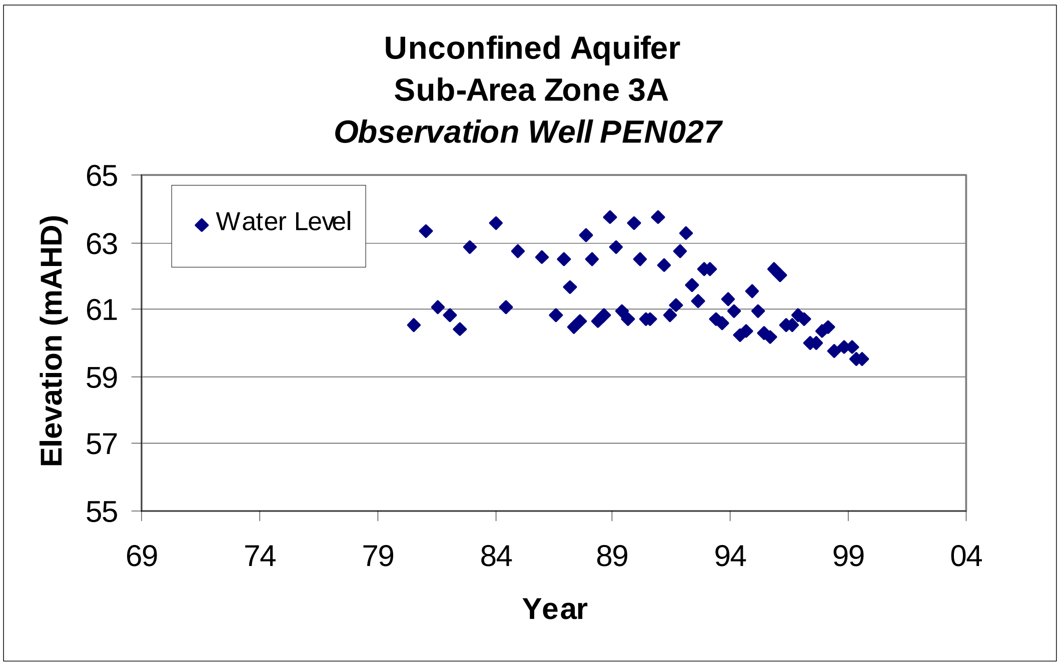
54
52
50
69
74
79
84
89
94
99
04
Year

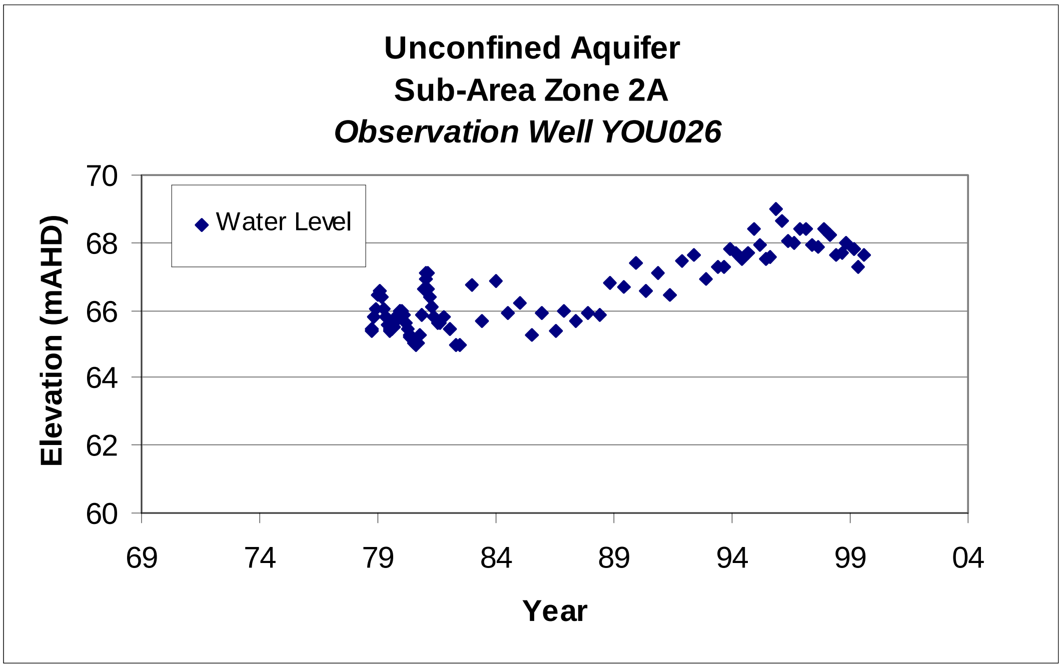

Unconfined Aquifer
Sub-Area Zone 2A
Observation Well GRY001
Water Level
Elevation (mAHD)
65
63
61
59
57
55
69
74
79
84
89
94
99
04
Year

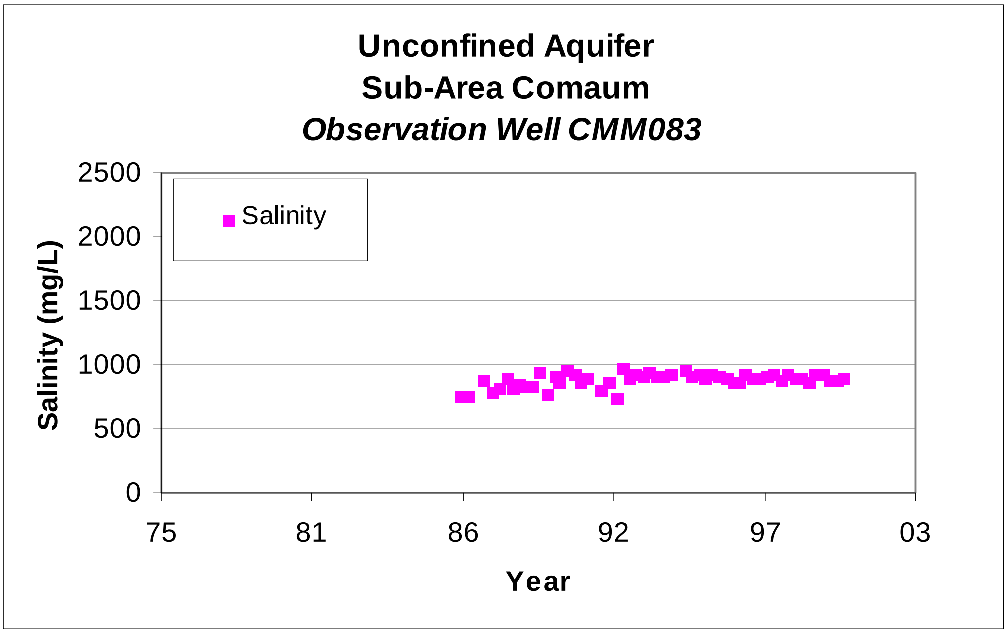

Unconfined Aquifer
Sub-Area Donovans
Observation Well MAC047
Water Level
Elevation (mAHD)
10
8
6
4
2
0
69
74
79
84
89
94
99
04
Year

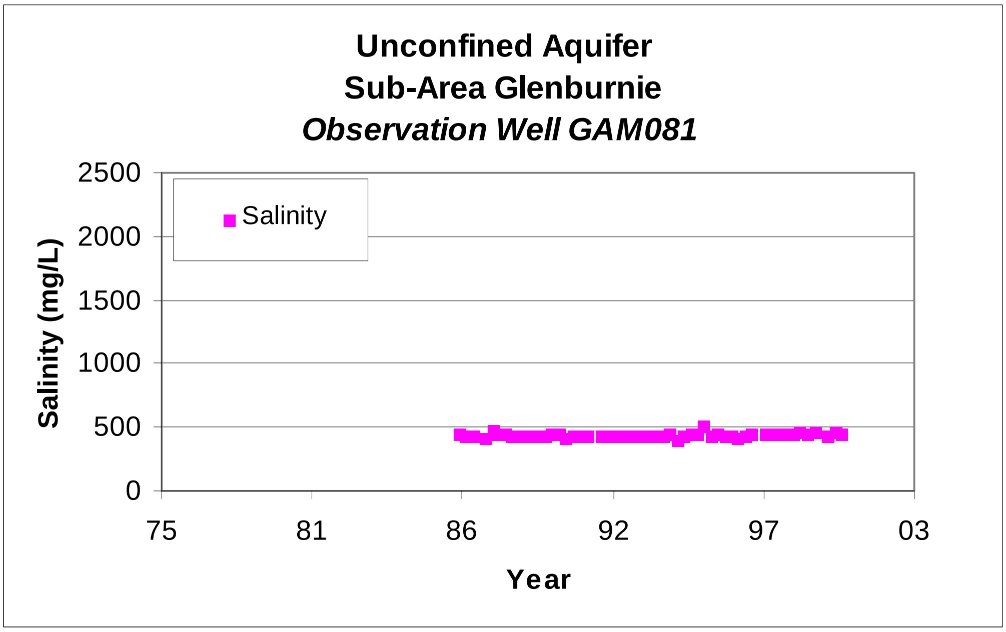

Unconfined Aquifer
Sub-Area Zone 2A
Observation Well NAN019
Water Level
Elevation (mAHD)
65
63
61
59
57
55
69
74
79
84
89
94
99
04
Year

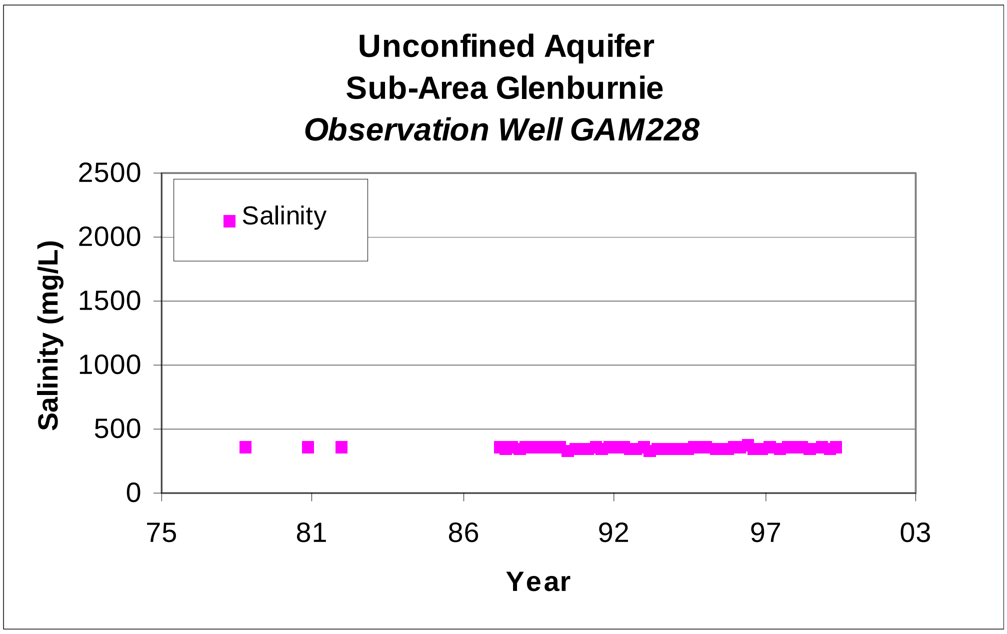

Unconfined Aquifer
Sub-Area Zone 3A
Observation Well PEN008
Water Level
Elevation (mAHD)
70
68
66
64
62
60
69
74
79
84
89
94
99
04
Year

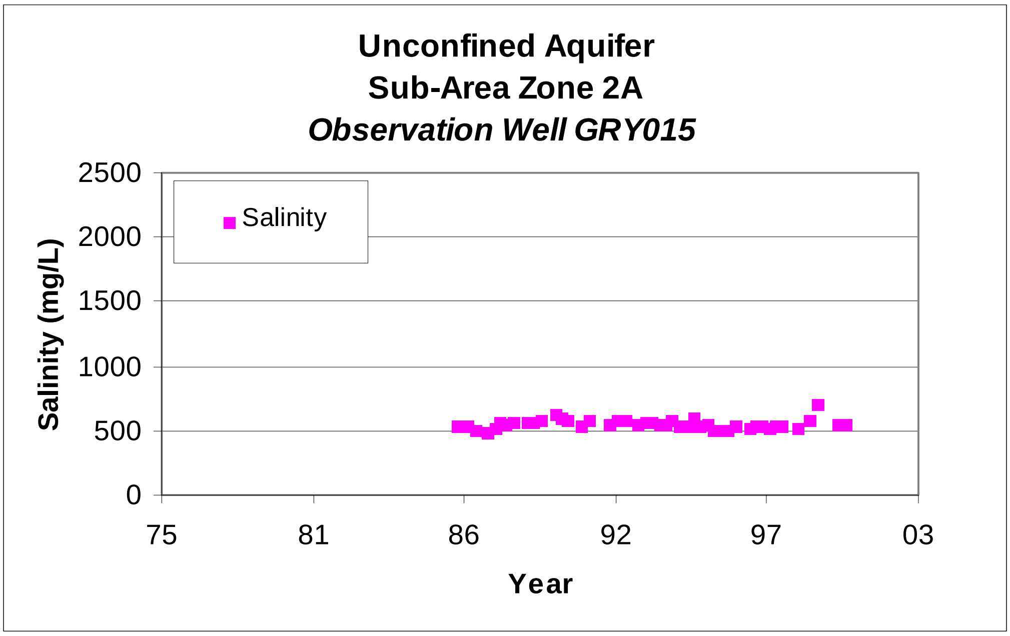

Unconfined Aquifer
Sub-Area Zone 3A
Observation Well PEN027
Water Level
Elevation (mAHD)
65
63
61
59
57
55
69
74
79
84
89
94
99
04
Year

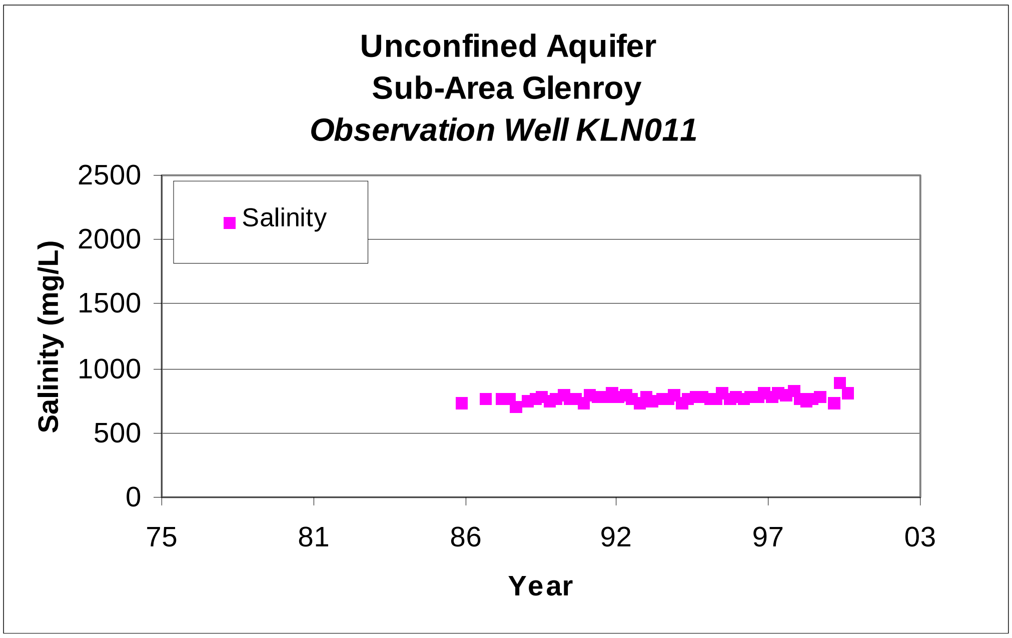

Unconfined Aquifer
Sub-Area Zone 2A
Observation Well YOU026
Water Level
Elevation (mAHD)
70
68
66
64
62
60
69
74
79
84
89
94
99
04
Year

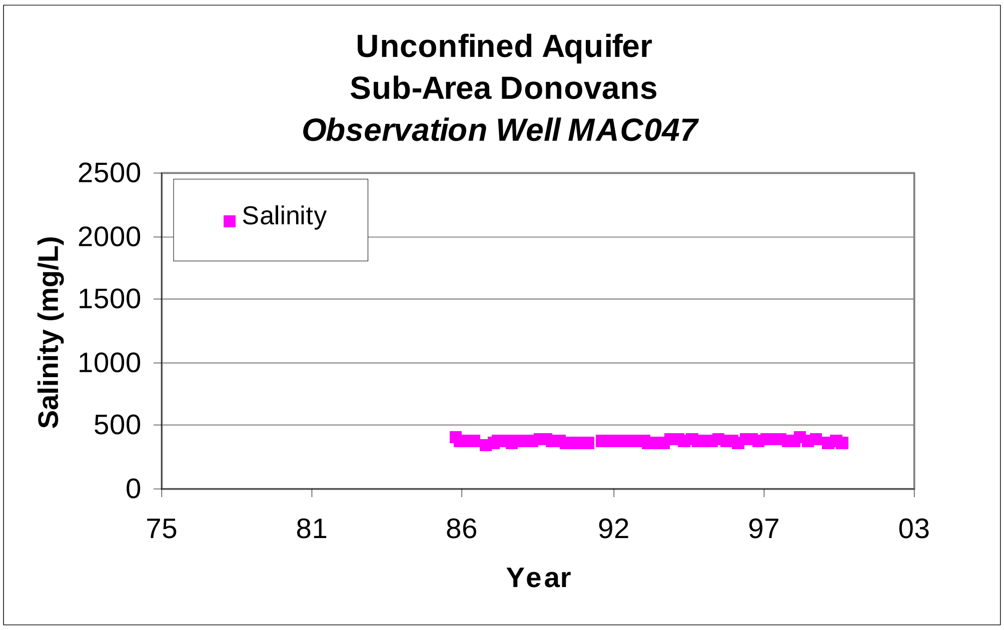

Unconfined Aquifer
Sub-Area Comaum
Observation Well CMM083
Salinity (mg/L)
2500
2000
1500
1000
500
0
Salinity
75
81
86
92
97
03
Year

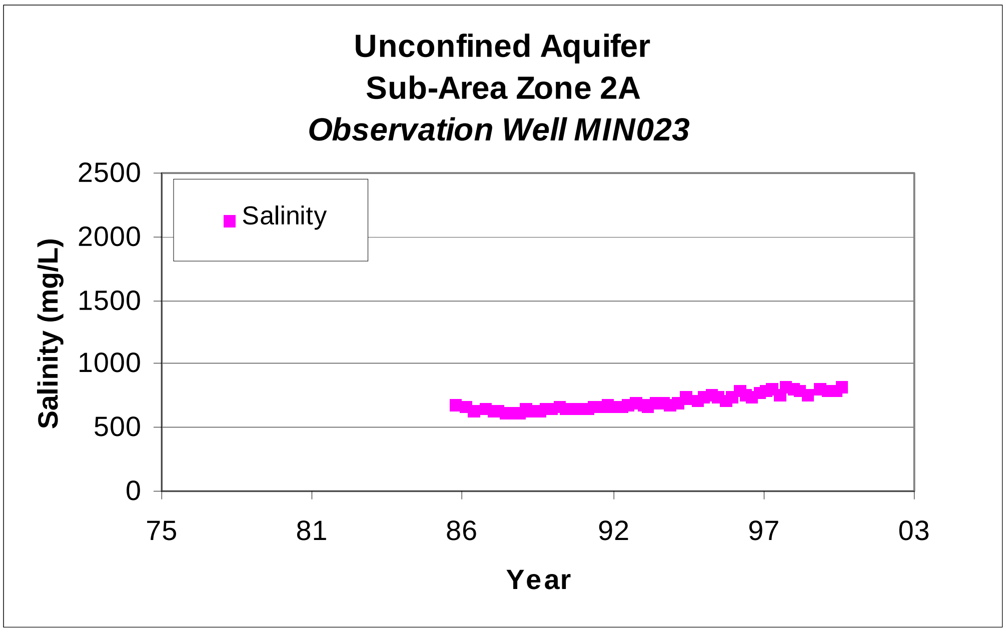

Unconfined Aquifer
Sub-Area Glenburnie
Observation Well GAM081
Salinity (mg/L)
2500
2000
1500
1000
500
0
Salinity
75
81
86
92
97
03
Year

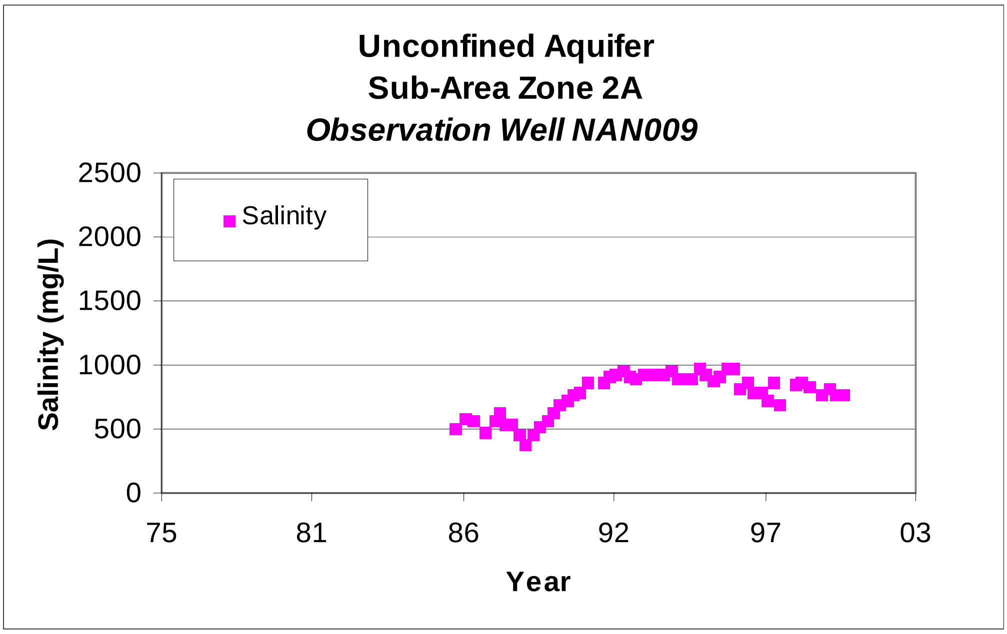

Unconfined Aquifer
Sub-Area Glenburnie
Observation Well GAM228
Salinity
Salinity (mg/L)
2500
2000
1500
1000
500
0
75
81
86
92
97
03
Year

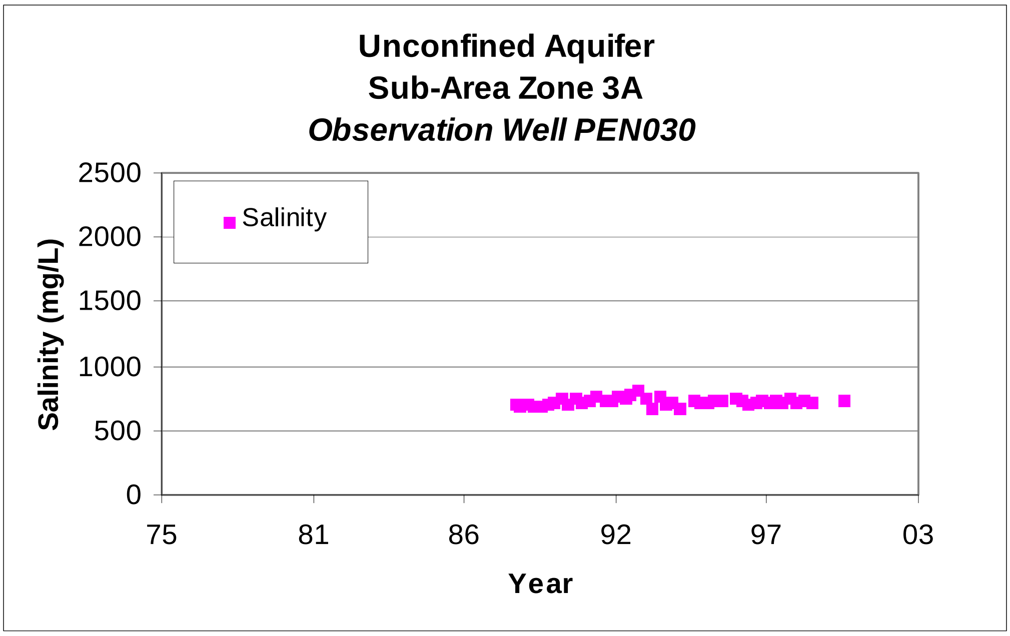

Unconfined Aquifer
Sub-Area Zone 2A
Observation Well GRY015
Salinity
Salinity (mg/L)
2500
2000
1500
1000
500
0
75
81
86
92
97
03
Year


Unconfined Aquifer
Sub-Area Glenroy
Observation Well KLN011
Salinity (mg/L)
2500
2000
1500
1000
500
0
Salinity
75
81
86
92
97
03
Year

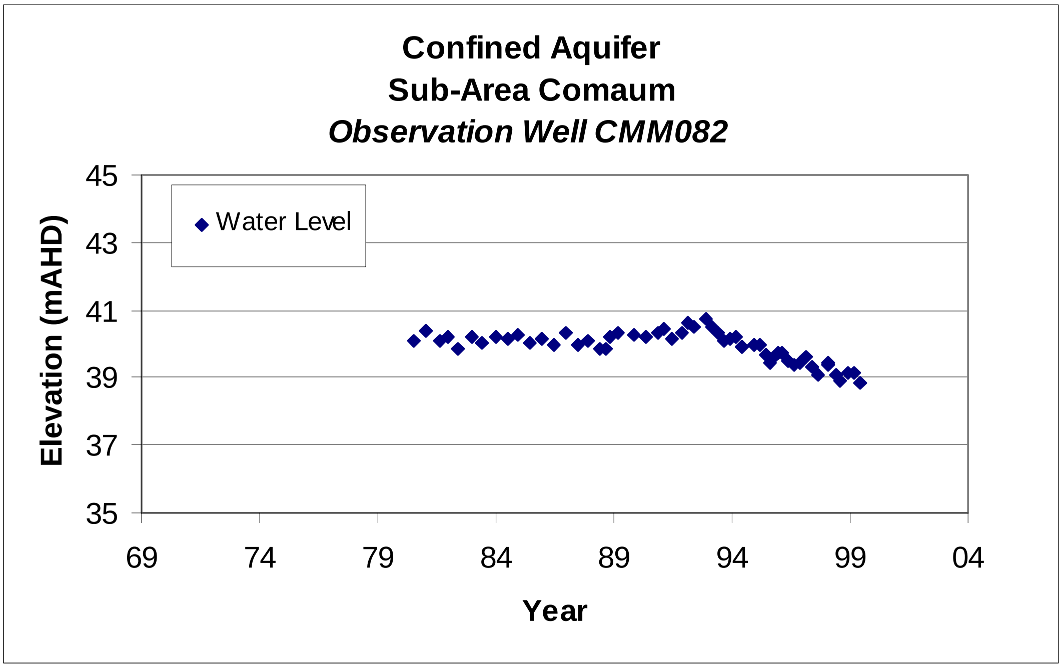

Unconfined Aquifer
Sub-Area Donovans
Observation Well MAC047
Salinity (mg/L)
2500
2000
1500
1000
500
0
Salinity
75
81
86
92
97
03
Year


Unconfined Aquifer
Sub-Area Zone 2A
Observation Well MIN023
Salinity
Salinity (mg/L)
2500
2000
1500
1000
500
0
75
81
86
92
97
03
Year

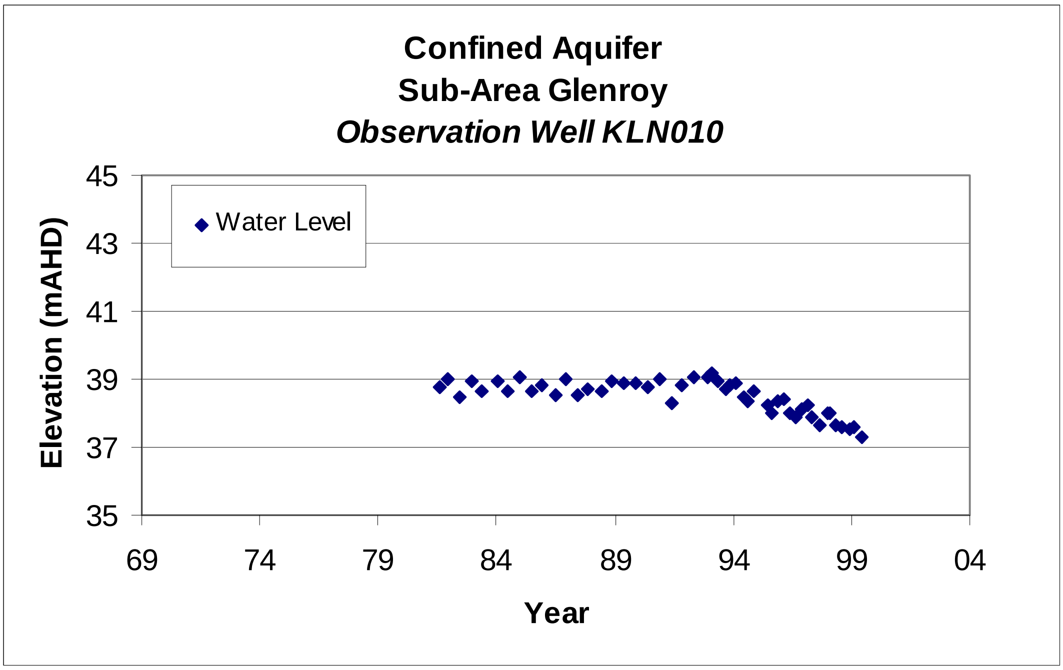

Unconfined Aquifer
Sub-Area Zone 2A
Observation Well NAN009
Salinity
Salinity (mg/L)
2500
2000
1500
1000
500
0
75
81
86
92
97
03
Year

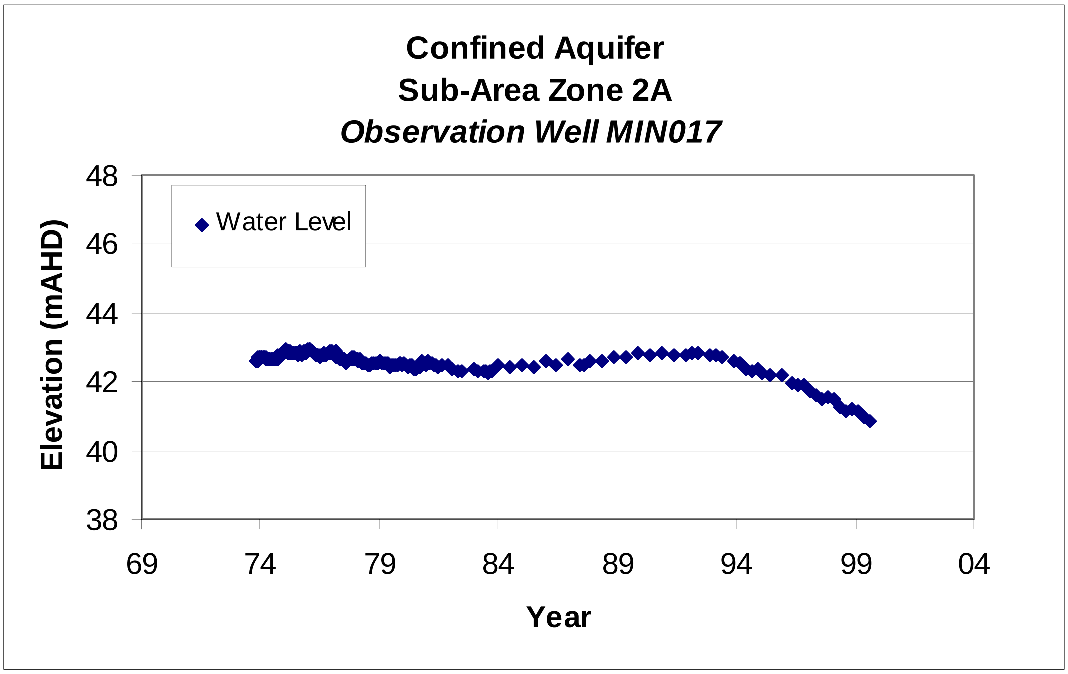


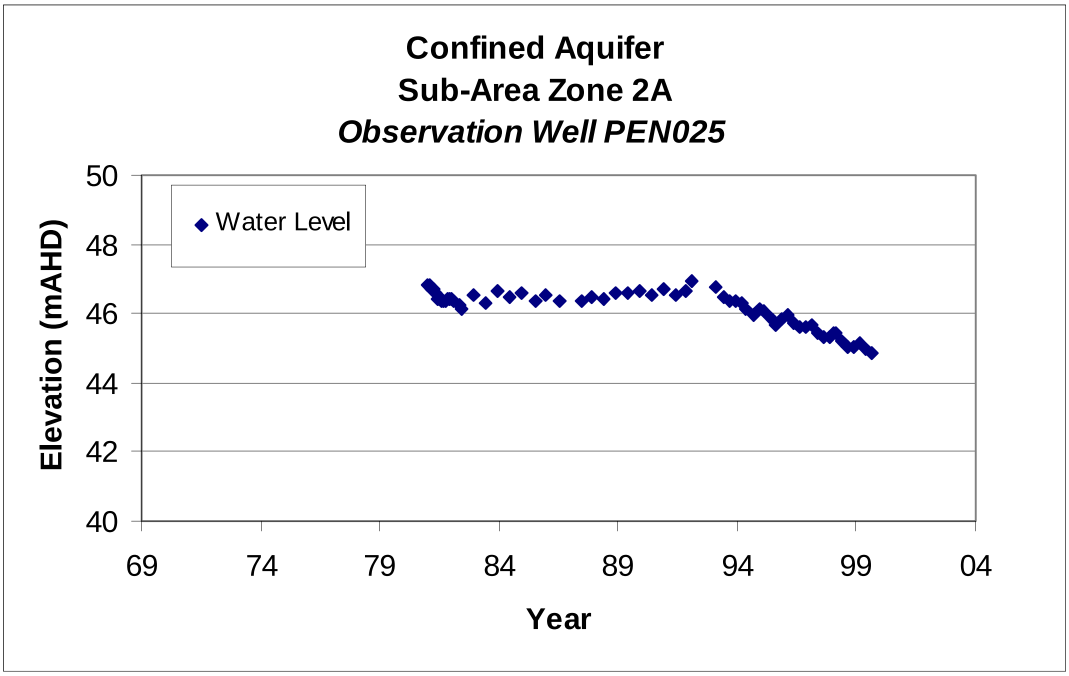
Unconfined Aquifer
Sub-Area Zone 3A
Observation Well PEN030
Salinity
Salinity (mg/L)
2500
2000
1500
1000
500
0
75
81
86
92
97
03
Year

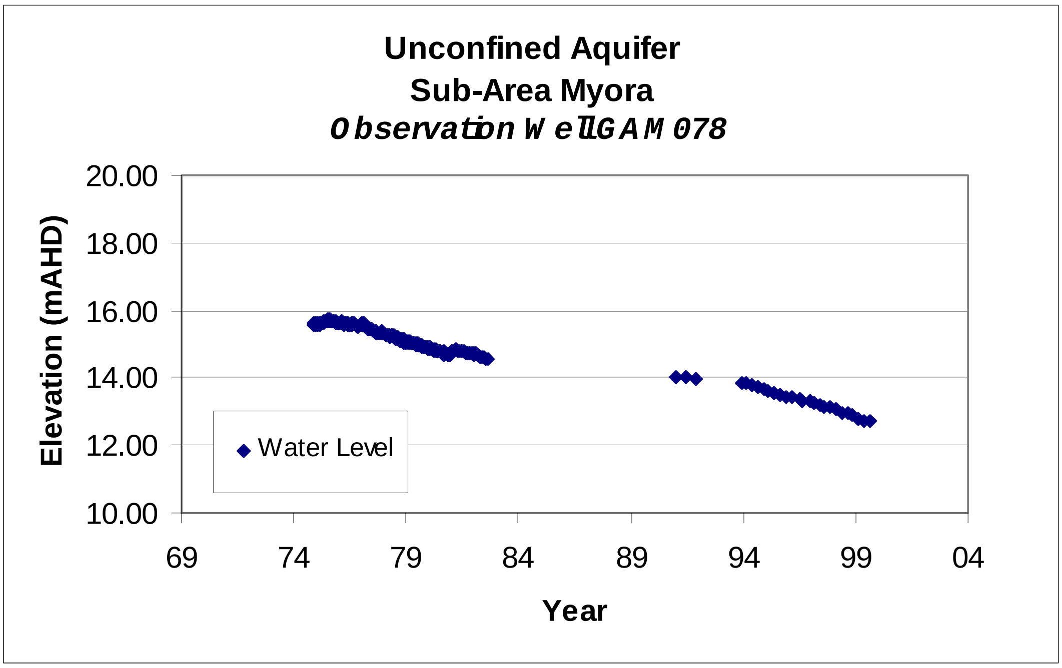


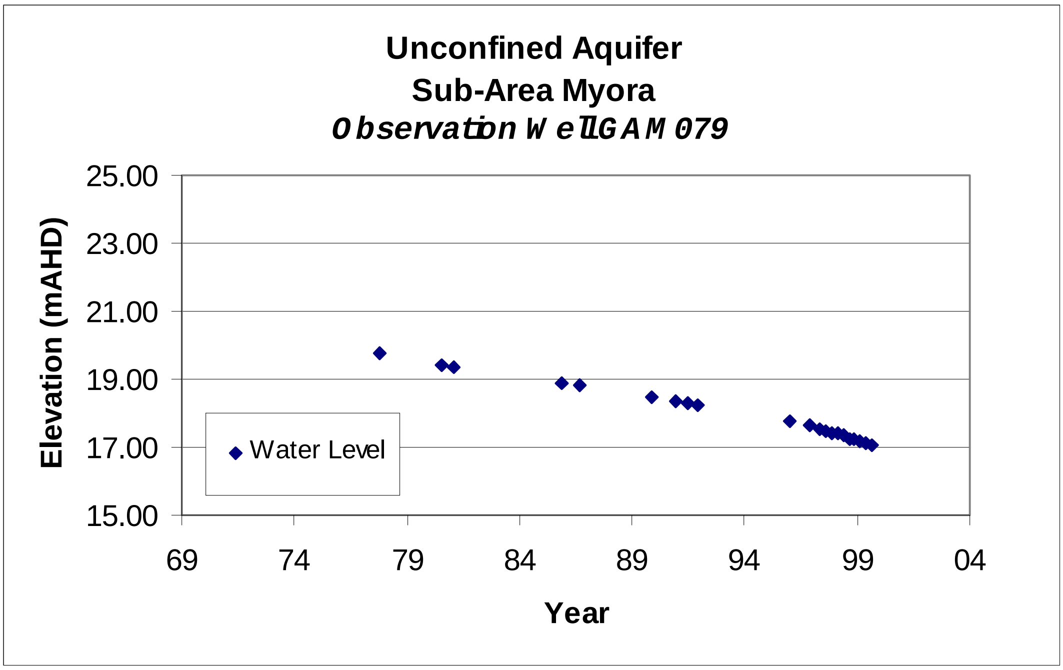
Confined Aquifer
Sub-Area Comaum
Observation Well CMM082
Water Level
Elevation (mAHD)
45
43
41
39
37
35
69
74
79
84
89
94
99
04
Year

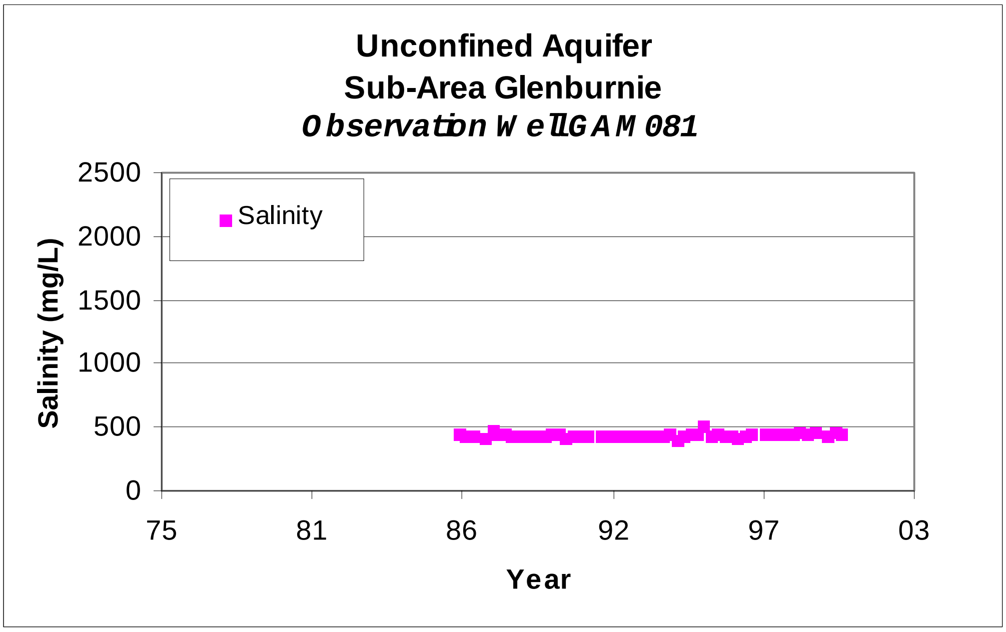

Confined Aquifer
Sub-Area Glenroy
Observation Well KLN010
Elevation (mAHD)
45
43
41
39
37
35
Water Level
69
74
79
84
89
94
99
04
Year


Confined Aquifer
Sub-Area Zone 2A
Observation Well MIN017
Elevation (mAHD)
48
46
44
42
40
38
Water Level
69
74
79
84
89
94
99
04
Year


Confined Aquifer
Sub-Area Zone 2A
Observation Well PEN025
Water Level
Elevation (mAHD)
50
48
46
44
42
40
69
74
79
84
89
94
99
04
Year


Unconfined Aquifer
Sub-Area Myora
Observation Well GAM078
Water Level
Elevation (mAHD)
20.00
18.00
16.00
14.00
12.00
10.00
69
74
79
84
89
94
99
04
Year


Unconfined Aquifer
Sub-Area Myora
Observation Well GAM 079
Elevation (mAHD)
25.00
23.00
21.00
19.00
17.00
15.00
Water Level
69
74
79
84
89
94
99
04
Year


Unconfined Aquifer
Sub-Area Glenburnie
Observation Well GAM 081
Salinity (mg/L)
2500
2000
1500
1000
500
0
Salinity
75
81
86
92
97
03
Year

Appendix C

Stock water use consumption figures

Sheep (dry pasture)	7 Litres/Head
Sheep (irrigated pasture)	4 Litres/Head
Lambs (dry pasture)	2.5 Litres/Head
Lambs (irrigated pasture)	1 Litres/Head
Beef Cattle	45 Litres/Head
Calves	23 Litres/Head
Dairy Cattle (in lactation)	68 Litres/Head
Dairy Cattle (dry)	45 Litres/Head
Horses (working)	55 Litres/Head
Horses (grazing)	36 Litres/Head
Sows	23 Litres/Head
Pigs	11 Litres/Head
Poultry (100)	3.2 Litres/Head
Turkeys (100)	5.5 Litres/Head