# South Australian – Victorian Border Groundwaters Agreement Review Committee

Government of South Australia

State Government Victoria

Management Review
Tertiary Limestone Aquifer and Tertiary Confined Sand Aquifer in Province 1 of the Designated Area

**Melbourne and Adelaide**

**May 2008**

# Foreword

The Border Groundwaters Agreement (the Agreement) was established in 1985 to make provision to protect the groundwater resources adjacent to the South Australia and Victoria border and to provide for the co-operative management and equitable sharing of those resources and to guard against their undue depletion or degradation.

The 'Designated Area' established by the Agreement is a 40 kilometre wide strip centred on the border and extending for its full length. This Designated Area is divided into 22 zones, 11 in each State. There are three hydrogeological provinces as shown in Figure 1.

The Border Groundwater Agreement Review Committee (the Committee) is required to review certain management prescriptions at periods not exceeding intervals of five years. The Committee advised the Ministers of the outcomes of the formal review in May and June 2007 and advised that it would provide further discussion and advice on the significant management issues in each province.

This document consolidates the Committee's new understanding of the resources and makes recommendations on the strategic direction and a range of other actions to be undertaken in Province 1.

A summary of the historical management framework relating to Province 1 is set out in the Appendix to this report.

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# 1. Overview

Groundwater is the only source of water for industry and municipal use in the region. Industries including forestry, viticulture, dairy and associated secondary industries depend on groundwater availability for their ventures. The current management settings are based on the premise that this resource is renewable.

Province 1 has two prime regional groundwater aquifers: the unconfined Tertiary Limestone Aquifer and the underlying Tertiary Confined Sand Aquifer.

It was recognised during the Committee's previous review (BGARC 2001) that water levels in both the Tertiary Limestone Aquifer and the Tertiary Confined Sand Aquifer in various parts of Province 1 were experiencing long term declines. Whilst generally the groundwater entitlements were within the Permissible Annual Volumes for the Tertiary Limestone Aquifer and the Tertiary Confined Sand Aquifer, further information was needed to establish the causes of these declines and the relative impacts groundwater extraction, climate variability and land use were having on the declines.

The Committee recommended to the Contracting Governments that metering be implemented and that research be undertaken to identify the reasons for the water level declines. Since 2001 a range of technical investigations have been undertaken and are summarised in the report SKM (2007).

It is now apparent from the investigations carried out since 2001 that the original assumptions on which the Permissible Annual Volumes were based did not fully take into account the structure within the Tertiary Limestone Aquifer giving rise to a variety of groundwater flow patterns.

The current mix of land use and groundwater extractions is clearly out of balance and is not sustainable in the longer term. The preliminary estimates of the quantities of the water utilised by plantation forestry is a significant component of the regional water balance being some three times that used for irrigation purposes. A new management approach is needed to achieve long-term sustainability. This is likely to require reductions in both the area under plantation forestry and the volume extracted via bores under groundwater entitlements.

In the immediate term the Committee has proposed a management strategy to address four key issues. These are:

- water accounting;
- interaquifer connection;
- seawater intrusion; and
- aquifer depletion.

An integrated water accounting system encompassing all of the major users is essential. It is noted that each of the States has recognised this requirement but to date a coordinated system has yet to be developed. The Committee recommends, in accordance with clause 21 of the Agreement, that the two States develop a consistent approach to account for the water utilised by plantation forestry. The Committee recommends that the States introduce a moratorium on new plantation developments and maintain the moratorium on the issuing of additional water entitlements from the Tertiary Limestone Aquifer in the Designated Area, including the Minister's reserve in Zone 2A, pending the satisfactory incorporation of the water used by plantation forestry into the water accounts.

The deeper Tertiary Confined Sand Aquifer is exhibiting declines similar to those observed in the Tertiary Limestone Aquifer even though there is very little water being extracted from the Tertiary Confined Sand Aquifer. This may well indicate a higher degree of connection between these aquifers than previous models indicated. The resolution of this issue is critical in determining whether the two aquifers should be managed together or separately. The Committee recommends that the States undertake studies on the interaction between the Tertiary Confined Sand Aquifer and the Tertiary Limestone Aquifer and implement a moratorium on the issuing of additional water entitlements from the Tertiary Confined Sand Aquifer in the Designated Area pending the satisfactory resolution of the reasons for the declining levels within the Tertiary Confined Sand Aquifer.

There are two particular issues of immediate concern to be resolved as a result of the declines now being observed in the Tertiary Limestone Aquifer. These are: the potential for seawater intrusion along the South Australian coast, and the other is the effect of the declines on groundwater users in the shallow and thin aquifer around the Lake Mundi area in Victoria. The Committee recommends that the South Australian government undertake a study to assess the salt water interface in the Tertiary Limestone Aquifer and develop arrangements to manage the resource to prevent seawater intrusion. The Committee also recommends that the Victorian government undertake an assessment of the potential impacts of falling groundwater levels on groundwater bores in the Lake Mundi area and develop a management plan to address adverse impacts arising from water level decline.

# 2. Key Factors Affecting Sustainability

## 2.1 Hydrogeology and structure

A number of features of the Tertiary Limestone Aquifer have been reviewed; viz. regional stratigraphy, lithology, structure, depth, thickness, groundwater flow and potentiometric surface.

The Tertiary Limestone Aquifer had been regarded as a single lithological unit. Evidence from drilling investigations now indicates that it comprises a number of lithological sub-units as illustrated in Figure 2. At this stage there is not sufficient evidence to define the nature of these differences with any confidence.

The Kanawinka Fault marks the boundary between Province 1 and Province 2 (i.e. the Otway Basin and the Murray Basin). North of the fault in Zone 3B lies the Dundas Tablelands on the western fringe of the Great Dividing Range. The Tertiary sediments of the Otway and Murray basins are thin or absent on the Tablelands.

The Tertiary Limestone Aquifer varies in thickness over the region. It is thin adjacent to the Dundas Tablelands and thickens towards the coast and to the west. The broad Plateau Region south of the Kanawinka Fault extends to Mount Gambier. Within the Plateau Region south of the Nangwarry and Lake Mundi areas the aquifer is thin and is interpreted to have a saturated thickness of 20 metres or less. In this area the aquifer is most at risk from groundwater depletion due to over-extraction. The aquifer thickens towards the coast in a number of steps as a result of faulting during sedimentation.

The regional groundwater flow in Province 1 is predominantly southward to the Glenelg River and the coast. In the north (Zones 3A and 4A) the flow is mainly to the west (Figures 3 and 5). The upper units in the aquifer are likely to be connected to the Glenelg River, although the nature of this interaction has not yet been determined.

Geological structures have a significant influence on the behaviour of groundwater. There is a transition zone across the Tartwaup fault in South Australia. Levels are elevated on the northern side of the Tartwaup Fault and are much lower on the southern side (Figure 4 and 5). The Tartwaup Fault is a major feature in the region that acts to constrain groundwater flow. The water levels of the Tertiary Limestone Aquifer are above the potentiometric surface of the Tertiary Confined Sand Aquifer north of the fault. South of the Tartwaup Fault the potentiometric surface of the Tertiary Confined Sand Aquifer is higher than the water levels in the Tertiary Limestone Aquifer (Figure 6).

## 2.2 Distinct hydrogeological regions

Geological structure and aquifer behaviour indicate that Province 1 comprises a number of distinct hydrogeological regions. These are identified in Figure 7 and a detailed description of each is provided in Table 1. The Tertiary Limestone Aquifer should be managed having regard to these hydrogeological regions.

*Table 1 Hydrogeological regions in Province 1*

| Regions (see Figure 7) | Description |
|---|---|
| Victoria Coast Region | • The area is south of the Glenelg River in Zone 1B.<br>• The Tertiary Limestone Aquifer is thick (approximately 200 m).<br>• The Glenelg River is a hydraulic barrier to groundwater flow for the upper part of the Tertiary Limestone Aquifer.<br>• The potentiometric levels of the Tertiary Confined Sand Aquifer are higher than the Tertiary Limestone Aquifer water levels. |
| South Australia Coast Region | • The area is in Zone 1A adjacent the South Australian coast.<br>• The Tertiary Limestone Aquifer is thick (approximately 200 m) and karstic.<br>• The land elevation is low and the groundwater levels in the Tertiary Limestone Aquifer are no greater than 10m above sea level.<br>• Hydraulic gradients are generally upwards from the Tertiary Confined Sand Aquifer to the Tertiary Limestone Aquifer. |
| Mount Gambier Region | • The area is in the northern part of Zone 1A.<br>• The Tartwaup Fault occurs in the northern part of the region where a reversal in vertical gradient between the Tertiary Confined Sand Aquifer and the Tertiary Limestone Aquifer occurs. |
| Plateau Region | • The area is between the Kanawinka Fault and the Tartwaup Fault in South Australia and the Glenelg River in Victoria.<br>• The region is a flat, elevated plateau with numerous marshes and wetlands but an absence of streams.<br>• The depth to groundwater is shallow (less than 20 m).<br>• In some areas the Tertiary Confined Sand Aquifer may outcrop. |
| Penola Plains Region | • The area is west of the Kanawinka Fault in Zones 3A and 4A.<br>• Significant Tertiary Limestone Aquifer thickness (between 80m and 140 m) |
| Dundas Tablelands Region | • The area is elevated and undulating land north and north east of the Kanawinka Fault in Zones 3B, 4A and 4B.<br>• The Tertiary Limestone Aquifer and Tertiary Confined Sand Aquifer are thin and in some places absent in Victoria.<br>• The water quality is variable (between 1,500 to 3,500 mg/L TDS). |

Note: There is a small area in the northern part of Zone 4A and Zone 4B north of the Kanawinka Fault and the Dundas Tablelands that forms part of Province 2.

## 2.3 Groundwater processes

### 2.3.1 Climate and Rainfall

Province 1 has a Mediterranean type climate, characterised by warm to hot and dry summers and cool to cold and wet winters with the average annual rainfall ranging from approximately 900mm along the coast to 600mm in the north.

The period from the 1970s to the 1990s often experienced average annual rainfall above that of the long term average, rendering it an overly wet period in the climatic record.

Since 1993, rainfall has exhibited a generally negative deviation from average (approximately 30 mm below average) as a result of long-term below average rainfall in autumn and to a lesser extent in winter.

The below average rainfall during this period is likely to be a consequence of a positive pressure anomaly, which may be a naturally occurring feature of the climate in this region (Whetton et al. 2002).

The frequency of the rainfall deficiency in Province 1 in the 1990s is notably high, but not dissimilar to the frequencies that occurred in the 1900s. The recent dry conditions may be a dry period within the normal variability experienced in south eastern Australia. However the severity of the dry conditions has raised questions about the impact climate change is having on our water resources. It is possible that the south eastern part of Australia is suffering a major long term reduction in average rainfall due to climate change. The Intergovernmental Panel on Climate Change's fourth Assessment Report (IPCC 2007) concludes that warming of the earth's climate is unequivocal. As a result parts of south eastern Australia are expected to become warmer and drier. This means less recharge to aquifers. It is forecast that there will be significant reduction in rainfall and it will be more variable. The climate and the processes affecting it are the subject of continued investigation by the CSIRO and the Bureau of Meteorology.

### 2.3.2 Recharge

Recharge to the Tertiary Limestone Aquifer occurs predominantly in the wetter winter months via infiltration of rainwater.

A review of recharge studies in Australia (Petheram et al. 2000) developed a simple empirical relationship that can be applied to rainfall and land use to estimate groundwater recharge. This relationship is, that in sandy soils under pasture, recharge increases with increasing rainfall above an annual rainfall threshold of 250mm. In this case 30% of the annual rainfall above this threshold could become groundwater recharge.

The below average rainfall experienced since 1993 is a contributing factor to the reduced groundwater recharge in the Tertiary Limestone Aquifer. The impact is not uniformly distributed. It is likely that the decline in recharge rates will be higher than the rainfall decline, as a consequence of reduced antecedent soil moisture conditions.

### 2.3.3 Discharge

The potentiometric surface indicates that groundwater in the Tertiary Limestone Aquifer discharges to the Glenelg River in Victoria and along the coast in South Australia, as well as to the predominant discharge features of Piccaninnie Ponds, Deep Creek and 8 Mile Creek. Measurement of the groundwater discharge in these features has been carried out since 1970 but there has not been any correlation with water budget calculations for the region.

### 2.3.4 Inter-aquifer leakage

Vertical flow, especially drainage from the Tertiary Limestone Aquifer to the Tertiary Confined Sand Aquifer, is likely to be more important than has previously been credited. While the evidence for this conceptual picture is still being collated there are initial indications that vertical connection between the two aquifers is important and needs further consideration.

The current understanding is that the Tertiary Limestone Aquifer in Province 1 is a highly transmissive aquifer. While recharge primarily occurs during winter, groundwater levels indicate that discharge to the Glenelg River may be relatively constant throughout the year irrespective of the volumes of rainfall recharge. Recharge to the Tertiary Confined Sand Aquifer appears to occur via two predominant pathways, direct infiltration of rainfall where the overlying unconfined aquifer is thin, and infiltration via preferential pathways as a result of faulting. Field testing studies (Brown et al. 2006) concluded that in the area north of the Tartwaup Fault the Tertiary Confined Sand Aquifer is recharged by diffuse leakage through a low permeability aquitard via steep faults. Radiocarbon analysis indicated that the water within the Tertiary Confined Sand Aquifer is a mixture of older water sourced via the overlying aquitard, implying leakage, and younger water sourced from faults. As the recharge mechanisms are not well understood the interaction processes are also not well understood.

Groundwater levels in the Tertiary Limestone Aquifer north of the Tartwaup Fault are slightly higher than the potentiometric surface levels in the Tertiary Confined Sand Aquifer. In this area the aquifers are likely to be in hydraulic connection and groundwater may leak from the Tertiary Limestone Aquifer to the Tertiary Confined Sand Aquifer. South of the Tartwaup Fault the hydraulic gradient is reversed with the potential leakage being from the Tertiary Confined Sand Aquifer to the Tertiary Limestone Aquifer, however the confining layers are thicker. Figure 6 shows the direction of potential groundwater leakage between the two aquifers.

Observation of water levels and groundwater extraction information indicate that the groundwater level declines in the Tertiary Confined Sand Aquifer north of the Tartwaup Fault are not caused by groundwater extraction from the Tertiary Confined Sand Aquifer. The declines in the Tertiary Confined Sand Aquifer reflect the trends in the Tertiary Limestone Aquifer.

This correlation suggests that the degree of interaction between the two aquifers is greater that previously understood. The implication of the revised conceptual model is that:

- the groundwater levels in the Tertiary Confined Sand Aquifer are likely to continue to decline if the Tertiary Limestone Aquifer trends continue to decline. It is expected that at the current rates of decline the groundwater levels would be 2m deeper in 10 years time; and
- further development of groundwater extraction in the Tertiary Confined Sand Aquifer may increase the declines in the Tertiary Confined Sand Aquifer and may lead to increased drawdown in the Tertiary Limestone Aquifer. This may increase the declining trends already observed in the Tertiary Limestone Aquifer and the impacts of those declines.

Vertical flow between the Tertiary Limestone Aquifer and the Tertiary Confined Sand Aquifer is likely to be significant. The accurate calculation of inter-aquifer leakage is difficult and requires significant amounts of data. Further investigations (i.e. pumping tests) are needed to establish the inter-aquifer flow relationships and to test the conceptual models before water budgets and sustainable extraction volumes can be further developed.

### 2.3.5 Water level observations

An assessment of groundwater level trends involved grouping bores of similar water level patterns and sorting as to whether the long-term trends in recovered water levels were stable, declining or rising. Groundwater trends are a key indicator of the condition of the groundwater resource. The term “trend” is applied here to mean the recovered (winter/spring) peak water level compared with previous peak(s). Figures 8, 9, 10 and 11 illustrate the distribution of the water level trends for the Tertiary Limestone Aquifer and the Tertiary Confined Sand Aquifer.

The pertinent observations are summarised below.

***Tertiary Limestone Aquifer***

Stable water level trends

Stable groundwater level trends are evident in:

- Dundas Plateau region;
- the area between Penola and Naracoorte in Zone 4A; and
- adjacent to the Glenelg River.

The area between Penola and Naracoorte in Zone 4A has large seasonal drawdowns.

Declining water level trends

There are a number of distinctive declining water level trends across Zones 1A, 1B, 2A, 2B, 3A (western part) and 3B (south western part)(Figures 10 and 11).

Long term declining groundwater trends (30 years as observed by the hydrographs) occur in the eastern part of Zone 1A and the area south of the Glenelg River in Zone 1B. Since records began in 1972 the total change in water level has been approximately 3.5 m, which equates to a rate of decline of 0.11 m/yr.

At Nangwarry (the eastern part of Zone 2A), water levels declined from 1975 to 1983. The water levels rose in 1983 following the bushfires and have been declining since.

In the Mount Gambier area (the north western part of Zone 1A) the groundwater levels have been in long term decline since 1925, as observed by the water level in Blue Lake (Figure 13). The hydrographs show that that the water levels have declined approximately 3.5m since 1972.

The water levels in the coastal area (the southern part of Zone 1A) were relatively stable up until 1997 with negligible seasonal fluctuation. Since 1997 groundwater levels have fluctuated seasonally and there is a small (approximately 0.5 m) decline in recovered levels.

The declining water level trends in Zones 2A (west and southern parts), 1B (parts north of the Glenelg River), 2B and the southern part of 3B began in 1992-93 and have declined approximately 1.5 to 2 m (0.12 to 0.16 m/yr).

***Tertiary Confined Sand Aquifer***

Stable water level trends

Groundwater levels have remained stable south of the Tartwaup Fault (Figure 9 and Figure 12a).

Declining water level trends

Declining water level trends in the Tertiary Confined Sand Aquifer north of the Tartwaup Fault began in 1993. The groundwater levels stabilised somewhat in 2000 to 2004 with above average annual rainfall but declined further with subsequent drier years and by 2007 water levels had fallen between 2 and 3m (Figure 9 and Figure 12b).

## 2.4 Plantation forestry, groundwater interception and use

Land use principally consists of pasture, crops, plantation forestry and native vegetation. Land use has a direct impact on the recharge to the groundwater which affects the volume and quality of the groundwater resources. Recharge rates are in the order of 1% of annual rainfall under plantation forestry and native vegetation and up to 20% under pasture or crop.

Where plantation forestry can access the water table, the plantations can obtain a significant proportion of their total water use from groundwater. In addition to interception of rainfall recharge, plantations can directly extract up to 2.6 ML/ha/yr for softwood and 2.3 ML/ha/yr for hardwood, annualised over the growth cycle of the forest (Benyon and Doody 2004).

In Zones 1A, 2A, 3A and 4A, changes to the area under plantation forestry over the last ten or more years has been relatively minor, whereas, there has been significant plantation forestry development in Zones 1B, 2B and 3B in the period 1992 to 2002 with a corresponding decrease in the area of pasture land.

Long-term declining groundwater trends are observed under plantation forestry in the Mount Gambier Region, in the southern part of the Plateau Region in Victorian Zone 1B and in the Victoria Coast Region. Since 1972 the total change in water level has been approximately 3.5m, or a rate of decline of 0.11m/yr. Under the plantation forestry at Nangwarry in the Plateau Region, water levels rose in 1983 following the bush fires and have since declined following the re-establishment of the plantations. The seasonal influence of groundwater extractions and rainfall recharge are not evident in the water level record, indicating that any recharge to the region is significantly offset by the magnitude of recharge interception and groundwater use by plantation forestry.

A partial water budget for the Tertiary Limestone Aquifer in Province 1 was developed to identify the general magnitude of potential recharge versus the magnitude of groundwater debit (SKM 2007). The components of the debit include:

- the rainfall recharge intercepted by plantation forestry;
- the rainfall recharge intercepted by native forests and lakes;
- the groundwater extracted by plantation forestry; and
- the groundwater extracted under licences.

The water budget indicates that impacts on water levels from plantation forestry are significant. Of the total potential recharge available over the Province 1 (approximately 300,000 ML/yr), two thirds is used by plantation forestry, either as interception of rainfall or as groundwater uptake. A summary of the results of this water budget are provided in Table 2.

This water budget indicates that the region is in deficit with respect to recharge to the Tertiary Limestone Aquifer as exemplified by the persistent regional decline in groundwater levels.

The partial water budget undertaken excludes assessment of throughflow, discharge, inter-aquifer flow or direct groundwater uptake by native forests. The groundwater budget would be in greater deficit if these components were included.

*Table 2 Summary of impact of land use on the Tertiary Limestone Aquifer – Partial water budget (SKM 2007)*

| Zones 1A, 1B, 2A, 2B, 3A, 3B, 4A and 4B | Groundwater Input | Groundwater Debit | | | | | Groundwater Balance (Difference b/n the Total potential recharge and Total Groundwater debit) (ML/yr) |
|---|---|---|---|---|---|---|---|
| | Total potential recharge volume (ML/yr) | Recharge volume intercepted by plantation forestry (ML/yr) | Recharge volume intercepted by lakes & native forest (ML/yr) | Groundwater used by plantation forestry (ML/yr) | Licensed groundwater entitlement (at June 2005) (ML/yr) | Total groundwater debit (ML/yr) | |
| TOTAL | 320,000 | 110,000 | 70,000 | 100,000 | 130,000 | 410,000 | - 90,000 |

Note 1: 'Total Potential Recharge Volume' represents the volume of rainfall recharging to the Tertiary Limestone Aquifer assuming 100% cleared land. This Table should be reviewed in conjunction with the limitations provided in SKM (2007). Zero recharge is assumed under plantation forests, native vegetation and lakes. For plantation forests where water tables are shallow (<7m in Spring 2003) the calculations assumed, in addition to interception of rainfall recharge, that plantations directly extract 2.6 ML/ha/yr for softwood and 2.3 ML/ha/yr for hardwood, annualised over the growth cycle of the forest.

Note 2: Some of the native forests within the region may be adapted to directly utilise groundwater. Due to the lower canopy cover and tree density of native forests as compared with plantation forests, the groundwater uptake is likely to be half of the maximum uptake rates for plantation forests. This has not been incorporated in the above partial water balance, and as such, the total deficit will be underestimated.

Note 3: The intention of this water balance is to indicate the relative impacts of plantation forestry and groundwater extraction on groundwater levels in Province 1. As previously discussed the water balance above is a partial balance and does not include aquifer throughflow, interaquifer leakage or discharge.

Note 4: Order of magnitude estimates provided as a relative indicator.

Note 5: Licensed groundwater use is estimated at 50% of licensed entitlement (i.e. 65,000ML).

Water used by plantation forestry is not accounted for in the Agreement. Both States have a process under way to consider the water impacts of plantation forestry and, in consultation with stakeholders, the States are developing appropriate arrangements to account for the impact of plantation forestry on water resources.

## 2.5 Groundwater entitlement and extraction

A total of 130,000 ML of groundwater entitlements has been granted in Zones 1A, 1B, 2A, 2B, 3A, 3B, 4A and 4B as of June 2007. The distribution of groundwater entitlements for Province 1 is detailed in Table 3 and presented in Figures 10 and 11. Regions of relatively high entitlement (greater than 100 ML/km$^2$/year) exist in the Mount Gambier Region, the South Australia Coastal Region, the Plateau Region and the Penola Plains Region.

Zones 1B, 2A, 2B, 3B and 4B are currently under-allocated relative to the Permissible Annual Volume. Zones 1A, 3A and 4A are currently over-allocated.

Extractions for domestic and stock purposes are not a significant contributor to decline in regional groundwater levels.

*Table 3 Permissible Annual Volumes and total groundwater entitlements for the Tertiary Limestone Aquifer at 30 June 2007 (BGARC 2007)*

| South Australia | | | | Victoria | | | |
|---|---|---|---|---|---|---|---|
| Tertiary Limestone Aquifer | | | | | Tertiary Limestone Aquifer | | |
| Permissible Annual Volume (ML) | Total Groundwater Entitlements (ML) | Total Estimated Use (ML) | Zones | Zones | Permissible Annual Volume (ML) | Total Groundwater Entitlements (ML) | Total Metered Use (ML) |
| 20000 | 22076 | 14631 | 4A | 4B | 14000 | 2339 | 650 |
| 24000 | 24043 | 16754 | 3A | 3B | 16500 | 515 | 164 |
| 25000 | 21643 | 15005 | 2A | 2B | 25000 | 24586 | 10137 |
| 30900 | 31874 | 25156 | 1A | 1B | 45720 | 4780 | 4535 |

In Zones 1B, 3B and 4B significant areas of plantation forestry have been developed since the recharge estimates and Permissible Annual Volumes were determined for those zones.

Metering of groundwater extraction in Victoria was complete in 2004. The meter installation program in South Australia was completed by June 2007 with ongoing compliance checking.

The groundwater resource in the Tertiary Confined Sand Aquifer has not been developed to any significant degree. Since 2001 1,924 ML of groundwater entitlements have been granted from the Tertiary Confined Sand Aquifer in South Australia. The actual volume extracted is very small.

*Table 4 Permissible Annual Volumes, groundwater entitlements and metered use for Tertiary Confined Sand Aquifer at 30 June 2007 (BGARC 2007)*

| South Australia | | | | | Victoria | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Tertiary Confined Sand Aquifer | | | | Zones | Zones | Tertiary Confined Sand Aquifer | | | |
| PAV (ML/yr) | Licensed Entitlements | | | | | PAV (ML/yr) | Licensed Entitlements | | |
| | Total No of Licences | Total Groundwater Entitlements (ML) | Total Volume Metered Use (ML) | | | | Total No of Licences | Total Groundwater Entitlements (ML) | Total Volume Metered Use (ML) |
| 710 | 1 | 63 | N/A | 4A | 4B | 300 | 0 | 0 | 0 |
| 1900 | 0 | 0 | 0 | 3A | 3B | 1000 | 0 | 0 | 0 |
| 2900 | 2 | 150 | N/A | 2A | 2B | 5100 | 0 | 0 | 0 |
| 9200 | 4 | 1711 | N/A | 1A | 1B | 14500 | 0 | 0 | 0 |

## 2.6 Water level response and predictions

### 2.6.1 Tertiary Limestone Aquifer

Stable groundwater level trends occur in the Dundas Plateau Region where there are low groundwater extractions either because the groundwater quality is unsuitable or due to land use.

The area between Penola and Naracoorte in Zone 4A has stable water levels but has large seasonal drawdowns due to groundwater extraction. It is considered that the groundwater use in this area is sustainable in respect to yields, as the long-term trends in recovered levels are stable.

Long-term declining groundwater trends are observed under plantation forestry in the Mount Gambier Region, in the southern part of the Plateau Region in Victorian Zone 1B and in the Victoria Coast Region. There is negligible seasonal fluctuation indicating negligible recharge from rainfall or seasonal extraction from groundwater pumping. Since 1972 the total change in water level has been approximately 3.5 m, or a rate of decline of 0.11 m/yr.

Geologic faulting impedes groundwater flow across the Tartwaup Fault line in the Mount Gambier Area. The evidence suggests the effects of plantation forestry exacerbate the declines. The long-term declines in the Mount Gambier area do not align with climatic variations or groundwater extractions, but coincide with the development of the plantation industry since the 1920s. The water level in the Blue Lake has declined eight metres in the period from 1925 to 2000 (Figure 13). These declines occurred in spite of the fact that over the interval 1925 to 1992 there have been periods of above average rainfalls (SKM 2005). Above average rainfall has not resulted in the recovery of water levels. There is no evidence from the water level trends in the Mount Gambier Region to indicate that the Tertiary Limestone Aquifer will reach a new equilibrium in the near future. Groundwater levels are therefore likely to continue to decline in the future with the current land use, groundwater extraction regime and climate predictions.

Under plantation forestry at Nangwarry in the Plateau Region water levels were declining up until 1983 then rose following the bush fires. Levels declined in response to the re-establishment of the plantations.

In the coastal area in South Australia (the southern part of Zone 1A) the seasonal fluctuation in water levels is due to groundwater development that has occurred since 1997. It is considered that while the rate of decline in the recovered levels is low given the proximity to the coast the potential risk of seawater intrusion warrants special attention. At this stage there are insufficient records of water level data to conclude that the aquifer has reached a new equilibrium in response to groundwater pumping.

The declining water level trends under cleared land in Zones 2A (west and southern parts), Zone 1B (parts north of the Glenelg River), Zone 2B and the southern part of Zone 3B are due to a combination of increased plantation forestry in Zones 1B and 2B, climate and groundwater extraction. The declines are likely to continue.

In a few isolated areas (especially Zone 2B) the Tertiary Limestone Aquifer is likely to be thin and is interpreted to have a saturated thickness of 20 m or less (south of Nangwarry and

Lake Mundi areas). In these areas the drawdown effect of a single bore will be more pronounced. Further, the risk of aquifer depletion is increased.

### 2.6.2 Tertiary Confined Sand Aquifer

Minimal extraction occurs from the Tertiary Confined Sand Aquifer. As such, the declining water levels observed are of interest. The declines reflect the groundwater level declines observed in the Tertiary Limestone Aquifer from 1992/93.

## 2.7 Surface water – groundwater interaction

The Glenelg River is the major surface water feature in Province 1.

The degree of connectivity between the Glenelg River and the aquifers in the region has not been assessed in detail. However, the review of stratigraphy and potentiometric levels indicates that the upper units in the Tertiary Limestone Aquifer are likely to be connected to the Glenelg River and groundwater is likely to discharge into the river. In addition the Tertiary Confined Sand Aquifer outcrops near the Glenelg River and may be recharged by the river.

Groundwater levels in the vicinity of the Glenelg River are stable. It does not appear that the regional declines observed elsewhere in Province 1 are affecting the groundwater levels adjacent to the river. From this it can be inferred that there is little immediate risk of reduced baseflow to the Glenelg River as a result of the declining groundwater levels.

Mosquito Creek in the north of Province 1, a major source of water for the Ramsar-listed Bool Lagoon and Hacks Lagoon, is likely to be subject to surface water - groundwater interaction. The degree and location of groundwater interaction with Mosquito Creek, and the risks from changes in the groundwater regime, are only known to a rudimentary degree and are the subject of further investigations under the National Heritage Trust Regional Competitive project *Connecting the Catchment: the Integrated Management of Mosquito Creek*.

## 2.8 Groundwater dependent ecosystems

Notable groundwater dependent ecosystems in Province 1 include Blue Lake in Mount Gambier Region, Ewens Ponds and Piccaninnie Ponds in the South Australia Coast Region and Bool Lagoon west of the Plateau Region. Groundwater dependent ecosystems may also exist in the vicinity of the Glenelg River, but this needs further investigation.

The National Heritage Trust Regional Competitive project *Connecting the Catchment: the Integrated Management of Mosquito Creek* is investigating the groundwater dependent ecosystem for Mosquito Creek in Zones 4A and 4B. The research program addresses the importance of groundwater in maintaining summer pools and the potential risk from adjacent groundwater extraction. Two endangered species, the Yarra pigmy perch and the growling grass frog inhabit the creek. The perch depend on the remnant pools to survive in summer.

The location of ecosystems dependent on groundwater and the sensitivity to and risks from changes in the groundwater regime are only known to a rudimentary degree. Further work is needed to identify ecosystems, risks and implications for management of the groundwater resource.

## 2.9 Seawater intrusion

The potential intrusion of sea water into fresh aquifers is recognised as a risk if groundwater extractions increase in the South Australia Coast Region and Victoria Coast Region.

King and Dodds (2002) conducted an investigation into the likely location and extent of the freshwater-saltwater interface in the coastal area. Subsequent drilling and piezometer installation in the vicinity of Eight Mile Creek identified the interface as approximately 1 km from the coast, and approximately 150 m below surface. There are a number of irrigation wells extracting water from depths of between 145 and 180 m below surface. It is critical that the salt water interface is not induced further inland or to shallower levels as a result of groundwater extraction in coastal regions.

## 2.10 Groundwater salinity

The salinity in the Tertiary Limestone Aquifer in Province 1 is generally less than 1,500 mg/L TDS.

Monitoring reveals that groundwater level salinity level trends are stable in Province 1 with the exception of the Coonawarra area where some increasing trends have been observed.

In the Dundas Tablelands Region in the north east of Zone 3B and south east of Zone 4B the groundwater salinity exceeds 3,500 mg/L TDS. The probable cause for the higher salinity groundwater in this region is saline discharge from the adjacent Palaeozoic bedrock to the aquifer (BGARC 2003).

## 2.11 Groundwater salinisation

Groundwater salinisation refers to the process whereby the quality of groundwater is modified beyond the baseline condition by processes such as irrigation recycling, clearing of native vegetation and land use change. Aquifers are most at risk from these types of salinisation where the watertable is shallow and there are salts stored in the overlying strata.

Field investigations in the Lake Mundi area showed that the salt in the unsaturated zone has already been displaced and consequently the risks of groundwater salinisation are low (SKM 2004a).

Investigations indicate that there is a risk of groundwater salinisation in the Penola Plains Region (SKM 2004b).

# 3. Key Resource Issues

The key issues posing the greatest risk to the sustainability of the resource in Province 1 are as follows:

## 3.1 Groundwater level declines

Observations of water levels and recent research show that there are significant areas within Province 1 where groundwater levels are in long-term decline, particularly in Zones 1A, 1B, 2A and 2B.

There are three drivers affecting the current declines in groundwater levels in Province 1:

1. the effects of a drier climate than previously existed;
2. the utilisation of water by plantation forests by the processes of interception of rainfall and direct use from the aquifer where the roots can tap the water table; and
3. the use of water for irrigation and other purposes.

Water budget studies and observation of water levels indicate that plantation forestry is the major cause of water level declines through interception of rainfall and the direct uptake of groundwater. It is expected that groundwater levels will continue to decline under plantation forests in the Designated Area over the next management review period.

There is no evidence to indicate that the water levels in the Tertiary Limestone Aquifer in Mount Gambier Region or in the Victoria Coast Region will reach a new equilibrium over the next five to ten years.

## 3.2 Groundwater entitlements

Zones 1A, 3A and 4A are fully allocated in relation to the Permissible Annual Volumes. Zones 2A, 1B, 2B, 3B and 4B are not fully allocated. Further granting of groundwater entitlements up to the current Permissible Annual Volume, if made, may increase the declining water level trends in both the Tertiary Limestone Aquifer and the Tertiary Confined Sand Aquifer.

## 3.3 Interaction between the Tertiary Limestone Aquifer and the Tertiary Confined Sand Aquifer

Vertical flow between the Tertiary Limestone Aquifer and the Tertiary Confined Sand Aquifer is likely to be significant but is not well understood.

Further development of groundwater extraction in the Tertiary Confined Sand Aquifer may increase the declines in that aquifer and lead to increased drawdown in the Tertiary Limestone Aquifer. Consequently, the declining trends already observed in the Tertiary Limestone Aquifer and the impacts of those declines may be exacerbated.

In addition, continued drawdown due to extraction (licensed water entitlements and via plantation forests) in the Tertiary Limestone Aquifer may increase the drawdown in the Tertiary Confined Sand Aquifer.

Knowledge of the interconnection between the two aquifers is limited. The question of whether the resource should be managed as one or as separate resources needs further investigation.

## 3.4 Seawater intrusion

The potential intrusion of seawater into fresh aquifers is recognised as a risk if groundwater extractions increase in the South Australia Coast Region.

The seawater – fresh water interface in the Tertiary Limestone Aquifer has been identified approximately 1 km inshore from the coast and 150 metres below the surface. As irrigation supplies are being extracted from this area the threat of seawater intrusion may be high. It is critical to maintain the current position of the interface and not induce it further inland or to shallower depths.

Careful monitoring and management is required to minimise the risk of seawater intrusion.

This is currently not an issue in Victoria, as the current land use is largely native forest and there are no significant extractions.

## 3.5 Aquifer depletion

In the Lake Mundi area and areas west and south of Nangwarry (Zone 2A) where the saturated thickness of the aquifer is less than 20m there is a risk that existing users could lose water supplies due to declining groundwater levels.

## 3.6 Groundwater salinisation

In can be inferred from the Lake Mundi investigation (SKM 2004a) that in areas of similar climate, soil type and land use, the soil salt may have already been displaced from the unsaturated zone to the groundwater.

Consequently, the risk of significant salinisation of the groundwater is considered low within Province 1, with the exception of the Penola Plains Region. The risk of groundwater salinisation in the Penola Plains Region is associated with recycling of irrigation drainage water. The salinity rise in the Penola Plains Region is the subject of an intensive salt accession investigation.

The management approach in the Penola Plains Region is likely to focus on specific local strategies and farm practices. There does not appear to be a significant risk to the groundwater resource regionally.

# 4. Proposed Management Strategy

The Tertiary Limestone Aquifer is high yielding and is replenished by rainfall recharge. Parts of Province 1 are experiencing long term declines in groundwater levels, in both the Tertiary Confined Sand Aquifer and the Tertiary Limestone Aquifer. The system is out of balance in that outflow and extractions exceed inflows.

The use of the water includes both extractions for irrigation and other purposes under licence as well as interception and direct use by the plantation forests. This is a significant factor. The drier conditions of recent years are also contributing to the groundwater level declines. Without a change in the current land and water use these declines will continue over parts of Province 1.

There will need to be adjustments to current arrangements to achieve sustainable water levels.

<u>Water accounting</u>

The most significant deficiency in the management arrangements is the lack of comprehensive water accounts. The major missing component is the impact of plantation forestry.

The National Water Initiative requires that the impact of intercepting activities, including plantation forestry, is to be accounted for and managed by the year 2010.

The current management arrangements for State water accounts include licensed water entitlements and provide for metering of extractions, but do not take full account of water intercepted and extracted by plantation forests. Both States have a process under way to consider the water impacts of plantation forestry and, in consultation with stakeholders, develop appropriate arrangements to account for the impact of plantation forestry on water resources. There is a need to have a complementary water accounting system for the impacts of plantation forestry to provide a consistent approach between the States.

The development of new forest plantations or the issue of new water entitlements / licences with the attendant increase in water use will lead to further deterioration in the existing unsustainable situation.

The following steps are required to address this situation until the water accounting system is adopted.

- **The impacts of plantation forestry on the interception and extraction of water be included in the water accounting system.**
- **A commitment from the States to develop a consistent approach to account for the water utilised by plantation forestry.**
- **No additional water entitlements be granted from the Tertiary Limestone Aquifer pending the satisfactory incorporation of the water used by plantation forestry into the water accounts.**
- **A moratorium be implemented on new forest plantation developments pending the adoption of the water accounting system.**

Interaquifer connection

There are long-term groundwater declines being observed in the Tertiary Confined Sand Aquifer north of the Tartwarp fault. These declines cannot be attributed to groundwater extractions as the amount being taken from this aquifer is small.

Vertical flow between the Tertiary Limestone Aquifer and the Tertiary Confined Sand Aquifer is likely to be significant but is not well understood. Further investigations are required to gain a useful understanding of the relationship between the aquifers.

If there is a high degree of inter-connection between the two aquifers then they should be managed as one resource. In this event and given that the Tertiary Limestone Aquifer is over committed then no further additional groundwater entitlements should be granted from the Tertiary Confined Sand Aquifer. On the other hand if there is low degree of inter-connection between the aquifers they could be managed separately.

**A study involving a long term pumping test in the Tertiary Confined Sand Aquifer that monitors the Tertiary Limestone Aquifer is the most desirable method to determine the interconnection between the two aquifers. In addition, further hydrogeological modelling should be undertaken. This modelling will provide insight into the connectivity between the aquifers and allow modelling of future predictions under various land use, water extraction and recharge scenarios.**

If the Tertiary Limestone Aquifer is fully committed then the Tertiary Confined Sand Aquifer should be reserved for high value use such as public water supply. In South Australia access to water from the Tertiary Confined Sand Aquifer is limited to 50% for public water supply and 50% for major developments. In Victoria there is a moratorium on new entitlements from the Tertiary Confined Sand Aquifer. The issue of new water entitlements with the attendant increase in water use will lead to further decline in groundwater levels.

**A moratorium on the issuing of additional water entitlements from the Tertiary Confined Sand Aquifer in the Designated Area should be implemented pending the satisfactory resolution of the reasons for the declining levels within the Tertiary Confined Sand Aquifer.**

Seawater intrusion

The potential intrusion of seawater into fresh coastal aquifers is recognised as a risk in the South Australia coast region. In this region the seawater – fresh water interface in the Tertiary Limestone Aquifer has been observed one kilometre inshore from the coast and 150 metres below the surface.

There are irrigation supplies being extracted in this area and there are groundwater dependent ecosystems such as Piccaninnie Ponds and other wetlands and creeks which would be put in jeopardy by the intrusion of seawater.

This is currently not an issue in Victoria, as the current land use near the coast is largely native forests and plantation forests and there are no significant extractions.

The location of the seawater interface can be managed by ensuring that there are adequate programs of water level and water quality monitoring together with appropriate modification of groundwater extraction.

**A study is required to assess the salt water interface in the Tertiary Limestone Aquifer and develop arrangements to manage the resource to ensure that there is no landward advance of the interface, nor any risk of rise in the level of seawater in the aquifer.**

Aquifer depletion

The other area of concern with continuing declining levels (in the short term) is the Lake Mundi area. The Tertiary Limestone Aquifer is relatively thin which will lead to a loss of water supply if the groundwater levels continue to decline unabated.

There needs to be an assessment of the impacts of continuing declines on the irrigators and how these impacts can be managed.

**An assessment of the potential impacts of declining groundwater levels on groundwater bores should be undertaken and a local management plan should be developed to manage any adverse impacts.**

Groundwater salinisation

Previous reviews identified that groundwater salinisation was a risk to the resource and recommended studies to assess this. The Committee did not increase Permissible Annual Volumes due to the risk of salinisation. Studies have shown that for most parts of Province 1 the risk of salinisation is low.

In the Penola Plains Region the risk of salinisation is associated with recycling of irrigation drainage water and the salinity rise is the subject of an intensive salt accession investigation. The Committee will review the findings of this investigation work when it is finalised.

**Current studies are nearing completion and should be reviewed to provide a greater understanding of the risk of salinisation.**

# 5. Review of Management Prescriptions

## 5.1 Tertiary Limestone Aquifer

### 5.1.1 Permissible Annual Volumes

The Victorian Zones 1B, 2B, 3B and 4B are all under-allocated with respect to their Permissible Annual Volumes. It is noted that areas of useable groundwater resources in these zones have been declared Water Supply Protection Areas under the Water *Act (1989)*. These include two Water Supply Protection Areas:

- the Glenelg Water Supply Protection Area which covers the whole of Zone 1B and 2B and parts of Zones 3B and 4B; and
- the Apsley Water Supply Protection Area which covers part of Zone 4B.

The declarations were made with the aim of developing management plans for the areas. The *Water Act* requires that no additional licences or permanent transfers of licences be granted pending the Ministerial approval of a management plan for a Water Supply Protection Area. This moratorium should be kept in place until the accounting for the water used by plantation forestry is adequately incorporated into the water accounts.

The South Australian Zone 2A is under-allocated in respect to its Permissible Annual Volume. The unallocated water entitlement is held in the Minister's reserve and whilst so held should not be allocated for licensed use.

It is not the intention of the Committee to make any changes to the Permissible Annual Volumes pending outcome of the accounting of water used by forestry.

In the South Australian Zones 1A, 3A and 4A where the groundwater entitlements are overcommitted with respect to the Permissible Annual Volumes it is noted that that there is a State process in place to convert the existing crop area based water entitlements to volumetric entitlements and then to resolve the over commitment as part of the conversion process.

**The Committee has determined that the current Permissible Annual Volumes be maintained over the next management review period and recommends that the governments be asked to maintain the moratorium on the issuing of additional water entitlements from the Tertiary Limestone Aquifer, including the Minister's reserve in Zone 2A, pending the satisfactory incorporation of the water used by plantation forestry into the water accounts.**

### 5.1.2 Allowable Annual Volumes

There is the potential for groundwater entitlements in the north of Zone 1A to be transferred to the south of Zone 1A. This may increase the seasonal drawdown of water levels and hence increase the risk of sea-water intrusion. Sub-zoning Zone 1A would prevent this occurring.

The Committee considers it necessary to sub-zone Zone 1A and set an Allowable Annual Volume for the southern coastal portion of Zone 1A. A sub-zone boundary should align with the existing boundary between South Australian management zones Glenburnie and Donovans within the Lower Limestone Coast Prescribed Wells Area.

**It is recommended that:**

1. **a sub zone for Zone 1A be defined to align with the existing boundary between South Australian management zones Glenburnie and Donovans within the Lower Limestone Coast Prescribed Wells Area; and**
2. **an Allowable Annual Volume be set for the Sub-zone 1A South at the level of the current entitlement. This will permit the transfer of water licences from Sub-zone 1A South to the north of Zone 1A, but not transfers the other way.**

### 5.1.3 Permissible potentiometric surface lowering

The permissible potentiometric surface lowering rates and the observed rates for the zones of Province 1 are shown in Table 5 below.

*Table 5 Permissible potentiometric surface lowering rates and observed rates for the five year period ending 30 June 2007*

| South Australia | | | Victoria | | |
|---|---|---|---|---|---|
| Observed water level decline (m/yr) | PSL Rate (m/yr) | Zones | Zones | PSL Rate (m/yr) | Observed water level decline (m/yr) |
| 0 – 0.1 | 0.25 | 4A | 4B | 0.25 | 0 |
| 0 - 0.16 | 0.25 | 3A | 3B | 0.25 | 0.01 – 0.16 |
| 0.16 | 0.25 | 2A | 2B | 0.25 | 0.16 |
| 0.01 to 0.16 | 0.25 | 1A | 1B | 0.25 | 0 to 0.16 |

As discussed elsewhere in this report the current actual rates of decline in water levels are not sustainable in the long term and there will need to be a review of the mix of land and water use within the region. In the meantime the current arrangements should be maintained.

**The Committee determined (Meeting No 87 Dec 2006) that the current rates of potentiometric surface lowering be maintained over the next management review period.**

### 5.1.4 Permissible distance

The permissible distance is the distance from the border within which all applications for licences must be forwarded to the Committee for approval.

**The Committee determined (Meeting No 87) that the permissible distance of 1km for the Tertiary Limestone Aquifer be retained in all the Zones 1A, 1B, 2A, 2B, 3A, 3B, 4A and 4B.**

### 5.1.5 Permissible salinity

No permissible rate for groundwater salinity rise has been set to date, and there currently appears to be no need to set such a rate.

## 5.2 Tertiary Confined Sand Aquifer

### 5.2.1 Permissible Annual Volumes

The Victorian Zones 1B, 2B, 3B and 4B are not fully allocated with respect to their Permissible Annual Volumes. It is noted that areas of useable groundwater resources in these zones have been declared water supply protection areas as provided by the Victoria *Water Act 1989.* These are the Apsley Water Supply Protection Area and the Glenelg Water Supply Protection Area.

The declarations were made with the aim of developing management plans for the areas. The *Water Act* requires that no additional licences or permanent transfers of licences may be granted pending the Ministerial approval of a management plan for a Water Supply Protection Area. This moratorium should be kept in place pending the resolution of the reasons for the declining levels within the Tertiary Confined Sand Aquifer.

In South Australia groundwater entitlements from the Tertiary Confined Sand Aquifer are set aside 50% for public water supply and 50% for State development projects. The Committee considers that a moratorium be placed on granting new groundwater entitlements in these zones pending the satisfactory resolution of the reasons for the declining levels within the Tertiary Confined Sand Aquifer.

**It is recommended that the governments be advised to maintain the moratorium on the issuing of additional water entitlements from the Tertiary Confined Sand Aquifer, pending the satisfactory resolution of the reasons for the declining levels within the Tertiary Confined Sand Aquifer.**

### 5.2.2 Permissible potentiometric surface lowering

Currently the permissible potentiometric surface lowering is set for each zone based on the behaviour of the Tertiary Limestone Aquifer.

The observed rates are consistent with prescribed rates.

### 5.2.3 Permissible distance

The current permissible distance is 3 km for the Tertiary Confined Sand Aquifer and is satisfactory.

**The Committee determined (Meeting No 87) that the permissible distance of 3km for the Tertiary Confined Sand Aquifer be retained in all the zones of Province 1, namely Zone 1A, 1B, 2A, 2B, 3A, 3B, 4A and 4B.**

### 5.2.4 Permissible salinity

Permissible salinity has not been set to date. No technical reason currently exists for this to be set.

# 6. Summary of Recommendations for Further Technical Work

**Water Accounting**

The current management arrangements for State water accounts include licensed water entitlements and provide for metering of extractions, but do not take account of water intercepted and extracted by plantation forests. Both States have a process under way to consider the water impacts of plantation forestry and, in consultation with stakeholders, develop appropriate arrangements to account for the impact of plantation forestry on water resources. There is a need to have a complementary water accounting system for the water used by plantation forestry to provide a consistent approach between the States.

**Interaction between the Tertiary Limestone Aquifer and Tertiary Confined Sand Aquifer**

A study is required on the interaction between the Tertiary Confined Sand Aquifer and the Tertiary Limestone Aquifer. The study involving a long term pumping test in the Tertiary Confined Sand Aquifer that monitors the Tertiary Limestone Aquifer is the most desirable method. In addition, further hydrogeological modelling should be undertaken. This modelling will provide insight into the connectivity between the aquifers and allow modelling of future predictions under various land use, water extraction and recharge scenarios.

**Seawater intrusion - South Australian coast region**

There is potential seawater intrusion along the South Australian coast region and consequent impact on high value groundwater dependent ecosystems. It is recommended that a study be undertaken to assess the salt water interface and develop arrangements to manage the resource to ensure that there is no landward advance of the interface, nor any risk of rise in the level of seawater in the aquifer.

**Aquifer depletion – Lake Mundi area**

Declining groundwater levels are of concern in the Lake Mundi area. The Tertiary Limestone Aquifer is thin which will lead to a loss of water supply if the groundwater levels continue to decline unabated. There needs to be an assessment of the impacts of continuing declines on the irrigators and how these impacts can be managed. A survey of groundwater users and a local management plan should be developed to manage the adverse impacts.

**Groundwater salinisation - Penola plains region**

In the Penola Plains Region the risk of salinisation is associated with recycling of irrigation drainage water and the salinity rise is the subject of an intensive salt accession investigation. Current studies are nearing completion and should be reviewed to provide a greater understanding of the risk of salinisation.

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# Figures

*Figure 1 The Designated Area, zones and hydrogeological provinces*

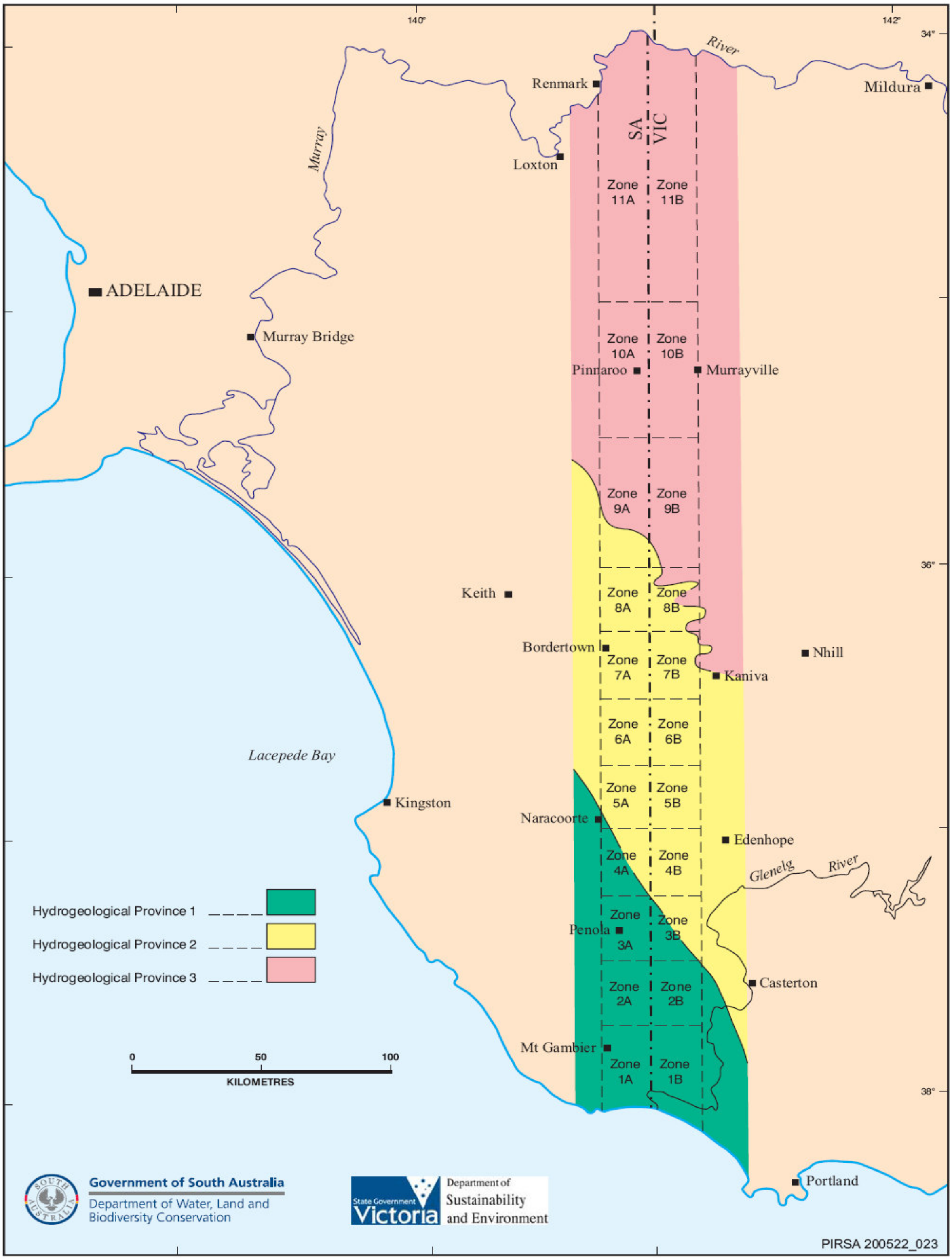


*Figure 2 Lithological sub units of the Tertiary Limestone Aquifer*

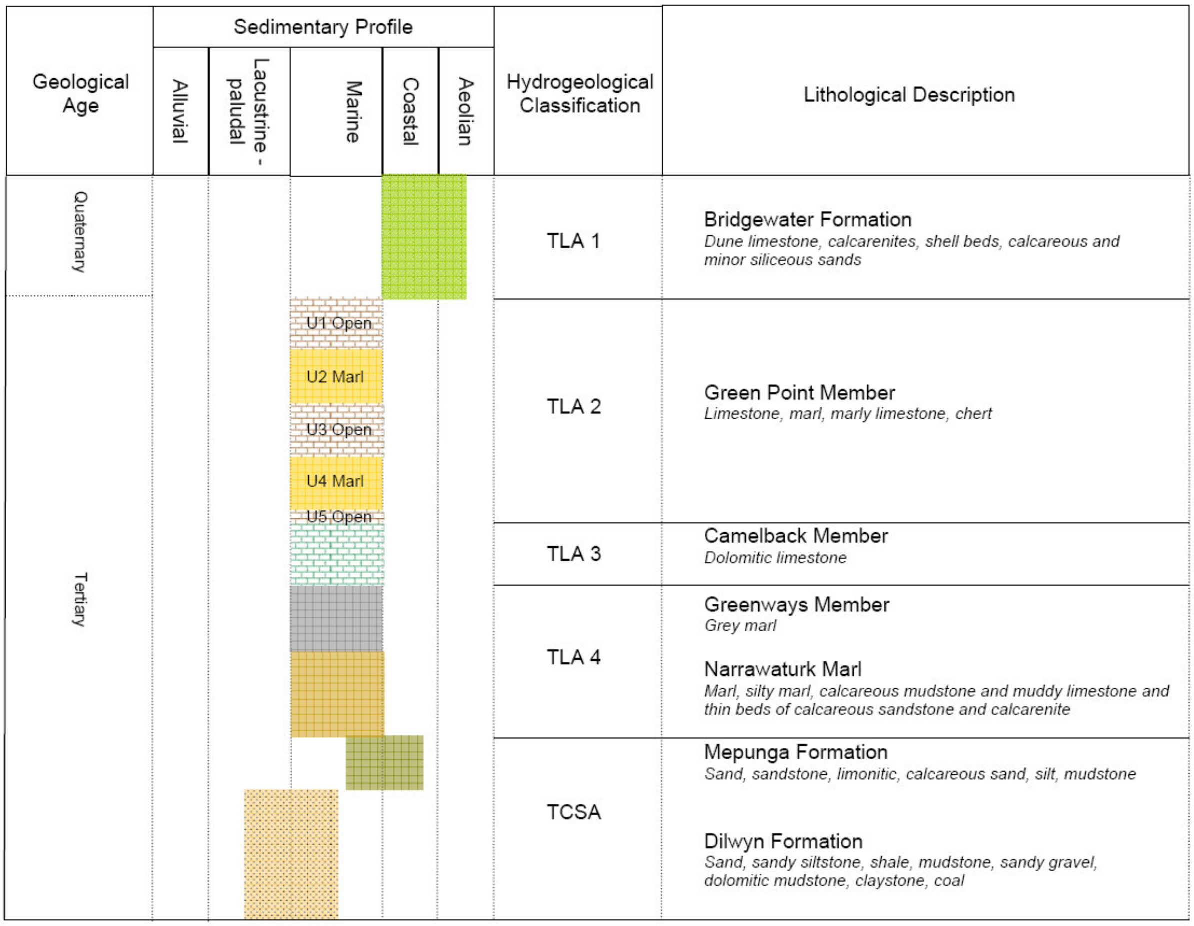


*Figure 3 Depth to water table (Tertiary Limestone Aquifer)*

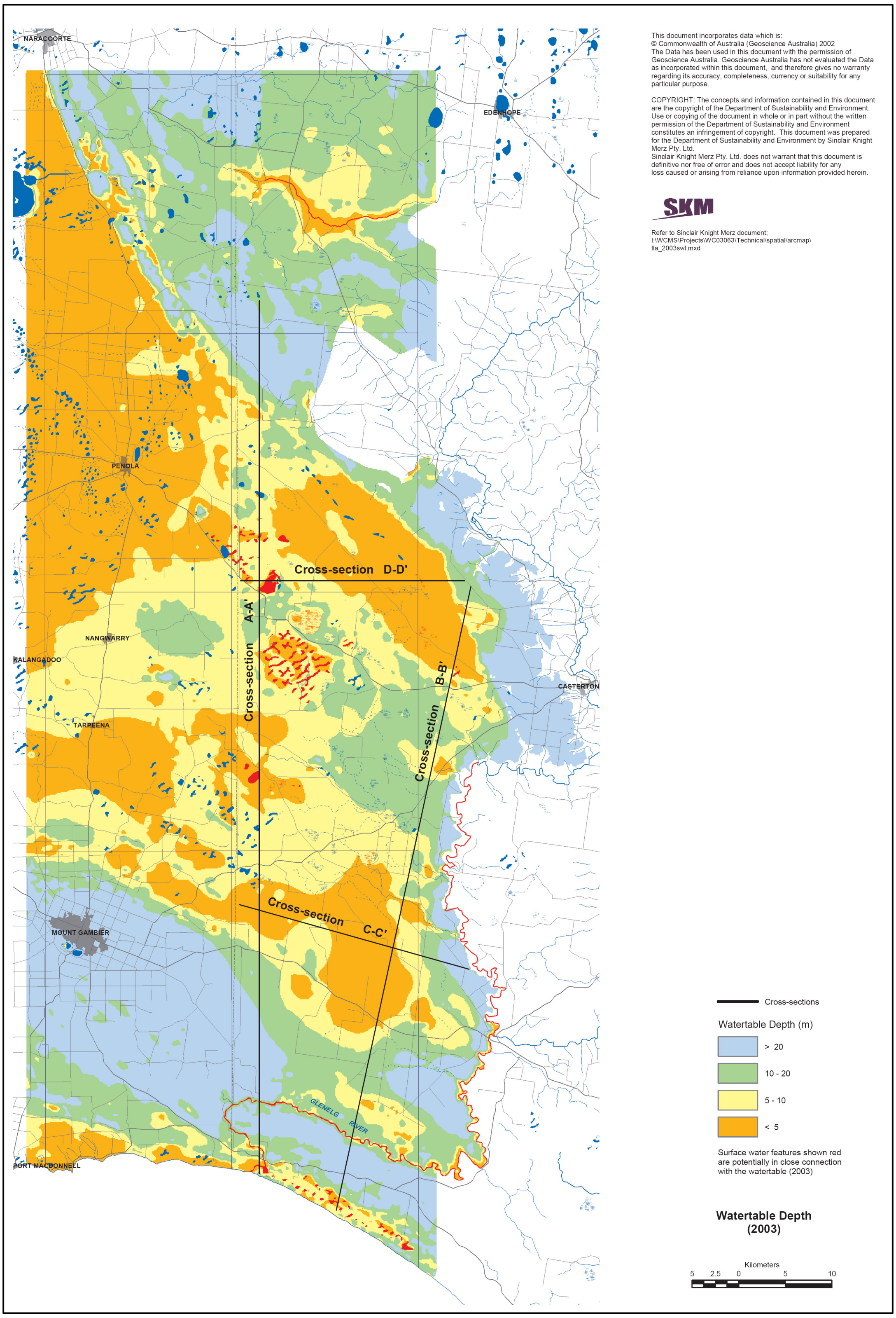


*Figure 4* *Lithological cross section A-A'*
(see Figure 3 for location of cross section)

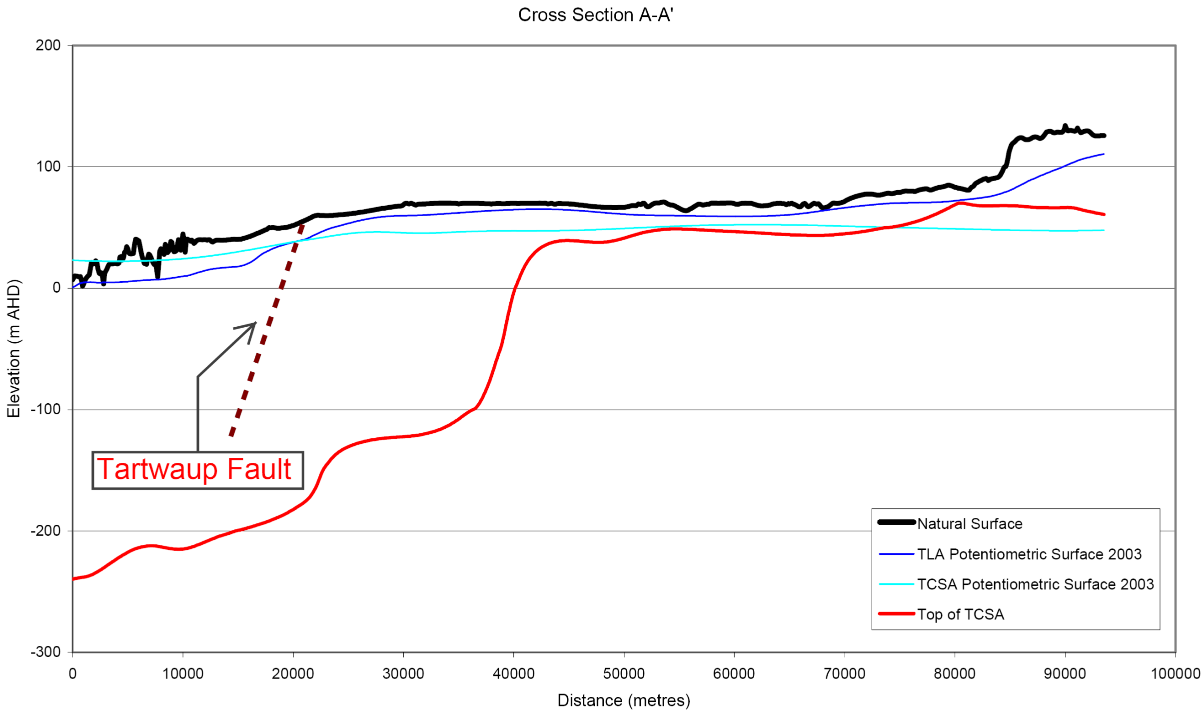


*Figure 5    Potentiometric surface of the Tertiary Limestone Aquifer*

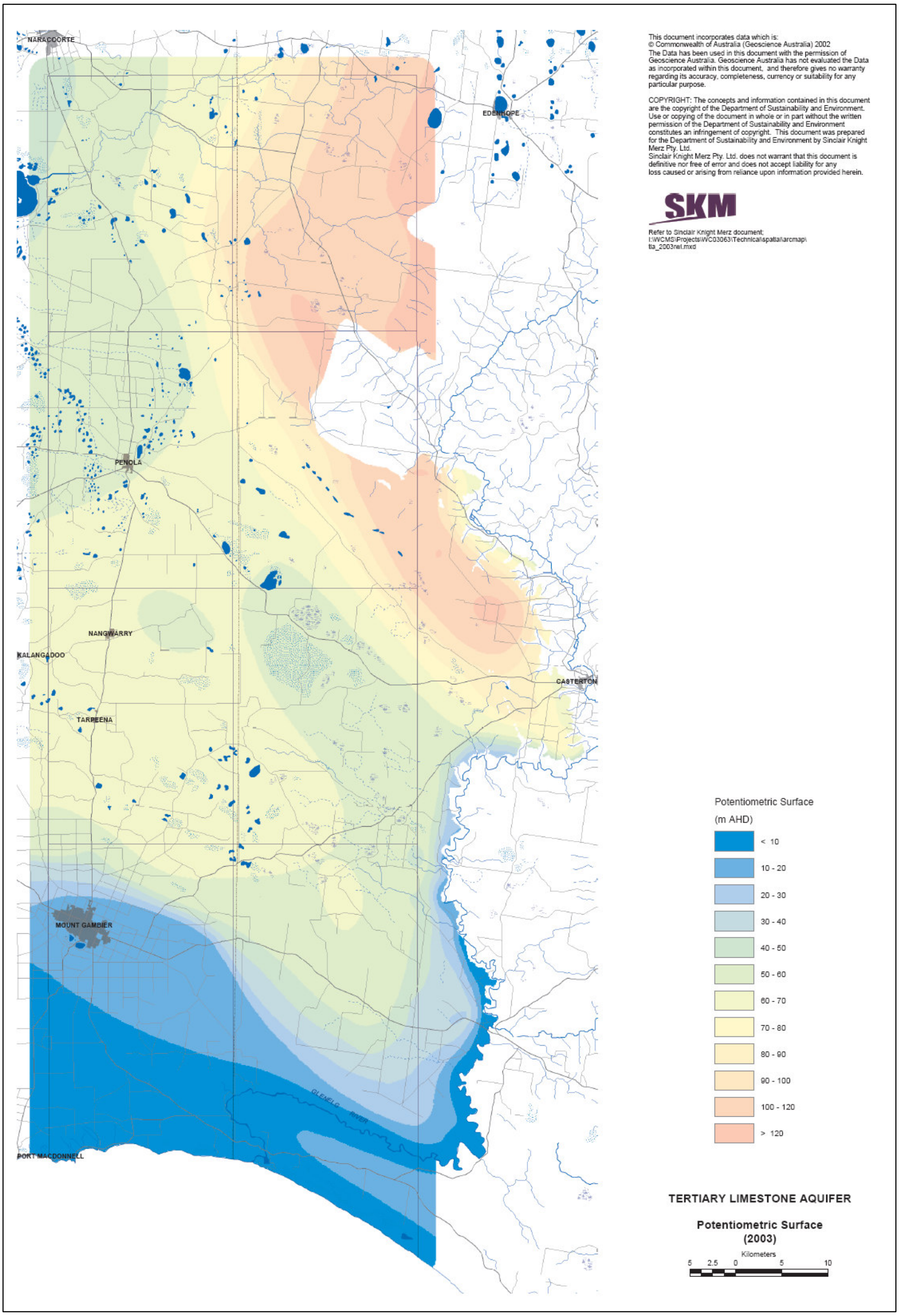


*Figure 6 Groundwater level difference between Tertiary Limestone Aquifer and Tertiary Confined Sand Aquifer*

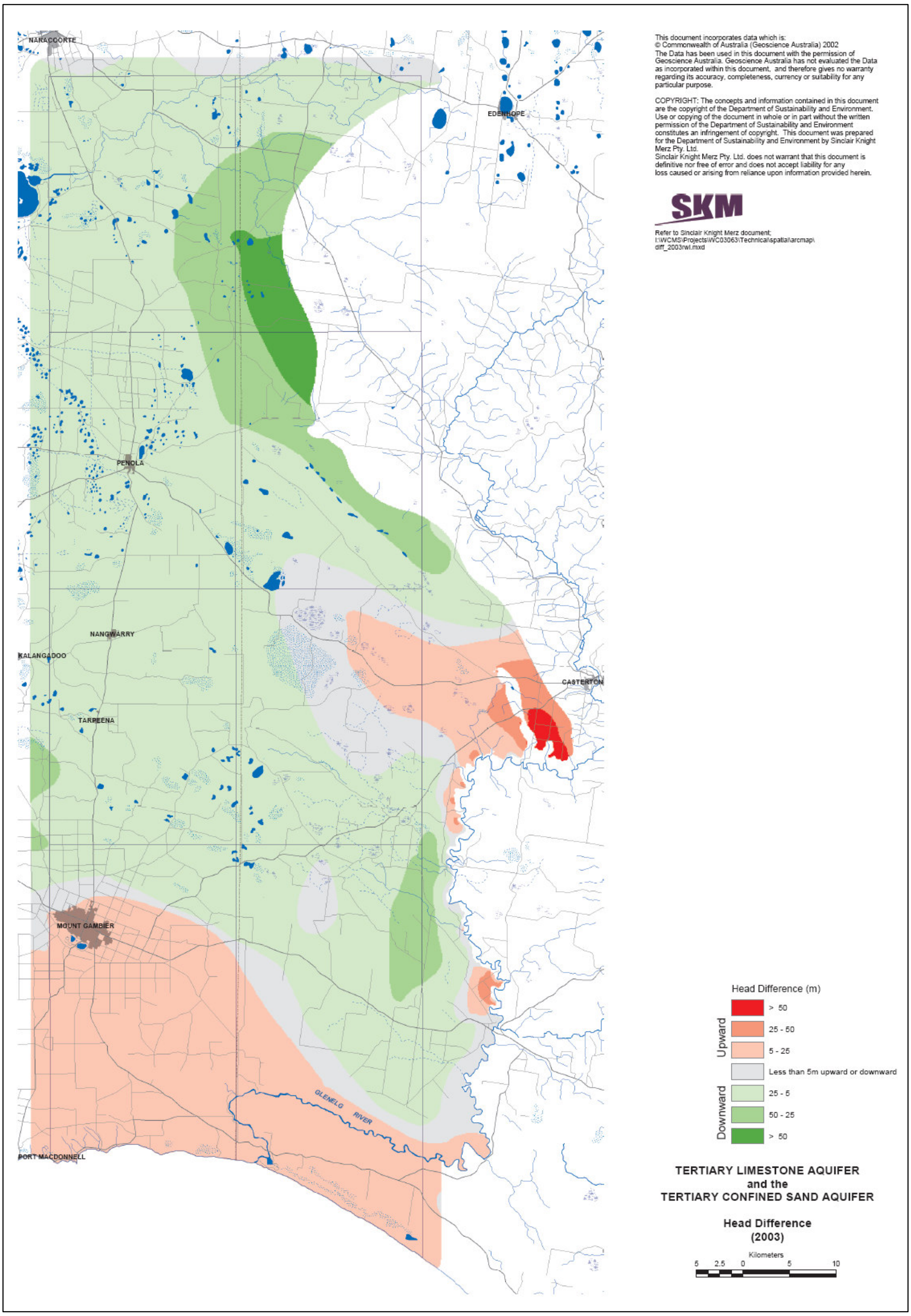


*Figure 7 Hydrogeological regions for Province 1*

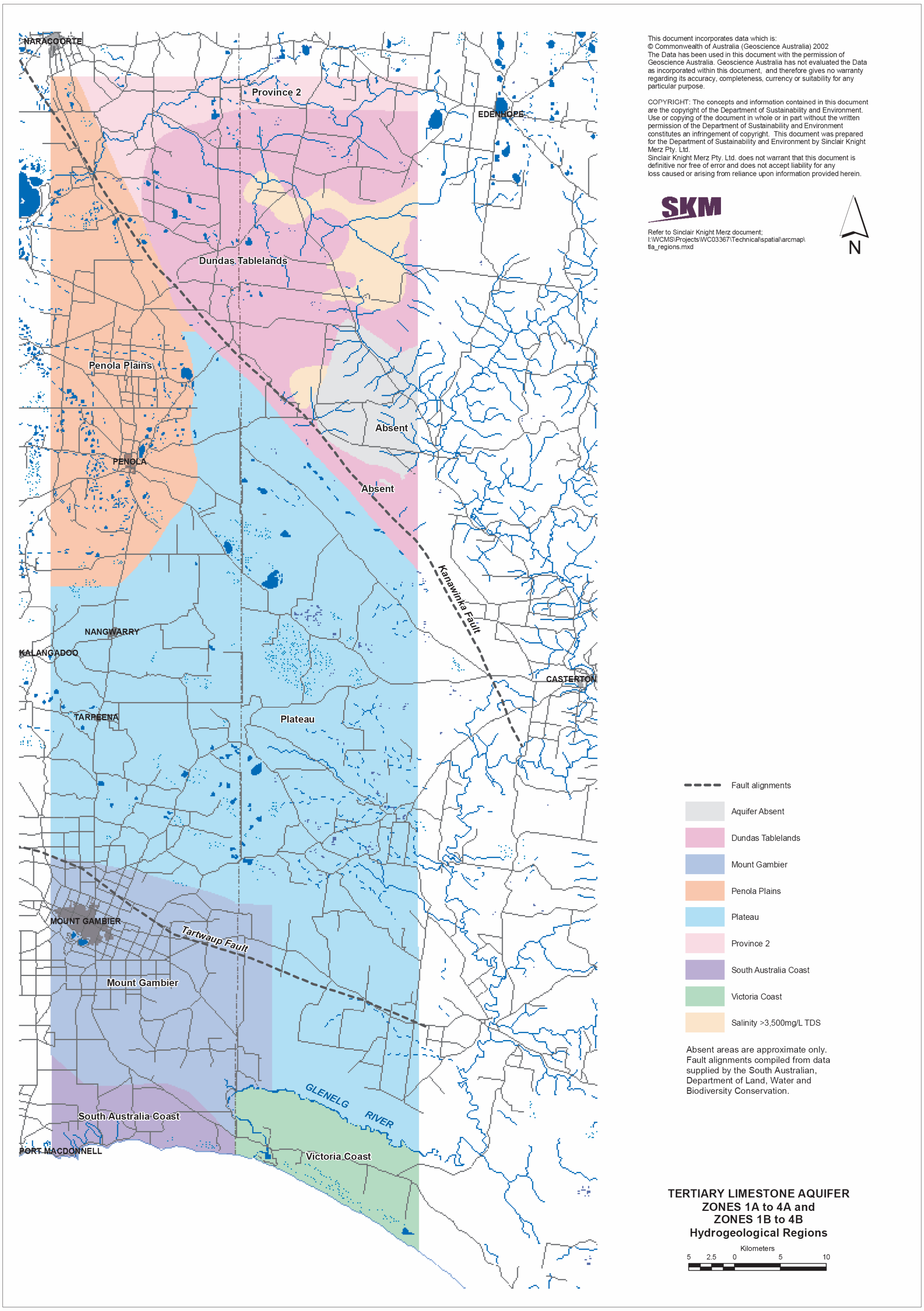


*Figure 8 Map of groundwater level trends for the Tertiary Limestone Aquifer*

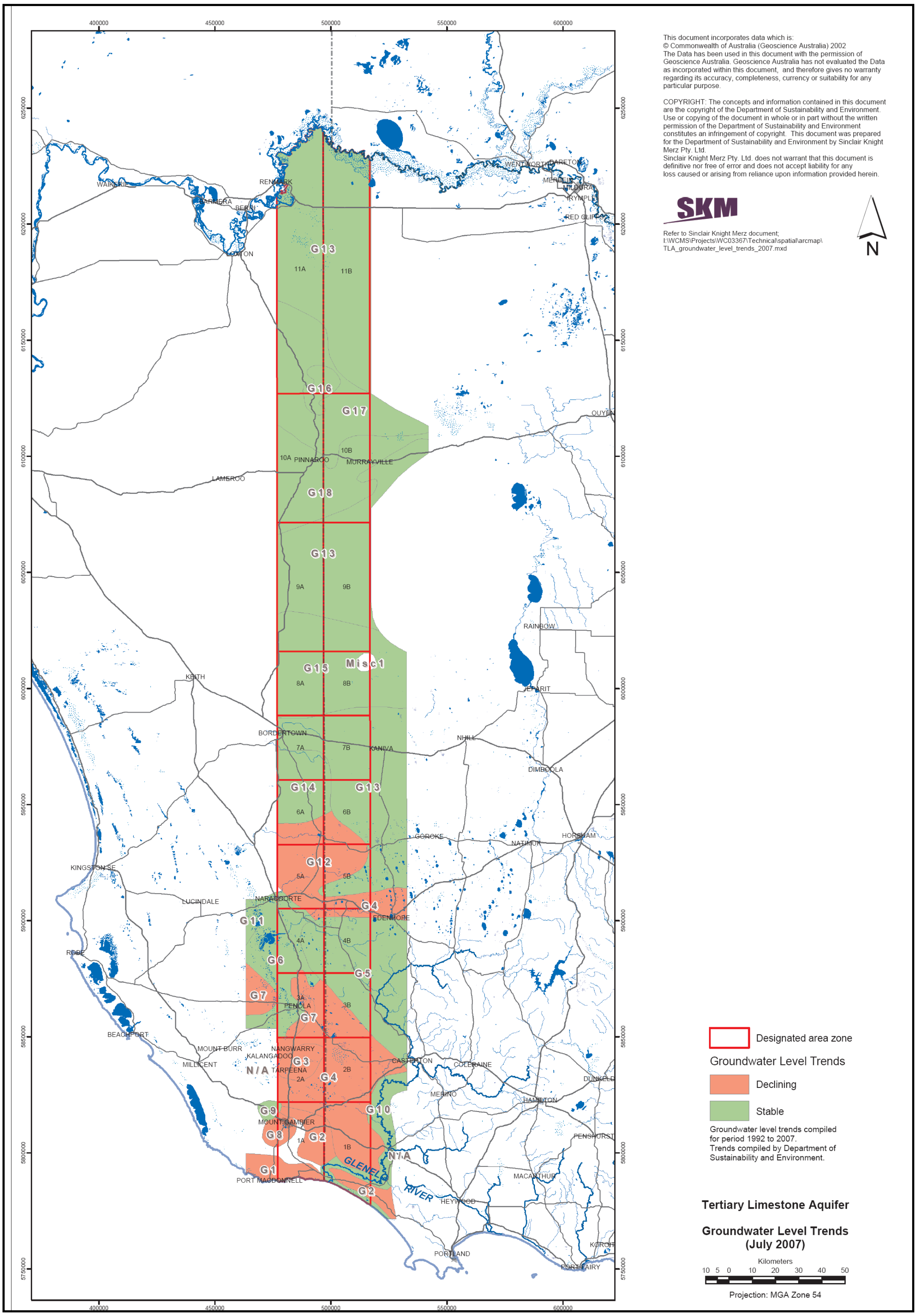


*Figure 9 Map of groundwater level trends for the Tertiary Confined Sand Aquifer*

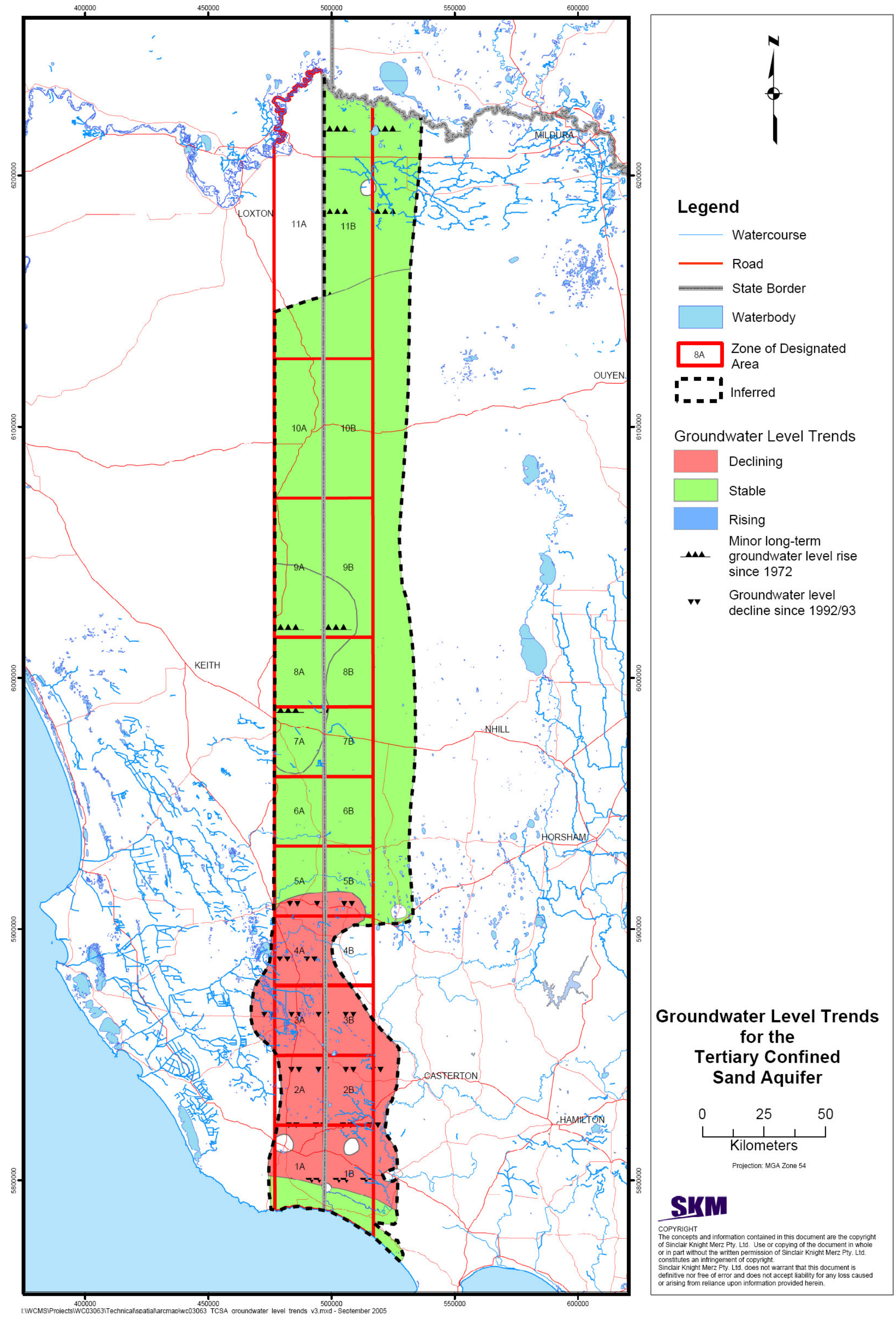


*Figure 10 Hydrograph groupings, groundwater allocations and land use, Zones 1A, 2A, 3A, and 4A*

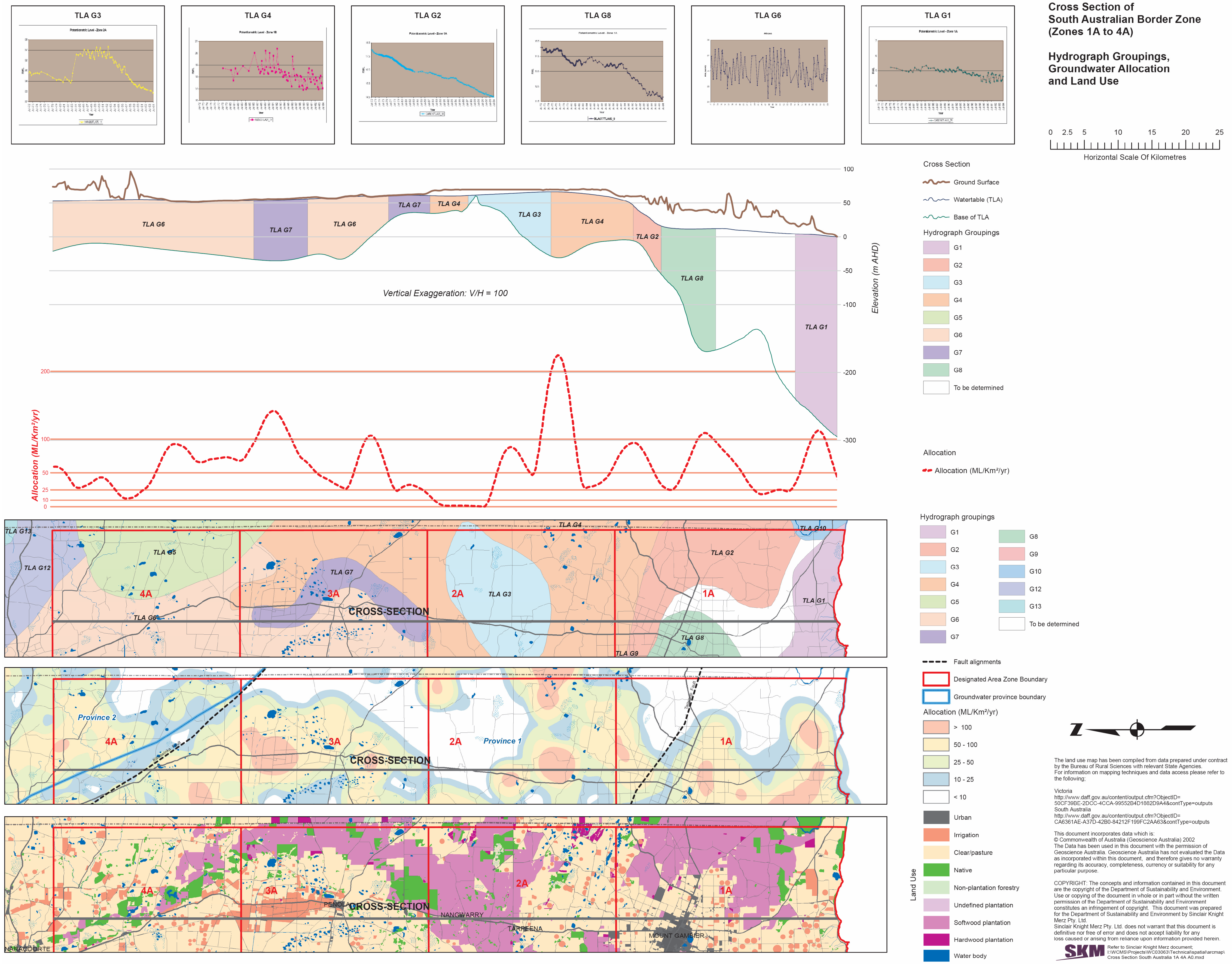


*Figure 11 Hydrograph groupings, groundwater allocations and land use, Zones 1B, 2B, 3B, and 4B*

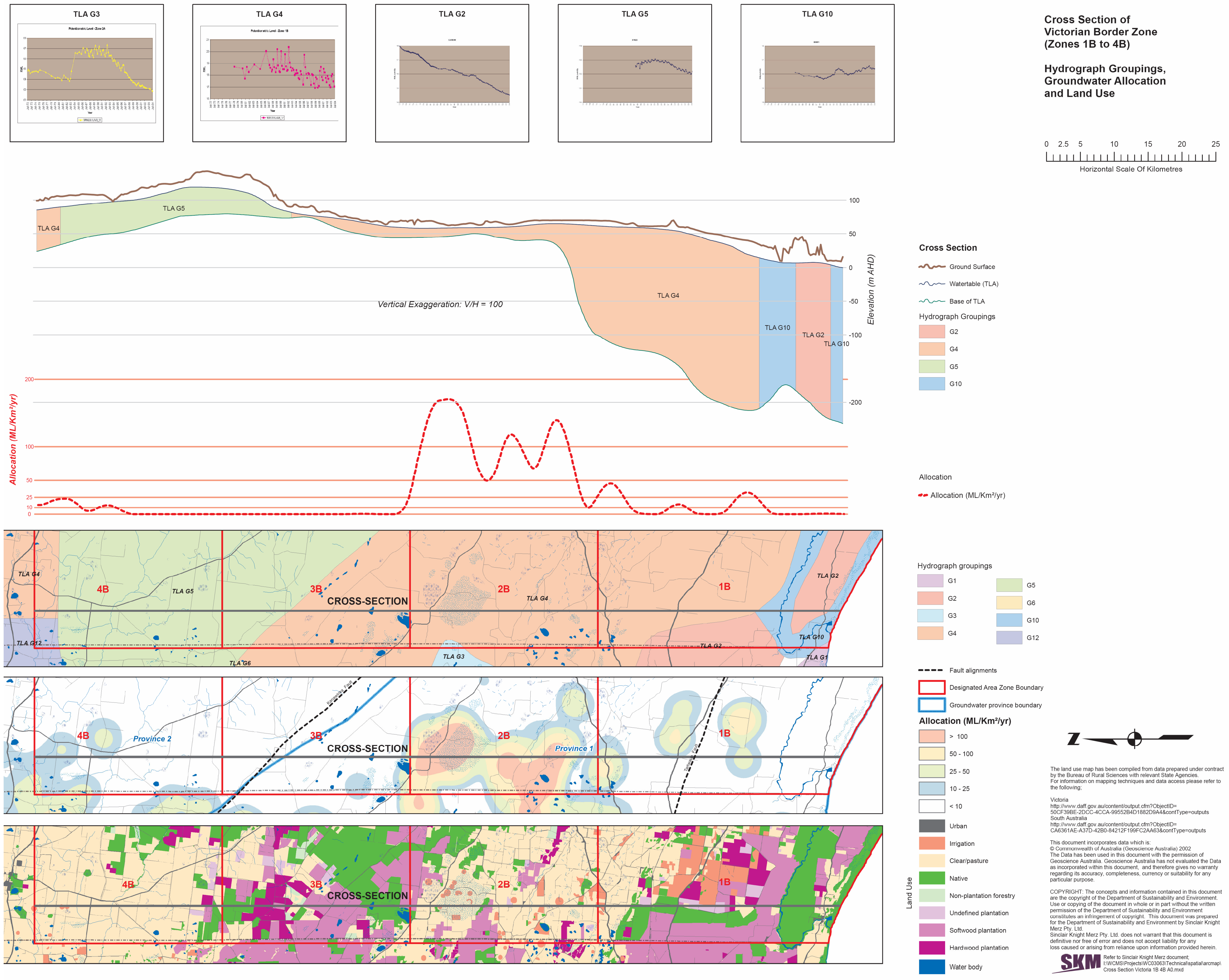
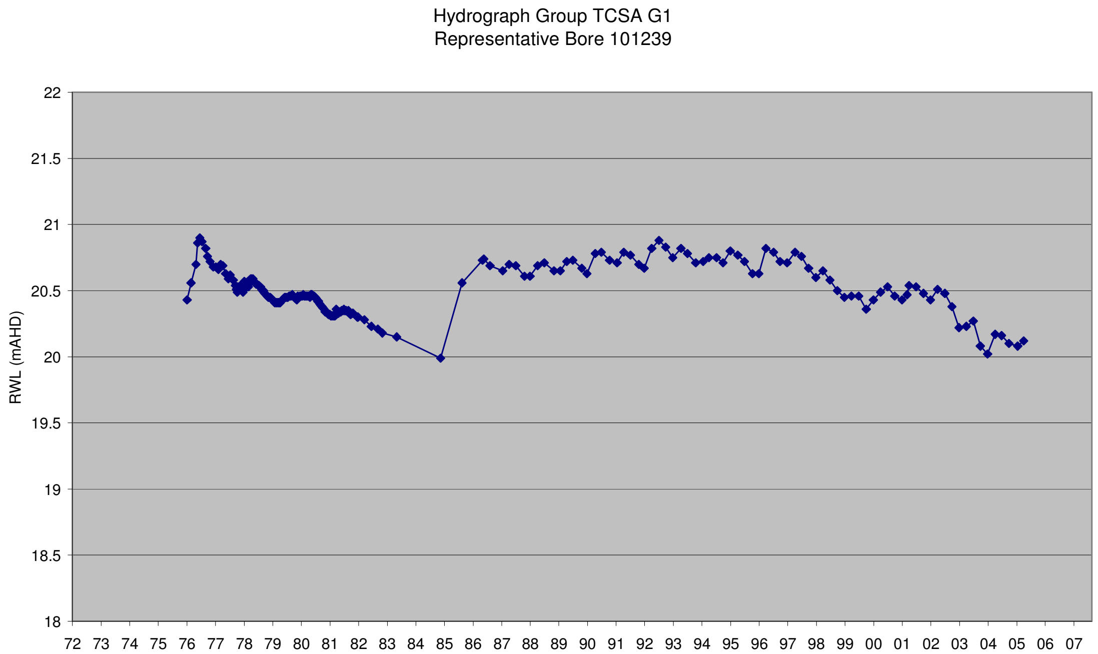


*Figure 12        Representative hydrographs Tertiary Confined Sand Aquifer*

*Figure 12a*




(Note: Bore 1010239 is planned for refurbishment because if the age of the bore and the possible failure and lack of confidence in the data since 2006.)

*Figure 12b*

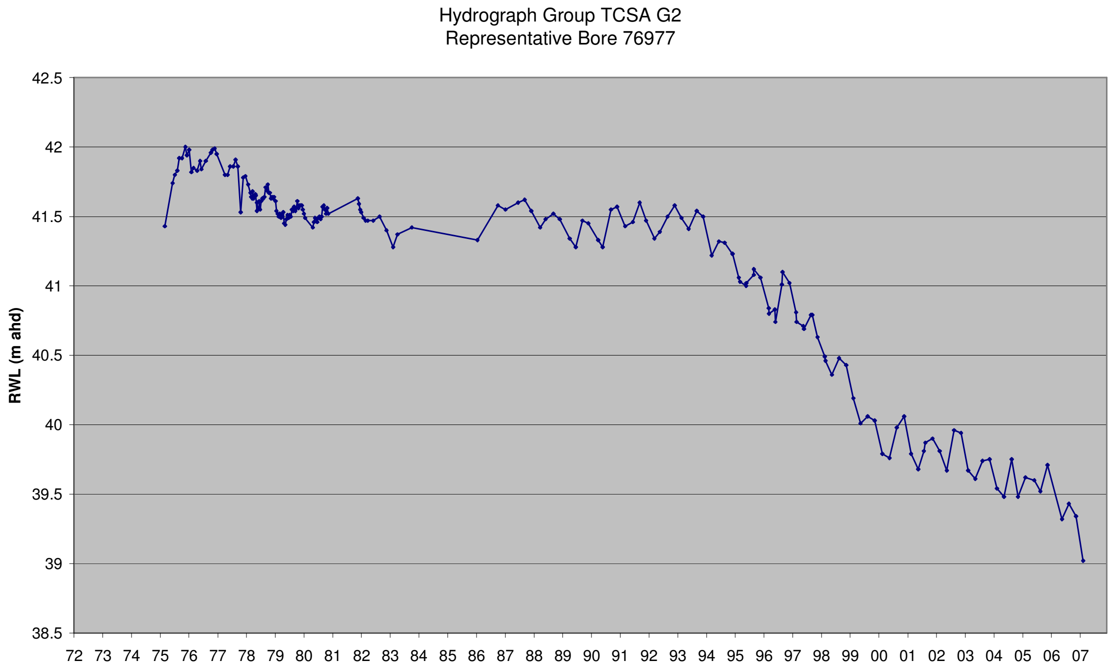
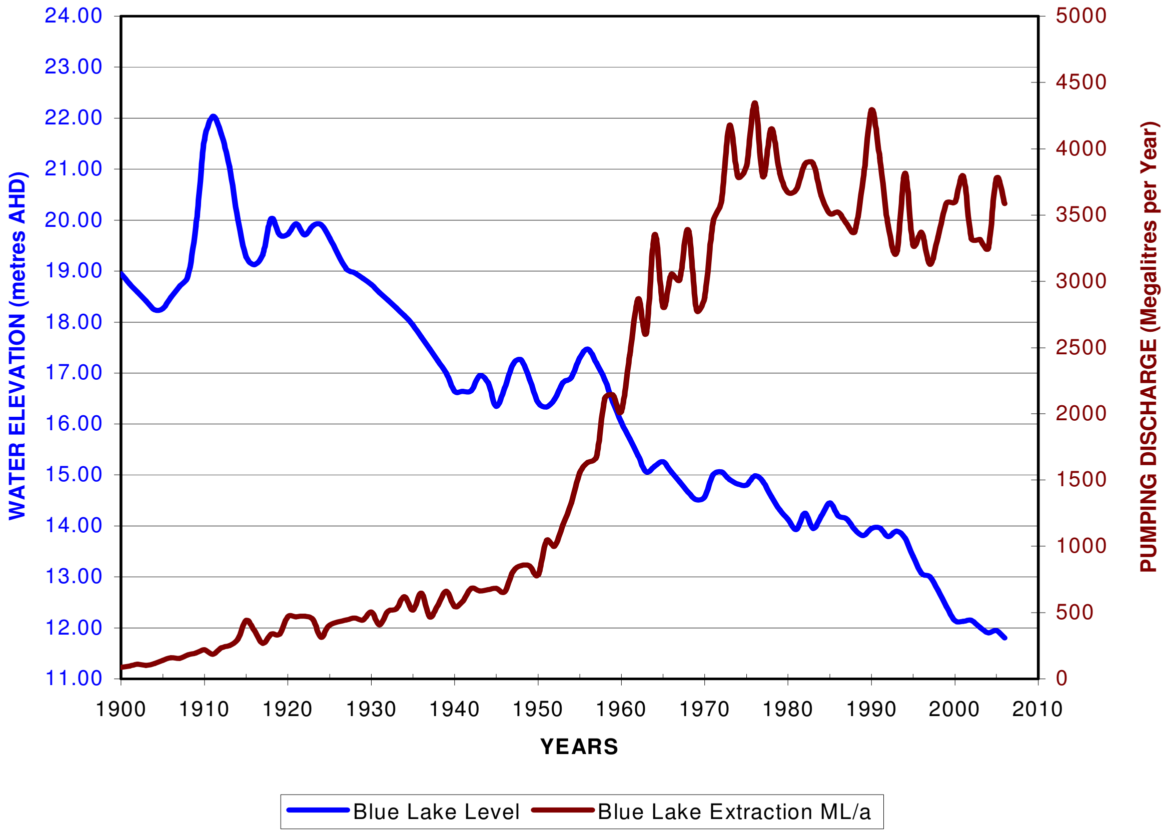


*Figure 13 Water levels in Blue Lake, Mount Gambier, South Australia*



# Appendix: Management Framework

The existing management prescriptions were documented in the Committee's Five Year Management Review in 2001 (BGARC 2001) and previous reviews (BGARC 1991, BGARC 1996). These are consolidated here in regard to Province 1.

## A.1 Tertiary Limestone Aquifer

### A.1.1 Permissible Annual Volumes

At the time the Agreement was being developed Permissible Annual Volumes were based on the assumption that vertical recharge to the Tertiary Limestone Aquifer was equal in corresponding zones across the border (for instance Zones 1A and 1B were both set at 71,000ML, Zones 2A and 2B were both set at 25,000ML).

A review of the vertical recharge was made in the 1985-1990 management review by considering the hydrographic response, through groundwater level information obtained from observation bores in the Tertiary Limestone Aquifer. The Committee amended the Permissible Annual Volumes to reflect the different rates of recharge across the zones. However the original principle of setting Permissible Annual Volumes which in effect assumed that 100% of the recharge could be available for allocation continued unchanged.

A detailed assessment of the vertical recharge was made in the 1990-1995 management review by considering the hydrographic response of the Tertiary Limestone Aquifer according to land use, depth to water table, the soil type and the spatial variation in vegetation type. The assessments indicated greater rates of recharge than previously calculated for many zones. The review also identified groundwater salinisation as a risk to the resource. The Committee determined to keep the PAVs unchanged pending further studies into the risk of groundwater salinisation.

In 2001 the Committee noted that modelling in Zone 1A indicated that the regional specific yield was about 0.1 resulting in a lower recharge volume than previously assumed. The calculated annual volume of recharge 30,900 ML/yr was set as the Permissible Annual Volume for the Tertiary Limestone Aquifer for Zone 1A. Similarly the Permissible Annual Volume for Zone 1B was reduced from 71,000 ML/yr to 45,720 ML/yr.

Declining water trends were observed in the management review 1995 - 2001 in parts of Zones 1A, 1B, 2A, 2B and 3A. The relative causes of the declines, whether groundwater extraction, climate variability or plantation forest development, were unclear. The Committee recommended to Contracting Governments that research be undertaken to identify the reasons for, and an understanding of, the components of the water level decline. The current Permissible Annual Volumes were maintained without change.

### A1.2 Permissible potentiometric surface lowering

The original Agreement defined the permissible rate of potentiometric surface lowering as '*an average annual rate of surface lowering of 0.05 metres, or in relation to a particular zone, such other rate as has been agreed by the Minister of each Contracting Government'.*

Declining water trends were observed in the management review 1995 - 2001 in parts of Zones 1A, 1B, 2A, 2B and 3A. At the recommendation of the Committee the Ministers agreed to amend the permissible rate of potentiometric surface lowering for these zones from 0.05m to 0.25m.

### A1.3 Permissible distance

The permissible distance is the distance from the border within which all applications for licences must be forwarded to the Committee for approval. For all zones in Province 1 (i.e. Zones 1A, 1B, 2A, 2B, 3A, 3B, 4A and 4B) the permissible distance is one kilometre for the Tertiary Limestone Aquifer.

## A.2 Tertiary Confined Sand Aquifer

### A.1.1 Permissible Annual Volumes

Management of the groundwater resources within the Designated Area up to 2001 concentrated on the Tertiary Limestone Aquifer.

In the management review 1995 - 2001 the Committee developed management prescriptions for the Tertiary Confined Sand Aquifer. A number of factors were critical in arriving at management prescriptions for this aquifer. These were:

- the need to ensure that there is no reversal in the potentiometric levels between the Tertiary Limestone Aquifer and the Tertiary Confined Sand Aquifer;
- modelling indicated that there could be a substantial change in the water balance of the Tertiary Limestone Aquifer as a result of an increase in the leakage from the Tertiary Limestone Aquifer following increased extractions from the Tertiary Confined Sand Aquifer; and
- because of the regional nature of the Tertiary Confined Sand Aquifer and its hydraulic behaviour, the determination of the volumes available for allocation needed to focus on the whole aquifer system.

The Committee specified volumes available for allocation for the Tertiary Confined Sand Aquifer as follows:

| Zones | Management Prescription for Allowable Annual Volume |
|---|---|
| All Designated Area Zones except 3B&4B | = 50% x (0.75 x Throughflow Volume) |
| Designated Area Zones 3B&4B | = (0.25 x Throughflow Volume) |

The percentage of the throughflow was set aside for allocation based on acceptable regional declines in potentiometric levels of two to four metres as advised by the South East Catchment Water Management Board.

Management areas were recommended for adoption by each of the States outside the Designated Area to provide a consistent approach in the development of this aquifer based on its characteristics, except for the Kingston zone which was set at current commitment. The volumes recommended for allocation were as follows:

| | |
|---|---|
| Zones outside Designated Area except Kingston | = 50% x (0.75 x Throughflow Volume) |
| Kingston Zone | = 25,000 ML/year |

The Committee also recommended to the Contracting Governments in its 1995 – 2001 management review that:

- an adequate monitoring network should be established for the Tertiary Confined Sand Aquifer to assess the response to withdrawals and to determine the cause of the decline in potentiometric levels in Victoria and the South East of South Australia over the last five years; and
- field testing should be undertaken to improve estimates of leakage from the Tertiary Limestone Aquifer to the Tertiary Confined Sand aquifer in the southern part of the Designated Area.