South Australian – Victorian Border Groundwaters Agreement Review Committee

Government of South Australia

State Government Victoria

Management Review
Tertiary Limestone Aquifer in Province 2 of the Designated Area

Melbourne and Adelaide

December 2007

Foreword

The Border Groundwaters Agreement was established in 1985 to make provision to protect the groundwater resources adjacent to the border between South Australia and Victoria 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. See Figure 1.

As part of the Agreement the Committee is required to review certain management prescriptions at periods not exceeding intervals of five years. This review consolidates the Committee's views in respect of new understandings of the resource and makes recommendations on the strategic direction and a range of other actions to be undertaken jointly by Governments and the local community.

CONTENTS

Tables

Figures

1. Introduction

The Border Designated Area has been divided into three hydrogeological provinces as shown in Figure 1. This paper forms one of a series covering Provinces 1, 2 and 3 it sets out the management strategy for Province 2. Province 2 has two prime regional groundwater aquifers, the Tertiary Limestone Aquifer and the underlying Tertiary Confined Sand Aquifer. This report deals with the Tertiary Limestone Aquifer. The paper provides a summary of key observations and technical issues and reviews the management arrangements for the Tertiary Limestone Aquifer in Zones 5A, 6A, 7A, 8A, 9A, 5B, 6B, 7B and 8B. The condition of the Tertiary Confined Sand Aquifer will be discussed in a separate report.

Declining water level trends in the Tertiary Limestone Aquifer were observed in 2001 in Zone 5A and parts of Zones 5B, 6A and 6B. Elsewhere levels were stable. At that time the principal causes of the declines, whether groundwater extraction or climate variability, were unclear. 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. In the meantime it was recommended that the Permissible Annual Volumes for the Tertiary Limestone Aquifer be maintained without change.

Since 2001 a range of technical investigations have been undertaken of which this paper presents a summary (SKM 2005a, SKM 2007a, SKM 2007b and SKM 2007c).

The Tertiary Limestone Aquifer in Province 2 had previously been considered a renewable resource receiving annual diffuse recharge supplemented with point source recharge. Technical assessments now indicate that this resource should be regarded as non-renewable for water allocation and management purposes.

2. Management Framework

The primary objective for the management arrangements for the groundwater of the Tertiary Limestone Aquifer in Province 2 is to protect the water quality, which is suitable for stock and domestic use and town water supplies. It is the only water resource in the region suitable for these purposes. Commercial uses of the resource and irrigation have been developed but the extent of the allocation for these purposes must be consistent with the primary objective for the resource.

Access to groundwater for purposes other than domestic and stock and town supplies cannot be guaranteed indefinitely as the water allocations are in excess of modern recharge and are drawn from water in storage. This continued use for commercial and irrigation purposes is only acceptable for such time as the primary objective for the aquifer continues to be met.

3. Key Technical Observations

Table 1 summarises the key hydrogeological features of the Tertiary Limestone Aquifer in Province 2.

Table 1 Summary of key hydrogeological features

Feature	Characteristics
Hydrogeology	The Tertiary Limestone Aquifer is approximately 70m thick, generally flat and regionally extensive. Up to 50m of the aquifer thickness is saturated. The Tertiary Limestone Aquifer becomes progressively more confined towards the east. Groundwater generally flows from east to west. A specific yield of 0.1 is generally applied for water balance calculations. A best estimate transmissivity of 2,000 m^2/day is usually applied for water balance calculations. The Tertiary Limestone Aquifer is karstic in some areas (e.g. Zone 6A and the western parts of Zones 5B and 6B) The Tertiary Limestone Aquifer is overlain by surficial sediments (Woorinen Formation) and the marine sands of the Parilla Sands Aquifer. The hydraulic gradient between the Parilla Sands and the Tertiary Limestone Aquifer is uniformly downward toward the Tertiary Limestone Aquifer and it is downward from the Tertiary Limestone Aquifer to the Tertiary Confined Sand Aquifer. A confining layer occurs between the Parilla Sands Aquifer and Tertiary Limestone Aquifer over parts of Zone 8B and 9A.
Age of groundwater	Leaney and Herczeg (1999) undertook an assessment of the origin of fresh groundwater beneath the Mallee region that included Zone 6B in Province 2. They concluded that over the last 20,000 years two recharge regimes have existed. Firstly, significantly higher recharge rates than today resulted from the wetter climatic conditions from approximately 20,000 years ago, and secondly there has been a period with lower recharge rates in semi-arid conditions similar to those experienced today. This investigation suggests that the water recharged close to its current location, probably through the sandy soils of the Big and Little Deserts and has not migrated a significant distance along the groundwater flow path since recharge.
Climate	Average annual rainfall is 545 mm (at Neuarpur, in Victoria), predominantly during winter (SKM, 2005b). The variability of rainfall has been higher during the second half of the 20^{th} century. Since 1993 rainfall has exhibited a general negative deviation from average rainfall (SKM, 2005a). The last significant flood event to provide episodic recharge to the aquifer occurred in the 1980s.
Landuse	The dominant land use is dryland farming and irrigated agriculture. The distribution of land use is illustrated in Figures 2 and 3. There is an extensive tract of native vegetation in the Little Desert National Park in the northern part of Zone 6B and southern part of Zone 7B.

<table>
<tr><th>Feature</th><th>Characteristics</th></tr>
<tr><td>Groundwater allocation and extraction</td><td><table><tr><td></td><td>Allocation</td><td>Water Use 03/04**</td></tr><tr><td>TLA G12* (1,200km^2)</td><td>45,500 ML (38 ML/km^2)</td><td>32,000 ML (26 ML/km^2)</td></tr><tr><td>TLA G13, TLA G14 and TLA G15 (2,677km^2)</td><td>20,000 ML (7 ML/km^2)</td><td>10,500 ML (4 ML/km^2)</td></tr><tr><td>Total</td><td>65,500 ML</td><td>42,500 ML</td></tr></table></td></tr>
<tr><td>Groundwater level trends</td><td>TLA G12 exhibits steady decline (approximately 0.14m/year) since 1992/1993.
TLA G13 and TLA G15 demonstrated stable long-term groundwater levels.
TLA G14 demonstrated long-term rising trends from 1980 to 2004. The level trends have been stable since 2004.
Refer to Figures 2 and 3 for location of these water level trend areas.</td></tr>
<tr><td>Water budget</td><td>The results of water budget calculation for area of TLA G12 indicate that for the volume of groundwater extracted the groundwater levels would be drawn down by approximately 1.6m over a 7 year period (SKM, 2007b). This correlates with the observed groundwater declines of 0.75 to 1.5 m over that 7 year period.</td></tr>
<tr><td>Groundwater Dependent Ecosystems</td><td>The depth to water table in the Tertiary Limestone Aquifer is deep (greater than 20m) throughout Province 2, and hence the potential for there to be ecosystems that are dependent on groundwater is considered to be low. Ecosystems may occur where the Tertiary Limestone Aquifer is karstic or where the groundwater levels are shallow in South Australia west of the Designated Area. There have not been any investigations into the distribution or significance of such ecosystems in Province 2 of the Designated Area.</td></tr>
<tr><td>Groundwater salinisation</td><td>Groundwater salinity trends are stable.</td></tr>
</table>

Note: *TLA G12, TLA G13, TLA G14, TLA G15 are hydrograph groupings that represent groundwater level trend patterns. For locations see Figures 2 and 3.

**For the South Australian portions of these regions the water use values are indicative pumped volumes (not metered use), as supplied by Department of Water, Land and Biodiversity Conservation. Victorian use data is metered use.

4. Key Technical Issues

4.1 Conceptual model

The declining water level trends in Zone 5A and parts of Zones 5B, 6A and 6B (TLA G12) (Refer Figure 2 and 3) have previously been attributed to changes in climatic conditions over the period of record, particularly the long-term reduction in rainfall throughout the region. However, the correlation of drawdown to extraction and information on dating of groundwater (Leaney & Herczeg, 1999) suggests that the groundwater resource is ancient and the rate of modern diffuse recharge to the Tertiary Limestone Aquifer is low.

In support of Leaney and Herczeg (1999), a simple calculation was undertaken for the area TLA G12 of the expected groundwater level decline as a result of indicative groundwater use. The aim of this calculation was to determine the estimated impact of total extraction on the water levels in the Tertiary Limestone Aquifer.

The results of this calculation indicated that for the volume of groundwater extracted the groundwater levels would be drawn down by approximately 1.6 metres over a seven year period. This correlates with the observed groundwater declines of 0.75 to 1.5 metres over the same period. The approximate equivalence of the calculated drawdown with the observed drawdown, suggests that:

- the aquifer is receiving little modern diffuse recharge and the observed change in water levels is the result of groundwater being removed from storage with no significant replenishment; or

- the aquifer receives modern recharge (perhaps as episodic recharge), but the combined aquifer outflow and extraction are significantly in excess of actual recharge and as a result the groundwater levels continue to decline.

The implication of the revised conceptual model is that:

- the groundwater extracted is being taken out of storage from the Tertiary Limestone Aquifer;

- groundwater levels are likely to continue to decline in TLA G12 under continued rates of extraction and the drawdown may expand in area. It is expected that at the current rates of decline the groundwater levels would be 2m deeper in 10 years time. The decline in water levels in TLA G12 is unlikely to adversely affect existing groundwater users or the environment over this timeframe. The potential impacts of continued water level declines over a long-term time frame may include:

    - *Depletion of the aquifer:* The saturated thickness of the aquifer is significant (approximately 50m) and the volume in store is large, therefore at the current rate of decline (approximately 2m over 10 years) it will take a significant amount of time before the resource would be depleted.
    - *Increased costs for groundwater users:* A decline in groundwater levels can result in groundwater users having to deepen bores and re-configure or purchase new pumps. This results in a cost to individual groundwater users. In the immediate

timeframe the rate of decline is small relative to the current lifting head capacities of the pumps, hence impacts are slight. In the long-term there may be increased costs to groundwater users.

  - *Groundwater Dependent Ecosystems:* The depth to water table is deep (greater than 20m) throughout Province 2, and hence the potential for there to be ecosystems that are dependent on groundwater is considered to be low. The Tertiary Limestone Aquifer is a very large aquifer system. Points of natural discharge are remote from areas of groundwater extraction in Province 2. Accordingly it is unlikely that groundwater extraction will impact on groundwater dependent ecosystems over the forthcoming review period. The groundwater extracted will be derived from storage. Due to the remoteness of discharge from Province 2 groundwater derived from storage will not have a discernible impact on discharge.

- The water extracted from Zones 6A (northern part), 7A, 8A, 7B and part of 8B (i.e. TLA G13, TLA G14 and TLA G15) is taken from storage. These areas have stable groundwater levels. The volumes extracted are significantly lower in these areas than in TLA G12 and hence the impact on water levels is not apparent. The volume allocated is less than Permissible Annual Volumes. Further allocation in these zones may lead to increased extraction with potential impact on water levels. However the extraction 'hinge-point' between stable water level trends (4 ML extracted per square kilometre) and declining levels (26 ML extracted per square kilometre) is not able to be quantified.

4.2 Groundwater salinisation

There is no overall discernible trend in groundwater salinity. There is a risk that recycling of irrigated groundwater (i.e. groundwater that percolates past the root zone of the crop and recharges the aquifer) may lead to an increase in the salinity of groundwater. This issue was identified in the Committee's five year management review in 2001 and investigations have since been instigated. Technical reports on this issue are in the final stages of publication. The likelihood of increasing groundwater salinity over the next 10 years is considered to be low.

5. Proposed Management Strategy

Future management settings need to consider the balance between the existing commitments to the use of the resource and the longer-term need to preserve the resource as the only readily available source of water. The future allocation and use of this water has to balance these demands.

The Intergovernmental Agreement on a National Water Initiative (CoA, 2004) states that the term *environmentally sustainable level of extraction* means – 'the level of water extraction from a particular system which, if exceeded would compromise key environmental assets, or ecosystem functions and the productive base of the resource'. The management strategy proposed in this review would comply with this National Water Initiative definition.

Where groundwater utilisation is relatively low and there is no discernible change to groundwater levels, no management intervention is required but a management policy for the use of non-renewable resources still needs to be developed.

Groundwater levels are declining where groundwater utilisation is relatively high. The resource is overcommitted in this area and continued use at current levels is unsustainable in the long term.

Due to changes in the understanding of the nature of the resource in Province 2 from recharge-driven to a largely non-renewable resource, a fresh agreement needs to be developed by the two States to the principles to be used in the allocation and use of the groundwater. As a consequence, and using the precautionary principle, allocations should be capped at current commitments pending the outcome of the States' agreement discussed above. Therefore the Permissible Annual Volumes for Zones 7B, 8A and 8B are to be reduced to the level of existing commitment.

An extrapolation of the rates of groundwater level decline from the current extraction regime is in the order of two metres over ten years and as such will not compromise the productive base of this resource. This needs to be monitored and periodically reviewed.

In Zone 6A there is potential for transfers from the lowly-stressed northern portion of the zone to the highly-stressed southern portion. To overcome this risk, a sub-zone (Sub-zone 6A south) should be established with its boundary to coincide with the boundary between the Frances and Bangham management zones within the Lower Limestone Coast Prescribed Wells Area. The Allowable Annual Volumes for the sub zones should be set at the levels of current commitment. The permissible potentiometric surface lowering for Zone 6A should be set at a rate of 0.2 m/year as calculated by the Committee's protocol for setting potentiometric surface lowering.

6. Review of Management Prescriptions

6.1 Permissible Annual Volumes and Allowable Annual Volumes

The Permissible Annual Volumes in Province 2 are reassessed on the basis that:

- The Tertiary Limestone Aquifer has very low rates of modern recharge;
- In TLA G12 area (Zones 5A, northern part of Zone 5B and southern part of Zones 6A and 6B);
    - The current level of groundwater extraction is resulting in ongoing groundwater level declines;
    - Zones 5A, 5B, 6A, and 6B are fully allocated;
    - This rate of decline is likely to continue in the future at the current rates of extraction and it is not known whether these declines might stabilise;
    - There are no immediate risks to users or the environment over the short term management horizon (say 10 years);
    - Increasing the groundwater allocation may lead to increased extraction and increase the rate of decline.
    - A precautionary approach is adopted to limit increasing the rate of water level decline. No further allocations be made and Permissible Annual Volumes remain unchanged in Zones 5A, 6A, 5B and 6B.
- In TLA G13, TLA G14, TLA G15 area (northern part of Zones 6A and 6B, and Zones7A, 8A, 9A, 7B, and 8B):
    - The water levels are stable at the current level of groundwater use;
    - Further allocations could be made in a number of zones as current allocations are less than the Permissible Annual Volumes;
    - The rate of extraction that would cause groundwater levels to change from being stable to declining has not been quantified.
    - A precautionary approach is adopted to prevent the risk of water level decline as a result of increased allocations. The Permissible Annual Volumes are to be set at current allocations for Zones 7A, 8A, 9A, 7B and 8B.

There is the potential for groundwater allocations in the north of Zone 6A to be transferred to the south of Zone 6A. This would increase the current rate of groundwater decline in the south of Zone 6A.

Sub-zoning Zone 6A and setting an Allowable Annual Volume for each sub-zone would address this issue. The sub-zones would consist of Sub-zone 6A South and Sub-zone 6B North. The sub-zone boundary would align to the existing boundary between South Australian management zones Bangham and Frances within the Lower Limestone Coast Prescribed Wells Area. This boundary is consistent with the boundary between the hydrograph response regions TLA G12 and TLA G14.

An Allowable Annual Volume is set at current allocations for the Sub-zone 6A South. This will permit the transfer of licences from Sub-zone 6A South to Sub-zone 6A North. This would allow for a reduction in extractions in the highly-stressed area. Therefore there is no need to set an Allowable Annual Volume for Sub-zone 6A North.

Zone 8B comprises areas where the Tertiary Limestone Aquifer is both confined and unconfined. The exact boundary of the confining layer is not discernable. There is no technical reason to distinguish these areas for the purpose of managing allocation and extraction. For these reasons sub zoning 8B is not required. There is no need to sub zone Zones 5A, 7A, 8A or 7B.

The Tertiary Limestone Aquifer in the cleared land south of the Ngarkat Conservation Park is partly confined and partly unconfined and as a result different methods of calculation were used to determine the available resource. The boundary of the confining layer is gradational in this area. Zone 9A is to be divided into two sub-zones, one north of the Conservation Park and the other south of the Conservation Park. The cleared land in Zone 9A north of the Ngarkat Conservation Park is within Province 3 and this will be discussed further in the Committee's report on Province 3.

There is uncommitted water in Zones 7B and 8B in Victoria and 8A in South Australia. Pending the development of an agreed rational basis for setting Permissible Annual Volumes in Province 2 they should be reduced to the level of commitment. The new values will be as follows;

Table 2 Proposed Permissible Annual Volumes and Allowable Annual Volumes for the Tertiary Limestone Aquifer in Province 2

Zone or proposed Sub-zone	Permissible Annual Volume for the Tertiary Limestone Aquifer (ML/year)	Allowable Annual Volume for the Tertiary Limestone Aquifer (ML/year)
Zone 5A	18500	
Zone 5B	11949	
Zone 6A	8758	
Sub-zone 6A South		4658
Zone 6B	9838	
Zone 7A	7500	
Zone 7B	5782	
Zone 8A	4854	
Zone 8B	3500	
Sub-zone 9A South		7760

These figures are based on BGARC 22nd Annual Report and advice from the States

In South Australia meters are progressively being introduced into the South East. A process is under way to introduce volumetric allocations to replace the crop area based Irrigation Equivalent System of water allocations to better manage the water.

6.2 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'.

The current permissible potentiometric surface lowering rates (PSL) and the observed rates for the zones in Province 2 are shown in Table 2 below.

Table 3 Permissible potentiometric surface lowering rates and observed rates 30 June 2007

South Australia				Victoria			
Observed Hydrograph Rate (m/yr)	**Calculated Rate (m/yr)**	**PSL Rate (m/yr)**	**Zones**	**Zones**	**PSL Rate (m/yr)**	**Calculated Rate (m/yr)**	**Observed Hydrograph Rate (m/yr)**
0.0	0.00	0.65	9A				
+0.01	0.01	0.05	8A	8B	0.65	-*	0**
0**	0.01	0.05	7A	7B	0.05	+0.01	0**
0 to 0.15	0.01	0.05	6A	6B	0.05	0.02	0 to 0.15
0.15	0.13	0.25	5A	5B	0.25	0.05	0 to 0.15

*No available data for analysis period
** Stable trends observed in hydrographs for Zones 7A, 7B and 8B.

The calculated rates of potentiometric surface lowering are determined by a method adopted by the Committee. This determines the arithmetic average of the observed water level trends of representative monitoring bores in a zone. The method does not distinguish between the different water level trends that may exist within a zone.

Zone 5A and Zone 5B

The observed rate of decline is within the permissible potentiometric surface lowering rate. The peak rate of decline within Province 2 is 0.2 m/year. This is consistent with the Permissible Annual Volumes and reflects the accepted observed rates of decline. Therefore it is recommended that the permissible potentiometric surface lowering rate for Zones 5A and 5B be amended to reflect the accepted rate of 0.2 m/year.

Zone 6A

The calculated observed rate for Zone 6A is 0.01 m/year, however the zone has two areas of distinct groundwater trends, TLAG12 and TLAG13. Groundwater levels in TLAG12 are declining at 0.15 m/year whilst groundwater levels in TLAG13 are stable.

The use of the method across the whole zone is not representative and as such the method should be applied separately to each sub-zone.

The permissible potentiometric surface lowering rate in Sub-zone 6A south should be 0.2 m/year and the permissible potentiometric surface lowering rate for Sub-zone 6A North should be 0.05 m/year.

Zone 6B

The calculated rate for Zone 6B is 0.02 m/year, whilst the observed rates ranged from 0 to 0.15 m/year.

The permissible potentiometric surface lowering rate should be amended from 0.05 m/year to 0.2 m/year.

Zone 7A, Zone 7B and Zone 8A

No change to the permissible potentiometric surface lowering rates in these zones is required.

Zone 8B and Zone 9A

These areas being partly confined could behave as a confined aquifer and as such the permissible potentiometric surface lowering rates should remain at its current figure of 0.65 m/year.

6.3 Permissible distance

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

Permissible distance is 1 km for the Tertiary Limestone Aquifer and this is to be retained.

6.4 Permissible salinity

There are no current technical reasons that warrant setting a permissible salinity rates or levels.

7. Recommendations for Further Technical Work

The SKM report (2007c) and the Technical Audit Panel report (2007) recommended that further investigations be undertaken to refine the conceptual model. Specifically, studies of recharge and the determination of aquifer properties including storage coefficient through long-term pumping tests and isotopic hydro chemical studies.

Greater insight on specific yield and recharge rates would improve the technical understanding of the hydrology of the resource. However based on the understanding of the lack of modern recharge more immediate results to aid the management of the resource would be gained by metering extractions and monitoring water levels. For these reasons pumping tests and hydro chemical studies are not recommended at this stage.

Hydro-chemical studies on salt accession are currently being finalised and the Committee will evaluate these results in the light of the current understanding on recharge.

It would be desirable to undertake studies of the future water level trends and their impacts. The Frances-Neuarpur groundwater flow model may be useful in predicting water level trends. This model was constructed in 2003 but could not be calibrated due to lack of data on groundwater extraction. Meters were installed in Victoria in 1999 and South Australia in 2006. Calibration of the model might now be achieved as South Australia has obtained metered data.

Some parts of the TLA G12 area have intensive extraction but no observation bores. Additional observation bores should be installed in these areas.

The Technical Audit Panel report recommended that studies be undertaken into the relationships between groundwater and ecosystems. As discussed previously the risk to groundwater dependent ecosystems is considered to be low, however the Committee will consider further studies in its work program.

References

CoA (2004). *Intergovernmental Agreement on a National Water Initiative Between the Commonwealth of Australia and the Governments of New South Wales, Victoria, Queensland, South Australia, the Australian Capital Territory and the Northern Territory*, 24 June 2004.

Leaney, F.W.J, and Herczeg A.L. (1999). *The Origin of Fresh Groundwater in the SW Murray Basin and its Potential for Salinisation*. CSIRO Land and Water Technical Report #7/99.

SKM (2005a). *Assessment of the Impacts of Climate Variability and Change to Groundwater in Province 1 and 2 of the South Australian – Victorian Designated Area.*

SKM (2005b). *Five Year Technical Review of the Neuarpur WSPA Groundwater Management Plan.*

SKM (2007a). *Five year Technical Review Summary 2001 – 2005, Province 2*. Report prepared by Sinclair Knight Merz for the Border Groundwaters Agreement Review Committee (South Australia – Victoria).

SKM (2007b). *Implications of Water Level Declines in the Tertiary Limestone Aquifer, South Australia – Victoria Designated Area, Zones 5A, 5B, 6Aand 6B.*

*SKM (*2007c). *Analysis of Potentiometric Surface Lowering for Border Zone Hydrographical Provinces 1, 2 and 3.* Report prepared by Sinclair Knight Merz for the Border Groundwaters Agreement Review Committee (South Australia – Victoria).

Technical Audit Panel (2007). *Review of 'Implications of Water Level Declines in the Tertiary Limestone Aquifer, South Australia – Victoria Designated Area, Zones 5A, 5B, 6Aand 6B'.* 24th August 2007.

Figures

Figure 1 Provinces of the Designated Area

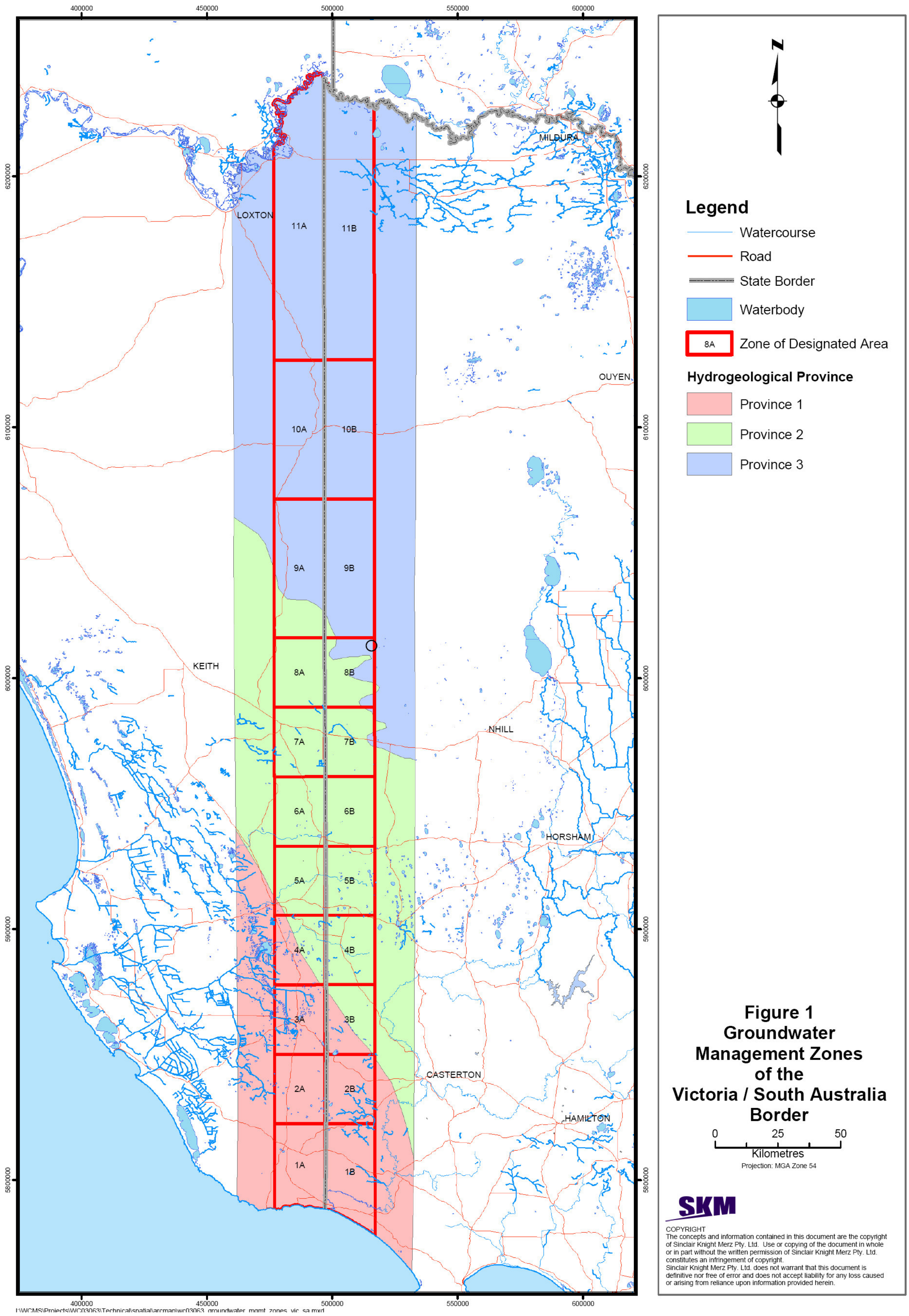

Figure 2 Hydrograph groupings, groundwater allocations and land use, Zones 5A, 6A, 7A, 8A and 9A

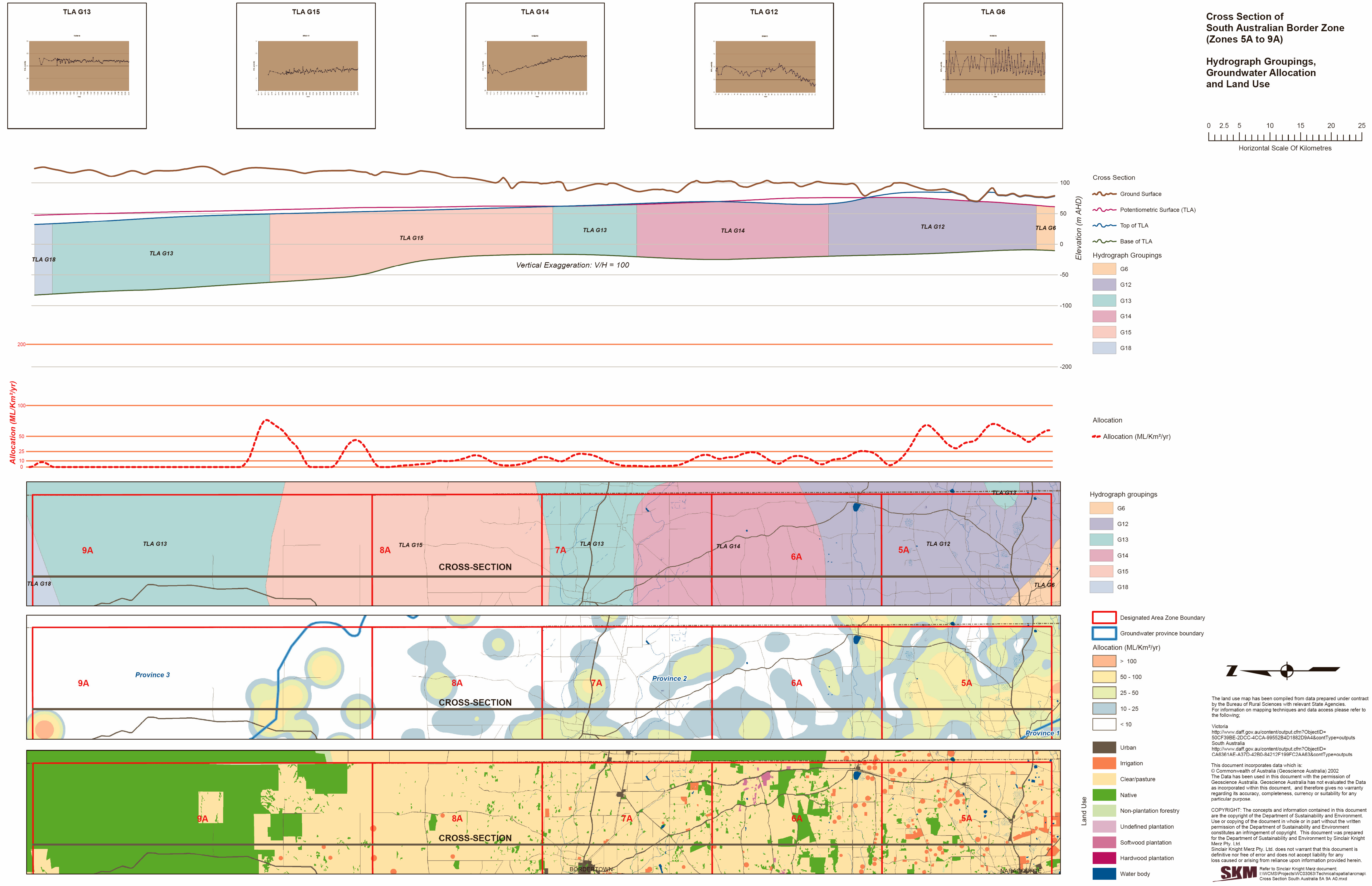

Figure 3 Hydrograph groupings, groundwater allocations and land use, Zones 5B, 6B, 7B, 8B and 9B