Lower Campaspe Valley

Water Supply Protection Area

Groundwater Management Plan





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Department of
Sustainability and Environment

Lower Campaspe Valley

Water Supply Protection Area

Groundwater Management Plan

October 2012

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Approval

I, Peter Walsh, Minister for Water, approve this management plan in accordance with section 32A(6) of the Water Act 1989.

Peter Walsh MLA

Minister for Water

Date 17-10-2012

Foreword

There is significant demand for groundwater from irrigated agriculture, domestic and stock use and urban communities in the Lower Campapse Valley. This demand must be managed to provide an equitable share for all groundwater users and the environment.

A large part of the Lower Campaspe Valley has been under plan management since 2003, during which time a range of conditions have been experienced including severe drought with low surface water allocations and heavy flooding. These vastly different events have enabled the aquifer response to be observed, providing real experience to supplement a growing body of historical data. This Plan reflects that experience and knowledge.

This Plan covers a wider area than the previous management area, which better reflects the extent of the Deep Lead aquifer system. It provides licence holders with greater flexibility to manage their entitlements through improved trading opportunities and the introduction of carryover.

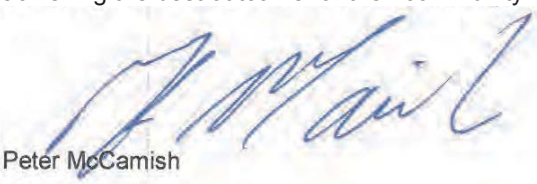
This Plan also provides protection for existing groundwater users as well as the environment, through supporting a cap on licensed entitlement and restricting the extraction of groundwater when predetermined trigger points are reached. Further, it places limits on the concentration of groundwater pumping.

This Plan has been developed to be easily understood and to ensure up-dated information is available to licence holders such that they are able to plan their operations with more certainty.

I want to thank the members of the Consultative Committee for the effort they have made to understand and come to grips with the task before them. We had a mix of community members, some who had previous experience working to develop groundwater management plans and others who had not. I believe this mix helped to test previous assumptions as well as bring new insight enabling enhanced Plan outcomes.

I also want to thank the members of the technical working group and Goulburn-Murray Water for the efficient and capable way they have served the Consultative Committee.

For my part it has been a privilege to work with and observe a group of people dedicated to achieving the best outcome for their community.



Peter McCamish

Chairman

Lower Campaspe Valley Water Supply Protection Area Consultative Committee

Preface

The preparation of the Lower Campaspe Valley Water Supply Protection Area Groundwater Management Plan commenced in November 2010 following the appointment of a consultative committee in accordance with the Water Act 1989. The Consultative Committee has developed this draft plan following extensive discussions, consideration of technical information and public consultation.

The members of the Lower Campaspe Valley Water Supply Protection Area Consultative Committee are:

Peter McCamish Chair

John Bickley Landholder

Ross McKinstry Landholder

Cathy Hains Landholder

Max McLean Landholder

Della Palmer Landholder

Sue Stewart Landholder

Ron Traill Landholder

Ian Whatley Community

James Williams Environment Victoria and Landholder

Peter Clydesdale Goulburn-Murray Water

Chris Corr Coliban Water

Rohan Hogan North Central Catchment Management Authority

Acknowledgements

The consultative committee would like to thank members of the community who provided input to the development of the draft groundwater management plan through discussions at public meetings and written submissions.

The consultative committee acknowledges the work undertaken by the Goulburn-Murray Water Groundwater Reference Committee that reviewed the former Campaspe Deep Lead Water Supply Protection Area Groundwater Management Plan and developed management proposals.

The consultative committee acknowledges the technical working group for its commitment to providing the best available data to assist the committee's decisions. The technical working group included Dr Phillip Macumber (Phillip Macumber Consulting); Brendan Cossens and Luke Richards (Goulburn-Murray Water); Rob Rendell (RMCG consulting), Simon Baker (Department of Sustainability and Environment); and Rohan Hogan (North Central Catchment Management Authority). Patrick O'Halloran from the Department of Sustainability and Environment is acknowledged for advice provided to the consultative committee.

Glossary of terms

This section defines the terms used throughout the document.

Term/Acronym	Description
Act	Water Act 1989
AHD	the Australian Height Datum is used as a reference for groundwater level measurement where the mean sea level for 1966-68 is assigned a value of zero
Allocation	a percentage of licence entitlement that may be extracted in a given season
Corporation	Goulburn-Murray Water Rural Water Corporation
Entitlement	licensed volume of groundwater in megalitres per year
GDE	groundwater dependent ecosystem
GL	gigalitre or one thousand megalitres
GMA	groundwater management area
km	kilometre
Licence	licence issued under section 51 of the Water Act 1989 to take and use groundwater
m	metre
ML	megalitre or one million litres
Plan	Lower Campaspe Valley Water Supply Protection Area Groundwater Management Plan
Season	period of 12 calendar months beginning on 1 July in any year and ending on 30 June in the following year
WSPA	water supply protection area
Zone	a defined part of the water supply protection area

1 Introduction

1.1 Groundwater management

Groundwater resources in the Lower Campaspe Valley Water Supply Protection Area (WSPA) provide an important source of water for domestic and stock use, irrigation supply, commercial and industrial purposes, reticulated urban supply and the environment.

The Lower Campaspe Valley WSPA Groundwater Management Plan (the Plan) aims to provide security of access to existing users and protect the environment from over development of groundwater resources by supporting a cap on licence entitlement and placing restrictions on groundwater extractions when triggered.

The Plan also enables groundwater users to better manage their licence entitlement by encouraging trade and describing how carryover can be utilised.

Goulburn-Murray Water (the Corporation) is responsible for administering and enforcing the Lower Campaspe Valley WSPA Groundwater Management Plan under section 32A(5) of the Water Act 1989 (the Act).

Coliban Water Elmore urban supply bore

1.2 Lower Campaspe Valley WSPA

The Lower Campaspe Valley WPSA extends from Lake Eppalock in the south to the River Murray in the north and includes the towns of Axedale, Goornong, Elmore, Lockington, Rochester and Echuca. It covers an area of approximately 2,100 km^2 (refer Figure 1).

The Plan applies to the management of groundwater resources at all depths except where it is overlain by the Campaspe West Salinity Management Plan area and the region north of the Waranga Western Channel. In these areas the Plan applies to the management of groundwater resources from 25 m to all depths.

The Shepparton Irrigation Region WSPA overlies the Lower Campaspe Valley WSPA over much of the region north of the Waranga Western Channel; however it does not align exactly.

The shallow aquifers in the upper 25 m of the Shepparton Irrigation Region WSPA and the Campaspe West Salinity Management Plan Area are managed to provide watertable relief and land salinity benefits to improve agricultural productivity (Shepparton Irrigation Region Groundwater Supply Protection Area Consultative Committee, 1997).

Chapter 5.1 outlines the prescriptions of the Plan that do not apply to licences to take groundwater from the shallow (less than 25 m depth) aquifers north of the Waranga Western Channel and in the Campaspe West Salinity Management Plan area.

1.3 Development of groundwater resources

High watertables and land salinity problems emerged in the late 1970's in the lower Campaspe valley in response to land use change. Groundwater levels were reported to be rising by 0.2 to 0.26 m/year south of Elmore between 1900 and the mid 1970s (Macumber, 2008). The watertable was within 2 m of the surface in some parts and groundwater pumping was encouraged under the Campaspe West Salinity Management Plan (Campapse West Salinity Implementation Group, 1992).

Development of the deeper aquifers for irrigation supply commenced in the late 1970's in the lower Campaspe valley. Groundwater use continued to increase steadily until the 1982/83 drought whereupon there was a rapid increase in development of groundwater resources.

There was a continued steady increase in groundwater development in the 1980s and 1990s in the former Diggora and Echuca South Groundwater Management Areas until a moratorium was placed on the issue of new entitlement in 1998.

In 2003 a groundwater management plan was approved for the Campaspe Deep Lead WSPA, which extended from around Elmore in the south to Echuca in the north, incorporating the Diggora and Echuca South Groundwater Management Areas.

Groundwater resources to the north and south of the Campaspe Deep Lead WSPA continued to be developed. A moratorium was placed on the issue of new groundwater licence entitlement in the Southern Campaspe Plains Groundwater Management Area (GMA), which extended from Lake Eppalock to the southernmost boundary of the Campaspe Deep Lead WSPA.

Groundwater extractions were restricted under the Campaspe Deep Lead WSPA Groundwater Management Plan from 2006/07, but groundwater recovery levels continued to decline in response to the prolonged dry conditions.

A review of the Campaspe Deep Lead WSPA Groundwater Management Plan was undertaken which recommended that a new WSPA be declared to manage an area that better represented the fuller extent of the aquifer (G-MW, 2010).

The Lower Campaspe Valley WSPA was declared in June 2010 in accordance with section 27 of the Act. It incorporated the former Campaspe Deep Lead WSPA, part of the Southern Campaspe Plain GMA, and the unincorporated area north to the Murray River and to the west of Lockington.

1.4 Plan objectives

The object of the groundwater management plan, as defined in section 32A(1) of the Act, is to make sure that the water resources of the protection area are managed in an equitable manner, so as to ensure the long-term sustainability of those resources.

More specifically, the objectives of the plan seek to balance economic, environmental and social values through:

(i) Protecting existing authorised groundwater users and the environment, including base flow and groundwater dependent ecosystems, by managing:

- groundwater levels; and
- the potential for change in groundwater salinity.

(ii) Enabling equitable development of the groundwater resources to realise the potential for its use in the region by:

- providing opportunity for new developments through the transfer of licence entitlement (groundwater trading);
- providing flexibility for licence holders to manage their entitlement through trading and carryover; and
- providing the ability to deal with different climatic scenarios.

(iii) Communicating Plan objectives, management rules and resource status by:

- developing a plan that is practical and easy to communicate with transparent rules; and
- establishing a communication strategy that will provide groundwater users and the wider community with monitoring data, allocations and any changes to groundwater management.

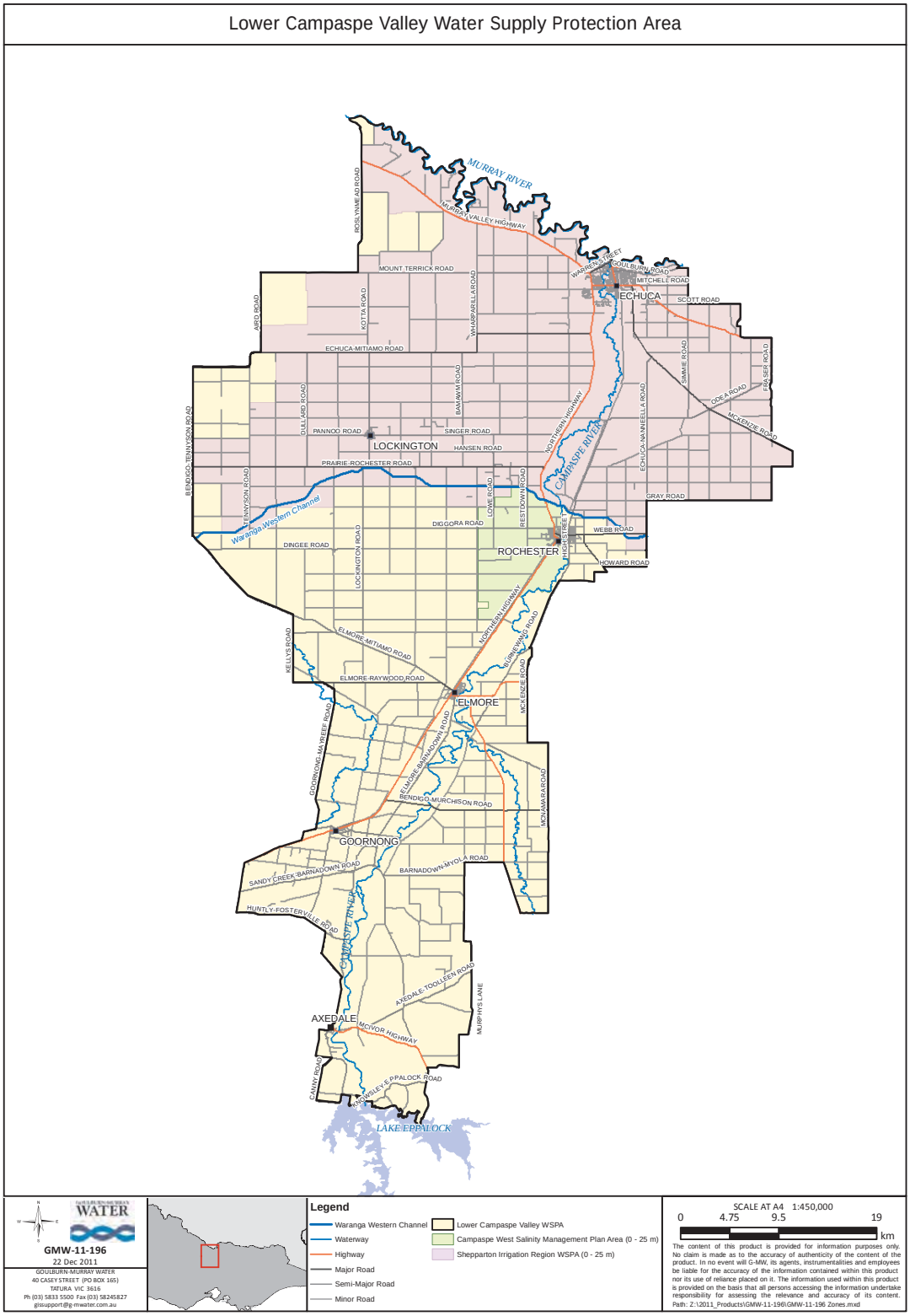


Figure 1 Lower Campaspe Valley Water Supply Protection Area

2 Groundwater resources

2.1 Groundwater system

The key aquifers in the Lower Campaspe Valley WSPA are the Shepparton Formation sands and the underlying Deep Lead coarse sands and gravels.

The Shepparton Formation is found at the surface over much of the Lower Campaspe Valley WSPA. It increases in thickness and clay content to the north.

The Deep Lead, which comprises the Calivil Formation and Renmark Group sediments, is the primary aquifer system developed in the Lower Campaspe Valley WSPA because it is high yielding and the groundwater is generally of good quality. The Deep Lead underlies the Shepparton Formation. It broadens and increases in thickness to the north (SKM, 2011a).

Axedale gravel quarry where Deep Lead material is extracted

The Lower Campaspe Valley WSPA has been divided into four zones based on recharge characteristics, the aquifer's response to pumping and groundwater salinity (G-MW 2012a). From south to north the zones are Barnadown, Elmore-Rochester, Bamawm and Echuca (refer Figure 2).

Groundwater flows northward through the aquifer, draining to the Murray Basin (refer Figure 3). The groundwater salinity in the Deep Lead generally increases along its flow path.

Barnadown Zone

In the Barnadown Zone the Deep Lead is narrow and the valley defined by outcropping bedrock. Basalt is also found underlying the Shepparton Formation in the Barnadown Zone which may confine the Deep Lead in parts.

In the Barnadown zone there is significant recharge from rainfall as well as leakage from the Campaspe River.

Groundwater levels have remained relatively constant in the Barnadown Zone despite the severe dry conditions experienced over the last decade.

Monitoring records suggest that groundwater levels in the Barnadown Zone are largely unaffected by pumping in zones further to the north. That is, groundwater pumping in the Elmore-Rochester Zone does not affect levels in the Barnadown Zone and conversely pumping in the Barnadown Zone does not appear to have a discernible impact on groundwater levels in the Elmore-Rochester Zone. A hinge line, where groundwater levels have remained relatively steady, is interpreted to occur around the boundary between the Barnadown Zone and Elmore-Rochester Zone (Macumber & Macumber, 2011).

Elmore-Rochester Zone

In the Elmore-Rochester Zone the Deep Lead begins to broaden. There is a good hydraulic connection between the Shepparton Formation and the Deep Lead in the Elmore-Rochester Zone such that groundwater pumping from the Deep Lead results in watertable decline.

There is significant recharge from rainfall and irrigation accessions as well as leakage from the Campaspe River where it overlies the Deep Lead.

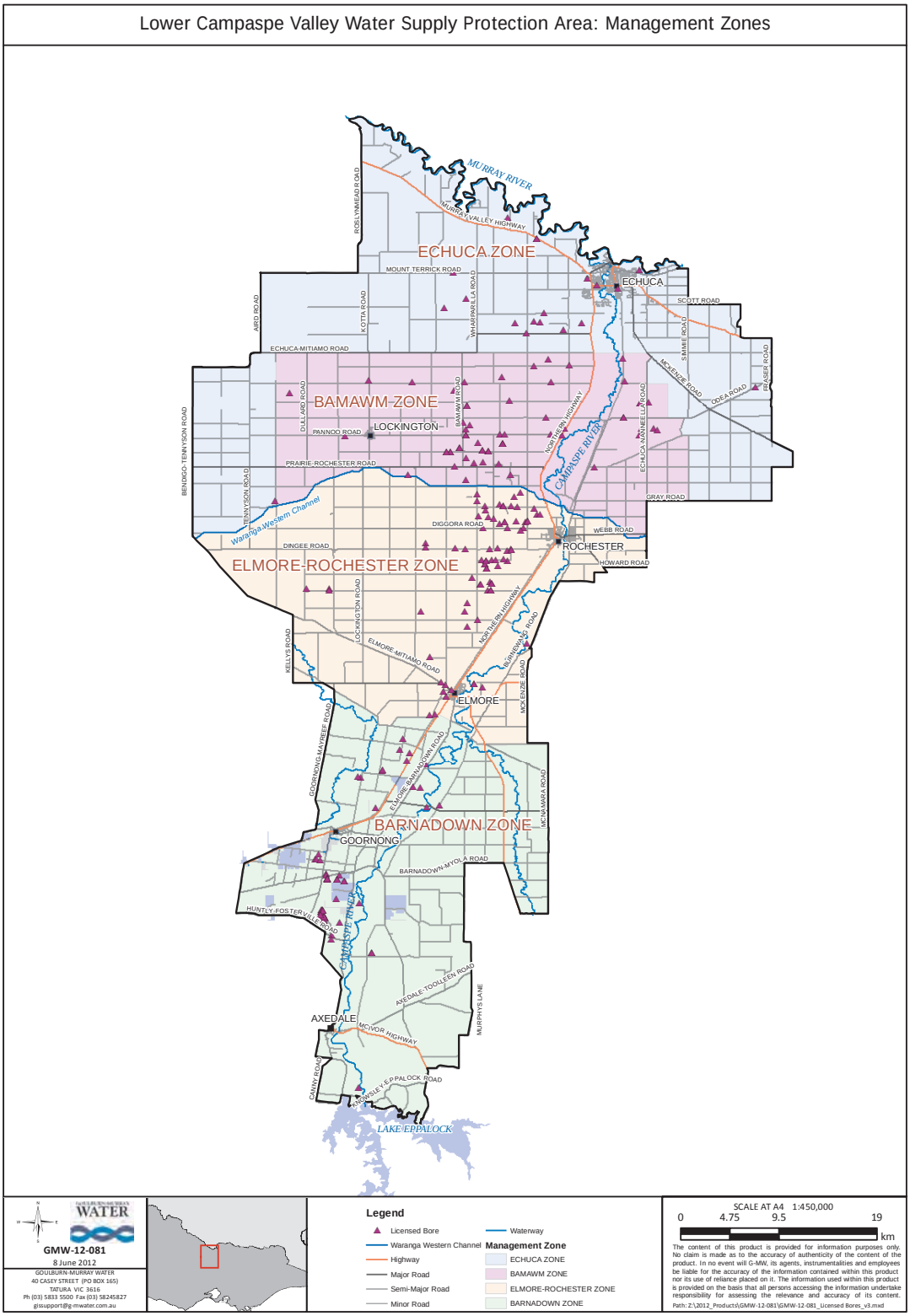


Figure 2 Management Zones

Groundwater levels in the Deep Lead were relatively steady in the Elmore-Rochester Zone between the early 1980's and the mid 1990's. From the mid 1990's to 2010 groundwater recovery levels (the level to which groundwater rises during winter/spring each year) fell by up to 10 m in response to dry conditions and groundwater pumping. Increased rainfall recharge and reduced groundwater pumping resulted in rising groundwater levels in 2010/11 (refer Figure 3).

Seasonal drawdown (the difference in groundwater levels between pumping and non-pumping conditions) of up to 20 m has been observed in areas of intensive groundwater pumping in the Campaspe Irrigation District.

Lowering the watertable in the Elmore-Rochester Zone can impact on surface water features, ecosystems that depend on groundwater and supply for shallow domestic and stock bores. However, lowering the watertable has provided land salinity benefits in the region and could reduce discharge of saline groundwater to the Campaspe River between the Campaspe Weir and Rochester.

Bamawm Zone

The Deep Lead is more confined in the Bamawm Zone, north of the Waranga Western Channel. In this region the Campaspe valley opens up to the riverine plain and is no longer bordered by outcropping bedrock.

Groundwater throughflow from the Elmore-Rochester Zone to the Bamawm Zone is significant as it is driven by a steep hydraulic gradient. This indicates that groundwater pumping in the Bamawm Zone has an impact on the resource in the Elmore-Rochester Zone.

Groundwater mounding at the Waranga Western Channel may be caused by leakage from the channel and a backing up of groundwater created by more confined aquifer conditions further north.

In the Bamawm Zone the Deep Lead is also recharged slowly from water leaking downward through clays of the Shepparton Formation.

Groundwater level trends in the Bamawm Zone are similar to those in the Elmore-Rochester Zone. Groundwater levels were relatively steady between the early 1980's and the mid 1990's; there was a fall in recovery levels of up to 10 m from the mid 1990's to 2010 in response to dry conditions and groundwater pumping; and good recovery in 2010/11.

Seasonal drawdown of up to 20 m has been observed in areas of intensive groundwater pumping in the Rochester Irrigation Area.

In contrast to the Elmore-Rochester Zone, groundwater pumping in the Bamawm Zone has negligible impact on the watertable because of the poor hydraulic connection between the Deep Lead and the shallow Shepparton Formation sands.

Echuca Zone

The characteristics of the groundwater system in the Echuca Zone are similar to the Bamawm Zone.

The Echuca Zone has been delineated in recognition of increasing groundwater salinity in the Deep Lead to the north.

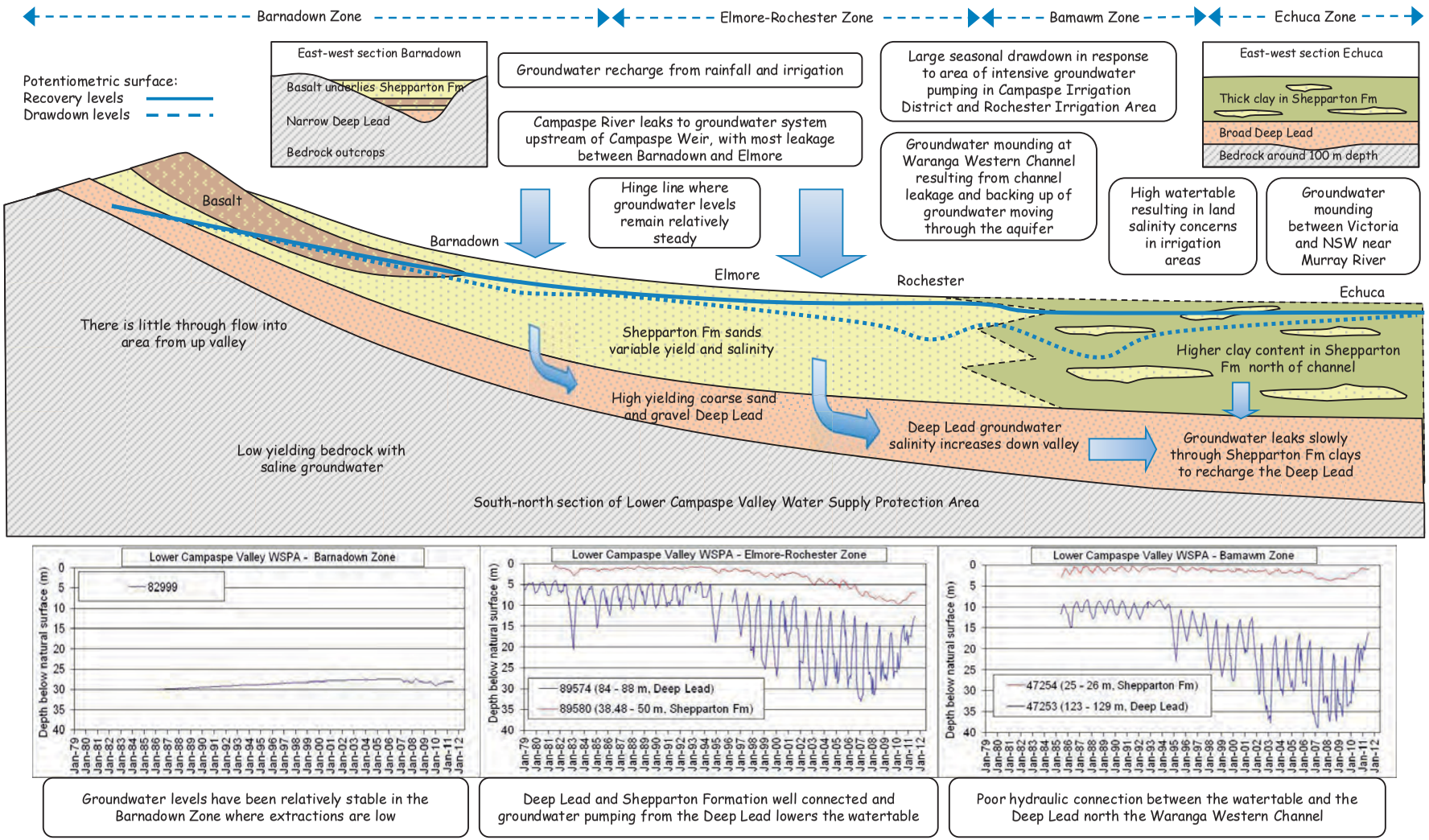


Figure 3 Groundwater flow

2.2 Groundwater use

2.2.1 Licensed use

The total licence entitlement in the Lower Campaspe Valley WSPA is 56.2 GL/year. Almost half of this entitlement is in the Bamawm Zone (Table 1). There is also significant entitlement in the Elmore-Rochester Zone.

Table 1 Number of licence holders and licence volume in June 2011

Management Zone	Number of licences	Total licence volume (GL/yr)
Barnadown	20	8.3
Elmore Rochester	55	15.3
Bamawm	46	26.0
Echuca	17	6.2
TOTAL	138	56.2

Good metered usage data exists across the entire Lower Campaspe Valley WSPA from 2007/08 (Figure 4). Groundwater use is greater in dry periods which correlate with reduced surface water availability.

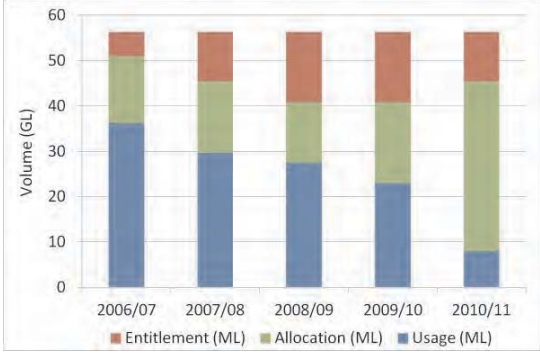


Figure 4 Metered use in the Lower Campaspe Valley WSPA

Restrictions on extractions under the former Campaspe Deep Lead WSPA Groundwater Management Plan between 2006/07 and 2009/10 resulted in lower usage. High rainfall and flooding in 2010/11 resulted in little groundwater usage.

A water balance has been prepared which suggests that groundwater levels would remain relatively steady under average climatic conditions for recent usage (G-MW, 2012b).

2.2.2 Domestic and stock use

There are around 100 registered domestic and stock bores in the Lower Campaspe Valley WSPA. There are also a number of older unregistered domestic and stock bores. The operating status of domestic and stock bores is not monitored and usage is considered to be relatively small.

Domestic and stock access to groundwater is a statutory right under section 8 of the Act. Landholders can apply to the Corporation for a works licence to install a bore for domestic and stock purposes.

Domestic and stock access will be protected by limiting the depth to which groundwater levels are allowed to fall before licensed groundwater use is restricted (refer chapter 3.2).

Domestic and stock bores will have continued access provided bores are constructed to depth in the aquifer, below artificial high groundwater levels experienced in wet periods.

The Corporation needs to consider impacts on domestic and stock users when making licensing decisions. For this reason, domestic and stock users are encouraged to ensure their bore is registered.

2.3 Environment considerations

2.3.1 Groundwater salinity

Macumber (2008) undertook an analysis of groundwater salinity and found that salinity increases are concentrated, although not restricted to, areas containing higher permeability soils. Further, he found that areas where salinity has risen coincide mostly to where deepest seasonal drawdown occurs.

The potential threats of increasing groundwater salinity from development of groundwater resources in the Lower Campaspe Valley WSPA include:

(i) increased leakage to the Deep Lead from the overlying Shepparton Formation;

(ii) lateral movement of groundwater into the WSPA at the northern margins; and

(iii) upward movement of groundwater from the Renmark Group to the Calivil Formation, particularly in the northernmost part of the WSPA where the Renmark Group aquifer has a high salinity.

The risk of rising groundwater salinity due to saline groundwater being drawn into the area in response to groundwater pumping is managed through restricting extractions from the Deep Lead (refer chapter 3.2). Monitoring of groundwater salinity is a key priority of this Plan (refer chapter 4.2).

2.3.2 Groundwater interaction with surface water

Flows in the Campaspe River are regulated by releases from Lake Eppalock. Regulation has effectively turned the Campaspe River into a perennial system whereas before regulation there were periods of no flow.

Upstream of the Campaspe Weir the Campaspe River leaks to the groundwater system and always has (pre and post regulation). The Campaspe River is well connected to the Coonambidgal Formation which slowly leaks to the regional groundwater system (Aquade, 2011).

The Coonambidgal Formation is the more recent shallow alluvial deposits found on the flood plains, which have cut into the Shepparton Formation forming terraces along the Campaspe River.

Downstream of the Campaspe Weir, where groundwater levels are elevated as a result of land use (i.e. irrigation), groundwater discharges to the Campaspe River. There is negligible impact of extraction from the Deep Lead on rivers north of the Waranga Western Channel, including the Murray River, as the Deep Lead is hydraulically not well connected to the shallow Shepparton Formation sands.

Closure of the Campaspe Irrigation District will result in reduced irrigation accessions. Falling groundwater levels can reduce groundwater discharge to the river, or induce further leakage from the river.

Groundwater levels are to be managed through restrictions on extractions to limit leakage from the river within the range of existing operational losses (refer chapter 3.2). Monitoring will be undertaken to better understand the interaction with the river and the potential for any additional losses (refer chapter 4.1).

While there is a good connection between the Campaspe River and the Coonambidgal Formation, there is a poor connection with the regional groundwater system because of the underlying clays that control the rate of leakage. In this case the groundwater and surface water resources should be managed independently.

2.3.3 Groundwater dependent ecosystems

Development of groundwater resources can impact on the water availability for groundwater dependent ecosystems (GDEs). GDEs are ecosystems that utilise groundwater to meet some or all of their water needs.

Satellite imagery has been used along with groundwater level data to determine the potential locations of GDEs in the Lower Campaspe Valley WSPA (SKM, 2011b). Investigations suggest that groundwater dependent ecosystems are likely to exist along watercourses, for example, River Red Gums along the Campaspe River accessing groundwater from the shallow Coonambidgal Formation (Figure 5).

River Red Gums along Campaspe River

Regulation of the Campaspe River maintains groundwater levels in the Coonambidgal Formation. Leakage from the Coonambidgal Formation is controlled by underlying clays in the Shepparton Formation. This suggests that there is little risk to riparian vegetation from seasonal groundwater pumping. Non-regulated streams, such as Bendigo Creek, may also have some GDEs, but sensitivity analysis indicates a lower sensitivity to groundwater system changes than along the Campaspe River (DPI, 2011).

Lowering of groundwater levels could induce further leakage from the river and may reduce water availability to GDEs during low flow periods. Groundwater levels are to be managed through restrictions on extractions to limit leakage from the river (refer chapter 3.2).

North of the Waranga Western Channel the Deep Lead is not well connected to the shallow Shepparton Formation sands. Therefore, groundwater pumping from the Deep Lead in this region is unlikely to adversely impact upon base flow or GDEs.

Field investigations are required to confirm the presence of GDEs. Ongoing monitoring should be established for high value GDEs to determine their water requirements. To assist with the monitoring it is recommended that at least one new monitoring bore be installed in the Coonambidgal Formation (refer chapter 4.1).

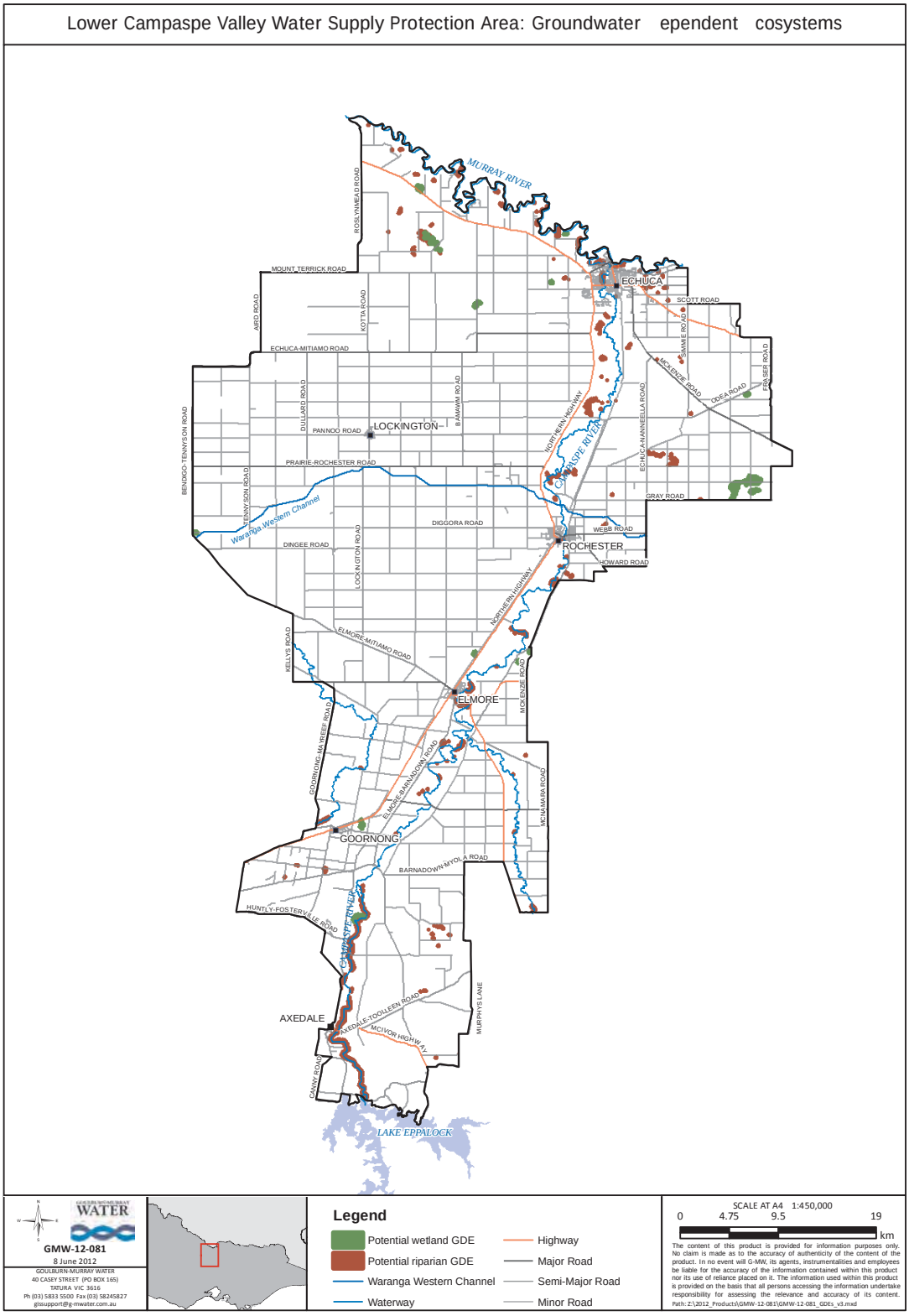


Figure 5 Potential GDEs in the Lower Campaspe Valley WSPA

3 Resource management

3.1 Licence entitlement

Licence entitlement has been capped in the Lower Campaspe Valley WSPA to protect existing authorised groundwater uses and preserve the integrity of the aquifer.

The cap is a permissible consumptive volume (PCV) of 56.3 GL/year declared by the Minister for Water under section 22A of the Act in August 2010.

The Permissible Consumptive Volume will be amended to exclude licences to take groundwater from the shallow (less than 25 m depth) aquifers north of the Waranga Western Channel and in the Campaspe West Salinity Management Plan Area. This will also have the effect of:

i. preventing these licences being transferred to take water from the Deep Lead within the Lower Campaspe Valley WSPA

ii. permitting new licences to be issued to take groundwater from the shallow (less than 25 m depth) aquifer in these areas.

The transfer of licence entitlement provides opportunity for new developments (refer chapter 3.3).

Groundwater licences may be issued for a period of up to 15 years in the Lower Campaspe Valley WSPA, in accordance with section 56(3) of the Act, as the aquifer response to groundwater pumping is well understood and groundwater levels are to be managed through restrictions on extractions.

3.2 Managing groundwater levels

Restrictions, when triggered, will be imposed to limit groundwater extractions to manage groundwater levels.

Trigger levels have been set using information gathered from key State observation bores to manage the long-term sustainability of the aquifer and protect existing groundwater users and the environment. Consideration was given to a range of factors to establish the triggers based on the risks of development of groundwater resources including:

- available drawdown for existing users;
- groundwater salinity;
- GDEs;
- groundwater interaction with surface water;
- watertable relief and land salinity benefits; and
- the current conceptual understanding of the aquifer system.

The greatest risk resulting from groundwater extraction was determined to be the potential to induce more saline groundwater into the Deep Lead aquifer from adjacent areas and increase leakage from the Campaspe River.

Trigger levels have been established at the following key State observation bores:

- Bore number 79324 for determining seasonal allocations in the Elmore-Rochester; Bamawm and Echuca Zones (Figure 6).
- Bore number 62589 for determining seasonal allocations in the Barnadown Zone (Figure 7).

A comprehensive monitoring program has been established to observe the aquifer response to pumping (refer chapter 4). The levels observed in the trigger bores will be validated against nearby State observation bores as well as levels seen along the length of the WSPA to verify northward groundwater flow (refer Figure 8).

Staged restrictions on the use of licence entitlement will apply when the trigger levels are reached in the respective bores. Restrictions will be introduced through the use of allocations announced at the start of each water season.

Allocations are a percentage of licence entitlement that may be extracted in a given season. For example, if a licence volume was 100 ML/year and a 50% allocation was announced, then up to 50 ML may be extracted in that season.

The allocation rationale is based on a rolling three year average of the maximum groundwater recovery level. The rolling average is calculated by summing the maximum seasonal groundwater recovery levels (generally seen between August and November) for the previous three seasons and dividing this number by three. An example of the rolling average method is provided below (refer Example 1).

The rolling average moderates the seasonal shift in groundwater levels providing users with time to adjust to changes in allocations. It can slow the introduction of restrictions in dry years and delay higher allocations in wetter periods when demand is likely to be low.

Allocations will be announced on 1 July each year based on the rolling average level compared to the trigger level. Allocations will be fixed for the whole season as they are determined from the maximum groundwater recovery level from the previous three seasons. This will enable licence holders to plan with more certainty for the season ahead.

For example, if the rolling average for bore 79324 is 16 metres or less below the natural surface then a 100% allocation will apply in the Elmore-Rochester, Bamawm and Echuca Zones as shown in Figure 6. If the rolling average is between 16 metres and 19 metres below the natural surface then the allocation will be 75%.

A deeper rolling average will result in lower allocations. If the rolling average for bore 79324 falls to deeper than 22 m below the natural surface then allocations will be 40% and it will trigger a review of the Plan.

If the rolling average falls below 18 m at bore 62589 then allocations in the Barnadown Zone will be the same as that for trigger bore 79324 as this would suggest that groundwater pumping in the Elmore-Rochester Zone is impacting on levels in the Barnadown Zone and/or vice versa (refer chapter 2).

Example 1

The rolling average for season 4 is the average maximum groundwater recovery level for the proceeding three seasons. In this example, it is calculated by summing the maximum levels in seasons 1, 2 and 3 (14 +15 + 16 = 45) and dividing by the time period (3) to get a value of 15, which would be assessed against the trigger level to determine allocations.

Season	1	2	3	4
Maximum groundwater recovery level	14	15	16	
Rolling Average			15	

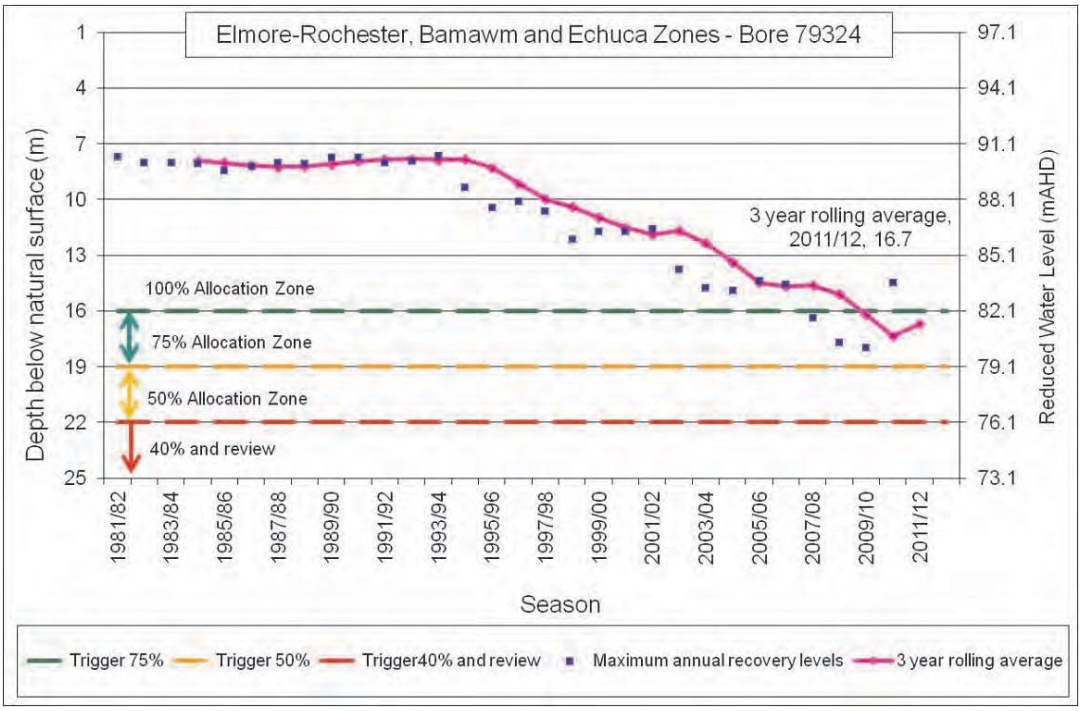


Figure 6 Triggers and allocations for Elmore-Rochester, Bamawm and Echuca Zones

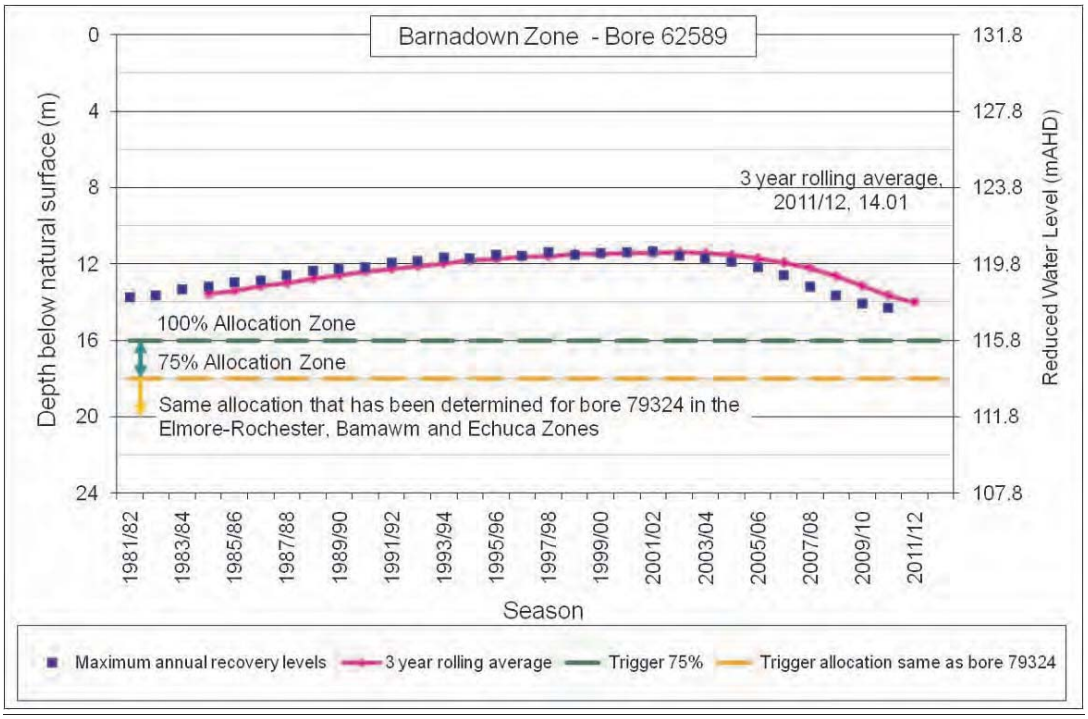


Figure 7 Trigger and allocations for Barnadown Zone

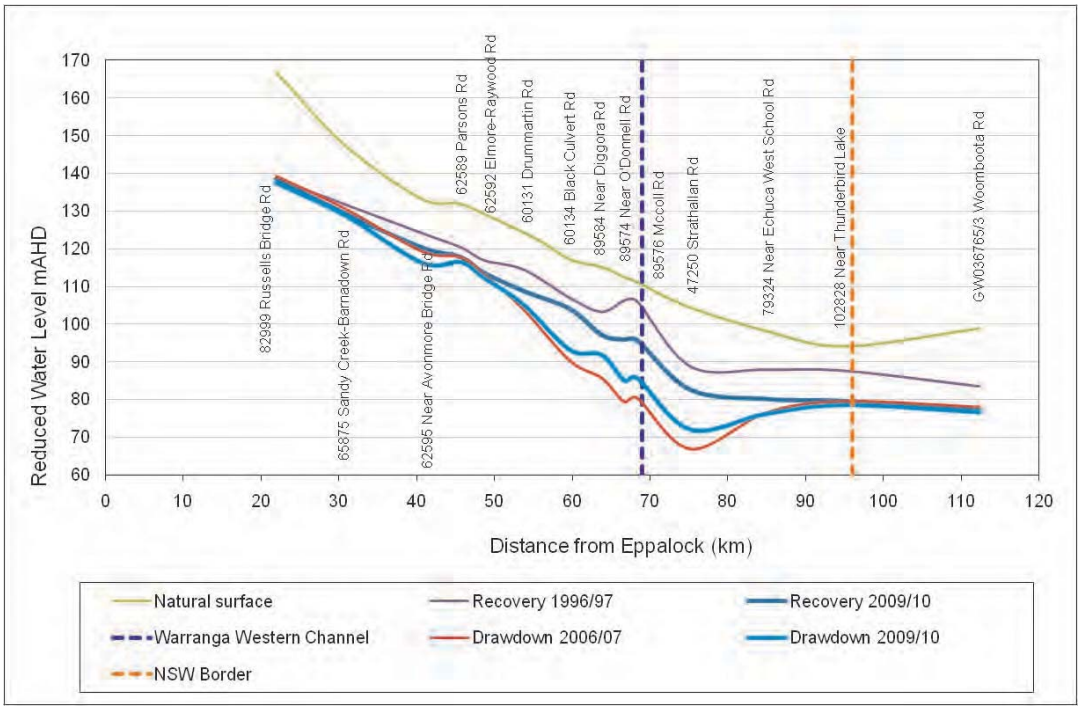


Figure 8 South-North section illustrating drawdown and recovery levels

Prescription 1: Triggers and restrictions

By 1 July each year the Corporation will:

(a) Determine the rolling average of the maximum annual groundwater recovery levels from the preceding three seasons for the relevant bore, or its replacement, and announce a corresponding allocation for the subsequent season for zones as detailed below:

(i) Echuca, Bamawm and Elmore-Rochester Zones

Bore 79324 located on Echuca West School Road	
Trigger level depth below natural surface	Allocation
16.0 m and above	100%
From 16.1 to 19.0 m	75%
From 19.1 to 22.0 m	50%
Below 22.0 m	40% allocation and review

(ii) Barnadown Zone

Bore 62589 located near Parsons Road	
Trigger level depth below natural surface	Allocation
16.0 m and above	100%
From 16.1 to 18.0 m	75%
Below 18.0 m	Same allocation that has been determined in (a)(i) above for bore 79324

(b) Announce seasonal allocations by listing them on its website; sending letters to all licence holders and placing public notices in local newspapers.

(c) Not apply restrictions to any water authorised to be taken in a subsequent water season (carryover).

3.3 Transfer of licence entitlement

The transfer of a licence, or part thereof, provides opportunity for further development of groundwater resources.

The temporary and permanent transfer of a licence is permitted in the Lower Campaspe Valley WSPA subject to conditions that protect the integrity of the aquifer and reduce the potential for unacceptable impacts to existing groundwater users and the environment.

Licence transfers may result due to the sale or conveyance of land, where the licence remains with the property, or through an off-property licence transfer, where the groundwater is to be extracted and used on a different property.

Consideration is to be given to trading zones, groundwater interference and the intensity of groundwater pumping when transferring a licence.

3.3.1 Trading zones

There are four zones in the Lower Campaspe Valley WSPA to facilitate groundwater transfers: Barnadown; Elmore-Rochester; Bamawm and Echuca (refer Figure 2).

Limits have been placed on the transfer of licence entitlement into each zone to manage the risk of increasing groundwater salinity and leakage from the river. It should be stressed that the total licence volume can not exceed the PCV and that the limits in each zone are mutually exclusive.

A licence can be temporarily or permanently transferred within the Barnadown Zone. However, it cannot be transferred into or out of the Barnadown Zone unless groundwater levels fall deeper than 18 metres below the natural surface at trigger bore 62589. If the groundwater levels were to fall to 18 metres below the surface at bore 62589 it would suggest that groundwater pumping in the Elmore-Rochester Zone is impacting on levels in the Barnadown Zone and/or vice versa (refer chapter 2).

3.3.2 Groundwater level interference

Groundwater pumping lowers groundwater levels around the bore being pumped. This decline in groundwater levels is referred to as the drawdown cone (Figure 9).

The size and shape of the drawdown cone depends primarily on the nature of the aquifer as well as the pumping rate and duration. Drawdown decreases with distance from the bore, and the cone expands in size whilst pumping continues until steady-state conditions are reached.

Groundwater level interference can occur when the drawdown cone intersects a neighbouring bore or environmental feature such as a river. The impacts from groundwater pumping are site specific as the aquifer characteristics can vary and the pumping requirements are likely to be different.

Interference is considered under section 40 of the Act by the Corporation when assessing groundwater licence applications, including the transfer of a licence.

Investigations have shown that there is a strong connection between the Coonambidgal Formation and the Campaspe River. Groundwater pumping from the Coonambidgal Formation is likely to have an effect on flows in the Campaspe River. To reduce the risk of adverse impacts to the Campaspe River, a take and use licence should not be issued for bores screened in the Coonambidgal Formation.

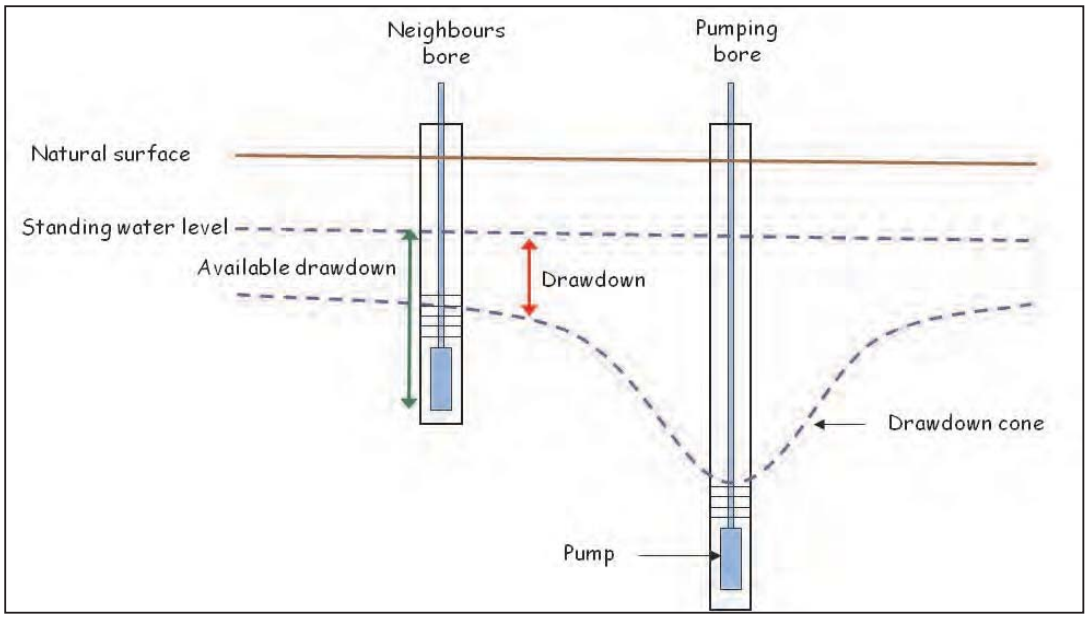


Figure 9 Drawdown cone resulting from groundwater pumping

Prescription 2: Trading rules

The Corporation may approve a transfer of a groundwater licence under section 62 of the *Water Act 1989* provided section 53 matters have been considered and it accords with the following:

(a) Transfer of licence entitlement can occur between zones as specified below:

Zone	Can trade to	Can trade from
Barnadown	Barnadown	Barnadown
Elmore-Rochester	Bamawm, Echuca	Bamawm, Echuca
Bamawm	Elmore-Rochester, Echuca	Elmore-Rochester, Echuca
Echuca	Elmore-Rochester, Bamawm	Elmore-Rochester, Bamawm

(b) Despite (a) above, if the groundwater level falls to a depth of 18 metres below the natural surface in bore 62589 a licence may be transferred between the Barnadown Zone and other zones.

(c) Limits on the maximum licence volume in each zone as specified below are not exceeded:

Zone	Maximum licence volume limit (GL)*
Barnadown	8.3
Elmore-Rochester	18.3
Bamawm	29.0
Echuca	9.6

*Note that licence entitlement cannot exceed the Permissible Consumptive Volume (refer chapter 3.1).

3.3.3 Intensive groundwater pumping

When bores located in close proximity are extracting from the same aquifer it can result in intersecting drawdown cones as illustrated in Figure 10. Unacceptable drawdown levels could be a consequence of the cumulative impacts of a number of pumps operating in a local area.

In order to protect existing users from any adverse impacts of intensive development arising from the transfer of entitlements, a limit on the volume of groundwater that may be extracted within a fixed radius of a licensed bore has been set based on metered use and observed resulting drawdown.

The intensity of groundwater pumping is to be considered when the entitlement in an area changes through the transfer of entitlement, or amending an existing licence to add a bore.

To manage areas of intensive development entitlement has been limited to 7.5 GL/year within a 4 km radius of an applicant's bore (refer Example 2).

In some areas the licence entitlement already exceeds the intensity limit. In this case a licence holder's usage is limited to 125% of licence volume (comprising use of licence entitlement and either temporary transfer or carryover) in any season.

A licence holder may be permitted to exceed 125% of licence volume if transferring from other licences within the 4 km radius where they can clearly demonstrate that there would not be any adverse impacts to surrounding groundwater users or the environment.

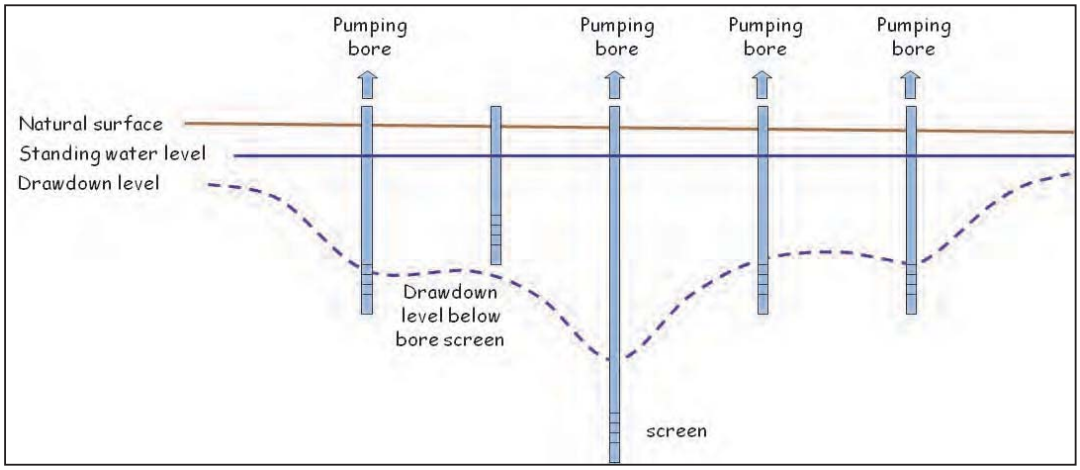


Figure 10 Intensive development of groundwater resources

Example 2

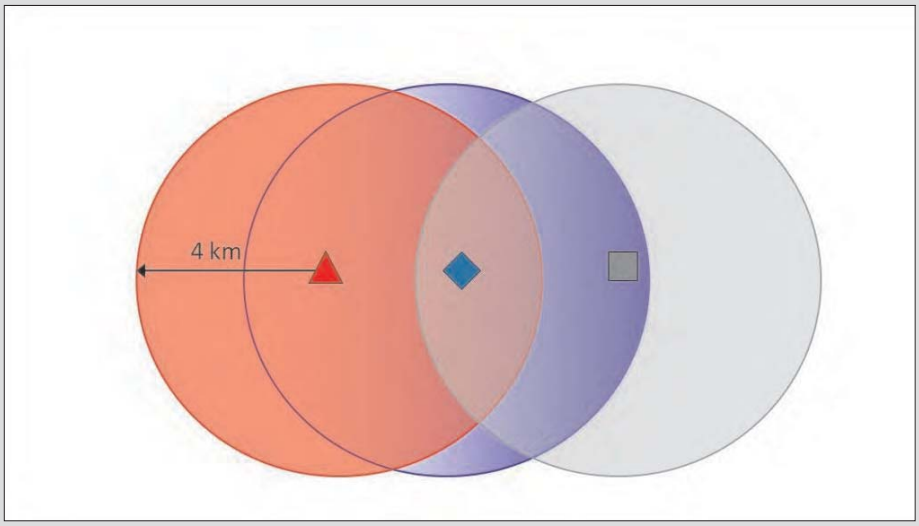
The three shapes in the figure below represent bores each licensed to extract 3,000 ML/year.

The sum of the licensed entitlement within a 4 km radius of both the red triangle and the grey square is 6,000 ML/yr. That is, the red triangle and the blue diamond are within 4 km of each other. Similarly, the grey square and the blue diamond are both within a 4 km of each other.

The licensed entitlement within a 4 km radius of the blue diamond is 9,000 ML/yr. That is, the red triangle and the grey square are both within 4 km of the blue diamond.

The owners of the red triangle and the grey square may apply to extract up to an additional 1,500 ML/year through a licence transfer as this is the difference between licensed entitlement and the 7,500 ML threshold within a 4 km radius of an applicant's bore.

As entitlement within a 4 km radius of the blue diamond exceeds the threshold of 7,500 ML, the owner of the blue diamond is limited to usage of 125% of entitlement (3,750 ML/yr) in one year unless trading from others within the 4 km radius (red triangle or grey square).



Prescription 3: Intensive groundwater pumping

The Corporation may approve an application to take and use groundwater under section 51 or a transfer under section 62 of the *Water Act 1989* provided that section 53 matters have been considered and the following conditions are satisfied:

(a) For a permanent transfer, the total licence entitlement of bores within a 4 km radius of an applicant's bore is less than 7.5 GL/yr.

(b) Where summed licence entitlement exceed the limits specified in (a) above, then a licence holder's usage is to be limited to 125% of entitlement in one water season whether it occurs through either temporary transfer of entitlement or carryover.

(c) Usage may exceed 125% of entitlement as specified in (b) above through temporary or permanent transfer of entitlement from others within the 4 km radius.

3.4 Carryover

Carryover is unused allocation that may be used in subsequent years. It provides groundwater users with the flexibility to use water when it is of greatest benefit to them.

To enable the use of carryover the Corporation will apply to the Minister for Water under section 62A of the Act to allow carryover in the Lower Campaspe Valley WSPA.

Initially, the Corporation will apply to allow carryover up to a maximum of 25% of licence entitlement. This limit provides some control over the potential fall in groundwater levels when carryover is used in a dry season. It also reduces the likelihood of harsher restrictions due to carryover use.

The percentage of licence entitlement that can be carried over can be altered subject to the Minister's approval, and the Corporation will consult with the Groundwater Reference Committee about the possibility of any changes to carryover (refer chapter 5.3).

Licence holders with carryover have the potential to use up to their allocation plus carryover in any season, provided they are able to extract the water under their licence conditions.

Licence conditions should be sufficient to effectively manage the impacts of drawdown to existing groundwater users and the environment with the introduction of carryover. Licence conditions limit daily extraction rates and volumes to manage interference. A licence holder may apply to the Corporation to increase their pumping rate to enable them to use carryover if their licence conditions are limiting.

Carryover volumes are not subject to restrictions and become part of the total water available to a licence holder in the following season. An example of carryover is provided below (refer Example 3).

Example 3

A licence holder has an entitlement of 100 ML/yr and a maximum carryover 25% of licence entitlement (25 ML).

Season	1	2	3	4	5
Entitlement (ML)	100	100	100	100	100
Allocation	100%	100%	100%	75%	75%
Carryover (ML)	0	20	25	25	10
Trade in (ML)	0	0	0	0	10
Trade out (ML)	0	-10	-20	-10	0
Usage (ML)	-80	-80	-80	-80	-85
Balance (ML)	20	30	25	10	10
Available for carryover (ML)	20	25	25	10	10

In season 1 the allocation is 100%. The licence holder uses 80 ML and has 20 ML remaining for carryover to season 2.

In season 2 the allocation is 100% and the licence holder has carried over 20 ML, providing a total of 120 ML for the season. The licence holder trades out 10 ML and uses 80 ML. This leaves 30 ML remaining. A maximum of 25 ML (25% of entitlement) may be carried over to season 3.

In season 3 allocation is 100% so the licence holder has 125 ML available for use including carryover. The licence holder trades out 20 ML and uses 80 ML. This leaves 25 ML for carryover to season 4.

In season 4 allocations are 75%, so the licence holder has 100 ML available for use including carryover. The licence holder trades out 10 ML and uses 80 ML. This leaves 10 ML for carryover to season 5.

In season 5 allocations are again 75%. The licence holder has 10 ML carryover and trades in 10 ML, providing a total of 95 ML. The licence holder uses 85 ML and can carryover 10 ML.

4 Monitoring program

Monitoring, evaluation and reporting of groundwater levels and quality from a network of strategically located State observation bores over time is critical to informing effective groundwater resource management.

A groundwater monitoring program has been established under section 32A(3)(a) of the Act for metering and monitoring of, and accounting for, groundwater.

The monitoring program will inform allocations and support transfer decisions and carryover determination.

Outcomes from the monitoring program will be reported annually and communicated to groundwater users. Further, the monitoring program will inform the review of this Plan (refer chapter 5.3).

4.1 Groundwater levels

The Lower Campaspe Valley WSPA has an extensive network of State observation bores, with over 100 bores currently monitored and maintained by the Department of Sustainability and Environment on a quarterly basis in February, May, August and November each year.

The Corporation will obtain monthly groundwater levels readings from key State observation bores identified in Schedule 1 to support the implementation of this Plan as part of the monitoring program. The State observation bores currently monitored are shown in Figure 11.

State observation bores, Rocky Crossing Road

Groundwater level monitoring enables consideration of groundwater interaction with surface water; GDEs; long-term sustainability of the resource; understanding the aquifer response to pumping (particularly in areas of intensive groundwater development); land salinity risk; and any changes in groundwater quality.

An assessment of groundwater monitoring in the Lower Campaspe Valley WSPA identified the need for additional monitoring of groundwater levels in the Coonambidgal Formation along the Campaspe River to better assess the impacts of groundwater development on leakage from the river and the role of river regulation in maintaining ecosystems along the river corridor.

Prescription 4: Monitoring groundwater levels

The Corporation will:

(a) Obtain monthly groundwater level readings (up to 480 readings per season) from key State observation bores from the list in Schedule 1, or their replacement, where practicable.

(b) Install at least one new observation bore in the Coonambidgal Formation to better inform groundwater interaction with the Campaspe River.

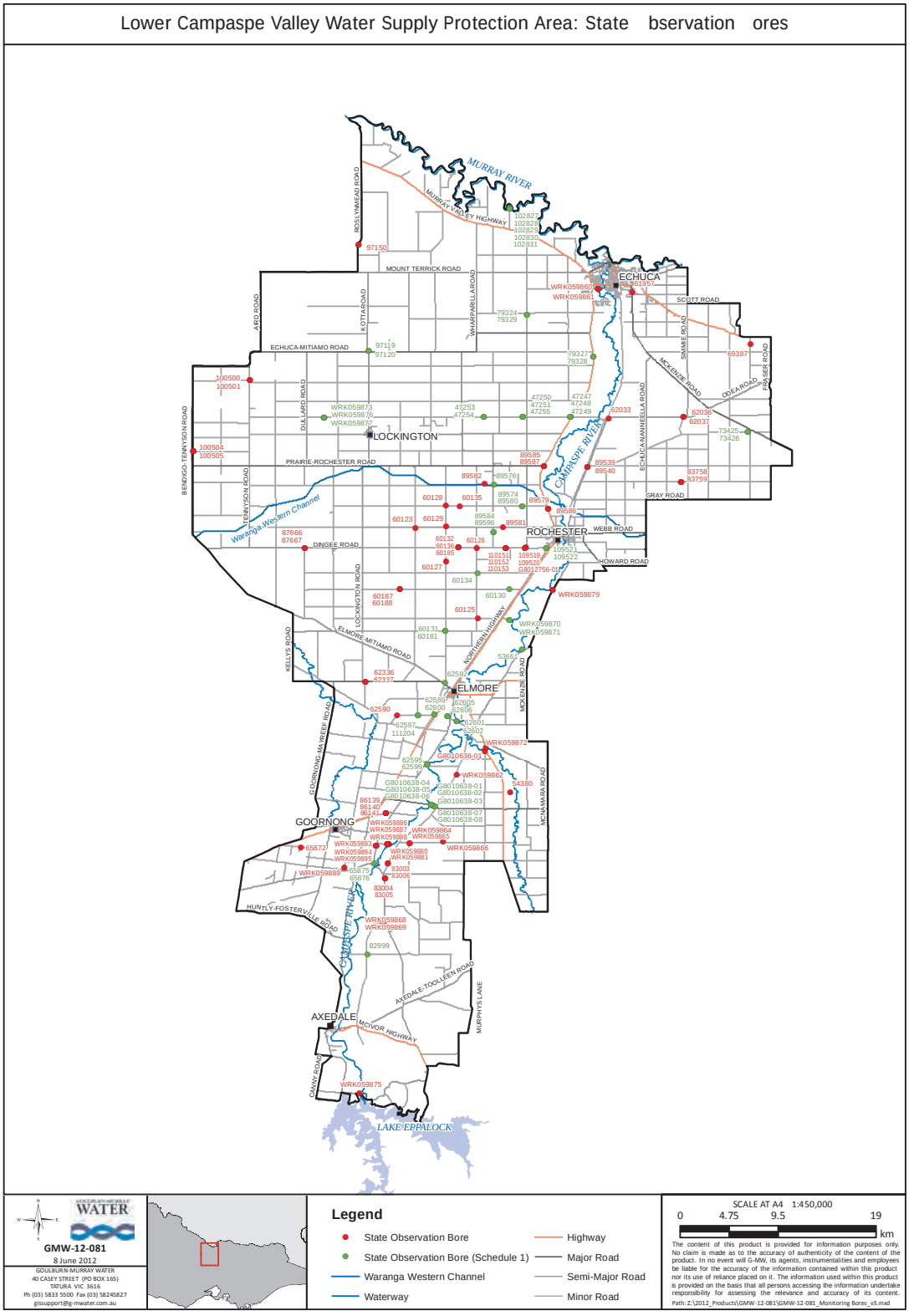


Figure 11 State observation bores

4.2 Groundwater salinity

Monitoring changes in groundwater salinity is necessary because of the risk that greater development of the resource may induce more saline groundwater into the Deep Lead (refer chapter 2.3.1).

Poor groundwater salinity can have significant economic impacts by reducing agricultural and horticultural productivity. There is also an obligation to protect beneficial users under Victoria's State Environment Protection Policy (Groundwaters of Victoria).

To observe any changes in groundwater salinity, accurate information on groundwater salinity over time is required from a large number of bores.

A three pronged approach has been adopted to monitor any changes in groundwater salinity that will provide improved data sets for future analysis:

(i) Groundwater user salinity sampling

(ii) Targeted sampling of licensed bores

(iii) Sampling of State observation bores

If there is a consistently increasing trend in groundwater salinity over time then investigations should be undertaken to determine the cause and identify mitigating options as part of the Plan review.

4.2.1 Groundwater user salinity sampling

The groundwater user salinity sampling program is the most efficient method of obtaining a large number of samples from across the region to identify any spatial changes in groundwater salinity.

Each year the Corporation will send sample bottles to all groundwater licence holders. Licence holders will be requested to sample all their licensed bores and return the sample to the Corporation in a supplied reply paid envelope. The Corporation will measure the groundwater salinity of the sample and provide the licence holder with the results.

The Corporation will also provide the service to domestic and stock users upon request.

The groundwater user salinity sampling program can provide important information to users on the salinity of the water from their bore and any changes over time. All groundwater salinity results will be stored in the State groundwater database.

All licence holders are strongly encouraged to participate in the program when requested.

4.2.2 Targeted sampling of licensed bores

A program of targeted salinity monitoring of licensed bores is to be established.

The purpose of the program is to ensure that samples are consistently collected each year from a number of licensed bores located in strategic locations that will provide a reliable data set to aid in understanding any changes in groundwater salinity over time.

Sampling is to be undertaken by the licence holder. The Corporation will provide training to the licence holder on groundwater sampling to provide greater confidence in the quality of the samples obtained. Samples will be tested by the Corporation.

The Corporation will invite licence holders with bores located in strategic locations to participate in the program. Licence holders are encouraged to apply to participate in the program.

4.2.3 Sampling of State observation bores

Sampling and analysis of selected nested State observation bores (screened in the Shepparton Formation and Deep Lead) in areas of intensive groundwater pumping and at the northern margins of the WSPA is to be undertaken to observe any changes in groundwater salinity between aquifers.

The bores will be sampled annually in summer by the Corporation and groundwater analysed at a NATA (National Association of Testing Laboratories) accredited laboratory for salinity, major ions, phosphorous and metals. The bores to be sampled are listed in Schedule 1.

Sampling from State observation bores and analysis at a NATA accredited laboratory provides the greatest level of confidence in water quality results.

Prescription 5: Monitoring groundwater salinity

The Corporation will:

(a) Support annual groundwater user salinity sampling by:

(i) Providing a sample bottle and a reply paid envelope to each groundwater licence holder and request that they collect a groundwater sample from all their licensed bores and return the samples to the Corporation for salinity analysis.

(ii) Providing a sample bottle and a reply paid envelope to any domestic and stock groundwater user upon their request for them to provide a sample for salinity analysis.

(iii) Measuring groundwater salinity in all returned sample bottles and providing the bore owner with the results.

(iv) entering the groundwater salinity results into the State groundwater database.

(b) Establish a targeted groundwater salinity monitoring program to collect and analyse groundwater samples from selected licensed bores each year.

(c) Collect groundwater samples from selected State observation bores identified in Schedule 1 where practicable, or their replacement if applicable, and send them to a NATA accredited laboratory for analysis.

4.3 Accounting for metered use

Data gathered through metering licensed use is critical to understand how the groundwater system responds to extraction and to ensure that users comply with their licence conditions.

All bores from which water is extracted under a section 51 licence will be metered.

Meters will be read at least once each year. In drier seasons, when demand is greater, they may be read more frequently.

Meter readings will be stored in the Water Register to enable reporting on usage.

Prescription 6: Metered licensed use

The Corporation will:

(a) Ensure that a meter is fitted to all operational licensed bores.

(b) Read each meter at least once a year and enter readings into the Water Register.

5 Plan implementation

5.1 Exclusions from prescriptions

The prescriptions 1 to 7 inclusive, do not apply to licences to take groundwater from the shallow aquifer (less than 25 m depth) north of the Waranga Western Channel (the Bamawm and Echuca Zones) and the Campaspe West Salinity Management Plan Area. These areas are excluded on the basis that:

- licence holders may be charged fees associated with the implementation of the Plan that they would otherwise not be subject to;
- licence holders would benefit from trading and carryover despite the undesirability of trading between the shallow aquifer of the Shepparton Formation and the Deep Lead;
- licence holders would be subject to restrictions that should otherwise not apply to licence holders extracting groundwater from the shallow aquifer of the Shepparton Formation;
- perversely, new licences could not be issued because of the Lower Campaspe Valley Permissible Consumptive Volume (refer chapter 3.1), which will undermine the ability to manage shallow groundwater for the protection of land.

5.2 Provide effective communication

By 30 September each year the Corporation will prepare an annual report on the administration and enforcement of the Plan for the Minister for Water as required under section 32C of the Act. The annual report will cover the period 1 July to 30 June. The report will be made available for inspection at the offices of the Corporation.

The Corporation will produce an annual newsletter in October each year to provide an update on the status of groundwater resources in the Lower Campaspe Valley WSPA and summarise outcomes from the annual report.

The Corporation will post on its website at www.g-mwater.com.au the Plan, annual reports and newsletters, rolling average levels and groundwater levels from other bores monitored to verify levels in the trigger bores.

Additionally, the Corporation will appoint a Groundwater Reference Committee, which will include licence holders, to meet with at least annually to report on the implementation of the Plan.

5.3 Plan review

A comprehensive review of the Plan will be undertaken after five years from approval, or sooner if warranted by any clause contained within the Plan.

The success of the Plan will be determined by the extent to which the Plan achieves the management objectives specified in chapter 1.4.

The Corporation will meet annually with an appointed Groundwater Reference Committee to consult on the need to review the groundwater management plan

Prescription 7: Plan implemetation

The Corporation will:

(a) Post on its website the Plan; annual reports and newsletters; groundwater levels; and rolling average for trigger bores.

(b) Mail a newsletter in October each year to groundwater licence holders, and domestic and stock users upon request, in the Lower Campaspe Valley WSPA and relevant agencies stating the resource position and summarising outcomes in the annual report.

(c) Meet with the Groundwater Reference Committee at least once each year to report on the groundwater resource status and implementation of the Plan and consider the need to review the Plan.

(d) Undertake a comprehensive review of the Plan after five years from approval, or sooner if warranted by any clause contained within the Plan.

5.4 Implementation costs

The annual implementation costs for the Lower Campaspe Valley WSPA Groundwater Management Plan, at the time the Plan was drafted, were estimated to be approximately $115,000 (GST inclusive).

Implementation costs include groundwater level monitoring, groundwater salinity sampling, meter reading, annual reporting and communications, meeting with the Groundwater Reference Committee and the review of the Plan.

Implementation costs are recovered by the Corporation through groundwater licence fees. These costs are built into the current tariff and pricing structure for the management of the resource.

5.5 Future technical investigations

Future technical investigations that would enhance the understanding of groundwater resource management and inform Plan review are provided in Table 2.

Table 2 Recommended technical investigations to enhance groundwater resource management

Project	Description
GDE mapping	Build on recent field mapping of GDEs undertaken by the North Central Catchment Management Authority and Goulburn-Murray Water and identify high value sites in consultation with the Department of Sustainability and Environment. Establish on-going monitoring of high value GDEs to inform the review of the groundwater management plan.
Groundwater chemistry	Undertake investigations to better understand the risks to groundwater salinity in the lower Campaspe catchment.

6 References

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Sinclair Knight Merz, 2011b. GDE Triggers Project. Analysis of remotely sensed evapotranspiration data to aid the management of groundwater dependent ecosystems. Unpublished report held by Goulburn-Murray Water, Tatura, Victoria. Reference DM 3277396.

7 Schedule 1 – Monitoring program

Groundwater levels are to be measured monthly and groundwater quality annually

Bore ID	Zone	Monitoring purpose							
		Groundwater quality	Interaction with surface water	Groundwater dependent ecosystems	Trigger levels	Support trigger levels (east-west section)	Pumping intensity	Aquifer response to pumping (north-south section)	Land salinity / deep drainage
62595	Barnadown		✓					✓	
62597	Barnadown					✓			
62599	Barnadown		✓	✓					
65875	Barnadown							✓	
65876	Barnadown								
82999	Barnadown							✓	
111204	Barnadown					✓			
G8010638-01	Barnadown		✓						
G8010638-02	Barnadown		✓						
G8010638-03	Barnadown		✓						
G8010638-04	Barnadown		✓	✓					
G8010638-05	Barnadown		✓						
G8010638-06	Barnadown		✓						
G8010638-07	Barnadown		✓						
G8010638-08	Barnadown		✓						
53661	Elmore-Rochester		✓						
60130	Elmore-Rochester		✓						
60131	Elmore-Rochester							✓	
60134	Elmore-Rochester							✓	
60181	Elmore-Rochester								
62589	Elmore-Rochester				✓			✓	
62592	Elmore-Rochester							✓	
62600	Elmore-Rochester					✓			
62601	Elmore-Rochester		✓			✓			
62602	Elmore-Rochester		✓	✓		✓			
62605	Elmore-Rochester		✓			✓			
62606	Elmore-Rochester		✓			✓			
89574	Elmore-Rochester						✓	✓	
89580	Elmore-Rochester						✓		✓
89584	Elmore-Rochester	✓					✓	✓	
89596	Elmore-Rochester	✓					✓		✓
109521	Elmore-Rochester		✓						
109522	Elmore-Rochester		✓						
WRK059870	Elmore-Rochester		✓						
WRK059871	Elmore-Rochester		✓						
73425	Echuca	✓							
79324	Echuca				✓			✓	
97119	Echuca					✓			
97120	Echuca					✓			✓
102827	Echuca	✓							
102828	Echuca	✓						✓	
102829	Echuca	✓							
102831	Echuca								
73426	Echuca (SIR)	✓							✓
79329	Echuca (SIR)					✓			✓
102830	Echuca (SIR)								✓
47247	Bamawm		✓				✓		
47248	Bamawm		✓				✓		
47250	Bamawm	✓					✓	✓	
47251	Bamawm	✓					✓		✓
47253	Bamawm						✓		
47254	Bamawm						✓		✓
47255	Bamawm						✓		
79327	Bamawm					✓			
79328	Bamawm					✓			✓
89576	Bamawm							✓	
WRK059873	Bamawm	✓							
WRK059876	Bamawm	✓							
WRK059877	Bamawm	✓							
47249	Bamawm (SIR)		✓				✓		✓