



Lower Campaspe Valley Water Supply Protection Area Groundwater Management Plan

Annual Report

For year ending 30 June 2018

Document History and Distribution

Versions

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Distribution

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Final	The Hon. Lisa Neville MP Minister for Water	21 September 2018	
Final	Mr Brad Drust Chief Executive Officer, North Central Catchment Management Authority	21 September 2018	

Foreword

Goulburn-Murray Water (GMW) is pleased to present the annual report for the Lower Campaspe Valley Water Supply Protection Area Groundwater Management Plan (the Plan) for the 2017/18 water year.

GMW is responsible for the implementation, administration and enforcement of the Plan which was approved by the Minister administering the *Water Act 1989* (the Minister) in October 2012.

This report has been prepared in accordance with section 32C of the *Water Act 1989* (the Act).

This report provides an overview of the groundwater management activities in the Lower Campaspe Valley Water Supply Protection Area under the Plan during the 2017/18 water year.

A copy of this report is available for inspection at the GMW Tatura office, or it can be downloaded from the GMW website.



Pat Lennon

MANAGING DIRECTOR

Date 18/09/2018

Executive summary

The Lower Campaspe Valley Water Supply Protection Area (WSPA) Groundwater Management Plan (the Plan) was approved by the Minister for Water in October 2012.

The 2017/18 water year marks the sixth year of operation under the Plan.

Allocations in 2017/18 were 100 per cent of licensed volume in all management zones of the Lower Campaspe Valley WSPA.

Recorded use in the Lower Campaspe Valley WSPA was 67 per cent (37,408.8 ML) of licensed volume, which is above average use for the area.

There were 14 temporary licence transfers for a total of 2,292 ML and eight permanent licence transfers for a total of 1,080.5 ML.

Licence holders in the Lower Campaspe Valley WSPA are entitled to carryover a maximum of 25 per cent of licensed volume. A total of 12,839.7 ML has been carried over to 2018/19.

Groundwater monitoring indicates that levels are generally within observed historical ranges. However, there has been a declining trend in groundwater recovery levels in recent years, which may be attributed to groundwater extraction and below-average rainfall. If these trends continue, restrictions may be required in the coming seasons.

Groundwater monitoring and metering programmes continue to be successfully undertaken to support the implementation of the Plan.

GMW is currently undertaking a review of the Plan to assess the success of the Plan and the need for any amendments.

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1 Introduction

1.1 Purpose

This annual report has been prepared to meet the requirements of Prescription 7 of the Lower Campaspe Water Supply Protection Area Groundwater Management Plan (the Plan) and section 32C of the *Water Act 1989* (the Act).

This report provides an overview of groundwater management activities undertaken in accordance with the Plan from 1 July 2017 to 30 June 2018.

1.2 Water Supply Protection Area

The Lower Campaspe Valley Water Supply Protection Area (WSPA) was declared in June 2010. It extends from Lake Eppalock in the south to Echuca in the north, and includes the towns of Axedale, Goornong, Elmore, Lockington and Rochester.

There are four management zones within the Lower Campaspe Valley WSPA: Barnadown (1034), Elmore-Rochester (1031), Bamawm (1032) and Echuca (1033) as shown in Figure 1.

The WSPA includes groundwater resources to all depths, except where it is overlain by the Campaspe West Salinity Management Plan Area and the region to the north of the Waranga Western Channel that includes the Shepparton Irrigation Region Groundwater Management Area. In these areas, the Plan only applies to the management of groundwater resources greater than 25 metres (m) in depth.

1.3 Groundwater Management Plan

The Plan was approved by the Minister for Water in accordance with section 32A(6) of the Act on 17 October 2012.

The objective of the Plan is to make sure that groundwater resources of the WSPA are managed in an equitable manner and to ensure the long-term sustainability of those resources. More specifically, the Plan seeks to:

- Protect existing groundwater users and the environment by managing groundwater levels and the potential for change in groundwater salinity.
- Enable equitable development of groundwater resources to realise the potential for its use in the region.
- Communicate the Plan's objectives, management rules and resource status with stakeholders and the wider community.

Goulburn-Murray Water (GMW) is responsible for the implementation, administration and enforcement of the Plan. An assessment summary of GMW's activities in accordance with Plan prescriptions is presented in Appendix A.

A copy of the Plan can be downloaded from the GMW website: www.gmwater.com.au

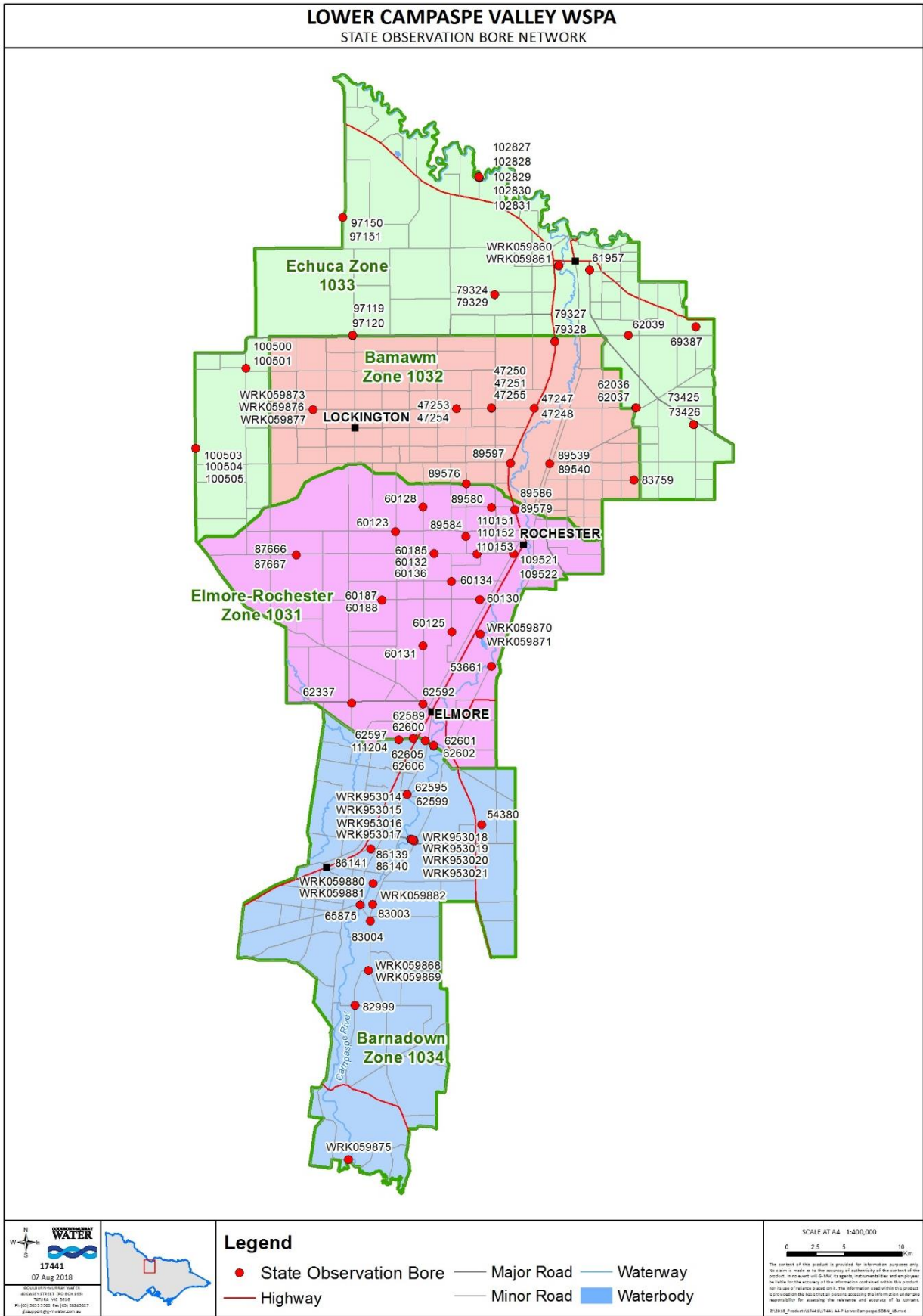


Figure 1 Lower Campaspe Valley Water Supply Protection Area

2 Groundwater Management

2.1 Licensed volume

The Minister declared the Permissible Consumptive Volume in the Lower Campaspe Valley WSPA to be 55,875 megalitres per year (ML/year) in March 2013 (Victorian Government Gazette, 2013).

The total groundwater licensed volume in the Lower Campaspe Valley WSPA was 55,860 ML/year on 30 June 2018 (Table 1), which remained unchanged from 30 June 2017.

Table 1 Groundwater licensed volume in the Lower Campaspe Valley WSPA in 2017/18

Management zone	Licences	Licensed bores	Licensed volume (ML/year)
Elmore-Rochester Zone – 1031	55	66	16,902.6
Bamawm Zone – 1032	41	47	26,003.3
Echuca Zone – 1033	17	19	4,959.5
Barnadown Zone – 1034	20	58	7,995.0
Total	133	190	55,860.4

Note: Data extracted from the Victorian Water Register 2 July 2018.

2.2 Groundwater allocations

Allocations are a percentage of licensed volume that may be extracted in a given water year. They are determined by comparing the three-year rolling average of the maximum annual groundwater recovery levels in bores 79324 and 62589 with trigger levels stipulated in the Plan (Figure 2 and Figure 3). Annual allocations of 100 per cent were announced on 1 July 2017 for all management zones in the Lower Campaspe Valley WSPA for the 2017/18 water year.

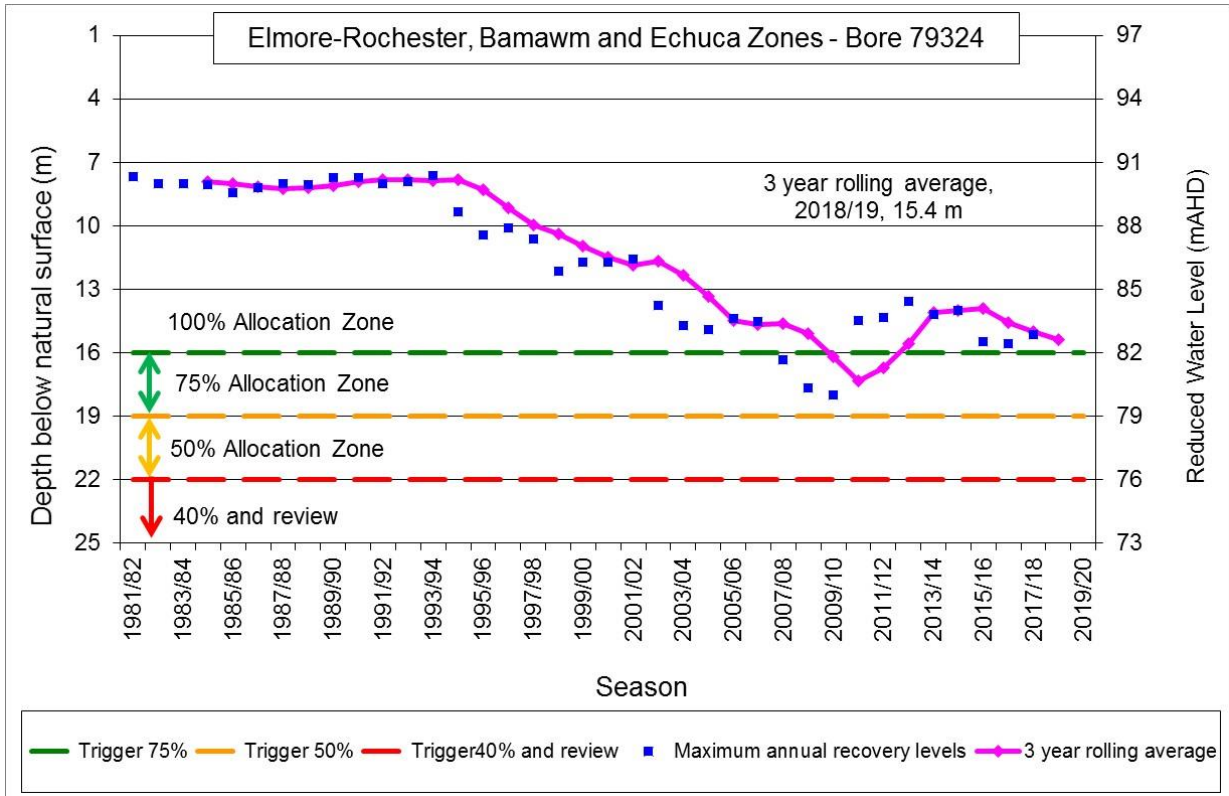


Figure 2 Trigger levels to determine allocations in the Elmore-Rochester, Bamawm and Echuca zones of the Lower Campaspe Valley WSPA

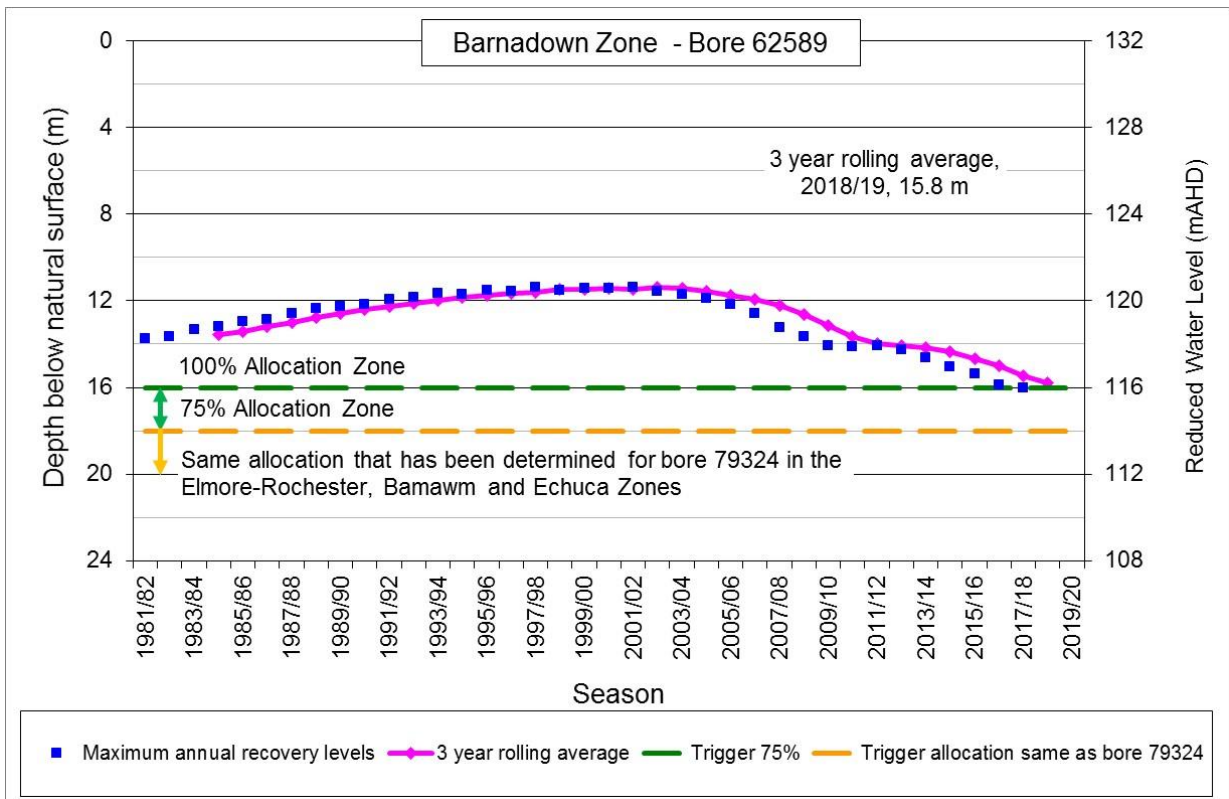


Figure 3 Trigger levels to determine allocations in the Barnadown zone of the Lower Campaspe Valley WSPA

2.3 Groundwater use

Recorded use in the Lower Campaspe Valley WSPA in 2017/18 was 37,408.8 ML or 67 per cent of total licensed volume, which is relatively high compared to historical use (Figure 4).

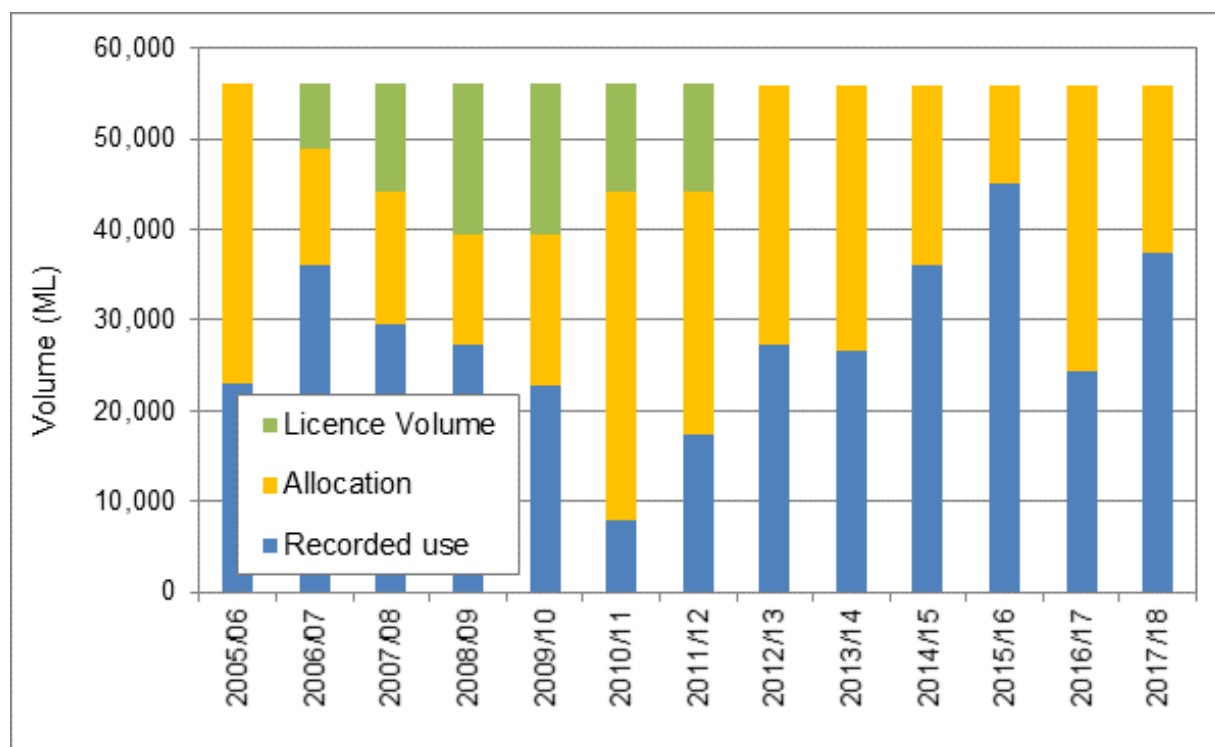


Figure 4 Total licensed volume, allocation and recorded use in the Lower Campaspe Valley WSPA

Recorded use was greatest in the Elmore-Rochester and Bamawm Zones, where the majority of the licensed volume is held (Table 2).

Table 2 Recorded use by Lower Campaspe Valley WSPA management zone in 2017/18

Management zone	Licensed volume (ML/year)	Recorded use (ML)	Proportion of total licensed volume used
Elmore-Rochester Zone – 1031	16,902.6	11,750.0	70%
Bamawm Zone – 1032	26,003.3	18,492.4	71%
Echuca Zone – 1033	4,959.5	2,984.3	60%
Barnadown Zone – 1034	7,995.0	4,182.1	52%
Total	55,860.4	37,408.8	67%

Note: Data extracted from Irrigation Planning Module on 1 July 2018.

2.4 Rainfall

Rainfall data from the Bureau of Meteorology (BoM) weather station at Rochester is provided in Figure 5. The data indicates that rainfall was high in the early-1970s; below average in the early-1980s; remained relatively steady to the mid-1990s; and was below average until the high rainfall events in 2010/11. In recent years, rainfall has mostly been below average except for 2013/14 and 2016/17 when above-average rainfall was reported.

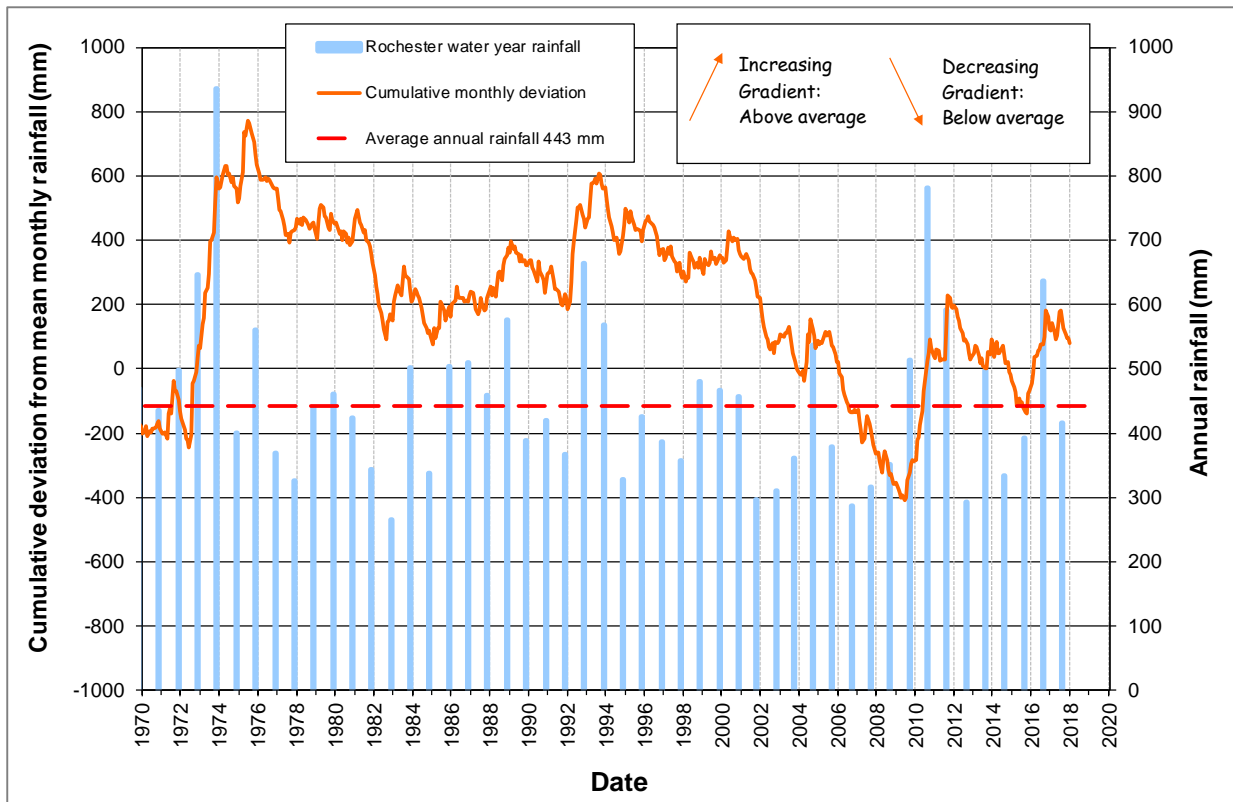


Figure 5 Rainfall recorded at Rochester (BoM station 080049) in the Lower Campaspe Valley WSPA

2.5 Licence transfers

The Plan allows groundwater licence holders to temporarily or permanently transfer licensed volume. In 2017/18 there were 14 temporary licence transfers for a total of 2,292 ML/year and eight permanent transfers for a total of 1,080.5 ML/year (Figure 6).

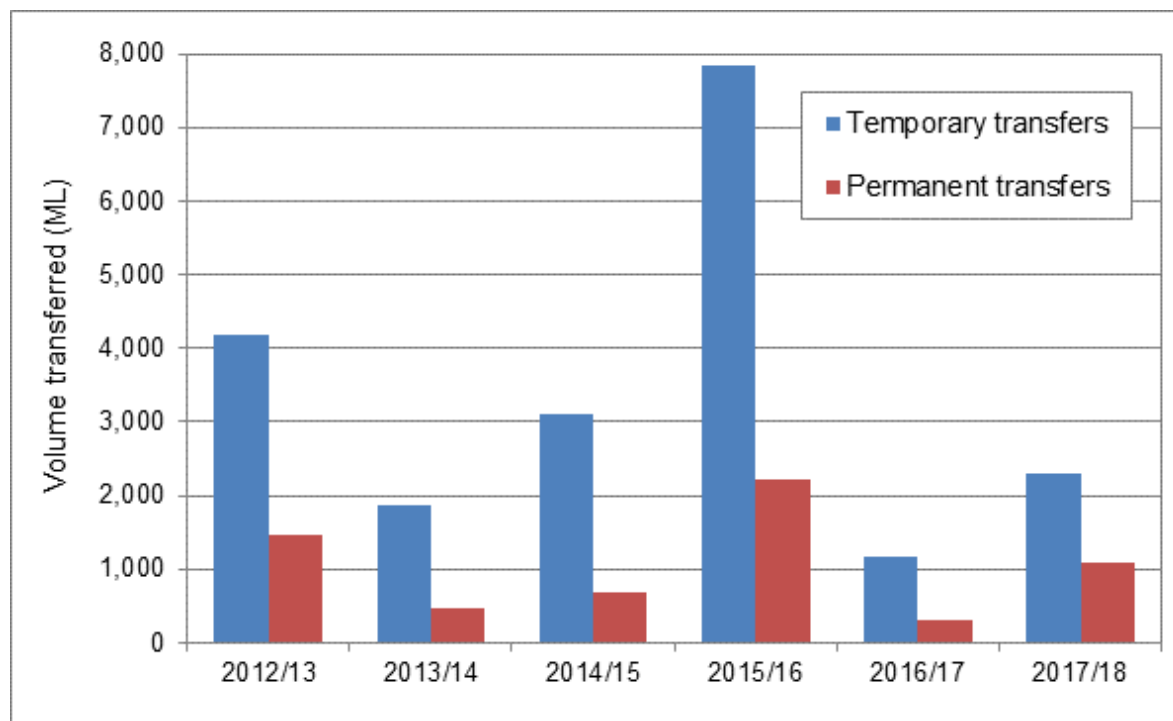


Figure 6 Total licensed volumes transferred in the Lower Campaspe Valley WSPA

The majority of licence transfers occurred within the same management zone (Table 3). There was a net temporary transfer from the Bamawm Zone to the Echuca Zone for 10 ML/year of licensed volume and 40 ML/year permanently transferred from the Bamawm Zone to the Echuca Zone.

Table 3 Licence transfers in the Lower Campaspe Valley WSPA in 2017/18

Management zone	Temporary				Permanent			
	Transfer from		Transfer to		Transfer from		Transfer to	
	No. of transfer	Volume (ML/yr)	No. of transfer	Volume (ML/yr)	No. of transfer	Volume (ML/yr)	No. of transfer	Volume (ML/yr)
Elmore-Rochester Zone – 1031	2	310.0	2	310.0	1	8.5	1	8.5
Bamawm Zone – 1032	8	1,437.0	7	1,427.0	5	522.0	2	482.0
Echuca Zone – 1033	0	0.0	1	10.0	0	0.0	3	40.0
Barnadown Zone – 1034	4	545.0	4	545.0	2	550.0	2	550.0
Total	14	2,292.0	14	2,292.0	8	1,080.5	8	1,080.5

2.6 Carryover

The Minister declared that groundwater licence holders in the Lower Campaspe Valley WSPA were authorised to take carryover in November 2012 (Victorian Government Gazette, 2012).

In the Lower Campaspe Valley WSPA licence holders may carryover up to a maximum of 25 per cent of their unused licensed volume for use in the subsequent water year.

In 2017/18 there was a total of 13,776.6 ML carried over by licence holders in the Lower Campaspe Valley WSPA. At the conclusion of the 2017/18 water year, groundwater licence holders in the Lower Campaspe Valley WSPA were able to carryover 12,839.7 ML into the 2018/19 water year.

2.7 Metering

All operational licensed bores in the Lower Campaspe Valley WSPA were metered as of 30 June 2018. There were 136 meter-related activities undertaken in 2017/18, including inspections, maintenance and battery replacements (Table 4).

All meters were read at least twice during the 2017/18 water year.

Table 4 Metering activities in the Lower Campaspe Valley WSPA in 2017/18

Metering activity	Year ending 30 June 2018
Total number of meters	152
Number of meters installed	1
Number of meters replaced	3
Meter maintenance events	132
Total number of meter reads	304

2.8 Licence compliance

There were no prosecutions or convictions relating to groundwater matters in the Lower Campaspe Valley WSPA in 2017/18.

There were four instances of unauthorised take and use of groundwater identified in 2017/18. These incidents have been investigated and GMW has taken action in accordance with the National Framework for Compliance and Enforcement of Systems for Water Resource Management (DSEWPC, 2012).

2.9 Domestic and stock bore licences

Domestic and stock use is not required to be licensed, as it is a private right under section 8 of the Act.

The installation of a bore for domestic and stock use requires a bore construction licence. Upon completion of a bore, a bore completion report is required to be submitted to GMW and details are recorded in the Water Measurement Information System at <http://data.water.vic.gov.au/monitoring.htm>.

During the 2017/18 water year in the Lower Campaspe Valley WSPA, 18 domestic and stock bore construction licences were issued by GMW and the Victorian Water Register (combined).

3 Monitoring Program

3.1 Groundwater levels

The Department of Environment, Land, Water and Planning (DELWP) monitors 98 bores from the State Observation Bore Network on a quarterly basis in the Lower Campaspe Valley WSPA (Figure 1). GMW conducted monthly monitoring of 60 key State observation bores identified in Schedule 1 of the Plan (Appendix B) where practicable during the 2017/18 water year.

Monitoring indicates that seasonal groundwater level recovery is within observed historical ranges. It is noted that over the period of Plan implementation there has been a falling groundwater level trend. This reduction in storage may be attributed to reduced recharge and groundwater extraction.

Groundwater recovery levels in the Elmore-Rochester Zone declined by less than 0.1 m in 2017/18 to 14.7 m depth at bore 60123, with seasonal drawdown of 14.5 m (Figure 7). In the Bamawm Zone, groundwater recovery levels declined by around 4.2 m at bore 47253 in 2017/18 to a depth of 19.12 m at bore 47253, with a seasonal drawdown of almost 16 m.

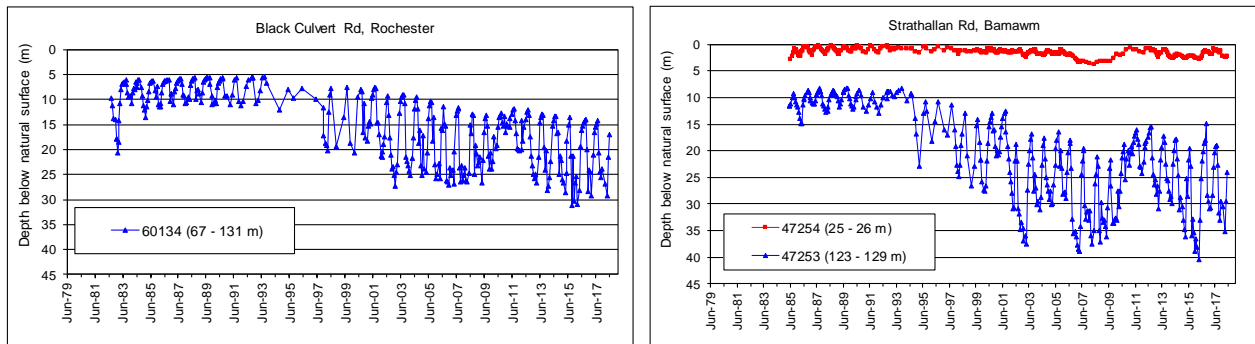


Figure 7 Groundwater monitoring in the Elmore-Rochester and Bamawm zones in the Lower Campaspe Valley WSPA

In the Echuca Zone, groundwater recovery levels remained steady and seasonal drawdown of 4.4 m was recorded at bore 79324. In the Barnadown Zone, groundwater recovery levels also remained relatively steady, with seasonal drawdown of 0.6 m at bore 82999 (Figure 8).

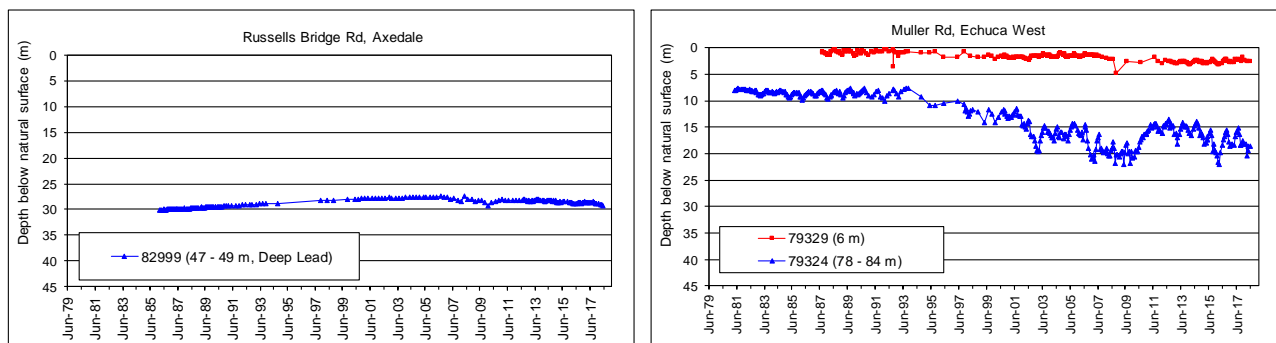


Figure 8 Groundwater monitoring in the Barnadown and Echuca zones in the Lower Campaspe Valley WSPA

3.2 Groundwater quality

Groundwater user salinity sampling

GMW sent 189 sample bottles and a reply paid envelope to licence holders, and domestic and stock users upon request, to collect a groundwater sample from their bore for analysis. There were 46 samples returned for analysis (a return rate of 24 per cent).

GMW measured the groundwater salinity, advised each bore owner of the result and recorded the data in the State groundwater database. The results are shown spatially in Figure 9 and show more saline groundwater in the northern parts of the Lower Campaspe Valley WSPA. Higher groundwater salinity levels west of the Campaspe River in the Barnadown Zone may be influenced by groundwater contributions from the Huntly Deep Lead.

A higher and more consistent sample return rate would assist with spatially assessing any changes in groundwater salinity over time. Groundwater users are strongly encouraged to participate in this program so that they can identify any changes in groundwater salinity.

Targeted sampling of licensed bores

GMW has enlisted six licence holders to participate in the targeted groundwater salinity monitoring program. The purpose of the program is to ensure that samples are consistently collected each year from private bores in strategic locations that will provide a reliable data set to aid in understanding any changes in groundwater salinity over time.

Results from this sampling are presented in Appendix C. Groundwater salinity varies between seasons, although there appears to be a rising trend in groundwater from some bores. Continued monitoring will enable trends to be better understood and inform the Plan review.

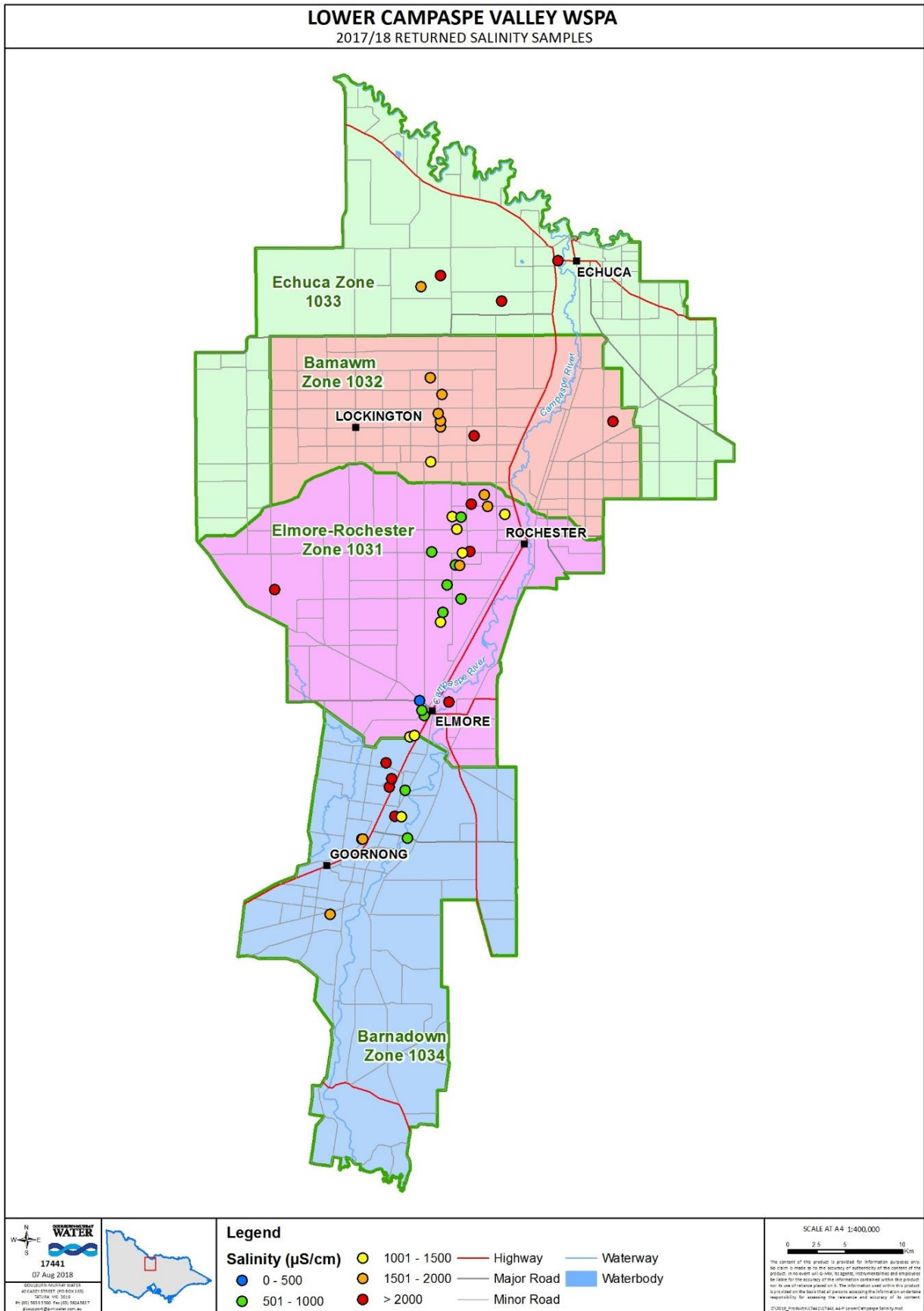


Figure 9 Location of returned samples analysed for groundwater salinity in the Lower Campaspe Valley WSPA

Sampling from State observation bores

Groundwater samples from nested State observation bores were sent to a National Association of Testing Authorities (NATA) accredited laboratory for analysis. Nested sites feature two or more monitoring bores in close proximity, each monitoring a different aquifer. The State observation bores used for water quality testing are located in the areas of intensive groundwater pumping west of Rochester and at the northern margins of the Lower Campaspe Valley WSPA.

Groundwater salinity results are presented in Table 5. The results have been compared to earlier measurements of groundwater salinity (Appendix C). Groundwater salinity varies between seasons but no strong trends are identified. Continued monitoring of groundwater quality will enable any trends to be identified to inform Plan review.

Table 5 Results from groundwater quality sampling between January and April 2018 in the Lower Campaspe Valley WSPA

Management zone	Location	Bore ID	Screened interval (m below natural surface)	Aquifer screened	Electrical Conductivity (µS/cm)
Echuca Zone – 1033	Casey Road, Wharparilla	102827	108 – 114	Deep Lead aquifer	4,200
		102828	160 – 167	Deep Lead aquifer	3,700
		102829	70 – 74	Shepparton Formation	4,000
	Craig Road, Koyuga	73425	87 – 89	Deep Lead aquifer	9,000
		73426	6 – 18	Shepparton Formation	10,000
Bamawm Zone – 1032	Strathallan Road, Lockington	WRK059873	82 – 87	Deep Lead aquifer	3,800
		WRK059876	91 – 97	Deep Lead aquifer	3,000
		WRK059877	34 – 37	Shepparton Formation	4,200
	Strathallan Road, Bamawm	47251	22 – 27	Shepparton Formation	4,000
Elmore-Rochester Zone – 1031	Lowe Road, Diggora	89584	84 – 88	Deep Lead aquifer	3,700
		89596	2 – 14	Shepparton Formation	Bore dry

4 Future Management Considerations

4.1 Groundwater Reference Committee

The Groundwater Reference Committee, appointed in accordance with Prescription 7(c) of the Plan, met on 27 October 2017.

Key points of discussion included:

- Resource condition
- Plan implementation including use, trading, carryover, monitoring
- Review of the Plan

4.2 Management Plan review

GMW has commenced a review of the Plan in accordance with Prescription 7(d) of the Plan. The review will be finalised in the last quarter of 2018.

5 References

Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2012. *National Framework for Compliance and Enforcement of Systems for Water Resource Management*. [WWW document]

<http://www.environment.gov.au/system/files/resources/d4367a3b-28a9-430d-a869-2effbda8a447/files/ris-water-compliance-enforcement.pdf>

Department of Sustainability and Environment, 2012. *Lower Campaspe Valley Water Supply Protection Area Groundwater Management Plan*. Department of Environment and Primary Industries, Melbourne

Goulburn-Murray Water, 2013. *Lower Campaspe Valley Water Supply Protection Area Groundwater Targeted licensed bore sampling*. Unpublished report by Goulburn-Murray Water, Tatura. Document reference number 3503975.

Victorian Government, 2012. *Victorian Government Gazette No. G43 25 October 2012*. Victoria Government, Melbourne

Victorian Government, 2013. *Victorian Government Gazette No. G10 7 March 2013*. Victoria Government, Melbourne

Appendix A – Assessment of activities against Plan prescriptions

Prescription	Activity	Compliant
PRESCRIPTION 1 Triggers and Restrictions		
<p>By 1 July each year the Corporation will:</p> <ul style="list-style-type: none"> (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 in the Plan. (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). 	<p>GMW determined the rolling average of the maximum annual groundwater recovery levels from the preceding three water years and announced allocations of 100 per cent in all management zones on 1 July 2017.</p> <p>GMW announced allocations by listing them on their website, sending letters to all licence holders and placing public notices in local newspapers.</p>	Yes
PRESCRIPTION 2 Trading rules		
<p>The Corporation may approve a transfer of a groundwater licence under section 62 of the <i>Water Act 1989</i> provided section 53 matters have been considered and it accords with the following:</p> <ul style="list-style-type: none"> (a) Transfer of licence entitlement can occur between zones as specified in the Plan (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 in the Plan are not exceeded. 	<p>GMW processed 14 temporary transfer transactions for a total of 2,292 ML; and 8 permanent transfer transactions for a total of 1080.5 ML in 2017/18.</p> <p>GMW processed all groundwater licence applications in accordance with Prescription 2(a) and (c).</p>	Yes
PRESCRIPTION 3 Intensive groundwater pumping		
<p>The Corporation may approve an application to take and use groundwater under section 51 or a transfer under section 62 of the <i>Water Act 1989</i> provided that section 53 matters have been considered and the following conditions are satisfied:</p> <ul style="list-style-type: none"> (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. 	<p>GMW processed all groundwater licence applications in accordance with Prescription 3.</p>	Yes

Prescription	Activity	Compliant
PRESCRIPTION 4 Monitoring groundwater levels		
<p>The Corporation will:</p> <ul style="list-style-type: none"> (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. 	<p>GMW obtained monthly groundwater level readings from bores listed in Schedule 1 of the Plan where practicable.</p> <p>A new observation bore is still to be installed in the Coonambidgal Formation. Consideration will be given to the installation of this bore now that the Department of Environment, Land, Water and Planning have completed the review of the State Observation Bore Network.</p>	No
PRESCRIPTION 5 Monitoring groundwater salinity		
<p>The Corporation will:</p> <ul style="list-style-type: none"> (a) Support annual groundwater user salinity sampling by: <ul style="list-style-type: none"> (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. 	<p>GMW provided a sample bottle to licence holders and domestic and stock users upon request. GMW measured the groundwater salinity in returned samples, advised bore owners of the result and entered the results into the State groundwater database.</p> <p>GMW engaged with the six land holders participating in the target sampling of licensed bores. A total of eight bores were sampled in 2017/18.</p> <p>GMW collected groundwater samples from nested State observation bores identified in Schedule 1 where practicable and sent them to a NATA accredited laboratory for analysis.</p>	Yes
PRESCRIPTION 6 Metered licensed use		
<p>The Corporation will:</p> <ul style="list-style-type: none"> (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. 	<p>All operational licensed bores are metered.</p> <p>Meters were read in February/March and May/June 2018 and data entered into the Water Register.</p>	Yes

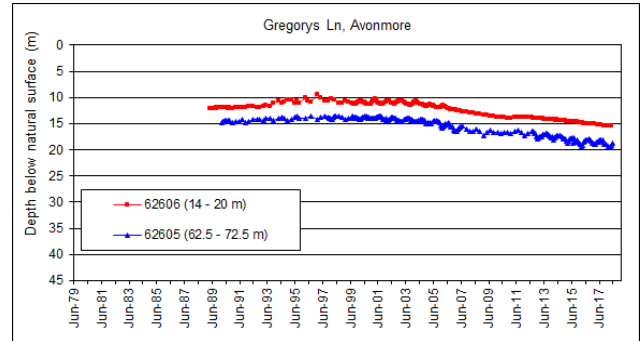
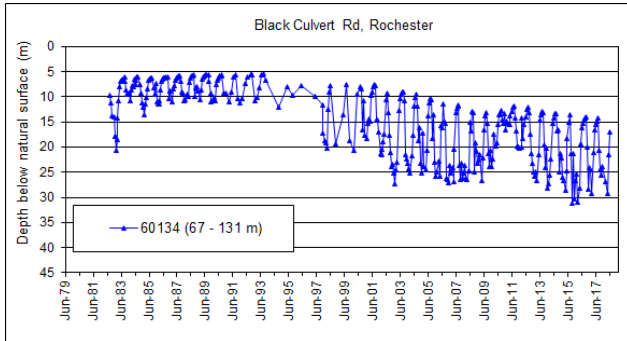
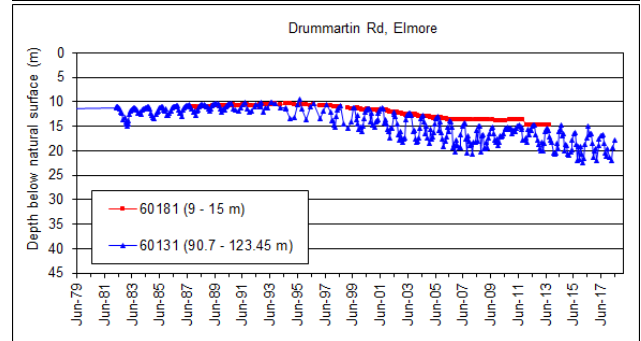
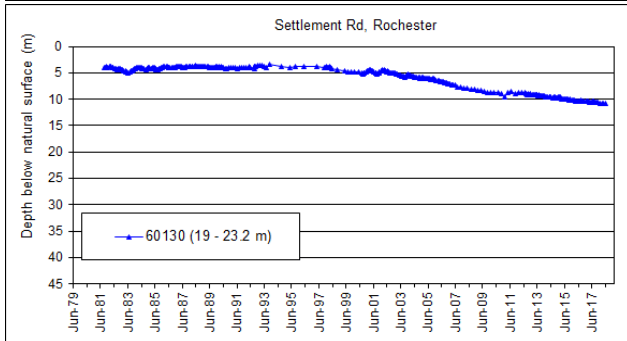
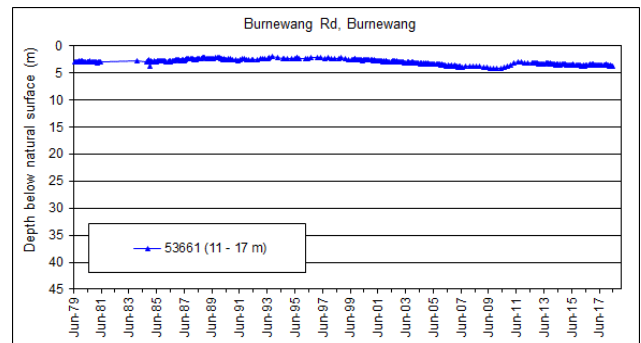
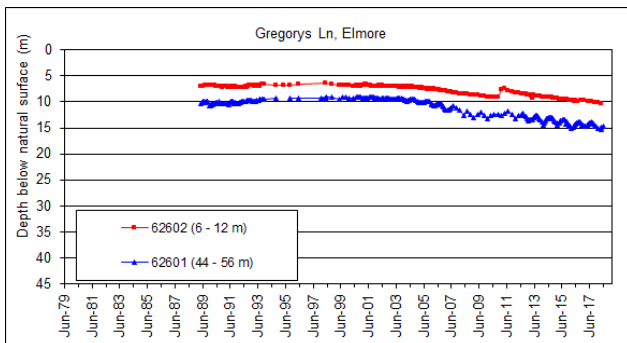
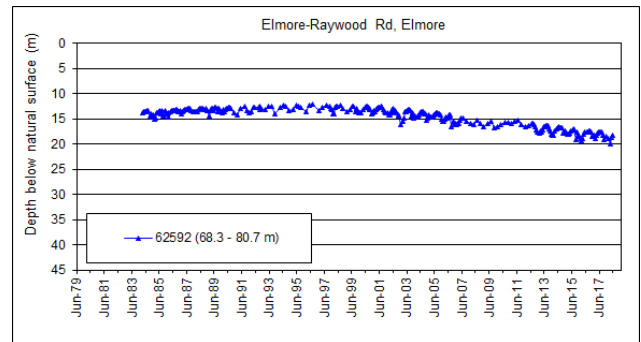
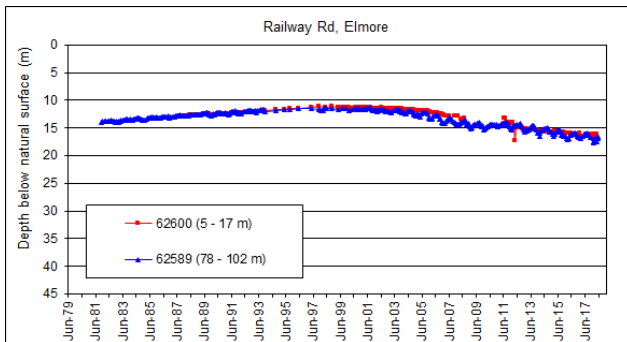
Prescription	Activity	Compliant
PRESCRIPTION 7 Plan implementation		
<p>The Corporation will:</p> <ul style="list-style-type: none"> (a) Post on its website the Plan; annual reports and newsletters; groundwater levels; and rolling average for trigger bores. (b) Mail a newsletter in October each year 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 	<p>GMW has posted on its website the Plan, annual reports, groundwater level and rolling average for trigger bores.</p> <p>Newsletters reporting on resource status and implementation of the Plan were provided in September 2017.</p> <p>GMW met with the Groundwater Reference Committee in October 2017 to discuss Plan implementation and resource conditions. They also provided input to the review of the Plan and effectiveness of the management prescriptions.</p> <p>GMW commenced the review of the Plan which be completed before June 30 2019.</p>	<p>Yes</p>

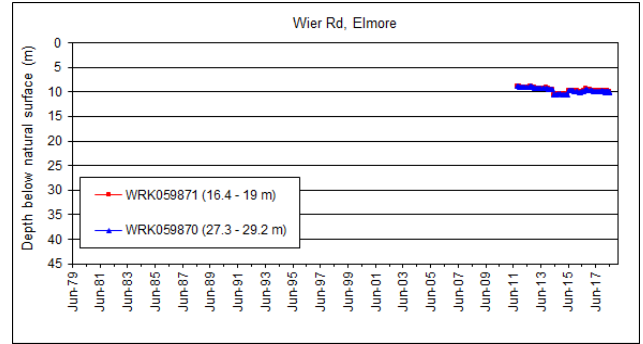
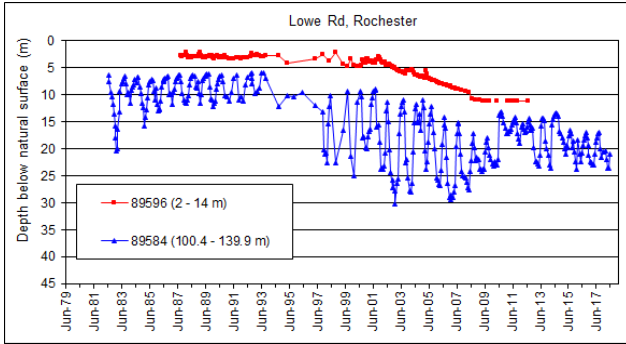
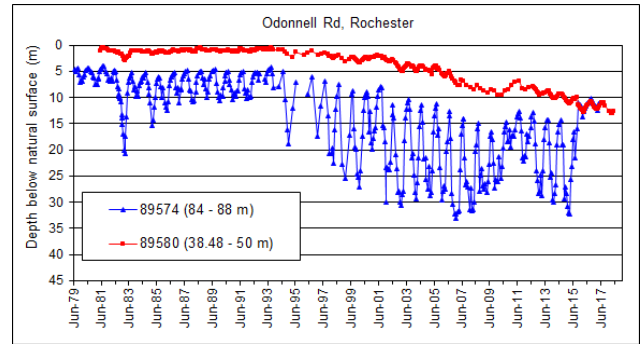
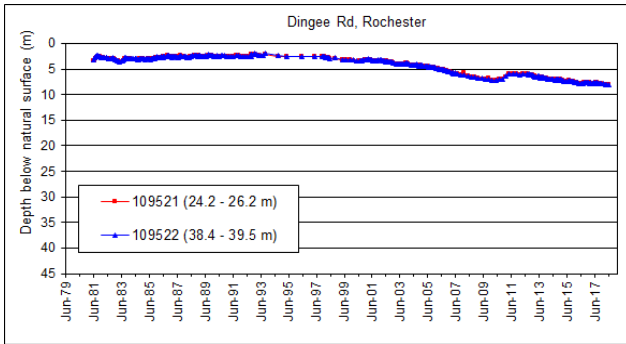
Appendix B – Hydrographs for key monitoring bores

Hydrographs are provided for key monitoring bores listed in Schedule 1 of the Plan.

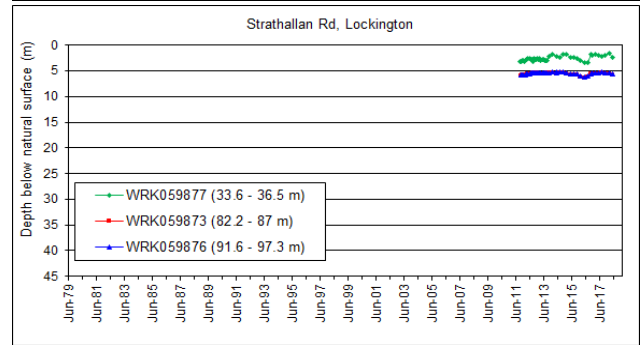
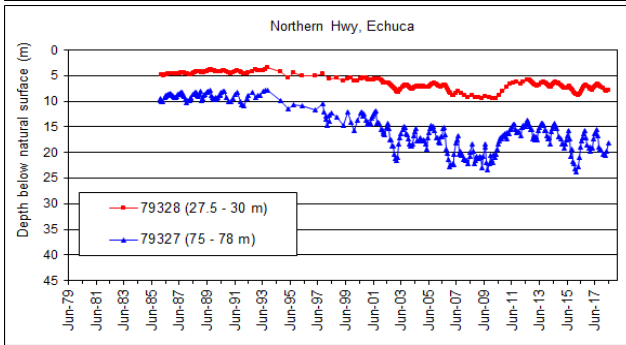
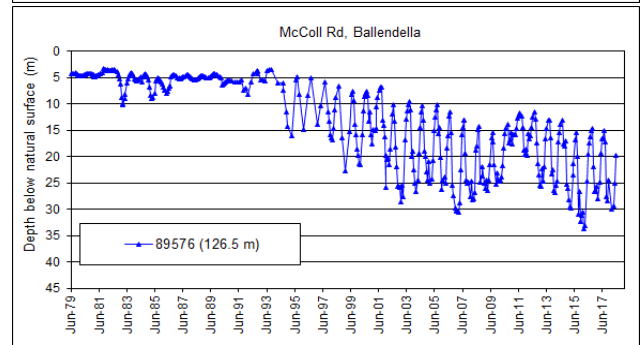
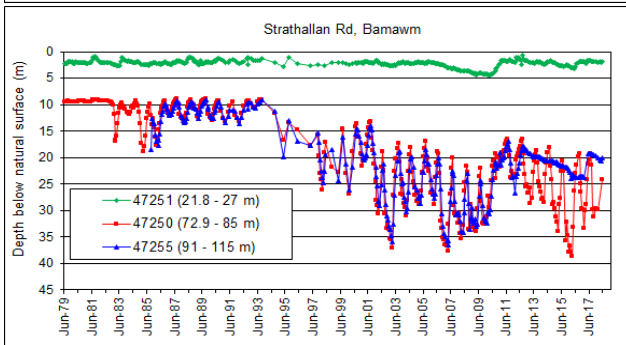
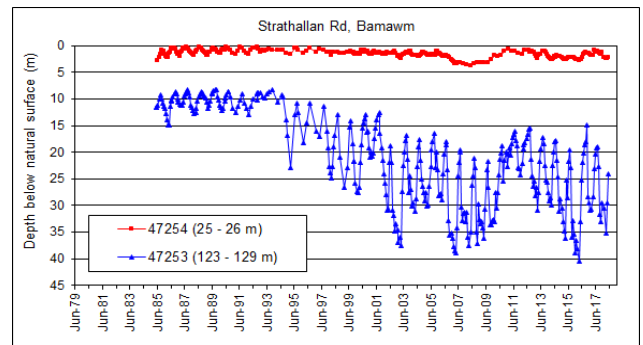
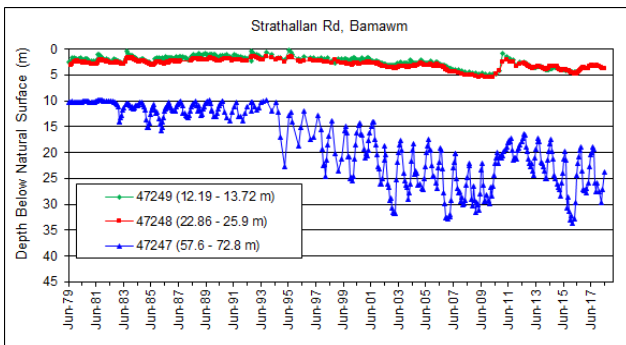
Further groundwater level information from other State observation bores is available on the Water Measurement Information System at <http://data.water.vic.gov.au/monitoring.htm>

Elmore-Rochester Zone – 1031

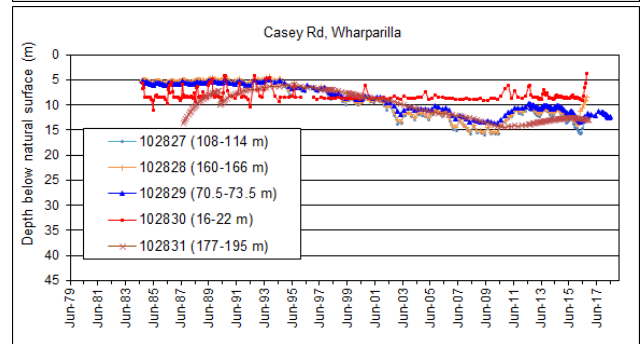
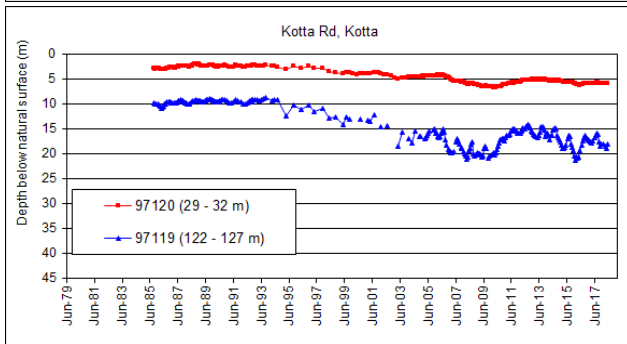
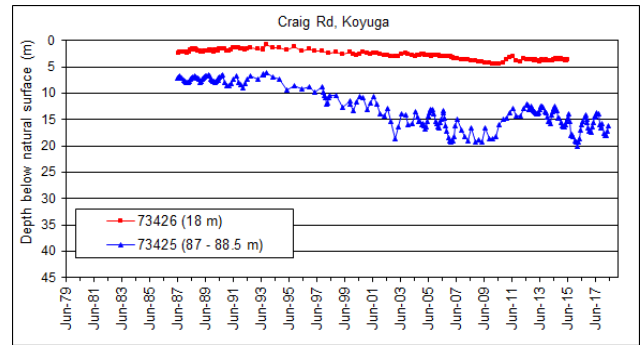
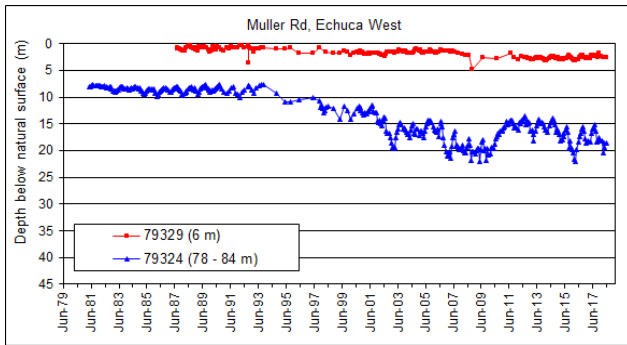




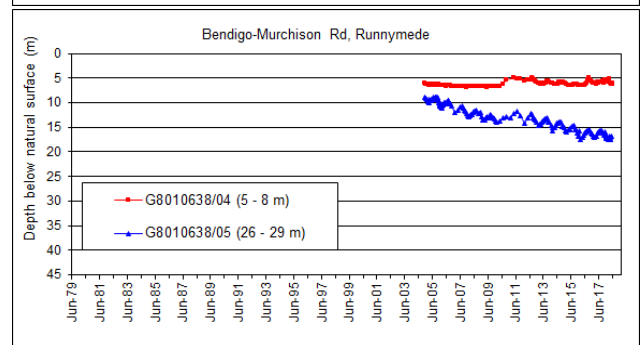
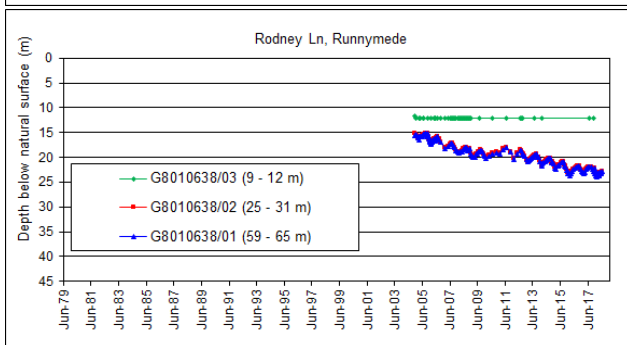
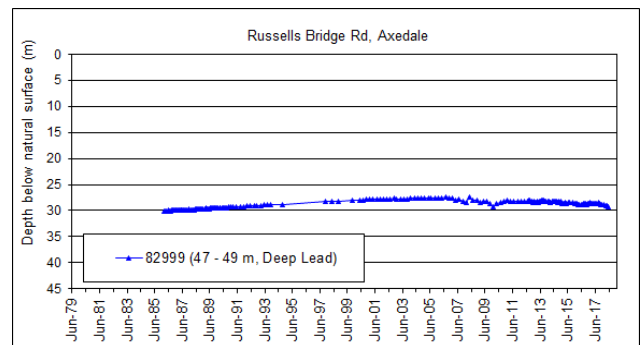
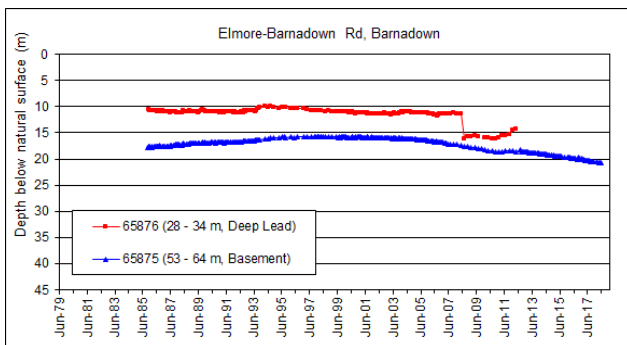
Bamawm Zone – 1032

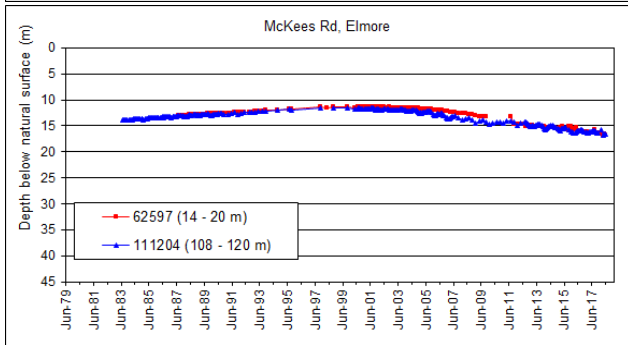
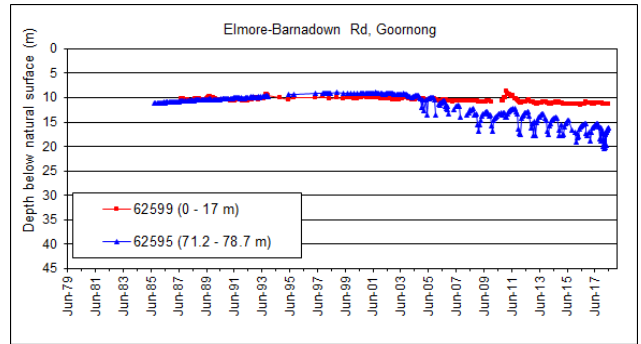
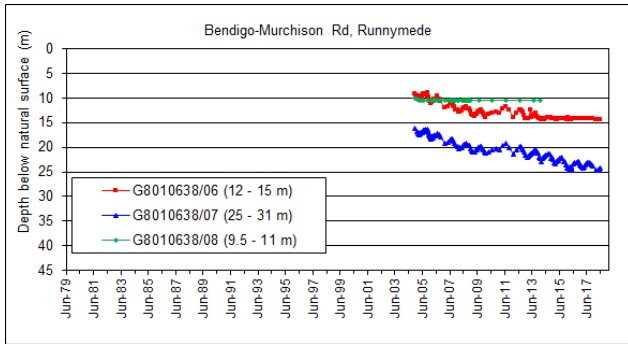


Echuca Zone – 1033



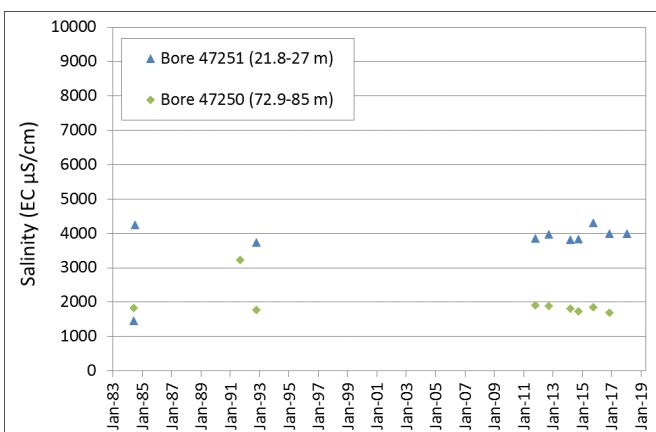
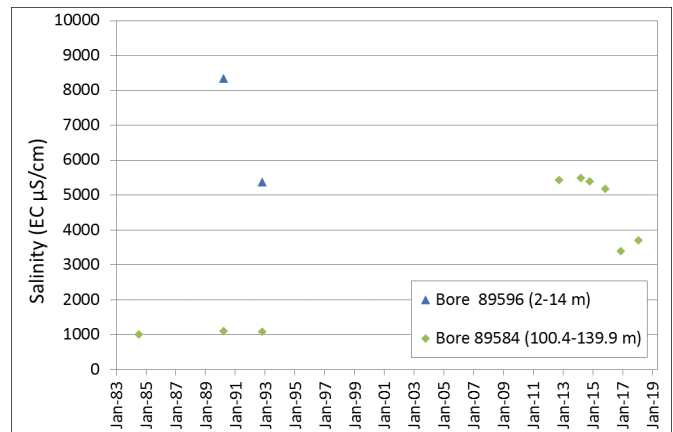
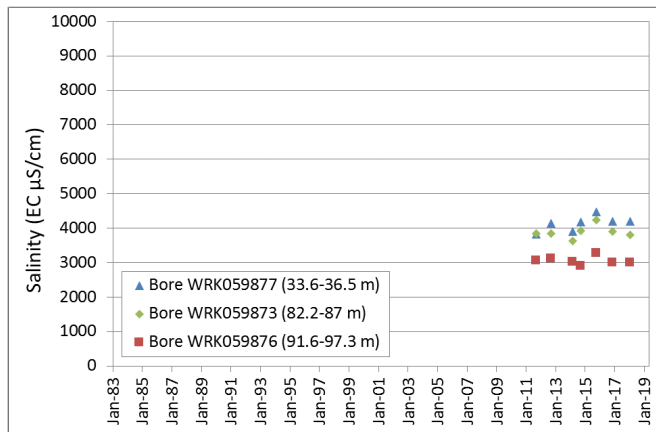
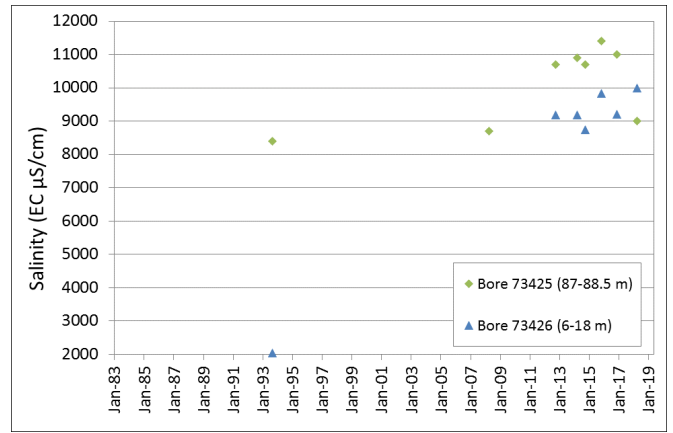
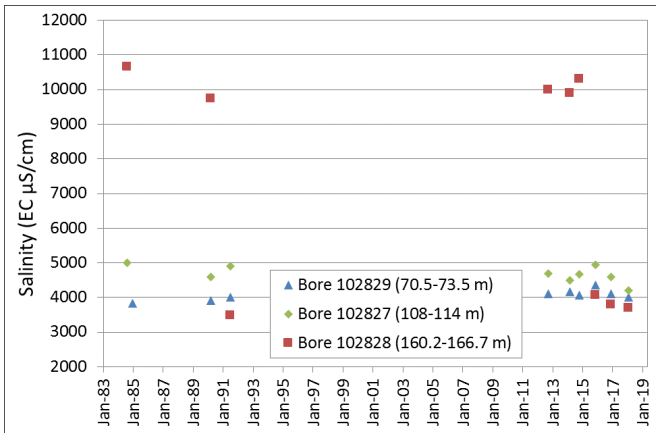
Barnadown Zone – 1034





Appendix C – Groundwater quality results

Groundwater salinity from key monitoring bores listed in Schedule 1 of the Plan



Groundwater chemistry results from key monitoring bores listed in Schedule 1 of the Plan

Analyte	Bore	102828	102827	102829	WRK 059873	WRK 059876	WRK 059877	47251	73425	73426	89584
	Date	29/01/2018	29/01/2018	30/01/2018	1/02/2018	1/02/2018	1/02/2018	30/01/2018	9/04/2018	9/04/2018	31/01/2018
Electrical Conductivity @ 25°C	µS/cm	3700	4200	4000	3800	3000	4200	4000	9000	10000	3700
pH	Units	9.49	8	7.06	6.51	6.54	6.65	9.13	6.66	6.26	6.68
Sulphate as SO ₄ - Turbidimetric	mg/L	270	6	280	210	<1	290	170	780	550	<1
Total Anions	meq/L	36	39	38	38	29	40	38	93	106	34
Total Cations	meq/L	34	39	40	38	28	41	37	101	109	33
Total Alkalinity, as CaCO ₃	mg/L	220	100	180	130	160	150	150	34	200	<2
Calcium	mg/L	24	4	38	74	50	63	13	130	130	39
Carbonate Alkalinity as CaCO ₃	mg/L	<2	45	<2	<2	<2	<2	42	<2	<2	<2
Chloride	mg/L	930	1300	1000	1100	910	1100	1100	2700	3200	1200
Hydroxide Alkalinity as CaCO ₃	mg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Potassium	mg/L	6	9	7.6	10	9	11	13	8	13	6
Sodium	mg/L	630	790	700	560	450	670	710	1700	1800	340
Ammonia	mg/L	<0.1	<0.1	<0.1	0.1	0.2	<0.1	0.3	0.2	0.2	<0.5
Nitrite	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	1.1	<0.01	2.8	0.08	<0.05
Total Kjeldahl Nitrogen as N	mg/L	<0.1	<0.1	<0.1	0.1	0.2	0.1	0.5	-	-	<0.1
Total Nitrogen as N	mg/L	<0.1	<0.1	<0.1	0.1	0.2	1.2	0.5	2.9 - 3	0.3 - 0.32	<0.1
Arsenic	mg/L	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	0.001	<0.001
Iron	mg/L	0.42	<0.01	0.04	4.9	0.23	<0.01	<0.01	0.06	0.65	120
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Magnesium	mg/L	64	55	87	110	72	100	67	250	290	120
Manganese	mg/L	0.33	0.038	0.005	0.12	0.086	0.002	0.049	0.007	0.12	8
Total Dissolved Solids @ 180°C	mg/L	1300	2300	2300	2400	1800	2400	2100	5300	6300	2000
Turbidity	NTU	15	2.3	6.2	6.9	3.2	0.3	5	6.1	2	39
Total Phosphorus as P	mg/L	<0.05	<0.05	<0.05	<0.05	0.12	0.06	<0.05	0.038	0.026	<0.05

Analyte	Bore	102828	102827	102829	WRK 059873	WRK 059876	WRK 059877	47251	73425	73426	89584
	Date	29/01/2018	29/01/2018	30/01/2018	1/02/2018	1/02/2018	1/02/2018	30/01/2018	9/04/2018	9/04/2018	31/01/2018
Total Organic Carbon (TOC)	mg/L	0.7	1.5	0.9	0.8	3.5	0.6	0.9	<0.5	1.1	<0.5
Lead	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	mg/L	<0.001	<0.001	0.044	<0.001	<0.001	0.004	<0.001	0.004	<0.001	<0.001
Cadmium	mg/L	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Chromium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	0.007	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001
Zinc	mg/L	0.007	0.002	0.011	0.014	<0.001	0.01	<0.001	0.013	0.025	0.036

Groundwater salinity results from targeted sampling program and available historical data

