hydrology and risk
CONSULTING

Review of historical use of water: Barmah to the SA Border

Final 2

20 January 2020

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Executive Summary

Over recent years there have been significant changes in water use on the River Murray between Barmah and the South Australian border including:

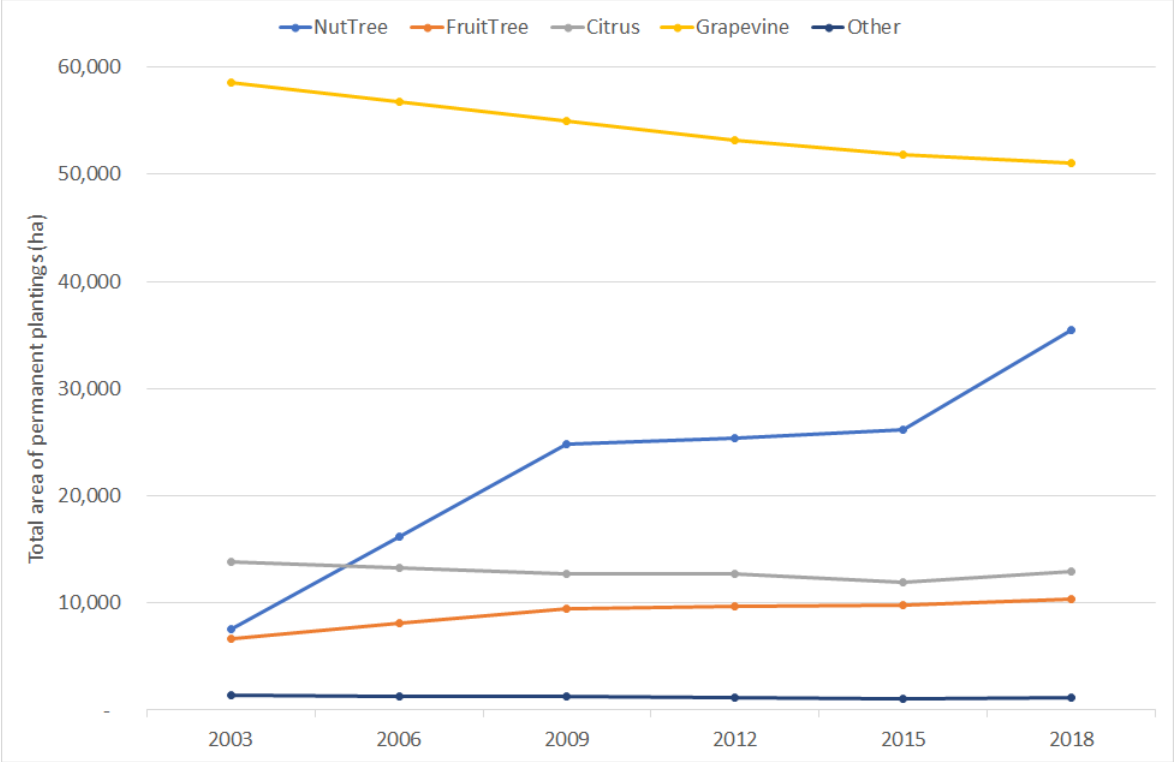
- expansion in permanent horticulture in the Sunraysia region
- recovery of water for the environment
- increased trade of water from the Murrumbidgee and Goulburn rivers to the Murray, and
- increased flows to SA due to trade and environmental flows.

These changes have resulted in community concern that the river system will not be able to meet the changes in demand placed upon it.

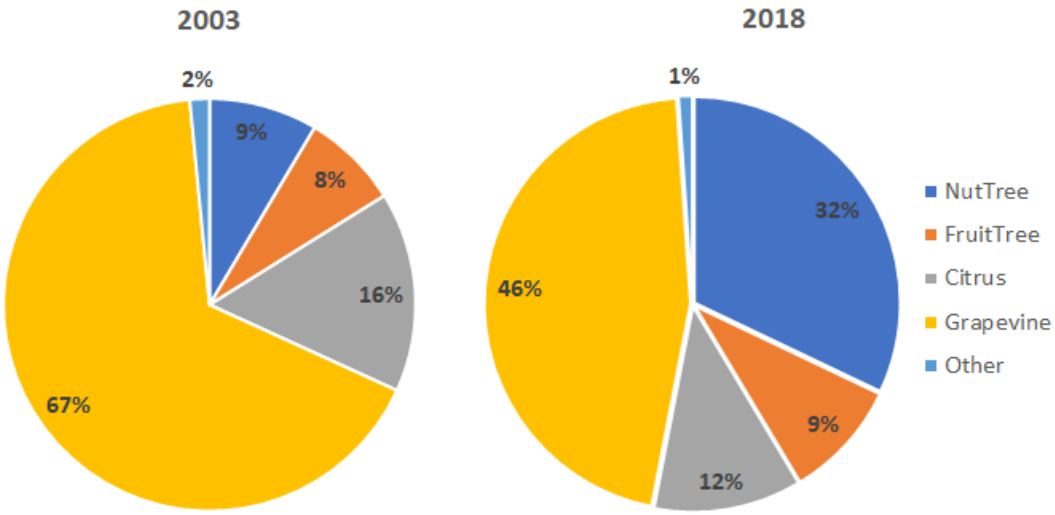
This study investigates the changes historical data shows over time, specifically the period between 1993 and 2018. It looks at changes in irrigated crop types in the Lower Murray and South Australia. It also analyses changes in consumptive use along the River Murray between Barmah and the SA border, and in deliveries to the SA border.

Changes to irrigated crop types

SunRISE crop area data for New South Wales (NSW), Victoria and South Australia (SA) was examined to look at trends in crop area and crop type. Analysis showed that increases in crop area were due to increases in permanent plantings. This increase is largely due to the growth in the area of nut trees, predominantly in Victoria. Grapevines remain the dominant crop overall (Figure E-1 and E-2), and in NSW and SA.



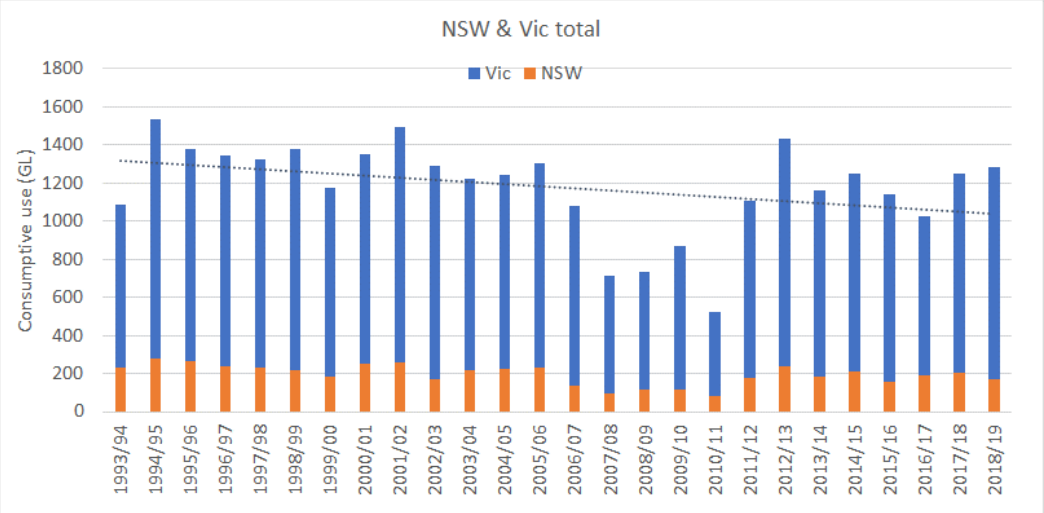
- **Figure E-1: Area of permanent plantings by crop type in SA, Victoria and NSW downstream of Barmah**



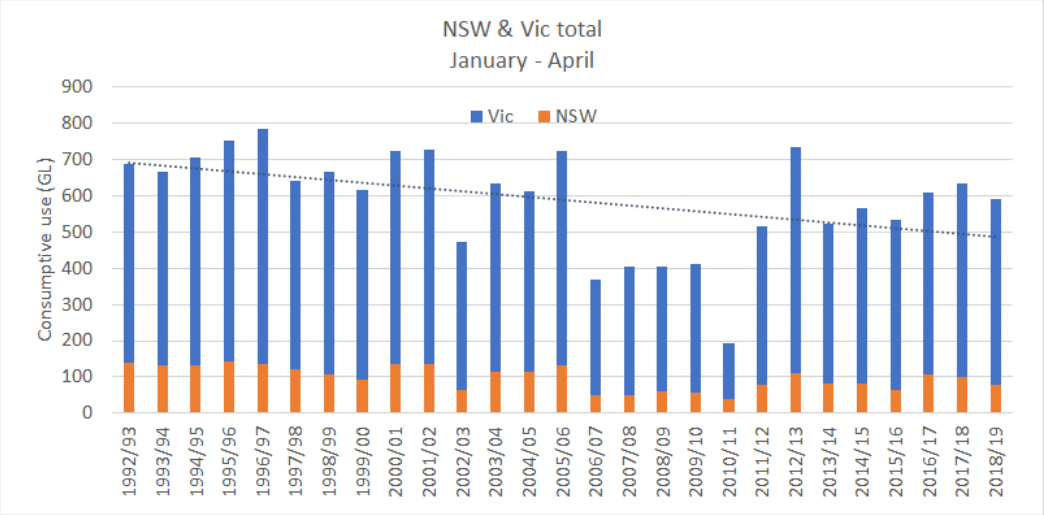
- **Figure E-2: Share of area by crop – permanent plantings in SA, Victoria and NSW downstream of Barmah**

Changes in consumptive use

With the increase in horticultural plantings there is a perception that water use has increased over time. Historic consumptive use data was taken from the MDBA accounts sheet provided to the states each month. Analysis shows that annual consumptive use in the reach between Barmah and Wakool Junction has decreased in both Victoria and NSW. Consumptive use in the reach between Wakool Junction and the SA border has increased slightly in both Victoria and NSW. When the two reaches are combined, the historic data shows that the overall trend in consumptive use is relatively static both annually and over the peak consumptive use period between January and April (Figures E-3 and E-4).



■ **Figure E-3: Trends in annual consumptive use**



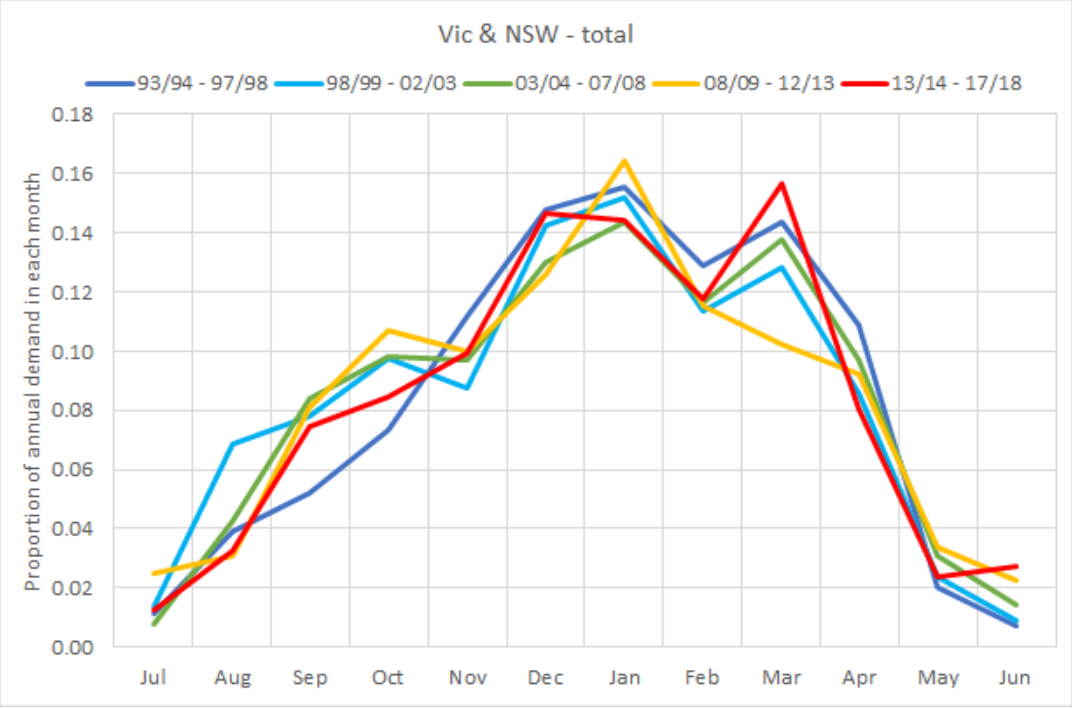
■ **Figure E-4: Trends in January to April consumptive use**

The assessment of changes in consumptive use over time needs to be considered in conjunction with increases in regulated supply to the reach because of Inter Valley Trade (IVT), and increased regulated flow to South Australia as a result of trade and delivery of environmental flows. These factors are discussed later in the executive summary.

Change in patterns of consumptive use

With the expansion in permanent horticultural plantings public concern has been expressed that the consumptive demand period has compressed and thus the risk of shortfall in the peak consumptive demand period has increased. Monthly data from the MDBA accounts sheet was analysed to determine if there has been a significant change in the within-year pattern of consumptive use over time as a result of changes in crop type from annual plantings to horticulture. When all data between Barmah and the SA border is combined it can be seen that there is no clear trend over time in the proportion of use in each month (Figure E-5).

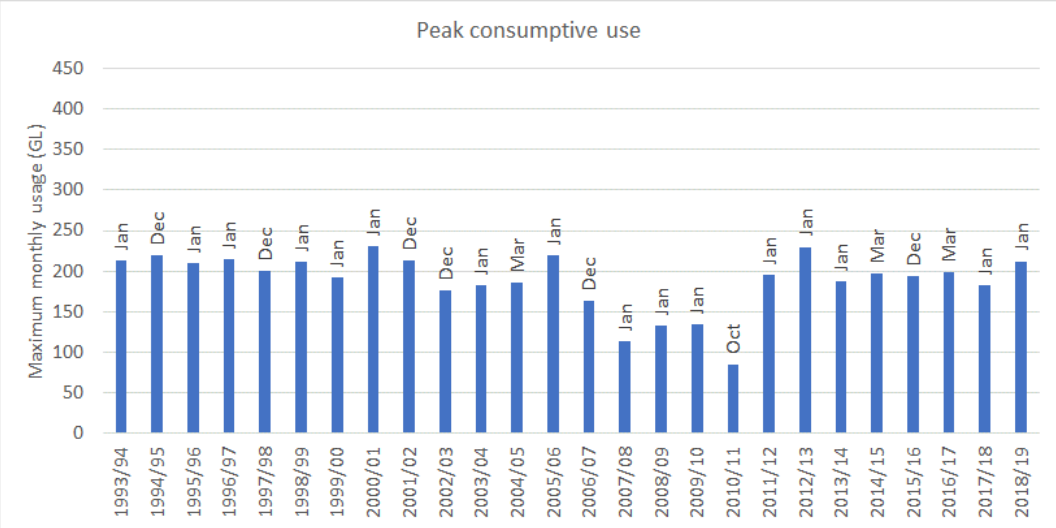
There are some minor trends on a reach by reach basis. In Victoria between Barmah and Wakool Junction, there has been a general increase in the proportion of total annual use delivered in September and October, and a reduction in the proportion delivered between November and February. In NSW the proportion of total annual use delivered in September has also increased. Between Wakool Junction and the SA border the pattern of consumptive use has changed little over time.



■ **Figure E-5: Change in pattern of demand over time – all demands**

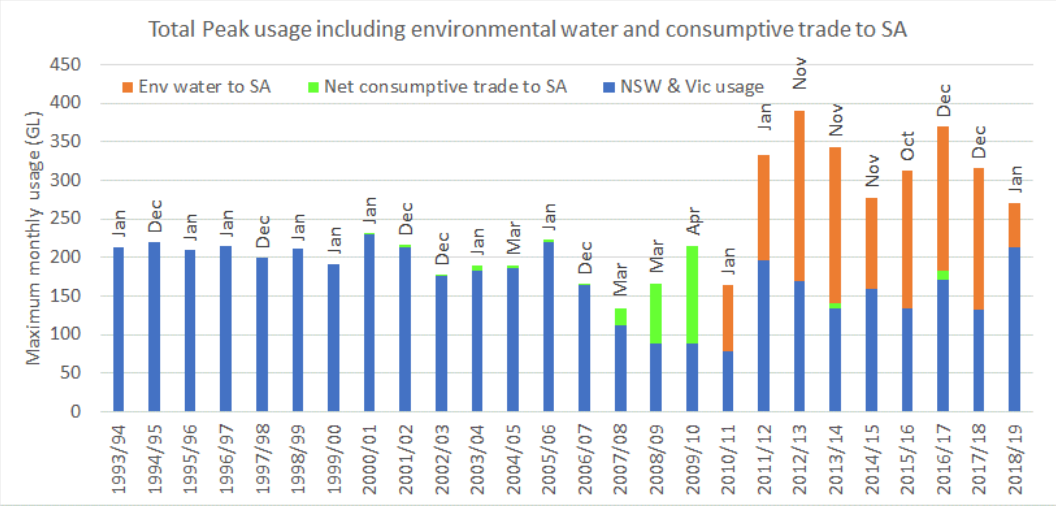
Change in peak usage

Monthly data from the MDBA accounts sheet was analysed to investigate changes in the magnitude of peak use over time, and the month in which peaks occur. Results show that there has not been an increase in peak consumptive use over time in either NSW or Victoria, or in the combined peak (Figure E-6).



■ **Figure E-6: Change in peak monthly consumptive use over time**

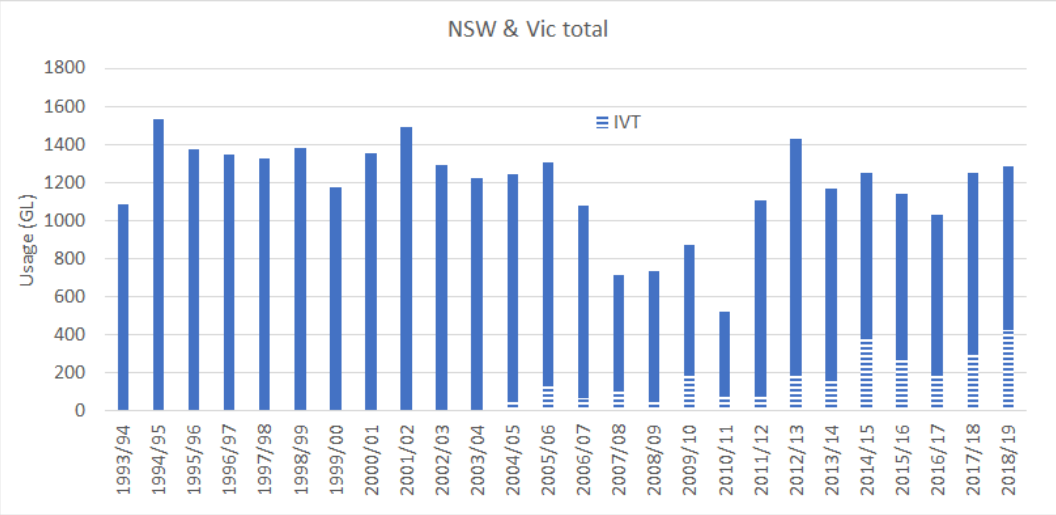
With the advent of environmental water, the magnitude and timing of peak regulated supply (consumptive use plus deliveries to the SA border) has changed, with the peak moving earlier in the year and increasing (Figure E-7). This is consistent with environmental watering in the spring and early summer period resulting in increased environmental flows through the system. In this period environmental flows are generally targeting overbank watering and do not compete with consumptive water for channel capacity.



- **Figure E-7: Change in peak monthly usage over time with and without environmental water and consumptive trade to SA**

Inter-valley trade

Consumptive use from the Murray between Barmah and the SA border has been influenced by two opposing movements of water since 2004/05, inter-valley trade (IVT) of water from NSW and Victorian tributaries into the reach, and recovery of water for the environment from the reach. As a result, the magnitude of total consumptive use over time has been relatively static, but a growing proportion of that demand is being supplied by IVT (Figure E-8).



- **Figure E-8: Total usage and IVT over time**

Changes in environmental deliveries

In recent years, trade and environmental water recoveries have been used to deliver environmental flows to SA. Water can be supplied from environmental water entitlements held in the Murray, Murrumbidgee or Goulburn systems. On the Murray there are significant environmental entitlements held below the Barmah choke.

Analysis of historic data shows that environmental deliveries to SA tend to occur largely in winter-spring, and do not coincide with peak consumptive use (Figure E-9). This June to December period is shaded grey in the figure. Directed environmental water releases from Hume have also been confined to this period, which avoids the peak consumptive demand period and is consistent with the timing of environmental water demand for the Barmah-Millewa forest.

Environmental water holders have also consistently delivered environmental water to South Australia during early summer. While this might appear to be a conflict for channel capacity with consumptive users, historic data shows that the environmental supply in summer is only being met by environmental entitlements held below Barmah choke.

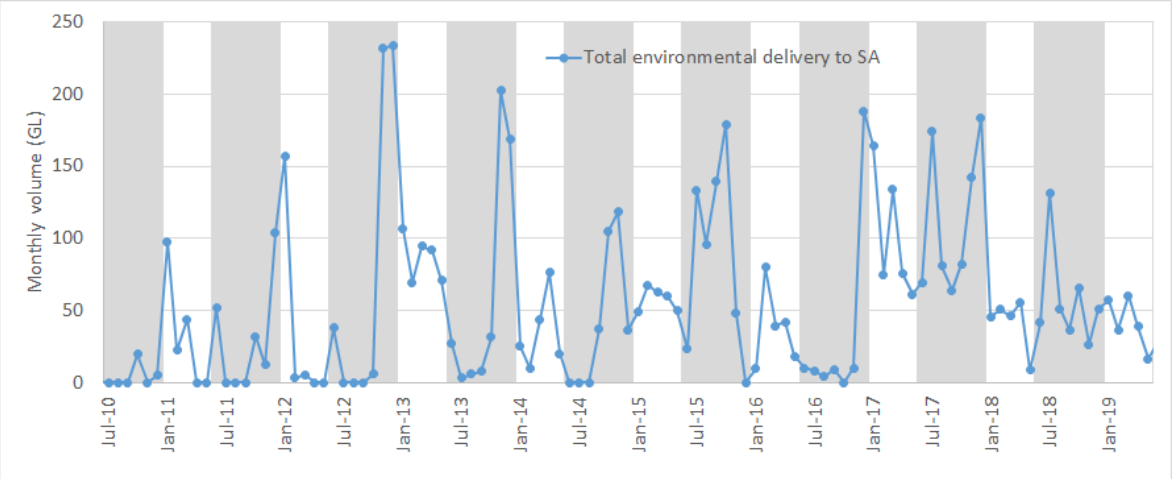


Figure E-9: Timing of environmental flows to SA

An estimate can be made of what the Murray demand would have been if environmental entitlements had not been purchased using the volume of available environmental water each year and the pattern of consumptive usage in that reach for that year (Figure E-5). This has been described as nominal demand. Comparison of environmental deliveries from Murray entitlements with nominal demand shows that the magnitude of demands in the peak January to April period are similar.

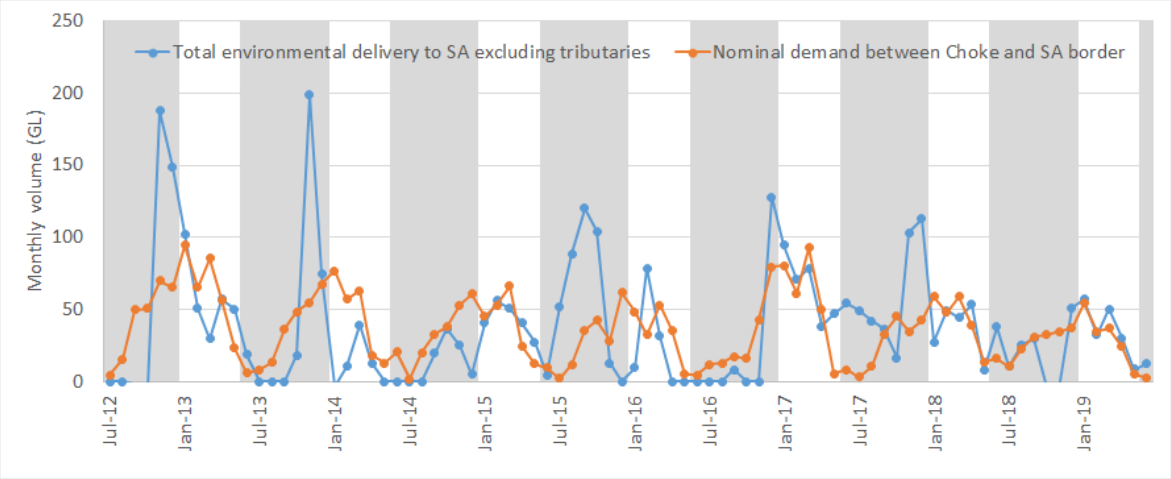


Figure E-10: Environmental flows to SA excluding tribs compared to Murray nominal demand

Historic data from the MDBA accounts sheet also showed that the timing of delivery of environmental flows to wetlands between Barmah and the SA border (for example Hattah Lakes) does not coincide with peak consumptive use, and return flows from wetlands can assist with delivering peak demands later in that water year.

Combined impacts

The combined effect of changes in demand, how they are supplied and how much additional water now passes through the reach to SA was examined over the January to April (peak demand) period.

Entitlements for consumptive use in the reach between Barmah and the SA border have reduced due to environmental water recoveries. The resultant reduction in usage has however been offset by trade into the reach via IVT as shown in panel a) of Figure E-11.

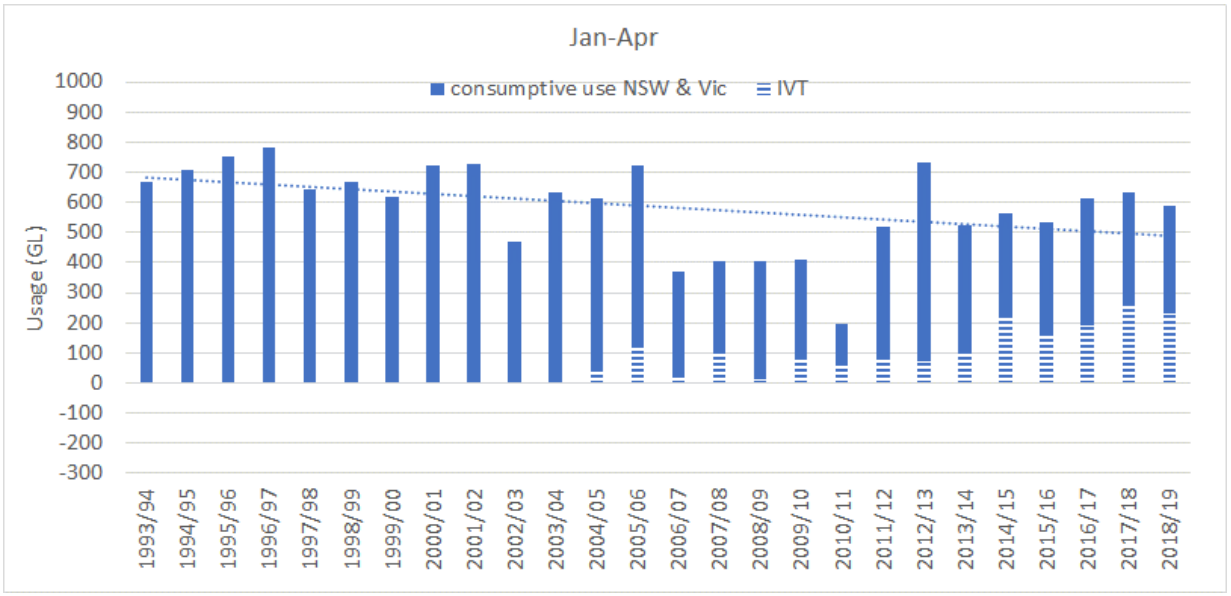
Because of IVT, additional flows have been entering the reach from the NSW and Victorian tributaries. Therefore, use in the reach has been partly supplied by additional IVT flows. This net use is shown in panel b) of Figure E-11.

Use of environmental entitlements and trade mean that additional water is now being passed to SA for consumptive use and for the environment. This water has been supplied from NSW and Victorian tributaries and other parts of the Murray system. Peak usage of environmental water has been generally timed in winter-spring to maximise ecological benefit, which does not conflict with the peak consumptive demand period. Therefore, total demand on the Murray system over the peak demand period has been made up of the combination of use net of IVT, and environmental flows and trade to SA. This is shown in panel c) of Figure E-11. The high environmental water deliveries in 2016/17 were supplied from Lake Victoria and so did not impact upon the ability to supply consumptive demands in that year.

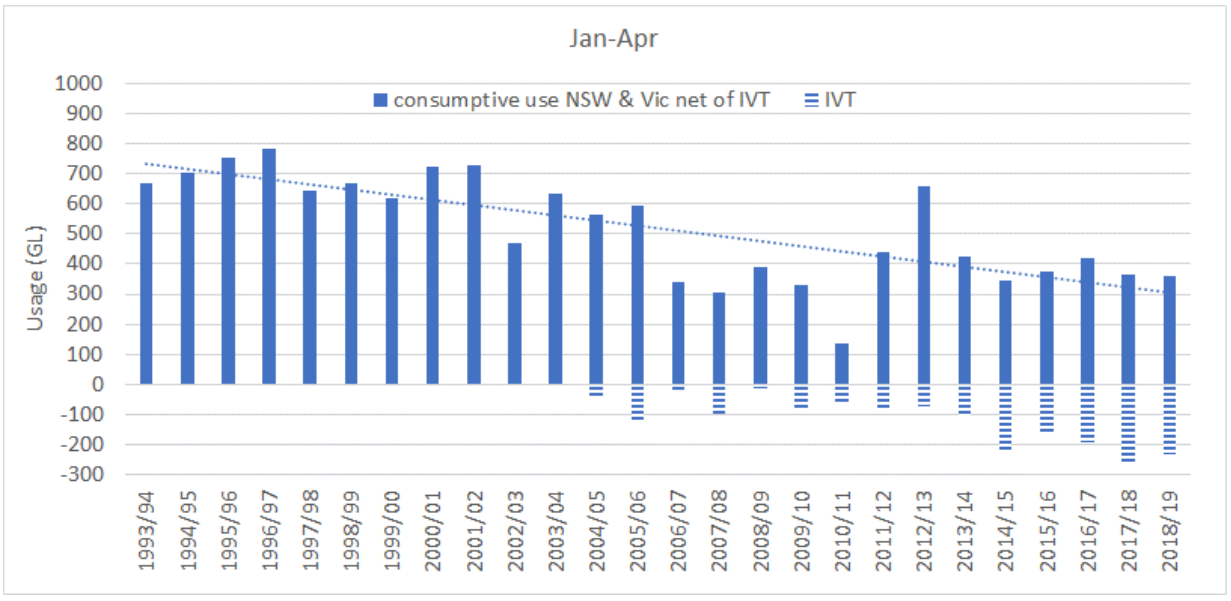
Finally, panel d) adds in the historic SA entitlement order to show total supply to SA over time.

This figure shows that in line with the Murray Darling Basin Cap, total demand on the Murray system has not increased over time.

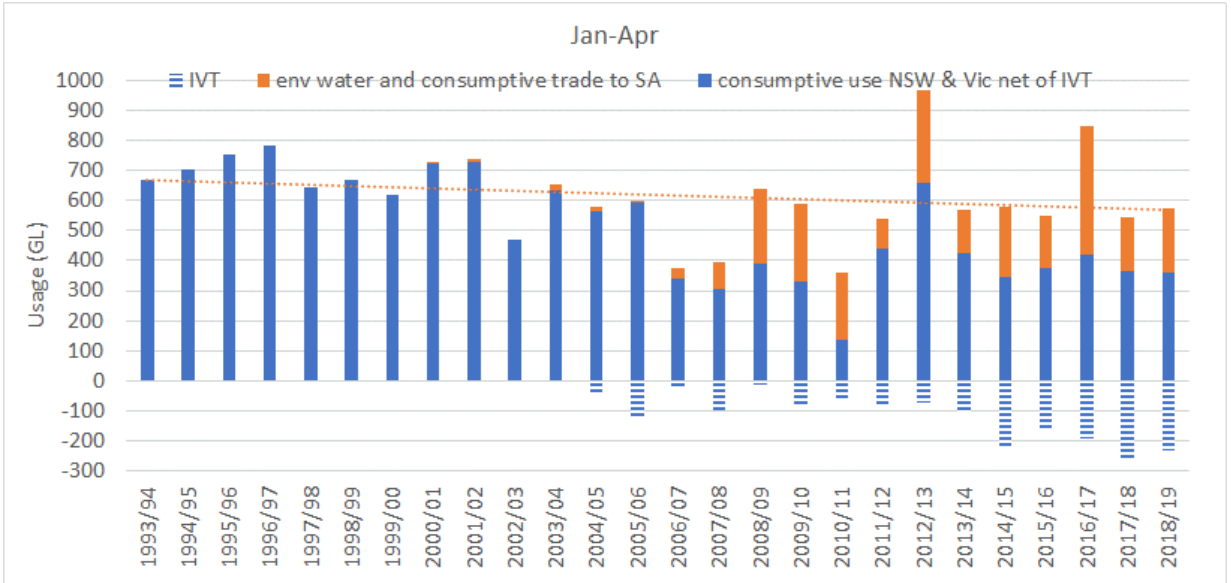
a)



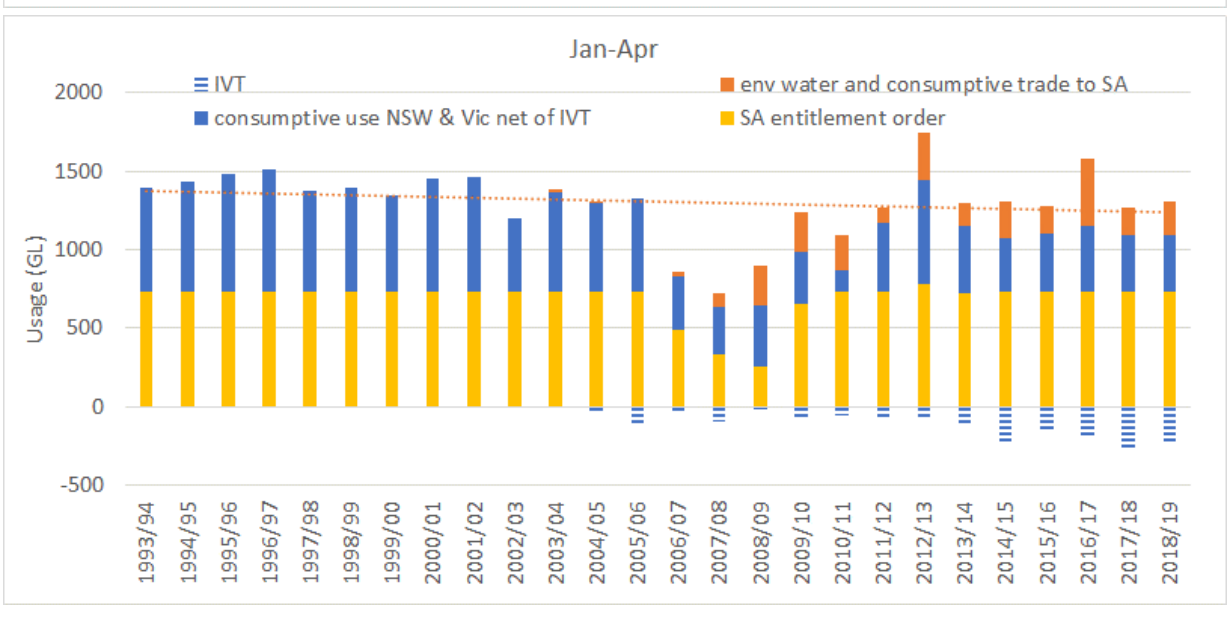
b)



c)



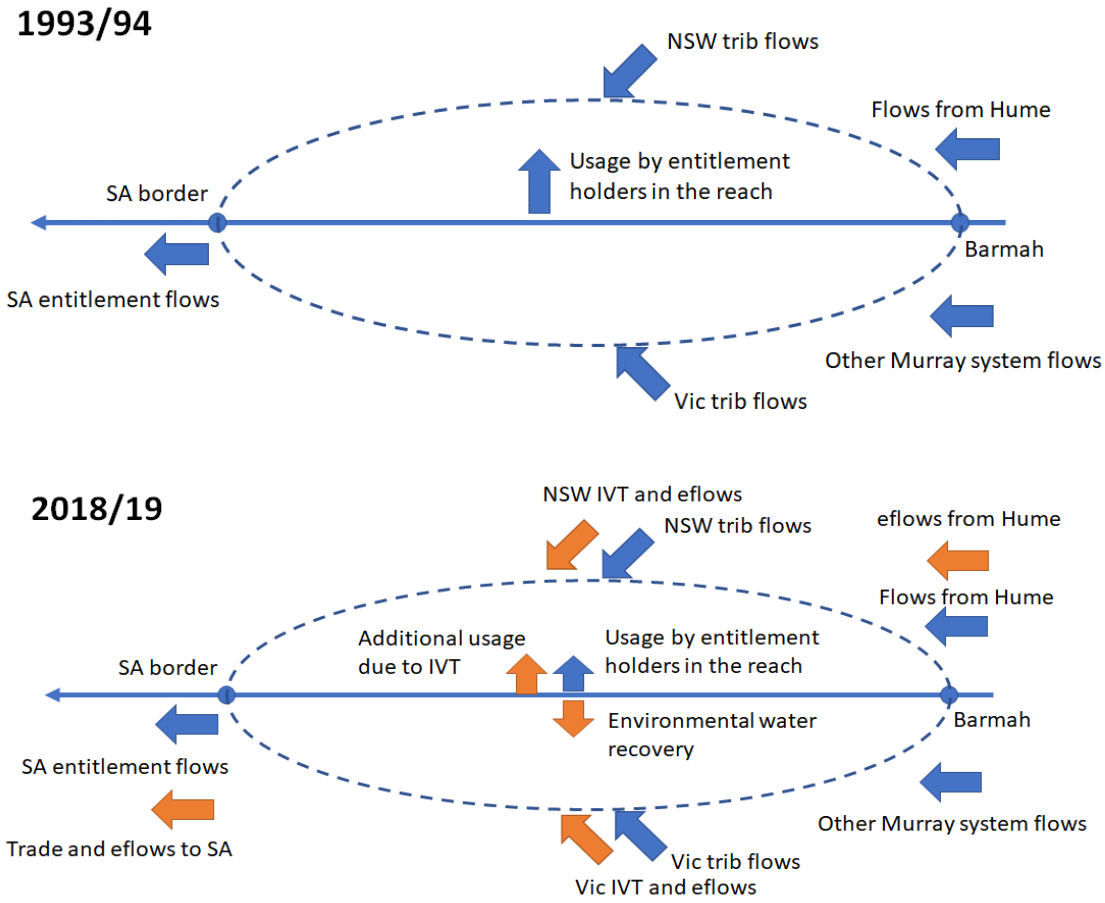
d)



- **Figure E-11: Combined consumptive use, IVT and flows to SA (January to April)**

Figure E-12 summarises how components of the reach balance from Barmah to SA border have changed since 1993/94.

It should be noted that the analysis for this project has focussed on the change in demands, not change in supply. For example the change in flow contribution from Menindee over time has not been analysed.



- **Figure E-12: Reach balance 1993/94 and 2018/19**

Conclusions

In summary:

- Irrigated crop types have changed over time with large areas of nut trees added to the system (Figure E-1), however there has been little change to the within year pattern of consumptive use (Figure E-5).
- Total consumptive use in the reach has not increased (Figure E-3), but some demand has moved from the upstream end (Torrumbarry system) to the downstream end (Sunraysia).
- The reduction in consumptive entitlement due to environmental recoveries has been offset by IVT (Figure E-8). IVT has also resulted in increased regulated inflows to the reach.
- Environmental deliveries and trade for consumptive use have increased the volume of flow passed to SA. This flow is supplied from the Murrumbidgee, Goulburn and Murray systems.
- Delivery of environmental water has largely been timed in the winter – spring – early summer period to maximise ecological benefit (Figure E-9). Summer deliveries when they occur have not exceeded the volume that would have been delivered for consumptive use if buybacks had not occurred.
- Directed releases of environmental water from Hume are timed to maximise environmental benefit to Barmah Forest and avoid increased pressure on the Barmah choke.
- Examination of combined consumptive use, IVT and environmental, SA entitlement flow and consumptive trade to SA shows that there has been no increase in total demand on the River Murray system over time (Figure E-11).

These conclusions relate to historical observations from 1993/94 to 2018/19 and are focussed on changes in demand rather than changes in supply.

1. Introduction

Over recent years there have been significant changes in water use on the River Murray between Barmah and the South Australian border including:

- expansion in permanent horticulture in the Sunraysia region
- recovery of water for the environment
- increased trade of water from the Murrumbidgee and Goulburn rivers to the Murray, and
- increased flows to SA due to trade and environmental flows.

These changes have resulted in community concern that the river system will not be able to meet the changes in demands placed upon it.

This study investigates what changes historical data shows over time. It looks at changes in irrigated crop types in the Lower Murray and South Australia. It also analyses changes in consumptive use along the River Murray between Barmah and the SA border, and in deliveries to the SA border. Section 2 of the report focuses on the changes in crop area and crop type, and Section 3 summarises the changes in consumptive and non-consumptive use.

The focus of this study has been on the reach Barmah to the SA Border as this reflects the operational challenges of the River Murray system. Regulated flows to supply this reach in summer must pass through the Barmah choke which is a significant restriction on flow. Flow to South Australia is supplied downstream of Lake Victoria which provides major storage and reregulation capability.

During the peak demand periods in summer SA is primarily supplied from Lake Victoria (and Menindee if available), while demands between Barmah and Lake Victoria (effectively the SA Border) must be supplied from Hume Dam through the Barmah choke, or from Inter Valley Trade (IVT) from the Murrumbidgee or Goulburn system. This means that in assessing historic changes in demands that might impact upon shortfall to consumptive users, the area of concern is between Barmah and the SA Border. Therefore this reach is the focus of this analysis.

2. Changes in irrigated crop types

Changes in crop area and crop type over time are captured by the SunRISE Mapping and Research (formerly SunRISE 21) data set (refer www.sunrisemapping.org.au). This data set uses GIS-based information to track irrigated horticulture across the lower Murray-Darling. Both permanent and seasonal crops are reported. The crop types and categories are summarised in Table 2-1.

- **Table 2-1: SunRISE crop types and categories**

Table 1: Crop type and category

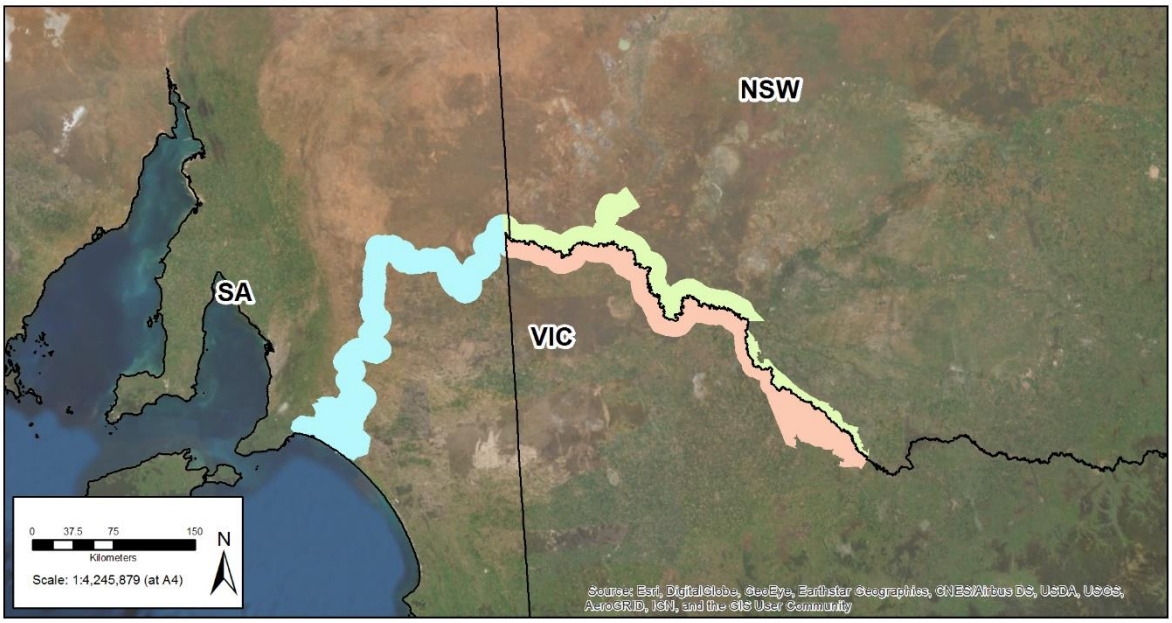
	Crop type	Category	Description
Permanent	Grapevine	Grape Dried	Dried grapes
		Grape Table	Table grapes
		Grape Wine	Wine and juiced grapes
	Citrus	Citrus	All citrus: grapefruit, lime, lemon, mandarin, navel, valencia etc.
	Fruit tree	Olive	Olive fruit trees
		Stonefruit	Apricot, cherry, nectarine, peach, plum
		Other	All other fruit trees: avocado, date palm, mango, persimmon, pomegranate, pome fruits etc.
	Nut tree	Almond	
		Other	All other nut trees: pecan, pistachio, walnut etc.
	Other	Miscellaneous	Nurseries, tree plantations, berry fruit, fresh flowers etc.
Seasonal	Field crop	Field crop	All irrigated field crops: cereal, fodder crops, pasture, lucerne etc.
	Vegetable	Vegetable	All vegetables: asparagus, carrot, cucurbit, onion, potato etc.
Vacant	Vacant P		Not irrigated, but previously an irrigated permanent planting and the area could still be irrigated (i.e. no change in land use).
	Vacant S		Not irrigated, but previously an irrigated seasonal crop and the area could still be irrigated.

For this analysis SunRISE data has been collated and analysed for the Victorian and NSW Murray between Lake Boga and the SA border and for the Murray in SA. NSW and Victorian data was available for 1997, 2003, and then every three years up to 2018. SA data was available for this same period, excluding 1997.

Table 2-2 and Figure 2-1 shows how the SunRISE data provided by the MDBA was combined to create the NSW, Victorian and SA data sets used for this study. As NSW Murray River diverters between Hume and Murrumbidgee were lumped into one item in the SunRISE data, this area was split 60:40 to correspond with the magnitude of historic usage data upstream and downstream of Barmah.

■ **Table 2-2: Collation of SunRISE Mapping regions into states for this study**

Demand node	Description
NSW	
NSW MR IRRI Western Murray	Western Murray Irrigation limited
NSW IRRI USMB (60% of total)	NSW Murray River diverters between Hume and Murrumbidgee, split 60:40 to correspond with the magnitude of historic usage data
NSW MR IRRI DSMB	NSW Murray River diverters between Murrumbidgee and the SA border. Includes Darling River diverters downstream of Burtundy.
Victoria	
TIS	Torrumbarry Irrigation Scheme
Vic IRRI Nyah	Victorian Murray River diverters between Barmah and Nyah
Vic IRRI Nyah-SA	Victorian Murray River diverters between Nyah and the SA border
Vic IRRI Sunraysia Pumps	Sunraysia district
VIC TIS Swan Hill Pumps	Torrumbarry system Swan Hill pumps
Vic Urban SP Millewa Scheme	
SA	
SA IRRI LMRIA	Lower Murray River reclaimed irrigation area
SA IRRI Lower Lakes	
SA IRRI Riverlands	

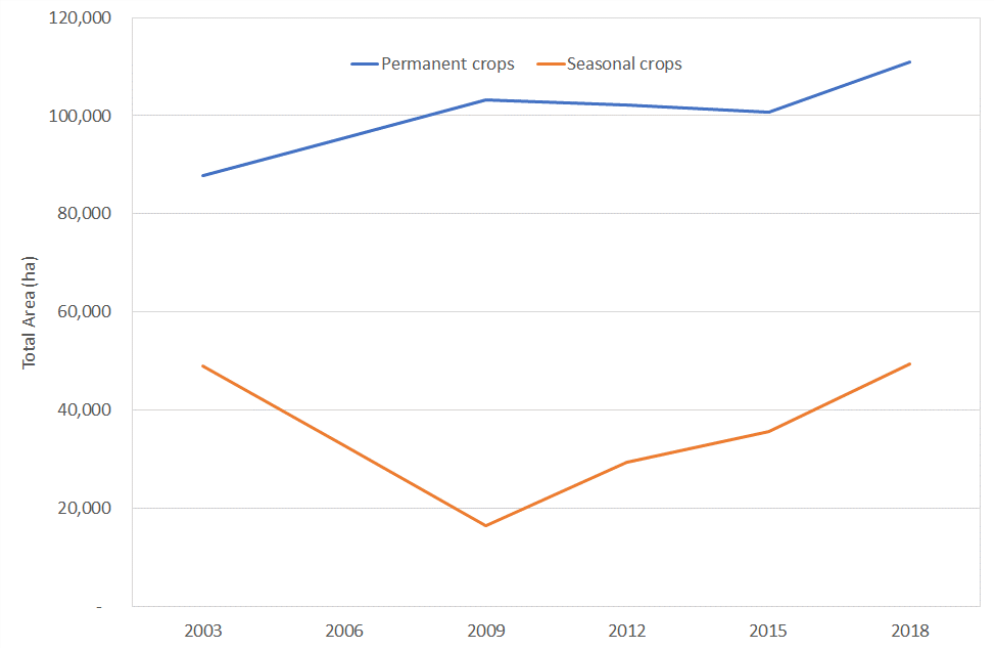


■ **Figure 2-1: Area covered by SunRISE data analysis**

2.1 Trends in permanent and seasonal cropping

The total area planted across the three states increased from 140,000 ha to 155,000 ha between 2003 and 2018 (1997 cannot be analysed as data is not available for SA). Figure 2-2 shows that this increase has been in permanent plantings, and that permanent plantings make up the dominant share of crops grown (73% of total cropped area in 2018). The impact of drought is seen in the drop in seasonal plantings in 2009.

Analysis for this project has focused on trends in permanent plantings in the study area.



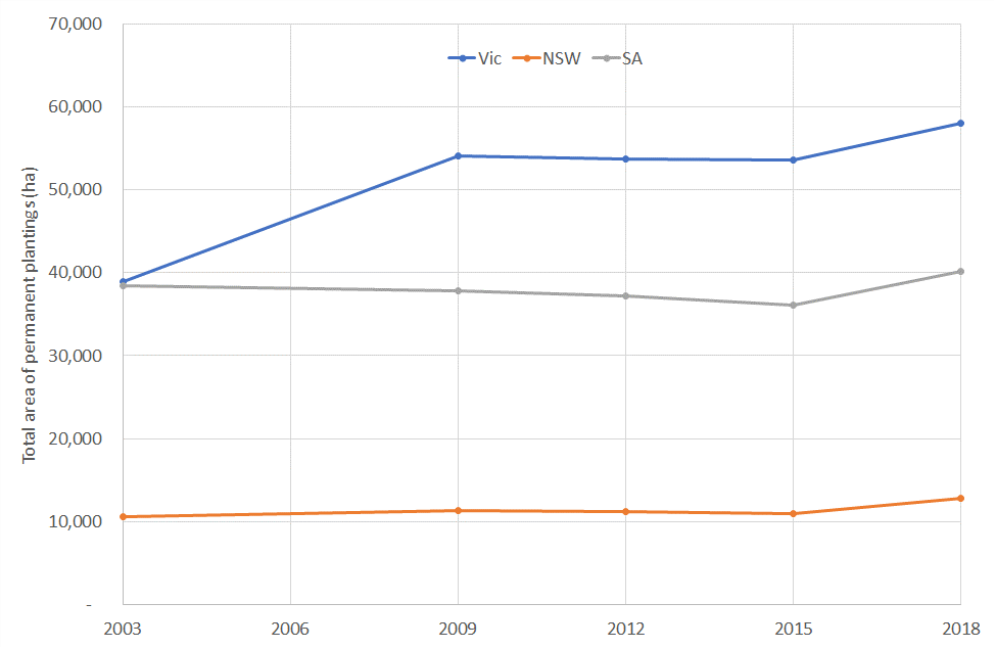
■ **Figure 2-2: Trends in permanent and seasonal cropping**

2.2 Trends in permanent plantings

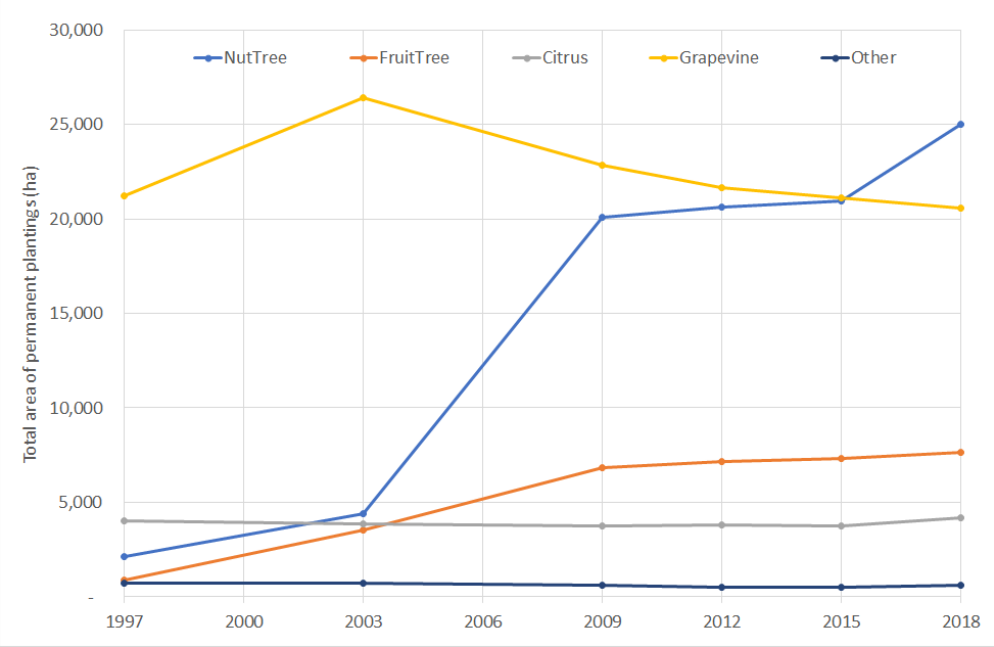
Results show that the total area under permanent plantings across all states increased by 26% between 2003 and 2018, and that this increase has been largest in Victoria. The total area of permanent plantings in Victoria has increased by 49% over this time, compared to a 21% increase in NSW and a 5% increase in SA (Figure 2-3).

In Victoria the crop area that has increased the most is nut trees, and this is now the largest area of crop in this state, exceeding the previously dominant grapevines which have reduced since 2003 (Figure 2-4). An increase in the area of nut trees is also seen in NSW and SA (Figure 2-5 and Figure 2-6), but the areas are much smaller than in Victoria.

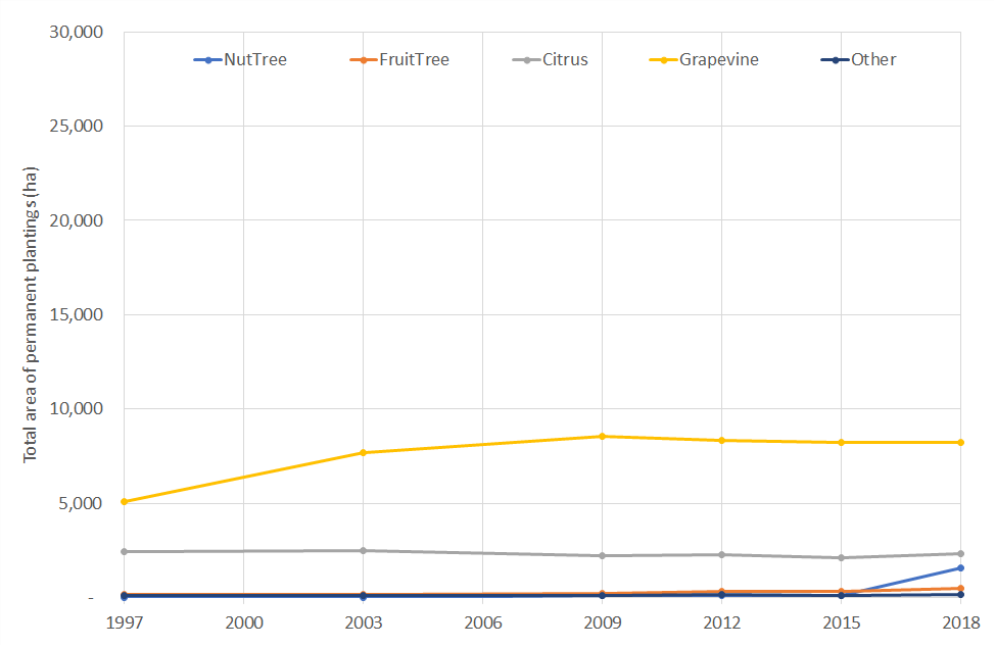
Figure 2-7 shows the trend in areas by crop type across all states, while Figure 2-8 shows how the share of crop area has changed over time.



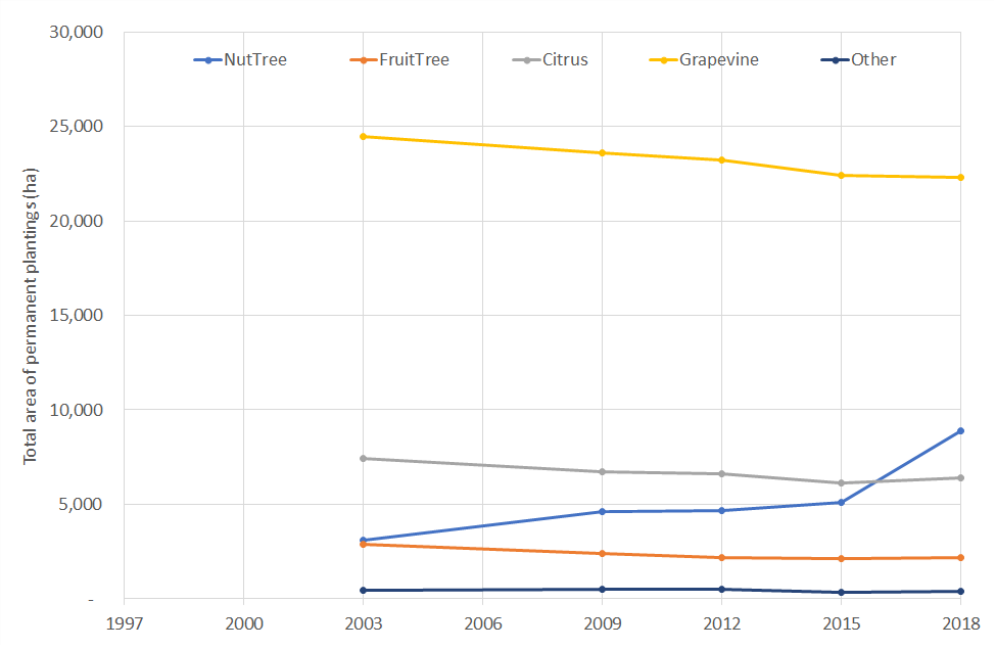
■ **Figure 2-3: Total area of permanent plantings by state downstream of Barmah**



■ **Figure 2-4: Area of permanent plantings by crop in Victoria downstream of Barmah**



■ **Figure 2-5: Area of permanent plantings by crop in NSW downstream of Barmah**



■ **Figure 2-6: Area of permanent plantings by crop in SA**

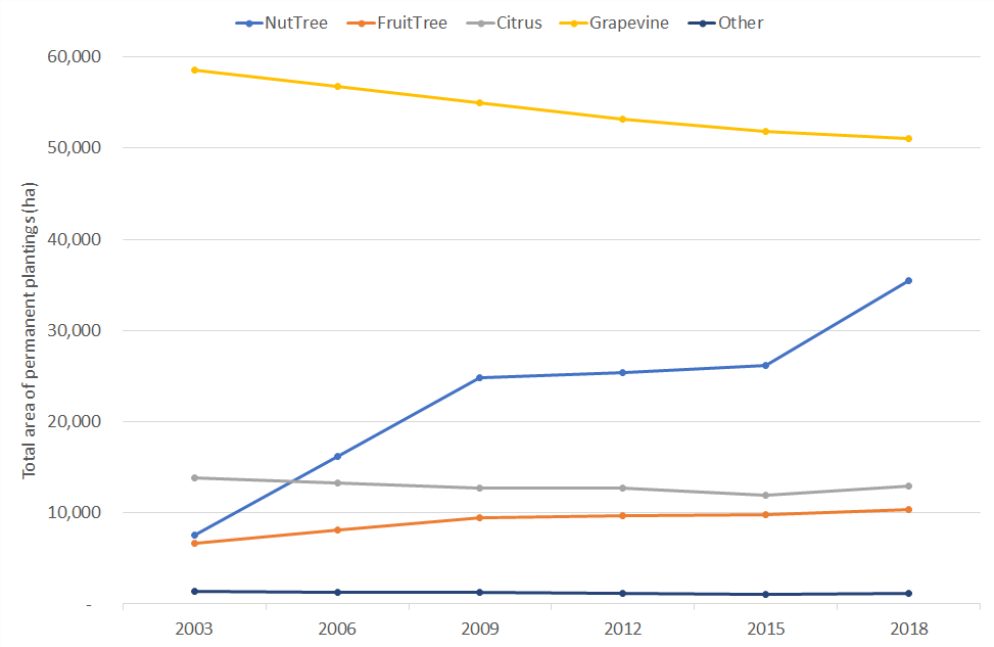


Figure 2-7: Area of permanent plantings by crop all states

In 2003 grapevines made up two thirds of the area of all permanent plantings. By 2018 this share had decreased to less than half. When all states are combined however, grapevines still make up the largest planted area in total, and are still the dominant crop in NSW and SA. NSW has had an increase in the area of grapevines over time, but in SA and Victoria the grapevine area has declined since 2003.

In summary, the area of permanent plantings has increased since 2003, largely due to the growth in the area of nut trees, predominantly in Victoria. Grapevines remains the dominant crop overall, and are the dominant crop in NSW and SA.

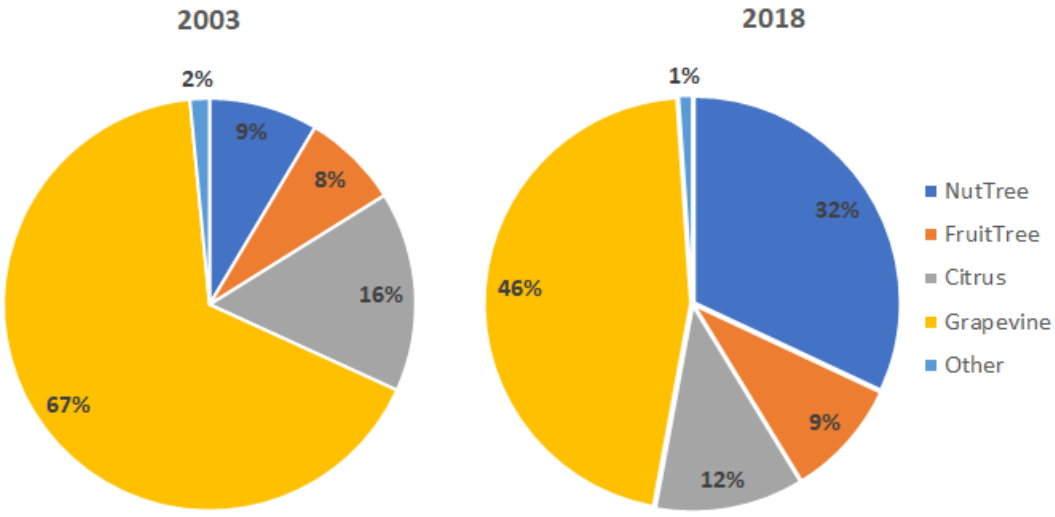


Figure 2-8: Share of area by crop – permanent plantings NSW, Victorian and SA

3. Changes in water usage

With the increase in horticultural plantings there is a perception that water use has increased over time. Historic consumptive and non-consumptive use data was provided by the MDBA. Consumptive use data is taken from the MDBA accounts sheet provided to the states each month. Environmental water delivery data was taken from MDBA River Operations environmental water delivery sheets, that are used for operational environmental accounting purposes.

Historic consumptive use data from 1989/90 to 2018/19 was examined, however usage data was not available for Victoria between Wakool Junction and the SA Border until 1993. The data sets that were combined to represent each state are shown in Table 3-1.

Data was analysed over two periods, the July to June water year and over the January to April period. This period was chosen to show "summer" use (or peak demand) as it avoids the environmental deliveries through Barmah Forest that occur in December, and extends to April to capture supply that may be required when Lake Victoria is low.

Table 3-1: Data sets combined to determine consumptive use for each reach

Reach	Data sets used
NSW Barmah to Wakool Junction	NSW LICENSED PUMPS - BARMAH TO TORRUBRY NSW LICENSED PUMPS - TORRRY TO WAKOOL J
NSW Wakool Junction to SA border	NSW LICENSED PUMPS - WAKOOL JN TO EUSTON NSW LICENSED PUMPS - EUSTON TO WENTWORTH NSW LICENSED PUMPS - WENTWORTH TO RUFUS Net - Western Murray Irrigation DARLING DIVERSION - POMONA I. D. BURTUNDY TO WENTWORTH DARLING DIV
Victoria Barmah to Wakool Junction	Torrumbarry System - Net VIC LICENSED PUMPS - BARMAH TO TORRRY VIC LICENSED PUMPS - TORRRY TO WAKOOL J (up to July 1996) VIC LICENSED PUMPS - NYAH TO WAKOOL JUNC (from August 1996) VIC LICENSED PUMPS - TORRUMBARRY TO NYAH (from August 1996)
Victoria Wakool Junction to SA border	Sunraysia Rural Water Authority - Pumped Irrigation District VIC LICENSED PUMPS - WAKOOL JN TO EUSTON VIC LICENSED PUMPS - EUSTON TO WENTWORTH VIC LICENSED PUMPS - WENTWORTH TO LOCK 8 VIC LICENSED PUMPS - LOCK 8 TO BORDER

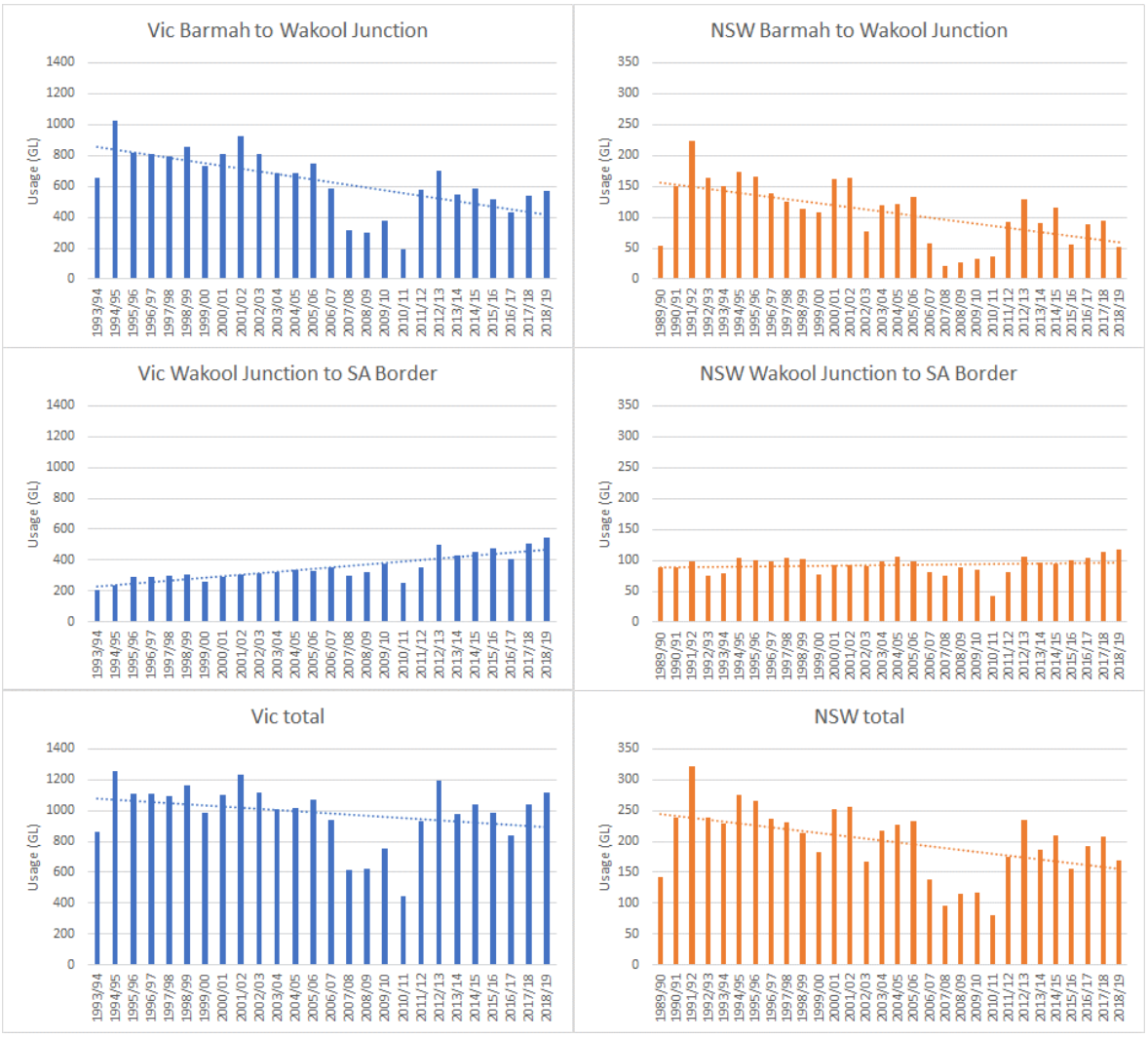
3.1 Annual usage

Consumptive use is shown by reach and by state. Analysis shows that consumptive use in the reach between Barmah and Wakool Junction has decreased over time in both Victoria and NSW. Consumptive use in the reach between Wakool Junction and the SA border has increased slightly

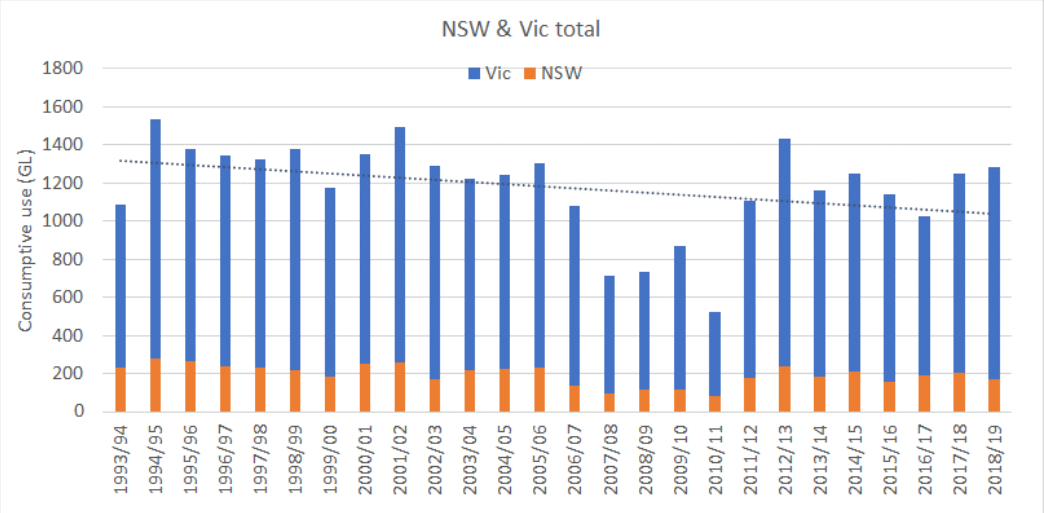
in both Victoria and NSW, but as this is only a small proportion of total consumptive use, the overall trend is reducing in both NSW and Victoria (refer Figure 3-1).

When the two reaches are combined, historic data shows that the overall trend in consumptive use is relatively static (Figure 3-2).

While not the focus of this study, it is noted that variability in use from year to year is influenced by a combination of forces including seasonal conditions, water availability and commodity markets. Low usage from 2006/07 to 2010/11 was driven by the Millennium Drought.



■ **Figure 3-1: Trends in annual water usage by reach and state**

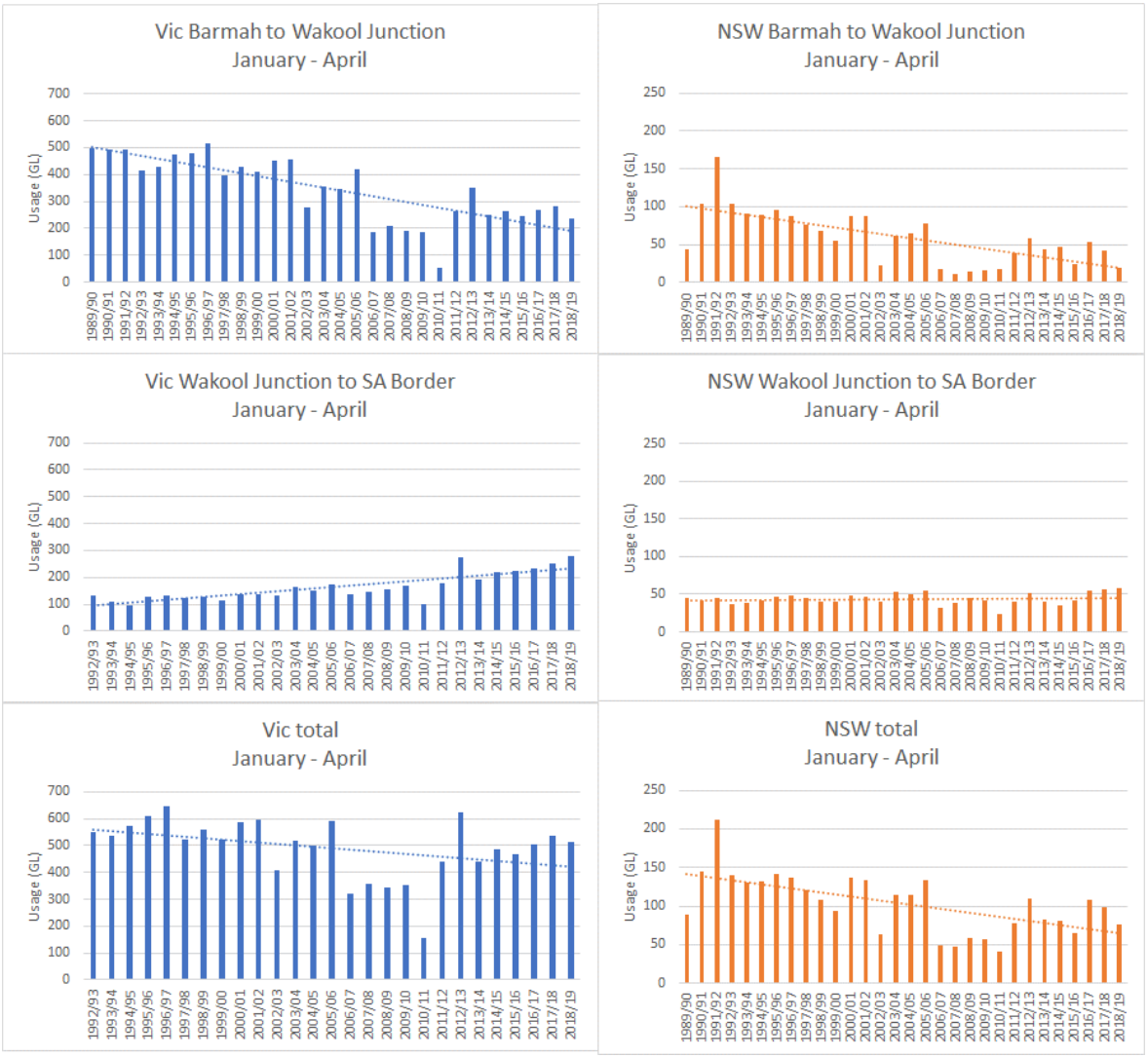


■ **Figure 3-2: Trends in annual consumptive use**

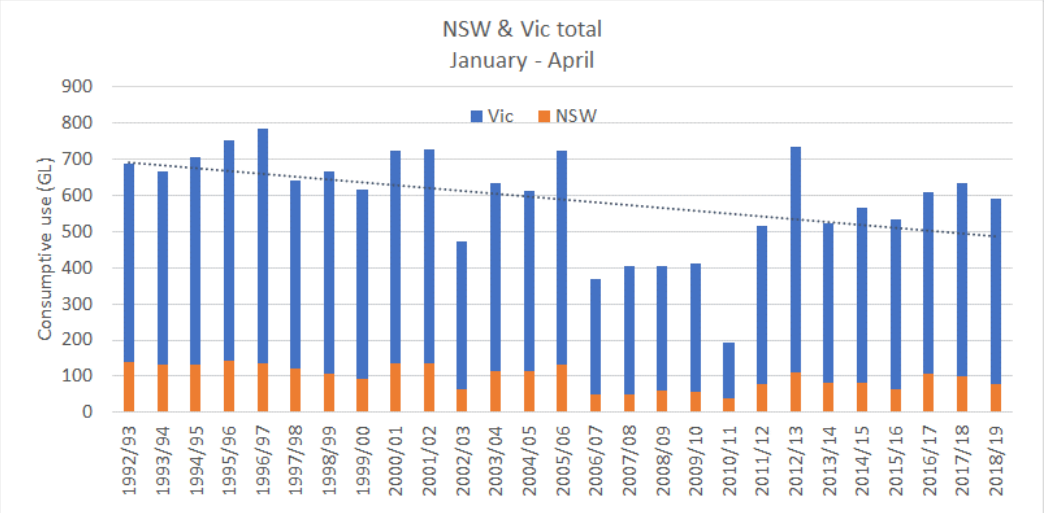
3.2 January to April usage

Trends in NSW and Victorian consumptive use are consistent if January to April only is examined (see Figure 3-3).

The assessment of changes in consumptive use over time needs to be considered in conjunction with increases in regulated supply to the reach because of Inter Valley Trade (IVT), and increased regulated flow to South Australia as a result of trade and delivery of environmental flows. These factors are discussed in later sections.



■ **Figure 3-3: Trends in January to April water usage by reach and state**



■ **Figure 3-4: Trends in January to April water usage**

3.3 Within-year pattern of consumptive use

With the expansion in permanent horticultural plantings public concern has been expressed that the consumptive demand period has compressed, and thus the risk of shortfall in the peak consumptive demand period has increased. Monthly data was analysed to determine if there has been a significant change in the within-year pattern of consumptive use over time (from 1993 to 2018) as a result of changes in crop type from annual plantings to horticulture.

The proportion of total annual consumptive use occurring in each month was determined for each water year. As this results in many data points, this information was then averaged over five-year blocks so that changes over time could be more easily examined.

When consumptive use is combined for Victoria and NSW it can be seen that there is no clear trend over time in the proportion of annual use occurring in each month (Figure 3-5). This stable pattern means that behaviour of demands on the system are fairly predictable, making risk of shortfall easier to manage and mitigate.

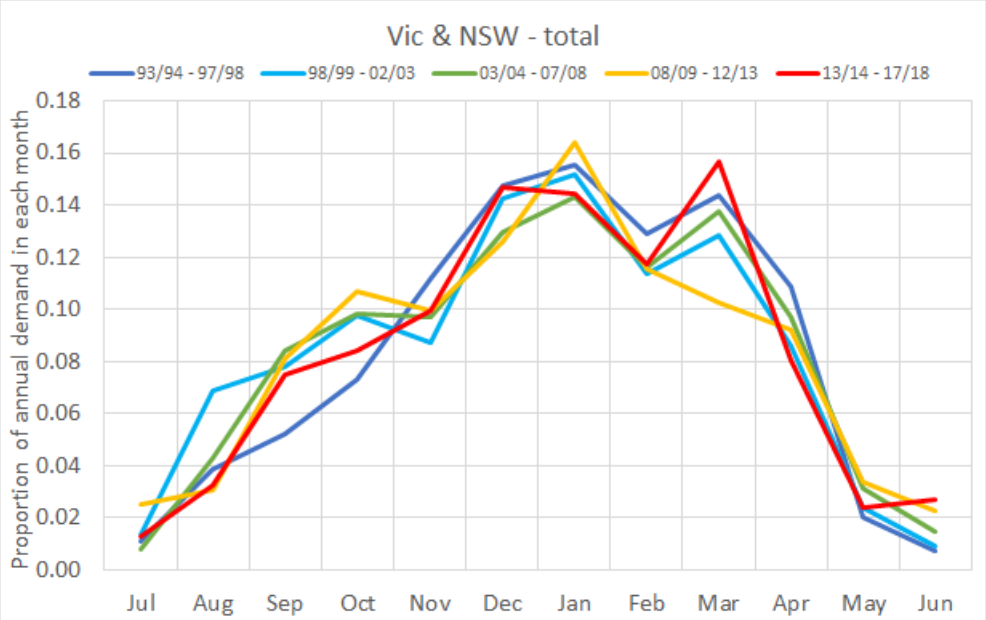


Figure 3-5: Change in pattern of demand over time – all demands

There have been, however, some minor trends at a more local level. In Victoria between Barmah and Wakool Junction there has been a general increase in the proportion of use occurring in September and October, and a reduction in the proportion of use occurring between November and February. Usage patterns in this reach are more volatile in NSW, generally because the magnitude of use is smaller. In general, the proportion of use occurring in September has also increased, but clear trends do not exist for other months (Figure 3-6).

Between Wakool Junction and the SA border the pattern of use is more stable and has changed little over time (Figure 3-7).

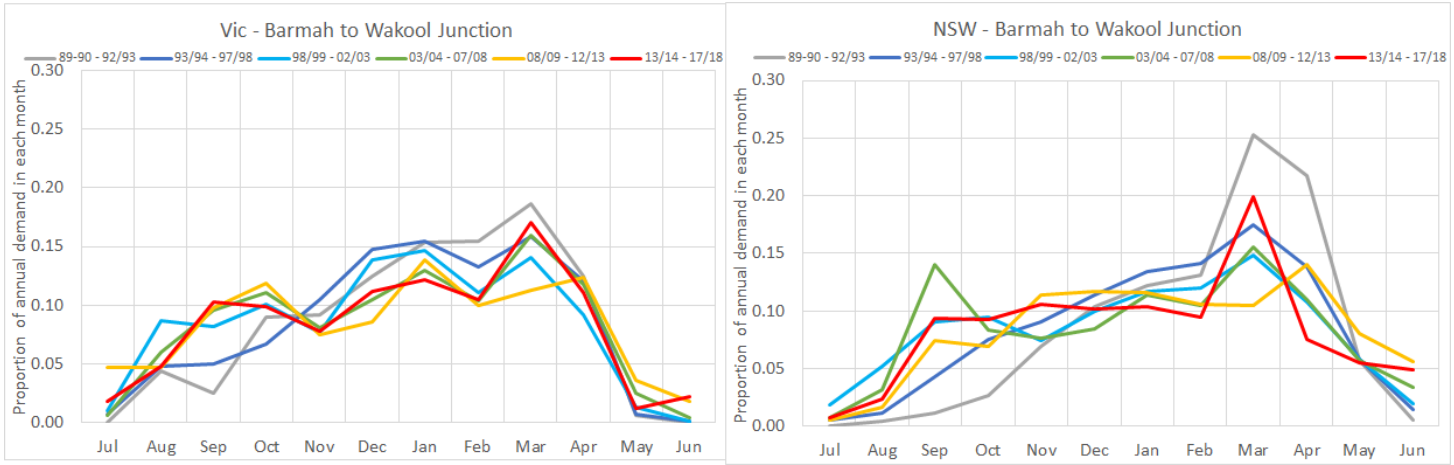


Figure 3-6: Pattern of demand – Barman to Wakool Junction

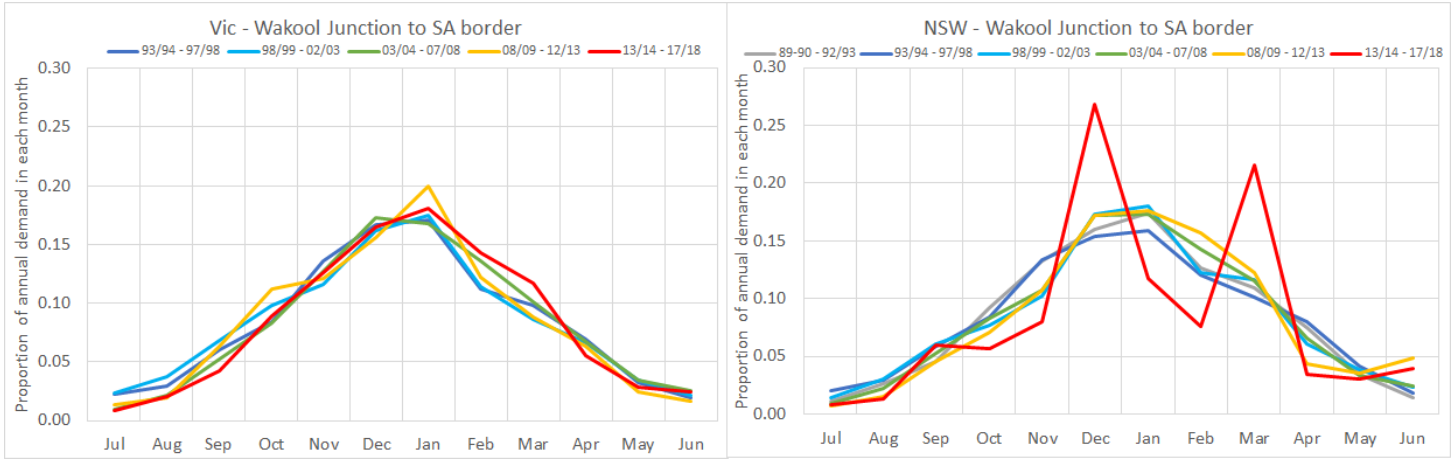


Figure 3-7: Pattern of demand – Wakool Junction to SA border

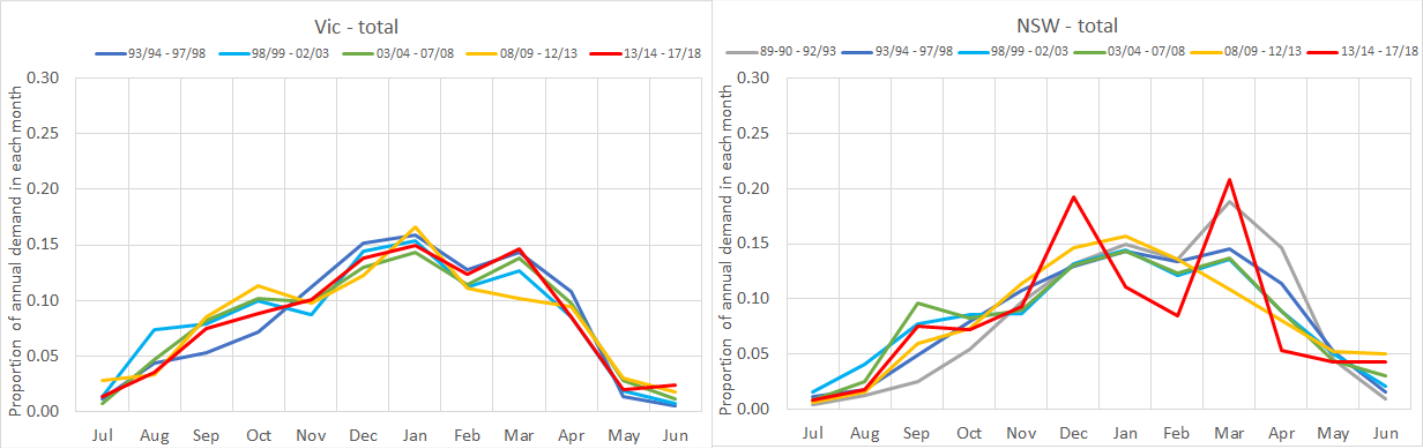


Figure 3-8: Pattern of demand – Victoria and NSW

3.4 Peak demands

The change in the magnitude of peak use over time, and the month in which peak use occurred was also examined. Results show that there has not been an increase in peak consumptive use over time in either NSW or Victoria, or in the combined peak (Figure 3-9).

With the advent of environmental water, the magnitude and timing of peak regulated supply (consumptive use plus deliveries to the SA border) has changed, with the peak moving earlier in the year and increasing (Figure 3-10). This is consistent with environmental watering in the spring and early summer period resulting in increased environmental flows through the system. In this period environmental flows are generally targeting overbank watering and do not compete with consumptive water for channel capacity.

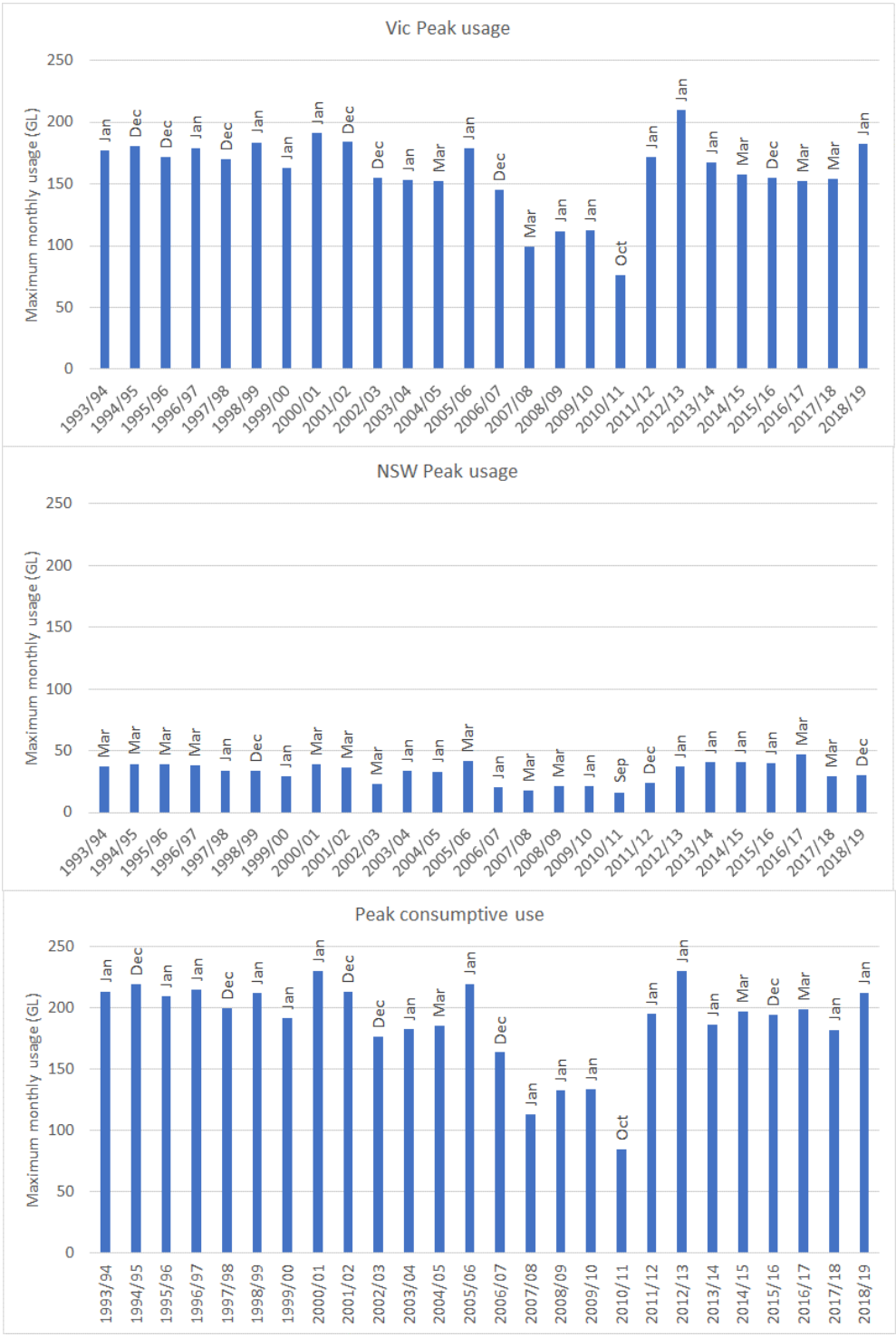
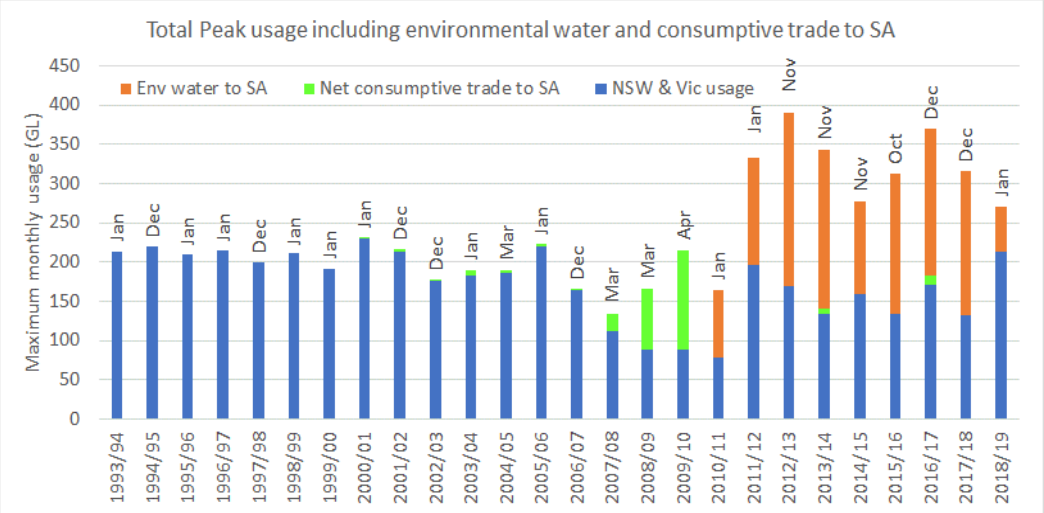


Figure 3-9: Peak monthly usage over time



- **Figure 3-10: Change in peak monthly usage over time with and without environmental water and consumptive trade to SA**

3.5 Inter-valley trade and environmental water recovery

Consumptive water use from the Murray between Barmah and the SA border has been influenced by two opposing movements of water since 2004/05, Inter-Valley Trade (IVT) of water from NSW and Victorian tributaries into the reach, and recovery of water for the environment from the reach.

Water traded from a NSW or Victorian tributary into the Murray is added to the IVT account. Historically, operators have used this account as another source of water, drawing on it to best meet demands in the Murray. Historic IVT is shown in Figure 3-11.

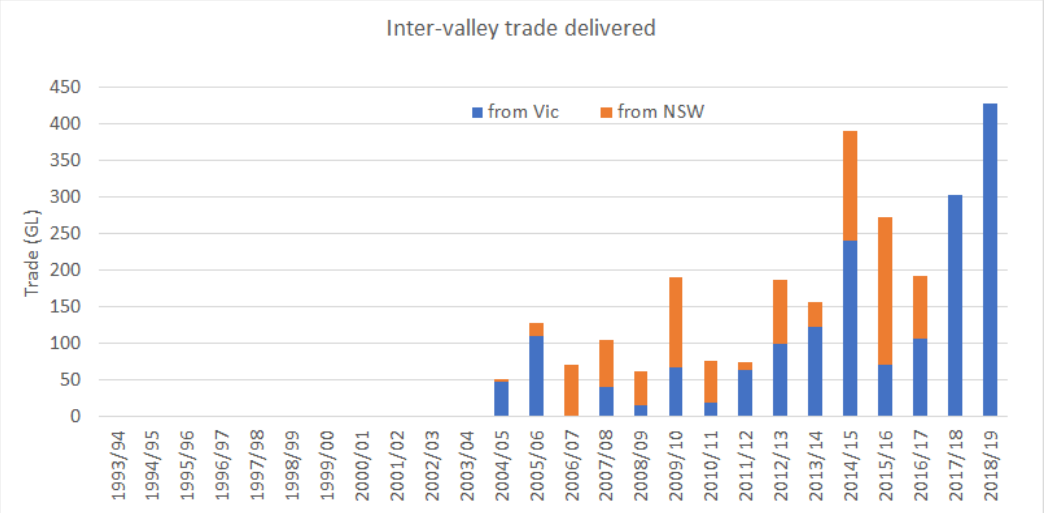
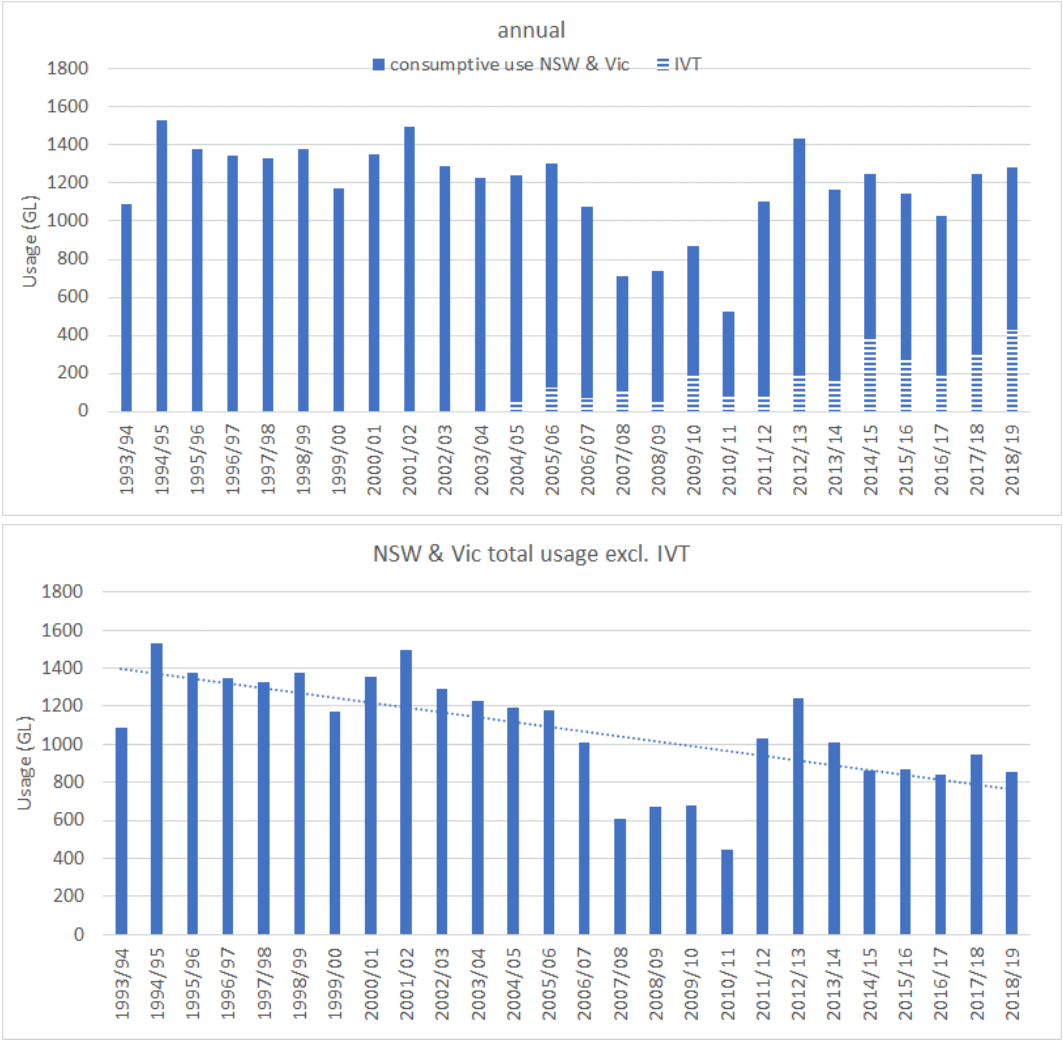


Figure 3-11: Trends in trends in inter-valley trade over time

Figure 3-12 shows the growing share of demand that is met by IVT, and that if IVT is excluded, (consumptive use net of IVT) use in the reach has been trending downward over time. So the magnitude of total consumptive use over time has been relatively static, but a growing proportion of that demand is being supplied by IVT.



■ **Figure 3-12: Total use including and excluding inter-valley trade**

This downward trend in use net of IVT is driven by recovery of environmental water. The volume of environmental water entitlements recovered over time from the Murray between Barmah and SA border are summarised in Table 3-2.

Table 3-2: Recovery of environmental water between Barmah and the SA border

Licence type	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18
NSW high security	3.3	9.2	17.8	18.3	20.3	20.5	20.5
NSW general security	129.9	139.3	144.3	146.5	147.8	149.9	151.0
NSW conveyance			30.0	30.0	30.0	30.0	30.0
NSW unregulated		13.0	13.0	13.0	13.0	13.0	13.0
NSW supplementary		0.0	0.1	0.1	0.1	0.1	0.1
Vic high reliability water share	215.0	225.4	252.5	259.9	278.6	278.6	280.0
Vic low reliability water share	66.8	67.1	72.4	72.4	75.7	75.7	75.7
Vic unregulated	74.3	74.3	74.3	74.3	74.3	74.3	74.3
Total	489.2	528.3	604.4	614.5	639.8	642.1	644.6
Long term diversion limit equivalent*	366.8	397.6	464.9	474.0	496.2	497.9	499.9

* long term diversion limit equivalent converts entitlement volumes into average long term water use

The quantum of environmental water recovery is not dissimilar to the volume of increased consumptive use in the reach between Barmah and the SA border due to IVT, as shown in Figure 3-13. These two movements of water result in relatively static total annual use, as shown in Figure 3-14.

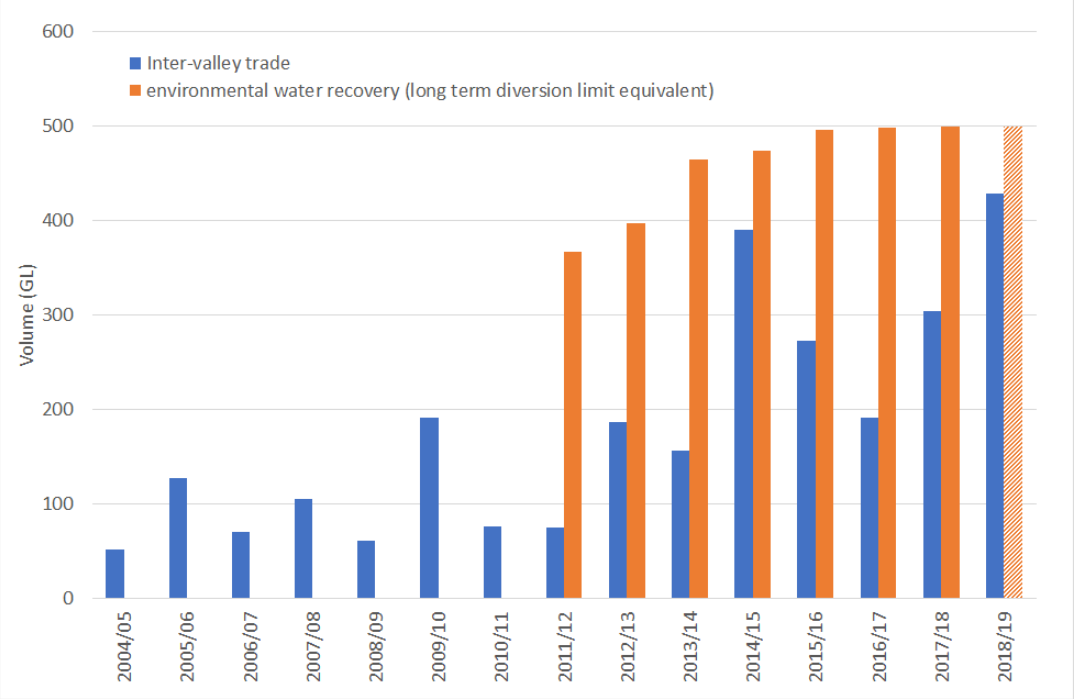
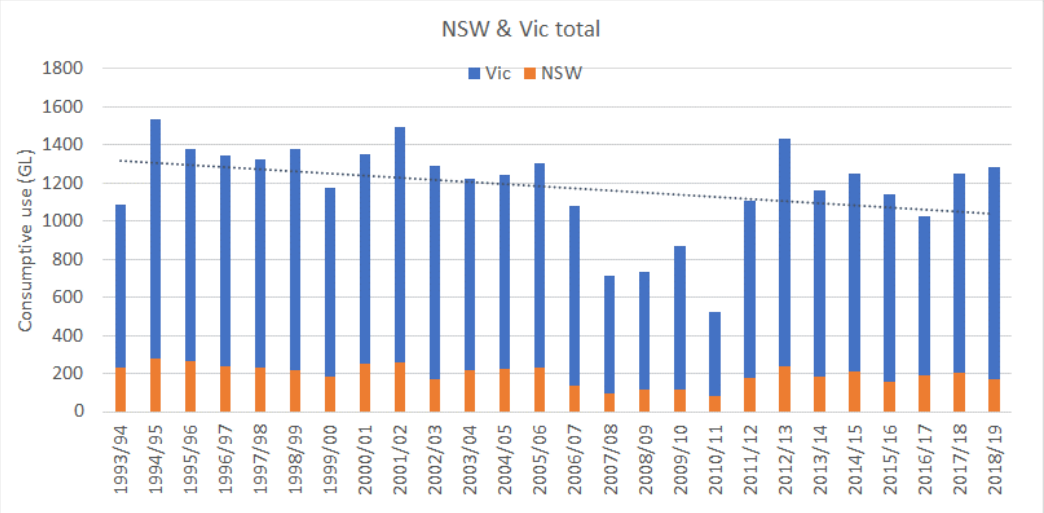


Figure 3-13: Comparison of IVT and environmental water recovery

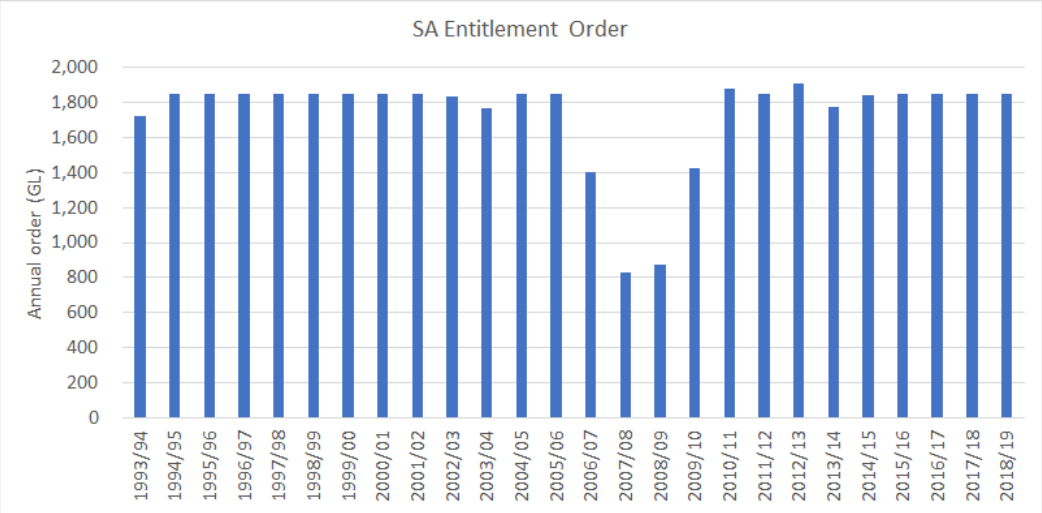


■ **Figure 3-14: Trends in annual consumptive use**

3.6 Environmental deliveries

3.6.1 Entitlement flows

The Murray-Darling Basin Agreement defines the SA entitlement flows. These flows total 1,850 GL/yr, except where entitlements are varied in extremely dry conditions. Historic entitlement orders are shown below.



■ **Figure 3-15: Historic SA entitlement orders**

3.6.2 Additional environmental flows to SA

In recent years, trade and the environmental water recoveries described in Section 3.5 have been used to deliver additional environmental flows to SA. Water can be supplied from environmental water entitlements held in the Murray, Murrumbidgee or Goulburn systems. On the Murray there are significant environmental entitlements held below the Barmah choke. Annual historic deliveries at the SA border are shown in Figure 3-16.

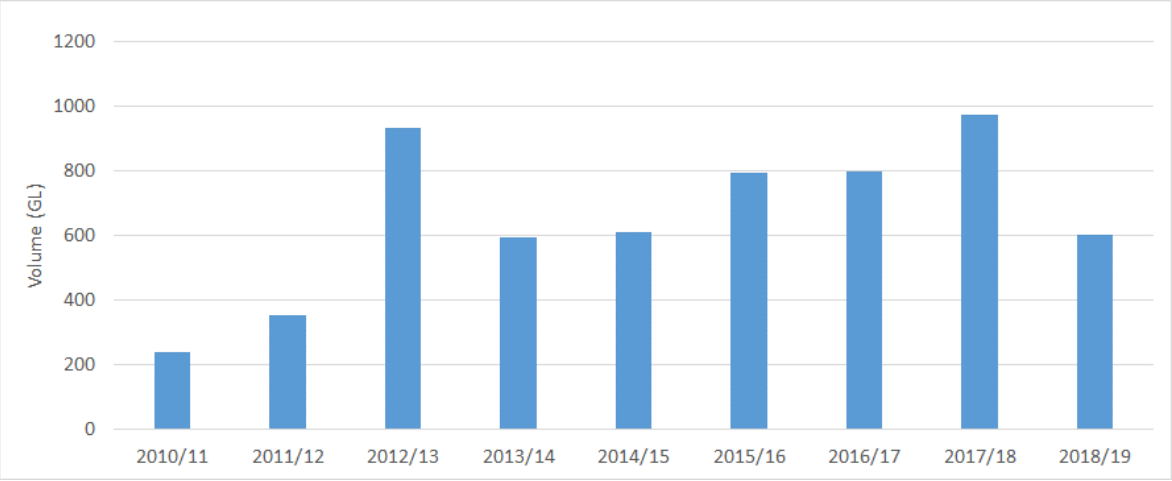


Figure 3-16: Additional environmental flows at SA border

When this data is examined seasonally (Figure 3-17 and Figure 3-18) it can be seen that environmental deliveries each year are largest over the May to December period (shaded grey in Figure 3-18) and smaller during the peak consumptive demand period of January to April. Apart from avoiding the peak demand period, this timing also coincides with the timing of environmental watering requirements.

Environmental water deliveries over summer tend to be relatively high in years that the environmental water holders are limited in their use during winter-spring, for example in 2015/16 the February delivery was high due to limited delivery in the December to January period. In 2016/17 spring deliveries were limited due to flooding, while in 2018/19 spring deliveries were limited due to Hume to Lake Victoria transfers. When more environmental water can be delivered in spring, pressure on the system in summer is reduced (e.g. in 2013/14, 2015/16 and 2017/18). 2012-13 has high environmental flows in summer, however this year also had high allocations and water available in Menindee.

Historically, environmental water holders have based their orders on advice from MDBA on how much could be delivered (good neighbour policy).

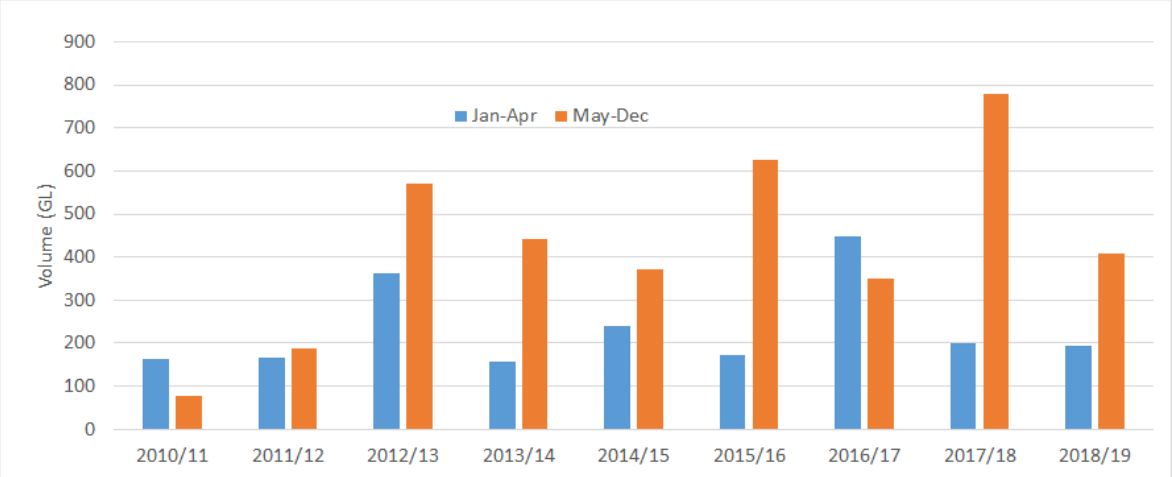


Figure 3-17: Comparison of total environmental flows at SA border by time of year

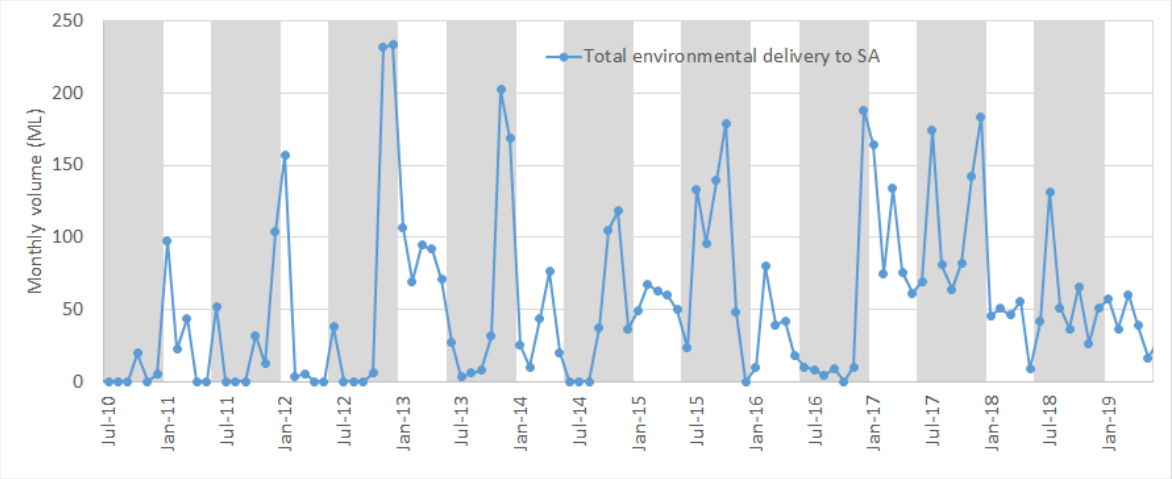
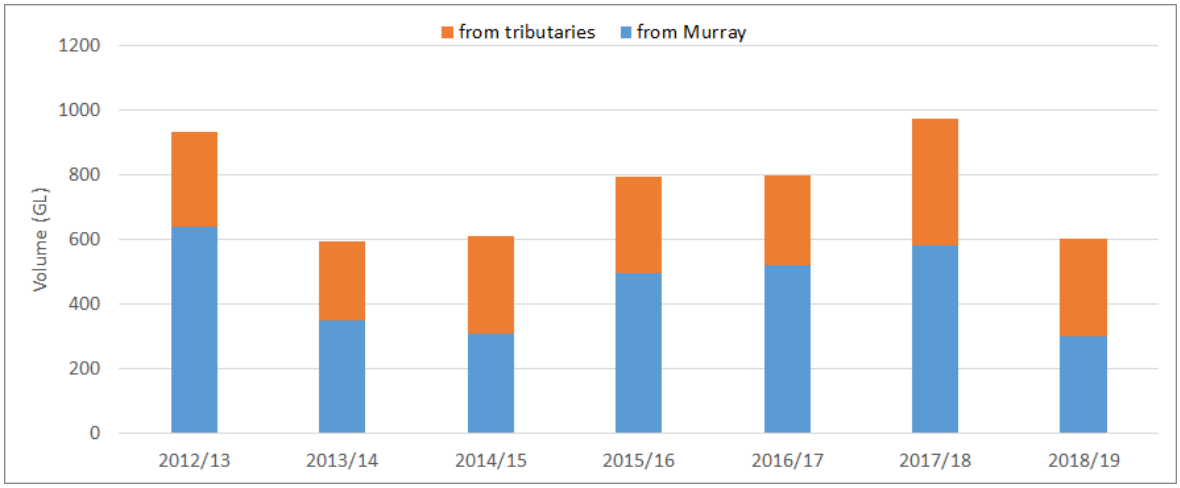


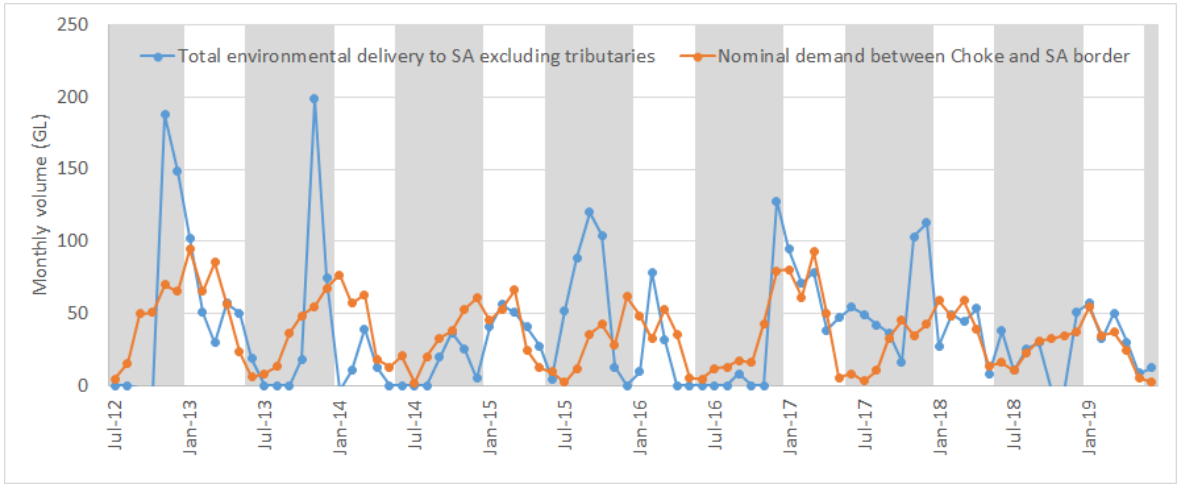
Figure 3-18: Timing of environmental flows to SA

Environmental flows to SA can be split into Murray and tributary contributions, as shown in Figure 3-19. Years prior to 2012/13 are excluded from this plot as accurate tributary data is not available.



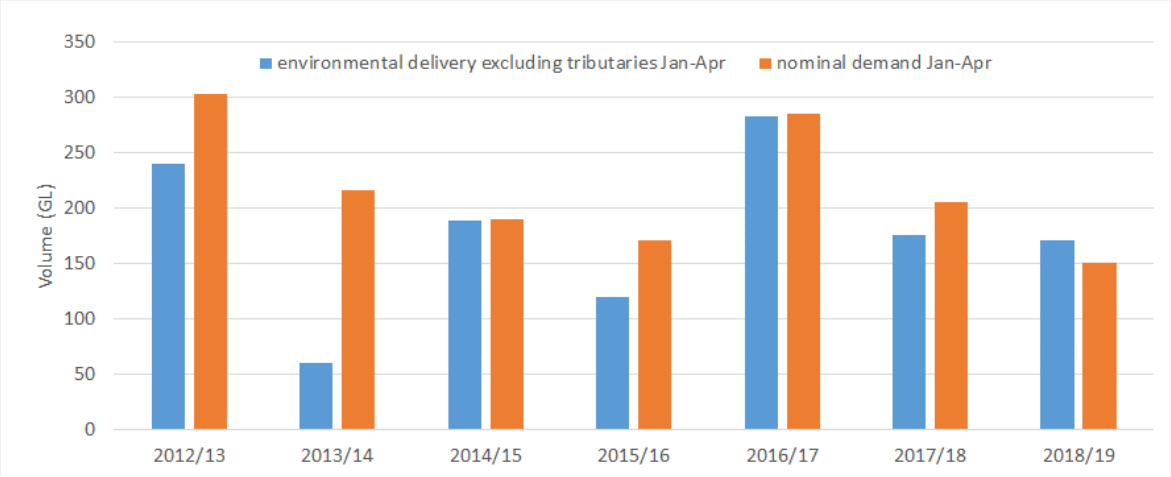
- **Figure 3-19: Additional environmental flows at SA border by source**

Once split, a comparison can be made between environmental flows to SA excluding flows from tributaries and an estimated "nominal" Murray demand between the choke and the SA border (Figure 3-20). This represents what the Murray demand would have been if environmental entitlements had not been purchased. The nominal demand is estimated using the volume of available environmental water each year and the pattern of consumptive usage in that reach for that year.



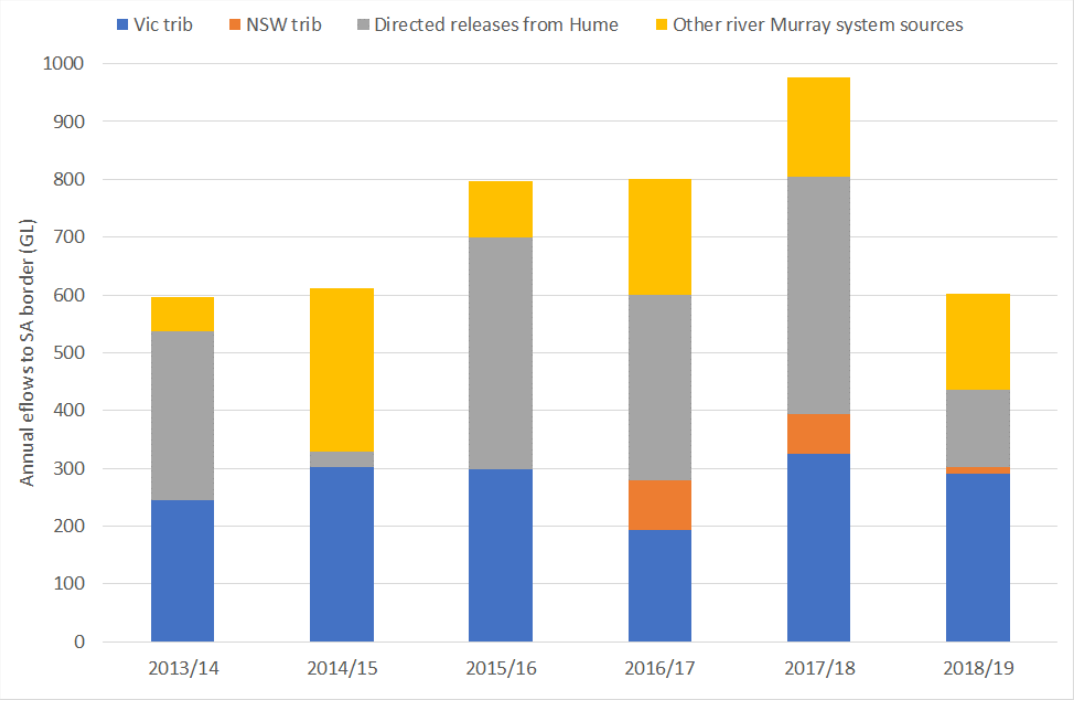
- **Figure 3-20: Environmental flows to SA excluding tribs compared to Murray nominal demand**

In general, the volume delivered to SA over summer excluding tribs does not exceed nominal Murray demand over the peak usage period of January to April, as shown in Figure 3-21.



- **Figure 3-21: Environmental flows to SA excluding tribs compared to Murray nominal demand (Jan-Apr)**

Environmental flows that have been released from Hume at the request of the environmental water holder are called directed releases. These make up a proportion of the environmental flows to SA. Other Murray system sources include Murray trade, releases from Lake Victoria, supply from Burtundy and supply from the Great Darling Anabranch. Another component of the environmental flow to SA is made up of contributions from Victorian and NSW tributaries, as shown in Figure 3-22.



- **Figure 3-22: Annual environmental flows at SA border by source**

Supply of water from Hume is subject to constraints at Barmah choke. Figure 3-23 shows that Hume directed releases are confined to the May to December period to avoid the peak consumptive demand period, except in 2016/17 where Lake Victoria was available to deliver consumptive water. This is also consistent with the timing of environmental water demand for the Barmah-Millewa forest.

Since 2010/11, environmental water holders have consistently delivered environmental water to South Australia during early summer. While this might appear to be a conflict for channel capacity with consumptive users, historic data shows that the environmental supply in summer to date has been met by those environmental entitlements held below Barmah choke.

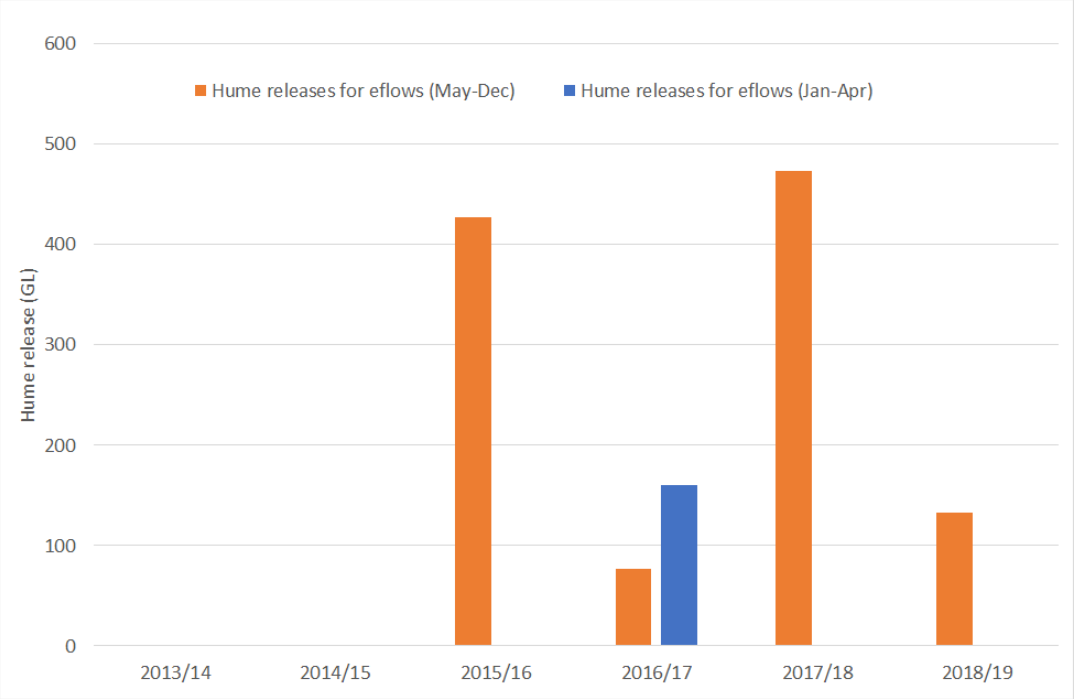
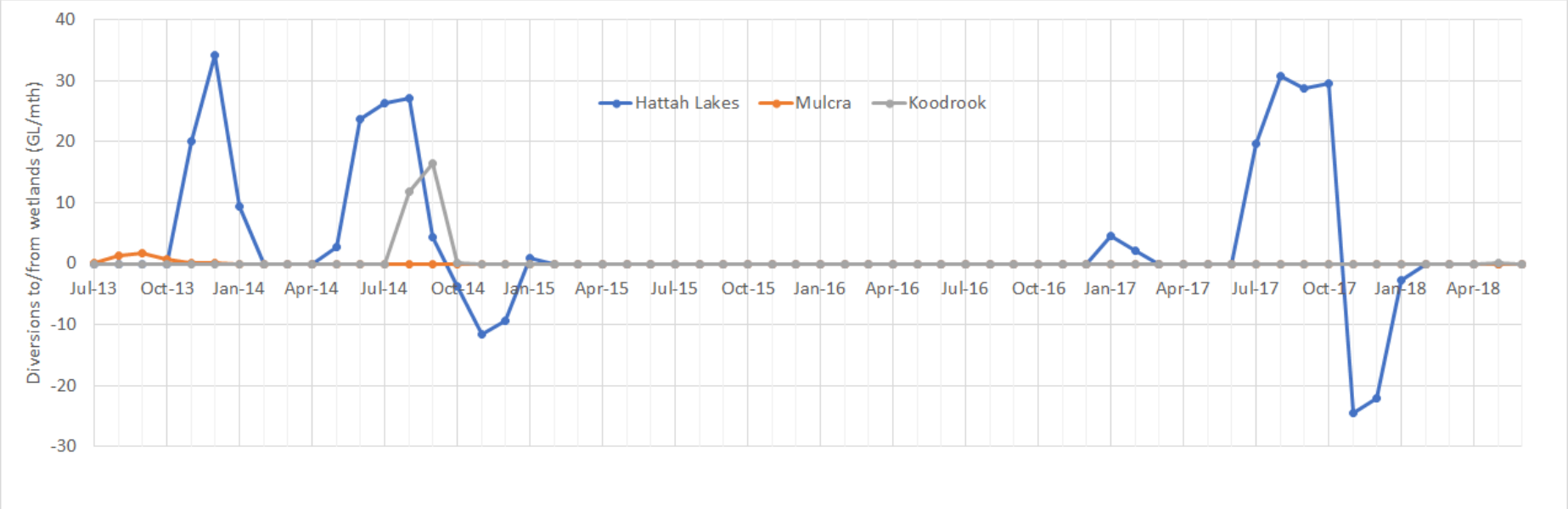


Figure 3-23: Hume directed releases by time of year

3.6.3 Wetland watering and returns

Since the recovery of water for The Living Murray program commenced in 2007 environmental water has been delivered to water wetlands in this region including Hattah Lakes, Mulcra Island and the Koondrook-Perricoota forest. Again, the timing of these diversions has been prior to the peak demand period, as shown in Figure 3-24. This figure also shows that some of the water provided to Hattah Lakes is later returned to the system, aiding in supply at peak usage times later in that water year.



- **Figure 3-24: Timing of wetland diversions and returns**

3.7 Combined demands

The combined effect of changes in demand, how they are supplied and how much additional water now passes through the reach to SA was examined over the January to April (peak demand) period.

Entitlements held for consumptive purposes in the reach between Barmah and the SA border have reduced due to environmental water recoveries. The resultant reduction in usage has however been offset by trade into the reach via IVT as shown in panel a) of Figure 3-25.

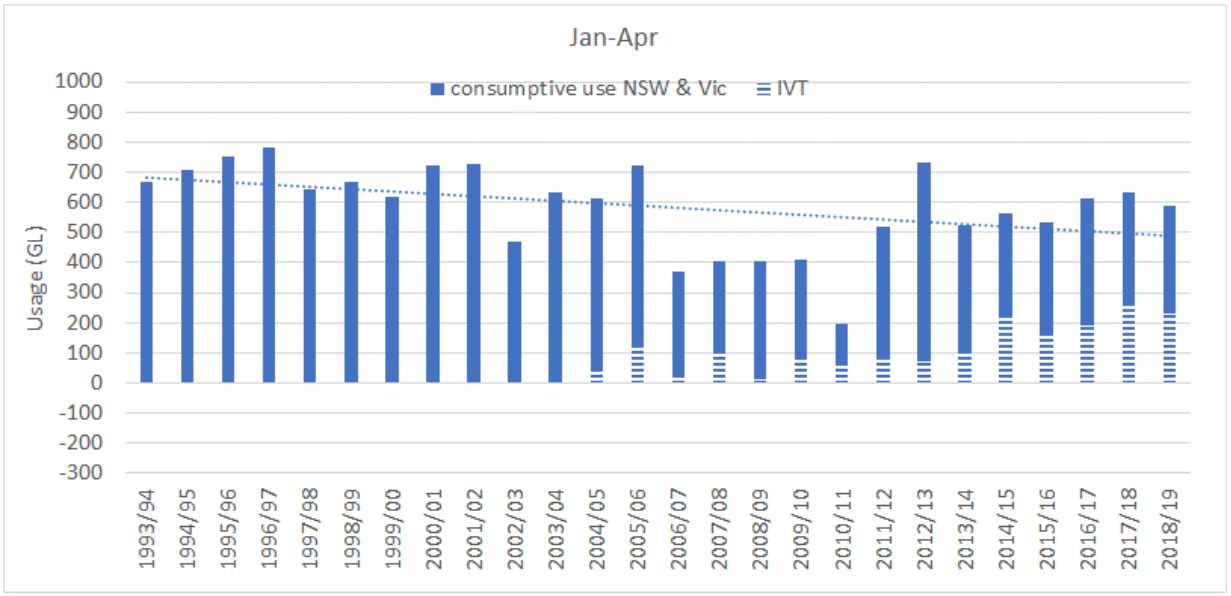
Because of trade patterns, in recent years, additional flows have been entering the reach from the NSW and Victorian tributaries. So, use in the reach has been partly supplied by additional IVT flows, this net use is shown in panel b) of Figure 3-25.

Use of environmental entitlements and trade mean that additional water is now being passed to SA for consumptive use and for the environment. This water has been supplied from NSW and Victorian tributaries and other parts of the Murray system. Usage of environmental water has been being timed to maximise ecological benefit and minimise conflict with the peak consumptive demand period. So total demand on the Murray system over the peak demand period has been made up of the combination of consumptive use net of IVT plus environmental flows and trade to SA, as shown in panel c) of Figure 3-25. The high environmental water deliveries in 2016/17 were supplied from Lake Victoria and so did not impact upon the ability to supply consumptive demands in that year.

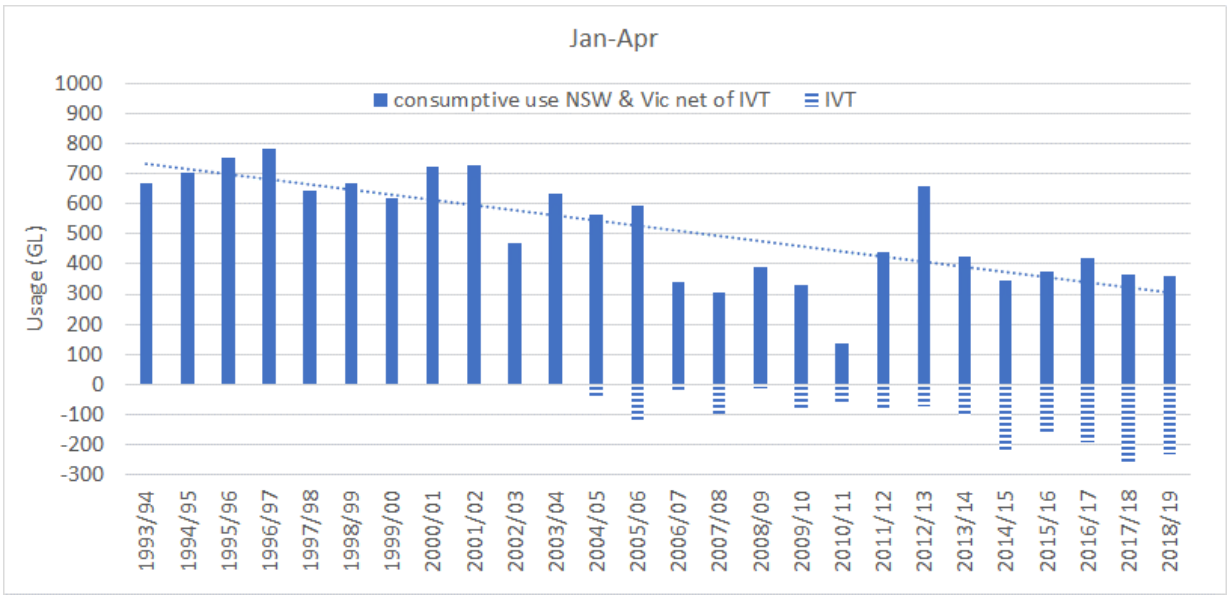
Finally, panel d) adds in the historic SA entitlement order to show total supply to SA over time.

This figure shows that in line with the MDB Cap, total demand on the Murray system has not increased over time.

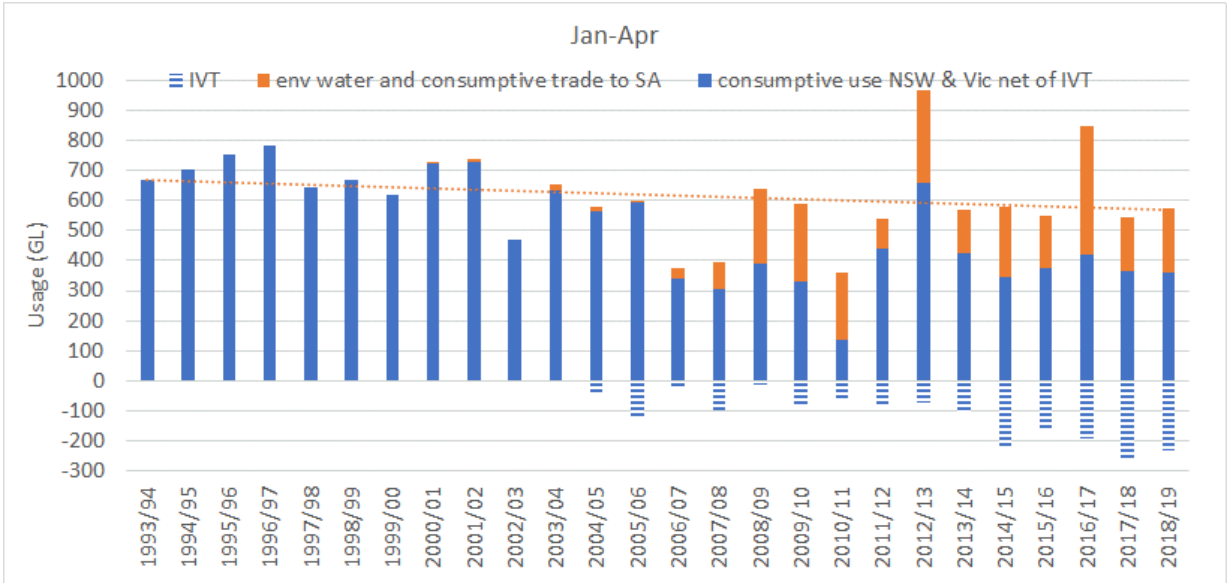
a)



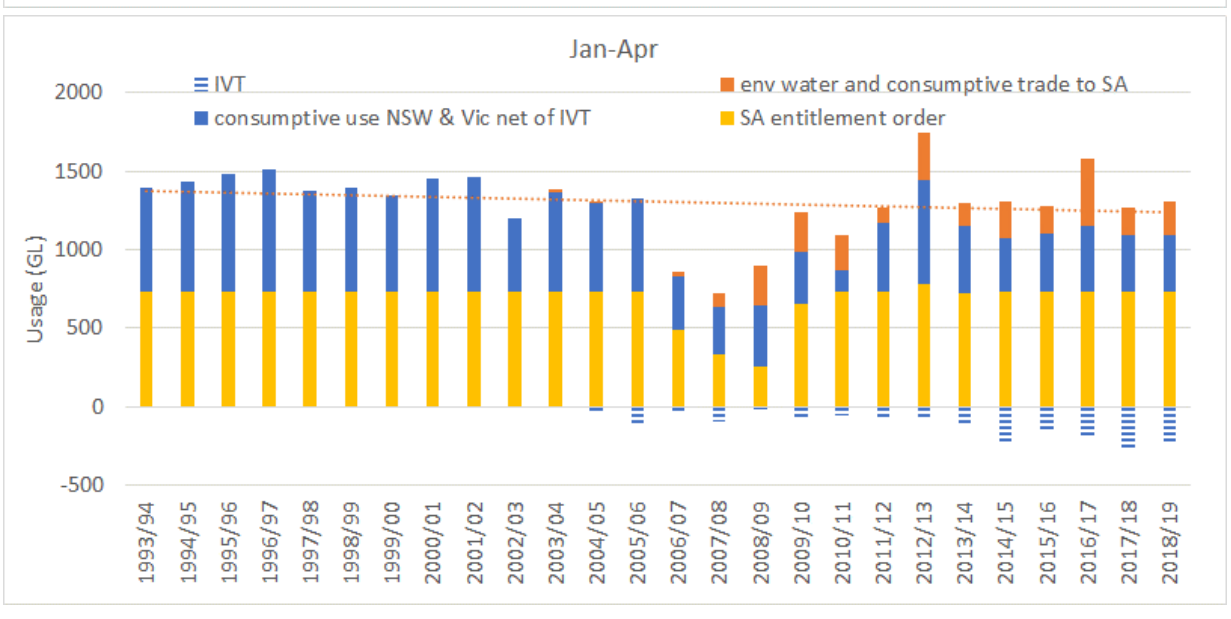
b)



c)



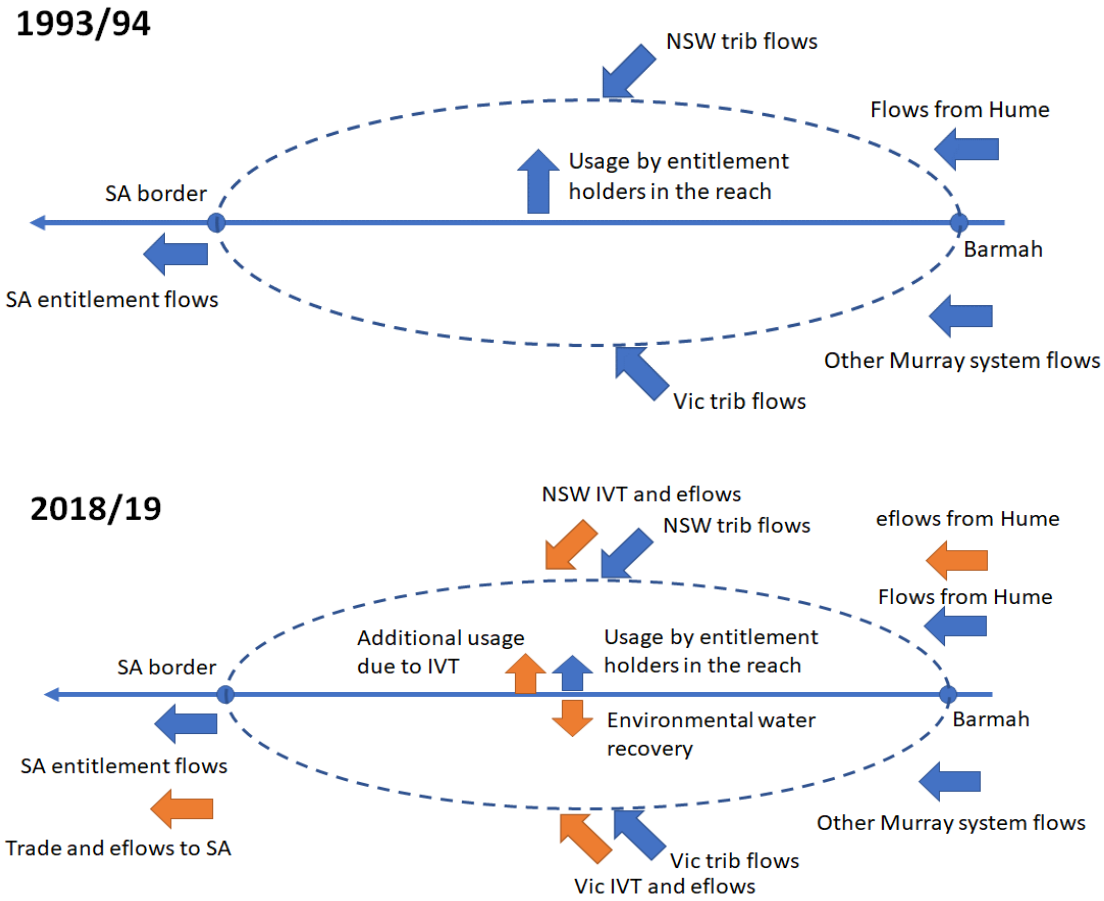
d)



- **Figure 3-25: Combined consumptive use, IVT and flows to SA (January to April)**

Figure 3-26 summarises how components of the reach balance from Barmah to SA border have changed since 1993/94.

It should be noted that the analysis for this project has focussed on the change in demands, not change in supply. For example the change in flow contribution from Menindee over time has not been analysed.



- **Figure 3-26: Reach balance 1993/94 and 2018/19**

4. Conclusions

Data showing consumptive use from the Murray between Barmah and the SA border, irrigated crop types and flows passing to SA over time were examined. In summary:

- Irrigated crop types have changed over time with large areas of nut trees added to the system (Figure 2-7) particularly in Victoria, however there has been little change to the within year pattern of consumptive use (Figure 3-5).
- Total consumptive use in the reach has not increased (Figure 3-2), but some demand has moved from the upstream end (Torrumbarry system) to the downstream end (Sunraysia) (Figure 3-1).
- The reduction in consumptive entitlement due to environmental recoveries has been offset by IVT (Figure 3-12). IVT has resulted in increased regulated inflows to the reach.
- Environmental deliveries and trade for consumptive use have increased the volume of flow passed to SA. This flow is supplied from the Murrumbidgee, Goulburn and Murray systems (Figure 3-22).
- Delivery of environmental water has largely been timed in the winter – spring – early summer period to maximise ecological benefit (Figure 3-18). Summer deliveries when they occur have not exceeded the volume that would have been delivered for consumptive use if buybacks had not occurred.
- Directed releases of environmental water from Hume are timed to maximise environmental benefit to Barmah Forest and avoid increased pressure on the Barmah choke (Figure 3-23).
- Examination of combined consumptive use, IVT and environmental, SA entitlement flow and consumptive trade to SA shows that there has been no increase in total demand on the River Murray system over time (Figure 3-25).

These conclusions relate to historical observations from 1993/94 to 2018/19 and are focussed on changes in demand rather than changes in supply.