Water supply and demand in the southern Murray-Darling Basin

An assessment of future water availability and permanent horticulture irrigation water demand

A Final Report prepared for the Victorian Department of Environment, Land, Water and Planning (DELWP)

Friday 7 June 2019
Contents

Executive summary .................................................................................................................. v

1. Introduction ......................................................................................................................... 1
   1.1. Background .................................................................................................................. 1
   1.2. Report scope .............................................................................................................. 1

2. Water supply and demand in the connected Murray ......................................................... 6
   2.1. Approach to assessing water supply and demand ....................................................... 6
   2.2. Drivers of water demand and use .............................................................................. 7
   2.3. Water use by irrigated agriculture in the connected Murray ...................................... 8
   2.4. Estimating existing and projected permanent horticulture water demand ............... 9
   2.5. Future water availability scenarios ........................................................................... 12
   2.6. Additional environmental water recovery scenarios ................................................. 13

3. Water supply for permanent horticulture and other irrigation industries ....................... 15
   3.1. Headroom under existing permanent horticulture demand ........................................ 15
   3.2. Headroom under projected growth in permanent horticulture demand ................... 16
   3.3. Headroom under additional environmental water recovery ....................................... 18
   3.4. Summary of headroom analysis ................................................................................ 19

4. Conclusions ......................................................................................................................... 21
   4.1. Conclusions ............................................................................................................... 21
   4.2. Potential market and industry impacts ....................................................................... 21
   4.3. Trade, carryover and delivery constraint assumptions and impacts ......................... 24
   4.4. Implications of Aither’s analysis .............................................................................. 26
   4.5. Further research ....................................................................................................... 27

5. References .......................................................................................................................... 28

Appendix A – Detailed water demand estimates .................................................................... 30

Appendix B – Detailed water supply estimates ...................................................................... 32
Tables

Table 1 Water supply and demand assessment summary, extreme dry water availability (no groundwater) scenario, connected Murray region ........................................... 20
Table 2 ABS water use data by irrigated agriculture industry and year, connected Murray, 2005-06 to 2016-17 (GL) ................................................................. 30
Table 3 Estimated permanent horticulture water demand, Aither 2018-19 baseline demand, connected Murray (GL) ................................................................. 30
Table 4 Estimated permanent horticulture water demand, Aither projected demand, connected Murray (GL) ................................................................. 31
Table 5 Total volume of entitlement on issue, connected Murray (GL) ........................................... 33
Table 6 End of season water allocation percentage scenarios, connected Murray .......... 34
Table 7 Total volume of water available, connected Murray (GL) ........................................... 35
Table 8 Volumes of environmental water recovered from the consumptive pool and not available to irrigated agriculture, connected Murray (GL) ........................................... 37

Figures

Figure ES1 Water availability scenarios and existing permanent horticulture water demand (at fully maturity), connected Murray region ............................................................... viii
Figure ES2 Water availability scenarios and existing permanent horticulture water demand (at full maturity), lower Murray region ............................................................... ix
Figure 3 Map of connected Murray region water trading zones ........................................... 2
Figure 4 Map of lower Murray region water trading zones ........................................... 3
Figure 5 Water use by irrigated agriculture industry, connected Murray, 2005-06 to 2016-17 . 8
Figure 6 Comparison of water use and diversions by all permanent horticulture by NRM region, lower Murray, 2015-16 ABS estimate and DELWP estimates .................. 10
Figure 7 Comparison of water demand from permanent horticulture, connected Murray, 2015-16 ABS estimate and Aither 2018-19 baseline demand estimates .................. 11
Figure 8 Water availability scenarios and existing permanent horticulture water demand (at full maturity), connected Murray region ........................................... 16
Figure 9 Water availability scenarios and projected permanent horticulture water demand (at full maturity), connected Murray region ........................................... 17
Figure 10 Water availability scenarios and projected permanent horticulture water demand (at full maturity), lower Murray region ........................................... 18
Figure 11 Additional environmental water recovery and existing and projected permanent horticulture water demand (at full maturity) under extreme dry water availability scenario with no groundwater access, connected Murray ........................................... 19
Figure 12 Aither southern Murray-Darling Basin Entitlement Price Index, 2014-15 to 2018-19 .......................................................................................... 22
Figure 13 Comparison of permanent horticulture water use, ABS and irrigation corporation estimates, New South Wales Murray ........................................... 31
Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABA</td>
<td>Almond Board of Australia</td>
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<tr>
<td>ABARES</td>
<td>Australian Bureau of Agriculture and Resource Economics and Sciences</td>
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<td>ABS</td>
<td>Australian Bureau of Statistics</td>
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<td>CEWH</td>
<td>Commonwealth Environmental Water Holder</td>
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<td>DELWP</td>
<td>Victorian Department of Environment, Land, Water and Planning</td>
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<td>DAWR</td>
<td>Australian Government Department of Agriculture and Water Resources</td>
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<td>GL</td>
<td>Gigalitre</td>
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<td>GS</td>
<td>General Security</td>
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<td>HS</td>
<td>High Security</td>
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<td>HRWS</td>
<td>High Reliability Water Share</td>
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<td>IVT</td>
<td>Inter-valley trade</td>
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<td>LRWS</td>
<td>Low Reliability Water Share</td>
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<tr>
<td>LTTAY</td>
<td>Long-term average annual yield</td>
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<tr>
<td>MDB</td>
<td>Murray–Darling Basin</td>
</tr>
<tr>
<td>MDBA</td>
<td>Murray–Darling Basin Authority</td>
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<tr>
<td>ML</td>
<td>Megalitre</td>
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<tr>
<td>NRM region</td>
<td>Natural resource management region</td>
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<tr>
<td>NSW</td>
<td>New South Wales</td>
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<tr>
<td>SA</td>
<td>South Australia</td>
</tr>
<tr>
<td>SDL</td>
<td>Sustainable diversion limit</td>
</tr>
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<td>Vic</td>
<td>Victoria</td>
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Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tr>
<td>Entitlement on issue</td>
<td>The total number of water entitlements for an entitlement reliability and water course.</td>
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<tr>
<td>Carryover</td>
<td>Unused water that can be retained in water storages from one year to the next by water owners.</td>
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<tr>
<td>Horticulture headroom</td>
<td>The difference between water available to all irrigated agriculture (supply) and water demand from permanent horticulture.</td>
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<tr>
<td>LTAAY</td>
<td>Long-term average annual allocations to entitlements, adjusting for reliability. Can be used to determine how much each entitlement type contributes to water recovery.</td>
</tr>
<tr>
<td>Permanent horticulture</td>
<td>Inclusive of perennial fruit and nut trees (such as almonds, stone fruit, pome fruit and citrus), grapevines (both table grapes and wine grapes) and berry fruits.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
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<td>-------------------------------------------</td>
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<tr>
<td>Water allocation</td>
<td>The volumes of water allocated to water entitlement holders during the water year (1 July to 30 June). They are a physical good analogous to a commodity, and are extracted from water courses and applied as inputs to production or the environment.</td>
</tr>
<tr>
<td>Water allocated that is available for consumptive use</td>
<td>Refers to the total volume of water allocated by state governments to water entitlement holders during the water year (1 July to 30 June), excluding water allocated to water entitlements held by the Australian Government associated with water entitlement purchases in the southern Murray-Darling Basin and on-farm water recoveries by the Victorian Government. Measured as an aggregate volume at the end of the water year (30 June).</td>
</tr>
<tr>
<td>Water entitlement</td>
<td>Water entitlements are ongoing rights to receive an annual share of available water resources in a consumptive pool as established in a specific river system, catchment, or aquifer. Entitlements are generally secure, tradeable, divisible and mortgageable in the same way as land.</td>
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Executive summary

Background

The statutory water entitlement and markets framework that exists in Australia has proven effective in managing the competing demands for scarce water resources in the southern Murray-Darling Basin – especially during times of severe drought. The broadening and deepening of water markets since their establishment has promoted new investment and driven more efficient water allocation and use. However, the equation of water supply and demand has been changing.

Governments and industry are now asking important questions about the long-term implications of these water supply and demand changes in the context of:

- increased investment in and development of permanent irrigated horticulture with long-term fixed water demands (such as almonds and citrus)
- the impacts of existing volumes of environmental water recoveries as a function of reducing the overall consumptive water supply for other users
- the potential for and impacts of additional environmental water recovery from the consumptive pool to meet further commitments under the Murray-Darling Basin Plan.

In particular, a key question is being raised about how much of the consumptive water supply in the southern Murray-Darling Basin in any given future year will be required by permanent irrigated horticulture and therefore how much water may be available for use by other irrigated industries (such as dairy, cotton and rice).

We define permanent horticulture as industries with fixed long-term water requirements such as tree crops (e.g. almonds, fruit, citrus etc) and grapevines (e.g. wine, table and dried grapes).

Scope

Aither was engaged by the Victorian Department of Environment, Land, Water and Planning (DELWP) to provide insight into the questions posed above. The primary purpose of this report is to explore current and possible future water supply and demand conditions across the southern Murray-Darling Basin. The focus of the analysis is on assessing how much water supply ‘headroom’ above permanent horticultural water demand exists or may exist in the future – especially in extreme dry periods. The scope of work also includes qualitative discussion about how supply and demand changes will impact the water market and its participants in the future.

In this report we define ‘headroom’ as the gap between the total volume of water available for consumptive use and the volume of water demanded by permanent horticulture in a given year.

The findings of this assessment aim to provide greater clarity on the implications of recent supply and demand changes for the southern Murray-Darling Basin water market, market participants and government policy makers.
Analytical approach and key assumptions

This report examines what is known about current and future permanent horticulture water demand in the southern Murray-Darling Basin. The primary piece of analysis in this report is an assessment of the potential future supply and demand balance as it relates to estimating the remaining ‘headroom’ of available water for other water users (such as other irrigation industries) over and above permanent horticultural water demand.

It is difficult to model exactly how much future demand for irrigation water may exist from different industries in the southern Murray-Darling Basin as well as compare this to future water availability conditions and how much water supply may be available to each industry (both from a physical location and a market perspective). Uncertainty about future water supply and demand conditions are primarily driven by the fact that:

- water availability is highly variable in the southern Murray-Darling Basin – including accounting for the different water systems and the complex set of rules which dictate how water can move across the system at certain points in time
- industry conditions can change over time and this can materially alter demand for water (for example the recent increase in cotton production in the southern Murray-Darling Basin)
- the water market and participant water strategies are becoming increasingly sophisticated (for example the use of carryover, leasing, forwards and options). These emerging risk management tools and changing behaviours materially affect the assumption that the volume of water allocated in a given year is available to be used in that same year.

To account for this uncertainty, Aither has adopted a scenario-based assessment approach, which estimates water supply and demand in the southern Murray-Darling Basin under various plausible future scenarios.

The analysis in this report specifically focuses on the connected Murray region within the southern Murray-Darling Basin (see Figure 3 in main report). Where sufficient data is available, Aither also draws conclusions about the lower Murray region – which is a part of the connected Murray downstream of the Barmah Choke. These regions are of most relevance to this analysis because of the recent growth in permanent horticulture and concerns over future water availability in these regions, as well as being directly relevant to the Victorian Government and basin state policy makers.

A critical assumption in this report is that ‘headroom’ above horticultural demand represents the total volume of water available to all other water users and irrigation industries, including for irrigated pasture (dairy), cropping including rice and cotton, and annual vegetables. Therefore, if headroom above horticultural demand is limited, then there is a risk of significant market impacts (such as allocation price increases) and potential impacts on the viability of other irrigated agriculture industries.

In addition, a basic premise of this headroom analysis is that we assume available water in the consumptive pool would and can be traded to permanent horticultural users in times of drought (i.e. a highly efficient rational market with limited trade barriers, and assuming that permanent horticulture has a higher willingness to pay for water compared with annual cropping). However, in practice the water market does not behave perfectly rationally. This is due to individual decisions made by water users and physical system constraints. Our assumption of a highly rational market is therefore likely to cause the possible market impacts described in this report to be observed before modelled horticultural ‘headroom’ is fully exhausted.

The analysis throughout the report also assumes that no carryover of water between years is available. In reality, carryover will likely play an important role in covering short-term shortfalls in water
supply. However, carryover was excluded from this analysis to highlight the potential for supply shortfalls in a sequence of extreme dry water availability years where carryover reserves are exhausted.

There are several other important assumptions that have been made to undertake the analysis presented in this report and there are also challenges with data availability and reliability. Aither has been explicit about these assumptions and transparent about our confidence in the data presented throughout this report and appendices.

Findings

Connected Murray region

A key finding of Aither’s analysis is that there are significant existing areas of permanent horticulture in the connected Murray and the water demands of these developments are growing as more recent plantings mature. Based on the water use and diversion evidence assessed by Aither, we estimate that the current (2018-19) use by existing permanent horticulture in the connected Murray is approximately 1,230 GL per annum. Our estimate is that existing permanent horticulture in the connected Murray region will demand approximately 1,400 GL of irrigation water per annum at full maturity (approximately 55 percent growth from 2015-16 Australian Bureau of Statistics (ABS) water use estimates).

Figure ES1 below plots several possible future water availability scenarios in the connected Murray region against Aither’s best estimate of the future water demands of all existing permanent horticulture (at full maturity). The analysis highlights that the growing fixed water demands of permanent horticulture industries will begin to push the limits of annual water availability in this region. Of critical importance, the analysis suggests that during periods of future extreme dry water availability, existing permanent horticulture may demand essentially all surface and groundwater available in the connected Murray region (i.e. there may be no or very little water available to other industries such as dairy, cotton and rice).

However, due to the geographic location of permanent horticulture developments in the connected Murray, physical constraints and trade rules, it is unlikely that permanent horticulture will be able to access all available water in the connected Murray in any given year (this is further explored in the lower Murray assessment below).

If groundwater (approximately 390 GL of entitlement on issue across the connected Murray) is removed from the extreme dry scenario presented in Figure ES1, estimated water requirements of existing permanent horticulture (at full maturity) equate to approximately 125 per cent of the estimated total water available. In other words, under this scenario, demand from permanent horticulture may exceed total supply by a material margin. In this situation, we would assume no water is available to

1 Groundwater sources that exist in the connected Murray region either do not overlap with the existing and projected growth of permanent horticultural demand in the lower Murray region of the connected Murray (which is where the highest concentration of permanent demand exists) or those sources that do overlap are not of high enough quality to be used outright for irrigated agriculture. In this context it is valid to remove groundwater from the supply side of the equation to present a worst-case water availability scenario in the connected Murray.
other irrigated industries and permanent horticulture would need to compete with each other for the available water supply.  

In addition to the existing areas of permanent horticulture in the connected Murray (presented in Figure ES1), we understand that there are plans (at differing stages of approvals) to establish more permanent horticulture in the region. We estimate that additional development could demand up to an additional 165 GL per annum on top of Aither’s estimate of existing development at full maturity. This additional development would increase the total estimated future water demand from permanent horticulture in the connected Murray up to approximately 1,555 GL per annum (at full maturity).

As permanent horticulture development increases across the connected Murray region, a greater proportion of irrigated agricultural water demand will be derived from industries with fixed rather than flexible water demands as well as industries with a higher willingness to pay for water. This is a significant change from a system that was historically characterised by a large proportion of annual and semi-interruptible irrigated industries like annual cropping and dairy that have more flexible water use requirements and a generally lower willingness to pay for water as an input to production.

A situation such as presented above, where headroom above horticultural demand in the connected Murray is exceeded or is close to exceeded, is likely to cause significant impacts on the water market and other water users. In particular, we would expect to observe both short and long-term increases in water market prices.

Beyond our estimates of increasing permanent horticulture water demand (Figure ES1 above), Aither’s broader analysis of supply and demand shows that additional environmental water recovery from the consumptive pool will further decrease the headroom available above estimated horticultural demand – especially under dry and extreme dry future water availability scenarios. Additional environmental water recovery from the consumptive pool is expected to have similar impacts on the market and other water users as long-term increases in permanent horticulture water demand are expected to have.

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2 Please note that this is an estimate of total demand and does not take into account the ability of permanent horticulture to reduce irrigation application rates or dry-off old orchards or blocks during times of severe drought or low water availability.
Lower Murray region

The lower Murray region is a subset of the connected Murray and includes regions downstream of the Barmah Choke, such as the Victorian Sunraysia, New South Wales Murray and South Australian Riverland regions. The lower Murray has a high concentration of permanent horticulture and there are greater concerns over future water availability in this region compared to the connected Murray as a whole. These heightened concerns are primarily driven by constraints that limit the ability to trade water into the lower Murray from above the Barmah Choke and out of the Goulburn and Murrumbidgee.

Aither’s analysis for the lower Murray assumes no water allocations are able to be traded into the lower Murray from connected zones (such as the Goulburn, Murray above the Barmah Choke and Murrumbidgee). In most years we would expect trade from these zones into the lower Murray to meet a portion of permanent horticulture demands, but it is not guaranteed. We also assume there is no groundwater available in the lower Murray region on the basis that the groundwater sources that exist in the lower Murray region are generally not of high enough quality to be used outright for irrigated agriculture. This analysis presented here therefore presents a worst-case water supply scenario based on within-region surface water supply only.

Our estimate is that existing permanent horticulture in the lower Murray will demand approximately 1,315 GL of irrigation water per annum at full maturity. This equates to approximately 95 per cent of estimated permanent horticulture demand across the connected Murray region as a whole.

Similar to the analysis presented above for the connected Murray, Figure ES2 below plots several possible future water availability scenarios in the lower Murray region against Aither’s best estimate of the future water demands of all existing permanent horticulture in this region (at full maturity). The analysis for the lower Murray region presents a much more concerning outlook compared to the connected Murray. This is a function of the concentration of permanent demand in this region and a lower estimate of water supply in this region (i.e. we assume total water supply in the connected Murray will not be available to permanent horticulture in the lower Murray).

Source: Aither 2018.

Notes: For the lower Murray region, a surface water only water supply scenario is presented as we assume no groundwater is available to any irrigation industry in this region – including permanent horticulture.

Figure ES2 Water availability scenarios and existing permanent horticulture water demand (at full maturity), lower Murray region
Of particular importance, our analysis for the lower Murray region suggests that under an extreme dry scenario there may be a significant shortfall of water directly available to meet the fixed water demands of permanent horticulture. Aither’s analysis suggests that directly available consumptive surface water supply within the lower Murray may only meet approximately 40 per cent of total existing permanent horticulture demand (at full maturity) under an extreme dry water availability scenario.

This projected supply shortfall in the lower Murray will need to be met through carryover and the trade of water into the region, which whilst possible and likely to a certain degree, the ability to meet the entire shortfall through trade into the region is not guaranteed and is likely to have serious implications for irrigated industries in connected water trading zones.

In addition to the existing areas of permanent horticulture in the lower Murray (presented in Figure ES2), we understand that there are plans (at differing stages of approvals) to establish more permanent horticulture in the region. For this analysis we assume that the total 165 GL per annum of additional permanent horticulture demand that is estimated for the connected Murray will occur in the lower Murray region. This additional development would increase the total estimated future water demand from permanent horticulture in the lower Murray up to approximately 1,480 GL per annum (at full maturity).

**Potential implications**

The analysis and conclusions presented in this report have several important implications for existing irrigated agricultural enterprises, proponents of new developments and government policy makers:

- **Existing irrigated agricultural enterprises** – The analysis in this report points to a future scenario where there are increased risks in average to extreme dry water availability years associated with meeting the water demands of permanent horticulture and all other irrigated agricultural industries in the southern Murray-Darling Basin. If this scenario transpires, it will likely lead to increased water prices across the connected Murray and especially the lower Murray region into the future. All existing irrigated agricultural enterprises should consider how these changes and risks can be managed. For example, a revised assumption about the average future cost of water may affect the economic viability of production for some industries or certain enterprises and could influence adjustment decisions.

- **New permanent horticulture entrants** – Investors in new permanent horticulture in the connected Murray, and lower Murray region in particular, should be mindful of the material existing water supply risks that this analysis has highlighted. Investors should also consider their ability to secure water in dry and extreme dry conditions and consider the costs of water before making long-term investment decisions.

- **Implications for policy makers** – Policy makers should consider the findings of this report when making decisions about further water market reform and the possible impacts of and design of any further environmental water recovery in the connected Murray and lower Murray regions. The recovery of additional environmental water from the consumptive pool would further reduce supply for all water users in the southern Murray-Darling Basin. This will both exacerbate the likelihood of permanent horticulture water demand exceeding available supply and also reduce the volume of water available for all irrigation industries in all future years.
Opportunities for further research

To expand on the findings and conclusions drawn in this report, Aither recommends that further research be undertaken to provide a more detailed and accurate picture of the current and likely future water supply and demand balance in the southern Murray-Darling Basin. In particular, Aither recommends that more accurate and timely water use data (disaggregated by region corresponding to water trading zone and industry) is collected on a more frequent and consistent basis across all basin-states to help inform decision-making for agricultural enterprises, policy makers and market participants.

Furthermore, this report does not extend to updating previous economic modelling undertaken to estimate the specific water market effects of growth in permanent horticulture demand, existing and additional environmental water recovery, and the impacts of trade constraints or market behaviours. Undertaking new economic modelling is possible (see previous reports by Aither and others on this topic listed at Section 1.2.3) and would importantly quantify the likely impacts of the changing water supply and demand balance across different regions in the southern Murray-Darling Basin. The results of this economic modelling would assist existing agricultural enterprises, new market entrants and governments to make more informed decisions about the future.

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3 Previous modelling undertaken by Aither and others is potentially based on underestimates of permanent horticultural water demand and therefore could underestimate potential impacts. Please see Section 1.2.3 and list of references at the conclusion of this report for full list of previous reports on similar topics.
1. **Introduction**

1.1. **Background**

The statutory water entitlement and markets framework that exists in Australia has proven effective in managing the competing demands for scarce water resources in the southern Murray-Darling Basin – especially during times of severe drought. The broadening and deepening of water markets since their establishment has promoted new investment and driven more efficient water allocation and use. However, the equation of water supply and demand has been changing.

From a water demand perspective, there has been significant recent investment in permanent horticulture in the southern Murray-Darling Basin (such as almonds, citrus and table grapes), which has been primarily concentrated in the lower Murray (downstream of the Barmah Choke). Additionally, cotton has emerged as a large water user in the Murrumbidgee region. Growth in these industries is a clear sign that the economics of production are strong and that these regions are attractive places for investment. However, as permanent horticulture continues to grow and developments mature, these industries will require an increasing volume of irrigation water on a relatively fixed long-term basis.

Growth in permanent horticulture development has occurred at the same time as significant efforts by Australian governments to recover water from consumptive users (particularly irrigators) for environmental purposes under the Murray-Darling Basin Plan. To date, Australian governments have recovered approximately 1,745 GL (LTAAY) of water entitlements across the southern Murray-Darling Basin (DAWR 2018). These water entitlements have been recovered through purchases from the consumptive pool, infrastructure savings and state government recoveries. Where coming from the consumptive pool, water recovery has reduced the volume of water that is available to irrigated agriculture and other consumptive users (i.e. it has reduced water supply on an annual basis).

Driven by these shifting water supply and demand dynamics, governments and industry are now asking important questions about the long-term implications for the southern Murray-Darling Basin. In particular, questions are being asked as to how much of the available consumptive water supply in any given year will be required by permanent horticulture, how much water may be available for use by other irrigated industries (such as dairy, cotton and rice), and how these changes will shape the water market and its participants in the future.

1.2. **Report scope**

Aither was engaged by the Victorian Department of Environment, Land, Water and Planning (DELWP) to explore current and future water supply and demand conditions across the southern Murray-Darling Basin. The key focus of this report is to assess how much ‘headroom’ or water availability above horticultural demand exists in the southern Murray-Darling Basin. The scope of the report also includes qualitative discussion about the implications for water users and policy makers.

We define horticultural ‘headroom’ as the gap between the total volume of water available for consumptive use and the volume of water demanded by permanent horticulture in a given year.

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4 Long-Term Average Annual Yield (LTAAY) is used to standardise the calculation of expected recoveries in the Murray–Darling Basin from different water entitlement types and across different catchments.
1.2.1. Geographic scale of the analysis

This report primarily focuses on the connected Murray region within the southern Murray-Darling Basin. Where sufficient data is available, Aither also draws conclusions about the lower Murray region – which is a part of the connected Murray downstream of the Barmah Choke. These regions are of most relevance in terms of the recent growth in permanent horticulture and concerns over future water availability. These regions are also directly relevant to the Victorian Government and basin state policy makers.

**Connected Murray region**

The connected Murray region is defined as all major water systems within the southern Murray-Darling Basin with connectivity to the Murray River excluding the NSW Murrumbidgee (Figure 3).

![Map of connected Murray region water trading zones](image)

Source: Aither 2018.

**Figure 3** Map of connected Murray region water trading zones

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5 The specific water systems captured under the connected Murray region are Vic 6 Murray, Vic 7 Murray, Vic Greater Goulburn, Vic 2 Broken, Vic Campaspe, Vic Loddon, Vic Lower Broken Creek, northern Victorian groundwater (Katunga, Shepparton and Lower Campaspe Valley), NSW 10 Murray, NSW 11 Murray, NSW Lower Darling, NSW lower Murray groundwater and South Australian Murray.
**Lower Murray region**

The **Lower Murray** region is defined as all water systems within the connected Murray downstream of the Barmah Choke **excluding the Victorian Goulburn and NSW Murrumbidgee** (Figure 4).⁶

![Map of lower Murray region water trading zones](source: Aither 2018)

**Figure 4  Map of lower Murray region water trading zones**

For the purposes of the analysis presented in this report, both the connected Murray and lower Murray regions exclude the NSW Murrumbidgee. Allocation trade out of the NSW Murrumbidgee to the connected Murray has become increasingly limited due to growing water demands in the Murrumbidgee (from both cotton and permanent horticulture) and the existence of an inter-valley trade limit between these two regions. While in some instances water may be available to be traded to the lower or connected Murray from the Murrumbidgee, including the NSW Murrumbidgee as a supplier of water to these regions could potentially overstate supply conditions in these regions under dry or worse water availability scenarios.

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⁶ The specific water systems captured under the lower Murray region are Vic 7 Murray, NSW 11 Murray, NSW Lower Darling and South Australian Murray.
1.2.2. **Scope**

This report primarily examines what is known about current and future water demand from permanent horticulture in the southern Murray-Darling Basin. The key piece of analysis is an assessment of the potential future supply and demand balance as it relates to estimating the remaining ‘headroom’ of available water for other water users (such as other irrigation industries) over and above permanent horticultural water demand.

In this context, the scope of work requested by DELWP and covered in this report includes:

- Examination of current data on permanent horticulture water demand in the connected Murray region of the southern Murray-Darling Basin and a projection of future demand under plausible future development scenarios (Section 2).
- Examination of total water availability as well as water available to meet the demands of permanent horticulture and other irrigated agricultural industries in the connected Murray region under several future water availability scenarios (Section 2).
- An assessment and graphical representation of the potential future supply and demand balance as it relates to estimating remaining ‘headroom’ above horticultural demand in the connected Murray region (Section 3).
- Sensitivity testing ‘headroom’ estimates by assuming several different scenarios of additional environmental water recovery from the consumptive pool (Section 3).
- Specific examination of the potential future supply and demand balance in the lower Murray region as it relates to estimating remaining ‘headroom’ above horticultural demand (Section 3).
- Discussion about the implications of these supply and demand changes for the southern Murray-Darling Basin water market, and by association market participants and government policy makers (Section 4).

1.2.3. **Analytical intent of this report**

The overall intent of this report is to inform water market participant decision making and the development of government water policy into the future. However, given publicly available data for this kind of analysis is incomplete, the report intends to provides the best possible assessment of likely supply and demand scenarios in different regions of the southern Murray-Darling Basin and a best estimate of available water supply headroom above that required by permanent horticulture industries.

Alongside challenges with data availability and reliability, there are a number of important assumptions that need to be made to undertake this type of headroom analysis. Aither has been explicit about these assumptions and transparent about our confidence in the data presented throughout this report and appendices.

Furthermore, this report has been prepared on the basis of information available to Aither at the date of publication. The analysis or conclusions presented in this report are general in nature and do not purport to represent investment, commercial, financial advice, and should not be relied upon as such.

This report builds on the following previous reports on similar topics (please see reference section for links to these reports):

• Water market drivers in the southern MDB: Implications for the dairy industry, Aither, 2016.
• Understanding delivery shortfall risks in the lower Murray, DELWP, 2018.
• Understanding future water availability in Northern Victoria, DELWP, 2018.
2. Water supply and demand in the connected Murray

To set the context for this report, this section presents analysis about possible future water supply and demand conditions in the connected Murray region – including updated projections about the expected future growth in permanent horticulture water demand. Analysis on historical water use by all irrigated agricultural industries and other water users (such as the environment and urban water authorities) across the connected Murray region and how this has changed across time is also presented in this section.

2.1. Approach to assessing water supply and demand

Estimating the future availability of water across different regions of the southern Murray-Darling Basin and how this relates to current and expected future water demand is challenging. This is because data on this topic is imperfect and there is uncertainty around the exact volumes of water that may be available for consumptive use in each region into the future. There is also uncertainty about how rationally water market participants will behave under these conditions (e.g. the trade of water between different industries and water trading zones).

Uncertainty about future water supply and demand conditions are primarily driven by the fact that:

- water availability is highly variable in the southern Murray-Darling Basin – including accounting for the different water systems and the complex set of rules which dictate how water can move across the system at certain points in time
- industry conditions can change over time and this can materially alter demand for water (for example the recent increase in cotton production in the southern Murray-Darling Basin)
- the water market and participant water strategies are becoming increasingly sophisticated (for example the use of carryover, leasing, forwards and options). These emerging risk management tools and changing behaviours materially affect the assumption that the volume of water allocated in a given year is available to be used in that same year.

To account for this uncertainty, Aither has adopted a scenario-based assessment approach, which first seeks to understand the drivers of water demand, and then estimates water supply and demand under various plausible future scenarios. To develop and assess possible supply and demand scenarios, Aither used the following approach:

- Collected and analysed historical water availability and irrigated agricultural water usage data for the connected Murray region.
- Used best available information and industry projections to estimate current and future water demand by permanent horticulture.\(^7\)
- Using data on historical water availability, constructed several future water availability scenarios (wet, average, dry and extreme dry) and estimated the volume of water that could theoretically be

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\(^7\) The reason for this report’s focus on permanent horticulture is that water use by these crops is most easily modelled and has larger market impacts as it is relatively ‘fixed’, while water use by annual crops (rice and cotton) or semi-interruptible crops (dairy pasture) will change more significantly between years.
available to both permanent horticulture and all other irrigated agriculture industries under these scenarios.

• Stress tested these future supply and demand scenarios by assuming additional water recovery from the consumptive pool for the environment (i.e. increasing the demand for water by the environment into the future based on the Basin Plan agreement to recover additional water beyond the 2,750 GL (LTAAY) target from the southern Murray-Darling Basin).

A detailed description of Aither’s approach, method and assumptions in modelling future water availability and demand can be found at Appendix A and Appendix B to this report.

2.2. Drivers of water demand and use

With the introduction of water markets over the past decade, the dynamics of water ownership and use in the connected Murray has been continually altered by the growth and contraction of different agricultural industries as well as the entrance of environmental water holders and urban water authorities into the market.

The demand for water from different water users is driven by several factors. Explaining these drivers is important to understanding how demand for water across the connected Murray has changed in the past and how demand in this region may look in the future. The points below provide a brief overview of the drivers of water demand by several water user groups in the connected Murray:

• **Irrigated agriculture** – Irrigated agriculture remains the primary user and owner of water across the southern Murray-Darling Basin, including in the connected Murray region and northern Victoria (Tim Cummins & Associates, 2016). Based in part on the profitability of different crops (which can change over time), different agricultural industries have a different willingness to pay for irrigation water and this drives changes in demand for water and ultimately use over time. Understanding the willingness to pay of different agricultural industries (both on a short and long-term basis) is important as it determines how water allocation and entitlement markets will behave during periods of demand change from different industries and variability in water availability.

• **Environmental water recovery and use** – Under the Murray-Darling Basin Plan, Australian governments have sought to recover 2,750 GL (LTAAY) of water from both consumptive and non-consumptive sources across the Murray-Darling Basin. This water is being recovered as a way to improve the sustainability of the resource and meet the water needs of important environmental assets. The use of environmental water is determined through planning processes undertaken by environmental water holders and state governments. Each year environmental water holders broadly have the choice to use water they own to meet the water demands of environmental watering priorities and some constrained potential to buy and sell water allocations from or into the market.

• **Urban water authorities** – Urban water authorities are also water market participants, both as buyers and sellers of allocations and entitlements. At this point in time, urban water authorities in the connected Murray region are generally sellers into the allocation market in wet to average years (for example urban water authorities in Victoria sold 116 GL of allocation into the market in 2017-18). In this scenario, urban water authorities are adding supply to the consumptive supply

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8 Aither’s water supply scenarios take into account surface water and groundwater availability, and what is known about environmental holdings and urban use.

9 Noting that while environmental water holders can and do sell water allocations back to consumptive users, such as irrigators, there are rules governing environmental water holders’ participation in the market.

pool which is available to irrigators. However, in low allocation water years, urban water authorities can also enter the market to buy water allocations to supplement low urban supplies. An example of this occurred in 2008–09 when the South Australian Government bought more than 200 GL of water allocations to secure urban water supplies for Adelaide. Purchases of this nature reduce consumptive supply for irrigation and could further reduce water available for permanent horticulture and other irrigation industries if this were to occur in the future.

2.3. Water use by irrigated agriculture in the connected Murray

2.3.1. Significant historical water use flexibility

The connected Murray is one of Australia’s most important irrigated agricultural regions. There are three primary types of irrigated agriculture water use in this region: permanent horticulture (such as wine grapes, table grapes, citrus and almonds); livestock (including pasture for dairy); and annual crops (such as cotton and rice). The historical volumes of water available for consumptive use in the connected Murray has ensured the fixed demands of permanent horticulture have been met on an annual basis whilst also supporting the existence of a diverse mix of other irrigated agricultural industries (Figure 5). The existence of a ‘headroom’ of available water above permanent horticultural demand is important as it:

- facilitates for the existence of permanent horticulture, semi-interruptible irrigated industries and a diverse mix of annual irrigated production that has driven considerable flexibility in water use in the connected Murray region across the past decade
- moderates how the water market behaves during extreme dry periods (e.g. annual cropping is responsive to prevailing water availability and water prices) or in reaction to the entrance of new market participants (such as environmental water holders).

Source: Aither 2018 based on ABS 2018.
Note: Water use data for 2016-17 does not include the New South Wales Lower Darling region given changes to the Australian Bureau of Statistics’ (ABS) reporting boundaries. This may result in an underestimate of water use by fruits and nuts and grapevines for 2016-17.

Figure 5 Water use by irrigated agriculture industry, connected Murray, 2005-06 to 2016-17

2.3.2. Uncertainty about exact volumes of water use and current demand

The Australian Bureau of Statistics (ABS) water use dataset that is used to underpin Figure 5 above is the only aggregated assessment of annual water use by irrigated agricultural industries across the connected Murray as a whole. While it tells an important story about water use flexibility between years, this does not mean that it provides a perfectly accurate estimate of water use by each industry.
in each year. In particular, it is difficult to reconcile the relative stability of water use by permanent horticulture (fruits and nuts and grapes) between 2012-13 and 2016-17 represented in ABS data with the level of permanent horticulture development that has occurred in the connected Murray since this time. That is, an expectation that permanent horticulture water use should have materially increased over this period as a result of this new development.

As growth in permanent horticulture increases, a greater proportion of irrigated agricultural water demand in the connected Murray will come from industries with fixed rather than flexible water demands as well as industries with a higher willingness to pay for water. In this context, uncertainty regarding the accuracy of ABS water use estimates has prompted Aither to undertake the additional detailed demand estimates which is presented in the following section of this report.

2.4. Estimating existing and projected permanent horticulture water demand

While we know from on-ground reports that there are significant and increasing areas of permanent horticulture across the connected Murray region, accurate and complete public estimates of the exact area under planting or expected future developments are difficult to acquire – especially by specific water trading zone or region such as the connected Murray or lower Murray. Below Aither draws on the best available industry and government evidence to establish a baseline estimate of existing permanent horticulture water demands in the connected Murray and then explore what is known about likely future water demand from these industries.

2.4.1. Existing permanent horticulture water demand

ABS water use estimate

Historical water use data sourced from the ABS suggests that in 2016-17 (the most recently available year of data) the fruit and nut and grape industries (permanent horticulture) located across the connected Murray region applied (used) approximately 453 GL and 253 GL of irrigation water respectively (for a total of approximately 706 GL).

The 2016-17 ABS data suggests a decrease in permanent horticulture water use in the connected Murray by around 200 GL from the previous year (2015-16). This reported decrease in water use between years is likely to have been driven by changes in ABS reporting boundaries, methods for estimating water use, and higher in-crop rainfall rather than an actual reduction of permanent horticulture by planted area in the connected Murray region.

In this context, the 2015-16 ABS water use estimates for permanent horticulture likely represent a more reliable baseline for the existing water demand from permanent horticulture in the connected Murray region. However, given these ABS water use estimates are now several years old, more triangulation with other sources of information is needed to establish a robust 2018-19 water demand baseline.

11 Water use data for 2016-17 does not include the New South Wales Lower Darling region, whereas previous data does. This may result in an underestimate of water use by fruits and nuts and grapevines in 2016-17 for the connected Murray.

12 Rainfall at Mildura Airport across the period October to March in 2015-16 was 5 per cent below long-term median, whereas for the same period in 2016-17 rainfall was 40 per cent above median.
**Aither estimate of existing (2018-19) permanent horticulture water demand**

Based on comparing ABS data (2015-16) with other industry estimates of permanent horticulture water demand sourced by Aither, we believe that the current (2018-19) water demand from existing permanent horticulture in the connected Murray is likely already higher than that published by ABS in both the 2015-16 and 2016-17 data releases. The primary reason for this conclusion is the substantial evidence from industry publications, irrigation corporation data and media coverage of recent new permanent horticulture developments in the connected Murray and therefore the expectation of increased demand for and use of water by these industries.

For example, in 2015-16 the Almond Board of Australia (ABA) estimated that approximately 15,000 ha of new almond orchards would be established across Australia’s four major growing regions between 2016-17 and 2018-19. Using the ratios of existing production, this forecast equated to approximately 13,000 ha of new almond orchards being established in the connected Murray region (primarily in lower Murray regions of the Victorian Sunraysia and South Australian Riverland). In 2017-18, the ABA reported that approximately 8,500 ha of new almond developments had been planted across all Australian growing regions between 2016-17 and 2017-18.

**Comparison of lower Murray Water use estimates**

To sense check ABS water use data for the lower Murray region in particular (where there is the highest concentration of permanent horticulture in the connected Murray), Aither compared ABS water use estimates to recent water diversions data provided by DELWP from its recent water availability fact sheets. The comparison highlights that the 2015-16 ABS water use estimates are significantly lower (around 165 GL) than the more recent permanent horticulture water diversion estimates compiled by DELWP for the lower Murray region (Figure 6).

![Comparison of water use and diversions by all permanent horticulture by NRM region, lower Murray, 2015-16 ABS estimate and DELWP estimates](image)

Source: Aither 2018 based on ABS 2018 and data provided to Aither by DELWP.

Note: For both ‘total’ columns in this comparison, Aither has relied on 2015-16 ABS water use data for the NSW Murray (adjusted to account for permanent horticulture located in Murray Irrigation) and Victoria North Central regions.

Figure 6 Comparison of water use and diversions by all permanent horticulture by NRM region, lower Murray, 2015-16 ABS estimate and DELWP estimates

In addition to ABA almond planting estimates, we sourced information from other public and confidential sources, such as from the Victorian Government, industry bodies, irrigation corporations (Lower Murray Water, Goulburn-Murray Irrigation District, Murray Irrigation and Western Murray Irrigation information – see Appendix A), as well as public announcements and media articles on certain large permanent horticulture developments or transactions.
On the basis of the water use and diversion evidence assessed by Aither, we estimate that the current (2018-19) use by existing permanent horticulture in the connected Murray is approximately 1,230 GL per annum, which adds an additional 325 GL per annum of permanent water demand on top of the 2015-16 ABS water use estimate and is also higher than DELWP diversion estimates which only accounted for the lower Murray region. Aither’s estimate of additional demand over 2015-16 ABS water use data is primarily comprised of accounting for new almond developments in the lower Murray region, with some new demand from grapes, citrus and avocados also being accounted for.

Given a portion of the permanent horticulture developments included in the current demand estimate presented above are not yet fully mature, we expect total permanent horticulture water use in this region will continue to grow over time as existing but new orchards fully mature. At full maturity, we estimate that the water demand from all existing permanent horticulture will be closer to 1,400 GL per annum. This estimate adds an additional 490 GL per annum of permanent water demand on top of the 2015-16 ABS water use estimate and approximately 160 GL in addition to estimated current 2018-19 demand.

Aither’s baseline estimate of existing permanent horticulture water demand (both current and at full maturity) are compared to ABS water use data for 2015-16 in Figure 7 below.

Source: Aither 2018 based on ABS 2018 and other industry sources.

**Figure 7** Comparison of water demand from permanent horticulture, connected Murray, 2015-16 ABS estimate and Aither 2018-19 baseline demand estimates

### 2.4.2. Projected water demand from additional permanent horticulture

Building on existing permanent horticulture water demand estimates presented above, DELWP provided Aither with best estimates of future permanent horticulture development in the connected Murray region (i.e. planned permanent horticulture developments at differing stages of approvals not captured in the baseline estimates presented above). This development information was cross-referenced by Aither against other industry projections – both public and confidential – and used by Aither to establish a plausible future water demand pathway for permanent horticulture in the connected Murray region.

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13 Note the connected Murray region excludes the Murrumbidgee region.

14 For the purposes of constructing a baseline water demand estimate and comparing this estimate to future growth projections, Aither has calculated what we refer to as the “2018-19 baseline demand scenario (at full maturity)” on the basis of all existing permanent horticulture developments being at full maturity.
Projecting future permanent horticulture development and water demand is inherently difficult. To develop an estimate of projected demand Aither has relied on the best available information at time of writing and these estimates may be subject to considerable change in the future. For example, new planned developments may not proceed for a range of reasons, including availability and the cost of water or changing commodity conditions.

On the basis of the information Aither considered, we understand that there are plans (at differing stages of approvals) to establish additional permanent horticulture in the connected Murray region which at full maturity could use up to an additional 165 GL per annum on top of Aither’s estimate of existing demand (at full maturity). This additional development would increase total demand from permanent horticulture in the connected Murray region up to approximately 1,555 GL per annum (at full maturity).

A detailed description of Aither’s estimates for current and projected permanent horticulture water demand in the connected Murray can be found at Appendix A.

2.5. Future water availability scenarios

The total underlying supply of water in the connected Murray region is a combination of the volume of water carried over into a new water year and the volume of water allocated to all entitlements in a given year (both surface water and groundwater). Based on what is known about historical allocations to entitlements in the southern Murray-Darling Basin, representative years can be chosen to develop a series of water availability scenarios that account for likely variability in future water availability. For this analysis, Aither has chosen to use the following representative water availability scenarios: extreme dry (similar to 2007-08); dry (similar to 2015-16); moderate (similar to 2014-15); wet (similar to 2011-12).

By applying these scenarios, we can estimate what volume of water may be available to meet the demands of irrigated agricultural industries in the connected Murray in future years. To do so, we need to exclude certain types of environmental water, urban water and carryover as a possible source of consumptive supply, take into account trade constraints and include allocations to groundwater. For this analysis we have also assumed Victorian Low Reliability Water Share (LRWS) entitlements do not receive material allocations in any future years.

Note on treatment of water allocation trade constraints

A simplified approach to assessing water allocation trade constraints was adopted for this analysis. For the connected Murray region, it is assumed that the Murray and Goulburn systems are one system with no binding constraints (but no trade in from or into the Murrumbidgee).

In reality, trade is limited out of the Goulburn and from above the Barmah Choke to below on the Murray. Therefore, the analysis presented for the connected Murray might overestimate the total

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15 Aither has accounted for environmental water that was purchased from the market from relevant systems in Victoria, New South Wales and South Australia and volumes of water recovered in Victoria through on-farm programs. Consolidated data by region for environmental water recovery through on-farm programs in other states was not available and other types of environmental water recoveries, such as infrastructure savings projects, are not included in Aither’s calculations. Please see Appendix B for more a detailed explanation of assumptions.

16 In all future water availability scenarios, we have assumed that consumptive water entitlements held by urban water authorities continue to be available to irrigators. This may overstate the volume of consumptive water available to irrigators in extremely dry water availability scenarios where urban water authorities do not sell excess water allocations back into the consumptive market.
volume of water available to irrigated agriculture in certain parts of the connected Murray, such as the lower Murray region. Our Lower Murray case study in Section 3.2 assumes that these trade constraints are fully binding and provides a worst-case scenario with respect to trade constraints.

In recent years allocation trade out of the NSW Murrumbidgee to the connected Murray has become increasingly restricted due to growing water demands in the Murrumbidgee (from both cotton and permanent horticulture) and the existence of an inter-valley trade limit between these two regions. Therefore, including the NSW Murrumbidgee as a supplier of water to the connected Murray or lower Murray regions would potentially overstate supply conditions under certain water availability scenarios. For this reason, we have assumed zero trade into the connected Murray from the NSW Murrumbidgee, however, this may change in reality depending on seasonal conditions.

On the basis of Aither’s analysis of future water availability in the connected Murray, it is reasonable to assume that the total underlying consumptive supply of water (both surface water and groundwater) potentially available to all irrigation water users in this region in future years could be equal to:

- 1,510 GL in extreme dry sequences (similar to 2007-08)
- 3,100 GL in dry sequences (similar to 2015-16)
- 3,790 GL in moderate sequences (similar to 2014-15)
- 4,370 GL in wet sequences (similar to 2011-12).

The above water availability scenarios importantly assume that there are no allocation sales from the environment to irrigators. Furthermore, in dry and extreme dry sequences we assume the market to behave rationally with major reductions in annual crop production as a function of available water allocations being traded to permanent horticulture industries driven by their higher willingness to pay for this water.\(^{17}\)

A detailed description of Aither’s method and analytical approach to determining future water availability scenarios can be found at Appendix B.

### 2.6. Additional environmental water recovery scenarios

In addition to increasing permanent horticulture water demand across the connected Murray, the Australian Government is currently pursuing the recovery of up to an additional 450 GL (LTAAY) of ‘upwater’ or efficiency measures for the environment through infrastructure projects.\(^ {18}\) The recovery of this additional water for the environment is on the basis that social and economic effects of these recoveries are neutral or positive and in accordance with the criteria agreed on 14 December 2018 by the Murray-Darling Basin Ministerial Council.

Given uncertainty about the exact volumes of water that may be recovered and the means of recovering this additional water, Aither has analysed several additional water recovery scenarios and applied these to the headroom analysis presented in the following sections. The specific recovery

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\(^{17}\) Historically we have observed the market act relatively rationality where periods of low water availability have caused major reductions in annual crops such as rice (for example during the Millennium Drought), however, the market is unlikely to behave perfectly rationally under these conditions due to individual decisions and trade constraints.

\(^{18}\) This additional recovery is above the existing Basin Plan water recovery target of 2,750 GL (LTAAY).
scenarios that Aither has assumed are an additional 50, 100, 200 and 450 GL (LTAAY) of water recovery from the consumptive pool.

The location and type of water entitlements recovered for the environment can have large impacts on the resulting supply and headroom analysis. For instance, the recovery of higher reliability entitlements will have relatively larger impacts on reducing consumptive supply in extreme dry conditions and the systems that environmental water is recovered in may impact on the local availability of water for consumptive use.

It is difficult to predict exactly where and in what volumes additional water will be recovered for the environment. Therefore, in constructing these scenarios Aither has assumed additional water will be recovered proportional to existing water purchases for the environment by the Australian Government. If water is recovered in proportion to water purchases that have already been undertaken, each additional 100 GL (LTAAY) of water recovery may reduce water available to consumptive users in the connected Murray by around 29 GL under an extreme dry water availability scenario.
3. Water supply for permanent horticulture and other irrigation industries

Using the estimates of water supply and permanent horticulture water demand established in the previous section, we can assess the volume of ‘headroom’ in the connected Murray region under each water availability scenario. As previously explained, in this report, ‘headroom’ is defined as the gap between the volume of water available for consumptive use and the water demanded by permanent horticulture in a given year. This headroom represents the total volume of water available to all other water users, such as other irrigated industries, including dairy and annual cropping.

Estimating the exact remaining headroom in the connected Murray region is challenging given imperfect data and uncertainty around future changes in permanent horticulture water demand and water available for consumptive use by region. To reflect this uncertainty, this report takes a scenario-based approach, estimating system headroom under various plausible demand and supply scenarios.

3.1. Headroom under existing permanent horticulture demand

A key finding of Aither’s analysis is that there are significant existing areas of permanent horticulture in the connected Murray and the water demands of these developments are growing as more recent plantings mature. Based on the water use and diversion evidence assessed by Aither, we estimate that the current (2018-19) use by existing permanent horticulture in the connected Murray is approximately 1,230 GL per annum. Our estimate is that existing permanent horticulture in the connected Murray region will demand approximately 1,400 GL of irrigation water per annum at full maturity (approximately 55 percent growth from 2015-16 Australian Bureau of Statistics (ABS) water use estimates).

Figure 8 over page plots several possible future water availability scenarios in the connected Murray region against Aither’s best estimate of the future water demands of all existing permanent horticulture at full maturity. The analysis highlights that the growing fixed water demands of permanent horticulture industries in the connected Murray will begin to push the limits of annual water availability in this region. Of critical importance, the analysis suggests that during periods of future extreme dry water availability (with no carryover from the previous year), existing permanent horticulture may demand essentially all available surface and groundwater in the region (i.e. there may be no or very little water available to other industries such as dairy, cotton and rice).

Groundwater sources that exist in the connected Murray region generally either do not geographically overlap with existing permanent horticultural demand or those groundwater sources that do overlap are not of high enough quality to be used outright for irrigated agriculture. In this context it is valid to remove groundwater from the supply side of the equation to present a worst-case water availability scenario in the connected Murray.

If groundwater (approximately 390 GL of entitlement on issue across the connected Murray) is removed from the extreme dry scenario presented in Figure 8, the estimated water requirements of existing permanent horticulture (at full maturity) equate to 125 per cent of the estimated total consumptive water supply in the connected Murray region. In other words, under this scenario, demand from existing permanent horticulture may exceed total consumptive supply. In this situation,
we would assume no water is available to other irrigated industries and permanent horticulture would need to compete with each other for the available water supply.\(^\text{19}\)

![Figure 8](image)

Source: Aither 2018.

**Figure 8** Water availability scenarios and existing permanent horticulture water demand (at full maturity), connected Murray region

### 3.2. Headroom under projected growth in permanent horticulture demand

Beyond our estimates of existing permanent horticulture water demand (Figure 8 above), when demand from projected new permanent horticulture developments (i.e. above baseline demand) is accounted for, Aither’s analysis raises more serious concerns for the connected Murray region. Specifically, the analysis shows that additional permanent horticulture development in the connected Murray will further exacerbate concerns about available headroom above horticultural demand – especially under dry and extreme dry future water availability scenarios (Figure 9).

The analysis suggests that during periods of future extreme dry water availability, existing permanent horticulture may demand more than the combined available consumptive supply of surface water and groundwater in the region (i.e. there may be no supply available to other industries such as dairy, cotton and rice). Furthermore, if groundwater (approximately 390 GL of entitlement on issue across the connected Murray) is removed from the extreme dry scenario presented in Figure 9, estimated water requirements of existing and projected permanent horticulture (at full maturity) equate to approximately 140 per cent of the estimated total consumptive water supply in the region. Under either of these situations (with no carryover available), we would similarly assume no water is available to other irrigated industries and permanent horticulture would need to compete with each other for the available water supply.

\(^{19}\) Please note that this estimate does not take into account the ability of permanent horticulture to reduce irrigation application rates or dry-off old orchards or blocks during times of severe drought or low water availability.
Lower Murray region water supply and demand case study

The lower Murray region is a subset of the connected Murray and includes regions downstream of the Barmah Choke, such as the Victorian Sunraysia, New South Wales Murray and South Australian Riverland regions (see Figure 4 for map). The lower Murray has a high concentration of permanent horticulture and there are greater concerns over future water availability in the lower Murray compared to the connected Murray as a whole. These concerns are primarily driven by physical and trade constraints that limit the ability to trade water into the lower Murray from above the Barmah Choke and out of the Goulburn and Murrumbidgee.

Our estimate is that existing permanent horticulture in the lower Murray region will demand approximately 1,315 GL of irrigation water per annum at full maturity. This equates to approximately 95 per cent of estimated permanent horticulture demand across the connected Murray region as a whole.

In addition to the existing areas of permanent horticulture in the lower Murray, we understand that there are plans (at differing stages of approvals) to establish more permanent horticulture in the region. For this analysis we assume that the total 165 GL per annum of additional permanent horticulture demand that is estimated for the connected Murray (above) will occur in the lower Murray region. This additional development would increase the total estimated future water demand from permanent horticulture in the lower Murray up to approximately 1,480 GL per annum (at full maturity).

Similar to the analysis presented above for the connected Murray, Figure 10 below plots several possible future water availability scenarios in the lower Murray region against Aither’s best estimate of the future water demands of all existing and projected permanent horticulture in the region (at full maturity). The headroom analysis for the lower Murray region presents an increasingly concerning outlook. This heightened concern is driven by the concentration of permanent demand in the lower Murray region and a lower estimate of supply in this region (i.e. total water supply in the connected Murray will not be available to permanent horticulture in the lower Murray).
3.3. Headroom under additional environmental water recovery

The analysis presented in the above sections highlights that headroom above horticultural demand in the connected Murray is most likely to be exhausted under an extreme dry future scenario. As

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additional environmental water recovery from the consumptive pool will further decrease estimated remaining headroom, we have used an extreme dry future water availability scenario to assess the additional headroom impact of additional environmental water recovery.

Based on the four additional water recovery scenarios developed for this analysis (see Section 2.6) and using estimates of total water supply in the connected Murray under an extreme dry scenario (no groundwater), Aither’s analysis shows that as more water is recovered from the consumptive pool for the environment, less water is available for other consumptive water users (i.e. additional recovery reduces available headroom) (Figure 11).

Importantly the analysis presented in the above sections suggests that even under existing recovery volumes, if an extreme dry scenario transpired, we expected there to be a shortfall of water supply to meet existing permanent horticulture demand. Therefore, any additional permanent demand or water recovery from the consumptive pool is expected to further exacerbate the expectation that a shortfall could occur in the future if worst case scenario water supply conditions transpired.

![Graph showing additional environmental water recovery and existing and projected permanent horticulture water demand](image)

Source: Aither 2018.

Notes: Water recovery in this figure is expressed in LTAAY terms and is assumed to come from the consumptive pool.

**Figure 11** Additional environmental water recovery and existing and projected permanent horticulture water demand (at full maturity) under extreme dry water availability scenario with no groundwater access, connected Murray

From a quantitative perspective, if 450 GL (LTAAY) is recovered from the consumptive pool and a worst-case water availability and demand scenario unfolds (i.e. projected permanent horticulture demand with an extreme dry water availability scenario with no access to groundwater), our analysis in Figure 11 estimates a supply shortfall in the connected Murray of approximately 570 GL (i.e. under that expected to be demanded by permanent horticulture). In comparison to a no additional recovery scenario, the recovery of 450 GL (LTAAY) from the consumptive pool is expected to cause 135 GL of additional shortfall under a worst case water availability scenario in the connected Murray.

### 3.4. Summary of headroom analysis

Table 1 summarises the headroom analysis presented in the above sections for the connected Murray region, specifically focusing on estimates of water available for permanent horticulture and other irrigation industries under an extreme dry (no groundwater) water availability scenario – which is a worst-case scenario.
### Table 1  Water supply and demand assessment summary, extreme dry water availability (no groundwater) scenario, connected Murray region

<table>
<thead>
<tr>
<th>Demand scenario</th>
<th>Estimated total volume of permanent water demand (GL)</th>
<th>Volume of consumptive water supply available – extreme dry no groundwater (GL)</th>
<th>Estimated water availability above permanent horticulture demand</th>
<th>Volume (GL)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing demand estimate (2018-19 current)</td>
<td>1,230</td>
<td>1,117</td>
<td>-113</td>
<td>-10%</td>
<td></td>
</tr>
<tr>
<td>Existing demand estimate (at full maturity)</td>
<td>1,392</td>
<td>1,117</td>
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<td>-25%</td>
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</tr>
<tr>
<td>Projected demand estimate (at full maturity)</td>
<td>1,556</td>
<td>1,117</td>
<td>-439</td>
<td>-39%</td>
<td></td>
</tr>
<tr>
<td>Projected demand estimate (+ 50 GL recovery)</td>
<td>1,556</td>
<td>1,100</td>
<td>-456</td>
<td>-41%</td>
<td></td>
</tr>
<tr>
<td>Projected demand estimate (+ 100 GL recovery)</td>
<td>1,556</td>
<td>1,088</td>
<td>-468</td>
<td>-43%</td>
<td></td>
</tr>
<tr>
<td>Projected demand estimate (+ 200 GL recovery)</td>
<td>1,556</td>
<td>1,058</td>
<td>-498</td>
<td>-47%</td>
<td></td>
</tr>
<tr>
<td>Projected demand estimate (+ 450 GL recovery)</td>
<td>1,556</td>
<td>985</td>
<td>-571</td>
<td>-58%</td>
<td></td>
</tr>
</tbody>
</table>

Source: Aither 2018.
4. Conclusions

4.1. Conclusions

This report documents updated research and analysis about the growth in permanent horticulture water demand that is currently occurring in the southern Murray-Darling Basin (particularly in the connected Murray and lower Murray region). The report highlights that:

- **Previous estimates of existing permanent horticulture water demand are likely to be underestimates** – Most of the recent research on water demand and economic modelling of market impacts in the southern Murray-Darling Basin has been based on historical ABS water use data. In this report, Aither has highlighted that ABS data likely underestimates current permanent horticulture water demand in the connected Murray region by a material margin.

- **Existing and projected permanent horticulture demand is expected to push the limits of water supply in very dry periods** – The existing and projected growing fixed water demands of permanent horticulture industries will begin to push the limits of annual consumptive water availability in the connected Murray under future extreme dry seasons, assuming no carryover.

- **Additional water recovery could further reduce consumptive water supply** – If additional water recovery for the environment comes from the consumptive pool, it will increase concerns about whether permanent horticultural water demand in the connected Murray will exceed supply under dry and extreme dry water availability scenarios.

- **Assumptions about rational behaviour and efficient market operation are important** – Even if theoretical headroom above horticultural demand is not exhausted, the market will need to operate efficiently and behave rationally to avoid significant market impacts even in dry and average years. Based on what is known about how the market operates and has behaved in the past, we can assume that the market will not act perfectly rationally in the future. This means that estimates of water availability in this report are likely to overestimate supply for horticulture.

A situation where the headroom of water supply above horticulture demand in the connected Murray is exhausted or is close to exhausted in the future (acknowledging physical constraints and assuming the market is not perfectly efficient) will cause substantial impacts for agricultural industries, the market and policy makers alike. These impacts and the implications for these parties are explored in more detail in the section below.

4.2. Potential market and industry impacts

4.2.1. Water market price impacts

The exact impacts on the water market and its participants of permanent horticulture water demand outpacing supply depends on several factors, but in summary, any increase in permanent demand and decrease in supply is expected to increase both water allocation prices and by association entitlement prices over the short and long-term.

The degree to which prices may increase in the future depends on the exact permanent development pathway and additional environmental water recovery scenario that occurs, the efficiency and rationality of the market, and the future water availability scenario that unfolds. These factors are difficult to predict but could be modelled.
**Allocation markets**

If headroom above permanent horticultural demand in the connected Murray was close to or actually exhausted under an extreme dry water availability scenario, seasonal water allocation prices would, at a minimum, be expected increase up to the short-run willingness to pay of the lowest value permanent horticultural enterprises in the connected Murray. While there is uncertainty about the willingness to pay for water across different industries and individual enterprises within each industry, it is reasonable to assume that allocation prices higher than $450 to $550 per ML (mid-season 2018-19 southern Murray-Darling Basin allocation market prices) may be observed.

If, over the longer-term, headroom was either expected to be or was sufficiently exhausted under less extreme water availability scenarios (e.g. average and dry), such that there was insufficient consumptive water available to meet water demands from permanent horticulture in most future years, average water allocation prices would be expected to significantly increase over the long-term. In other words, we would expect to observe a reasonably significant step-change in average allocation prices both in the connected Murray and the southern Murray-Darling Basin as a whole. In this situation, Aither also expects to observe significant increases in the demand for carryover by permanent horticulture and other industries.

**Entitlement markets**

As a function of underlying increases in long-term average allocation prices, entitlement prices would also be expected to increase. The assumption that the connected Murray region is heading towards a scenario where the water demands of permanent horticulture cannot be met in all future years, and therefore the expectation of increased allocation prices over the long-term, is one logical explanation of the significant growth in water entitlement values across the southern Murray-Darling Basin in recent years (Figure 12).

It is important to point out that the expectations of some market participants that a headroom exhausted scenario will occur may have already been priced in to current entitlement market prices and may have driven some or all of the recent increases in entitlement prices.21

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21 In this report Aither has not undertaken economic modelling of future allocation or entitlement prices.
4.2.2. Impacts on irrigated agricultural industries

Considering the analysis presented in this report, under future average and wet water availability scenarios it is likely that there will be water available for use by irrigated agricultural industries in the connected Murray above estimated permanent horticultural demand.\(^{22}\) However, in future years with dry or extreme dry water availability scenarios (the latter being akin to or worse than the Millennium Drought), the analysis presented in this report suggests there may be an actual shortfall of available water for permanent horticulture in the connected Murray. As a result, water availability will be reduced for other industries and there is likely to be significant upward allocation price impacts. In these types of scenarios, it will be harder for non-permanent irrigation industries to access affordable water.

In practice, it is likely that permanent horticultural enterprises will use carryover as a tool to avoid a short-term water availability shortfall (for example identifying a drying cycle and making provisions to carryover water as a supply reserve – potentially across multiple years). However, to build these carryover reserves, horticultural enterprises need to enter the allocation spot market to buy water in water be years prior to the irrigation season in which the water will used.

Compounding impact of cotton production in average and dry years

Compounding the impacts of growth in permanent horticulture is the growth of cotton production within the Murrumbidgee. From less than 5,000 ha of cotton grown in the Murrumbidgee region in the early 2000s, production volumes have grown significantly with estimates of around 70,000 ha of irrigated cotton grown in the Murrumbidgee during the 2017-18 season (requiring around 700 GL of irrigation water) and approximately 35,000 ha planted in 2018-19 (requiring around 350 GL of irrigation water).

Driven by current strong commodity prices for cotton and on average a higher willingness to pay for water than the previous dominant annual crop being rice, large-scale cotton production in the Murrumbidgee is likely to increase average water allocation prices from a historical baseline in both average and dry water availability years (i.e. when cotton is competing with rice for water but not yet directly competing with permanent horticulture). In this context, we expect in all but extremely wet future years cotton will use most of the available supply of water above that required by permanent horticulture in the Murrumbidgee and thus set allocation prices at or above the cotton industry’s willingness to pay for water allocations.

For example, in 2017-18 and less so continuing into 2018-19 we have observed the cotton industry set a new ‘floor’ price for water allocations across the Murrumbidgee region which is above what would be expected from considering the historical record. As long as cotton commodity prices remain strong and sufficient water is available, we expect cotton to push allocation prices in the Murrumbidgee above what is economical for most rice producers and some dairy enterprises.

Long-term structural adjustment

If permanent horticulture water demand begins to exceed available supply over a prolonged period or further development of additional permanent horticulture occurred, structural adjustment for irrigated agricultural industries in the southern Murray-Darling Basin may be required. This may occur even if

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\(^{22}\) This importantly does not take into account the price impacts that growth in demand from permanent horticulture may still have in wet and average water availability years. This conclusion is also based on Aither’s projections of additional growth in demand from permanent horticulture, if actual plantings are higher than Aither’s projections then this conclusion may no longer hold.
the market acts efficiently or rationally under these water availability scenarios and within physical system constraints.

The industries that are most likely to be affected are the rice industry located within the Murray Irrigation Area the dairy industry located in the Goulburn Murray Irrigation District. Structural adjustment might take the form of individual exit decisions and significant long-term reductions in production by rice and dairy first, with cotton following. An extreme scenario may also necessitate water being traded from wine grape or other horticulture towards almonds or other more profitable permanent horticulture. The profitability of wine grapes as well as almonds over the next few years, including in relation to the affordability of increased long-term allocation prices for these industries, will be critical to shaping possible adjustment outcomes.

4.3. Trade, carryover and delivery constraint assumptions and impacts

There are several important caveats to the analysis presented in this report that materially impact on the conclusions drawn. Most important of which is that existing and projected permanent horticulture in the connected Murray is not evenly distributed across the region. Rather, developments are primarily concentrated around specific locations in the lower Murray – including the Victorian Sunraysia, New South Wales Murray and South Australian Riverland regions.

This concentration of permanent horticulture and thus water demand is important as under a dry or extreme dry future water availability scenarios, where there is very low water availability combined with higher than average permanent crop water requirements, the ability to meet the estimated water requirements of permanent horticulture in these specific locations will hinge on the ability to trade and physically delivery water to the lower Murray region not the connected Murray as a whole.

4.3.1. Trade constraints

Previous analysis that Aither has completed regarding the Vic 7 Murray region (which is one of the most highly concentrated permanent horticulture regions in the lower Murray) found that the ability to meet the estimated water requirements of permanent horticulture in this region will hinge on the ability to trade hundreds of gigalitres of water allocations into Vic 7 Murray per annum, which while possible, is not guaranteed in all years due to physical and trade constraints. Recent analysis on water availability in the lower Murray region published by the Victorian Government presents similar concerns about water availability in the lower Murray region.23

While there are very complex interactions that determine exactly how much water can be traded into the lower Murray at any given point in time or over a specific irrigation season, the key trade constraints to meeting permanent water demands in the lower Murray region in the future are:

- **Barmah Choke** – The volume of water that can pass downstream through the Barmah Choke is restricted to avoid water losses and third-party impacts. Trading rules have been established to restrict the trade of water from above to below the Choke and limit the impacts that trade has on the ability to deliver committed water through the Choke. A decline in water use by the rice

industry above the Barmah Choke may put more pressure on trade through the Barmah Choke as permanent horticulture industries attempt to access this supply.  

- **Goulburn inter-valley trade (IVT) limit** – Introduced in 2012, the volume of water allowed to be traded from the Goulburn, Campaspe, Broken and Loddon into the Victorian Murray, or to New South Wales and South Australia is restricted via a net IVT balance. This trade limit protects against impacts on entitlement holders from the risk of spill of the IVT. A decline in water use by the dairy industry in the Goulburn region has already put pressure on trade out of the Goulburn as permanent horticulture industries are increasingly using the Goulburn system for carryover parking space and as a within-season allocation supply source.  

- **Murrumbidgee IVT limit** – The annual volume of net trade out of the Murrumbidgee system into the Murray is restricted via a net IVT balance. The Murrumbidgee IVT limit exists to minimise spill losses in Murrumbidgee storages during periods of high inflows (i.e. water held in Murrumbidgee storage but “owed” to downstream users can increase spill losses by taking up storage space) and to minimise transmission losses during dry periods (i.e. delivering water through the length of the Murrumbidgee system into the Murray). The IVT prevents more than 100 GL of net trade out of or into the NSW Murrumbidgee on an annual basis.

The profitability of the cotton industry in the Murrumbidgee will be key to determining whether on a net basis water is traded from the Murrumbidgee to the lower Murray or the opposite direction in any given year. In extreme dry years with high allocation prices we would expect to observe lower cotton production and water being traded out of the Murrumbidgee to the lower Murray to meet permanent demand.  

### 4.3.2. Carryover usage

Owners of certain water entitlements in the connected Murray and broader southern Murray-Darling Basin are allowed to carryover water against owned or leased water entitlements into future water years (both surface water and groundwater). With increased permanent horticulture in the connected Murray Aither expects to observe significant increases in the demand for carryover as it is used by these industries as a water supply and price risk mitigation tool.

While carryover is able to be modelled based on historical evidence, given a large range of possible determining factors, it is complex to estimate exactly how much carryover may be available in future years. For this reason, for the analysis in this report we excluded carryover from all water availability analysis. The impact of this assumption is that the analysis estimates a lower bound water availability scenario than may occur in most future dry, average and wet years.

However, in future extreme dry sequences, such as a repeat of the Millennium Drought, carryover is likely to add marginal or no additional supply in some systems – especially if a dry period is prolonged where carryover reserves are drawn down across multiple years.

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24 The majority of water owned by rice growers in the Murray Irrigation district (i.e. above the Barmah Choke) is New South Wales Murray General Security and therefore during extreme dry periods it is unlikely large volumes of water would be allocated to these entitlements and therefore be available to trade downstream.

25 The majority of water owned by dairy farmers in the Goulburn region are High Reliability Water Shares and therefore during extreme dry periods it is still likely that large volumes of water would be allocated to these entitlements and could be available to trade downstream.

26 Noting that there is significant permanent demand which exists in the Murrumbidgee as well – comprised of mainly wine grapes and citrus within the Murrumbidgee Irrigation Area and almonds and other nut crops located on river outside of the irrigation districts.
4.3.3. **Physical water delivery**

As a result of the growth and concentration of permanent horticulture in the lower Murray region, there are concerns that the physical delivery of water to these developments may be constrained during peak irrigation demand periods. The physical delivery of water relates to system operational constraints rather than the total volume of consumptive water available in the system on an annual basis.

Permanent horticulture (such as almonds, other horticulture and grapes) generally require the maximum application of water across summer months (i.e. as evapotranspiration is at its highest, and fruit is maturing and moisture content is rising). As described above, the Barmah Choke acts as a key constraint as it physically limits the volume of water that can be delivered from the upper Murray storages (Hume and Dartmouth) to the lower Murray at any point in time.

At this stage, Aither is unable to quantitatively assess how material the Barmah Choke constraint is to the delivery of water to the lower Murray during peak demand periods, however, we are aware that several stakeholders (including irrigators, river operators and state governments) are concerned about the impact of permanent developments and resulting water demands on this constraint.

For example, the Victorian Government recently published analysis on this topic concluding that whilst river operators have a strong track record in actively managing the southern Murray-Darling Basin system to avoid delivery constraints (noting the last delivery rationing event occurred in March 2002), there are increasing pressures on delivery in the lower Murray region due to growth in demand from permanent horticulture.27

At the recent December 2018 Minco meeting, Basin Ministers requested that the Murray-Darling Basin Authority (MDBA) work with the Basin states to address deliverability challenges in the Murray River (for both environmental and consumptive water users). Options to be considered include changes to river operations and trade rules, constraints measures and infrastructure projects.

4.4. **Implications of Aither’s analysis**

The analysis and conclusions presented in this report have several important implications for existing agricultural enterprises, proponents of new developments and governments:

- **Existing irrigated agricultural enterprises** – The analysis in this report points to a future scenario where there are increased risks in average to extreme dry water availability years associated with meeting the water demands of permanent horticulture and all other irrigated agricultural industries in the southern Murray-Darling Basin. If this scenario transpires, it will likely lead to increased water prices across the connected Murray and especially the lower Murray region into the future. All existing irrigated agricultural enterprises should consider how these changes and risks can be managed. For example, a revised assumption about the average future cost of water may affect the economic viability of production for some industries or certain enterprises and could influence adjustment decisions.

- **New permanent horticulture entrants** – Investors in new permanent horticulture in the connected Murray, and lower Murray region in particular, should be mindful of the material existing water supply risks that this analysis has highlighted. Investors should also consider their ability to secure water in dry and extreme dry conditions and consider the costs of water before making long-term investment decisions.

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Implications for policy makers – Policy makers should consider the findings of this report when making decisions about further water market reform and the possible impacts of and design of any further environmental water recovery in the connected Murray and lower Murray regions. The recovery of additional environmental water from the consumptive pool would further reduce supply for all water users in the southern Murray-Darling Basin. This will both exacerbate the likelihood of permanent horticulture water demand exceeding available supply and also reduce the volume of water available for all irrigation industries in all future years.

4.5. Further research

4.5.1. The case for further research

The questions posed at the start of this report and explored throughout are critical to answer. Answers to these questions will inform the decisions that agricultural enterprises, water market participants and governments are making in relation to investments into irrigated agriculture, government policy on water recovery for the environment and the operational management of the southern Murray-Darling Basin. If these decision-makers do not have informed answers, then there is an increased risk that poor investment, operational and policy decisions will be made.

Poor investment or policy decisions have the potential to impact the future of communities and agricultural enterprises located in the southern Murray-Darling Basin as well as erode trust in the foundations of the environmental water recovery program, Basin Plan and government stewardship of our water resources. Therefore, it is imperative that the market understands the current and potential future balance of water supply and demand in the southern Murray-Darling Basin.

4.5.2. Recommended actions

To expand on this report, Aither recommends that further research be undertaken to provide a more detailed and accurate picture of the current and likely future water supply and demand situation. As a priority, Aither recommends the following actions be undertaken:

- Data collection and availability – Aither’s research for this report has revealed information gaps in knowledge about current areas of permanent horticulture, scale of water demand and potential for new developments in specific regions of the southern Murray-Darling Basin. For example, information sources disagree over exact current areas of permanent horticulture (particularly outside of established irrigation districts) and there is no easily accessible and aggregated detailed timeseries survey that provides sufficiently robust estimates on which to estimate future water demand. Aither recommends that this type of information is collected on a more frequent and consistent basis across all basin-states and with a higher degree of accuracy across time.

- Economic modelling of market impacts – Aither’s analysis in this report does not extend to undertaking economic modelling to estimate the specific water market impacts of growing permanent demand, existing and additional environmental water recovery, nor taking into account the impacts of trade constraints or market behaviours. Noting that previous modelling of this nature is potentially based on underestimates of permanent horticulture water demand, and therefore could underestimate potential impacts, undertaking new modelling would importantly quantify the potential impacts of the changing water supply and demand balance across different regions in the southern Murray-Darling Basin (see previous reports by Aither and others on this topic mentioned at Section 1.2). The results of updated economic modelling could be more tangibly used by existing agricultural enterprises, new market entrants and governments to make more informed decisions about the future.
5. References


Appendix A – Detailed water demand estimates

Appendix A provides a detailed description of estimates and underpinning assumptions for current and projected permanent horticulture water demand as summarised in Section 2 of the main report.

Historical water use by irrigated agriculture industry and year

Table 2  ABS water use data by irrigated agriculture industry and year, connected Murray, 2005-06 to 2016-17 (GL)

<table>
<thead>
<tr>
<th>Year</th>
<th>Fruits and nuts</th>
<th>Grapevines</th>
<th>Cotton</th>
<th>Livestock (inc. dairy)</th>
<th>Rice</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005-06</td>
<td>312</td>
<td>394</td>
<td>0</td>
<td>2141</td>
<td>544</td>
<td>351</td>
</tr>
<tr>
<td>2006-07</td>
<td>317</td>
<td>421</td>
<td>0</td>
<td>1273</td>
<td>40</td>
<td>218</td>
</tr>
<tr>
<td>2007-08</td>
<td>249</td>
<td>350</td>
<td>0</td>
<td>684</td>
<td>7</td>
<td>128</td>
</tr>
<tr>
<td>2008-09</td>
<td>278</td>
<td>321</td>
<td>0</td>
<td>545</td>
<td>15</td>
<td>137</td>
</tr>
<tr>
<td>2009-10</td>
<td>362</td>
<td>322</td>
<td>0</td>
<td>740</td>
<td>0</td>
<td>194</td>
</tr>
<tr>
<td>2010-11</td>
<td>308</td>
<td>238</td>
<td>3</td>
<td>585</td>
<td>343</td>
<td>221</td>
</tr>
<tr>
<td>2011-12</td>
<td>408</td>
<td>296</td>
<td>11</td>
<td>1088</td>
<td>477</td>
<td>276</td>
</tr>
<tr>
<td>2012-13</td>
<td>480</td>
<td>371</td>
<td>91</td>
<td>1765</td>
<td>718</td>
<td>372</td>
</tr>
<tr>
<td>2013-14</td>
<td>632</td>
<td>326</td>
<td>13</td>
<td>1663</td>
<td>508</td>
<td>430</td>
</tr>
<tr>
<td>2014-15</td>
<td>410</td>
<td>342</td>
<td>12</td>
<td>1619</td>
<td>418</td>
<td>342</td>
</tr>
<tr>
<td>2015-16</td>
<td>551</td>
<td>354</td>
<td>9</td>
<td>1167</td>
<td>77</td>
<td>360</td>
</tr>
<tr>
<td>2016-17</td>
<td>453</td>
<td>253</td>
<td>16</td>
<td>1173</td>
<td>483</td>
<td>292</td>
</tr>
</tbody>
</table>

Source: Aither 2018 based on ABS 2018.

Note: Water use data for 2016-17 does not include the New South Wales Lower Darling region given changes to ABS’s reporting boundaries. This may result in an underestimate of water use by fruits and nuts and grapevines for the connected Murray region in 2016-17.

Existing permanent horticulture water demand

Table 3  Estimated permanent horticulture water demand, Aither 2018-19 baseline demand, connected Murray (GL)

<table>
<thead>
<tr>
<th>Estimate</th>
<th>Total permanent horticulture water demand (GL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABS 2015-16 water use estimates</td>
<td>905</td>
</tr>
<tr>
<td>Aither existing baseline estimate (2018-19 current)</td>
<td>1,230</td>
</tr>
<tr>
<td>Additional existing demand at full maturity</td>
<td>162</td>
</tr>
<tr>
<td>Aither existing baseline estimate (at full maturity)</td>
<td>1,392</td>
</tr>
</tbody>
</table>

Source: Aither 2018 based on ABS 2018.
Projected permanent horticulture water demand

Table 4  Estimated permanent horticulture water demand, Aither projected demand, connected Murray (GL)

<table>
<thead>
<tr>
<th>Estimate</th>
<th>Total permanent horticulture water demand (GL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aither existing baseline estimate (at full maturity)</td>
<td>1,392</td>
</tr>
<tr>
<td>Plus additional projected demand at full maturity</td>
<td>164</td>
</tr>
<tr>
<td>Aither projected demand estimate (at full maturity)</td>
<td>1,556</td>
</tr>
</tbody>
</table>

Source: Aither 2018 based on ABS 2018 and other industry sources.

Comparison of irrigation corporation data to ABS water use data, connected Murray region

Notes: Please note that data for Murray Irrigation and Western Murray Irrigation does not capture water use outside of irrigation districts whereas ABS water use data does. This comparison is presented to triangulate permanent horticulture water use estimates for the lower Murray case study based on what we understand to be produced inside and outside of irrigation districts in the New South Wales Murray.

Figure 13  Comparison of permanent horticulture water use, ABS and irrigation corporation estimates, New South Wales Murray
Appendix B – Detailed water supply estimates

Appendix B provides a detailed description of Aither’s method, approach and assumptions for estimating future water availability as summarised in Section 2 of the main report.

Analytical framework

Aither’s approach and analytical framework to estimating water available for consumptive use in future years is as follows:

- Collected data on historical water availability across the southern Murray-Darling Basin (2005-06 to 2017-18).
- Constructed four different future water availability scenarios based on historical years (wet, moderate, dry and extreme dry).
- Multiplied entitlement on issue for all major surface water and groundwater entitlement types in the southern Murray-Darling Basin by the end of season allocation percentages determined through the selection of the four different future water availability scenarios.
- Estimated the volume of water that could theoretically be available to permanent horticulture in the connected Murray and lower Murray regions (assuming a perfectly efficient market) under these availability scenarios on an annual basis – including taking into account surface water and groundwater availability, trade constraints, and what is known about environmental water holdings and water use by urban water authorities.

Key assumptions

Treatment of carryover

Owners of certain water entitlements in the southern Murray-Darling Basin are allowed to carryover water into future water years. While carryover is able to be modelled based on historical evidence, given a large range of possible determining factors, it is complex to estimate exactly how much carryover may be available in future years. For this reason, we have excluded carryover from all water availability analysis in this report. The impact of this assumption is that we will estimate a lower bound water availability scenario than may occur in most future dry, average and wet years. However, in future extreme dry sequences, such as repeat of the Millennium Drought, carryover is likely to add marginal or no additional supply in some systems.

Treatment of environmental water holdings

In calculating the volumes of environmental water that will not be available to the consumptive pool in future years, Aither has accounted for both environmental water that was purchased from the market from relevant systems in Victoria, New South Wales and South Australia and volumes of water recovered in Victoria through on-farm programs. All other types of environmental water recoveries are not included in Aither’s calculations.
Treatment of trade constraints

There are several trade constraints in the southern Murray-Darling Basin that can limit the availability of water to various regions. A simplified approach to accounting for trade constraints was adopted for this analysis. Specifically, it was assumed that the connected Murray is one system with no binding constraints (but no trade in from the Murrumbidgee), and the Murrumbidgee is a separate system with no trade in from the connected Murray. To the extent that trade is limited out of the Goulburn and from above the Barmah Choke, the analysis might overestimate the volume of water available to permanent horticulture located in the lower Murray region of the connected Murray.

Water supply in the connected Murray

The total underlying supply of water in the connected Murray region is a combination of the volume of water carried over into a new water year and the volume of water allocated to all entitlements in a given year (both surface water and groundwater). To estimate consumptive supply, we have approximated what percentage of the total underlying supply permanent horticulture and all other irrigated agricultural industries will likely have access to in future years.

Total underlying supply of water

For the 2018-19 water year, the various southern Murray-Darling Basin state water registers report that there is approximately 6,065 GL of water entitlements on issue across major systems in the connected Murray (Table 5). The total volume of entitlement on issue does not change dramatically year to year and is not expected to materially change into the foreseeable future.

Table 5  Total volume of entitlement on issue, connected Murray (GL)

<table>
<thead>
<tr>
<th>Entitlement type</th>
<th>2018-19 volume on issue (GL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vic 1A Greater Goulburn HRWS</td>
<td>950</td>
</tr>
<tr>
<td>Vic Murray HRWS</td>
<td>1,220</td>
</tr>
<tr>
<td>NSW Murray HS</td>
<td>194</td>
</tr>
<tr>
<td>SA Murray HS</td>
<td>548</td>
</tr>
<tr>
<td>Vic 1A Greater Goulburn LRWS</td>
<td>427</td>
</tr>
<tr>
<td>Vic Murray LRWS</td>
<td>300</td>
</tr>
<tr>
<td>NSW Murray GS</td>
<td>1,675</td>
</tr>
<tr>
<td>NSW Lower Darling HS</td>
<td>8</td>
</tr>
<tr>
<td>NSW Lower Darling GS</td>
<td>80</td>
</tr>
<tr>
<td>Vic 2 Broken HRWS</td>
<td>18</td>
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<tr>
<td>Vic 2 Broken LRWS</td>
<td>3</td>
</tr>
<tr>
<td>Vic 4A Campaspe HRWS</td>
<td>22</td>
</tr>
<tr>
<td>Vic 4A Campaspe LRWS</td>
<td>19</td>
</tr>
<tr>
<td>Vic 4C Campaspe HRWS</td>
<td>2</td>
</tr>
<tr>
<td>Vic 1B Boort HRWS</td>
<td>81</td>
</tr>
<tr>
<td>Vic 1B Boort LRWS</td>
<td>37</td>
</tr>
</tbody>
</table>
Based on what is known about historical allocations to entitlements in the southern Murray-Darling Basin, representative years can be chosen to develop a series of potential water availability scenarios that account for possible variability in future water availability (Table 6).

### Table 6

**End of season water allocation percentage scenarios, connected Murray**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vic 1A Greater Goulburn HRWS</td>
<td>57%</td>
<td>90%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Vic Murray HRWS</td>
<td>43%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>NSW Murray HS</td>
<td>25%</td>
<td>97%</td>
<td>97%</td>
<td>100%</td>
</tr>
<tr>
<td>SA Murray HS</td>
<td>32%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Vic 1A Greater Goulburn LRWS</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Vic Murray LRWS</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>NSW Murray GS</td>
<td>0%</td>
<td>23%</td>
<td>61%</td>
<td>100%</td>
</tr>
<tr>
<td>NSW Lower Darling HS</td>
<td>0%</td>
<td>80%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>NSW Lower Darling GS</td>
<td>5%</td>
<td>0%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Vic 2 Broken HRWS</td>
<td>71%</td>
<td>26%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Vic 2 Broken LRWS</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Vic 4A Campaspe HRWS</td>
<td>100%</td>
<td>66%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Vic 4A Campaspe LRWS</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>Vic 4C Campaspe HRWS</td>
<td>100%</td>
<td>66%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>
--- | --- | --- | --- | ---
Vic 1B Boort HRWS | 57% | 90% | 100% | 100%
Vic 1B Boort LRWS | 0% | 0% | 0% | 0%
Vic 3 Goulburn HRWS | 57% | 90% | 100% | 100%
Vic 3 Goulburn LRWS | 0% | 0% | 0% | 0%
Vic 5A Loddon HRWS | 3% | 84% | 100% | 100%
Vic 5A Loddon LRWS | 0% | 0% | 0% | 0%
Vic 6B Lower Broken Creek HRWS | 43% | 100% | 100% | 100%
Vic 6B Lower Broken Creek LRWS | 0% | 0% | 0% | 0%
NSW Lower Murray Groundwater | 100% | 100% | 100% | 100%
Victorian groundwater | 100% | 100% | 100% | 100%

Source: Aither 2018 based on Victorian, South Australian and New South Wales water registers.

Note: Allocation percentages are based on what is reported on state water registers for actual past years and in some cases for specific entitlement types allocations are higher in extreme dry years than in dry years (for example NSW Lower Darling GS).

On the basis of the known entitlement on issue and constructed water allocation scenarios, Table 7 presents total underlying supply of water in the connected Murray in future years.

Table 7    Total volume of water available, connected Murray (GL)

|--- | --- | --- | --- | ---
| Vic 1A Greater Goulburn HRWS | 542 | 855 | 950 | 950 |
| Vic Murray HRWS | 525 | 1,220 | 1,220 | 1,220 |
| NSW Murray HS | 49 | 188 | 188 | 194 |
| SA Murray HS | 175 | 548 | 548 | 548 |
| Vic 1A Greater Goulburn LRWS | 0 | 0 | 0 | 0 |
| Vic Murray LRWS | 0 | 0 | 0 | 0 |
| NSW Murray GS | 0 | 385 | 1,022 | 1,675 |
| NSW Lower Darling HS | 0 | 6 | 8 | 8 |
| NSW Lower Darling GS | 4 | 0 | 80 | 80 |
| Vic 2 Broken HRWS | 13 | 5 | 18 | 18 |
| Vic 2 Broken LRWS | 0 | 0 | 3 | 3 |
--- | --- | --- | --- | ---
Vic 4A Campaspe HRWS | 22 | 15 | 22 | 22
Vic 4A Campaspe LRWS | 0 | 0 | 0 | 19
Vic 4C Campaspe HRWS | 2 | 1 | 2 | 2
Vic 1B Boort HRWS | 46 | 73 | 81 | 81
Vic 1B Boort LRWS | 0 | 0 | 0 | 0
Vic 3 Goulburn HRWS | 12 | 19 | 21 | 21
Vic 3 Goulburn LRWS | 0 | 0 | 0 | 0
Vic 5A Loddon HRWS | 1 | 18 | 21 | 21
Vic 5A Loddon LRWS | 0 | 0 | 0 | 0
Vic 6B Lower Broken Creek HRWS | 10 | 24 | 24 | 24
Vic 6B Lower Broken Creek LRWS | 0 | 0 | 0 | 0
NSW Lower Murray Groundwater | 85 | 85 | 85 | 85
Victorian groundwater | 305 | 305 | 305 | 305
**Total (environmental and consumptive)** | **1,790** | **3,747** | **4,598** | **5,276**

Source: Aither 2018 based on Victorian, South Australian and New South Wales water registers.

Note: Allocation percentages are based on what is reported on state water registers for actual past years and in some cases for specific entitlement types allocations are higher in extreme dry years than in dry years (for example NSW Lower Darling GS). Please note that individual figures have been rounded and may not sum exactly to total.

### Access to underlying water supply for irrigated agriculture

Knowing the total potential underlying supply of water is one part of the equation, but the scope of this engagement is to assess how much of this water may be available to irrigated agricultural industries – in particular permanent horticulture. To estimate this, we need to approximate what percentage of the total underlying supply irrigated agricultural industries will likely have access to in future years.

By using the above water availability scenarios and excluding certain types of environmental water (Table 8), urban water and carryover as a possible source of water, taking into account trade

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28 In calculating the volumes of environmental water that will not be available to the consumptive pool in future years, Aither has accounted for environmental water that was purchased from the market from relevant systems in Victoria, New South Wales and South Australia and volumes of water recovered in Victoria through on-farm programs. All other types of environmental water recoveries are not included in Aither’s calculations. Please see Appendix B for more detailed data.

29 Note we have assumed a fixed 20 GL urban water demand by Lower Murray Water, which is removed from the consumptive pool in all future water availability scenarios. Melbourne’s metropolitan retailers own approximately 75 GL of water entitlements in the Murray which are currently not used for urban purposes and rather sold back into
constraints,\textsuperscript{30} including allocations to groundwater and assuming Victorian Low Reliability Water Share (LRWS) entitlements do not receive ‘large’ allocations in any future years, we can estimate what volume of consumptive supply may be available to meet the demands of permanent horticulture industries in the connected Murray in future years. Taking these factors into account, it is reasonable to assume that the total underlying consumptive supply of water potentially available to permanent horticulture and all other irrigation industries in the connected Murray in future years could be equal to:

- 1,510 GL in extreme dry sequences (similar to 2007-08)
- 3,100 GL in dry sequences (similar to 2015-16)
- 3,790 GL in moderate sequences (similar to 2014-15)
- 4,370 GL in wet sequences (similar to 2011-12).

Table 8 Volumes of environmental water recovered from the consumptive pool and not available to irrigated agriculture, connected Murray (GL)

<table>
<thead>
<tr>
<th>Entitlement type</th>
<th>Environmental water purchases (GL)</th>
<th>On-farm recovery from Victoria (GL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vic 1A Greater Goulburn HRWS</td>
<td>194</td>
<td>22</td>
</tr>
<tr>
<td>Vic Murray HRWS</td>
<td>241</td>
<td>21</td>
</tr>
<tr>
<td>NSW Murray HS</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>SA Murray HS</td>
<td>101</td>
<td>0</td>
</tr>
<tr>
<td>Vic 1A Greater Goulburn LRWS</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>Vic Murray LRWS</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>NSW Murray GS</td>
<td>254</td>
<td>0</td>
</tr>
<tr>
<td>NSW Lower Darling HS</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>NSW Lower Darling GS</td>
<td>38</td>
<td>0</td>
</tr>
<tr>
<td>Vic 2 Broken HRWS</td>
<td>0</td>
<td>0.3</td>
</tr>
<tr>
<td>Vic 2 Broken LRWS</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vic 4A Campaspe HRWS</td>
<td>6</td>
<td>0.1</td>
</tr>
<tr>
<td>Vic 4A Campaspe LRWS</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

the market on an annual basis. In all future water availability scenarios, we have assumed that this water continues to be available to irrigators.

\textsuperscript{30} A simplified approach to assessing trade constraints was adopted for this analysis. Specifically, it is assumed that the Murray and Goulburn systems are one system with no binding constraints (but no trade in from the Murrumbidgee), and the Murrumbidgee is a separate system with no trade in from the Murray. To the extent that trade is limited out of the Goulburn and from above the Barmah Choke, the analysis might overestimate the volume of water available to irrigated agriculture in the lower Murray region.
<table>
<thead>
<tr>
<th>Entitlement type</th>
<th>Environmental water purchases (GL)</th>
<th>On-farm recovery from Victoria (GL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vic 4C Campaspe HRWS</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vic 1B Boort HRWS</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vic 1B Boort LRWS</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vic 3 Goulburn HRWS</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vic 3 Goulburn LRWS</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vic 5A Loddon HRWS</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Vic 5A Loddon LRWS</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vic 6B Lower Broken Creek HRWS</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vic 6B Lower Broken Creek LRWS</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>NSW Lower Murray Groundwater</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Victorian groundwater</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>892</strong></td>
<td><strong>44</strong></td>
</tr>
</tbody>
</table>

Source: Aither 2018 based on DAWR 2018 and provided to Aither by DELWP.
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