Regional Water Strategy

Western – Attachment 5: Analysis on replenishment flows

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Cover image Image courtesy of Destination NSW. Menindee Lakes, Menindee.

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This attachment presents the analysis of the benefits and the impacts of breaking up cease-to-flow periods in the Barwon–Darling periods by releasing replenishment flows from the northern tributaries. This was Option 46: Deliver replenishment flows from the Border Rivers, Gwydir, Namoi and Macquarie valleys in the Draft Western Regional Water Strategy.

This option has been shortlisted in the Final Western Regional Water Strategy as Action 3.3: Further investigate ways to provide replenishment flows from the northern tributaries during dry periods.

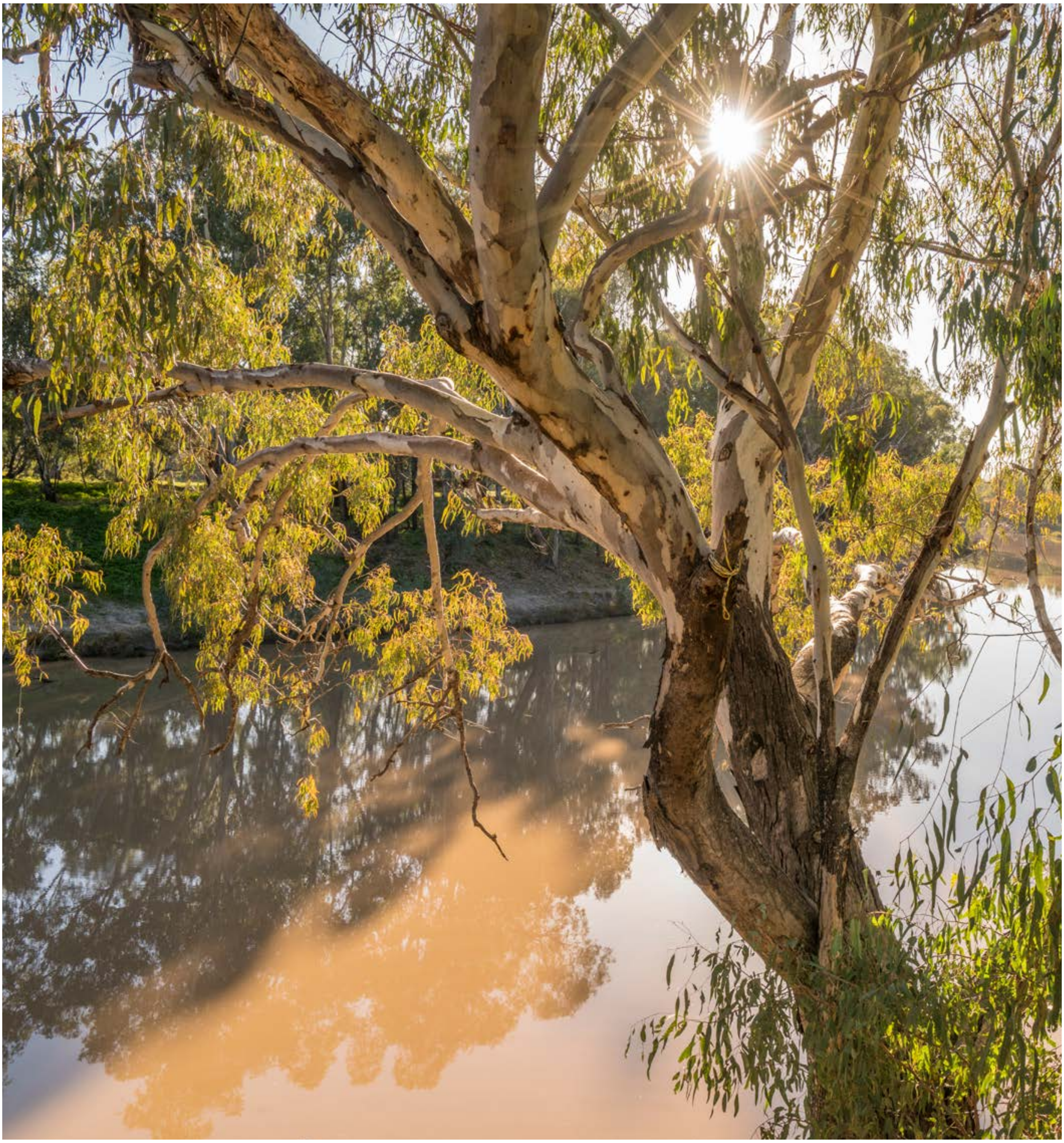


Image courtesy of Destination NSW. Darling River, Bourke.

1. Connectivity objectives addressed by this option

This option aims to meet the connectivity objective of reducing the impact of low-flow and cease-to-flow events. The premise of replenishment flows is to provide water from storages in the tributaries to meet connectivity benefits in the Barwon–Darling River.

2. Option proposed in the Draft Western Regional Water Strategy

Option 46 in the Draft Western Regional Water Strategy examined whether water from the Border Rivers, Gwydir, Namoi and Macquarie catchments could help to address extended cease-to-flow events in the Barwon–Darling. The option canvassed the following implementation pathways:

- exploring more opportunities to use held environmental water to reduce extended low-flow and cease-to-flow events in the Barwon–Darling and provide replenishment flows from the northern tributaries
- increasing the amount of water that would be required to flow into the Barwon–Darling by introducing end-of-system flow targets in the Macquarie–Castlereagh and Gwydir valleys and amending the Namoi and Border Rivers end-of-system targets
- increasing dam reserves in the northern tributaries to store and deliver water to the Barwon–Darling
- strategic purchase or trade of licences for critical needs – during good water years, the excess allocations could be sold on the temporary water market to make it cost neutral for the government over time.

Image courtesy of Michael Scotland. Barwon–Darling River, Bourke.

3. Outcomes of the analysis

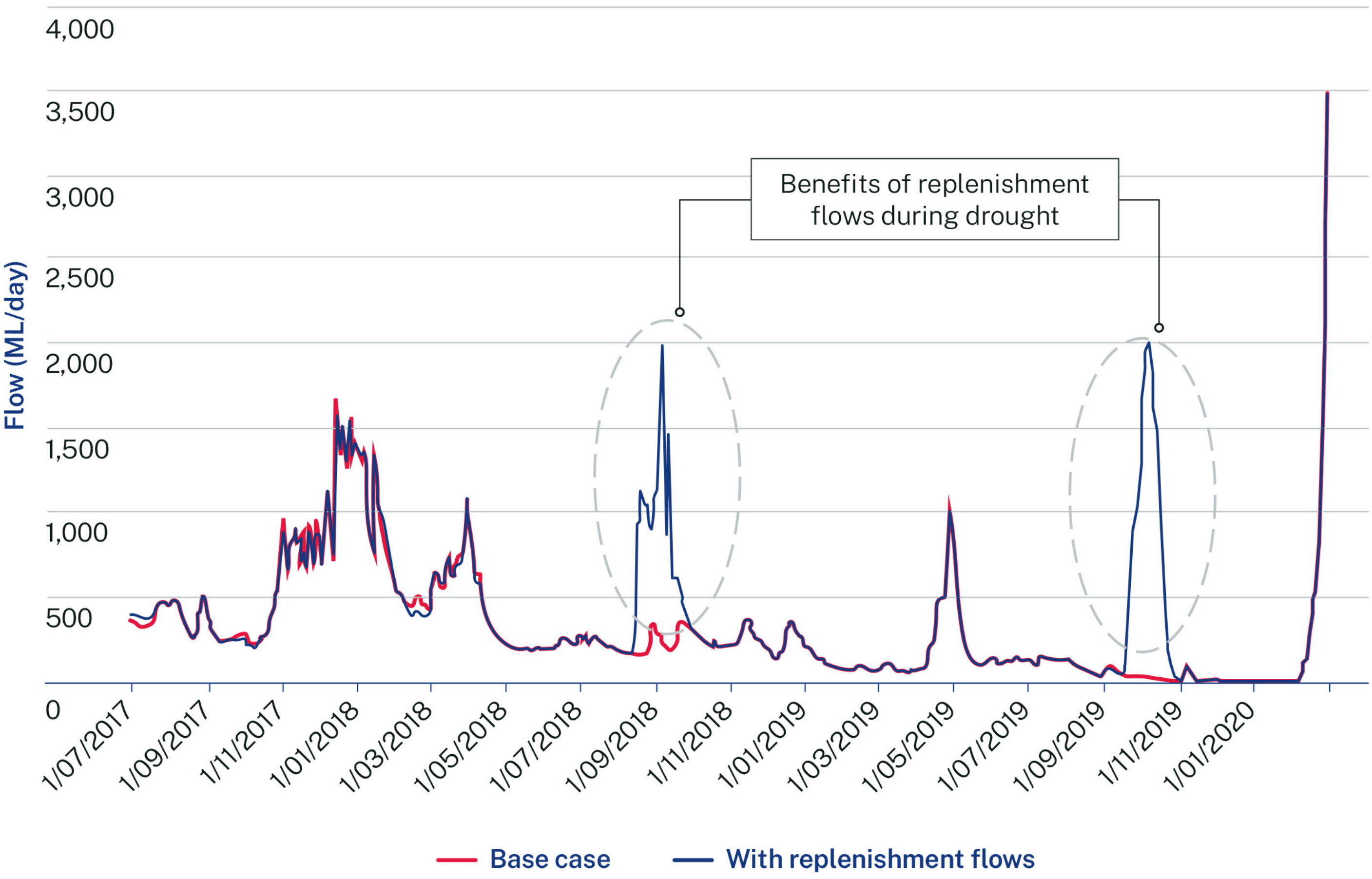
A high-level, strategic analysis was undertaken for the final strategy to understand whether this option could help achieve its objective and whether it merited further investigation. It did this by using the river-system models to make replenishment-style releases from major dams in the Border Rivers, Gwydir and Namoi valleys when a dry condition target had been met.

The option was modelled by:

- releasing water from northern valley dams when the resumption of flow (RoF) rule requires a 'No-Flow Class' to be declared (as defined in the Barwon–Darling Water Sharing Plan) in the Brewarrina to Bourke river section or the Bourke to Wilcannia River section
- the target for this modelling was at least a week of flows at Bourke with peak flows above 972 ML/day (for up to 10 days), and at least 30 GL total event volume. This is consistent with the resumption-of-flow rule in the Barwon–Darling Water Sharing Plan and is a useful proxy for estimating when conditions have been dry for too long.

The modelling results show that replenishment flows from dams in the northern Basin could have been used to break up 2 particularly dry spells (September 2018 and October 2019) at Bourke during the last drought (Figure 1). Figure 1 also shows that the use of replenishment flows would need to be considered strategically as there were other times when their use provided little additional benefit to flows beyond the resumption of flow restrictions at Bourke.

Figure 1. Flows at Bourke with and without replenishment flows during the last drought

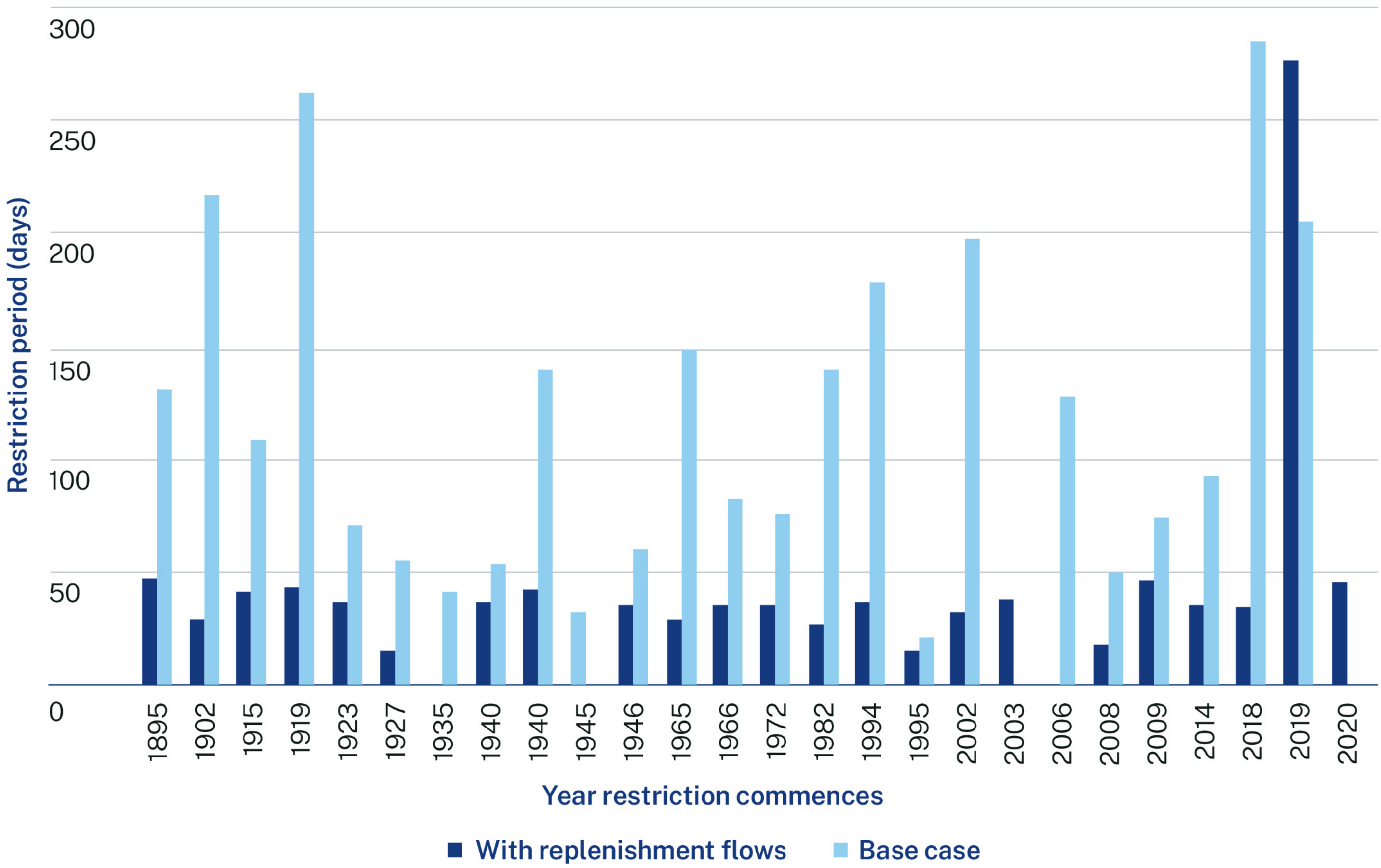


We looked at how often the resumption of flow rule would be triggered in the Barwon–Darling with and without the replenishment flow scenario as a proxy to understand whether the option could reduce the time the river is 'too dry for too long'.

The analysis suggests that replenishment flows could considerably reduce the time a resumption-of-flow rule is triggered in the Barwon–Darling and as a result, reduce restriction periods for Barwon–Darling water users in the years where restrictions would have been required. Under the base case, the resumption-of-flow restrictions would be triggered in over 22% of years.

Although the replenishment flows made little change to the number of events, the average number of days for each restriction event drops from 105 days (base case) to 38 days (replenishments scenario). The replenishment flows significantly reduced the restriction times, particularly for the longer events (Figure 2).

Figure 2. Number of days resumption-of-flow restrictions are in place at Bourke with and without replenishment flows



This analysis is high level and strategic and suggests the option merits further investigation. Further work would need to be undertaken on appropriate triggers and implementation models.

There are a number of different ways that replenishment flows could be delivered including by using held environmental water, temporary purchase or trade of licences at certain times for critical needs, or provided by setting aside additional water in dams for connectivity purposes. Each implementation option has benefits, impacts and costs; and will need to be thoroughly investigated.

If the option was to be pursued by setting aside more water in dams, the modelling indicates that the average changes to long-term diversions range from a 1% increase in diversions in the Barwon–Darling to a 2.9% reduction in diversions in the Namoi as a result of reserving water in dams for connectivity releases (Table 1).

Table 1. Long term average and maximum annual impact on diversions from using replenishment flows releases from tributary water storages*

Valley	Long term average impact on diversions	Maximum annual impact on diversions
Border Rivers	-2.9%	-31.8 (-19%)
Gwydir	-1.1%	-36.6 (-6%)
Namoi	-2.9%	-35.9 (-9%)
Barwon–Darling	+1.2%	N/A

*Corrections to this table were made in August 2023.
Note: Maximum annual impacts are expressed as a volume, and in parentheses as a percentage of the base case diversions in that year.

Image courtesy of Department of Planning and Environment – Environment and Heritage. Western Floodplain, Toorale.

On average over a 40-year period, this could lead to a reduction in economic activity of $89 million across all impacted catchments, which equates to a reduction of 1.8% in compared to the base case. This impact is greater in the Border Rivers and Namoi, with reductions in economic activity of approximately 3% in each (Table 2).[1]

Table 2. Average present value (40 years) economic impacts to northern tributaries and Barwon–Darling

Valley	Average Economic Impact ($PV, million)	Average Economic Impact (%)
Border Rivers	-31.7	-3.1
Gwydir	-24.3	-1.0
Namoi	-34.4	-3.2
Barwon–Darling	1.3	0.2
Total	**-89.0**	**-1.8**

There are positive impacts likely in the Barwon–Darling, with small improvements as restrictions subsequently end following the replenishment flows and take longer to reoccur. This is expected to lead to an average economic improvement of $1.3 million over a 40-year period, which represents an average improvement of nearly 12% for towns, and 0.2% for the Barwon–Darling overall.

Further analysis needs to be undertaken on additional implementation pathways as well as the most appropriate trigger for releasing replenishment flows if there is merit found in implementing this option.

How this option changes flows

The main flow component changes from this option were to baseflows, low flows and cease-to-flow periods. The effects on these flow components were in ecologically beneficial directions with improved flow conditions in the Barwon–Darling River.

There were improvements in the amount of water in the Barwon–Darling River during lower flows. In particular, the 80th, 90th and 95th percentile flows all increased – with overall extreme improvements and ranging from minor to extreme improvements (Table 3). The average number and the duration of days that flows were at or below the 90th percentile also improved with overall minor to extreme improvements. These results suggest there would be more water in the river during these lower flows.

Cease-to-flow periods also improved under this option. Cease-to-flow periods were modelled to reduce in the frequency and duration of events (Table 3). It is important to note that the variability in the results for the gauges was high, ranging from extreme improvements to no change and this reflects the ongoing difficulties in modelling cease-to-flow and low flows. The variability in results may require further exploration as inflows and extraction pressure throughout the systems are variable.

1. The economic analysis considered major extractive water users including towns, annual agriculture users, and permanent agriculture users within each region. Environmental benefits have not been captured within this analysis due to the high degree of uncertainty of their economic valuation. However, ecohydrology analysis has been completed which provides an understanding of changes in environmental metrics. All economic values presented are averages of present values calculated over 13 overlapping 40-year periods of a historical climate dataset, from 1896 to 2020.

Table 3. Modelled change in ecological flow metrics in the Barwon–Darling River when replenishment flows are delivered by restricting B Class and C Class licences in the Barwon–Darling and additional releases from the Border Rivers, Gwydir and Namoi catchments

Metric	Tributary replenishment with inland diversion (average % effect)	Tributary replenishment with inland diversion (range of effects across gauges)
Years in record	No change	No change
Mean annual flow	Little improvement	Little improvement to minor improvement
Median annual flow	Minor improvement	Little improvement to minor improvement
Number of years with a cease-to-flow event	Major improvement	Extreme improvement to no change
Number of cease-to-flow events	Extreme improvement	Extreme improvement to no change
Mean duration of cease-to-flow events	Minor improvement	Moderate improvement to no change
Number of freshes	Little improvement	Little impact to minor improvement
Mean duration of fresh events	No change	Minor impact to minor improvement
Number of years with ≥ 1 fresh event	Little improvement	Little impact to minor improvement
1.5-year ARI flow rate	No change	Minor impact to little improvement
2.5-year ARI flow rate	Little improvement	No change to little improvement
5-year ARI flow rate	No change	Little impact to no change
10-year ARI flow rate	No change	No change
95th percentile flow rate	Extreme improvement	Minor improvement to extreme improvement
90th percentile flow rate	Extreme improvement	Minor improvement to extreme improvement
80th percentile flow rate	Extreme improvement	Major improvement to extreme improvement
20th percentile flow rate	Little improvement	Little improvement to minor improvement
10th percentile flow rate	Little improvement	Little improvement
Mean days below base case 90th	Extreme improvement	Extreme improvement to major improvement
Mean duration of base case 90th or lower	Minor improvement	Moderate improvement to minor impact
Mean duration of base case 20th or lower	No change	Little improvement to no change

Changes to end of system tributary flows

This option provides a range of benefits to the different flow components in the 3 valleys (Table 4).

The Border Rivers end-of-system was modelled to have a minor benefit in the average duration of cease-to-flow events. Low flows were also modelled to provide a moderate to extreme improvement for the 80th and 90th percentiles and a minor improvement in the number of days below the 90th percentile. There was little to no change in the other metrics.

The Gwydir River end-of-systems (Mehi and Gil Gil) were modelled to have minor improvements in the median annual flow. Contributing to this increase was minor to extreme improvement for all flow percentiles (95th, 90th, 80th, 20th, and 10th). Mean days below the 90th percentile and freshes flow threshold had minor improvements. There was a minor impact on the mean duration of cease-to-flow events in the Mehi River.

Cease-to-flow conditions in the Mehi River also had a minor to moderate improvement in the number of years with at least one event and the number of cease-to-flow events, respectively. However, the mean duration of events increased, showing a minor impact. There was little to no change in the Gil Gil at Galloway.

The Namoi River had an extreme improvement in the 80th percentile, however results are likely overestimates as flow rates are very low and the proportional changes are large. Fresh flows discharges (20th percentile) and the number of fresh-sized events increased, showing minor improvements. Cease-to-flow conditions had a minor improvement. There was a minor impact on the mean duration of freshes.

Image courtesy of Sally Anderson-Day. Barwon River, Brewarrina.

Table 4. Modelled change in ecological flow metrics when replenishment flows are delivered from the Border Rivers, Gwydir and Namoi catchments

Metric	Border Rivers	Gwydir		Namoi
	416001 Barwon River at Mungindi	418055 Mehi at Collarenebri	416052 Gil Gil at Galloway	419091 Namoi at upstream of Walgett
Number of years in the time series data	No change	No change	No change	No change
Mean annual flow	Little improvement	Little improvement	Little improvement	No change
Median annual flow	Little improvement	Minor improvement	Minor improvement	Little improvement
Number of water years with at least one identified cease-to-flow event	Little improvement	Minor improvement	No change	Little improvement
Number of cease-to-flow events	Little improvement	Moderate improvement	Little improvement	Minor improvement
Mean duration (days) of cease-to-flow events	Minor improvement	Minor impact	Little improvement	Little improvement
Flow rate (ML/day) for 20th percentile discharge of daily flows	No change	No change	No change	No change
Number of freshes (freshes flow)	Little improvement	Minor improvement	No change	Minor improvement
Mean duration (days) of 'freshes flow' events	Little impact	Little improvement	Minor improvement	Minor impact
Number of years with ≥ 1 'freshes flow'	Little improvement	Little improvement	No change	Little improvement
1.5-year ARI flow rate (ML/day)	Little impact	No change	No change	No change
2.5-year ARI flow rate (ML/day)	No change	No change	Little improvement	No change
5-year ARI flow rate (ML/day)	Little impact	No change	Little improvement	No change
10-year ARI flow rate (ML/day)	No change	Little improvement	No change	No change
Flow rate (ML/day) for 95th percentile discharge of daily flows	No change	Moderate improvement	No change	No change

Table 4. Modelled change in ecological flow metrics when replenishment flows are delivered from the Border Rivers, Gwydir and Namoi catchments (continued)

Flow rate (ML/day) for 90th percentile discharge of daily flows	Extreme improvement*	Minor improvement	Extreme improvement*	No change
Flow rate (ML/day) for 80th percentile discharge of daily flows	Moderate improvement	Minor improvement	Extreme improvement*	Extreme improvement*
Flow rate (ML/day) for 20th percentile discharge of daily flows	No change	Minor improvement	Minor improvement	Minor improvement
Flow rate (ML/day) for 10th percentile discharge of daily flows	Little improvement	Moderate improvement	Minor improvement	No change
Mean number of number of days ≤ base case 90th percentile	Minor improvement	Minor improvement	Minor improvement	Minor improvement
Mean duration of consecutive days at base case 90th percentile or lower	No change	Little improvement	Little improvement	No change
Mean number of days flows are below the base case freshes flow threshold	Little improvement	Minor improvement	Little improvement	Minor improvement

*The results are likely overestimates as flow rates are very low and the proportional changes are large.

Note on the gauges used to analyse this option

We analysed the hydrologic time-series model outputs for 15 flow gauges along the Barwon–Darling and at the end-of-system of the Border Rivers, Gwydir and Namoi rivers. Flow data from the Macquarie Valley was omitted because the overall contributions were considered to be less significant than the other 3 valleys. These gauges provided a good representation of how flow conditions can change along the Barwon–Darling when the inflows from different valleys are also changed. Hydrologic models are imperfect, and can occasionally generate results that are unlikely to be accurate. By assessing modelled data from all possible gauges, we were able to more readily identify results that seemed unlikely or anomalous when compared to gauges that were immediately upstream or downstream.

The flow gauges used in our models were:

- Barwon River at Mungindi (416001)
- Barwon River upstream of Presbury (416050)
- Barwon River at Mogil Mogil (422004)
- Barwon River at Collarenebri (422003)
- Barwon River at Tara (422025)
- Barwon River at Dangar Bridge (Walgett) (422001)
- Barwon River at Boorooma (422026)
- Barwon River at Geera (422027)
- Barwon River at Brewarrina (422002)
- Barwon River at Beemery (422028)
- Darling River at Warraweena (425039)
- Darling River at Bourke Town (425003)
- Darling River at Louth (425004)
- Darling River at Tilpa (425900)
- Darling River at Wilcannia Main Channel (425008).

End-of-system gauges used in the models were:

- Barwon River at Mungindi (416001) – Border Rivers end of system
- Mehi River at Collarenebri (418055) – Gwydir River end of system
- Gil Gil at Galloway (416052) – Gwydir River end of system
- Namoi River at upstream Walgett – Namoi River end of system.

Image courtesy of John Spencer, Department of Planning and Environment. Darling River, Kinchega National Park.

4. Proposed approach

The analysis demonstrates that replenishment flows could have a beneficial impact – reducing the duration or preventing periods of very low flow and substituting these with baseflows or small freshes to replenish town water supplies and supply critical environmental needs. As a result, this option merits further investigation.

There are a range of ways of implementing this option and these implementation methods have not been thoroughly analysed. Each implementation option has its own benefits, costs and impacts.

Using dam reserves comes with impacts to water users. It may be that the other replenishment flows options such as purchasing or trading water entitlements or using held environmental water for replenishment flows have less impact on most water users, but they have other trade-offs such as how water can be used for other environmental needs.

This option has been shortlisted as an action in the Western Regional Water Strategy. Progressing this action will require significant additional analysis and consultation with the community and various levels of government.

Image courtesy of Destination NSW. Menindee Lake, Menindee.

Image courtesy of Annette Corlis. Paroo River, Wilcannia.

Department of Planning and Environment