Connectivity Expert Panel
Interim Report

March 2024

Acknowledgements
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Cover image: Barwon-Darling River, between Wilcannia and Menindee. Image courtesy of Mark Southwell.

Acknowledgement of Country

The Panel acknowledges and pays respect to all the traditional owners and their Nations of the Murray-Darling Basin and the Barwon-Darling area. We recognise and acknowledge that the traditional owners have a deep cultural, social, environmental, spiritual and economic connection to their lands and waters. We value and respect the knowledge and cultural values in natural resource management and the contributions of earlier generations, including the Elders. First Nations people comprise a minority of the population across the NSW Murray Darling Basin Northern Basin. However, in some Local Government jurisdictions, First Peoples are the majority of the populations. Many of those First Peoples and communities are oppressed, marginalised and dispossessed of land, water, knowledge and a cultural life. The legacy of the dispossession continues in economic, social and political disadvantage.

People and Country (including lands and waterways) are interdependent entities that are intrinsically linked in the landscape through cultural and spiritual significance. This means that there is no separation of nature and culture - the health of the natural environment and cultural wellbeing of Aboriginal people is directly influenced by the health of the cultural landscapes.

Over these millennia, First Peoples and communities have sustainably managed their lands, waters and natural resources for the health of our Countries and their peoples. First Peoples have understood the importance of water and its centrality to life and have cherished it accordingly. First Peoples' traditional ecological knowledge, like their stories, are passed down from generation to generation and continue up until this day. This has allowed First Peoples to live in a symbiotic relationship with the land and water.

The First People of the NSW Northern Murray Darling Basin communities have complex knowledges, which support and reinforce their relationship and deep connection to Country as the Traditional Owners of their cultural landscapes. They have distinct responsibility to care for Country and in particular, protect cultural sites of significance. Increasingly, in Australia and globally, Indigenous knowledges are being recognised as an increasingly important factor in human and planet survival[1]. Application of First Peoples' knowledges is recognised internationally as relevant and practical importance to adaptation and mitigation of adverse impacts of a changing climate[2].

[1] Luisa Maffi and Ellen Woodley, Biocultural Diversity Conservation: A Global Sourcebook (Earthscan, London and Washington DC, 2010

[2] Douglas Nakashima, Kirsty Galloway McLean, Hans Thulstrup, Ameyali Ramos Castillo and Jennifer Rubis *Weathering Uncertainty Traditional knowledge for climate change assessment and adaptation UNESCO,UNU,2012*

Executive summary

The Connectivity Expert Panel was convened by the Minister for Water to provide advice on the adequacy and potential improvements to rules in the NSW Northern Basin water sharing plans that might materially impact on hydrological connectivity. The Panel was specifically asked to consider the adequacy of current and proposed targets and triggers for restricting supplementary and floodplain harvesting, as well as A, B and C class licences in the Barwon-Darling.

There are many definitions of connectivity including longitudinal, lateral (floodplain) and vertical (surface to groundwater) connectivity. Given the scope of the Terms of Reference, the Panel agreed to focus on longitudinal connectivity within the Northern Basin – that is, ensuring connectivity from the Northern Tributaries through the Barwon-Darling down to Menindee Lakes. We recognise the importance of other forms of connectivity and encourage those to be investigated further where needed.

River connectivity plays a crucial role in maintaining the health and functionality of aquatic ecosystems and supporting socio-economic activities and communities reliant on water resources. It is essential for the health of First Peoples and their ability to sustain their traditional life, languages, cultures and knowledge.

This interim report presents the Panel's proposed approach to managing connectivity holistically across the Northern Basin, focusing not just on restoring connectivity following dry periods, but maintaining connectivity when water is readily available to provide for healthy and resilient ecosystems. The Panel has sought to provide clear targets and objectives for achieving connectivity.

Previous findings and government responses related to connectivity

Several previous reviews have highlighted a decline in the health of downstream ecosystems and considerable impacts to communities due to the lack of consideration of connectivity in the NSW Northern Basin water sharing plans. Water sharing plans are, by their nature, designed to maximise outcomes *within* the Plan area, which typically covers regulated, unregulated or groundwater sources in a particular catchment. There is no clear legislative requirement or governance arrangements to drive consideration or coordination of system-wide connectivity. While there are many tools that could contribute to connectivity available within water sharing plans, these are currently not used, or are not designed, to achieve inter-valley connectivity.

The Department has taken recent steps to address concerns with connectivity, but the responses have been somewhat piecemeal. They have largely focused on how to address connectivity during or immediately following dry times, citing this as the most difficult time to achieve connectivity. However, the evidence indicates that the current rules are jeopardising social and environmental needs, not just during dry times, but at all times. There is evidence that opportunistic take in the tributaries (supplementary and floodplain harvesting) is impacting on achievement of baseflows downstream. The Panel is of the view that this is not appropriate or consistent with the priorities specified in the water sharing principles of the Act[3]. Our recommendations aim to address this by seeking to rebalance extraction with downstream social and environmental needs.

Panel's proposed approach for improving connectivity outcomes

[3] Water Management Act 2000, Section 5(3)

Low flow and cease to flow periods form a part of the natural flow regime of the Northern Basin. However, the frequency and duration of these periods have increased over the past several decades. In addition, small and medium sized flow events have been impacted due to extraction for irrigation. These changes to the hydrology of the system are having a significant effect on connectivity, ecosystem resilience and environmental, social and cultural outcomes.

The system is currently being operated in a way that runs it dry and then restarts it much more frequently than would have historically occurred. This is highly inefficient as the riverbed acts like a sponge; the drier it gets the more water it takes to get flows downstream as the riverbed soaks up flows, and the pools and weirs must be filled along the way. This has negative impacts on the ecosystem and communities downstream, particularly the Aboriginal communities who place a high cultural value on flowing rivers.

The Panel recognises that in varying climatic conditions, different management approaches and targets are necessary. We have focused our recommendations on trying to maintain adequate connectivity during non-dry times, when water is more readily available, to keep the system wetter more often and rebuild the resilience of the system so that it can tolerate dry times better.

This will become more and more critical given climate change predictions. We have identified a subset of environmental water requirements from the Long-Term Water Plans that are related to ecosystem function and intended to provide for connectivity as representing critical needs for connectivity downstream. These include providing baseflows, and occasional small and large freshes, which we feel should be met during non-dry times.

The Panel has also recommended improvements to rules for managing connectivity during and following dry periods and recognises that in these times different management approaches and targets are necessary.

Consideration of impacts

The Panel has remained acutely aware of the potential impacts of recommendations on upstream users. Unfortunately, we have identified considerable shortcomings of the modelling available, which make it difficult to fully assess the potential impacts to upstream users and to accurately assess the benefits to downstream communities of our proposed rules. This includes modelling limitations related to: the simulation of low flows; return flows due to floodplain harvesting restriction; and unregulated water source flows. As such, we have had to rely on first principles and a precautionary approach for many of our recommendations. We also acknowledge ongoing concerns with the accuracy and lack of transparency of forecasting, which must be addressed. The Panel will work with agencies to further assess potential impacts for our final report, and looks forward to engaging with stakeholders to gain their perspectives on our interim recommendations.

Need to act based on current information

In the past the lack of available data, difficulties with forecasting over long distances and modelling limitations have been used as an excuse to not take action. It is clear that to support healthy, resilient ecosystems and basic downstream community needs we can no longer afford to wait for better data and modelling, but need to take action now and adaptively manage solutions as better information becomes available.

Table i details our interim findings and recommendations:

Table i: Interim findings and recommendations

Findings

CHAPTER 2 FINDINGS – A HOLISTIC APPROACH TO CONNECTIVITY IS NEEDED

A holistic approach is needed

1. NSW Northern Basin water sharing plans primarily focus on in-valley outcomes without effectively considering overall system-wide connectivity, making it difficult to achieve efficient and effective connectivity outcomes.
2. There is a lack of appropriate governance at the whole of Northern Basin system, inter-valley scale. This gap has led to a lack of an overall approach to managing connectivity and a lack of accountability for achieving connectivity objectives. While some steps have been taken to embed connectivity requirements into NSW Northern Basin water sharing plans, these have been piecemeal rather than considering the system as a whole.

Critical needs definition and focus on dry conditions

3. The Western Regional Water Strategy definition for "critical needs" is overly narrow for achieving connectivity as it focuses only on trying to prevent catastrophic outcomes for towns and ecosystems during extreme dry conditions. Connectivity targets should aim to achieve a broader range of critical needs across various climatic conditions.
4. Currently implemented triggers and targets proposed by the Department are predominantly focused on restoring flow after extended dry periods. This is only one aspect of connectivity. Additional triggers are needed to maintain water in the system, which should enhance the resilience of the system and reduce the amount of water needed to restore systems after dry periods.
5. There is strong evidence that flows necessary to maintain the health of the rivers and critical ecosystem functions are not being met during non-dry times, when there is water available to meet these needs.
6. Supplementary and floodplain harvesting take (opportunistic take) are by their nature less available during dry and very dry times, and therefore restricting them is unlikely to achieve downstream flow targets without other simultaneous interventions. Restricting opportunistic take is likely to be more beneficial during wetter times when targets are not currently being met, including during recovery times.

Ecosystem function environmental water requirements

7. The Long Term Water Plans identify environmental watering requirements, expressed in terms of flow level, frequency and duration that are fundamental for providing basic ecosystem function and health, including flows necessary to maintain adequate connectivity. The Panel views the ecosystem function environmental water requirements represent critical needs for achieving adequate connectivity.
8. The ecosystem function environmental water requirements should be achievable during non-dry periods when water is available in the Northern Tributaries. The Panel accepts they may not be feasible to fully achieve during dry times.

CHAPTER 3 FINDINGS – THE PANEL'S PROPOSED APPROACH

9. The Department's proposed critical dry condition triggers for the Barwon-Darling and tributaries are not likely to be effective for achieving connectivity, as they do not provide for sufficient flows for connectivity or an adequate "first flush" through to Menindee Lakes following an extended dry period. The Menindee Lakes trigger may not adequately represent critically dry conditions and should be reviewed further.

Importance of riparian targets

10. The Department proposes to eliminate the riparian targets from the North-West Flow Plan and replace them with the proposed "critical dry condition triggers." The proposed critical dry condition triggers have a very different purpose than the riparian targets. They are focused on restoring flows after an extended dry period, whereas the riparian targets aimed to continually protect flows along the system.

11. There is insufficient evidence to support the Department conclusion that supplementary rules, the recent changes to the Barwon-Darling cease to pump rules and the inclusion of the resumption of flow rules effectively achieve the riparian targets. Further, the riparian rules were meant to restrict take in the tributaries to ensure they were adequately contributing to downstream flows, and the Barwon-Darling cease to pump and resumption of flow rules only apply in the Barwon-Darling.

CHAPTER 4 FINDINGS – FLOODPLAIN HARVESTING AND MENINDEE LAKES TRIGGERS

Floodplain harvesting

12. Data on actual floodplain harvesting take is not available as this form of take has only recently been licensed. Further, limitations of surface water models in regard to examining rules that restrict floodplain harvesting, and assessment of downstream benefits of those restrictions create considerable challenges for identifying appropriate floodplain harvesting restrictions.

13. The taking of overland flow is not managed consistently across water sharing plans, which creates difficulties for considering equitable and consistent restrictions on this form of take.

14. Current rules do very little to restrict floodplain harvesting. Restrictions in regulated plans only apply when Menindee Lakes is below 195GL storage and if in-valley flows are below a level where most floodplain harvesting occurs. There are no access rules based on river flows that restrict unregulated floodplain harvesting licences.

15. The current rules and proposed "critical dry condition" rules focus on Menindee Lakes volumes as the sole trigger for restricting floodplain harvesting. There is no clear logic for the volume in Menindee Lakes to be the primary trigger for when floodplain harvesting would be restricted.

Menindee

16. The volume in Menindee Lakes is not a good indicator of whether the system is entering a critically dry period. Flows past Wilcannia provide a much better indicator of this.

17. The objectives of the current and proposed rules for triggering restrictions upstream based on Menindee Lakes volumes, and around how the 60GL "restart allowance" works in practice are unclear and there appears to have been limited analysis to support the proposals. This has resulted in different options that overlap and have not been assessed relative to each other to date.

18. Storing water in Menindee Lakes requires careful consideration. The lakes have a large surface area and hot climate, resulting in significant evaporative losses. They are also prone to water quality issues. However, the lakes also have important ecological functions. As such it is desirable to minimise storage in the lakes where possible while still maintaining ecosystem health.

19. The estimation of how much water is necessary to store in Menindee Lakes to provide for 12 months of critical needs, and whether 12 months of supply is the correct time period are based on a limited analysis.

20. The proposal for storing 195GL in Menindee Lakes is based on outdated minimum flow requirements and mean evaporation rates. Latest data indicates that higher minimum flow rates are likely required for mitigating persistent stratification, elevated algal loads and mitigating fish deaths in Menindee weir pool during high risk periods. This would require storing additional water in the upper Menindee Lakes, unless alternative approaches such as translucent flows were implemented. Latest available advice indicates that in order to provide 12 months of minimum flows, 238-290GL of active storage in the upper lakes is required. This does not include an additional 55GL, which is necessary if the Pamamaroo inlet regulator is not repaired.

21. The Menindee volume trigger creates a requirement that is not directly related to connectivity needs. The significant volumes necessary to supply downstream needs are due to the limitations of the structures that have been put in place to manage the system, rather than a natural flow necessary for connectivity.

CHAPTER 5 FINDINGS – IMPLEMENTATION ISSUES

Limitations of the department's surface water modelling

22. While they have been assessed to be "fit-for purpose" for assessing floodplain harvesting entitlement, the current models have not been demonstrated to be "fit-for purpose" for assessing environmental and connectivity outcomes – particularly those at lower flows. As such they have significant limitations for assessing potential impacts and benefits of rule changes, particularly those that target lower flow regimes.

23. Analysis of various restrictions assessed in the Western Regional Water Strategy relied on modelling, which has significant limitations for assessing the connectivity outcomes from those restrictions. These results were not "ground-truthed" against actual flow data.

Forecasting

24. Forecasting ability for connectivity events down the Barwon-Darling with multi-valley contributions remains limited despite numerous previous recommendations that this forecasting be improved as a matter of urgency. Data and criteria used to make forecasting decisions are not transparent. Gauging that is needed for improving forecasting may not be adequate.

25. During times when restrictions are in place, it is appropriate for forecasting to take a precautionary approach such that there is a high level of certainty that targets will be achieved before restrictions are lifted. However, this will likely mean greater restriction on users until forecasting ability is improved.

26. In previously forecasted events, some downstream users were allowed to extract water that upstream users were required to leave in the system. This is not equitable. Flows protected upstream should be protected all the way through the system to Menindee Lakes.

27. Prescriptive rules based on relaxing restrictions when specific flows have been achieved at various gauges would provide greater clarity for users and be easier for WaterNSW to implement. However, these would very likely result in greater restrictions on users than sound forecasting.

Unregulated system

28. The unregulated water sources provide important contributions for connectivity and rules need to be developed to ensure that equitable restrictions are placed on unregulated water sources in line with restrictions imposed in regulated water sources to achieve connectivity outcomes.

29. The lack of data regarding flows and extractions in the unregulated system creates challenges for developing sound rules for restricting take to achieve connectivity.

30. There is currently no assessment of compliance with the long-term average annual extraction limit undertaken in the unregulated water sources (other than the Barwon-Darling). This creates concerns over whether restrictions in unregulated sources are likely to be effective.

31. There are inequities in access rules between unregulated water sources adjacent to the Barwon-Darling and Barwon-Darling users, which impact on connectivity.

32. The difference in the way that overland flow is managed between unregulated water sources with no floodplain harvesting licences and water sources with floodplain harvesting licenses create difficulties for equitably restricting unregulated users to achieve connectivity outcomes.

CHAPTER 6 FINDINGS – IMPACTS OF RECOMMENDATIONS

33. Limitations of the models make it difficult to accurately assess the potential impacts of rules, particularly as a combined suite of rules that work together. Assumptions that underpin economic studies to date are flawed and should be reviewed for any future analyses to ensure they reflect actual irrigator behaviour.

Recommendations

CHAPTER 2 RECOMMENDATIONS– A HOLISTIC APPROACH TO CONNECTIVITY IS NEEDED

A holistic approach is needed

1. The NSW government should take a holistic and adaptive management approach to water management across the entire Northern Basin, considering how rules work together to achieve agreed connectivity outcomes. This should involve moving away from a reactionary approach. Upstream water sharing plans should actively consider and provide for downstream environmental and community needs to ensure the overall health and connectivity of the system.
2. To improve accountability for system-wide connectivity the NSW Government should:
    a) assign a governance body responsible for reviewing the implementation of any agreed connectivity recommendations and ensuring that efforts are coordinated across various government agencies. This body should be independent of the Water Group.
    b) create a community advisory group including representatives from the Aboriginal community, industry stakeholders from upstream and downstream, and local community groups to advise the governance body described above regarding on-ground experiences and issues.

Providing for a range of critical needs in different climatic conditions

3. The Department should ensure that rules are implemented that provide for adequate connectivity needs across the range of climatic conditions likely to be experienced. This should:
    a) Ensure that an adequate share of water is protected for downstream river health during non-dry times by ensuring that the ecosystem function environmental water requirements are met throughout the Barwon-Darling.
    b) Provide for restrictions earlier in dry times to minimize the length of dry periods and support recovery.

CHAPTER 3 RECOMMENDATIONS – PANEL'S PROPOSED APPROACH

4. The Department should implement rules to achieve the targets and triggers in Table ii that aim to:
    a) During non-dry times – ensure that baseflow is protected across the Northern Basin and provide for small and large freshes consistent with the environmental water requirements. Baseflows should be achieved through restrictions on supplementary and floodplain harvesting access along with an end of system flow rule for each valley requiring dam releases where necessary.
    b) During dry times – extend the current resumption of flow rules into the Northern Tributaries and provide for a small flushing flow following an extended dry period all the way to Menindee Lakes prior to allowing extraction.
    c) Establish a "connectivity" environmental water allowance in each Northern Tributary to assist with meeting end of system flow rules and provide for periodic pulses during dry times to maintain system health and water quality.
5. The Department should ensure this environmental water is appropriately protected from downstream extraction:
    a) any water protected through these rules should be protected through to Menindee Lakes.

b) once protected flows reach Menindee Lakes the water should be held as an environmental water allowance for use in supplying critical needs for the Lower-Darling or used for translucency flows protected through the Lower-Darling.

Table ii – Summary of Panel's recommendations – Connectivity targets and triggers

Non-dry times			
Proposal	**Proposed targets**		
Protection of baseflow – *Regulated water sharing plans should have a continual end of system flow requirement to enable baseflow targets in the Barwon-Darling to be achieved during non-dry times. This should be achieved first through restriction on supplementary and floodplain harvesting, with releases made from storage if these flows are not adequate.*	Mungindi	160 ML/d	
	Collarenebri	280 ML/d	
	Walgett (Dangar Bridge)	320 ML/d	
	Wilcannia	350 ML/d	
Protection of small freshes- *Regulated water sharing plans should include restrictions on supplementary and floodplain harvesting, and A, B and C licences in the Barwon-Darling to achieve annual small fresh flows.*	Mungindi	540 ML/d	A minimum of 14 days between September and April every year. (note this covers both SF1 and SF2 targets in the Long Term Water Plan). 14 days must be targeted. However, if an event is targeted with restrictions and the small fresh flow is only achieved for 12 days or more it will be considered as met for that period. Restrictions begin at the start of September until the target is achieved
	Collarenebri	650 ML/d	
	Walgett	700 ML/d	
	Brewarrina	1,000 ML/d	
	Bourke	1,550 ML/d	
	Louth	1,500 ML/d	
	Wilcannia	1,400 ML/d	
Protect large freshes – *Regulated water sharing plans should include restrictions on supplementary and floodplain harvesting, and A, B and C class licences in the Barwon-Darling to achieve periodic large fresh flows.*	Mungindi	3,000 ML/d	15 days minimum at least once every 2 years. Anytime, but ideally July to September. 15 days must be targeted. However, if an event is targeted with restrictions and the large fresh flow is only achieved for 12 days or more, it will be considered as met for that period.
	Collarenebri	4,200 ML/d	
	Walgett	6,500 ML/d	
	Brewarrina	9,000 ML/d	
	Bourke	15,000 ML/d	
	Louth	15,000 ML/d	
	Wilcannia	14,000 ML/d	

Transition arrangements	
Proposal	**Proposed targets**
Commence transition to new resumption of flow rules - *When the system begins to enter a 'dry' stage, there will be a transition to 'dry' time resumption of flow rules which are triggered when flows drop below baseflow for a certain duration at various locations throughout the system.*	In development: The Panel is working with relevant agencies to identify the specific appropriate trigger for this transition. It will be based upon the inflows into the dams versus the volume of water necessary to achieve end of system flows. **Note**: Given that the current resumption of flow rule requires that flows drop below baseflow for greater than 90 days, there will be a transition period between when the end of system flow rule is suspended and when the resumption of flow rule restrictions are triggered. As the supplementary rules would be revised to include a requirement that supplementary not be taken when baseflows aren't met, this restriction would continue during this transition period and would protect any minimal flows that may occur.

Dry Times			
Proposal	**Location**	**Proposed target**	**Proposed lifting target**
Revise the resumption of flow rules - *The resumption of flow rules should be applied in the Northern Tributaries as well as the Barwon-Darling. The trigger for lifting restrictions should be raised to a small fresh all the way down the system to ensure flows through to Wilcannia and into Menindee Lakes.*	Mungindi	<160ML/d for 90 days	540ML/d for 10 consecutive days forecast to be met
	Collarenebri	<280 ML/d for 90 days	650ML/d for 10 consecutive days forecast to be met
	Walgett (Dangar Bridge)	<320 ML/d for 90 days	700ML/d for 10 consecutive days forecast to be met
	Brewarrina	<550 ML/d for 90 days	1,000ML/d for 10 consecutive days forecast to be met
	Bourke	<500 ML/d for 90 days	1,550ML/d for 10 consecutive days forecast to be met
	Louth	<450 ML/d for 90 days	1,500ML/d for 10 consecutive days forecast to be met
	Wilcannia	<350 ML/d for 90 days	1,400ML/d for 10 consecutive days forecast to be met

All times	
Proposal	**Proposed targets**
Menindee Lakes trigger	In development The Panel is reviewing the proposed "critical dry condition" trigger for Menindee Lakes, which indicates that upstream supplementary, floodplain harvesting and A, B, and C licence extraction should be restricted when the upper Menindee Lakes reaches 195GL active storage. Current evidence indicates the amount stored would need to be in the range of 238-290GL to maintain flows for critical needs downstream for 12 months if the Pamamaroo inlet regulator is repaired. The Panel will continue to investigate this proposed rule further for the final report.
Establish 'Connectivity' environmental water allowance – *Each of the four regulated Northern Inland Basin water sharing plans should include a 'connectivity' EWA to allow for releases to meet end of system targets during normal times and provide pulses as needed for water quality and other environmental outcomes during dry times. This should be managed by DCCEEW Biodiversity, Conservation and Science to achieve connectivity objectives.*	In development: The Panel will work with agencies to further investigate this option, including proposed volumes that would be necessary and potential impacts for the final report. **Note**: as a principle, the Panel proposes that this "connectivity" EWA should provide adequate water for meeting end of system targets when restrictions are inadequate to meet baseflow as well as some water for periodic "pulsing". The "connectivity" EWA should have the highest security status and therefore take precedence in the dam storage.
Update rules in unregulated water sharing plans	In development: Given the timeframe, the Panel has only completed a high-level review of the unregulated systems. The final report will include proposed rules for relevant unregulated water sources.

Recommendations (continued)

CHAPTER 4 RECOMMENDATIONS – FLOODPLAIN HARVESTING AND MENINDEE LAKES TRIGGERS

6. Additional analysis of the basis for the volume necessary to be stored in Menindee Lakes to provide for critical needs in the Lower-Darling should be undertaken including:

a) Validating the basis for a 12 month supply storage, and the analysis of volumes needed for critical needs.

b) Ensuring the assessment of storage needs is robust, based on best available evidence and considers various operating approaches to achieve efficient water usage during dry times.

7. Further analysis for the timing of the need for 60GL restart allowance and how it would work in practice should be undertaken. Once objectives are clear, analysis of various rules should be completed to determine the most efficient way to achieve intended objectives. This analysis should include assessment of the best indicator for when the system is likely to be entering a dry phase and therefore a restart allowance might be needed.

8. The dam safety constraint at Pamamaroo inlet regulator should be repaired as a matter of urgency to reduce storage requirements.

9. The Panel's proposed restrictions on floodplain harvesting should be implemented and outcomes monitored to determine if additional restrictions are necessary in the future to facilitate longitudinal connectivity.

The Panel will work with the agencies to try to advance recommendations 6 and 7 prior to the final report with the aim of providing more specific advice on the best rules for managing Menindee Lakes volumes for needs during dry times.

CHAPTER 5 RECOMMENDATIONS – IMPLEMENTATION ISSUES

Limitations of the department's surface water modelling

10. Until such time as the modelling can accurately assess low flows, floodplain harvesting restrictions, and changes to contributions from unregulated water sources, assessment of rule changes should be ground-truthed using a first principles approach and considering other sources of data, such as actual historic flows. Further, rules should be devised using a precautionary approach and adaptively managed based on monitoring and evaluation of outcomes.

11. In the longer term, the Department should take steps to ensure the models are fit for purpose to support analysis of connectivity and achievement of environmental outcomes in the tributaries and across the entire Northern Basin. This should include:

a) Identifying future model development needs and committing to a timeline for implementing these.

b) Independent review of the model development plan and changes made to the surface water models

Forecasting

12. WaterNSW should immediately take steps to improve whole of system forecasting ability in cooperation with the Department. The Department should work with WaterNSW to determine where additional gauging is necessary to effectively manage connectivity and ensure that gauging is available.

13. WaterNSW should develop a transparent set of guidelines for what data and criteria will be used for making forecasting decisions. This should be made public and adaptively managed to improve forecasting ability over time.

14. Water protected through restrictions should be actively managed and restrictions should be relaxed from the top of the system downward to prevent inequities.

15. Forecasting should continue to take a precautionary approach such that WaterNSW has a high level of confidence of the targets being met before relaxation rules are triggered.

Unregulated system

16. For the final report the Panel will develop clear recommendations for rules necessary to adequately restrict unregulated users to equitably achieve connectivity outcomes. If data is insufficient, then the Panel will identify steps the Department needs to take to allow for such rules to be developed and implemented.

CHAPTER 6 – POTENTIAL IMPACTS ON UPSTREAM USERS

17. As part of the development of the final report we will work with the Department to assess as accurately as possible potential impacts of the proposed rules, and to examine if there are alternative rules that may achieve the same connectivity outcomes with less impacts. This may require analysis of actual flow data where models are insufficient to assess connectivity outcomes.

Table of Contents

1 Introduction and background

1.1 About the review

The Connectivity Expert Panel was established in August 2023 under water sharing plan provisions to provide independent expert advice to the Minister for Water regarding issues related to connectivity in the Northern Murray-Darling Basin (Northern Basin). Broadly, the Panel is to provide advice on the adequacy of:

- the assessment already carried out by the Department[4] and the proposed amendments to flow targets in water sharing plans that aim to restrict supplementary, A-Class, B-Class, C-Class and floodplain harvesting licenses in order to improve flows for downstream connectivity outcomes, including during critical dry conditions.
- floodplain harvesting access rules in enabling environmental and human needs to be met.

In December 2023, in response to the Office of Chief Scientist and Engineer's report Independent review into the 2023 fish deaths in the Darling-Baaka River at Menindee[5] the Minister for Water requested that the Expert Panel expand their terms of reference to examine the adequacy of rules in all of the NSW Northern Basin[6] water sharing plans, which in the Panel's view may materially impact on hydrological connectivity between valleys.

See Appendix A or the DCCEEW Independent Connectivity Expert Panel website for the full terms of reference[7].

Box 1 – Definitions of connectivity, Northern Basin and Northern Tributaries

Connectivity
The Panel recognises that there are many definitions of hydrological connectivity including longitudinal, lateral (floodplain) and vertical (surface to groundwater) connectivity. Given the scope of the Terms of Reference, the Panel agreed to focus on longitudinal connectivity within the Northern Basin – that is, ensuring connectivity from the Northern Tributaries through the Barwon-Darling (Barwaan-Baaka) down to Menindee Lakes.
The Terms of Reference includes questions regarding floodplain harvesting. While this initially impacts lateral connectivity, the Panel has focused on the flow on effects to longitudinal connectivity.
The Panel recognises the importance of all forms of connectivity and encourages further investigation, where needed, into issues related to lateral and vertical (groundwater) connectivity.

Northern Basin
In this report the term "Northern Basin" means the northern portion of the Murray Darling Basin, including all the catchments that contribute to the Barwon Darling River upstream of Menindee Lakes in NSW and the catchments that extend into Queensland. The **NSW Northern Basin** includes water sources in the following NSW surface water sharing plans:

- NSW Murray and Lower Darling Regulated Rivers Water Sources 2016
- Intersecting Streams Unregulated River Water Sources 2011

[4] NSW Department of Climate Change, Energy, the Environment and Water
[5] Office of the NSW Chief Scientist & Engineer (2023) *Independent review into the 2023 fish deaths in the Darling-Baaka River at Menindee*
[6]
[7] https://water.dpie.nsw.gov.au/our-work/plans-and-strategies/regional-water-strategies/final/western-regional-water-strategy/connectivity-expert-panel

- NSW Border Rivers Regulated River Water Source 2021
- NSW Border Rivers Unregulated River Water Sources 2012
- Gwydir Regulated River Water Sources 2016
- Gwydir Unregulated River Water Sources 2012
- Upper Namoi and Lower Namoi Regulated River Water Sources 2016
- Peel Regulated River Water Source 2022
- Namoi and Peel Unregulated Rivers Water Sources 2012
- Macquarie-Cudgegong Regulated Rivers Water Source 2016
- Macquarie-Bogan Unregulated Rivers Water Sources 2012
- Castlereagh Unregulated River Water Sources 2011

Northern Tributaries
In this report this term refers to the NSW major regulated rivers that contribute to the Barwon-Darling upstream of Menindee. Specifically, the water sources in the following water sharing plans:

- NSW Border Rivers Regulated River Water Source 2021
- Gwydir Regulated River Water Sources 2016
- Upper Namoi and Lower Namoi Regulated River Water Sources 2016
- Macquarie-Cudgegong Regulated Rivers Water Source 2016

1.2 Why is connectivity important?

River connectivity plays a crucial role in maintaining the health and functionality of aquatic ecosystems and supporting socio-economic activities reliant on water resources. It is essential for the health of First Peoples and communities and their ability to sustain their traditional life, languages, cultures and knowledge.

The NSW Government Western Regional Water Strategy outlines that connectivity is important to fulfill different purposes during all times[8]:

- during non-drought times connectivity builds the resilience of the system, providing opportunities for movement, spawning, and recruitment, and improving water quality and productivity in the system
- in wet periods connectivity supports large-scale productivity, replenishing wetlands and flushing rivers to prepare systems for dry conditions
- in extreme droughts connectivity helps to avoid irretrievable damage to species, ecological communities and ecosystems.

1.2.1 Connectivity is critical for ecosystem function

Connectivity between river reaches and their surrounding environment is important for maintaining healthy ecosystems, fulfilling environmental functions like moving nutrients and sediment throughout the river, allowing native fish and other organisms to move and disperse, and improving water quality.

[8] DPE Water (2022), *Western Regional Water Strategy* – See Page 57

The Barwon–Darling plays a critical role in the Murray–Darling Basin, providing the hydrological and ecological link between the Northern and Southern Basins, and is one of the most important ecological corridors across the Murray Darling Basin. The majority of the river is classified as an aquatic endangered ecological community[9] and many of the species that occur in the Barwon-Darling River have evolved in flowing water environments. While they can withstand periods of no flow by retreating to deep waterholes, flow connectivity is critical to allow them to move through the system to access new habitats to feed and breed. Maintaining healthy individuals and populations during periods of flow, increases their resilience to survive during droughts, which is especially important given the predicted impacts of climate change. The river and native species have high cultural significance for local Aboriginal people.

The NSW Long Term Water Plans, which guide the management of water for environmental outcomes, outline how different flow categories contribute to river connectivity (Table 1 and Figure 1).

Table 1 Description of the role of each flow category[10]

Flow category	Description
Overbank flow	Floodplain connection flows provide broad scale lateral connectivity with floodplain and wetlands. They support nutrient, carbon and sediment cycling between the floodplain and channel, and promote large-scale productivity.
Bankfull flow	Inundates all in-channel habitats and connects many low-lying wetlands. They provide partial or full longitudinal connectivity and drown out most small in-channel barriers (e.g. small weirs).
Large fresh (pulse)	High-magnitude flow pulse that remains in-channel, connects most in channel habitats, provides partial longitudinal connectivity by drowning out some low-level weirs and other in channel barriers and may engage flood runners and inundate low-lying wetlands.
Small fresh (pulse)	Low-magnitude in-channel flow pulse that improves longitudinal connectivity by inundating low lying benches, connecting sections of a channel or river, triggering animal movement and flushing pools.
Baseflow	Provides connectivity between pools and riffles and along channels. They provide sufficient depth for fish movement along reaches.
Very low flow	Minimum flow in a channel that prevents a cease to flow. They provide connectivity between some pools.
Cease-to-flow	Partial or total drying of the channel. The stream contracts to a series of disconnected pools and there is no surface flow.

[9] DPE Water (2022), *Western Regional Water Strategy* – See Page 26
[10] NSW Government – DPIE (2020), *Barwon–Darling Long Term Water Plan Part A*

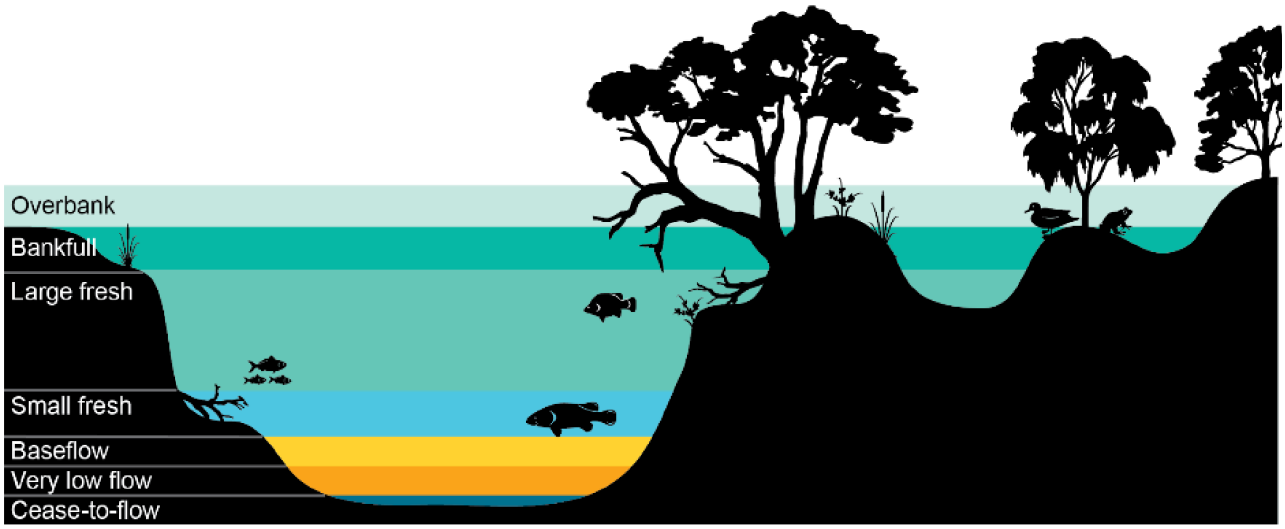

Figure 1. A simplified conceptual model of the role of each flow category[11]

1.2.2 Connectivity is inherent in First People's culture

Connectivity is important to First Peoples as flowing rivers play a very important role in their culture. Communities rely on rivers for their health, wellbeing, food supply and connection to Country. The region's rivers are considered classrooms for maintaining the continuity of First Peoples culture. Further, connectivity is innate in the culture of Aboriginal communities, as it incorporates a duty to provide for downstream communities.

A disconnected system poses a major threat to the physical health of First Peoples' communities and their ability to sustain their traditional life, languages, cultures and knowledge. There is a lot at stake – for the long term sustainability and resilience of the First Peoples and communities across the NSW Northern Murray Darling Basin. Water is central to Indigenous health and wellbeing, food security, cultural education and employment opportunities.

Consultation undertaken with Aboriginal communities as part of the Western Regional Water Strategy stressed that that loss of access to water resulted in significant negative impacts on the mental health and wellbeing of their people. Key messages included[12]:

- the river is healing, unifying, provides identity and continues culture; water is the lifeblood of communities
- a flowing river is important for recreation such as fishing and swimming and important for social wellbeing
- a healthy river system with good quality water has an overall calming influence
- Aboriginal Water Lore requires water to be looked after for people that live downstream
- water quality is poorest when the river isn't flowing and fishing can only be done when the river has been flowing for a few months
- concern that river flows weren't protected during the drought and that flows should reach the end of the system before any water extraction occurs upstream

[11] NSW Government – DPIE (2020), *Barwon–Darling Long Term Water Plan Part A*
[12] NSW Government – DPE (2022), *Draft Western Regional Water Strategy What we heard*

- the importance of water in maintaining traditional foods, including medicinal plants
- the importance of protecting significant Aboriginal sites along the river.

Socio-economic: Connectivity supports the communities that swim and fish in rivers, take water for domestic and stock purposes, as well as agriculture and other industries that rely on water from the river for commercial purposes. Downstream communities are reliant on connectivity to maintain water levels in weir pools that are used for town water purposes.

1.3 Connectivity challenges in the Northern Basin

1.3.1 Overview of the Barwon-Darling (Barwaan-Baaka) system

Understanding the hydrology of the Barwon-Darling is important for understanding some of the challenges for achieving connectivity. Due to these many challenges, achieving connectivity efficiently in the Northern Basin is highly complex.

Highly variable flow regime

The Barwon-Darling has some of the most variable hydrology in Australia[13]. The hydrology of the Barwon-Darling is characterised by flood events and intervening low flow periods, which can last a few months, or occasionally, a few years. Despite the semi-arid nature of the plan area itself, flow events can be expected at least once or twice a year, and long periods of no flow are generally the exception[14] .

[13] Puckridge, J. T., F. Sheldon, K. F. Walker and A. J. Boulton (1998). "Flow variability and the ecology of large rivers." Marine and Freshwater Research 49(1): 55-72.
[14] NSW Government – DPIE (2020), *Barwon–Darling Long Term Water Plan Part A*

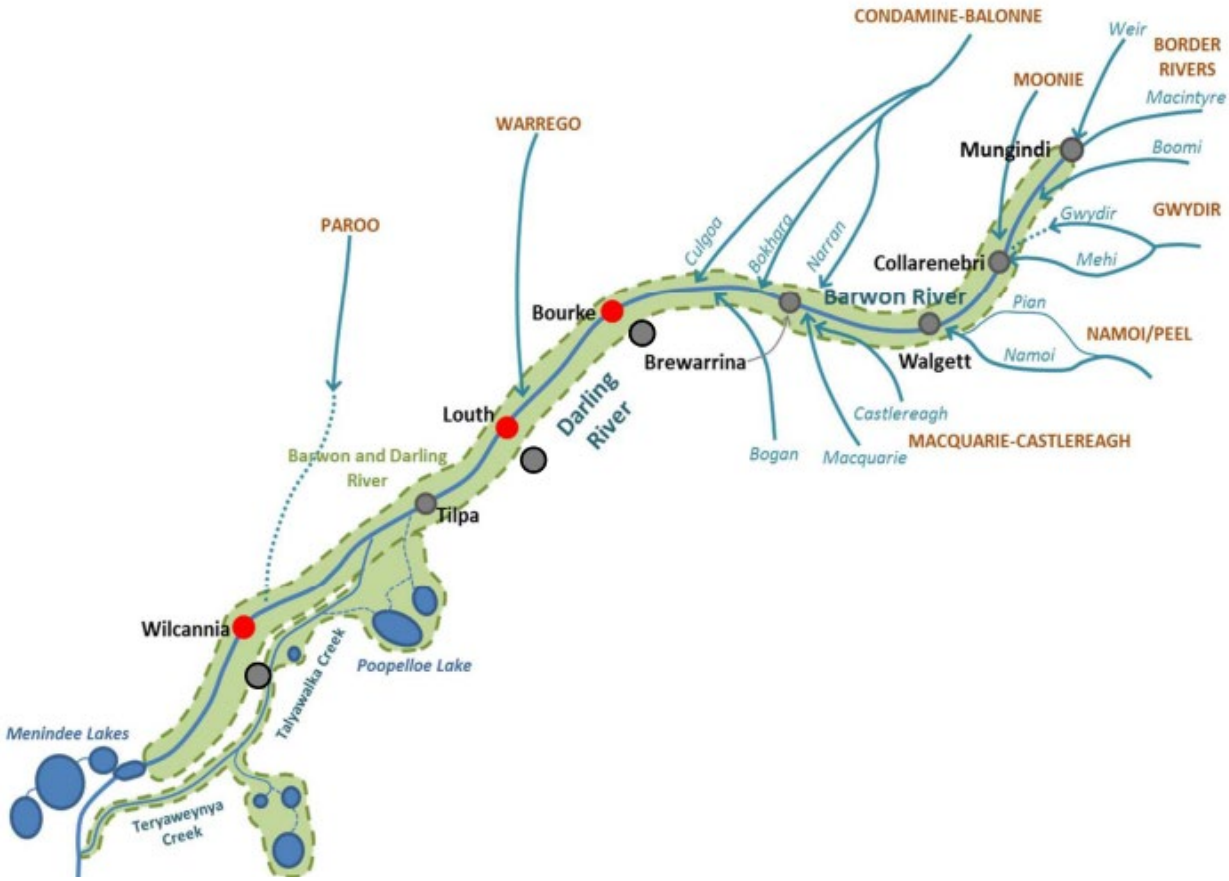

Figure 2. Stylised map of the Barwon-Darling river system[15]

Impact of upstream dams on flows in the Barwon-Darling

The Barwon–Darling River upstream of Menindee does not have a large headwater storage that regulates flows along the length of the river. However, the river flow in the Barwon-Darling is impacted by the storages within its tributaries[16]. There are nine major headwater dams across the Northern Basin that have a combined storage capacity of about 4,708,000 ML[17] . When the dams aren't spilling, these storages capture and control the vast majority of inflows. This significantly dampens the natural variation in flows in the downstream rivers that would exist without the dams, particularly during non-spilling periods.

Over 90%[18] of the Barwon-Darling's inflows come from upstream catchments in NSW and QLD

The Barwon-Darling is fed by both regulated and unregulated upstream catchments. Major tributaries and their modelled long term average contribution to the Barwon-Darling are as follows:[19],[20]

[15] Alluvium Consulting (2021), *Review of the Interim Unregulated Flow Management Plan for the North West*
[16] NSW Department of Industry, Skills and Regional Development (2017) Barwon–Darling Water Resource Plan: Surface water resource description,
[17] Data collected from Current Basin water in storage report | Murray–Darling Basin Authority (mdba.gov.au) Accessed on 20 February 2024 and Catchment snapshots | Water (nsw.gov.au)
[18] Over 90% of the inflows into the Barwon-Darling system on average over the long term come from upstream catchments
[19] DPE Water (2022), *Western Regional Water Strategy* – See Table 6
[20] Australian Government (2011). *Water resource assessments for without-development and baseline conditions.* , Supporting information for the preparation of proposed Basin Plan Technical report 2010/20 Version 2 November 2011.

River System	Contribution – without development*	Contribution – Baseline**
Local Barwon Darling	20.8%	17.4%
Namoi	18.8%	23.6%
Border Rivers	18.1%	18.5%
Castlereagh, Macquarie/ Wambuul and Bogan Rivers	17.3%	20.8%
Condamine-Balonne	12.9%	8.7%
Gwydir	8.3%	6.3%
Moonie	2.2%	2.6%
Warrego	1.6%	2.1%

Note: These values represent the total inflow from gauged and ungauged tributaries. The flow contribution percentages are 10 years old and require further verification as some of the river system contribution for Moonie do not align with the figures released more recently as part of the Northern Stocktake Report.

Connectivity of tributaries to the Barwon-Darling system varies

The tributary rivers vary in their connectivity to the Barwon–Darling system. Factors such as rainfall patterns, water management rules, presence of drought conditions, water extraction and geomorphology influence their flow contribution.

Well-connected catchments such as Border Rivers and Namoi are the most efficient at contributing flows to downstream reaches and are able to contribute flows of higher peaks and shorter durations[21]. The Western Regional Water Strategy analysis showed that over the last 130 years, the Namoi and Border Rivers have contributed more flows to the Barwon–Darling than other tributaries – particularly during average or wet years. An additional complexity is that water management in the Border Rivers is guided by the Intergovernmental Agreement between Queensland and NSW.

The Paroo and Warrego rivers only reach the Barwon-Darling after significant rain events in their catchments, contributing relatively infrequent flows downstream and west of Bourke. However, they can provide significant volumes in flood events, increasing the duration of high flow events in the Darling River[22] .

End of System floodplains and wetlands

Catchments that have large floodplains and wetlands in their lower reaches, such as the Macquarie/ Wambuul, Gwydir, Condamine-Balonne and Paroo rivers, can be less efficient at contributing flows to the Barwon-Darling. One reason is because the floodplain and wetlands at the end of the systems can absorb significant volumes of water before reaching the Barwon-Darling. Within these systems, there are channels for water to flow around some wetlands and provide flows into the Barwon–Darling. These channels include the Mehi River and Carole/Gil Gil Creek in the Gwydir Valley and the Bogan River or the Bulgerega and Northern Bypass Channel in the Macquarie Marshes[23] .

[21] NSW Government – DPIE (2020), *Barwon–Darling Long Term Water Plan Part A*
[22] Natural Resources Commission (2019), *Final report Review of the Water Sharing Plan for the Barwon-Darling Unregulated and Alluvial Water Sources 2012*
[23] DPE Water (2022), *Western Regional Water Strategy* – Page 60

Travel time

The time it takes for water to reach the Barwon-Darling River from its tributaries can also vary depending on the location and the antecedent conditions of the catchments. It can take anywhere from weeks to months for flows to reach the end of the Barwon-Darling. Travel times can be significantly longer when the river channel is dry due to the large volumes of water needed to re-wet the river channel, and refill water holes.[24] This can make forecasting flows downstream difficult.

Large volume take at the end of systems

In some catchments, there are large volumetric licences located at the end of the system (on or below the wetlands/floodplains) that are able to take significant volumes of water, for example, the Bogan River[25]. This can impact on connectivity between the valleys and the Barwon-Darling.

On-farm storages

The large storage capacity of on-farm storages pose a challenge to connectivity. An estimate of permanent on-farm storage capacity is 1,300,000 ML[26] which is just under 30% of combined Northern Basin state dam capacity. The total volume of water that can be stored in the Northern Tributaries between the headwater dams and on farm dams may have a significant impact on downstream flows.

Contribution of unregulated systems

There are many unregulated rivers in the Northern Basin that contribute directly and indirectly to flows in the Barwon-Darling River. Many of these unregulated rivers and creeks contribute significant flows to the Barwon-Darling River. On average, unregulated rivers across the Northern Basin directly contribute up to one third[27] of the inflows into the Barwon-Darling River. As highlighted in recent NSW and Queensland reports[28], some of the most significant unregulated rivers are the Boomi River, Bogan River, Castlereagh River and Thalaba Creek, which combined are estimated to contribute about 19 per cent of the total inflows into the Barwon-Darling River. In addition, the 2019 report on the Stocktake of Northern Basin Connectivity Rules indicates that the Moonie River and Condamine-Balonne River, which enters the Barwon River from Queensland, contribute between 11% - 16% of inflows.[29] These figures differ somewhat to the figures quoted in the Western Regional Water Strategy and require further verification to ascertain the actual flow contributions into the Barwon-Darling River.

Several unregulated rivers and creeks also indirectly contribute to flows into the Barwon-Darling by providing inflows into major northern inland regulated rivers, downstream of major storages. For example, the Mooki River and Coxs Creek provide inflows into the

[24] Australian Government (2018), *Northern connectivity event update 7*
[25] NSW Government (2018) *Risk assessment for the Macquarie– Castlereagh water resource plan area (SW11): Part 1 Schedule D*
[26] NSW Government (2020), *On-farm storage volumes Tracking water capture in on-farm storages during the North-west flows in 2020.*
[27] Department of Planning and Environment (2022) Building the river system model for the Barwon-Darling Valley unregulated river system. Reference number: INT22/59396;
Barma Water Resources (2019) Stocktake of Northern Basin Connectivity Rules – Analysis of implementation and effectiveness
[28] Department of Planning and Environment (2022) Building the river system model for the Barwon-Darling Valley unregulated river system. Reference number: INT22/59396
; Barma, D. (2018) Stocktake of Northern Basin Connectivity Rules- (review of Implementation and model analysis). Report to NSW Department of Industry – Water and Queensland Government, Border Rivers – Queensland Border Rivers Model Results to Support Basin Plan Requirements (November 2018).
[29] Barma, D. (2018) Stocktake of Northern Basin Connectivity Rules- (review of Implementation and model analysis). Report to NSW Department of Industry – Water

Namoi River, downstream of Keepit Dam, and therefore contribute flows to the Lower Namoi River and then into the Barwon-Darling.

1.3.2 Overview of Menindee Lakes

Menindee Lakes (the Menindee Lakes Storage system) further complicate the achievement of connectivity between the Northern and Southern Basin. The ephemeral lakes would naturally fill when the Darling River flooded but were augmented in the 1960s to secure water supply for Broken Hill[30] and Menindee township, and for downstream water needs. This water infrastructure is owned by the NSW Government and maintained and operated by WaterNSW.

The Menindee Lake Storage system comprises several lakes that fill from inflows from the Northern Basin via the Barwon-Darling River. There are four main lakes including Pamamaroo and Wetherell (upper lakes) and lakes Menindee and Cawndilla, and seven main regulating structures (Figure 3). Lake Tandure is also part of the upper lakes.

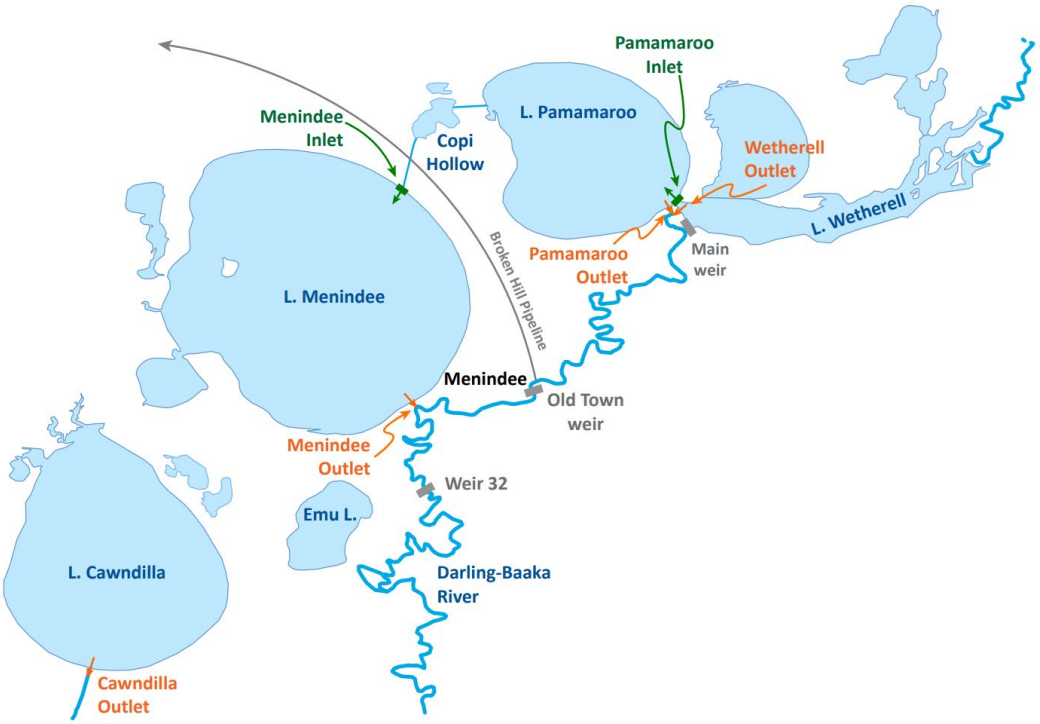

Figure 3 Menindee Lakes system. Key infrastructure regulating storage and distribution of water within four main interconnected lakes[31]

These lakes have active and dead storage (water that cannot be physically delivered via existing infrastructure unless pumped). The combined total storage (at full supply level) is around 1,731 GL and dead storage is around 93 GL. Lakes Menindee and Pamamaroo have the highest dead storage of around 51.4 GL and 31.7 GL respectively.[32]

Management of the lakes is complex and subject to a range of rules set out in the Water Sharing Plan for the NSW Murray and Lower Darling Regulated Rivers Water Sources 2016

[30] Since 2019 Broken Hill has received its water supply from a pipeline from the Murray River.
[31] Office of the NSW Chief Scientist & Engineer (2023) *Independent review into the 2023 fish deaths in the Darling-Baaka River at Menindee* –*See page 5*
[32] Data provided by DCCEEW Water

and the Murray Darling Basin Agreement. The lakes have been managed as a shared resource for around 60 years following agreement between the NSW and Australian, Victorian and South Australian governments to provide for downstream needs when the combined volume of the lakes reaches 640 GL until they fall to 480 GL when the lakes return to NSW control. When managed as a shared resource, the MDBA is to direct operation of the lakes in accordance with the objectives and outcomes for river operations in the River Murray System document, which is approved by the Basin Officials Committee.[33]

Given its location in a semi-arid environment, the lakes system experiences high evaporative losses. Lakes Menindee and Cawndilla have the highest evaporative losses given their large surface area and shallow depth. Evaporative losses depend on ambient conditions and lake levels. Historically the lakes have been managed to minimise these losses by preferentially draining Lake Menindee before drawing on the upper lakes for meeting downstream needs.

The water management infrastructure and operation of the lakes for water efficiency purposes are recognised as contributing factors to fish deaths in the Lower Darling-Baaka River, particularly within the Menindee weir pool (upstream Weir 32).[34,,35] Lack of fish passage through the lakes to allow for fish movement between the Northern and Southern Basin is also a contributing factor and has led to aggregations of fish in the Menindee weir pool, particularly in response to flow events that cue upstream movements, and following floods when the populations of some species (e.g. Bony herring and Carp) boom.

Over the past year the operation of the lakes has shifted in recognition of the importance of releasing water from the upper lakes (Pamamaroo and Wetherell) for managing water quality in the Menindee weir pool and mitigating fish deaths. Releases made from Lake Menindee bypass the majority of the weir pool given the junction of Menindee Creek and the Lower Darling-Baaka is roughly 30 kilometres downstream of Main Weir and are not effective for managing water quality events in this reach.

1.4 Changes to flows in the Northern Basin

Flows in the Barwon-Darling River system have changed significantly since European colonisation, with the most significant changes occurring since the 1960s, owing to river regulation, extraction[36], land development and climate change across the tributary catchments of NSW and QLD, and within the Barwon–Darling plan area itself [37]. This has resulted in modifications to how water moves laterally and longitudinally through the region's landscape and connected systems[38] .

The extraction of water and the operation of water infrastructure changes the timing, magnitude, duration, and frequency of flows and, in turn, impacts river ecology. By the mid-

[33] Murray-Darling basin Authority (2023) *Objectives and outcomes for river operations in the River Murray System, effective from June 2023*.
[34] Vertessy, R., Barma, D., Baumgartner, L., Mitrovic, S., Sheldon, F., Bond, N. (2019*), Independent Assessment of the 2018-19 fish deaths in the lower Darling – Final Report*, for the Australian Government, 29 March 2019

[35] Office of the NSW Chief Scientist & Engineer (2023) *Independent review into the 2023 fish deaths in the Darling-Baaka River at Menindee*
[36] In the Northern Basin, water extraction is comprised of: regulated extractions (high security, general security and supplementary licences); unregulated extractions in the Barwon-Darling (A, B and C class and) and unregulated tributaries and floodplain harvesting.
[37] NSW Government – DPIE (2020), *Barwon–Darling Long Term Water Plan Part A*
[38] DPE Water (2022), *Western Regional Water Strategy* – See Page 52

1990s, it was generally acknowledged that habitats along the entire river had been degraded by hydrological changes[39].

The health of river systems depends on there being a range of flows. Evidence indicates that the full spectrum of flows have been impacted in the Barwon-Darling[40], specifically changes in hydrology have led to:

- Reduced inflows from tributaries, with significant decline in the time the Barwon-Darling flows
- Increased frequency and duration of low and cease-to-flow periods
- Reduced annual average flow through the river
- Reduced number, frequency, and duration of higher flow events including small and large freshes and overbank flows

Changes to tributary inflows

The reductions in tributary inflows place the Barwon-Darling under pressure, reducing the volumes of flow available to meet environmental, social and cultural needs. In addition, they have a significant impact on outcomes at Menindee and the Lower Darling. Extractions in the Barwon-Darling itself have limited impacts on downstream inflows to Menindee compared with the impact of extraction in upstream tributaries[41].

Analysis has shown that long term average end of system flows in the Barwon-Darling tributary catchments have reduced by 37% [42]. Prior to river regulation, the Barwon–Darling River flowed for more than 90% of the time and was characterised by short spells (generally less than one month) of zero flow.[43]

Changes to low flows and cease to flows

System connectivity has changed, with an increase in the frequency, magnitude and duration of cease-to-flow events and low flow conditions. Pre- regulation, cease to flow periods were typically less than one month.[44] Since river regulation, cease to flow periods at some sites are more frequent and longer in duration. In addition, there have been substantial impacts, along the entire river, on low flows, which are now frequently below lotic (flowing) thresholds[45].

Although low flow and cease to flow periods form a part of the natural flow regime, changes in the timing and magnitude of these flows are having a significant effect on connectivity, ecosystem resilience and environmental, social and cultural outcomes.

Comprehensive analysis on the changes to cease to flow periods in the Barwon-Darling has been completed:

[39] DPE Water (2022), *Western Regional Water Strategy* – See Page 52
[40] NSW Government – DPIE (2020), *Barwon–Darling Long Term Water Plan Part A*
[41] Vertessy, R., Barma, D., Baumgartner, L., Mitrovic, M., Sheldon, F., Bond, N. (2019), Independent Assessment of the 2018-19 fish deaths in the lower Darling – Final Report, for the Australian Government, 29 March 2019.
[42] NSW Government – DPIE (2020), *Barwon–Darling Long Term Water Plan Part A*
[43] Mallen-Cooper, M., & Zampatti, B. P. (2020). Restoring the ecological integrity of a dryland river: why low flows in the Barwon–Darling River must flow. Ecological Management & Restoration, 21(3), 218-228
[44] Mallen-Cooper, M., & Zampatti, B. P. (2020). Restoring the ecological integrity of a dryland river: why low flows in the Barwon–Darling River must flow. Ecological Management & Restoration, 21(3), 218-228
[45] Mallen-Cooper, M., & Zampatti, B. P. (2020). Restoring the ecological integrity of a dryland river: why low flows in the Barwon–Darling River must flow. Ecological Management & Restoration, 21(3), 218-228.

Barwon-Darling Long Term Watering Plan: Analysis on observed flow data showed that observed flows at Bourke from 1944 to 1990, cease-to-flow conditions were experienced about 4% of the time. From 2000 to 2019, the proportion of time that cease-to-flow conditions were experienced at Bourke increased to about 25% of the time.

Western Regional Water Strategy[46]: The Western Regional Water Strategy analysis shows that development has likely increased the frequency of shorter cease-to-flow periods (0–1 month) and low-flow periods in the Barwon–Darling. In some instances, low flows have increased by up to 50%, with a measurable increase in the frequency of low flows since the early 1990s. The Strategy indicates this is due to extraction in upstream water sharing plan areas. It suggested longer cease-to-flow events are more likely driven by the climate, rather than irrigation development because very little inflow occurs during these events.

Changes to annual average flow

Changes in inflows to the Barwon-Darling, as well as diversions within the Barwon-Darling have reduced annual average flow through the river. Annual average flows under modelled without development and current conditions, show that flow volumes have reduced by 39% at Mungindi, 49% at Walgett, 50% at Bourke, and 50% at Wilcannia[47]. These patterns of decrease in mean annual flow volumes are observed across all dry and wet climatic regimes and for the complete flow regime[48].

Changes to higher flows and freshes

Moderate and high flows have been impacted by development upstream. The Western Regional Water Strategy modelling shows that the number of small fresh, large fresh, bankfull and large overbank flow events have reduced in the Barwon-Darling at Wilcannia and Bourke[49] . Peaks of higher flows and freshes are extracted by water users in both NSW and Queensland, resulting in longer or more frequent low-flow events[50] . A significant change has been a reduction in the magnitude of near-annual flow pulses during droughts, which have been reduced by over 90%.[51]

In addition, unconstrained floodplain harvesting, which is the capture and storage of water that flows across floodplains by irrigators for later use, has reduced the volume, frequency, and duration of floods[52]. The NSW Government is implementing the Floodplain Harvesting Policy to address this. Floodplain harvesting in three of the four regulated water sharing plan areas has been licenced, which is the first step towards being able to better manage this form of take.

Changes to flow variability

Large headwater impoundments have a significant impact on the rivers which they dam. Not only do they restrict the downstream movement of water, but they also restrict the movement of sediment, nutrients and animals along the river. In addition, they have a significant influence on the thermal regime of the river downstream. The regulated tributaries of the Barwon-Darling contain dams that can hold 1 to 6 times the mean annual inflow[53] . This means that in most cases, other than during periods of spilling, the flow of

[46] DPE Water (2022), *Western Regional Water Strategy* – See page 59
[47] NSW Government – DPIE (2020), *Barwon–Darling Long Term Water Plan Part A*
[48] Stocktake of Northern Basin Connectivity Rules – Analysis of implementation and effectiveness Barma Water Resources 2019
[49] DPE Water (2022), *Western Regional Water Strategy* – See Figure 21 and 22
[50] DPE Water (2022), *Western Regional Water Strategy* – See page 59
[51] Mallen-Cooper, M., & Zampatti, B. P. (2020). Restoring the ecological integrity of a dryland river: why low flows in the Barwon–Darling River must flow. Ecological Management & Restoration, 21(3), 218-228..
[52] DPE Water (2022), *Western Regional Water Strategy* – See page 54
[54] DPE Water (2022), *Western Regional Water Strategy* – See page 30

water immediately downstream of dams is totally reliant upon controlled releases from the dam.

In most cases, the hydrological impact of large dams manifests great distances downstream, though this is dependent on the location and hydrology of major tributaries. Most dams are operated to provide controlled releases for extraction downstream, with water orders delivered in a way to minimise conveyance 'losses'. This eliminates the natural variability of river flow, which is critical, especially in hydrologically variable rivers in the Northern Basin, for the maintenance of habitats and ecosystem processes. More recently, environmental water stored in the dams, has been used to try and reinstate some variability in the flows downstream. However, outcomes are constrained by the amount of environmental water available.

Potential changes due to climate change

The Barwon-Darling River system faces significant challenges due to climate change, with potential shifts in rainfall seasonality, higher evaporation rates, and increased variability in inflows. Ongoing increases in temperatures and reduced rainfall, combined with additional regulation and storage in upstream tributaries of the Barwon–Darling could lead to longer and more frequent cease-to-flow periods, lower average flows and longer dry periods.

The Western Regional Water Strategy climate change analysis outlined that under a dry 'worst case' climate change scenario the following could occur:

- more frequent occasions when the Northern Tributaries do not connect to the Barwon-Darling [54]
- reduced volume of water flowing into the Barwon-Darling system from tributaries in NSW and Queensland, with median annual inflows potentially 42% lower when compared to long-term historical projections
- reduction in the number and duration of high-flow events and freshes: on average, a 37% reduction in the number of high-flow events that fill the banks, the number of freshes occurring every year is predicted to decrease by 33%, and the duration of these flows when they do occur is expected to decline by 19%
- increases in the frequency and duration of cease-to-flow events – this is most pronounced in the unregulated river systems[55]

These future climate changes may make it more difficult to achieve connectivity throughout the system.

1.5 Impacts of changes to Barwon-Darling Baaka hydrology

The reduction of inflows and changes to flow regimes can impact on downstream communities who rely on a healthy flowing river for food, water and amenity. Aboriginal communities in particular have a strong connection to the Darling–Baaka river. The hydrological changes in the Barwon–Darling system have had an impact on ecological processes and overall resilience of the system.

[54] DPE Water (2022), *Western Regional Water Strategy* – See page 30
[55] DPE Water (2022), *Western Regional Water Strategy* – See page 56

The importance of flow (and flow variability) in the Barwon-Darling river system can be articulated under the four principles of Bunn and Arthington (2002)[56]. Changes to the flow regime at floods/high flows, in-channel flows pulses, small flow pluses, and no flow periods has implications for all the following principles.

Principle 1: Flow is a major determinant of physical habitat in streams and rivers, which is a major determinant of biotic composition – in the Barwon-Darling, flow variability which includes small and large freshes provides a range of habitats that can be utilised by different life stages of a range of species.

Principle 2: Aquatic species have evolved life history strategies primarily in direct response to the natural flow regimes of a specific river or stream – in the Barwon-Darling many aquatic species require small and large freshes for spawning and recruitment with large overbank flows vital for large scale dispersal and booms in abundance.

Principle 3: Maintenance of natural patterns of longitudinal and lateral connectivity is essential to the viability of populations of many riverine species – in the Barwon-Darling longitudinal connection allows movement of aquatic species upstream along the main channel and into the headwater tributaries, this provides vital population connectivity, lateral connection during overbank flows connects the channel with floodplain environments and vastly increases the area of available aquatic habitat.

Principle 4: The invasion and success of exotic and introduced species in rivers is facilitated by the alteration of flow regime – invasive carp dominate the fish abundance in the Barwon-Darling and while they respond to floods and flow pulses in a similar manner to natives there is some evidence that the reduction in abundance and populations of native fish, likely due to hydrological impacts, may facilitate the dominance of carp.

Periods of higher than average flows are crucial for breeding and recruitment of various aquatic species and for replenishing soil moisture for riparian trees. Increasing dry periods and reducing in-channel flows can negatively impact water quality, native fish and turtle populations, macroinvertebrate diversity, and riparian tree health.

No-flow periods can lead to stratification in refugial pools, with conditions on the bottom water layers often becoming anoxic or severely hypoxic with high levels of nutrients and low light. This can be associated with increased incidence of algal blooms. In addition, saline inflows from groundwater can worsen water quality, leading to physiological stress in freshwater organisms.

Extended periods of no flow are detrimental to the long-term viability of native fish and invertebrate populations through:

- the impacts of declining water quality which can directly cause mortality to adults, juveniles or eggs,
- reduced availability of habitat for spawning and recruitment and,
- in many cases, the absence of triggers for spawning and recruitment.

Small in-channel flow pulses are critical for the reproduction and survival of many aquatic organisms. Small flow pulses can provide the flushing flows required to disrupt algal blooms, or prevent their formation. These small in-channel flow pulses are vital for the long-term survival of a range of small bodied, short-lived, fish. Small flow pulses also

[56] Bunn, S. E., and A. H. Arthington. 2002. Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity. Environmental Management 30:492-207

provide longitudinal connection along the channel network, increased access to a range of habitats, and a stimulus for spawning in some fish.

Small in-channel flow pulses play a crucial role in managing water quality in pools and waterholes. However, if these pulses are infrequent and too short, they may only serve to push batches of saline water downstream, potentially impacting different reaches instead of diluting the saline water and preventing additional ecological damage.

Reducing the frequency of small pulses along the channel network could lead to increased instances of poor water quality in refugia and restricted channel sections. It may also potentially increase the frequency of algal blooms, reduce the success of spawning in small-bodied native fish, and increase the mortality of various other aquatic organisms.

1.6 Previous reviews and recommendations

Several studies over the past five to ten years have highlighted the considerable negative impacts to the environment and downstream communities due to a lack of adequate connectivity in the Northern Basin. The reports have examined pre and post regulation hydrology[57, 58] and associated changes in water chemistry, algal blooms, river ecology[59] and the decline in populations of ecologically and culturally important species such as native fish populations, freshwater mussels and the introduction of pest species like carp.[60] (See Box 2).

[57] Thoms M. C. and Sheldon F. (2000) Water resource development and hydrological change in a large dryland river: The Barwon-Darling River, Australia. *Journal of Hydrology* 228, 10–21.
[58] Carlisle, P. (2019) *Hydrological impacts of water management arrangements on low flows in the Barwon-Darling River system*. Report prepared for the Commonwealth Environmental Water Office.
[59] Thoms, M. C. and Delong, M. (2018) Ecosystem responses to water resource developments in a large dryland river. *Water Resources Research* 54, 6643–6655
[60] Sheldon, F. and McCasker, N. (2020) *Habitat and flow requirements of freshwater mussels in the northern Murray Darling Basin,*

Box 2 – Previous studies and reports that have highlighted issues with Northern Basin connectivity

Barwon — Darling Long Term Water Plan – includes objectives and targets for improving connectivity within the Barwon — Darling itself, with its tributaries, and with the Lower Darling as longitudinal connectivity is vital to achieving Basin-wide outcomes.

NSW and Regional Water Strategies – The NSW Water Strategy includes actions to improve system connectivity and all the northern basin regional water strategies, include actions to progress water sharing plan changes to improve connectivity with the Barwon- Darling on a multi-valley scale. The Western Regional Water Strategy identifies a lack of connectivity as a significant concern and acknowledges that rules in upstream water sharing plans are impacting on adequate connectivity. Improving connectivity across the Northern Basin was one of three priority areas identified for action.

Northern connectivity stocktake (2019)[61] – examined the water sharing rules that potentially contribute to connectivity between the Barwon – Darling and its NSW tributaries. This analysis recognised the importance of focusing on intervalley outcomes, with improved hydrological forecasting and deemed implementation of the Interim Unregulated Flow Management Plan important for achieving intervalley connectivity.

Review of the Interim Unregulated Flow Management Plan for the North West (2021)[62] **–** DPIE Water requested a review of the appropriateness of the targets in the North -West Flow Plan, a historic assessment of when the Plan targets were met, and the role that restrictions on supplementary use and B- and C-class licences could have had. The report recommended revised riparian, algal suppression and fish migration targets.

Water sharing plan reviews[63]**-** the Natural Resources Commission has completed several independent reviews of Northern Basin water sharing plans, including the Barwon-Darling Water Sharing Plan in 2019. This review called for an integrated approach to managing the Northern Basin to address reduced inflows, implementation of rules for protecting resumption of flows and ensuring enabling provisions for implementation of the Interim Unregulated Flow Management Plan.

The Commission's reviews of unregulated water sharing plans in the Northern Basin identified that compliance with the long-term average extraction limits is not undertaken, there is very limited data on usage and limited gauging stations in these systems. The review raised serious concerns about the heavy reliance on "no visible flow" rules that allow users to pump until the rivers stop flowing. All of these shortcomings in the unregulated water sharing plans have a direct impact on downstream connectivity.

Independent reviews of fish deaths – these reviews span the mass fish deaths that occurred in the Lower Darling-Baaka over 2004[64], 2018-19 (Australian Academy of Science[65] and Vertessy reviews)[66,67] and 2023 (Office of NSW Chief Scientist and Engineer review)[68]. These reviews highlight the importance of providing connectivity and protection of flows to support native fish.

The Australian Academy of Science review attributed the root cause of the 2018-19 mass fish deaths as not enough water in the Darling system to avoid catastrophic decline of condition through dry periods.

The Vertessy review emphasised the impact of the fragmented approach to water management in NSW and how that effects inflows to Menindee Lakes. It outlined that water use in the Barwon-Darling tributaries had a greater impact on Menindee inflows compared to extraction along the Barwon–Darling in certain conditions. However, during low flows, A-class licence access posed a significant threat to inflows and connectivity, particularly between Bourke and Menindee.

The 2023 review by the Office of the NSW Chief Scientist and Engineer recommended that the Connectivity Expert Panel examine the adequacy of rules in all Northern Basin water sharing plans (regulated and unregulated) in contributing to hydrological connectivity with the Lower

Darling-Baaka River and southern Basin. It also recommended prioritisation of changes to Northern Basin water sharing plans to support system scale outcomes.

1.7 NSW Government response to connectivity recommendations

In response to the many findings and recommendations regarding concerns with connectivity in the Northern Basin, in recent times the NSW Government has taken several steps to try to improve outcomes. These include:

- **Changes to A-Class Cease to Pump:** In 2020, amendments were made to the Water Sharing Plan for the Barwon–Darling Unregulated River Water Source 2012 to help protect low flows by raising the thresholds at most locations for when A Class licence holders can access water.
- **Individual daily extraction components (IDEC):** were implemented in 2020, and limit total daily extraction for A, B and C Class access licences across the Barwon-Darling water source. Daily extraction limits restrict the impact of rapid removal of water during peak irrigation periods. This mitigates localised and downstream impacts for the benefit of all water users, including for social, cultural and environmental needs**.**
- I**nclusion of a "resumption of flow" rule in the Barwon-Darling water sharing plan:** The Plan was amended to incorporate rules to protect initial flows in the Barwon–Darling River after an extended dry period. This rule only applies in the Barwon-Darling water sharing plan.
- **Section 324 orders:** These orders were placed on the regulated water sharing plan areas, the Barwon-Darling and some of the connected unregulated water sharing plan areas to restrict water during the "first flush" after the extended dry periods in 2018 - 2020.
- **Floodplain harvesting restriction target:** A target was added to the Gwydir, Border Rivers and Macquarie-Cudgegong regulated water sharing plans that requires floodplain harvesting to be restricted if Menindee Lakes storage falls below 195GL. That restriction is removed if flows are maintained above various in-valley "relaxation triggers", which are typically a small or large fresh flow.
- **Implementation of active management:** Rules were added to provide for active management in the unregulated Gwydir, unregulated Macquarie and the Barwon-Darling water sources in the Northern Basin to allow certain environmental water to be protected through the system.
- **Clauses requiring Expert Panel review:** When the regulated water sharing plans were amended as part of the development of the Water Resource Plans under the Murray

[61] Barma Water Resources (2019) *Stocktake of Northern Basin connectivity rules – analysis of implementation and effectiveness*
[62] Alluvium Consulting (2021), *Review of the Interim Unregulated Flow Management Plan for the North West*
[63] NSW Natural Resources Commission (2019) *Review of the Water Sharing Plan for the Barwon-Darling Unregulated and Alluvial Water Sources – final report*.
[64] Ellis, I, and Meredith, S (2004) An independent review of the February 2004 Lower Darling River fish deaths: guidelines for future release effects on Lower Darling River fish populations.
[65] Australian Academy of Science (2019) *Investigation of the causes of mass fish kills in the Menindee Region NSW over the summer of 2018-2019*, Canberra
[66] Vertessy, R., Barma, D., Baumgartner, L.J., Mitrovic, S.M. , Sheldon, F. and Bond, N.R. (2019) *Final report of the Independent Assessment of the 2018-19 fish deaths in the lower Darling*.
[67] Sheldon, F. and Barma, D. Baumgartner, L.J., Bond, N.R. Mitrovic, S.M. and Vertessy, R. (2021) Assessment of the causes and solutions to the significant 2018–19 fish deaths in the Lower Darling River, New South Wales, Australia, Marine and Freshwater Research
[68] Office of NSW Chief Scientist and Engineer (2023) *Independent review into the 2023 mass fish deaths in the Darling-Baaka River at Menindee*

Darling Basin Plan[69], the references to the interim North-West Flow Plan were removed but the targets were retained. These targets require restrictions on supplementary take if in the Minister's opinion they are necessary to meet the targets. Clauses were included in the water sharing plans requiring that an Independent Expert Panel be convened to provide advice on the adequacy of the assessment of the critical needs of the environment, basic landholder rights, domestic and stock access licence holders and local water utility access licence holders in the Barwon-Darling River. The Panel is also to provide advice on the adequacy of flow targets to meet those needs.

Similarly, when the floodplain harvesting restrictions were included in the Plans a clause was included requiring an Independent Expert Panel to assess whether rules are adequate in the context of the needs of the environment, basic landholder, stock and domestic access licence holders and water utility needs. In addition, the Independent Expert Panel is to consider any changes to the flow targets and volumes that would be required to meet these needs.

The Department is continuing its efforts to advance connectivity work through its Northern Connectivity Program, which is focused on advancing the connectivity priorities identified in the Western Regional Water Strategy. This Expert Panel has been convened consistent with the water sharing plan clauses outlined and the Terms of Reference to provide further advice regarding connectivity issues.

1.7.1 Analysis of options for improving connectivity in the Western Regional Water Strategy

The Western Regional Water Strategy identifies improving connectivity across the Northern Basin as one of three priorities for water management in the region. The Strategy indicates that the intent is to:

- Protect the first flush of water after an extended drought
- Reduce the impact of cease to flow periods
- Suppress algal blooms
- Support fish migration

However, the majority of the discussion in the Strategy is focused on what is identified as the "critical dry condition triggers." These are shown in Table 2. The Panel's assessment of these triggers is discussed in Section 3.3.

Table 2. Critical dry condition triggers proposed in the Western Regional Water Strategy

Proposed trigger for implementing temporary water restriction	Proposed trigger for lifting temporary water restriction
Wilcannia When there is a high confidence forecast cease-to-flow period of 120 days at Wilcannia (20 ML/day at Darling River at Wilcannia 425008).	Forecast 400 ML/day for 10 days (or 4,000 ML) at Wilcannia.

[69] This applies to the Border Rivers and Gwydir Regulated Plan. For the Macquarie and Cudgegong Regulated Plan, the reference to expert panel advice only relates to floodplain harvesting and the Upper and Lower Namoi Regulated Plan does not include any reference to the panel as this plan has not been amended yet.

Bourke When there is a high confidence forecast cease-to-flow for 60 days at Bourke (0 ML/day at Darling River at Bourke 425003).	Forecast 972 ML/day for 10 days (or 9,720 ML) at Bourke.
Northern valleys All or most of the northern valleys and/or Barwon–Darling River system are classified as Drought Stage 4 criticality under the Department of Planning and Environment's NSW Extreme Events Policy. And/or ▪ Cease-to-flow for 30 days or more extended periods for any of the following locations: ▪ Border Rivers – Macintyre at Goondiwindi (416201A) ▪ Gwydir River – Mehi at Moree (418002) ▪ Macquarie – below Warren Weir (421004) ▪ Namoi – below Mollee Weir (419039).	Resumption of flow targets for the Northern Tributaries such as: ▪ Border Rivers – Macintyre at Goondiwindi – 3,600 ML over 7 days ▪ Gwydir River – Mehi at Moree – 3,600 ML over 7 days ▪ Macquarie – below Warren Weir – 21,000 ML over 7 days ▪ Namoi – below Mollee Weir – 8,000 ML over 7 days.
Menindee Lakes When the active storage in the upper lakes of the Menindee Lakes storage (primarily Wetherell and Tandure lakes) is forecast to fall below 195 GL capacity. Once this trigger is reached there would be no releases beyond the minimum flow requirements from Wetherell, Pamamaroo and Tandure lakes. Note: If the Pamamaroo inlet regulator has not been upgraded then the trigger would be 250 GL active storage in Wetherell, Pamamaroo and Tandure lakes to provide 12 months supply to the Lower Darling River.	If the active storage in the upper Menindee lakes storage is less than 195 GL and the Lower Darling has ceased to flow then restrictions would be lifted when the lakes are forecast to have enough water to restart the river. This is likely to be approximately 255 GL: 195 GL (active) + 60 GL to restart the river. If the Lower Darling has not ceased to flow then the restrictions can be lifted earlier (when there is 195–255 GL of water in Menindee Lakes). Restrictions can be lifted upstream once the peak of the flow has passed as long as the Menindee Lakes are forecast to have the required volume. If the upper Menindee Lakes active storage is greater than 195 GL but the critical dry conditions triggers (defined below) have been reached at other locations, then restrictions will be lifted once the lifting triggers at each location are reached.

In addition to the critical dry condition triggers proposed, the Western Regional Water Strategy also indicates that the Expert Panel should be convened to provide further advice on the achievement of the algal bloom and fish migration targets. It proposes not to maintain the riparian rights targets in the North-West Flow Plan as the original riparian

targets are said to be surpassed by water sharing plan rules. Instead, the critical dry conditions targets are proposed to meet critical human and environmental needs.

It also proposes further consideration of provision of replenishment flows from the Northern Tributary dams during dry periods. The Panel's analysis of these issues is provided in Chapter 3.

2 A holistic approach to connectivity is needed

Findings

A holistic approach is needed

1. NSW Northern Basin water sharing plans primarily focus on in-valley outcomes without effectively considering overall system-wide connectivity, making it difficult to achieve efficient and effective connectivity outcomes.
2. There is a lack of appropriate governance at the whole of Northern Basin system, inter-valley scale. This gap has led to a lack of an overall approach to managing connectivity and a lack of accountability for achieving connectivity objectives. While some steps have been taken to embed connectivity requirements into NSW Northern Basin water sharing plans, these have been piecemeal rather than considering the system as a whole.

Critical needs definition and focus on dry conditions

3. The Western Regional Water Strategy definition for "critical needs" is overly narrow for achieving connectivity as it focuses only on trying to prevent catastrophic outcomes for towns and ecosystems during extreme dry conditions. Connectivity targets should aim to achieve a broader range of critical needs across various climatic conditions.
4. Currently implemented triggers and targets proposed by the Department are predominantly focused on restoring flow after extended dry periods. This is only one aspect of connectivity. Additional triggers are needed to maintain water in the system, which should enhance the resilience of the system and reduce the amount of water needed to restore systems after dry periods.
5. There is strong evidence that flows necessary to maintain the health of the rivers and critical ecosystem functions are not being met during non-dry times, when there is water available to meet these needs.
6. Supplementary and floodplain harvesting take (opportunistic take) are by their nature less available during dry and very dry times, and therefore restricting them is unlikely to achieve downstream flow targets without other simultaneous interventions. Restricting opportunistic take is likely to be more beneficial during wetter times when targets are not currently being met, including during recovery times.

Ecosystem function environmental water requirements

7. The Long Term Water Plans identify environmental watering requirements, expressed in terms of flow level, frequency and duration that are fundamental for providing basic ecosystem function and health, including flows necessary to maintain adequate connectivity. The Panel views the ecosystem function environmental water requirements represent critical needs for achieving adequate connectivity.
8. The ecosystem function environmental water requirements should be achievable during non-dry periods when water is available in the Northern Tributaries. The Panel accepts they may not be feasible to fully achieve during dry times.

Recommendations

A holistic approach is needed

1. The NSW government should take a holistic and adaptive management approach to water management across the entire Northern Basin, considering how rules work together to achieve agreed connectivity outcomes. This should involve moving away from a

reactionary approach. Upstream water sharing plans should actively consider and provide for downstream environmental and community needs to ensure the overall health and connectivity of the system.

2. To improve accountability for system-wide connectivity the NSW Government should:
   a) assign a governance body responsible for reviewing the implementation of any agreed connectivity recommendations and ensuring that efforts are coordinated across various government agencies. This body should be independent of the Water Group.
   b) create a community advisory group including representatives from the Aboriginal community, industry stakeholders from upstream and downstream, and local community groups to advise the governance body described above regarding on-ground experiences and issues.

Providing for a range of critical needs in different climatic conditions

3. The Department should ensure that rules are implemented that provide for adequate connectivity needs across the range of climatic conditions likely to be experienced. This should:
   a) Ensure that an adequate share of water is protected for downstream river health during non-dry times by ensuring that the ecosystem function environmental water requirements are met throughout the Barwon-Darling.
   b) Provide for restrictions earlier in dry times to minimize the length of dry periods and support recovery.

Each of the NSW Northern Basin catchments that contribute to inflows into the Barwon-Darling River system is governed by one or more water sharing plans. Each of these water sharing plans focus on in-valley outcomes without an explicit legislative requirement to achieve overall system-wide connectivity. Water that leaves a plan area is generally 're-regulated', meaning it is again available for extraction in the downstream plan in accordance with the downstream plan rules. Therefore, by design, the NSW Northern Basin water sharing plans fundamentally work in isolation, with limited to no consideration of the needs and outcomes in adjacent and downstream catchments.

The *Water Management Act 2000* includes principles and objectives that relate to connectivity; however, it is not explicit in the requirements to provide for connectivity. Several of the Northern Tributary water sharing plans were recently amended to include an objective related to connectivity, but the Department has advised these objectives will be removed.

Such a set-up, which focuses on each plan area individually without considering the whole system, makes it difficult to achieve system-wide connectivity outcomes in an efficient and effective manner. The lack of integration between catchments fundamentally impacts overall system connectivity and environmental and basic needs outcomes in the Barwon-Darling River, the Menindee Lakes and the Lower Darling River.

With over 90% of its inflows provided from Northern Basin catchments, the Barwon-Darling is inherently dependent on the management and operations of the upstream tributary catchments to provide for adequate inflows. This is particularly the case as the Barwon-Darling has limited infrastructure to manage flows within the plan area. As such, it is critical that upstream water sharing plans actively consider and provide for downstream environmental and community needs.

Some steps have been taken to embed connectivity requirements into the NSW Northern Basin water sharing plans as outlined in Chapter 1. The Western Regional Water Strategy outlined further steps that should be taken to assess proposed rules and opportunities to further enhance connectivity. The establishment of this Panel is the next step in this process.

While positive, the steps taken to date have been somewhat piecemeal, often focusing on one specific aspect of connectivity, such as recovery after a severe dry, or on specific locations rather than considering the system as a whole and how the rules work together to achieve connectivity. There has been minimal consideration on what is fundamentally required to provide the background hydrological conditions that enhance connectivity most of the time to ensure that the system is, and remains, resilient, healthy and able to withstand the variability in inflows that are prevalent in the Northern Basin system.

Considering the system holistically is fundamental. This systems thinking approach to river management is not new, Aboriginal cultural science is strongly rooted in this sentiment and should be foundational to how we address connectivity within the Northern Basin. Caring for Country means there is a cultural obligation to get water to communities downstream.

In order to consider connectivity across the Northern Basin more holistically, the Panel has considered the evidence around current connectivity outcomes as well as the levers that are available to improve connectivity across the range of climate conditions likely to be experienced. This has crystalised that it is essential to maintain connectivity during non-dry times (outside of extended dry periods), when water is available in the system to keep the system 'wetter' more consistently. During these non-dry times, more levers and more water are available to achieve basic ecosystem function needs.

The Western Regional Water Strategy clearly identified significant issues with connectivity during non-dry periods. It highlighted the increases in short cease-to-flow events and low flow periods and specifically attributed these to upstream irrigation development indicating that changing rules in upstream plans can help manage these short cease-to-flow and low flow events[70]. It also recognises that improving connectivity during non-drought times may help to build resilience to future extended dry periods[71]. However, despite the evidence included in the Strategy, the proposed actions did not address this issue.

Maintaining connectivity during non-dry times overcomes the limitations of the current approach to management where the lower parts of the system are allowed to dry therefore requiring large volumes of water to 'restart' the system. In many ways this represents a 'waste' of water and results in unnecessary ecosystem stress by increasing the frequency of drying and carries significant risks, in terms of water quality, for downstream communities. An approach that enhances natural levels of connectivity is likely to be more effective and efficient.

Northern Basin connectivity governance arrangements

The Panel is of the view that previous attempts and recommendations have in part failed to address connectivity holistically because there has been a lack of accountability. Implementation of the Panel's proposed rules will require coordination across the four valleys, the Barwon-Darling and the Lower-Darling in order to be successful. Connectivity is complex and must be adaptively managed in order to be efficient and effective. While the Panel has based its recommendations on best available information, that information has severe limitations and approaches should be adaptively managed as new information

[70] DPE Water (2022), *Western Regional Water Strategy* – See page 59
[71] DPE Water (2022), *Western Regional Water Strategy* – See page 58

becomes available. Further, stakeholder concerns and input will be important to understand and address in order to make connectivity efforts successful.

Therefore, the Panel recommends that additional governance arrangements be implemented to ensure that the holistic approach is not lost and there is accountability for ensuring system-wide connectivity. Specifically, the Panel recommends that the Government:

- Assign a governance body responsible for reviewing the implementation of any agreed connectivity recommendations, and ensuring that efforts are coordinated across various government agencies. This body should be independent of the Water Group.
- Create a community advisory group including representatives from the Aboriginal community, industry stakeholders from upstream and downstream, and local community groups to advise the governance body described above regarding on-ground experiences and issues. The Panel notes that there is currently a Northern Basin Environmental Watering Group[72] that could perhaps be leveraged for this purpose; although the Panel recognises this group does not currently include community stakeholders.

The Panel will develop more specific governance recommendations for our final report following consultation with stakeholders and Government agencies. Consideration should also be given to how to embed a requirements for system-wide connectivity into legislative requirements.

2.1 Current focus is predominantly on recovering from drought

The Panel was asked to consider what flow targets are needed to ensure that the "critical needs" of the environment, basic landholders and local water utilities are not jeopardised. This section outlines the Department's definition of critical needs, the Panel's concerns with this definition and presents an alternate approach for defining critical needs across the range of operating conditions likely to be encountered.

2.1.1 Department definition of "critical needs"

In the work done to date by the Department, "critical needs" assessments have focused on meeting needs during "critical dry periods". The Western Regional Water Strategy supporting documents[73] indicate that critical dry conditions for human water use are defined as the point when the risk of insufficient water for high priority domestic supply for towns and individual landholders is escalated. Critical dry conditions for the environment are defined as the point when the risk of a catastrophic event has sharply escalated. Focusing narrowly on critical needs during critical dry periods ignores that there are critical needs that should be met during all times. This approach essentially takes the view that there is only a critical need when there is a possibility of catastrophic impacts to ecosystems or communities.

The Western Regional Water Strategy focuses the analysis on critical human needs during critical dry periods based on the argument that during extreme events, such as drought, under Section 60 of the *Water Management Act 2000*, critical human needs are the first priority and the environment the second. Whereas, outside these extreme events, the priority is providing water for the environment[74]. The Panel notes that our understanding is

[72] https://www.dcceew.gov.au/water/cewo/nbew-group
[73] DPE Water (2022), *Draft Western Regional Water Strategy: Attachment E : Critical dry condition triggers to reduce risk to environmental and human water needs: discussion paper*
[74] DPE Water (2022), *Western Regional Water Strategy* – See page 11

that the "flipping" of priorities requires that the Plan (or portions of the Plan) be suspended, which often does not happen even during these critical dry periods. Regardless, even if the priorities are flipped, the environment is still the second highest priority and warrants greater consideration.

2.1.2 Proposed rules have largely been related to dry or critically dry periods

Consistent with their definition of critical needs, the majority of the Department's analysis undertaken to date has focused on restricting the diversion or pumping of "opportunistic flow" during dry times for the purpose of drought recovery. Opportunistic flow is water that is not captured in a dam but can be made available for capture or extraction. In addition, the analysis to date has focused predominantly on restriction of supplementary flows and A ,B and C class access in the Barwon-Darling only. While there has been some analysis of potential outcomes that could be achieved from floodplain harvesting restrictions, the limitations of the modelling outlined in Section 5.1 make it difficult to assess potential benefits of floodplain harvesting restrictions.

This approach raises two key concerns:

- During dry times there is likely to be very little opportunistic diversion of flow as this form of take is supplied by rain. In dry and extremely dry times there is obviously little rain. It is somewhat contradictory to try to address a lack of flow by restricting a form of take that is unlikely to occur. Unsurprisingly, this is what the Department's analysis shows. During very dry times restricting supplementary take provides minimal benefit.
- It does not address that during **non-dry** times, fundamental flows downstream are being impacted by upstream development (peaks of higher flows and freshes are extracted and short cease-to-flow and low flow periods are increasing)[75]. Supplementary restrictions are more likely to be beneficial for achieving outcomes during non-dry times, including when flows resume following a dry time to provide a "first flush".

2.2 Need to consider a broader definition of critical needs

The Panel acknowledges that during extreme events there will be different ecosystem and human needs and associated management responses compared with normal or wet periods. However, it's important to recognise that there are critical needs for the environment, basic land holders and local water utilities at all times, not just during critical dry periods. This was recognised in the development of the North-West Flow Plan, which has targets for riparian needs, algal suppression and fish migration. While the Western Regional Water Strategy focuses largely on dry conditions, it also identifies the need for further assessment of the algal suppression and fish migration targets.

Evidence suggests that the critical needs of the ecosystem are currently being jeopardised across a range of flow conditions[76],[77]. This has led to a less resilient system, which experiences increased frequencies of algal blooms and poor water quality, with serious impacts on native species and communities. (See Section 1.3 – 1.6 for further discussion of evidence of the problem). The Department's proposed targets do not address this range of needs.

[75] DPE Water (2022), *Western Regional Water Strategy* – See page 59
[76] F Sheldon, E Rocheta, C Steinfeld, M J. Colloff, B Moggridge, E Carmody, T Hillman, R T. Kingsford, J Pittock (In review). *Testing the achievement of environmental water requirements in the Murray-Darling Basin, Australia*. Submitted to Marine and Freshwater Research
[77] Wentworth Group of Concerned Scientists (2023) *Are Murray-Darling Basin rivers getting the water they need to stay healthy?*

The Panel has assessed critical needs more broadly, focusing on what we view to be the critical needs to ecosystem functions and to achieve basic connectivity within the system at all times.

2.2.1 Benefits of maintaining a "wet" system

Although the Panel agrees that there will be extended dry periods and it will be important to restore flows after these dry periods, evidence suggests that the frequency and duration of shorter cease-to-flow and low flow events has increased significantly over the past two decades (as shown in Figure 4), and that this is predominantly due to upstream extraction[78].

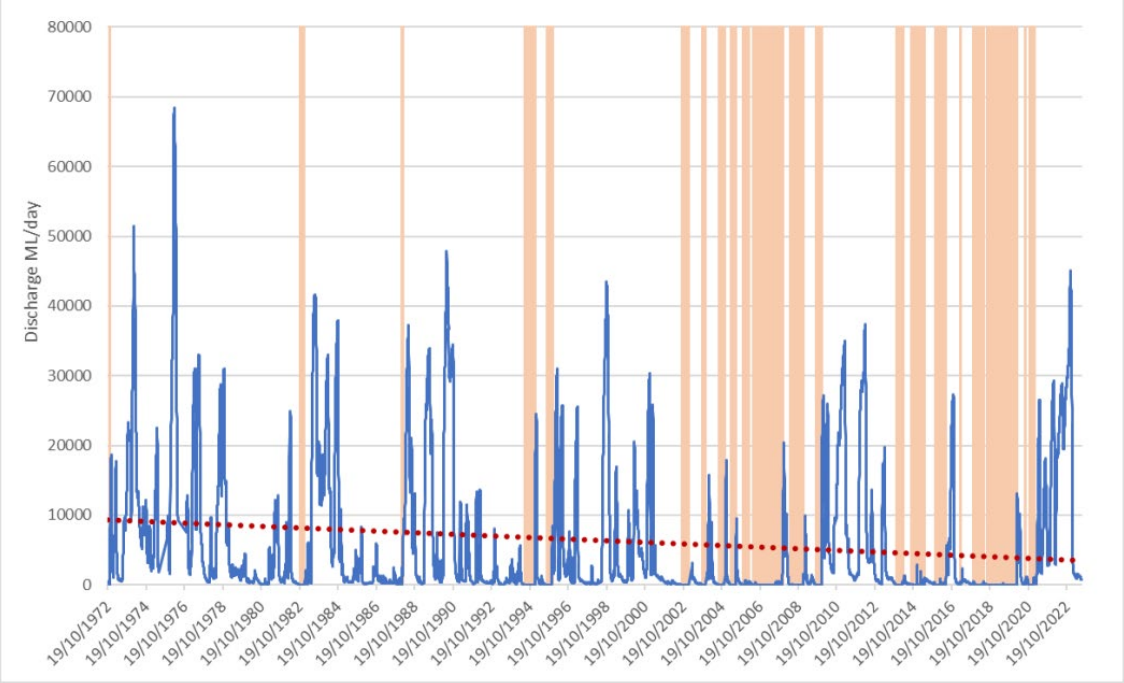

Figure 4 Historical flow (1972 to present) in the Lower Darling-Baaka River at Wilcannia (upstream of Menindee Lakes), showing mean value over time (red line) and periods of cease to flow and very low flow (<20 ML/day, orange vertical bars)[79].

While there have always been periods of no flow and potential drying in the system, in ecological timeframes it did not get as dry as it has in recent years, and especially the most recent 25 years. For example, many of the fauna and flora that dominate the assemblages of the Barwon-Darling River system – the river redgums along the banks, Murray Cod, catfish and the large river mussel (*Alathyria jacksoni*) within the channel are species that just do not occur in systems that dry for extended periods, and if they do their distribution is patchy, only being found in areas with permanent refugial waterholes[80]

[78] DPE Water (2022), *Western Regional Water Strategy* – See page 59
[79] Office of the NSW Chief Scientist & Engineer (2023) *Independent review into the 2023 fish deaths in the Darling-Baaka River at Menindee*

[80] Sheldon, F., S. E. Bunn, J. M. Hughes, A. H. Arthington, S. R. Balcombe and C. S. Fellows (2010). "Ecological roles and threats to aquatic refugia in arid landscapes: dryland river waterholes." *Marine and Freshwater Research* 61(8): 885-895.

In the context of more frequent and extended cease-to-flow events in recent years and in the context of future climate change, there are significant benefits of keeping the system "wetter" more frequently and for longer periods. It would allow more efficient and effective use of the available water resources as it reduces the need to utilise large volumes of water to restart the system. It would also help avoid the negative side effects, including water quality issues like algae blooms, that can arise when restarting a dried out system after a prolonged period. Finally, it would provide more favorable conditions for water-dependent ecosystems that would be reliant on permanent "pools" in an otherwise dry system.

It is well understood that the drier the system becomes the more water is necessary to "restart" the system. This is because the riverbed in effect acts like a sponge. The drier the riverbed is the more water it soaks up as it flows down the system. This was demonstrated anecdotally by the Northern connectivity event where the Commonwealth released significant water following an extended dry period, but just after the system had been "wetted up" by a small amount of rain. They achieved significantly more flow downstream than was anticipated and this was attributed to the fact that the system was already wet. WaterNSW similarly indicate that losses in very dry times are extremely high relative to the average losses.

The impact of the extraction of flows in the tributaries on flows in the Barwon-Darling is conceptualised in Figure 5. Here, flow pulse progression downstream in the modified system is greatly reduced thereby increasing the frequency and duration of cease-to-flow and low-flow events. This diagram also includes the important role the end of system wetland complexes play as sponges absorbing water and allowing future flows to pass further down the system. Targets for small-fresh and large-fresh flows from the tributaries would provide the water for the sponges throughout the system – keeping the system wetter for longer and allowing the passage of flows increasing connectivity.

The Panel is of the view that to improve the health and resilience of the system, and to use environmental water most efficiently, the system should be kept wetter more frequently and for longer periods. This will require early intervention and additional targets that are focused on ensuring that when water is available in the system, an adequate portion is provided for downstream river health and to try to extend the periods where there is water in the system.

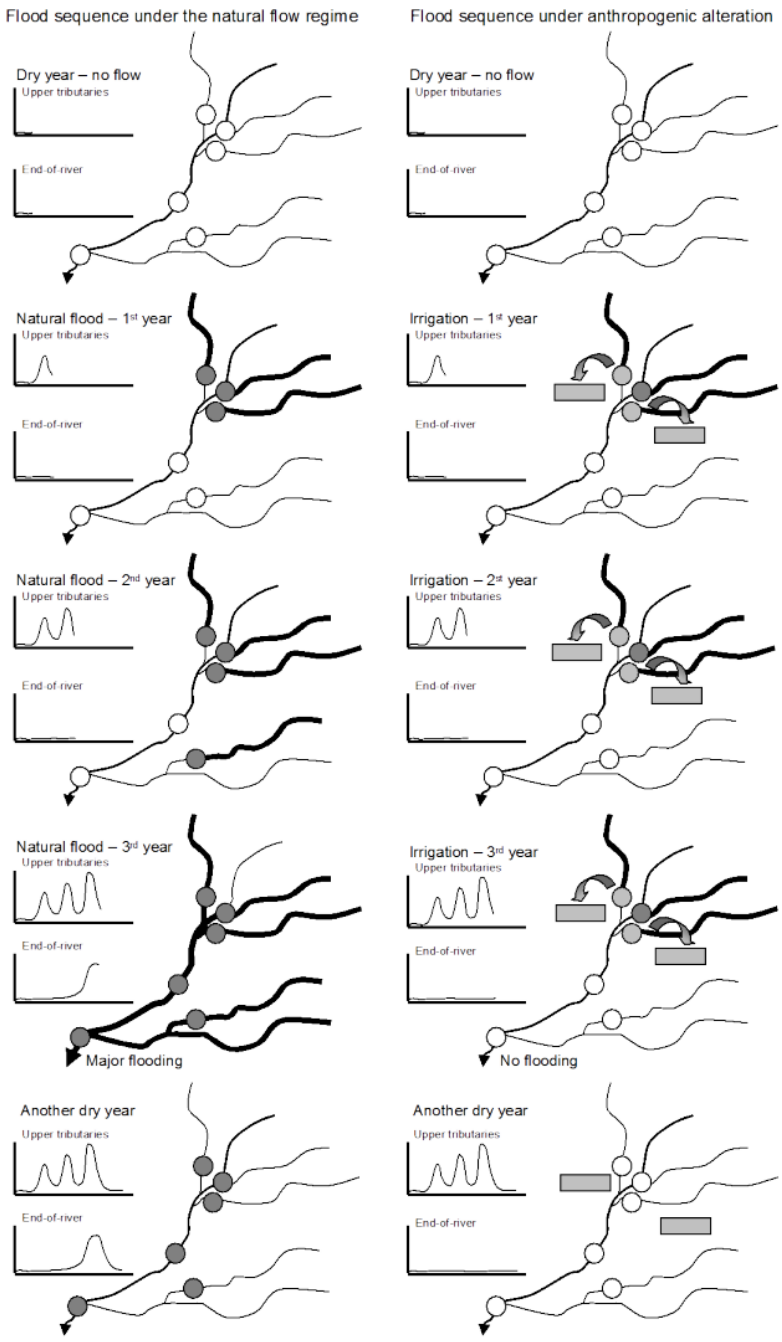

Figure 5 Sequential flooding: conceptual diagram (not to scale) for major tributaries, rivers and wetlands complexes (represented by circles) of a large river system (e.g. Murray–Darling Basin). In the left panel, from top to bottom, a 5-year sequence of a dry year, three floods and another dry year is depicted under natural (anthropogenically unmodified) flow conditions, where floodplain and terminal wetlands (closed circles) are progressively filled from uplands to lowlands (thick lines). This culminates in major flooding of rivers and wetlands in the third flood year, followed by a year of receding in-channel water levels but sustained aquatic habitat in the wetland refugia. This is contrasted with the same sequence under an irrigation scenario: upland wetlands are filled during the first flood year, but water is removed for irrigation (closed rectangles) so that lower wetlands do not fill and major flooding of the system does not eventuate, even after three consecutive years of upland flooding [81]

[81] Leigh, C., F. Sheldon, R. T. Kingsford and A. H. Arthington (2010). "Sequential floods drive 'booms' and wetland persistence in dryland rivers: a synthesis." Marine and Freshwater Research 61(8): 896-908.

2.2.2 Ecosystem function environmental water requirements as critical needs

The Panel has reviewed evidence of fundamental connectivity needs for all operating conditions. The most comprehensive assessment of the ecological needs of the system are the Long Term Water Plans (LTWPs).[82] These plans "*describe the flow regimes that are required to maintain or improve environmental outcomes. They identify strategies for maintaining and improving the long-term health of the riverine and floodplain environmental assets and the ecological functions they perform. This includes detailed descriptions of ecologically important river flows and risks to water for the environment.*"[83]

The LTWPs cover the Barwon-Darling River system and all tributaries and identify a wide range of environmental water requirements. Some of these requirements are specifically identified as necessary to provide what the Panel has identified as critical needs for maintaining ecosystem health through connectivity. These include baseflows, small freshes and large freshes as outlined in the table below:

Table 3 Baseflow, small freshes and large freshes environmental water requirements

Flow category	Description
Baseflow	Provides connectivity between pools and riffles and along channels. They provide sufficient depth for fish movement along reaches.
Small fresh (pulse)	Low-magnitude in-channel flow pulse that improves longitudinal connectivity by inundating low lying benches, connecting sections of a channel or river, triggering animal movement and flushing pools.
Large fresh (pulse)	High-magnitude flow pulse that remains in-channel, connects most in channel habitats, provides partial longitudinal connectivity by drowning out of some low-level weirs and other in channel barriers and may engage flood runners and inundate low-lying wetlands.

The definitions for these flow categories correlate most closely with the Panel's objective to maintain adequate longitudinal connectivity within the Northern Basin. Further, they fulfill the "ecosystem function" environmental water requirements, which are meant to provide for basic ecosystem function and health including adequate connectivity.[84] More broadly they aim to provide for drought refugia, quality instream habitat, movement and dispersal opportunities for aquatic biota (i.e. fish passage), instream and floodplain productivity, sediment, carbon and nutrient exchange, and inter-catchment flow contributions. The Panel views these as the critical connectivity needs of the environment. Without sufficient water, and/or with sufficient flow variability, ecosystem health and the resilience of the system will continue to decline.

These environmental water requirements do not need to be met 100% of the time. Rather, in the long term water plans the requirements include not only a target discharge but also a frequency and duration that should be achieved; for example, baseflows are required most of the time, and small and large freshes required periodically – generally once every year or two. In order for the ecosystems to maintain their health and resilience, it is important the system has periodic "pulses" of small and large flow. These pulses are

[82] NSW Government – DPIE (2020), *Barwon–Darling Long Term Water Plan Part A*
[83] NSW Government – DPIE (2020), *Barwon–Darling Long Term Water Plan Part A*
[84] NSW Government – DPIE (2020), *Barwon–Darling Long Term Water Plan Part A* – See Page 26

necessary for maintaining the overall health of the ecosystem through movement of nutrients and clearing out of debris, for the condition of fish and bird habitat, for fish spawning and migration and for maintaining water quality.

A comparison of hydrographs from pre-development models to observed flows during the lifetime of the water sharing plans demonstrates that the majority of what would historically have been small or large "pulses" are now either eliminated or greatly reduced. The hydrograph is significantly flatter than it used to be, particularly in the smaller pulses.

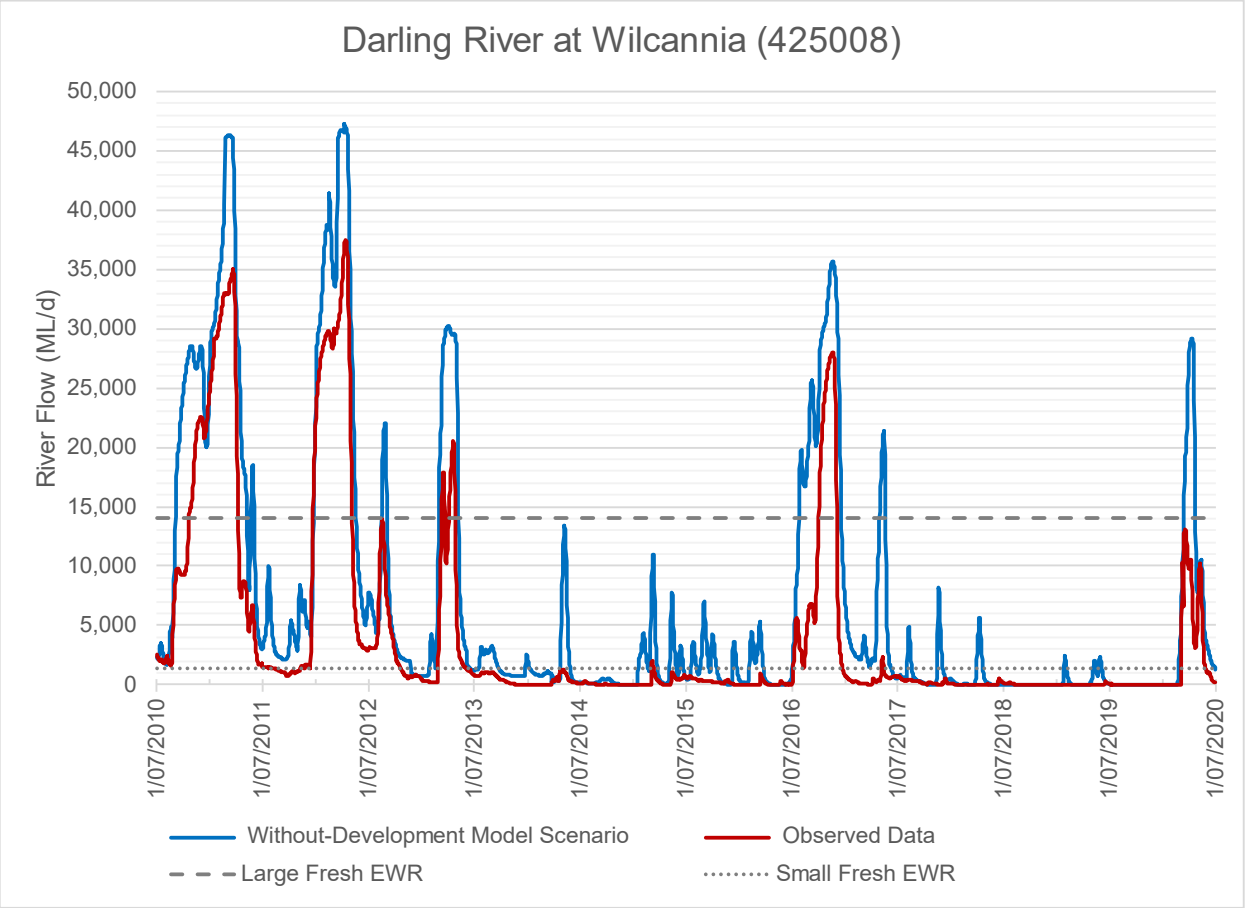

Figure 6 Flow in the Darling River at Wilcannia – Modelled without development compared to observed flows from 2010 to 2020[85]

It is important to note that the Panel is not recommending that *all* environmental water requirements should be met to meet critical needs. Rather we have focused on those that we feel are essential to be met to maintain the fundamental health of the system and ensure basic landholder rights are met through improved connectivity.

Given the extensive evidence of the decline of the ecosystem health in the Barwon-Darling, the Panel views that to meet the Act requirement that "*the sharing of water from a water source must protect the water source and its dependent ecosystems*[86]" at a minimum, targets should seek to restore baseflows, small freshes and large freshes.

[85] Without-Development Model data sourced from NSW Government Data.NSW: Water Modelling-Modelled Data-Without Development-Barwon-Darling; Observed flow data sourced from Water NSW WaterInsights: Barwon Darling Unregulated River Data

[86] Water Management Act 2000 Section 5(3).

However, the Panel also accepts that there are dry times when meeting the full range of ecosystem function environmental water requirements may not be possible. As such, we have focused our recommendations on targeting and achieving the requirements to the extent possible given the prevailing antecedent conditions.

2.3 Available tools for improving connectivity

There are many types of rules in water sharing plans that could be used to improve connectivity, if designed with connectivity specifically in mind rather than limited to in-valley outcomes.

The interim unregulated flow management plan for the North-West (North-West Flow Plan) was written in 1992 in recognition that connectivity between systems was an important consideration. The flow targets in this plan were subsequently integrated into the Northern Tributary and Barwon-Darling water sharing plans. However, they have not been implemented other than two initial trial attempts in the 1990s prior to the development of the water sharing plans. The Western Regional Water Strategy and Alluvium report indicate that they were not implemented because of flow forecasting limitations. In their absence there are no rules specifically designed to ensure downstream needs are adequately provided for.

2.3.1 Rules in Water Sharing Plans that could contribute to downstream connectivity

The Panel considered a range of water sharing plan rules and outlines why these are currently not achieving downstream connectivity. (Table 4).

Table 4 Rules in Water Sharing Plans that could contribute to downstream connectivity

Type of Rules	Comments
Excess of long-term average annual extraction limit (LTAAEL) is Planned Environmental Water (PEW)	Plans are designed such that any water above the long-term average annual extraction limit is meant to be reserved for the environment. However, as water availability is predicted to continue to decline under climate change predictions, this will result in less and less water for the environment. Further, as most water is captured in dams in the regulated systems, in practice water for the environment is what is specified as planned environmental water in the dam and anything reserved from opportunistic flows (supplementary and floodplain harvesting). System operation is focused on “efficient” delivery of water for irrigation. The more efficiently water is delivered for extraction, the less water is left in the system for the environment. Between climate change and increased “efficiency”, environmental water availability has been reduced. Data on actual end of system flows shows that significantly less water is reaching the end of system than was modelled to reach the end of system under the Plan rules when the plans were developed.
Minimum daily flow rule	These rules apply to regulated water sharing plans and require a minimum flow from dams or a flow at a specific reference location within the plan area. These minimum flow rules are predominantly targeted to provide downstream flows within the water sharing plan area, but not necessarily to the end of system or downstream plan areas. These flows are not protected beyond the reference point or end of the plan area. People often refer to “end of system flow rules”. These are minimum flow rules that target a flow at the gauge closest to the end of system.

	Across the Northern Tributaries, there is a myriad of minimum flow rules embedded into the water sharing plans that have various conditions attached. The ones most relevant for connectivity purposes include the following: ▪ In the Border Rivers catchment, the regulated water sharing plan specifies minimum flow requirements for Mungindi (end of the catchment) which reflect the rules codified in the Intergovernmental Agreement between Queensland and NSW (clause 23). ▪ In the Gwydir catchment, the regulated water sharing plan specifies minimum flow requirements to ensure planned environmental water for the RAMSAR listed Gwydir wetlands but not further downstream (clause 62). ▪ In the Namoi catchment, the regulated water sharing plan specifies minimum daily flow requirements at Walgett for specific times of the year; however, the plan also provides for exemptions when the minimum flow rules don't have to be met (clause 14). ▪ In the Macquarie, the regulated plan does not have minimum daily flows at a specific location, but includes replenishment flows for different water sources (clause 84) if sufficient water is available. These replenishment flows are also at the operator's discretion.
Resumption of flow rule	This rule only applies to the Barwon-Darling unregulated water sharing plan and is designed to protect the critical first flow after an extended low flow or dry period. The rule is triggered when a flow event in the Barwon-Darling occurs after a continuous period of dry or low flow conditions. It prevents licence holders in the Barwon-Darling from accessing the first flow for a period of time. Normal access conditions then apply after the flow has reached a required target flow. The rule does not protect the first flow in the Northern Tributaries. It was designed to get flows to Wilcannia, not to provide flow into Menindee Lakes and therefore flow requirements before relaxation of restrictions are in a lower flow band as you move further down the system.
Replenishment flows	These flows are similar to minimum daily flow rules except that they provide for releases of larger periodic flows according to the rules in the plans. These rules are focused specifically on in-plan outcomes and are usually to provide basic landholder rights. They are not protected downstream of the plan area. Some of these releases are left to "operator discretion" and historically have not been made.
Environmental watering allowances (EWAs)	These are the main sources of environmental water in the regulated water sharing plans. Typically they are released at the discretion of the NSW environmental water manager, though some plans have rules outlining specific requirements of releases. Annual planning for the use of EWA water is usually endorsed by Environmental Water Advisory Groups composed of stakeholders from with the water plan area. EWAs are usually targeted to environmental assets within a plan area and are rarely targeted for downstream connectivity. EWAs usually have the equivalent of general security protection in the dams. This means that they are generally allocated water as general security licences are allocated water, with allowances reduced consistent with any reduction received by general security users through the available water determination. The environmental water in the dam does not have priority over other water. These releases are not protected downstream of the water sharing plan area.
Supplementary access rules	Supplementary access is related to surplus flow that cannot be captured, or 're-regulated', into storages. There are rules within the Northern Tributary water sharing plans that aim to reserve a portion of supplementary water for the environment. The rules are valley specific reserving a specific percentage of the supplementary water event within specific reaches for the environment. Supplementary take is announced and cannot be taken until the Department determines that there is adequate water to meet the supplementary rules. The limited information available about the basis of the rules indicates they were

	designed largely to achieve environmental outcomes within the plan area; however, they do help to achieve some end of system flows.
Floodplain harvesting restrictions	Floodplain harvesting is restricted when Menindee lakes total storage drops below 195GL and relaxed based on in-valley triggers. (See Chapter 4 for further discussion).
North West Flow Plan targets	The Northern Tributary water sharing plans include targets from the Interim North West Flow Plan that are meant to restrict supplementary access in order to achieve flow targets in the Barwon-Darling for riparian needs, algal suppression and fish migration. These rules have not been implemented. (See Chapter 3 for specifics of these targets).

The Panel acknowledges that there is also a considerable amount of held environmental water that is owned by the Commonwealth Environmental Water Holder. NSW does not control how CEWO chooses to use this water. While the Panel has considered where it might be beneficial to work with the CEWO to achieve targets, we have focused on what can be achieved through rules in the water sharing plans.

3 The Panel's proposed approach

Findings

9. The Department's proposed critical dry condition triggers for the Barwon-Darling and tributaries are not likely to be effective for achieving connectivity, as they do not provide for sufficient flows for connectivity or an adequate "first flush" through to Menindee Lakes following an extended dry period. The Menindee Lakes trigger may not adequately represent critically dry conditions and should be reviewed further.

Importance of riparian targets

10. The Department proposes to eliminate the riparian targets from the North-West Flow Plan and replace them with the proposed "critical dry condition triggers." The proposed critical dry condition triggers have a very different purpose than the riparian targets. They are focused on restoring flows after an extended dry period, whereas the riparian targets aimed to continually protect flows along the system.

11. There is insufficient evidence to support the Department conclusion that supplementary rules, the recent changes to the Barwon-Darling cease to pump rules and the inclusion of the resumption of flow rules effectively achieve the riparian targets. Further, the riparian rules were meant to restrict take in the tributaries to ensure they were adequately contributing to downstream flows, and the Barwon-Darling cease to pump and resumption of flow rules only apply in the Barwon-Darling.

Recommendations

4. The Department should implement rules to achieve the targets and triggers in Table ii that aim to:

a) During non-dry times – ensure that baseflow is protected across the Northern Basin and provide for small and large freshes consistent with the environmental water requirements. Baseflows should be achieved through restrictions on supplementary and floodplain harvesting access along with an end of system flow rule for each valley requiring dam releases where necessary.

b) During dry times – extend the current resumption of flow rules into the Northern Tributaries and provide for a small flushing flow following an extended dry period all the way to Menindee Lakes prior to allowing extraction.

c) Establish a "connectivity" environmental water allowance in each Northern Tributary to assist with meeting end of system flow rules and provide for periodic pulses during dry times to maintain system health and water quality.

5. The Department should ensure this environmental water is appropriately protected from downstream extraction:

a) any water protected through these rules should be protected through to Menindee Lakes.

b) once protected flows reach Menindee Lakes the water should be held as an environmental water allowance for use in supplying critical needs for the Lower-Darling, or used for translucency flows protected through the Lower-Darling.

Table 5 Summary of Panel's recommendations – Connectivity targets and triggers

Non-dry times			
Proposal	**Proposed targets**		
Protection of baseflow – *Regulated water sharing plans should have a continual end of system flow requirement to enable baseflow targets in the Barwon-Darling to be achieved during non-dry times. This should be achieved first through restriction on supplementary and floodplain harvesting, with releases made from storage if these flows are not adequate.*	Mungindi	160 ML/d	
	Collarenebri	280 ML/d	
	Walgett (Dangar Bridge)	320 ML/d	
	Wilcannia	350 ML/d	
Protection of small freshes- *Regulated water sharing plans should include restrictions on supplementary and floodplain harvesting, and A, B and C licences in the Barwon-Darling to achieve annual small fresh flows.*	Mungindi	540 ML/d	A minimum of 14 days between September and April every year. (Note this covers both SF1 and SF2 targets in the Long Term Water Plan). 14 days must be targeted. However, if an event is targeted with restrictions and the small fresh flow is only achieved for 12 days or more it will be considered as met for that period. Restrictions begin at the start of September until the target is achieved.
	Collarenebri	650 ML/d	
	Walgett	700 ML/d	
	Brewarrina	1,000 ML/d	
	Bourke	1,550 ML/d	
	Louth	1,500 ML/d	
	Wilcannia	1,400 ML/d	
Protect large freshes – *Regulated water sharing plans should include restrictions on supplementary and floodplain harvesting, and A, B and C class licences in the Barwon-Darling to achieve periodic large fresh flows.*	Mungindi	3,000 ML/d	15 days minimum at least once every 2 years. Anytime, but ideally July to September. 15 days must be targeted. However, if an event is targeted with restrictions and the large fresh flow is only achieved for 12 days or more, it will be considered as met for that period.
	Collarenebri	4,200 ML/d	
	Walgett	6,500 ML/d	
	Brewarrina	9,000 ML/d	
	Bourke	15,000 ML/d	
	Louth	15,000 ML/d	
	Wilcannia	14,000 ML/d	

Transition arrangements	
Proposal	**Proposed targets**
Commence transition to new resumption of flow rules - *When the system begins to enter a 'dry' stage, there will be a transition to 'dry' time resumption of flow rules which are triggered when flows drop below baseflow for a certain duration at various locations throughout the system.*	In development: The Panel is working with relevant agencies to identify the specific appropriate trigger for this transition. It will be based upon the inflows into the dams versus the volume of water necessary to achieve end of system flows. **Note**: Given that the current resumption of flow rule requires that flows drop below baseflow for greater than 90 days, there will be a transition period between when the end of system flow rule is suspended and when the resumption of flow rule restrictions are triggered. As the supplementary rules would be revised to include a requirement that supplementary not be taken when baseflows aren't met, this restriction would continue during this transition period and would protect any minimal flows that may occur.

Dry Times			
Proposal	**Location**	**Proposed target**	**Proposed lifting target**
Revise the resumption of flow rules - *The resumption of flow rules should be applied in the Northern Tributaries as well as the Barwon-Darling. The trigger for lifting restrictions should be raised to a small fresh all the way down the system to ensure flows through to Wilcannia and into Menindee Lakes.*	Mungindi	<160ML/d for 90 days	540ML/d for 10 consecutive days forecast to be met
	Collarenebri	<280 ML/d for 90 days	650ML/d for 10 consecutive days forecast to be met
	Walgett (Dangar Bridge)	<320 ML/d for 90 days	700ML/d for 10 consecutive days forecast to be met
	Brewarrina	<550 ML/d for 90 days	1,000ML/d for 10 consecutive days forecast to be met
	Bourke	<500 ML/d for 90 days	1,550ML/d for 10 consecutive days forecast to be met
	Louth	<450 ML/d for 90 days	1,500ML/d for 10 consecutive days forecast to be met
	Wilcannia	<350 ML/d for 90 days	1,400ML/d for 10 consecutive days forecast to be met

All times	
Proposal	**Proposed targets**
Menindee Lakes trigger	In development The Panel is reviewing the proposed "critical dry condition" trigger for Menindee Lakes, which indicates that upstream supplementary, floodplain harvesting and A, B, and C licence extraction should be restricted when the upper Menindee Lakes reaches 195GL active storage. Current evidence indicates the amount stored would need to be in the range of 238-290GL to maintain flows for critical needs downstream for 12 months if the Pamamaroo inlet regulator is repaired. The Panel will continue to investigate this proposed rule further for the final report.
Establish 'Connectivity' environmental water allowance – *Each of the four regulated Northern Inland Basin water sharing plans should include a 'connectivity' EWA to allow for releases to meet end of system targets during normal times and provide pulses as needed for water quality and other environmental outcomes during dry times. This should be managed by DCCEEW Biodiversity, Conservation and Science to achieve connectivity objectives.*	In development: The Panel will work with agencies to further investigate this option, including proposed volumes that would be necessary and potential impacts for the final report. **Note**: as a principle, the Panel proposes that this "connectivity" EWA should provide adequate water for meeting end of system targets when restrictions are inadequate to meet baseflow as well as some water for periodic "pulsing". The "connectivity" EWA should have the highest security status and therefore take precedence in the dam storage.
Update rules in unregulated water sharing plans	In development: Given the timeframe, the Panel has only completed a high-level review of the unregulated systems. The final report will include proposed rules for relevant unregulated water sources.

The Panel has examined the flow conditions necessary to enhance connectivity under different hydrological conditions. The approach taken to support connectivity should be commensurate with the prevalent climate conditions. This means that different approaches should be taken depending how much water is available in the Northern Basin.

Currently, the Northern Basin water sharing plans do not provide an appropriate suite of tools to allow for a nuanced, climate dependent approach to providing for connectivity. As such, the Panel proposes a set of amendments to the Northern Basin water sharing plans in order to provide for the appropriate tools to manage connectivity across the whole system during all climate conditions.

3.1 Guiding principles

The Panel agreed on a number of principles for the assessment of options and the development of proposed rules and targets to meet connectivity.

Rules should be proactive to maintain fundamental ecosystem functions and improve whole-of-system resilience

- Rules should seek to maintain water within the system more often and keep it "wetter"
- Restrictions for smaller flows (baseflows and small freshes) should apply even if the targets will not be fully met. There will still be significant benefits for the ecosystem and communities when flow pulses move further down the system and baseflows and small freshes 'prepare' the system for more efficient delivery of the next flow.

Rules need to provide for equitable sharing of water

- Rules should be set so that water restrictions upstream to achieve downstream environmental and basic landholder rights, should not lead to this water being made available for extraction. Instead, this water should be "shepherded" through the system.
- Rules should provide for restrictions that seek to equitably distribute any impacts to extractive use between users
- Rules should be set such that low priority usage upstream should not be allowed when in will impact on baseflows downstream
- Rules should seek to achieve targets in a way which minimises impacts to extractive users

Rules need to adhere to the legislation, be clear and implementable

- Rules should adhere to the priorities outlined in the water sharing principles specified in the Act[87]
- A precautionary approach should be taken to managing restrictions where available data is inadequate to reasonably quantify outcomes. Restrictions should be applied where they are likely to improve targeted outcomes, and adaptively managed as information improves to minimize any negative impacts
- Rules should be clear on how, when and why water will be restricted to provide transparency for users and reduce reliance on Section 324 Orders
- Rules must be "implementable". If forecasting is not appropriate, possible or too uncertain, then prescriptive rules are needed until such time as forecasting improves.

[87] Water Management Act 2000, Section 5(3)

3.2 Proposed targets

In a system that displays highly variable flows, it is necessary to focus management efforts on the outcomes achievable under the conditions experienced. As outlined in Section 2.2.2 the Panel views the stated environmental water requirements in the LTWPs as robust and credible. They represent the best available information on the fundamental connectivity needs of the ecosystems.

The Panel is of the view that these environmental water requirements should be met during non-drought times when water is available in the system. Currently there are periods where there is no or little flow in the Barwon-Darling but opportunistic upstream extraction is still occurring. This is inequitable and does not adhere to the water sharing principles specified in the Act to first provide for water sources and their dependent ecosystems.

The Panel also recognizes that the ability to meet these environmental water requirements during times of drought is curtailed by the limited availability of water in the system. It is appropriate during these times to focus management options on those that will achieve the best environmental and community outcomes with the water that is available.

In order to meet some of the proposed rules and targets, releases from dams would be required. This is necessary as flows through the tributaries have been altered considerably by capture of headwater inflows in the dams. The Panel's analysis indicates that restriction of supplementary and floodplain harvesting alone will not be sufficient to meet connectivity needs.

The Panel proposes that additional planned environmental water should be included in each plan, effectively a "connectivity EWA", to provide for releases necessary to meet targets and that this water should have the highest level of security in the dam, as the environment is meant to have the highest priority under the Act. The Panel is further investigating the volumes that would be required and how this could be operationally achieved.

3.2.1 Rules during non-dry periods

Rules within the Northern Tributary regulated water sharing plans (Border Rivers, Gwydir, Namoi and Macquarie-Bogan) should be revised to ensure that the baseflow, small fresh and large fresh environmental water requirements are met in non-dry times (**when not in drought)** as follows:

To protect baseflows:

The Panel is of the view that it is critical that baseflow be met at all times when water is readily available in the Northern Tributaries. Modelling by the Department indicates that restricting supplementary take in the Northern Tributaries could provide a meaningful improvement in achievement of end of system baseflows. The Panel undertook analysis of the actual flow data during supplementary flow events over the past 20 years and identified that while current supplementary rules do provide some protection for baseflow (particularly in the river reaches where supplementary events are announced and managed) there are still times when extractions upstream appear to be impacting the achievement of end of system baseflows. The Panel is of the view that this is not acceptable.

Baseflows and very low flow periods, including the stable no flow periods where water can remain within the channel, are important for maintaining aquatic habitat within the channel,

such as inundated snags and the roots of riparian trees. These low-flow periods are a crucial component of the overall flow-regime. While they are not often associated with large scale reproductive responses in riverine species, there is evidence that some fish and freshwater mussels will preferentially reproduce when water levels are low and stable.

During periods of extended low flow, declining water quality in any remaining aquatic habitats can be a significant issue for resident biota. Given the hydrological variability of the Barwon-Darling and the associated variable lengths of time between large flow pulses and floods (even under natural flow conditions) baseflows that maintain remnant aquatic pools and reaches within the river channel network are critical for the maintenance of healthy populations of many aquatic organisms[88]. Feedback from Aboriginal stakeholders also indicates that these flows are extremely important culturally.

Therefore, the Panel recommends that:

- Supplementary rules should be revised to include the requirement that they do not compromise end of valley targets and downstream baseflow. Rules should also be added to restrict floodplain harvesting at any time that the end of system target is not being met. (See Chapter 4 for further discussion on floodplain harvesting triggers and targets). With the application of these restrictions, if flows are insufficient to meet the end of system targets, then releases from the dam should be made. This will require a minimum flow rule for each valley at the end of system gauge, to be met at all times **during non-dry periods**.

The targets identified in

- Table 6 are the baseflow environmental water requirements for the Barwon-Darling closest to the end of system for each of the valleys. To maintain simplicity of the rules, the Panel has focused only on baseflow targets near end of systems. This should be monitored and if baseflows in the Barwon-Darling are not being met, then additional trigger locations in the Barwon-Darling should be added.
- The Panel has not yet identified the specific gauges/flow requirements within the valleys that are necessary to achieve these baseflows. We will undertake additional analysis in conjunction with relevant agencies to establish appropriate minimum flow rules for the end of each system.
- It is our understanding that baseflow should be well protected through the Barwon-Darling from the changes that have already been made to the A class cease to pump rules, and therefore we do not propose additional restrictions for the Barwon-Darling plan area.

[88] Sheldon, F., S. E. Bunn, J. M. Hughes, A. H. Arthington, S. R. Balcombe and C. S. Fellows (2010). "Ecological roles and threats to aquatic refugia in arid landscapes: dryland river waterholes." Marine and Freshwater Research 61(8): 885-895

Table 6 Proposed baseflow targets versus previously proposed targets

Location	Panel Proposed*	**Alluvium Review of Riparian Targets**	**North-West Flow Plan Riparian Target**
Mungindi	**160ML/d**	850 ML/d	850 ML/d
Collarenebri	**280 ML/d**	760 ML/d	760 ML/d
Walgett (Dangar Bridge)	**320 ML/d**	N/A	N/A
Wilcannia	**350 ML/d**	350 ML/d	150 ML/d

*Based on baseflow environmental water requirements

The proposed targets are significantly lower than the proposed Alluvium and North-West Flow Plan targets at the upstream gauges. The Panel could not identify a clear rationale for why these were so high relative to other gauge locations. Walgett and Wilcannia are relatively consistent with bottom of baseflow, whereas the upstream gauges are well into the fresh ranges. The interim North-West Flow Plan says these targets would apply if there are no downstream inflows but would be adjusted if there were. Therefore, the Panel has assumed that the intent was if there was only water in the top two valleys these would need to provide more flow, but could provide less if all valleys were flowing. This seems inequitable and extremely difficult to implement – as well as not providing clarity of rules for users. As such, the Panel has maintained the principle that baseflow should be met across the system and proposed lower targets for these locations.

To meet small fresh needs:

Small freshes are important for reconnecting river reaches and moderating water quality in previously disconnected reaches or weir pools, providing opportunities for spawning and recruitment of fish. The increased turbidity and water movement associated with in-channel flows can reduce the concentrations of nuisance algae (green and cyanobacteria) in the water column. These small in-channel pulses are also important for increasing habitat availability – also required for spawning and recruitment of fish and invertebrates.

The increase in availability of snag habitat and in-channel bench surfaces is associated with in-channel flow pulses of different magnitudes[89]. The relatively frequent small flow pulses are important for maintaining connectivity along river channels and refreshing aspects of water quality in pools and isolated reaches[90]. Small pulses control the extent of physical aquatic habitat and thereby influence the composition and diversity of biota, trophic structure, and carrying capacity of river systems. The small fresh target would meet the algal suppression requirement outlined in the North-West Flow Plan during these times.

Rules should be added to each of the Northern Tributary plans to ensure that supplementary access and floodplain harvesting are restricted in the Northern Tributaries and A, B and C Class are restricted in the Barwon-Darling to achieve the following:

[89] NSW DPI (2015). *Fish and flows in the Northern Basin: responses of fish to changes in flows in the Northern Murray–Darling Basin*, report prepared for MDBA by the NSW Department of Primary Industries, Tamworth

[90] Poff, N. L., J. D. Allan, M. B. Bain, J. R. Karr, K. L. Prestegaard, B. D. Richter, R. E. Sparks and J. C. Stromberg (1997). "The natural flow regime: A paradigm for river conservation and restoration." Bioscience 47(11): 769-784.

Table 7 Proposed small fresh targets

Location	Flow rate (ML/day)*	Timing/duration
Mundgindi	540	A minimum of 14 days between September and April every year. (Note this covers both SF1 and SF2 targets in the LTWP)
Collarenebri	650	14 days must be targeted. However, if an event is targeted with restrictions and the small fresh flow is only achieved for 12 days or more it will be considered as met for that period.
Walgett	700	
Brewarrina	1,000	
Bourke	1550	Restrictions begin at the start of September until the target is achieved.
Louth	1500	
Wilcannia	1400	

*based on small fresh environmental water requirements

Similar to the baseflow rule, the Panel will work with the agencies to identify targets at the end of system gauges to be included in the water sharing plans. The Panel supports the use of forecasting to relax restrictions once the flow is at Brewarrina. However, this will require further discussions with WaterNSW. If forecasting is not possible, the Panel will propose specific rules for when the target can be assumed to be met downstream and restrictions can be relaxed. However, we are of the view that this is likely to create a greater impact on users than forecasting (See Section 5.2). Restrictions will be lifted from the top of the system downward so that water is not shifted from upstream users to downstream users.

The Panel's analysis indicates that restriction of supplementary and floodplain harvesting can improve achievement of small fresh targets.

To meet large fresh needs:

Large freshes are extremely important for increasing habitat availability and play a vital role in the spawning and recruitment of fish and invertebrates. There has been an increase in availability of snag habitat and in-channel bench surfaces associated with in-channel flow pulses of different magnitudes[91]. In many reaches large freshes can breach the sills on localized anabranches and connect this vitally important habitat to the channel, these small off-channels can be important habitats for recruitment of riverine fish, outside of large overbank events. The large fresh would meet the fish migration objective in the North-West Flow Plan as well as the fish spawning and fish dispersal and condition targets proposed by Alluvium.

Access to supplementary, FPH and B and C class should be restricted when the operator forecasts that flows are likely to achieve at least 85% of the following:

Table 8. Propose large fresh targets

Location	Flow rate (ML/day)*	Timing/duration
Mungindi	3,000	15 days minimum at least once every 2 years
Collarenebri	4,200	Anytime, but ideally July to September

[91] NSW DPI (2015) *Fish and flows in the Northern Basin: responses of fish to changes in flows in the Northern Murray–Darling Basin*, report prepared for MDBA by the NSW Department of Primary Industries, Tamworth

Walgett	6,500	15 days must be targeted. However, if an event is targeted with restrictions and the large fresh flow is only achieved for 12 days or more it will be considered as met for that period.
Brewarrina	9,000	
Bourke	15,000	
Louth	15,000	
Wilcannia	14,000	

*based on large fresh environmental water requirements

If a large fresh was achieved that met the small fresh requirements as well, then it would count for meeting both targets.

Our initial analysis indicates that restriction of supplementary and floodplain harvesting is not likely to achieve large freshes in many of the non-dry years. As such, the Panel proposes that options for achieving large freshes need to be further considered for our final report.

Considerations will include:

- Further analysis of how often large fresh may be met with opportunistic flow restrictions.
- Discussion with Government agencies including the CEWO to identify potential additional options for meeting large freshes when opportunistic flow is not sufficient.
- Further assessment of benefits if shorter duration could be achieved but not the full EWR suggested duration.

3.2.2 Transition from “non-dry” to “dry rules

The Panel proposes that when the system begins to enter a “dry” stage then there should be a transition to “dry” time resumption of flow rules. The resumption of flow rules are triggered when flows drop below baseflow for a certain duration at various locations along they system. However, the end of system flow rules would prevent this from occurring if they were not switched off. It would not be efficient or effective to try to maintain baseflow for extended periods where there are minimal flows into the system. The Panel proposes that there should be a trigger for transitioning from the non-dry rules to the dry time rules.

The Panel is working with relevant agencies to identify the specific appropriate trigger for this transition. It will be based upon the inflows into the dams versus the volume of water necessary to achieve end of systems flows. For example, once dam inflows reduce below baseflow levels – this could be defined as monthly inflows falling below the 75th or 80th percentile for example – end of system flow targets could be relaxed or suspended, as total system inflows are unlikely to continue supporting baseflows throughout the system.

Given that the proposed resumption of flow rule requires that flows drop below baseflow for greater than 90 days, there will be a transition period between when the end of system flow rule is suspended and the resumption of flow rule restrictions are triggered. As the supplementary rules would be revised to include a requirement that supplementary not be taken when baseflows aren’t met, this restriction would continue during this transition period and would protect any minimal flows that may occur.

3.2.3 Rules for "dry" periods

Once the system has transitioned into a dry period then the Panel proposes that the targets in Table should be implemented. Currently there is a resumption of flow rule in the Barwon-Darling water sharing plan which protects the "first flush" of water that comes through the system after a long dry period.

This first flush is essential to reconnect disconnected reaches throughout the system, mediate declining water quality and provide the hydrological settings (wetted river channel) that will allow further pulses to pass through the system. The first flows after an extended dry period have cultural benefits to Aboriginal communities who have a strong connection to the river. They are also important for local communities who rely on this water for human needs and for their stock.

The current first flush rule does not protect flows in the Northern Tributaries. Just protecting the first flush once it's in the Barwon-Darling is inequitable and is likely to lead to significantly longer restrictions within the Barwon-Darling. Further, the Department's documentation indicates that the current resumption of flow rule is not meant to achieve connectivity, rather it is meant to protect water within the valley down to Wilcannia.[92]

The Panel proposes that the resumption of flow rules should be expanded into the tributaries and protect a small fresh all the way through the system down to Menindee Lakes. The duration for when the targets apply was based on the initial position that once Wilcannia has gone 90 days or greater with flows below baseflow then a first flush is necessary to "restart" the system. The durations for the other locations are based on the Panel's analysis of the equivalent period below baseflow at those locations.

Table 9 Proposed resumption of flow rules versus current resumption of flow rules

Location	Panel Proposed Target (forecasted)	RoF Rule in WSP	Panel Proposed Target (Lifting - forecasted)	RoF Rule in WSP (Lifting)
Mungindi	**<160ML/d for 90 consecutive days**	N/A	**540ML/d for 10 consecutive days**	N/A
Collarenebri	**<280 ML/d for 90 consecutive days**	N/A	**650ML/d for 10 consecutive days**	N/A
Walgett (Dangar Bridge)	**<320 ML/d for 90 consecutive days**	<326 ML/day for 150 consecutive days	**700ML/d for 10 consecutive days**	>706 ML/d for 10 cons days
Brewarrina	**<550 ML/d for 90 consecutive days**	< 468 ML/day for 150 consecutive days	**1,000 for 10 consecutive days**	> 1,008 ML/d for 10 consecutive days

[92] Claydon, C (2021), Independent Assessment Of The Initial Implementation Of The Resumption Of Flows Rule, Idecs And Active Management In The Barwon-Darling: 01 December 2020 To 31 March 2021 Final Report – See Appendix 6

Bourke	**<500 ML/d for 90 consecutive days**	< 450 ML/day for 120 consecutive days	**1550 for 10 consecutive days**	> 972 ML/d for 10 consecutive days or 30 GL past Bourke
Louth	**<450 ML/d for 90 consecutive days**	N/A	**1500 for 10 consecutive days**	N/A
Wilcannia	**<350 ML/d for 90 consecutive days**	< 200 ML/day for 90 consecutive days	**1400 for 10 consecutive days**	> 400 ML/d for 10 consecutive days

Consistent with the current resumption of flow rules the Panel proposes that restrictions could be lifted when downstream targets are forecast to be met. The intent is to not restrict users longer than is necessary to meet the minimum flow target. Forecasting is discussed further in Section 5.2.

3.2.4 General requirements

Connectivity environmental water allowances

The Panel recommends that a "connectivity EWA" be established in each of the four regulated water sharing plans. This should provide adequate water for meeting end of system targets when restrictions are inadequate to meet baseflow and also provide some water for periodic "pulsing" during dry times. As the water sharing principles in the Act indicate that environmental water should have the highest priority this EWA should take precedence in the dam storage.

The Western Regional Water Strategy analysed the benefits and impacts of breaking up extended cease-to-flows by strategic releases from head water storages[93], and Action 3.3 in the strategy is to further investigate ways to provide replenishment flows from the Northern Tributaries during dry periods[94]. The Panel supports this action and suggests it should be achieved through an EWA.

The Panel recommends that the EWA be managed by the NSW environmental water holder. Water allocated should be able to be carried over so that there is additional water available in dry years when pulsing may be necessary to ensure water quality and periodically reconnect and wet pools and weirs. The environmental water holder should have the flexibility to use the water as they deem most effective to achieve connectivity outcomes, provided the baseflow requirement is met when required. This recognizes that connectivity needs are dynamic and that the most beneficial use of water may vary depending on the prevailing climate conditions and antecedent conditions of the rivers.

The Panel will work with agencies to further investigate this option, including proposed volumes that would be necessary and potential impacts for the final report.

Protection of environmental water

Any water protected through these rules should be actively managed so that it is protected through to Menindee Lakes. The Panel recommends that once any protected flows reach

[93] DPE Water (2022), *Western Regional Water Strategy - Attachment 5: Analysis on replenishment flows*
[94] DPE Water (2022), *Western Regional Water Strategy*, See page 103

Menindee Lakes the water should be held as an EWA for use in supplying critical needs for the Lower-Darling. This maintains our principles of equity, such that upstream users are not restricted so that downstream users can extract, but water is dedicated to connectivity purposes. Alternatively, the Panel agrees it may be beneficial for some of the water to be protected through to Menindee Lakes, but be used for translucency flows. This is because it is inefficient to store water in the lakes, so this may be a more efficient way to achieve connectivity outcomes in the Lower-Darling.

The Panel recognises the complexities of the governance arrangements for Menindee Lakes and that this recommendation would likely need to be negotiated with the MDBA. We will continue to work with the Department to investigate how this recommendation could be implemented for the final report.

Rules in unregulated water sharing plans

Many water sources in unregulated water sharing plans are anabranches for the regulated system, and/or provide flows into the Barwon-Darling. The expanded terms of reference asked the Panel to examine rules in all water sharing plans (not just regulated water sharing plans). Given time frames for completing the extensive scope of work, the Panel has only examined the unregulated system at a high level. Section 5.3 outlines steps that will be taken to address contributions from, and restrictions in, unregulated systems. The final report will include proposed rules for relevant unregulated water sources.

3.3 Assessment of the Department's proposed targets and triggers

The Panel is of the view that the targets outlined above would achieve improved outcomes over the triggers proposed by the Department in the Western Regional Water Strategy (see Table 2). The "non-dry" targets and proposed connectivity EWA address questions posed to the Panel in regard to the North-West Flow Plan targets. The Panel proposes that these would replace the current targets in the water sharing plans that were carried over from the North-West Flow Plan, and that they would adequately cover the riparian, algal bloom and fish migration objectives.

The changes to the resumption of flow targets are proposed in lieu of the Department's proposed "critical dry condition triggers" (other than Menindee Lakes trigger – which is discussed in Section 4.3).

The department's proposed critical dry condition triggers for Wilcannia and Bourke have the same relaxation triggers as the resumption of flow rules that are currently in the Barwon-Darling water sharing plan. However, the resumption of flow rule is triggered earlier - effectively when flows drop below baseflow for the same durations as in the proposed critical dry triggers. As such, it does not seem that these rules would have any effect because the resumption of flow rule would have been triggered already before the critical dry condition trigger and no additional restrictions are proposed by this rule.

The proposed in-valley critical dry condition triggers would not achieve connectivity beyond the valleys. The targets for relaxing restrictions are to our understanding based on the amount of water necessary to reconnect and refill critical pools within the valleys to provide for refugia. This is clearly important. However, it will still be important to achieve a "first flush" as provided for in the resumption of flow rule outlined by the Panel. The targets proposed for critical dry in-valley relaxation triggers would be achieved along the way through the restrictions proposed by the Panel; but, those restrictions would remain until

an adequate flushing flow is achieved. As such, the Panel does not see the need for these targets if the proposed changes to the resumption of flow rule are made.

The final "critical dry condition" trigger proposed by the Department relates to the volume in Menindee Lakes. This proposed trigger would restrict upstream usage when the active storage in the upper lakes falls below 195GL. The following chapter discusses the Panel's view on this trigger in detail. In summary, the Panel does not view the Menindee Lakes volume trigger to be an appropriate indicator of when the system is going dry. Additional analysis is needed in order to comment on a specific proposed trigger.

The Panel also notes that if the suite of critical dry condition triggers proposed by the Department were all implemented the Bourke, Willcannia and Northern Valley triggers would likely be superfluous as they would almost certainly be met whenever the lifting trigger at Menindee was met.

3.3.1 Replacement of riparian targets with "critical dry condition" triggers

The Terms of Reference specifically asked the Panel to consider whether the riparian targets from the North-West Flow Plan should be replaced by the critical dry condition triggers.

The Western Regional Water Strategy proposes to remove the riparian targets taken from the North-West Flow Plan, which require minimum flows to be achieved at all times in the Barwon-Darling and replace them with the critical dry condition rules, which only apply during severe drought. This is despite the fact that the Western Regional Water Strategy clearly outlines that there are increases in the frequency of short-term low and no flow events in the Barwon-Darling and a significant reduction in small and large freshes. The Western Regional Water Strategy also acknowledges that these issues are due to upstream extraction and could be addressed by changing rules in upstream water sharing plans. While the Strategy proposed further consideration of targets for algal suppression and fish migration, it does not propose changes to adequately address the low flow issues. It argues that riparian needs are already met by other rules in the water sharing plans. As outlined in this report, this is not the case.

The Panel has several concerns with this proposal:

- The riparian targets have very different purpose than the critical dry condition triggers. The riparian targets were meant to provide restrictions that would ensure ongoing lower flows downstream. While the Department has indicated that "riparian targets" are synonymous with our current definition for "basic landholder rights", this ignores the environmental needs and outcomes the riparian targets addressed. These targets were designed to essentially always be "on", whereas the critical dry condition triggers are specifically designed only to provide water in the most severe droughts.
- The Western Regional Water Strategy documents[95] indicate that due to changes to the A-Class cease to pump rules in the Barwon-Darling and the resumption of flow rule in the Barwon-Darling, the riparian targets are now met most of the time. There is insufficient observed data to assess the impacts of the increased cease to pump and resumption of flow rules. However, the purpose of the North-West Flow Plan was to provide water from the tributaries to the Barwon-Darling. The cease to pump and resumption of flow rules only apply **in** the Barwon-Darling. They do nothing to provide additional water to the system, only to protect it if it is already there.

[95] DPE Water (2022), *Draft Western Regional Water Strategy Attachment D: North-West Flow Plan Discussion Paper*

- The strategy also argues that the supplementary rules provide for the riparian targets in the Barwon-Darling to be met. However, the supplementary rules are designed to provide for in-valley connectivity, not downstream connectivity. And as outlined above the riparian targets are frequently not being met.

Given these concerns, the Panel does not support replacing the riparian targets with the critical dry condition triggers. The Panel proposes that the riparian targets should be replaced with the baseflow targets proposed by the Panel.

4 Floodplain harvesting and Menindee Lakes triggers

Findings

Floodplain harvesting

12. Data on actual floodplain harvesting take is not available as this form of take has only recently been licensed. Further, limitations of surface water models in regard to examining rules that restrict floodplain harvesting, and assessment of downstream benefits of those restrictions create considerable challenges for identifying appropriate floodplain harvesting restrictions.

13. The taking of overland flow is not managed consistently across water sharing plans, which creates difficulties for considering equitable and consistent restrictions on this form of take.

14. Current rules do very little to restrict floodplain harvesting. Restrictions in regulated plans only apply when Menindee Lakes is below 195GL storage and if in-valley flows are below a level where most floodplain harvesting occurs. There are no access rules based on river flows that restrict unregulated floodplain harvesting licences.

15. The current rules and proposed "critical dry condition" rules focus on Menindee Lakes volumes as the sole trigger for restricting floodplain harvesting. There is no clear logic for the volume in Menindee Lakes to be the primary trigger for when floodplain harvesting would be restricted.

Menindee

16. The volume in Menindee Lakes is not a good indicator of whether the system is entering a critically dry period. Flows past Wilcannia provide a much better indicator of this.

17. The objectives of the current and proposed rules for triggering restrictions upstream based on Menindee Lakes volumes, and around how the 60GL "restart allowance" works in practice are unclear and there appears to have been limited analysis to support the proposals. This has resulted in different options that overlap and have not been assessed relative to each other to date.

18. Storing water in Menindee Lakes requires careful consideration. The lakes have a large surface area and hot climate, resulting in significant evaporative losses. They are also prone to water quality issues. However, the lakes also have important ecological functions. As such it is desirable to minimise storage in the lakes where possible while still maintaining ecosystem health.

19. The estimation of how much water is necessary to store in Menindee Lakes to provide for 12 months of critical needs, and whether 12 months of supply is the correct time period are based on a limited analysis.

20. The proposal for storing 195GL in Menindee Lakes is based on outdated minimum flow requirements and mean evaporation rates. Latest data indicates that higher minimum flow rates are likely required for mitigating persistent stratification, elevated algal loads and mitigating fish deaths in Menindee weir pool during high risk periods. This would require storing additional water in the upper Menindee Lakes, unless alternative approaches such as translucent flows were implemented. Latest available advice indicates that in order to provide 12 months of minimum flows, 238-290GL of active storage in the upper lakes is required. This does not include an additional 55GL, which is necessary if the Pamamaroo inlet regulator is not repaired.

21. The Menindee volume trigger creates a requirement that is not directly related to connectivity needs. The significant volumes necessary to supply downstream needs are due to the limitations of the structures that have been put in place to manage the system, rather than a natural flow necessary for connectivity.

Recommendations

6. Additional analysis of the basis for the volume necessary to be stored in Menindee Lakes to provide for critical needs in the Lower-Darling should be undertaken including:
    a) Validating the basis for a 12 month supply storage, and the analysis of volumes needed for critical needs.
    b) Ensuring the assessment of storage needs is robust, based on best available evidence and considers various operating approaches to achieve efficient water usage during dry times.
7. Further analysis for the timing of the need for 60GL restart allowance and how it would work in practice should be undertaken. Once objectives are clear, analysis of various rules should be completed to determine the most efficient way to achieve intended objectives. This analysis should include assessment of the best indicator for when the system is likely to be entering a dry phase and therefore a restart allowance might be needed.
8. The dam safety constraint at Pamamaroo inlet regulator should be repaired as a matter of urgency to reduce storage requirements.
9. The Panel's proposed restrictions on floodplain harvesting should be implemented and outcomes monitored to determine if additional restrictions are necessary in the future to facilitate longitudinal connectivity.

The Panel will work with the agencies to try to advance recommendations 6 and 7 prior to the final report with the aim of providing more specific advice on the best rules for managing Menindee Lakes volumes for needs during dry times.

4.1 Floodplain Harvesting in NSW

As outlined in Chapter 2, the Panel considers it essential to maintain connectivity across the whole system during non-dry times in order to keep the system 'wetter' for longer. To achieve this, it is imperative to consider rules and triggers currently in place that allow for the take of water when there are high flow events in the Northern Basin.

The take of overland flow in NSW – often referred to as floodplain harvesting - has a long history. Prior to the introduction of the Water Management Act 2000, limited attention was given to the monitoring of overland flow extraction in NSW. Instead, overland flow extraction was often considered an implied right, in a similar manner to the taking of supplementary water (previously referred to as 'off-allocation' water). Since 2000, work has progressed to bring floodplain harvesting into the NSW water management framework.

In the *NSW Floodplain Harvesting Policy*[96] floodplain harvesting is defined as "*the collection, extraction or impoundment of water flowing across designated floodplain including rainfall run-off (external and on-farm rainfall) and overbank flow.*"[97] Floodplain harvesting activities can occur on sites where all or part of a property lies within a designated floodplain[98]. The definition and the geographical specification of where floodplain harvesting can occur has resulted in several inconsistent rules in some Northern Basin valleys. This is because the floodplain harvesting rules only apply where NSW has declared a floodplain a "designated

[96] *NSW Floodplain Harvesting Policy 2018*
[97] This definition excludes water taken under certain conditions, including the taking of water under a water access licence that is not a FPH access licence; taken of water under a basic landholder right; water under an applicable water access licence exemption; and used irrigation water.
[98] *NSW Floodplain Harvesting Policy 2018, p.4*

floodplain" and issued floodplain harvesting licences, whereas overland flow take occurs in many other areas, particularly in the unregulated plans.

There are substantial in-valley environmental, cultural and socio-economic benefits of floodplain flows. Flows that spill out onto the floodplain are important for maintaining floodplain vegetation communities and floodplain wetlands, which provide critical habitat for a range of species and support the overall productivity of river floodplain systems.[99] Also, the most recent fish kill events has highlighted that periodic overbank flows / floodplain flows can clear debris and nutrients from floodplains thereby reducing risks of water quality issues (like algae blooms) in downstream catchments.[100]

There are two types of overland flow take:

- water that spills out of the river onto the floodplain (overbank flow)
- water that flows across the floodplains towards the river that is captured before it gets to the river (rainfall runoff).

In NSW a portion of overland flows moving towards the river that is captured is exempt from the floodplain harvesting rules under the "rainfall runoff' exemption. Data provided to the Panel by the Department (**Table 10**) indicates that 77 percent of non-exempt overland flow capture is from overbank flow, while 23 percent is captured as it flows across the floodplain towards the river.

Table 10 Breakdown of floodplain harvesting and exemptions

Valley	Overbank flow harvesting (GL)	Rainfall runoff - exempt (GL)	Rainfall runoff - Non-exempt (GL)
Namoi Valley	24.9	23.4	21.1
Macquarie/Wambuul Valley	23.2	10.1	13.9
Gwydir Valley	82.7	42.7	11.3
Barwon-Darling	17.7	4.1	2.1
Border Rivers	32.9	5.1	6.1
Total	181.4	85.4	54.5

In general, the extraction of overland flows reduces the volume of water returning to the river or reaching the downstream catchment, which affects lateral connectivity in the valley[101]. This could also have implications for longitudinal connectivity, particularly as volumes of water are captured in on-farm storages instead of flowing downstream to meet water needs of the downstream catchment. As the Select Committee on FPH observed:

"floodplain harvesting has had a significant impact on downstream flows and river health, particularly to the Darling Baaka, Menindee Lakes, and Ramsar listed wetlands, leading to numerous economic, social, cultural and environmental impacts"[102]

[99] Sheldon, F., D. Barma, L. J. Baumgartner, N. Bond, S. M. Mitrovic and R. Vertessy (2022). "Assessment of the causes and solutions to the significant 2018–19 fish deaths in the Lower Darling River, New South Wales, Australia." Marine and Freshwater Research 73(2): 147-158.
[100] Periodic overbank flows avoids the build up of these organic materials on the floodplains
[101] The question of implication of floodplain harvesting on lateral connectivity in individual water sharing plan areas will be considered by the Natural Resources Commission in its review of relevant water sharing plans.
[102] NSW Legislative Council Select Committee on Floodplain Harvesting (2021) Floodplain harvesting

In addition, the Western Regional Water Strategy has stated that:

"Unconstrained floodplain harvesting, which is the capture of water that flows across floodplains by irrigators for later use, has reduced the volume, frequency, and duration of floods."

Information and modelling of floodplain harvesting is limited compared to information available on supplementary and other forms of water take. Therefore, it is difficult to comment with confidence on the specific implications of floodplain harvesting activities on longitudinal connectivity. In particular, given the shortcomings of hydrological models to adequately represent return flows to the rivers, it is challenging to assess the potential in-valley or downstream benefits of restricting floodplain harvesting take in Northern Basin catchments.

4.2 Licensing and management of floodplain harvesting

The roll-out of NSW's floodplain harvesting licencing framework has been phased. In the NSW Border Rivers and Gwydir catchments, the licensing framework came into effect in August 2022. In the Macquarie/Wambuul and Barwon-Darling catchments, the licence framework came into effect in March 2023 and April 2023 respectively. In the Namoi catchment, no particular date for the licensing roll-out has been set; however, the Department has provided preliminary/draft access rules on its website.[103]

Associated with the progressive rollout of the NSW floodplain harvesting licensing framework, relevant Northern Basin water sharing plans have been amended to set access rules for floodplain harvesting in the relevant plan area. To date, floodplain harvesting licences have been issued in the NSW Border Rivers, Gwydir, Macquarie-Cudgegong Regulated Water Sharing Plan areas as well as in the Barwon-Darling and Gwydir Unregulated Water Sharing Plan areas. The Department also intends to issue floodplain harvesting licences in the Upper and Lower Namoi Regulated and Unregulated Water Sharing Plan areas.[104]

It is important to note that the Department concluded that the amount of floodplain harvesting occurring created a growth in use above the allowable total extraction limits. As such, the volume of floodplain harvest licence entitlement issued is less than what is predicted to have occurred over the last decade. The Panel also recognises that there are many questions about whether the volume of floodplain harvesting licences issued accurately reflects take at the time when the capping of any growth was meant to occur. The OSCE report on fish death for example highlights that on-farm storages grew 2.3 times from the date extractions were meant to be capped (1993-94) to 2019-20.[105]

An assessment of the level of floodplain harvesting and whether it is consistent with historic take is beyond the scope of this review. We have sought to identify where restricting floodplain harvesting will assist in meeting our identified targets. We recognise that there may be need to further assess floodplain harvesting impacts - particularly in valley impacts - beyond our recommendations.

[103] NSW Government (2023), *Namoi Valley floodplain harvesting licensing and rules*
[104] The Panel however notes that other unregulated water sharing plans in the Northern Basin Plan include amendment provision that would enable the issue of floodplain harvesting.
[105] Office of the NSW Chief Scientist & Engineer (2023) *Independent review into the 2023 fish deaths in the Darling-Baaka River at Menindee* –*See page 43*

For those valleys were floodplain harvesting licences have been issued, the following specific access rules apply:

Valley	Issues Floodplain harvested licences rules
NSW Border Rivers, Gwydir Macquarie-Cudgegong Regulated Plan areas Barwon-Darling Unregulated Plan	**Floodplain harvesting take is permitted:** From overland flows after a Ministerial announcement and if volume of Menindee Lakes is above 195 GL **or** in-valley targets have been met.
Gwydir and Namoi unregulated Plan areas	**Floodplain harvesting take is permitted:** From overland flows under the same conditions as existing unregulated access licence or works approval conditions, with some exemptions[106]. This means that floodplain harvesting is allowed whenever there is overland flow.
Other unregulated plan take	**Overland flow take is permitted:** In many of the unregulated water sources in the Northern Basin take via overland flow was assessed and included in the licence holders unregulated access licence, and no floodplain harvesting licences were issued. Given that floodplain harvesting licences were not issued, the Department does not consider this floodplain harvesting, but classifies this as "overland flow" take. This means there is no differentiation between overland flow take and water taken from the river. Users may take their entire entitlement from either source. This creates significant difficulties when considering equitable restrictions on take of overland flow.

4.2.1 Current restrictions to floodplain harvesting take

The Northern Basin regulated water sharing plans where floodplain harvesting licences have been issued include rules that are meant to restrict floodplain harvesting take under certain conditions. Broadly, the current water sharing plan rules state that floodplain harvesting is **not permitted** if the volume of water stored in Menindee Lakes is less than 195GL **unless** in-valley relaxation targets are being met (see Table 11)

Table 11 Restrictions of floodplain harvesting take in relevant Northern Basin Regulated Rivers

Regulated Valley + BD	FPH restricted: Menindee Lake total storage <	In valley gauge site	(Relaxation targets when FPH is permitted: flows remain at or above (ML/d))	Relevant environmental water requirement

[106] Floodplain harvesting is exempt from certain access rules such commence and cease to pump rules.

Border Rivers Regulated	195 GL	Mungindi	3,000	3,000 = LF
Gwydir Regulated	195 GL	Galloway (unreg gauge: no environmental water requirement)	550	No environmental water requirement
		Teralba	250	250 = SF
		Tyreel	250	250 = SF
		Collarenebri	1,200	800 = LF
		Thalabh (unreg gauge: no environmental water requirement)	300	No environmental water requirement
Macquarie/Wambuul Regulated	195 GL	Marebone combined	3,400	4,000 = LF
Namoi Regulated (proposed on DCCEEW website)	195 GL	Bugilbone	4,500	4,500 = AC
Barwon-Darling Unregulated	195 GL *transition to active management	Wilcannia	7,900	1,400 = SF 14,000 = LF

Legend: LF: Large Fresh ; SF: Small fresh; AC: Anabranch Connection

These rules set one 'global' (Menindee Lakes) trigger to restrict floodplain harvesting in Northern Tributaries when the volume in Menindee lakes starts to get low. This trigger can be overridden by achieving local in-valley relaxation triggers. The level of flow required to remove floodplain harvesting restriction in-valley is well below where most floodplain harvesting would occur (when the river overbanks). As such, the plan rules do not restrict floodplain harvesting if an actual flooding (overbank) flow comes through. If the idea is that floodplain harvesting has the potential to provide large volumes relatively quickly down to Menindee, then these restrictions are inadequate to achieve that objective.

For Northern Basin unregulated water sharing plans where floodplain harvesting licences have also been issued, there are no specific plan rules restricting floodplain harvesting. General water sharing plan rules apply, with some exemptions. Effectively there are no specific access rules restricting floodplain harvesting access in these areas.

4.2.2 Western Regional Water Strategy proposed Menindee 'critical dry condition triggers'

The Western Regional Water Strategy proposes a new set of "critical dry condition triggers", including a rule to restrict floodplain harvesting, supplementary, and A, B and C class licences in the Northern Tributaries if active storage in the upper Menindee Lakes is forecast to drop below 195GL.

When this trigger is reached, the strategy proposes that no releases are made from the Menindee Lakes system beyond minimum flow requirements from Lake Wetherell, Lake Pamamaroo and Lake Tandure.[107]

The proposed 'relaxation triggers' to lift these restrictions are:

"If the active storage in the upper Menindee lakes storage is less than 195GL ***and the Lower Darling has ceased to flow*** *then restrictions would be lifted when the lakes are forecast to have enough water to restart the river. This is likely to be approximately 255GL: 195GL (active) + 60GL to restart the river.*

If the ***Lower Darling has not ceased to flow*** *when the restrictions can be lifted earlier (when there is 195GL – 255 GL of water in Menindee Lakes of water in Menindee Lakes). Restrictions can be lifted upstream once the peak of the flow has passed as long as the Menindee Lakes are forecast to have the required."*

The proposed critical dry condition rule would restrict supplementary, floodplain harvesting and A,B,C extraction to achieve flow to Menindee lakes. The Department has indicated that this rule would be intended to override the in-valley relaxation triggers. As such, it would have greater potential to provide flows to Menindee Lakes than the current rules. However, the guidelines for lifting restrictions are vague and do not provide sufficient guidance as to what the objective is. The Department has indicated the intent if the Lower-Darling is not flowing then 195GL plus the 60Gl restart would be needed. The Panel notes this would require significantly more than 60Gl of water as the Lower-Darling is not likely to stop flowing until the lakes hit dead storage, due to minimum release rules. It is also unclear what criteria would be used to lift restrictions in the event that the Lower-Darling was not dry, or whether the 60GL restart is still considered necessary in that case.

4.2.3 Current "restart allowance" rule

There is already a rule in the Lower-Darling water sharing plan related to the 60GL restart allowance (clause 72, Division 4, Part 10). This rule requires that once the storage in the lakes drops below 480 GL (when the lakes are in NSW control) AND the Lower-Darling has stopped flowing for 10 days at Weir 32, then the first 60 GL of inflow to Menindee Lakes would be reserved for a "restart allowance". The rule does not trigger any restrictions on upstream users in order to achieve these inflows.

The trigger of 10 days of cease to flow is not logical. The Lower-Darling is highly regulated and the NSW Murray and Work Approval require minimum flow releases for maintaining water quality and river health. In effect, the Lower-Darling would not stop running at Weir 32 until the lakes reach dead storage, and water can no longer be physically released downstream. Therefore, under this rule, the lakes are already exhausted before inflows would be set aside for a restart. Further, depending on how long it takes for flows to resume the lake volume could have dropped well below full dead storage, affecting the volume of inflows necessary to "restart" the system.

4.3 Menindee Lakes triggers

The Panel was unable to identify a clear logic for why the volume at Menindee would be used as the primary driver for restrictions on floodplain harvesting in the Northern Basin. It

[107] This is different to how the current minimum flow requirements are specified. At the moment, WaterNSW is required to make minimum releases from the Menindee Lakes[107] under WaterNSW's Works Approval but this same requirement is not specified in the water sharing plan.

is also unclear what the intended objective of the current floodplain harvesting restrictions in the water sharing plans are given that they would unlikely restrict a large volume of water that would reach and refill Menindee.

There does not appear to have been considered analysis of which of these various rules would take precedence, or clarity regarding their objectives. The Panel notes that in response to the OSCE report on the recent fish deaths, the Minister requested the Natural Resources Commission to undertake detailed analysis of the Murray and Lower-Darling water sharing plan's environmental provisions, including the environmental water allowance and water quality needs in the Lower-Darling. This work is currently being undertaken and provides a much more in depth assessment of the rules and issues in Menindee Lakes and the Lower-Darling than is possible for this Panel to undertake. The Natural Resources Commission has agreed to share its findings with the Panel. We have considered initial input from their work in developing comments for this report and will evaluate any further analysis provided by them as their work progresses for our final report.

The Panel makes the following general observations about the current and proposed rules related to Menindee Lakes volumes:

- **Link between Menindee volume and FPH is unclear:** Setting restrictions on FPH based solely on the levels in Menindee is arbitrary. The volumes in Menindee are subject to manipulation and are not necessarily representative of antecedent conditions in the system. Further there does not appear to be any sound analysis of whether it is feasible to provide substantial flows to the Menindee Lakes in a reasonable time period through restriction of floodplain harvesting.
- **Unclear link between volume and dry conditions:** The premise of the Menindee Lakes volume trigger appears to be that this is a signal that the system is entering a "critical dry" period. However, due to the lagged response of the lakes to upstream conditions, there are times when Barwon-Darling flows are low, but the lakes still have reasonable volumes of water in them. The most recent modelling provided by the Department indicates that often when the 195 GL active trigger is reached in the upper lakes there can still be moderate to high volumes of water in the other lakes and therefore total volumes in the system may still be quite high. For this reason, the Panel has focused our recommendations on supplying flows past Wilcannia and feels flow at Wilcannia is a more appropriate trigger for identifying if the system is entering a dry period.
- **Current and proposed rules overlap:** The current FPH access rules in the regulated water sharing plans and the proposed "critical dry condition trigger" rule are activated by the same thing (195 GL in Menindee Lakes – recognising that the Department has acknowledge the current plan rules should reflect active storage in the upper lakes rather than total storage). The Department has indicated the requirement to achieve 60 GL would override the in-valley relaxation trigger. If both rules were in place, then the in-valley relaxation triggers would almost certainly always be overridden and would be superfluous.

  The Department has indicated that the intent is that if the critical dry Menindee target were implemented, then the current rules in the Northern Tributaries would be modified such that they are not triggered by a Menindee Lakes volume, but rather are targets that must be met before the Minister announced floodplain harvesting.
- **Storing water in the Menindee Lakes is inefficient.** The Menindee lakes were naturally ephemeral wetlands before being engineered into a system of lakes for water storage purposes and would periodically fill and dry out. The lakes have large surface areas and the climate is hot, so evaporative losses are very high. The water

quality in the lakes is also often poor when water is stored for significant periods. As such, there can be diminishing returns to storing additional water in the lakes. However, it should be recognised that the lakes provide important habitat for native species, particularly golden perch, and volumes necessary for ecosystem health should be maintained.

- **Pamamaroo inlet regulated should be repaired:** Current dam safety issues with the Pamamaroo inlet regulator mean that an additional 55 GL of water is required to meet downstream needs during critical dry times. In the Panel's view this is highly inefficient, and the upgrade of this structure should be of the highest priority.
- **Need to store reserves in the upper lakes:** Given that the water quality issues and fish deaths predominantly occur in the 32 km between the Main Weir and Weir 32, water reserved for providing flows during dry times needs to be stored in the upper lakes. Analysis indicates that this results in considerably greater impacts on upstream water users to achieve the proposed critical dry condition trigger than using total storage in the lakes.
- **Limitations of the critical needs volume:** The assessment of the volume that is required to be stored for critical needs is based on a basic calculation of the minimum flow requirements and evaporative losses to provide water for 12 months. This is largely driven by the need to continually pass flows down the system even in very dry times to maintain water quality. This is inconsistent with the approach proposed for the rest of the system, where the Panel has proposed alternative approaches during dry times. The Panel is of the view that further consideration should be given to whether there are alternative operating approaches that would be more efficient during dry times and require less water to be stored while maintaining critical needs. The requirement for storing water for 12 months should also be reviewed as is it not clear the evidence base for choosing this time frame.
- **Infrastructure solutions are required:** In the longer term steps should be taken to allow the lakes and the Lower Darling-Baaka River to be operated in a more effective manner to improve environmental outcomes. This includes investment in fish passage through Menindee Lakes so that fish do not get trapped downstream of Main Weir and can move between the Northern and Southern Basin when cued. It should be noted that new fishways will require flows to pass through them to be effective. Removal of instream structures such as Old Town Weir would improve connectivity and would help to address some of the water quality issues in this reach of the Lower Darling-Baaka River. The Panel notes that removal of this weir was deferred in October 2023 to winter 2024. Such solutions will be important for improving connectivity.

The Panel has developed a set of targets upstream of Menindee (Table 5) that we feel if met, would achieve a considerable improvement in inflows to the lakes. For example, the baseflow target would provide 350 ML/d at Wilcannia, which should provide adequate volume for minimum flows out of Menindee for much of the year. From a connectivity perspective providing additional flows to Wilcannia and then to Menindee was our objective. Our view is that the Menindee volume trigger creates a requirement that is not directly related to connectivity needs. The significant volumes necessary to supply downstream needs are due to the limitations of the structures that have been put in place to manage the system, rather than a natural flow necessary for connectivity.

However, the Panel also accepts that any solutions that address the core issues will take time and the Government has developed rules and proposals aimed at preventing significant water quality problems and fish deaths within the Lower-Darling. Given this the

Panel has assessed the currently proposed solutions and steps that could be taken to improve outcomes if this approach is to be taken.

4.3.1 Volume needs at Menindee

The Panel has examined latest available expert advice on the minimum daily flow volumes that would be required to maintain water quality in the Lower-Darling. Based this, the current minimum downstream flow requirements, which the 195GL trigger is based on, are not adequate for their intended purpose. New data collected during the term of the NSW Murray and Lower Darling Water Sharing Plan indicates that higher minimum daily flows are required to reduce persistent stratification and the occurrence of algal blooms in the Lower Darling-Baaka, specifically in the Menindee Weir Pool (upstream of Weir 32), and particularly during summer months. However, this is based on conditions post-fish kill where the effects of the fish kills combined with high biomass (fish that have migrated to the weir pool from downstream and algae) have contributed to conditions that warrant higher daily flows over warmer months.

That advice indicates that an additional 43 to 95 GL would be required, in addition to the 195 GL active storage in the upper lakes, to provide adequate flows to maintain water quality. Therefore, the volume in the upper lakes would need to be maintained at **238 to 290 GL** to ensure adequate flows were available for 12 months. This does not consider any additional environmental water allowance which the Panel understands the Natural Resources Commission is considering. Further, an additional 55GL of water would need to be stored if the Pamamaroo inlet regulator is not replaced. This should be addressed as a matter of priority to reduce the need to store excess water inefficiently.

The basis for the critical needs calculation should be also reviewed to determine if it accurately reflects critical needs and if there are alternative operating approaches that could achieve desired outcomes in dry times with less water. This includes reviewing the need to provide for 12 months of critical needs in the Lower Darling. The basis for adopting 12 months (as opposed to say 6 months or 18 months) is not clear. The Department has indicated that it is based on considerable community consultation, but the evidence base is not clear. The Panel presumes the volume is meant to relate to reducing the risk of reaching dead storage in the Menindee Lakes and not being able to provide for downstream critical needs. How this risk changes with different storage triggers needs to be better understood.

The Panel will continue to work with agencies to further assess these issues for our final report.

Clarify the rules and objectives for the restart allowance

Currently the way the restart allowance would actually work is very unclear. While there is a rule in place it has never been implemented, and it does not currently trigger any restrictions upstream to provide for inflows. Under the current rule it's possible the first 60 GL reserve would not even refill the lakes to an active level, depending on how far into the dead storage the lakes have fallen, so it's not evident it would be effective.

The Panel understands the 60GL volume is based on operating experience regarding how much water is necessary to sufficiently "restart" the system once the Lower-Darling has ceased to flow. Previous experience indicates that if this is attempted with insufficient flows, then significant water quality issues arise. The Panel recommends that additional analysis be undertaken to clarify how the 60 GL is intended to be used, when it is most critically needed, and what the actual relaxation trigger would need to be to achieve the desired outcomes.

Once this analysis is undertaken options should be analysed to determine how to achieve the objective most efficiently. Options could include for example:

1. Keep the current rule in the Lower-Darling water sharing plan, but eliminate the requirement for the Lower-Darling to cease to flow for 10 days, such that you begin storing up the restart allowance when the lakes come into NSW control (480 GL). This could be evaluated with and without upstream restrictions.
2. Keep the current rule in the Lower-Darling water sharing plan, but trigger the storing of the restart allowance based on the dry condition trigger at Wilcannia (90 days below base flow). At this point if the Panel's proposed rules were in place restrictions would apply upstream to supplementary, floodplain harvesting and A, B and C class extraction. These restrictions could be extended to achieve the restart allowance.
3. Store an extra volume of water necessary for the restart allowance in the Menindee Lakes such that this volume is added onto the 12-month storage volume. This would ensure water is readily available to restart the system if necessary, but may lead to too much evaporative loss and be inefficient.
4. Apply the proposed critical dry condition trigger that all upstream usage be restricted until 60 GL is supplied to Menindee Lakes whenever the volume in the lakes falls below the trigger. The Panel has concerns that if the volume necessary to be stored for 12-months' supply downstream is raised significantly, then this would be frequently triggered when the 60 GL restart is not actually needed as there is a relatively low risk that the lakes will run dry, because this level would be a poor indicator of whether they system is actually dry.

4.3.2 Floodplain harvesting restrictions

The Panel was asked to consider whether the current floodplain harvestings restrictions are adequate to provide for environmental, basic landholder and water utility needs. This is a very broad question and given our scope we focused on the extent to which we felt floodplain harvesting should be restricted to supply water for downstream outcomes. This is a very difficult question to answer given the near complete lack of data on which to base such an assessment. There is little historical data on how much floodplain harvesting was taken during various flows in the past. The modelling available is not able to assess potential benefits to flows downstream of restricting floodplain harvesting at different times. It is also difficult to envision how to establish rules such as the supplementary rule that aims to provide 50 percent of flows to the environment as overbank flows are so highly variable in volume and it would be extremely difficult to forecast total flow for an overbank flow as is done for in channel supplementary events.

The Panel has therefore included floodplain harvesting restrictions when supplementary take would be restricted. This will for most restrictions only affect the floodplain harvesting that is capturing as overland flow before it enters the river. This only represents 23 percent of non-exempt floodplain harvesting licenced. However, it should provide some additional flow in rivers at important times such as for baseflows and small freshes. Our proposed rules would also restrict floodplain harvesting to achieve larger freshes, and to achieve the resumption of flow targets. We will continue to assess whether further restrictions are necessary or appropriate to provide additional flows to Menindee Lakes as outlined above.

The Panel was only very recently made aware of the Department's intent that the current "in-valley relaxation triggers" would be transitioned to activation targets (whereby the

Minister does not announce floodplain harvesting can be taken until they are achieved) if the critical dry condition trigger for Menindee were implemented. This requires further consideration, including what the objective of the restriction is and what the appropriate triggers would then be. The Panel will consider this further for the final report.

We are aware that it may be necessary and appropriate for there to be additional restrictions on floodplain harvesting in the future. In particular, in-valley outcomes from lateral connectivity that could be achieved from floodplain harvesting restrictions should be considered in the remake of the plans to ensure in-valley outcomes are not compromised.

We are of the view that given the limited information, and lack of a clear objective for further restrictions on floodplain harvesting at this time that the recent licensing of floodplain harvesting along with our proposed rules should be implemented and monitored, with adaptive management applied if additional restrictions are identified as necessary to achieve outcomes.

5 Implementation issues

Findings

Limitations of the department's surface water modelling

22. While they have been assessed to be "fit-for purpose" for assessing floodplain harvesting entitlement, the current models have not been demonstrated to be "fit-for purpose" for assessing environmental and connectivity outcomes – particularly those at lower flows. As such they have significant limitations for assessing potential impacts and benefits of rule changes, particularly those that target lower flow regimes.

23. Analysis of various restrictions assessed in the Western Regional Water Strategy relied on modelling, which has significant limitations for assessing the connectivity outcomes from those restrictions. These results were not "ground-truthed" against actual flow data.

Forecasting

24. Forecasting ability for connectivity events down the Barwon-Darling with multi-valley contributions remains limited despite numerous previous recommendations that this forecasting be improved as a matter of urgency. Data and criteria used to make forecasting decisions are not transparent. Gauging that is needed for improving forecasting may not be adequate.

25. During times when restrictions are in place, it is appropriate for forecasting to take a precautionary approach such that there is a high level of certainty that targets will be achieved before restrictions are lifted. However, this will likely mean greater restriction on users until forecasting ability is improved.

26. In previously forecasted events, some downstream users were allowed to extract water that upstream users were required to leave in the system. This is not equitable. Flows protected upstream should be protected all the way through the system to Menindee Lakes.

27. Prescriptive rules based on relaxing restrictions when specific flows have been achieved at various gauges would provide greater clarity for users and be easier for WaterNSW to implement. However, these would very likely result in greater restrictions on users than sound forecasting.

Unregulated system

28. The unregulated water sources provide important contributions for connectivity and rules need to be developed to ensure that equitable restrictions are placed on unregulated water sources in line with restrictions imposed in regulated water sources to achieve connectivity outcomes.

29. The lack of data regarding flows and extractions in the unregulated system creates challenges for developing sound rules for restricting take to achieve connectivity.

30. There is currently no assessment of compliance with the long-term average annual extraction limit undertaken in the unregulated water sources (other than the Barwon-Darling). This creates concerns over whether restrictions in unregulated sources are likely to be effective.

31. There are inequities in access rules between unregulated water sources adjacent to the Barwon-Darling and Barwon-Darling users, which impact on connectivity.

32. The difference in the way that overland flow is managed between unregulated water sources with no floodplain harvesting licences and water sources with floodplain harvesting licenses create difficulties for equitably restricting unregulated users to achieve connectivity outcomes.

Recommendations

Limitations of the department's surface water modelling

10. Until such time as the modelling can accurately assess low flows, floodplain harvesting restrictions, and changes to contributions from unregulated water sources, assessment of rule changes should be ground-truthed using a first principles approach and considering other sources of data, such as actual historic flows. Further, rules should be devised using a precautionary approach and adaptively managed based on monitoring and evaluation of outcomes.

11. In the longer term, the Department should take steps to ensure the models are fit for purpose to support analysis of connectivity and achievement of environmental outcomes in the tributaries and across the entire Northern Basin. This should include:

c) Identifying future model development needs and committing to a timeline for implementing these.

d) Independent review of the model development plan and changes made to the surface water models.

Forecasting

12. WaterNSW should immediately take steps to improve whole of system forecasting ability in cooperation with the Department. The Department should work with WaterNSW to determine where additional gauging is necessary to effectively manage connectivity and ensure that gauging is available.

13. WaterNSW should develop a transparent set of guidelines for what data and criteria will be used for making forecasting decisions. This should be made public and adaptively managed to improve forecasting ability over time.

14. Water protected through restrictions should be actively managed and restrictions should be relaxed from the top of the system downward to prevent inequities.

15. Forecasting should continue to take a precautionary approach such that WaterNSW has a high level of confidence of the targets being met before relaxation rules are triggered.

Unregulated system

16. For the final report the Panel will develop clear recommendations for rules necessary to adequately restrict unregulated users to equitably achieve connectivity outcomes. If data is insufficient, then the Panel will identify steps the Department needs to take to allow for such rules to be developed and implemented.

The Panel has focused its analysis for the interim report on trying to gain a sound understanding of the fundamental ecosystem and downstream community connectivity needs. Our aim for this report was a clear set of targets that we feel are necessary to meet those needs.

In discussing potential solutions to connectivity issues, the Western Regional Water Strategy states, "*The key will be in continuing to strive for a balanced approach that protects the fundamental health of the environment while supporting the wellbeing of communities and sustain the jobs and industries that drive regional economies.*" The current approach does not achieve this balance. Evidence indicates that despite the Act requirement that the water source and ecosystems be given the highest priority in water sharing[108], the health of the ecosystems is continuing to decline and downstream communities are experiencing increases to water security risk and reduced water quality. This is not just because of extended dry periods, but because of the water management approach at all times. The Panel's proposed rules contribute to restoring this balance. While this will have impacts on

[108] Water Management Act 2000 Section 5(3).

upstream water users, it is not appropriate for upstream extraction to put the fundamental needs downstream at risk.

The Panel also recognises that it is equally important not to restrict upstream users without a clear objective for downstream needs, or to use connectivity rules to shift irrigation water from one user to another. We have therefore attempted to be clear on what needs are being targeted for each restriction and sought to only restrict what is necessary to provide a reasonable level of confidence that downstream needs will be met.

We fully acknowledge that there are many details to work out as to how these targets can be achieved in the most efficient and effective manner and we will be actively working with the relevant agencies on these issues to inform our final report.

It is clear that our recommendations will result in impacts to upstream users. We have attempted to gain an understanding of the scale of impacts through modelling work undertaken previously on proposed options. However, we identified significant limitations in the modelling as far as its ability to assess the impacts and benefits of proposed rules. We will continue to work with the Department on appropriate assessment of impacts.

This chapter outlines the key challenges we've identified in regard to implementation and assessment of potential impacts of the proposed rules.

5.1 Limitations of the Department's surface water modelling

The Northern-Basin river system models have, in recent times, been assessed by the Department to be 'fit for purpose' to determine floodplain harvesting entitlements. However, the models have not been demonstrated to be 'fit for purpose' for the following tasks:

- Assessing connectivity between the tributaries and the Barwon-Darling, particularly during dry periods and periods of flooding.
- Assessing the achievement of important environmental outcomes, including environmental water requirements.
- Assessing the downstream impacts of potential floodplain harvesting restrictions.

The Department has recognised that the models that were used to undertake the assessments have limitations, particularly at low flows. There are known limitations with the Barwon-Darling IQQM, particularly the simulation of dry period flows, making it difficult to assess the full impacts and benefits (to connectivity) of potential changes to WSP rules across the Northern-Basin catchments. In addition, the current approach requires taking the simulated output of the tributary models and inputting them into the Barwon-Darling model. There is unquantified uncertainty associated with the simulation of major tributary catchment inflows to the Barwon-Darling, with the accuracy of simulated end of system flows in each tributary being impacted by the combined upstream model inaccuracies.

The Department indicated that the models are known to overpredict flows at the lower end of the flow regime. The Barwon-Darling Long Term Water Plan used both modelled and observed data for lower flow analysis due to known issues of the model.

Additional modelling limitations include:

- **Inability to explicitly model benefits of restricting floodplain harvesting:** the models are not able to model return flows from restricting floodplain harvesting. While some analyses were undertaken assuming all the floodplain harvesting that would have

been restricted is foregone and returned to the system at the end of system gauge, this is a very rough assessment. Further, this approach was only undertaken for the "bookend" scenario where restrictions apply all the time. The restrictions can't be turned on and off in the model based on specific rules. The inability to model floodplain harvesting restrictions makes it difficult to assess potential options for restricting floodplain harvesting, and the downstream benefits they may provide.

- **Lack of consideration of the unregulated system**: the models include a static contribution from unregulated tributaries. Evidence indicates the unregulated system can contribute a significant portion of flows to the Barwon-Darling, particularly during times important for connectivity, when these flows may often have a material impact on outcomes. The models do not identify any change in outcome from restricting take from unregulated rivers. This makes it difficult to assess potential outcomes from including unregulated water sources in temporary restrictions for connectivity, or to assess which sources it would be most beneficial to restrict, or which restrictions would be most appropriate.
- **No overall system model:** Currently there are separate models for the four northern valley regulated river systems, the Barwon-Darling, and below Menindee Lakes. This makes modelling the impact of rules changes targeting downstream outcomes onerous as the effect of rule changes in the valleys has to be assessed, then input into the downstream models, then potential impacts fed back into the valley models. It also makes the assessment of more complex rules or multiple changes very challenging. The Panel understands that this is being addressed through the MDBA model "uplift" project and that in the future the models should be integrated so that analysis can be run across the entire Northern Basin. However, this will not be done in time to inform the Panel's final recommendations.

The Department has indicated that despite the inaccuracies, the models should still be relatively accurate for comparing the relative connectivity benefit of different rules, but not the magnitude of the benefits. However, the Panel would require further information around this claim to be satisfied how accurate the models are for making those comparisons.

The limitations with the existing models created significant difficulties for the Panel in assessing potential options as the Panel determined that the models are insufficiently reliable to accurately predict the connectivity benefits of many potential rule changes. These issues were evident in review of the Department's modelling reports, such as the floodplain harvesting model reports, which acknowledged the models can't be used to assess downstream benefits of floodplain harvesting rule restrictions. The Barwon-Darling IQQM model report acknowledges that the dry period accuracy makes it difficult to assess available flows during extended dry periods for BLR and for towns relying on water from the Barwon-Darling River.

Given the issues with the models and their inability to accurately assess both low flows and potential rule changes, the Panel is not confident in the findings of the analysis undertaken to date regarding the potential benefits to connectivity of various restrictions, as these relied on the models in question. For example, the models indicate that there is limited impact on achievement of baseflow targets from some proposed rules where the Panel would have expected a greater benefit. However, this is likely because the model overestimates how often the baseflow is achieved under current rules.

While the Panel has attempted to take into consideration the uncertainties associated with the existing models, the current model limitations have led to the need to also consider a first-principles approach to WSP rule changes. In the absence of adequate modelling, the

precautionary principle requires that steps be taken to ensure no irreversible harm to the environment. As such, the Panel supports rules based on analysis of both modelled outcomes (where they may be reasonably accurate) and actual flow data to determine rules that have a reasonable likelihood of achieving outcomes. Rules should be devised using a precautionary approach and adaptively managed based on monitoring and evaluation of outcomes. Adaptive management should be used to ensure proposed rules are revised when improved information is available around how to effectively achieve objectives in an efficient manner.

5.2 Issues with forecasting

Many of the recommendations from the Panel are largely updates to rules that already exist in the water sharing plans. The need for ensuring that Plans adequately share water with the downstream communities and ecosystems has been well recognised for over three decades, with the interim North-West Flow Plan completed in 1992, and its targets incorporated into water sharing plans. However, these rules were never implemented.

The Panel's review indicates that the primary driver for not implementing the rules was a concern that to do so created a risk that it would "over-restrict" irrigators such that targets might be exceeded, or that irrigators might be restricted when targets would not be fully met. Similarly, the Department has indicated that given their inability to assess potential benefits of floodplain harvesting, restrictions during normal times cannot be implemented. This essentially means that due to the risk that rules might restrict users more than absolutely necessary, no action can be taken to ensure the needs of the environment and downstream communities are met. This is inconsistent with the Act requirement to follow the precautionary principle.

If there is a risk of "getting it wrong" the environment has continually borne the risk. The Panel's proposed rules take a reasonably precautionary approach, ensuring that steps are being taken to address the downstream impacts that have been clearly evidenced. We acknowledge that taking a precautionary approach will likely have greater impact on extractive use than if more perfect information was available. But perfect information will never be available. Best available information should be used to implement rules that adhere to the requirements of the Act and meet fundamental needs of all users, with outcomes actively monitored and an adaptive management approach implemented to ensure negative impacts are minimised.

5.2.1 Forecasting in the Panel's recommendations

Many of the rules that the Panel is proposing include the recommendation that restrictions should remain in place until targets are forecast to be achieved. The Panel is aware that forecasting has been problematic in the past and that it has potential to greatly affect the extent to which rules impact on users. While the 1992 interim North-West Flow Plan highlighted the need to improve forecasting and identified it as a priority for the stakeholders and Government, system-wide forecasting abilities have not advanced to a desired level. This is despite several reviews including the Claydon review of the 2021 resumption of flow event recommending that steps be taken to improve forecasting.[109]

The Panel has identified the targets that need to be met to achieve connectivity outcomes. However, the ability to forecast potential flows downstream remains a serious concern, as waiting until targets are met downstream would mean restricting users for considerably

[109] Claydon, C (2021), Independent Assessment Of The Initial Implementation Of The Resumption Of Flows Rule, Idecs And Active Management In The Barwon-Darling: 01 December 2020 To 31 March 2021 Final Report

longer than is necessary to meet the Panel's proposed targets due to the lengthy travel times. The Panel's focus is on meeting the targets with minimal impact to users.

The Panel has reviewed the assessment of the "first flush" event and the first implementation of the resumption of flow rules. These demonstrate that while challenges remain, it is possible to forecast downstream flows in the Barwon-Darling. In fact, the Claydon review found that given the complexities of the event, the systems worked reasonably well, and flow targets were achieved.

The main criticism of current forecasting is that it is conservative and lacks transparency – WaterNSW must have a reasonable level of certainty that the target flows will be achieved downstream before they advise that upstream usage can recommence. This means that they may overshoot the target. The Panel views that this is appropriate. The Act places a priority on achieving protection of the water sources and their ecosystems before provision of extractive use. Further, there is a notion that any water in excess of the target is "wasted". The targets are based on the ***minimum*** flow necessary to achieve the desired outcomes, additional water provides important additional connectivity benefits for community, cultural and environmental outcomes and ultimately provides for additional volume in Menindee Lakes, which is a clear connectivity objective.

Another criticism is that upstream users may be restricted but downstream users are allowed to extract water that "passed by" upstream users when restrictions are relaxed. The Panel agrees that this is not appropriate. Water protected upstream should be actively managed until it arrives at Menindee Lakes, and relaxation of restrictions should begin from upstream so that downstream users are not able to take water that was protected from upstream users.

The Panel also agrees that the current forecasting method lacks transparency. Users have a right to understand how decisions will be made that affect their ability to extract water. Greater transparency allows them to plan better. The Panel found that while the decision-making process for lifting restrictions appeared to be based on a conservative estimate of when downstream targets would be met, the specific data or criteria that was used to make that determination was not clear.

As forecasting is a necessary part of effective and efficient connectivity rules, WaterNSW should develop a clear set of guidelines outlining what data and assumptions they are relying on to assess that there is a strong likelihood of the downstream targets being met. That decision-making criteria and relevant data should be made publicly available, and WaterNSW should continue to refine that process based on experience with implementing forecasting.

In discussions with the Panel, WaterNSW highlighted that limitations of the gauging network available also creates issues with improving their forecasting ability. They indicated that they do not have working gauges in some of the places that they require to address some of the known limitations – such as in the unregulated systems. The Department should work with WaterNSW to determine where additional gauging is necessary to effectively manage connectivity and ensure that gauging is available.

The alternative to forecasting would be a set of "hard and fast" rules based on actual flows past gauges to guarantee flows downstream are going to be met. Realistically this would likely require a fixed rule to be achieved at Brewarrina as this is where all four of the regulated valleys have contributed to flow. This is in effect a less nuanced form of forecasting. The Panel is of the view that this would likely lead to greater restrictions than allowing WaterNSW to forecast when targets will be met. However, we will continue to

work with the Department and WaterNSW to understand constraints and consult with stakeholders for our final recommendations.

5.3 Addressing the unregulated systems

The Panel's expanded Terms of reference requires the Panel to consider rules from all water sharing plans (regulated and unregulated) that in our view materially impact on hydrological connectivity. Given the time since the change in the Terms of Reference, the Panel has not yet undertaken detailed analysis of the specific water sources and rules that would need to be changed to support our proposed targets. However, we have identified a range of issues that we recognise need to be addressed for our final report:

Unregulated system is a significant contributor to connectivity: Evidence suggests that on average, unregulated rivers across the Northern Basin contribute approximately one third of the inflows into the Barwon-Darling River. During high flow events, unregulated systems are even more connected with downstream systems. Unregulated rivers also indirectly contribute to longitudinal connectivity by providing inflows into major northern inland regulated rivers. There is a need to consider these unregulated systems and associated plan rules to ensure downstream connectivity can be supported through these unregulated systems.

Lack of information regarding extraction in the unregulated system: Currently, there is very limited information available on how much water is extracted in Northern Basin unregulated plan areas because the water sharing plans lack numeric LTAAELs and the Department does not undertake compliance assessment against the LTAAEL[110]. Despite the lack of compliance assessment, the Department continues to provide full allocations to all unregulated licence holders. While the Department has indicated they are examining option for undertaking compliance in the unregulated system, this is not yet being done. Not only does this raise questions about overall levels of take in the unregulated water sources, but this approach also creates potential equity issues between unregulated and regulated licence holders in the same catchment.

Access rules are often "no visible flow": Access rules in unregulated plans are often based on 'no visible flow' in the river. These are difficult to enforce and allow users to pump water until the river stops flowing. In principle, the Panel considers it important that restrictions on unregulated licence holders are aligned with connectivity restrictions in the regulated system or else they will not be as effective as they could be. Further, if unregulated users are not appropriately restricted then this would shift extraction from the regulated system (where it is restricted) to unregulated users which would be contrary to the Panel's proposed principle that connectivity restrictions should not shift water from one extractive use to another.

Inequitable provisions: There are several unregulated water sources that contribute directly to the Barwon-Darling (particularly in the Castlereagh and Macquarie-Bogan unregulated plan areas). These water sources typically have very lenient – often "no visible flow" extraction rules. This means that while the Barwon-Darling users are restricted by A, B, and C class cease to pump rules and IDECs, the rivers supplying water directly to the Barwon-Darling have virtually no access restrictions. There are even some sources where during higher flows water may back up from the Barwon-Darling into the unregulated system and while Barwon-Darling users are restricted from taking that water, the users in the adjacent unregulated system can take it. Steps need to be taken to ensure that these water sources adjacent to the Barwon-Darling have consistent access rules. This could be

[110] Reference the NRC briefs on LTAAELs

done for instance by implementing consistent rules in the unregulated water sharing plans, or by absorbing appropriate water sources into the Barwon-Darling plan to ensure they have the same access rules.

There are also unregulated water sources that are anabranches with water flowing from the regulated system through the unregulated and back into the regulated system. Current rules often allow users in the unregulated system to extract water that has been restricted from take in the regulated system. This is inequitable and affects connectivity . Rules must be developed to ensure equitable protection of flows being targeted for connectivity purposes.

Floodplain harvesting differences: Section 4.1 – 4.2 outlined the differences in access to overland flow between unregulated systems with no floodplain harvesting licenses and regulated plans with floodplain harvesting licences. Because most unregulated water sharing plans have incorporated overland flow take into the general unregulated access licence it will be very difficult (if not impossible) to restrict just overland flow access. Alternatives will need to be considered such as actively managing water protected in the regulated system through the unregulated system and options for how unregulated users could be equitably restricted. Carryover rules between unregulated and regulated floodplain harvest licences in the same floodplain are also inconsistent creating further inequities.

Addressing these fundamental shortcomings of the unregulated plans will be required to enable the Panel to provide explicit recommendations related to unregulated water sharing plans in the Northern Basin tributary catchments. This will in turn provide greater assurance that the proposed targets and restrictions will meet the intended outcomes.

6 Potential impacts on upstream users

Findings

33. Limitations of the models make it difficult to accurately assess the potential impacts of rules, particularly as a combined suite of rules that work together. Assumptions that underpin economic studies to date are flawed and should be reviewed for any future analyses to ensure they reflect actual irrigator behaviour.

Recommendations

17. As part of the development of the final report we will work with the Department to assess as accurately as possible potential impacts of the proposed rules, and to examine if there are alternative rules that may achieve the same connectivity outcomes with less impacts. This may require analysis of actual flow data where models are insufficient to assess connectivity outcomes.

The Panel has remained acutely aware of the potential for restrictions in water availability associated with improving connectivity across the Northern Basin and the Barwon-Darling to impact on the social and economic conditions of the respective communities. The Terms of Reference specifically asks the Panel to consider the potential impact on long-term average annual extraction limits, which is discussed in Section 6.1. However, the Department has provided the Panel with various economic analyses that look beyond just long-term average diversions to possible economic implications of proposed rules. The Panel has provided some comments on the adequacy of those analyses.

6.1 Assessment of impacts

The Panel has carefully considered where we feel restrictions on water access to improve connectivity are absolutely necessary and we are cognisant of the potential impacts on upstream users. The Department has provided us with modelled analysis undertaken in conjunction with the Western Regional Water Strategy, which provides a sense of the potential impacts on long-term average annual diversions for irrigators in the regulated tributaries. While the Panel has concerns with these – outlined above – we have used them to develop a sense of the relative potential impact of various proposed rules.

As part of the development of the final report we will work with the Department to assess as accurately as possible potential impacts of the proposed rules as a package, and to examine if there are alternative rules that may achieve the same outcomes with less impact.

6.1.1 Non-dry restrictions:

The restrictions proposed for non-dry times to achieve the baseflow, small fresh and large fresh align with the North-West Flow Plan targets, which are currently in the water sharing plans. As shown in the tables in Chapter 3 (Table 6Table 6)

For the baseflow versus the North-West Flow Plan riparian targets we note that the Panel's proposed baseflow target for Mungindi and Collarenebri are significantly lower than the

North-West Flow Plan targets, whereas the small and large fresh triggers would require water for a longer duration (and therefore greater restrictions) than the current targets.

The Department has provided the Panel with modelling of potential impacts of implementing the current North-West Flow Plan rules, which shows that these rules have less impact than other proposed rules such as the critical dry condition triggers. However, these analyses are based on "perfect forecasting" where restrictions are only applied when they would have historically been needed to meet the targets. Further, the analyses do not include any return flows from restricting floodplain harvesting, but do include potential impacts to users from restricting floodplain harvesting. This is likely to overestimate the impact to users.

The Panel will work with Department to better understand the likely impact of our rules as a package for our final report.

6.1.2 Dry-time restrictions

The Panel is proposing an expansion of the current resumption of flow rules that are currently in the Barwon-Darling water sharing plan. The key impacts of the proposed rule would be:

- Restrictions would begin earlier as we have proposed to reduce the days below baseflow that trigger the rule from 120-150 days at upstream locations to 90 days forecasted at all locations.
- We have proposed to raise the flow rate that the trigger is based on to the bottom of baseflow for each location. This slightly raises the flow level at Brewarrina and Bourke and raises it from 200ML/d at Wilcannia to 350ML/d.

The changes to when the restrictions begin and to the flow thresholds that should be met will result in increased restrictions for users. The difference for users in the Barwon-Darling is likely to be small as the resumption of flow rule already exists in the Barwon-Darling plan. In addition, given that the tributaries would be restricted, more water should be available to achieve the triggers. As such, further analysis is needed to fully understand impacts for Barwon-Darling users, along with the magnitude of impacts from restrictions in the tributaries.

Menindee Lake "critical dry condition" trigger

The Department's proposed "critical dry condition" trigger for restricting upstream to meet the Menindee Lakes relaxation trigger had the largest effect on users of the rules that the Department modelled. This requires that supplementary, floodplain harvesting and A, B, and C licences be fully restricted once Menindee Lakes drops below the level necessary to supply 12 months of "critical needs" downstream. Our analysis indicates that based on latest available information a larger amount would need to be stored in Menindee to provide for downstream critical needs and that it would need to be stored in the upper lakes. The Department's analysis indicates that this rule could have a significant impact on upstream users, though the Panel notes that the analysis did not consider floodplain harvesting return flows, so the impact was likely overestimated.

The Panel will continue to work with the Department to determine the most efficient way to ensure critical needs during dry times are adequately reserved, and that water quality issues can be managed following a dry period. Options are discussed in Chapter 3.

Connectivity Environmental Watering allowance

The recommended connectivity environmental water allowance would require allocating water in each of the major dams to provide for connectivity for at a minimum achieving end of system flows during non-dry times and providing for pulses during dry times.

The extent of the impact will depend on the volume that is determined to be necessary to achieve intended outcomes. This will be assessed for the final report. We recognise that the allocation would need to come from what is currently used for general security storage, which will impact on access for general security users. The Department had not previously modelled impacts of this option. The Panel is looking to develop a strategy for this proposal, taking into account its importance to achieving connectivity and doing so with minimal impacts on other water users.

6.2 Adequacy of economic studies undertaken to date

The Panel has concerns about the adequacy and suitability of the economic analysis carried out to date for informing our assessment of proposals for improving connectivity. The Department has indicated that their economic analyses must comply with the New South Wales government guide for cost-benefit analysis. This should not preclude them from investing in additional economic and social analysis methods, which are needed to assess the Panel's proposed connectivity rule changes. This would include having a greater than 10-year timeframe for economic analysis of the rules, accounting for the likely multiple periods of wet and dry years.

Modelling irrigated production (area and yield): Each of the economic analyses of possible actions to improve connectivity by restricting water access made available to the Panel by the Department have been based on estimated changes to irrigated agricultural production at a valley scale. These models do not appear to be sensitive enough to represent the true variability in irrigated production. For example, with reference to irrigated production in the Gwydir Valley, the Department models propose the minimum area or irrigated production as around 30,000 hectares and the maximum area as 70,000 hectares. Industry data used for the Northern Basin review (by the Murray Darling Basin Authority) had the minimum area as around 10,000 hectares and the maximum as closer to 100,000 hectares.

For the purposes of assessing the proposed connectivity rule changes, the potential impact on the area irrigated would not appear to be sufficiently sensitive to estimate the effects on the irrigation sector for dry years in particular. This is problematic for the subsequent economic modelling which relies on the estimates of irrigated area as an input to understand the impacts on the value of production, farm profitability and flow on effects to communities.

With respect to the potential changes to crop yields from the irrigated area planted, the existing models do not appear to represent the behaviour of irrigators. The modelling of crop outputs depends purely on a water balance approach. It assumes crop water demands relative to water available and keeps meeting the daily demands until the water runs out. This does not account for the various strategies irrigators have been employing to manage their water as conditions dry, such as skip-row irrigation or delaying irrigation water application. Without this understanding of how irrigators utilise the various types and volume of water available to them, it is difficult to assess how the proposed connectivity rule changes might impact on yield, gross value of production and farm profitability.

It is therefore recommended in the first instance, that irrigated agriculture production models, whose outputs of planted area and yield can be used as inputs to ensuing economic analysis, should be developed and validated in conjunction with industry.

Analyses focusing on averages across 10-40 years: In the economic analyses provided to the Panel, the reduction in irrigated area and yield are presented as average impacts across periods of 10 or 40 years. The average effect is not the most relevant estimate to inform the Panel deliberations as the connectivity options are focused on water access restrictions in drier years (critical dry periods), how to maintain the environmental conditions of the tributaries and Barwon-Darling during non-dry times as the climate dries (moving into drought) and the timing for lifting restrictions on water diversions when coming out of drought. The latter is quite relevant to irrigated production. When coming out of drought, irrigation farmers are seeking to ramp up their production and to re-start their irrigated production systems. Moving into drought, changes to water access for particular types of water entitlement will impact on how irrigated producers will use the water available to them for managing the crops already planted. This will affect the yields of existing crops and/or the area of irrigated production in the following 1-2 years.

Considering the water access restriction rule changes proposed by the Panel for improving connectivity, it is therefore necessary to focus on the potential impacts for irrigated production in the particular years where the restrictions apply and in the subsequent years. The connectivity options proposed by the Panel will impact how and when irrigation producers will use their different types of water entitlements, as well as the volume of water diversions. This will require them to review such new risks to water availability and to internalize those risks into their long-term, on-farm decision-making processes. Economic analyses should consider how irrigators are likely to respond to proposed rules in order to more accurately assess the potential impacts.

Rules have largely been modelled in isolation: It was difficult to utilize the findings of the analyses provided to the Panel, as they only represented the effects of individual connectivity-improving options. That is, algal suppression or fish migration or the Menindee Lakes storage level. Any future connectivity impact analysis should seek to examine the suite of proposals as a package in order to fully estimate the overall and combined effects of water access restrictions to improve connectivity.

The Panel's premise is that if you manage connectivity well in non-dry times, you should need less water overall to maintain connectivity. It will be important to consider how rules will work in tandem to understand total impacts to users. For example, the non-dry time restrictions may reduce the length of time that the resumption of flow rule is activated, and it may reduce the amount of water needed to achieve the relaxation triggers due to improved antecedent conditions.

Floodplain harvesting and unregulated contributions have not been considered: The majority of the analyses provided to the Panel do not include restriction on floodplain harvesting. As this has potential to provide a large volume of water, this could considerably shorten the length of time that restrictions are necessary to achieve targets, particularly for the resumption of flow rule. Some of the analyses considered the potential impact to irrigators in lost diversions but did not include any additional flow in the river from restricting floodplain harvesting. This is misleading and results in an overestimation of impacts to irrigators. Contribution from restrictions in unregulated water sharing plans (other than the Barwon-Darling) is also not included in the model and therefore the model may overestimate impacts on regulated users, and cannot be used to assess impacts to unregulated users.

Modelling assumptions: The models used by the Department are based on water availability versus daily crop water use. The models have static assumptions about how available water will be used by irrigators. They are not able to adapt to potential changes to how irrigators will use their water under different rules. As the proposed changes would

lead to a substantial change to current rules, water users are likely to significantly adjust their approaches to water management in terms of which water they use when to manage any change in risks. These changes in water management choices will affect the overall impacts to water users as they attempt to use water most efficiently but will not be picked up by the models.

6.3 Options for improved analysis

The Panel recommends that when looking more extensively at economic impacts that the Department consider these impacts at multiple levels of economic activity. In the first instance, this should include how any change in water availability through restricted access from the full suite of connectivity-improving changes is likely to impact on irrigated agriculture production.

The Panel understands the connectivity options will have both spatial and temporal effects which should be examined on a scale that is relevant to the spatial distribution of that production. A valley level assessment would appear to be too broad for such an analysis of direct impacts, given the scale of irrigated production relative to the size and value of non-irrigated agriculture in each tributary. A further consideration for having this analysis at a level which is finer than tributary scale, is the different mix of water entitlements (general security, supplementary, Class A, B and C, and floodplain harvesting) held by farmers in each of the communities, and how restrictions in access to the different types of water entitlement (and the timing of that restricted access) might flow onto area planted decision and crop yields.

Subsequent to the effects on irrigated production should be an examination of the possible flow-on effects for the agricultural sector, the sectors supporting agriculture and the non-agricultural sectors of the communities. Analytical approaches such as input-output modelling might be most effective for this second layer of impact assessment. However, caution is required when using input-output modelling. There is considerable potential for those models to underestimate how restrictions in water access might flow through smaller regional economies. The scale of this analysis is also quite important and where possible should be at less than shire scale. For example, Moree Plains Shire covers an area which includes production associated with the Border Rivers and the Gwydir-Mehi. Each of these areas is supported by different sets of water entitlements and potential access restrictions associated with improving connectivity. As such, the impacts should be modelled separately for the two locations. Irrigated production also has differing flow-on effects to social and economic conditions in the respective communities.

A third level of impact analysis should include a broader, large region analysis (such as employing CGE modelling). Finally, given the potential for the connectivity proposals to have far-reaching social and economic benefits (as well as costs) distributed across the northern tributary valleys and the Barwon-Darling, studies should be undertaken to fully value those benefits. The connectivity proposals being considered by the Panel are seeking to address and if possible reverse some of the evident decline in environmental conditions across a very large, connected landscape. As such, any assessment of the environmental, economic and social benefits of the proposed connectivity rule changes should be derived from purpose-built models relying on data collected from the location being assessed.

6.4 Next steps

The Panel has outlined the targets that we feel are necessary to achieve desired connectivity outcomes. There is considerable analysis necessary in order to determine the most efficient and effective rules for achieving these targets. Over the next few months we will undertake the following to inform our final report:

- Work with relevant agencies to identify the relevant end of system gauges and flow targets appropriate for the end of system flows, small and large freshes and an appropriate “transition” trigger for non-dry to dry times.
- Work with relevant agencies to further assess options for the “connectivity EWA” including necessary volumes and potential impacts.
- Undertake further analysis of the rules in the unregulated water sharing plans to identify more specific recommendations for necessary restrictions to align with our current recommendations.
- Work with relevant agencies to further assess the Menindee Lakes volumes necessary for supplying critical needs and the objectives and needs for the “restart allowance” so that we can make more specific recommendations around these issues.
- Further consider the proposal to transition the in-valley floodplain harvesting triggers to activation triggers, and what appropriate values for those triggers would be.
- Work with the Department to assess as accurately as possible the potential impact of our suite of proposed rules on the long-term average annual extraction for upstream users.
- Undertake limited engagement with stakeholders to understand issues and concerns they may have based on this interim report.

Attachment 1

Connectivity Expert Panel – Terms of Reference

Connectivity Expert Panel – Terms of Reference

1. Background

Water flowing across connected catchments supports essential human and ecological needs. The Barwon-Darling system relies on flows from 5 NSW valleys (Border Rivers, Gwydir, Namoi, Macquarie and the Intersecting Streams), as well as number of Queensland Rivers.

Analyses undertaken by NSW Department of Planning and Environment – Water (the department), previous independent reviews and legal requirements have suggested that the following actions should be considered as part of water sharing plan rule changes to improve water flowing across connected catchments at important times:

- implementing rules to protect the first flush of water after an extended drought in water sharing plans (critical dry condition triggers)
- finalising the review of the North-West Flow Plan to identify the best way to support algal suppression and fish migration. Some water sharing plans currently contain interim flow targets for algal suppression and fish migration.

The department is considering actions to improve water flowing across connected catchments in north-western NSW as part of the remake of the Barwon-Darling Water Sharing Plan, which must occur by June 2025.

Implementing these changes may require amendments to water sharing plans flow targets for supplementary and floodplain harvesting access licences for the Border Rivers, Gwydir, Namoi and Macquarie valleys.

The *Water Sharing Plan for the NSW Border Rivers Regulated River Water Source 2021* (clause 73) requires the Minister to seek and consider recommendations from an independent expert panel on the adequacy of assessments undertaken by the department before making any changes to water sharing plan flow targets that aim to improve downstream outcomes. Ministerial discretion is being used apply this requirement to all proposed critical dry condition trigger and North-West Flow Plan water sharing plan amendments for the Barwon-Darling and tributary valleys.

In addition, the water sharing plans for the NSW Border Rivers, Gwydir, Macquarie, Barwon-Darling and Namoi (in draft) catchments require that the Minister seeks independent expert advice on the adequacy of the Menindee Lakes and in-valley triggers for floodplain harvesting access by 1 July 2025.

The Office of Chief Scientist and Engineer's Independent review into the 2023 fish deaths in the Darling-Baaka River at Menindee[1] recommended that the newly established independent connectivity expert panel also examine the adequacy of rules in all northern Basin water sharing plans (regulated and unregulated) in contributing to hydrological connectivity with the Lower Darling-Baaka and southern Basin.

[1] The report can be accessed at Menindee Fish Deaths | Chief Scientist (nsw.gov.au)

2. Mandate of the Connectivity Expert Panel

The Connectivity Expert Panel is established under water sharing plan provisions[2] to provide independent expert advice to the Minister for Water on the adequacy of:

- the assessment already carried out by the department and the proposed amendments to flow targets in water sharing plans that aim to restrict supplementary, A-Class, B-Class, C-Class and floodplain harvesting licences in order to improve flows for downstream connectivity outcomes, including during critical dry conditions.
- of floodplain harvesting access rules in enabling environmental and human needs to be met.

The Connectivity Expert Panel will provide a high-level assessment of:

Critical dry condition triggers and North-West Flow Plan targets

- any changes to flow targets in the Barwon-Darling and northern tributaries (Border Rivers, Gwydir, Namoi and Macquarie) required so as not to jeopardise the critical needs of the environment, basic landholder rights, domestic and stock access licence holders and water utility licence holders in the Barwon-Darling River and the water source
- the adequacy of the department's assessment of the following in relation to the proposed changes:
  - the critical needs of the environment, basic landholder rights, domestic and stock access licence holders and local water utility access licence holders in the Barwon-Darling River and the water source
  - the adequacy of the existing flow targets to meet those needs
  - any changes to the flow targets that would be required to meet those needs, and
  - the impact of those changes to flow targets on the long-term average annual total amount of water able to be extracted under:
    - supplementary water access licences in the water source
    - floodplain harvesting access licences in the water source
    - unregulated river access licences in the Gwydir and Macquarie valleys.

Floodplain harvesting access rules

- adequacy of the access rules for floodplain harvesting including:
  - the needs of the environment, basic landholder rights, domestic and stock access licence holders and local water utility licence holders,
  - the adequacy of the existing flow targets and volumes to meet those needs,
  - any changes to the flow target and volume that would be required to meet those needs, and
  - the impact of those changes to the flow target and volumes on the long-term average annual total amount of water able to be extracted under floodplain harvesting (regulated river) access license in the water source.

[2] The relevant water sharing plan provisions are outlines in appendices A and B

The Connectivity Expert Panel is to specifically provide advice on:

Critical dry condition triggers and North-West Flow Plan targets

- algal suppression and fish migration flow targets in the Interim Unregulated Flow Management Plan for the North-West (North-West Flow Plan)[3]
- whether the riparian flows in the North-West Flow Plan should be replaced with triggers to protect water after extended dry periods to meet critical human, cultural and environmental outcomes.

Floodplain harvesting access rules

- the adequacy of local in-valley targets for lifting restrictions on the taking of water under floodplain harvesting access licences in the Border Rivers, Gwydir, Macquarie, Barwon-Darling and Namoi (draft) valleys while Menindee targets apply.

The panel will also be asked to provide advice on:

- appropriate in-valley and Menindee Lakes triggers needed to restrict, supplementary, A-Class, B-Class, C-Class and floodplain harvesting licences access in order to protect the first flush of water after an extended dry period.

The panel is to examine the adequacy of rules in the Northern Basin water sharing plans, which in the panel's view may materially impact on hydrological connectivity between valleys[4]. At a minimum this should include consideration of:

- end of system flow rules and supplementary access rules for the regulated Border Rivers, Gwydir, Namoi and Macquarie valleys
- access rules in the unregulated water sources in the western portions the Northern valleys:
  - Border Rivers: Whallan and Croppa Creek
  - Gwydir: Mehi, Millie, Thalaba, Gil, Carole, Gwydir
  - Namoi: Baradine, Lower Namoi, Brigalow, Bundook, Coghill, Pian
  - Macquarie: Lower Bogan, Lower Macquarie, Marra, Castlereagh below Coonamble.

The panel is to have reference to analysis undertaken by the department to date, relevant reports commissioned by the department and feedback from stakeholders, including relevant government agencies.

In making its recommendations to the Minister, the panel is to provide advice on:

- how the principles and objectives of the *Water Management Act 2000* have been considered, applied and balanced consistent with Act requirements,
- how effective the proposed interventions are at meeting their intended objectives, and
- the resources, processes or systems that are needed to implement the recommendations

[3] The North-West Flow Plan was developed in 1992 following mass algal blooms in the Barwon–Darling River. The intent of the North-West Flow Plan is to limit access to lower priority water licences upstream to enable certain flows and targets to be met in the Barwon– Darling River. The plan is reflected in existing water sharing plans through rules which aim to restrict access to supplementary water flows in the northern valleys (Border Rivers, Gwydir and Namoi) when riparian, algal suppression and fish migration flow targets in the Barwon–Darling have not been met.

[4] The panel's Terms of Reference was amended in February 2024 to include this task in response to recommendation 1.1 from the Office of Chief Scientist and Engineer's *Independent review into the 2032 fish deaths in the Darling-Baaka River at Menindee.*

- potential Aboriginal cultural implications of the recommendations.

In order to undertake this analysis, the panel will be required to agree on key definitions such as connectivity, critical needs, critical dry conditions.

3. Governance and deliverables

The Connectivity Expert Panel has an advisory role and will:

- be convened in September 2023
- meet at least three (3) times –meetings will be either be face-to-face in Sydney, or via video conference
- be provided with relevant background information to review prior to the first meeting
- may be required to participate in public consultation associated with the panel's findings
- provide a draft report to the Minister by March 2024 – timing to be determined by modelling report availability. The draft and final reports will be publicly available.

The department will seek the views of stakeholders, relevant government agencies and other community members on the draft findings and recommendations of the panel.

4. Roles, responsibilities and operating protocols

Roles and responsibilities

Term

The Connectivity Expert Panel is constituted from the date this terms of reference is approved and continues until the final report is published.

If required, the panel may to be reconvened to provide advice on other connectivity actions in the future.

Role of Chair

The Chair of the Connectivity Expert Panel will:

- ensure the panel operates within the terms of reference
- conduct meetings in a timely manner and in accordance with an agenda
- ensure the panel's report addresses all aspects of the terms of reference
- lead drafting of the report and coordination of feedback from members to ensure report is delivered in a timely way reflecting the views of members.

Role of Members

All Connectivity Expert Panel members (including the Chair) commit to:

- attending all scheduled meetings
- preparing for meetings by reading and familiarising themselves with any pre-reading material
- providing timely apologies to the Chair and Secretariat if unable to attend a scheduled meeting so the meeting can be rescheduled

- actively participating in panel meetings, discussions and contributing to the recommendations and report from the panel
- declaring any situation which may give rise to any perceived, potential, or actual conflicts of interest in relation to any matter under consideration by the panel.

All Connectivity Expert Panel members (including the Chair) can expect:

- to be issued any required pre-reading material or reports at least three (3) days before the scheduled panel meeting
- open and honest discussions
- to be notified by the secretariat of any risks and issues that could impact the project/timeline.

Role of Secretariat

The department will provide the Connectivity Expert Panel with secretariat support. The secretariat of the Expert Panel will:

- schedule meetings and set meeting agendas in agreement with Chair
- arrange meeting facilities and travel where needed
- provide additional information as requested by the panel
- ensure actions are recorded and completed. Ensure meeting minutes are stored in the department's official, electronic, record-keeping system
- assist the panel as directed to develop draft and final reports.

Payments

The panel will be procured in accordance with the NSW Government's procurement guidelines.

5. Obligations of Connectivity Expert Panel Members

Confidentiality

- All information in whatever form which is considered by the panel is typically classified as SENSITIVE or OFFICIAL[5] and must be treated as OFFICIAL unless labelled otherwise.
- A panel member tabling a document may identify the relevant dissemination limiting marker[6]. Where the document is commercial in confidence it should be labelled as SENSITIVE. Where the document is readily available in the public domain it should be labelled UNOFFICIAL.
- Information available to panel members must not be used to obtain any advantage, whether direct or indirect, for themselves or for any other person or body.
- Some of the information provided to the panel or the panel's recommendation could be market sensitive and where noted must not be discussed until the relevant information/recommendation is in the public domain or is no longer deemed market sensitive.

[5] DCS-2020-07 NSW Government Information Classification, Labelling and Handling Guidelines

[6] Dissemination limiting markers (DLMs) are labels used by the NSW Government to define sensitive information and data, both physical and digital.

- Confidential information available to panel members is to be used only for the official purposes of the panel and may only be used in ways that are consistent with the obligations of panel members to act impartially, with integrity and in the public interest.
- Where confidential information is provided to panel members, care must be taken to ensure that the information is kept secure, and that numbers of copies are kept to the minimum necessary. If such information is to be disposed of by a panel member, it must be physically destroyed.
- Panel members should avoid investments or business activities in relation to which they might reasonably be perceived to have access to confidential information which might give them an unfair or improper advantage over other persons.
- Panel members engaged in discussions or communications outside the Expert Panel meetings, may only refer to the outcomes of the meetings that have been published online.
- Panel members cannot comment publicly on behalf of the panel unless they have been nominated and authorised by the Chair as a nominated spokesperson and such communication has been agreed to by the panel. This includes any comments made via social media or other channels.

Conflict of interest

Connectivity Expert panel members should perform their functions in good faith, honestly and impartially and avoid situations that may compromise their integrity or lead to conflicts of interests.

Any situation which may give rise to an actual, perceived and potential conflicts of interest must be identified, disclosed and managed in a transparent way. panel members are not empowered to determine whether any specific situation constitutes a conflict of interest. Panel members are required to disclosure any situation which may give rise to a conflict of interest to any matter being considered by the panel as soon as they become aware.

Probity advice

To ensure independence, the processes for the selection and operation of the Connectivity Expert Panel have been informed by probity advice from an independent probity advisor. The role of the probity advisor includes assisting the panel in developing justified defensible outcomes in an open and transparent environment. Panel members may contact the probity advisor at any time. Communications with the probity advisor are confidential unless agreed otherwise.

Appendix A – **R**equirement for Minister to seek independent advice on of changes to flow targets

Excerpt from *Water Sharing Plan for the NSW Border Rivers Regulated River Water Source 2021*[7]

73 Schedules

(1) The Minister may amend Schedule 1 to add, modify or remove flow targets as reasonably necessary to ensure the taking of water under supplementary water access licences does not jeopardise the critical needs of the environment, basic landholder rights, domestic and stock access licence holders and local water utility access licence holders in the Barwon-Darling River.

(2) Before making any amendment under subclause (1) and before 1 July 2023, the Minister will:

(a) undertake an assessment of:

(i) the critical needs of the environment, basic landholder rights, domestic and stock access licence holders and local water utility access licence holders in the Barwon-Darling River,

(ii) the adequacy of the existing flow targets to meet those needs,

(iii) any changes to the flow targets that would be required to meet those needs, and

(iv) the impact of those changes to flow targets on the long-term average annual total amount of water able to be extracted under supplementary water access licences in the water source,

(b) seek and consider recommendations from an independent expert panel on:

(i) the adequacy of the assessment in (a), and

(ii) any changes to the flow targets in (a)(iii) required to meet the critical needs of the environment, basic landholder rights, domestic and stock access licence holders and local water utility access licence holders in the Barwon-Darling River, and

(c) consider the views of stakeholders and other community members on the expert panel's recommendations.

(3) Action under subclause (1) must not substantially alter the long-term average annual total amount of water able to be extracted under supplementary water access licences in the water source.

Note. If satisfied that it is in the public interest to do so, the Minister may amend this clause under s.45 (1) (a) of the Act to such an extent that it substantially alters the long-term average annual amount of water able to be extracted under water access licences. If this occurs, compensation may be payable under chapter 3 Part 2 Division 9 of the Act.

[7] NSW legislation - Water Sharing Plan for the NSW Border Rivers Regulated River Water Source 2021 – section 73

Appendix B – **R**equirement for Minister to seek independent advice on floodplain harvesting triggers

Excerpt from *Water Sharing Plan for the NSW Border Rivers Regulated River Water Source 2021 (NB equivalent requirements exist in other water sharing plans that licence floodplain harvesting)*[8]

43B Taking of water under floodplain harvesting (regulated river) access licences

(1) For the purpose of the clause *Menindee Lakes Storage* has the same meaning as it does under the Murray-Darling Basin agreement.

(2) The taking of water under a floodplain harvesting (regulated river) access licence, other than in accordance with Clause 43A, may only occur if the Minister has announced that the taking of overland flow is permitted.

(3) The Minister must not announce that the taking of overland flow water is permitted if the volume of water stored in Menindee Lakes Storage is less than 195 gigalitres.

(4) Subclause (3) does not apply during periods for which, in the Ministers opinion, the flow in the Barwon River at Mungindi gauge (416 001) will remain at or above 3,000 ML/day.

70 Amendments relating to floodplain harvesting

(5) This Plan may be amended to add, remove or modify rules in clause 43B.

(6) Before making any amendment under subclause (5) and before 1 July 2025, the Minister will:

(a) seek, consider and publish independent expert advice on the adequacy of rules in clause 43B including:

(i) the needs of the environment, basic landholder rights, domestic and stock access licence holders and local water utility licence holders,

(ii) the adequacy of the existing flow targets and volumes to meet those needs,

(iii) any changes to the flow target and volume that would be required to meet those needs, and

(iv) the impact of those changes to the flow target and volume on the long-term average annual total amount of water able to be extracted under floodplain harvesting (regulated river) access licences in the water source.

b) Consider the views of stakeholders and other community members on the independent expert advice

[8] Water Sharing Plan requirements for Minister to seek independent advice on floodplain harvesting triggers

NSW legislation - Water Sharing Plan for the NSW Border Rivers Regulated River Water Source 2021 – section 70

NSW legislation - Water Sharing Plan for the Gwydir Regulated River Water Source 2016 – section 80

NSW legislation - Water Sharing Plan for the Macquarie and Cudgegong Regulated Rivers Water Source 2016 – section 99

NSW legislation - Water Sharing Plan for the Barwon-Darling Unregulated River Water Source 2012 – section 84