Connectivity Expert Panel Final Report

July 2024

Acknowledgements
This report was written by the Connectivity Expert Panel for the NSW Government.

Ms Amy Dula (Chair)

Director of Programs, Natural Resources Commission

Professor Phil Duncan

First Nations representative, University of Canberra - Galambany Professorial Fellow
Centre of Applied Water Science

Professor Fran Sheldon

Head of School, School of Environment and Science, Griffith University

Mr Cameron Smith

Principal Water Engineer, Cleah Consulting

Dr Mark Southwell

Principal River Scientist, 2rog Consulting

Dr Phil Townsend

Senior Economic Analyst

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 (2010) *Biocultural Diversity Conservation: A Global Sourcebook*, Earthscan, London and Washington DC

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

The Hon Rose Jackson MLC
Minister for Water

52 Martin Place
SYDNEY 2000

8 July 2024

Connectivity Expert Panel Final Report

Dear Minister Jackson,

Enclosed is the Connectivity Expert Panel's final report addressing the revised Terms of Reference you provided to us in December 2024. This provides updates and additional analysis to the Interim Report submitted to you on 29 March 2024. We would like to thank you for this unique opportunity to contribute to addressing critically important issues for environmental, social and cultural outcomes in the Northern Basin.

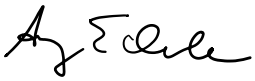
This review has reinforced for all of us what a complex and contentious issue connectivity across the Northern Basin is, as well as how urgently improved solutions need to be implemented. The evidence that reduced connectivity is having severe impacts on ecosystem health and downstream communities is undeniable. It is clear that despite the many efforts to assess connectivity in the past, insufficient progress has been made in improving connectivity outcomes.

We believe that progress has been stymied by barriers to a holistic approach and hesitation to act without perfect information. If there is a risk of "getting it wrong" the environment has continually borne the risk. We have delivered advice that will provide for improved connectivity across the whole Northern Basin, taking into account the highly variable climatic conditions likely to be experienced. There are considerable limitations of the evidence and tools available for assessing connectivity issues, including limitations of modelling, data regarding floodplain harvesting and unregulated system water use. However, these are merely limitations; they do not mean that suitable action cannot be taken using a precautionary approach based on the best information available to us now. This will in turn require that rules are adaptively managed as better information and improved modelling become available.

The Terms of Reference was very broad, covering a wide range of complex issues. We have done our best to outline a clear way forward to improve connectivity and related outcomes, but we acknowledge that there is more work to do. Implementing the recommendations will take concentrated effort, commitment and engagement with stakeholders to ensure any selected rules are as efficient and effective as possible. The Panel recommends that there continue to be independent oversight of any ongoing efforts to ensure that a holistic approach is maintained and the intent of recommendations is not lost.

We would like to thank the many Government staff across a range of agencies who have provided us with information, insights and analysis to inform this report, as well as the many stakeholders who have shown interest in our work and provided comments on our Interim Report. We are hopeful that this final report will contribute to a healthier and more resilient Northern Basin in the future.

Yours sincerely,

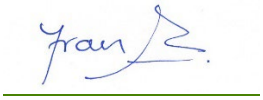


Amy Dula (Chair)

Professor Phil Duncan

Cameron Smith

Dr Mark Southwell



Professor Fran Sheldon

Dr Phil Townsend

Executive summary

The Connectivity Expert Panel (the 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 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

Evidence from several previous reviews, academic research and the Department's own analysis demonstrate a clear 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 can contribute to connectivity available within water sharing plans, these are currently not used, or are not specifically designed, to target 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) sometimes impacts 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]. Upstream extraction and capture by the dams also affects pulses across the entire flow spectrum, including small and large fresh flows, which are essential for downstream ecosystem health. Our recommendations aim to address this by

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

seeking to rebalance extraction with downstream social, cultural and environmental needs through improved connectivity.

Panel's proposed approach for improving connectivity outcomes

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 and capture by dams. 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.

Progress since the Interim Report

Since the Interim Report the Panel has expanded our analysis of floodplain harvesting, management of Menindee Lakes and rules in the unregulated water sharing plans. There remains a considerable lack of evidence regarding many aspects of these issues. However, the Panel has mapped out a way forward we believe will improve management, enhance connectivity and support adaptive management responses. We have made recommendations regarding floodplain harvesting restrictions as well as additional analysis we view is necessary. We have proposed improved rules for unregulated water sharing sources, which when combined contribute significant portion of flows to the Barwon-Darling. We have also leveraged recent analysis by the Natural Resources Commission on Menindee Lakes to propose a new way forward for improving outcomes in the Lower Darling-Baaka.

Impacts and benefits of proposed rules

The Panel has worked with the Department to try to model the potential benefits and impacts of our proposed rules. Given time constraints we have only been able to model our baseflow and resumption of flow rules, which we view as central to achieving improved connectivity. Modelling results indicate that these rules are likely to largely achieve the

expected baseflow, small fresh and large fresh targets the Panel has identified. This would provide substantial ecological, social and cultural benefits to downstream communities, providing flows vital for the long-term maintenance of ecosystem health in the Northern Basin rivers. Achievement of the flow targets is expected to enhance water quality, improve connection between more permanent river sections and improve fish movement, spawning and recruitment of a range of species. Improved in-channel flows would provide the healthy ecological background to allow the entire system to boom during periods of extensive over-bank floods, which occur less frequently. The baseflow results indicate over an additional month of baseflow on average annually in the Barwon-Darling, which will also provide important cultural benefits for communities.

Implementation of the Panel's proposed rules would have impacts on upstream extraction. The modelling results indicate that Panel's proposed baseflow and resumption of flow rules combined reduce annual diversions on average by approximately four percent across the Northern Basin, with around a six percent impact in the three upper valleys. The Department provided modelling that indicated if they could have "perfectly forecast" when current rules from the North-West Flow Plan should have been implemented they would have had approximately a three percent impact on diversions across the Northern Basin. Actual impacts from implementing the North-West Flow Plan rules would be higher as perfect forecasting is not possible. As such, the Panel's proposed baseflow and resumption of flow rules would likely have less than a three percent impact on diversions beyond current rules if current rules were fully implemented.

Need to act based on current information

In the past the lack of available data, difficulties with forecasting over long distances, modelling limitations, and lack of perfect certainty regarding benefits and impacts have been used as excuses to not take action. This inaction has placed considerable risk on the environment and resulted in negative consequences. 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. The Panel has proposed rules based on the best evidence available and implementing a suitably precautionary approach. We are firmly of the view that the Government needs to take action now and adaptively manage solutions as better information becomes available.

See below for our findings and recommendations:

Findings

These findings reflect the views and opinions of the Panel based on the analysis we've undertaken taking into consideration our Terms of Reference.

Chapter 2: A holistic approach to connectivity 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 at the system scale.

2 The Panel agreed on ten principles we feel should be followed for the assessment of options and the development of proposed rules and targets to achieve connectivity outcomes. These principles fall into three categories

- Rules need to adhere to the legislation, be clear and implementable
- Rules should be proactive to maintain fundamental ecosystem functions and improve whole-of-system resilience
- Rules need to provide for equitable sharing of water

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 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 rate, 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. Specifically, a subset of baseflow, small fresh and large fresh (considered ecosystem 'maintenance flows') environmental water requirements are necessary to provide for critical needs for maintaining ecosystem health through 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, but improvements are still possible.

Chapter 3: Available tools for improving connectivity

Supplementary rules and the North-West Flow Plan

9 Supplementary access rules (other than targets from the North-West Flow Plan) were not designed to protect downstream needs. North-West Flow Plan targets, which were originally developed in 1992 were maintained as these were recognised as necessary in addition to other supplementary rules to protect flows for downstream needs. The targets from the North-West Flow Plan have not been routinely implemented.

10 While the targets in the North-West Flow Plan are often met without restrictions being implemented they are not always met when there is sufficient supplementary water available that could meet them. Supplementary access is impacting on baseflows, small freshes and large freshes downstream at certain times, generally when there are small to medium flows.

Importance of riparian targets

11 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.

12 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: Panel's proposed approach for improving connectivity

13 In a system that displays highly variable flows, it is necessary to have different management options for different climatic conditions. Different rules are needed for non-dry compared to dry times, and the transition period in between.

14 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 system connectivity or an adequate "first flush" through to Menindee Lakes following an extended dry period.
- for Menindee Lakes does not adequately represent critically dry conditions and should be reviewed further.

Chapter 5: Floodplain Harvesting in NSW

15 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.

16 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.

17 Current rules do very little to restrict floodplain harvesting. Restrictions in regulated plans only apply when Menindee Lakes are below 195 GL total storage and when 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.

18 The objectives of the current and proposed rules for triggering restrictions upstream based on Menindee Lakes volumes, and around how the 60 GL 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 to date been assessed relative to each other.

19 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.

20 Rainfall runoff makes up 44 percent of floodplain harvesting, but 61 percent of this is exempt. The rules for exemption are unclear and difficult to enforce. Rainfall runoff is likely to be available at the same times that supplementary access is allowed and can provide important contributions to connectivity at important times.

Chapter 6: Management of Menindee Lakes

21 Current minimum flow rules are inadequate for addressing water quality and environmental needs in the Lower Darling-Baaka River, particularly the stretch between the upper lakes and Weir 32. Significantly higher flows are necessary during high risk months to reduce risks of water quality events. The rules also sit outside the water sharing plan and do not specifically require minimum flow releases to be made from the upper lakes.

22 The 30 GL environmental water allowance (EWA) for water quality is not available when the lakes are in NSW control and has been insufficient for mitigating water quality issues in the past two water years. Periodic flow pulses from the EWA are still expected to be necessary to mitigate risk of water quality issues even if minimum daily flows are increased as proposed.

23 Potential changes to rules or operation of the lakes and related agreements would require negotiation and support from the Basin Officials Committee and the Murray-Darling Basin Ministerial Council.

24 The 60 GL restart allowance is supported by operational experience and is likely to be adequate. It is only needed once the Lower Darling-Baaka River has completely stopped flowing. Therefore, it does not need to be continually stored but could be accumulated once the upstream rivers start flowing again. Improved guidance around how to operationally manage the restart is needed.

25 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. 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.

26 Storing water in Menindee Lakes requires careful consideration. They hold significant environmental, cultural and social values that must be considered when making decisions about how they are managed and operated. The lakes are shallow, have a large surface area and are situated in the semi-arid zone, resulting in significant evaporative losses. The upper lakes are more efficient for storing water than the lower lakes as they experience lower evaporative loss. A reasonable estimate of evaporative losses must be included when undertaking any assessment of proposed management rules for the lakes.

27 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. The proposal for storing 195 GL in Menindee Lakes is based on now outdated minimum daily flow requirements and mean evaporation rates. Recommended increases to minimum daily flow rates would require storing additional water in the upper lakes, unless alternative approaches such as translucent flows were implemented.

28 Latest available advice indicates that the total storage volume in the upper lakes should be reserved for priority needs including for supplying minimum daily flows. However, the capacity of the upper lakes is inadequate for supplying critical needs during some drought conditions. The risk of not being able to supply critical needs to the Lower Darling-Baaka River is higher than the risk in upstream valleys.

Chapter 7: Unregulated River Water Sources

29 The unregulated water sources of the Northern Basin can provide important contributions for connectivity. The cumulative entitlement across NSW unregulated water sources in the Northern Basin is significant (more than 600 GL not including the Barwon-Darling). 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.

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

31 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). There are risks with extraction limits not being enforced in unregulated plan areas, including uncertainty around LTAAEL exceedance and lack of action to address exceedance.

32 There are several limitations and inequities with current rules that impact on connectivity including the extensive use of “no visible flow” rules which are inadequate to protect the water sources and their dependent ecosystems, lack of protection of flows protected in the regulated system that flow through the unregulated system and inequities in access rules between unregulated water sources adjacent to the Barwon-Darling and Barwon-Darling licence holders.

33 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 licences create difficulties for equitably restricting unregulated users to achieve connectivity outcomes.

Chapter 8: Modelling Results and Impacts

34 Modelling results indicate that the Panel’s proposed baseflow and resumption of flow rules combined are likely to largely achieve the expected baseflow, small fresh and large fresh targets the Panel has identified. Proposed rules for the unregulated water sharing plans and floodplain harvesting, which cannot be accurately modelled would further contribute to fully meeting the targets.

35 Modelling results indicate that on average the combined baseflow and resumption of flow rules proposed by the Panel have a less than a four percent impact on diversions across the Northern Basin, with around six percent average impact in the three upper valleys. For comparison, the current rules in the water sharing plans taken from the North-West Flow Plan if implemented would have at least a three percent impact on diversions in the three upper valleys based on modelling using “perfect forecasting”.

Limitations of the Department's surface water modelling

36 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 downstream benefits of rule changes.

37 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

38 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.

39 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.

40 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.

41 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. WaterNSW has indicated that with more experience forecasting will improve.

Chapter 9: Implementation considerations

42 Limitations of forecasting, modelling and available data have led to some previously identified actions for improving connectivity from being implemented, despite evidence of declining ecosystem health.

43 Assumptions in the hydrological models that are input into the economic studies to date are flawed as they do not accurately reflect actual irrigator behaviour and are not undertaken at the most appropriate scale.

44 There is a need for integrated governance at the whole of Northern Basin system 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 inter-valley connectivity within the system as a whole.

Recommendations

Chapter 2: A holistic approach to connectivity 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, including maintaining connectivity objectives, to ensure the overall health and connectivity of the system.

2 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:

- 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.
- Provide for restrictions earlier in dry times to minimise the length of dry periods and support recovery.

Chapter 4: Panel's proposed approach for improving connectivity

3 The Department should implement rules to achieve the targets and triggers in Table i 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 outlined in the relevant LTWP. Baseflows should be achieved through minimum daily flow rules at the end of systems, floodplain harvesting access restrictions when supplementary take is not allowed, and dam releases where necessary to achieve the end of system flows.

b. During dry times – extend the current resumption of flow rules into the Northern Basin tributaries and provide for a small flushing flow following an extended dry period all the way to Menindee Lakes prior to allowing extraction. Baseflow end of system flow targets would remain in place and be met to the extent possible with uncontrolled flows, but dam releases to meet these targets would be suspended.

c. Establish a "connectivity" environmental water allowance in the Gwydir, Namoi and Border Rivers regulated water sharing plans to provide for replenishment flows during dry times to maintain system health and water quality, following additional analysis of volume needs, benefits and impacts.

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

- any water protected through these rules should be protected through to Menindee Lakes.
- once protected flows reach Menindee Lakes the water should be held as an environmental water allowance for use in supplying critical environmental needs for the Lower Darling-Baaka River, or used for translucency flows protected through the Lower Darling-Baaka River.

Chapter 5: Floodplain Harvesting in NSW

5 Rainfall runoff floodplain harvesting should be restricted whenever supplementary access is restricted to ensure equity and to contribute to connectivity flows.

6 Rules for exempt rainfall runoff should be reviewed and the Government should consider allocating a fixed volume for each licence that is exempt so that the rules can be adequately enforced. The Department should also work with landholders to improve their ability to return non-exempt rainfall runoff to the river.

7 The NRC should consider whether "activation triggers" for floodplain harvesting are warranted in their reviews of the water sharing plans.

Chapter 6: Management of Menindee Lakes

8 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.

9 In order to improve risk management for the Lower Darling-Baaka River the Panel recommends:

a. Separating the upper lakes from the shared resource so that all water available can be used to fulfill environmental and priority human needs and managing the upper lakes to keep them as full as possible.

b. Implementing the revised minimum flow rules proposed in Table 13 of this report.

c. Ensuring the Lower Darling environmental water allowance is available at all times, and considering options to allow it to be carried over and/or "topped up" in years when it is depleted

d. Further analysis of whether an additional trigger to "refill" the lakes is necessary.

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

Chapter 7: Unregulated River Water Sources

11 In order to improve equity of rules between plans:

a. Rules for water sources adjacent to the Barwon-Darling River should be subject to similar cease-to-pump rules as the Barwon-Darling, that protect baseflows. Alternatively, the Department should consider whether these water sources should be incorporated into the Barwon-Darling water sharing plan.

b. Align the floodplain harvesting rules in the unregulated and regulated water sharing plans.

12 Improve the distribution and function of the gauging network across the unregulated catchments. The Department should develop a plan for ensuring that any of the water sources identified as high risk for impacting connectivity have adequate gauging to support necessary rules within the next two years.

13 Implement cease-to-pump rules in water sources identified by the Panel as important for contributing to downstream connectivity. This includes establishing cease-to pump conditions using appropriate flow classes based on environmental and basic landholder needs and applying these consistently to licence holders of the same licence type within the same water source or management zone. The rules should be based on flows past specified gauges and ensure a flow equivalent to baseflow at the bottom of the water source to help maintain connectivity through the system. These conditions should replace existing no visible flow and instream pool draw down rules. Issues related to gauge reliability should be considered along with the precautionary principle, prioritising protection of flows that help improve connectivity.

14 The existing hydrological risk assessment approach developed by DCCEEW Water Science team should be reviewed and revised if necessary to fully address connectivity risks and then used to prioritise water sharing plans for rule changes and determine appropriate cease to pump rules.

15 Implement restrictions on extraction in unregulated tributaries that drain directly into the Barwon-Darling whenever there are restrictions in the regulated water sharing plan areas to achieve an annual small fresh or large fresh flow every other year, as outlined in the Panel's recommendations for regulated catchments.

Chapter 8: Modelling Results and Impacts

16 In undertaking any additional modelling to assess final rules the Department should:

a. Use the latest river system models available and include the use of gauged inflow data, particularly where it is considered to be a more accurate representation of system inflows.

b. Undertake additional analysis of the benefits and impacts of forecasting, protection of flows generated through proposed rules, refinement of end of system rules to account for the resource assessment process and evaluate options to improve equity across valleys.

c. Model connectivity EWA options once developed and consider whether small and large fresh rules require modelling.

d. Work with DEECCW-BCS to undertake a more detailed assessment of the achievement of baseflow, small fresh and large fresh EWRs using the EWR assessment tool, including post-processing of model results to account for low flow inaccuracies.

<u>Limitations of the Department's surface water modelling</u>

17 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.

18 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.

<u>Forecasting</u>

19 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.

20 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.

21 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.

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

Chapter 9: Implementation considerations

23 To improve accountability for system-wide connectivity the NSW Government should:

a. ensure there is independent oversight of the further assessment and implementation of any agreed recommendations over the next 18 months to ensure the intent of the recommendations and holistic focus are not lost.

b. In the longer-term, assign a governance body responsible for reviewing the ongoing 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.

c. create a community advisory group including representatives from the Aboriginal community, industry stakeholders from upstream and downstream, and local community groups to advise the longer-term governance body described above regarding on-ground experiences and issues.

24 Assumptions in the hydrological models that are input into the economic studies to date should be reviewed for any future analyses to ensure they reflect actual irrigator behaviour and are at the appropriate scale. The socio-economic analysis should consider the full range of benefits and impacts likely to be experienced and the Department should consider the four levels of analysis recommended in Chapter 9 of this report when designing their socio-economic assessment.

Summary of Panel's connectivity targets and triggers

Table i-a Summary of Panel's recommendations – connectivity targets and triggers for non-dry times

Non- Dry times		
Proposal	**Proposed in-valley targets**	**To meet proposed targets in the Barwon Darling**
Protection of baseflow *Regulated water sharing plans should have an end of system flow requirement to enable baseflow targets in the Barwon-Darling to be achieved during non-dry times. This should be achieved through limitations on supplementary and floodplain harvesting access in the first instance, with releases made from storage if these flows are not adequate.*	▪ Mungindi (416001): 160 ML/d ▪ Walgett - Namoi River at U/S Walgett (419091): 30 ML/d ▪ Collarenebri - Mehi Near Collarenebri (418055): 40 ML/d ▪ Galloway (416052): 25 ML/d	▪ Mungindi (416001): 160 ML/d ▪ Collarenebri - Barwon River at Collarenebri (422003): 280 ML/d ▪ Walgett- Dangar Bridge (422001): 320 ML/d ▪ Bourke (425003): 500 ML/d ▪ Wilcannia (425008): 350 ML/d
Proposal	**Proposed Targets**	**Additional details**
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. Restrictions should apply even if targets will not be fully met.*	▪ Mungindi (416001): 540 ML/d ▪ Collarenebri (422003): 650 ML/d ▪ Walgett (419091): 700 ML/d ▪ Bourke (425003) 1,550 ML/d ▪ Wilcannia (425008): 1,400 ML/d	A minimum of 14 days between September and April every year. (Note this covers both SF1 and SF2 targets in the Barwon-Darling 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 10 days or more it will be considered as met for that period. Restrictions begin at the start of September until the target is achieved, if a small fresh has not been achieved in the previous 12 months.

Protect large freshes *Regulated water sharing plans should include restrictions on supplementary and floodplain harvesting, and B and C class licences in the Barwon-Darling to achieve periodic large fresh flows.*	▪ Mungindi (416001) 3,000 ML/d ▪ Collarenebri (422003): 4,200 ML/d ▪ Walgett (419091): 6,500 ML/d ▪ Bourke (425003): 15,000 ML/d ▪ Wilcannia (425008): 14,000 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 10 days or more, it will be considered as met for that period. Starting in July restrictions begin if a large fresh has not been achieved in the previous 24 months and the operator forecasts that flows are likely to achieve at least 85% of the large fresh targets.

Table i-b Summary of Panel's recommendations – connectivity targets and triggers for transition periods

Transition arrangements	
Proposal	**Description**
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.*	When the inflows to the major dams in the individual tributary drops below the 75th percentile on average over a 30 day period, then releases from dams to achieve end of system flows are suspended in that tributary. Once flows in the Barwon-Darling drop below baseflows, the resumption of flow rule 90 day count would begin. The Panel recommends further sensitivity analysis of the specific trigger.[4] **Note**: There will be a transition period between when releases to achieve the end of system flow rule are suspended and when the resumption of flow rule restrictions are triggered. During this period the end of system minimum flow rule would still apply to uncontrolled flows. This restriction should apply even if the uncontrolled flows will not fully meet the targets as any contribution to flows downstream at this point is very beneficial for the ecosystems.

[4] The Panel based the selection of the trigger on analysis on historic inflows to the dam and a general principle that when inflows to the dam are no longer supporting the end of system flow, then the releases should be suspended. We recommend that the Department consider further sensitivity analysis to maximise achievement of targeted outcomes while minimising impacts.

Table i-c Summary of Panel's recommendations – connectivity targets and triggers for dry times

Dry Times		
Proposal	**Proposed trigger**	**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 forecasted small fresh all the way down the system to ensure flows through to Wilcannia and into Menindee Lakes.* **Note**: The end of system flow rule would still apply to uncontrolled flows during this time but releases from the dam would not be made.	▪ Mungindi: <160 ML/d for 90 days ▪ Collarenebri: <280 ML/d for 90 days ▪ Walgett (Dangar Bridge): <320 ML/d for 90 days ▪ Brewarrina: <550 ML/d for 90 days ▪ Bourke: <500 ML/d for 90 days ▪ Louth: <450 ML/d for 90 days ▪ Wilcannia: <350 ML/d for 90 days	▪ 540 ML/d for 14 consecutive days forecast to be met ▪ 650 ML/d for 14 consecutive days forecast to be met ▪ 700 ML/d for 14 consecutive days forecast to be met ▪ 1,000 ML/d for 14 consecutive days forecast to be met ▪ 1,550 ML/d for 14 consecutive days forecast to be met ▪ 1,500 ML/d for 14 consecutive days forecast to be met ▪ 1,400 ML/d for 14 consecutive days forecast to be met

Table i-d Summary of Panel's recommendations – connectivity targets and triggers for all times

All times	
Proposal	**Description**
Menindee Lakes trigger	Chapter 6 outlines the Panel's recommendations in regard to Menindee Lakes. The Panel recommends that once these recommendations have been implemented, further analysis be undertaken on whether a trigger for refilling upper Menindee Lakes is warranted. Any trigger should be based on addressing the specific risk that is being targeted and supported by analysis of whether the trigger is likely to achieve the intended outcome.

Establish 'Connectivity' environmental water allowance *The Gwydir, Namoi and Border Rivers regulated water sharing plans should include a 'connectivity' EWA to 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.*	<u>Further analysis required:</u> The Panel is of the view that the Connectivity EWA should at a minimum provide for reconnecting pools for critical human water needs, environmental needs and water quality needs during severe dry times. The Department's proposed critical dry condition triggers provide a basis for the flows that would be necessary to achieve this. Given time constraints the Panel was unable to fully investigate this option. Further steps necessary to assess this option are provided in Section 4.5.2. **Note**: The "connectivity" EWA should have the highest security status and therefore take precedence in the dam storage so that it can be used when it's required.
Update rules in unregulated water sharing plans (See Chapter 7 for further details)	<u>For non-dry times</u> ▪ Implement cease to pump rules in unregulated water sources identified as important for contributing to connectivity downstream and align rules in water sources adjacent to the Barwon-Darling with the rules in the Barwon-Darling for consistency and equity. ▪ Implement active management where necessary to protect water that is protected for environmental or connectivity purposes in the regulated system and flows into the unregulated system. ▪ Implement restrictions on unregulated water sources when restrictions are triggered in the regulated water sharing plans by the resumption of flow rule, or to achieve a small or large fresh. <u>For dry times</u> ▪ Unregulated users in plans identified as important for contributing to connectivity downstream should be restricted from accessing water while the resumption of flow rule restrictions are in place.

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Glossary

Act	The *Water Management Act 2000* (NSW)
AC	Anabranch Connection
Barwon Darling	Barwon Darling River
Basin Plan	Murray-Darling Basin Plan 2012
BCS	NSW Biodiversity, Conservation and Science
CEWH	Commonwealth Environmental Water Holder
CGE	Computable General Equilibrium modelling
CSIRO	Commonwealth Scientific and Industrial Research Organisation
d	day
DCCEEW	NSW Department of Climate Change, Energy, the Environment and Water
the Department	NSW Department of Climate Change, Energy, the Environment and Water - Water Group (formerly Department of Planning and Environment – Water)
EOS	End of System
EPA	NSW Environment Protection Agency
EWR	Environmental Watering Requirement
EWA	Environmental Watering Allowance
EWAGs	Environmental Water Advisory Groups
FPH	Floodplain Harvesting
Final Report	Connectivity Expert Panel Final Report
GAMS	General Algebraic Modelling System
GL	Gigalitres
HEW	Held Environmental Water
IDEC	Individual Daily Extraction Components
IGA	Inter-Governmental Agreement
Interim Report	Connectivity Expert Panel Interim Report
LF	Large Fresh

Lower Darling	Lower Darling River
LTAAEL	Long term annual average extraction limit
LTWP	Long-Term Water Plan
MDBA	Murray-Darling Basin Authority
MDB Agreement	Murray-Darling Basin Agreement
ML	Megalitre (unit of volume equivalent to one million (1×10^6) litres
Northern Basin	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.
northern tributaries	The NSW major regulated rivers that contribute to the Barwon-Darling River upstream of Menindee
North-West Flow Plan	Interim Unregulated Flow Management Plan for The North-West
NRAR	The Natural Resources Access Regulator
NRC	The NSW Natural Resources Commission
NSW	New South Wales
OCSE	NSW Office of the Chief Scientist and Engineer
PEW	Planned Environmental Water
Panel	Connectivity Expert Panel
QLD	Queensland
RoF	Resumption of flow
SF	Small Fresh
Yr	year

1 Introduction and background

1.1 About the review

The Connectivity Expert Panel was selected in August 2023 and held their first meeting in September 2023. The Panel was convened 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[5] 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[6] the Minister for Water requested that the Panel expand their Terms of Reference to examine the adequacy of rules in all of the NSW Northern Basin 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]

The Panel submitted the Connectivity Expert Panel Interim Report[8] (interim report) to the Minister on 29 March 2024, which was released publicly on 17 April 2024. This Connectivity Expert Panel Final Report (final report) builds on the initial findings and recommendations from the Interim Report.

1.2 Definitions

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) River 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.

[5] NSW Department of Climate Change, Energy, the Environment and Water.
[6] Office of the NSW Chief Scientist & Engineer (2023) *Independent review into the 2023 fish deaths in the Darling-Baaka River at Menindee.*
[7] NSW Government Water (2024) *Connectivity Expert Panel*.
[8] Connectivity Expert Panel for the NSW Government (2024) *Connectivity Expert Panel Interim Report*.

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.

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*
- *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 "northern tributaries" refers to the NSW major regulated rivers that contribute to the Barwon-Darling River 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.*

1.3 Northern Basin Connectivity

River connectivity is crucial for supporting the ecological heath of river systems and supporting the socio-economic wellbeing of local communities. The Barwon–Darling River plays a critical role in the Murray–Darling Basin, providing the hydrological and ecological link between the Northern and Southern basins.

Recognising the importance of maintaining river connectivity is not a new concept. The value of water is central to First Peoples' being and culture,[9] which includes placing a high priority on having a flowing river and protecting water for communities downstream.[10]

NSW water managers have also recognised this need for decades. In 1992, over 30 years ago, the Interim Unregulated Flow Management Plan for The North-West (North-West Flow Plan) was released, which recognised the need to ensure that upstream rivers are adequately contributing to the health of the Barwon-Darling River (further detail in Chapter 3). [11]

[9] Moggridge, B. J., & Thompson, R. M. (2021) *Cultural value of water and western water management: an Australian Indigenous perspective* Australasian Journal of Water Resources, 25(1), 4–14.
[10] NSW Government – DPE (2022) *Draft Western Regional Water Strategy What we heard.*
[11] Department of Water Resources (1992) *Interim Unregulated Flow Management Plan for the North West.*

Connectivity is important for many reasons:

Connectivity supports communities: by providing flows for domestic and stock, commercial and town water supply purposes. Healthy, flowing rivers provide amenity value, and support the wellbeing of local communities.

Connectivity is inherent in First People's culture: Flowing rivers play a very important role in Aboriginal culture. They are central to community health and wellbeing, food security, cultural education and employment opportunities. The region's rivers are considered classrooms for maintaining the continuity of First Peoples culture, language and knowledge.

A disconnected system poses a major threat to the mental and physical health of First Peoples' communities. Consultation undertaken with Aboriginal communities as part of the Western Regional Water Strategy outlined their concerns 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.[12]

Consultation undertaken with Aboriginal communities as part of the Western Regional Water Strategy also 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:[13]

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

Connectivity is critical for ecosystem function: 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**.** Connectivity is also important for moving nutrients and sediment throughout the river, improving water quality and providing fish passage. The hydrological changes in the Barwon–Darling River system have had an impact on ecological processes and overall resilience of the system.

[12] NSW Government – DPE (2022) *Draft Western Regional Water Strategy What we heard.*
[13] NSW Government – DPE (2022) *Draft Western Regional Water Strategy What we heard.*

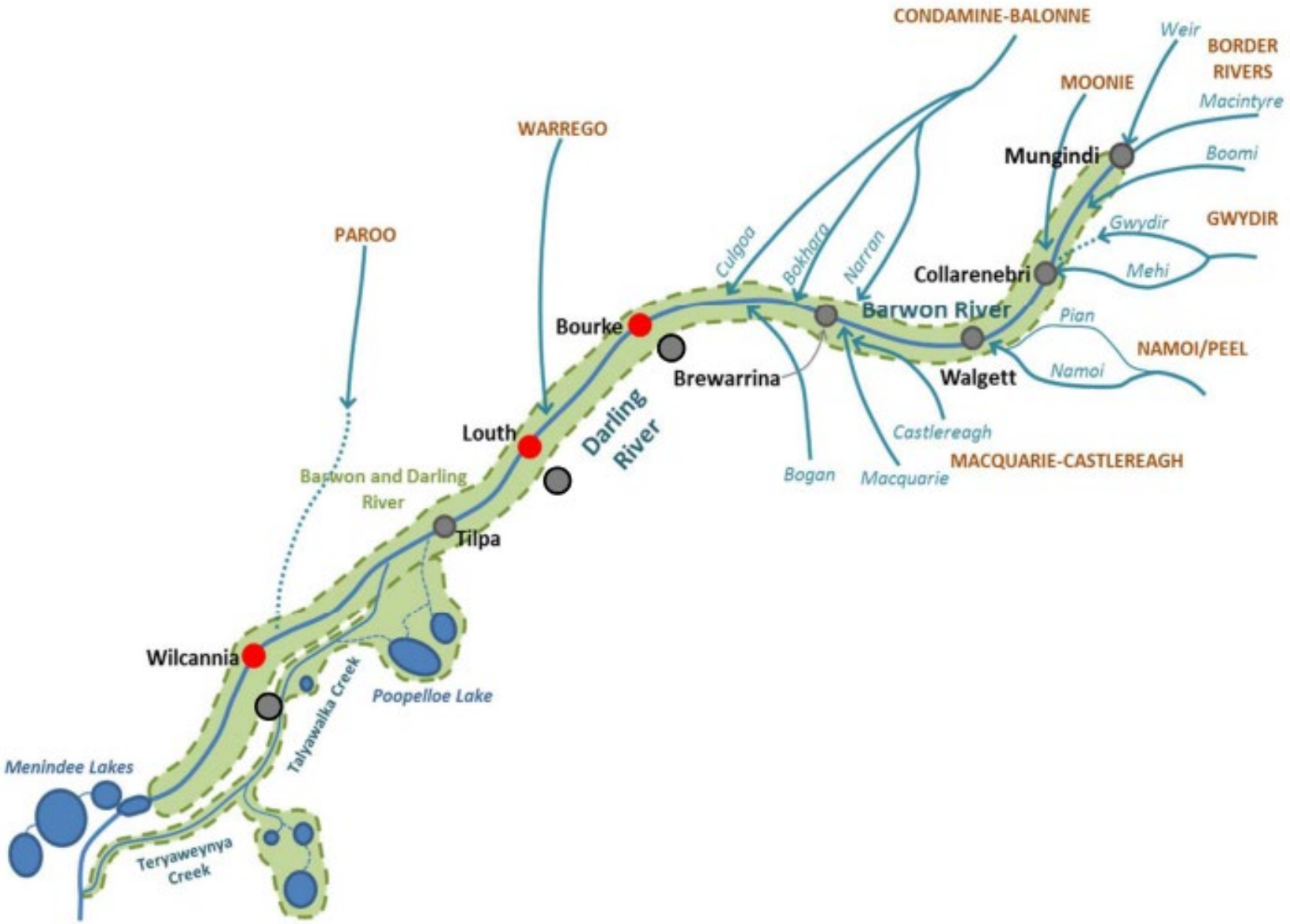

Figure 1 Stylised map of the Barwon-Darling River (Source MDBA)

1.4 Connectivity challenges in the Northern Basin

Understanding the hydrology of the Barwon-Darling River is important for understanding some of the challenges for achieving connectivity, as outlined below.

Highly variable flow regime: the hydrology of the Barwon-Darling River 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 system, flow events can be expected at least once or twice a year, and long periods of no flow are generally the exception.[14]

Over 90 percent[15] of the Barwon-Darling's inflows come from upstream catchments in NSW and QLD: the Barwon-Darling River is fed by both regulated and unregulated upstream catchments. The Panel estimates that around two-thirds of the inflows to the Barwon-Darling River come from the regulated tributaries.

Connectivity of tributaries to the Barwon-Darling system varies: 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.[16] The Paroo and Warrego rivers only reach the Barwon-Darling River after significant rain events in their catchments, contributing relatively infrequent flows downstream and west of Bourke. 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 River. However, they can provide significant volumes, particularly in flood events.[17]

Contribution of unregulated systems: unregulated rivers in the Northern Basin contribute directly and indirectly to flows in the Barwon-Darling River. On average, unregulated rivers across the Northern Basin directly contribute up to one third of the inflows into the Barwon-Darling River.[18] Significant contributing unregulated rivers include the Boomi, Bogan, Castlereagh, Moonie rivers and Thalaba Creek.

Menindee Lakes further complicate the achievement of connectivity between the Northern and Southern Basins: The Menindee Lake Storage system comprises several lakes that fill from inflows from the Northern Basin via the Barwon-Darling River. 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* and the Murray-Darling Basin Agreement.

Additional challenges to connectivity include:

- Water management in the Border Rivers is guided by the Intergovernmental Agreement between Queensland and NSW[19]
- Long travel times for water to reach the Barwon-Darling from its tributaries (weeks to months)

[14] NSW Government – DPIE (2020) *Barwon–Darling Long Term Water Plan Part A.*
[15] Over 90 percent of the inflows into the Barwon-Darling system on average over the long term come from upstream catchments.
[16] NSW Government – DPIE (2020) *Barwon–Darling Long Term Water Plan Part A.*
[17] Natural Resources Commission (2019) *Final report Review of the Water Sharing Plan for the Barwon-Darling Unregulated and Alluvial Water Sources 2012.*
[18] 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.*
[19] NSW and Queensland Governments (2008) New South Wales –Queensland Border Rivers Intergovernmental Agreement 2008

- Large volumetric licences located at the end of the system in some catchments for example, the Bogan River[20]
- Large storage capacity of on-farm storages. Permanent on-farm storage capacity across the NSW Northern Basin is estimated to be around 1,300,000 ML[21] which is just under 30 percent of combined NSW Northern Basin state dam capacity.

1.5 Evidence of reduced connectivity

Flows in the Barwon-Darling River system have changed significantly since European colonisation. There are numerous factors potentially contributing to the reduced flows in the Northern Basin and the Barwon-Darling River, including hydroclimate variability and climate change, catchment modification, irrigation development, floodplain harvesting, changes in river extraction rules, and non-compliance.[22] This has resulted in modifications to how water moves laterally and longitudinally through the system.[23]

Tributary inflows into the Barwon-Darling have reduced: long term average end of system flows in the tributary catchments of the Barwon-Darling River have reduced by 37 percent.[24] Prior to river regulation, the Barwon–Darling River flowed for more than 90 percent of the time and was characterised by short spells of zero flow (generally less than one month).[25]

Annual average flow in the Barwon-Darling has reduced: models of the system without development and current condition scenarios show that flow volumes have reduced by 39 percent at Mungindi, 49 percent at Walgett, 50 percent at Bourke, and 50 percent at Wilcannia[26] These patterns of decrease in mean annual flow volumes are observed across all dry and wet climatic regimes and for the complete flow regime.[27]

Natural variability of river flow has decreased: large headwater impoundments have a significant impact on the rivers which they dam. Most dams are operated to provide controlled releases for extraction downstream, with water orders delivered in a way to minimise conveyance 'losses'. This inhibits the natural variability of river flow.

Higher flows and freshes have reduced: the number of small and large fresh, bankfull and large overbank flow events have reduced in the Barwon-Darling River at Wilcannia and Bourke.[28] 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.[29] A significant change has been a reduction in the magnitude of near-annual flow pulses during droughts, which have been reduced by over 90 percent.[30]

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,

[20] NSW Government (2018) *Risk assessment for the Macquarie– Castlereagh water resource plan area (SW11): Part 1 Schedule D.*
[21] NSW Government (2020) *On-farm storage volumes Tracking water capture in on-farm storages during the North-west flows in 2020.*
[22] Chiew FHS, Weber TR, Aryal SK, Post DA, Vaze J, Zheng H, Peña-Arancibia JL and Robertson DE (2022) *Evaluation of causes of reduced flow in the northern Murray–Darling Basin* CSIRO Technical report for the Murray–Darling Basin Authority.
[23] DPE Water (2022) *Western Regional Water Strategy* – See Page 52.
[24] NSW Government – DPIE (2020) *Barwon–Darling Long Term Water Plan Part A.*
[25] 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.
[26] NSW Government – DPIE (2020) *Barwon–Darling Long Term Water Plan Part A.*
[27] Stocktake of Northern Basin Connectivity Rules – Analysis of implementation and effectiveness Barma Water Resources 2019.
[28] DPE Water (2022) *Western Regional Water Strategy* – See Figure 21 and 22.
[29] DPE Water (2022) *Western Regional Water Strategy* – See page 59.
[30] 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.

and duration of floods.[31] The NSW Government is implementing the Floodplain Harvesting Policy[32] 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. See Chapter 5 for further discussion of floodplain harvesting.

A comparison of hydrographs in Figure 2 of the pre-development model (blue line) to observed flows (red line) 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 observed flows hydrograph is significantly flatter, particularly in the smaller pulses.

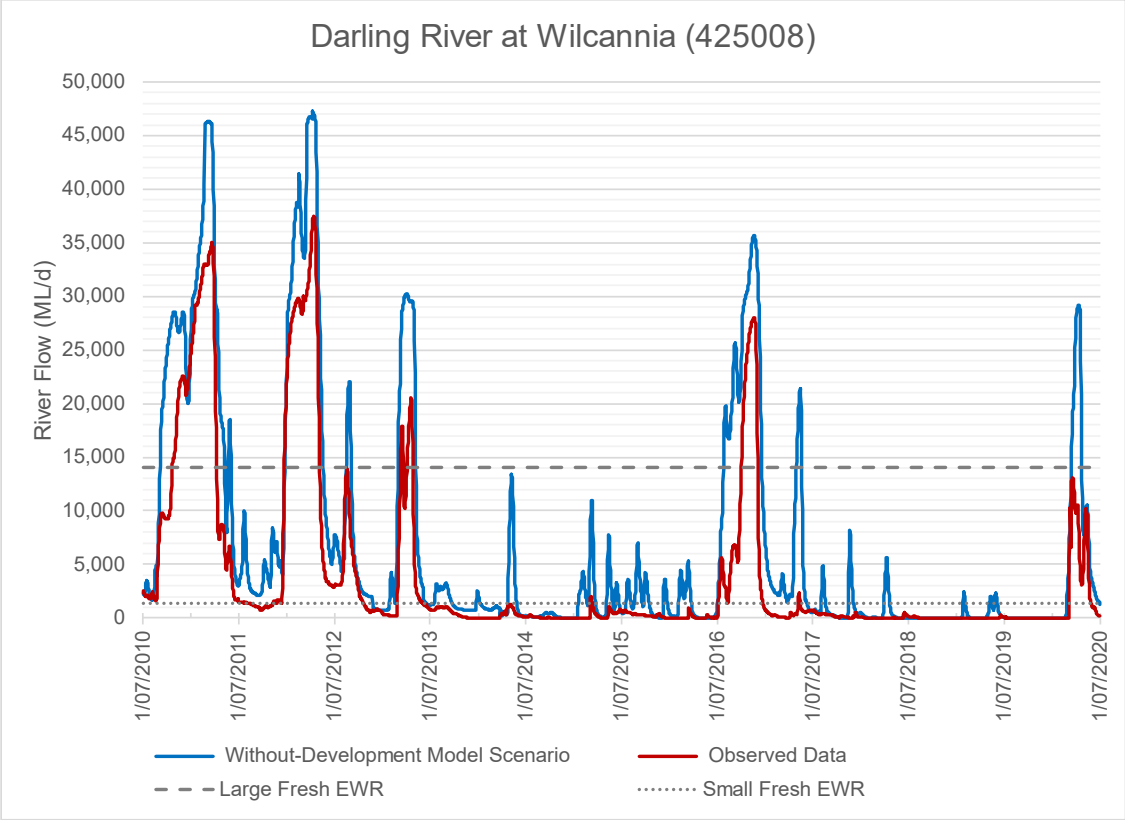

Figure 2 Flow in the Darling River at Wilcannia – modelled without development compared to observed flows from 2010 to 2020[33]

Cease-to-flow events (0-1 month) and low flow conditions have increased: development has likely increased the frequency of shorter cease-to-flow periods (0–1 month) and low-flow periods in the Barwon–Darling River.[34] In some instances, low flows have increased by up to 50 percent.[35] Although low flow and cease to flow periods form an essential part of the natural flow regime, changes in the timing and magnitude of these events are having a significant effect on ecosystem resilience and environmental outcomes such as water quality, species habitat and refugia.[36]

[31] DPE Water (2022) *Western Regional Water Strategy* – See page 54.
[32] NSW Government (2013) *NSW Floodplain Harvesting Policy*
[33] Without-Development data sourced from NSW Government *Water Modelling-Modelled Data-Without Development-Barwon-Darling*; Observed flow data sourced from Water NSW *Water Insights: Barwon Darling Unregulated River Data.*
[34] DPE Water (2022) *Western Regional Water Strategy* – See page 59.
[35] DPE Water (2022) *Western Regional Water Strategy* – See page 59.
[36] NSW Natural Resources Commission (2019) *Review of the Water Sharing Plan for the Barwon-Darling Unregulated and Alluvial Water Sources – final report*.

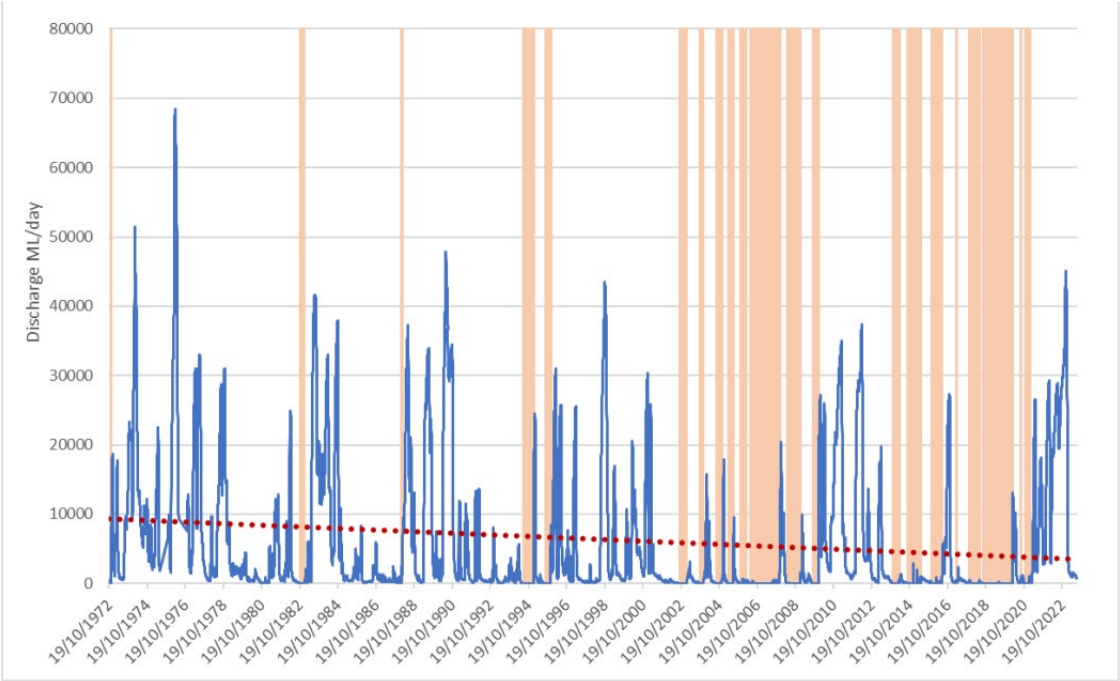

Figure 3 Historical flow (1972 to present) in the Lower Darling-Baaka River at Wilcannia (upstream of Menindee Lakes) (blue line), showing mean value over time (dotted red line) and periods of cease to flow and very low flow (<20 ML/day, orange vertical bars)[37]

Box 2 summarises the findings from the 2022 CSIRO report, which examined the causes of reduced flow in the Northern Basin.

Box 2 - Evaluation of causes of reduced flow in the northern Murray-Darling Basin[38] – CSIRO, 2022

The study was initiated by the Murray-Darling Basin Authority and aims to explain the causes of reduced flow in the Northern Basin. The project was undertaken by synthesising knowledge from previous reviews and technical reports and enhanced with data analysis.

Key findings:

- Rainfall and streamflow in the past 50 years of living memory have declined. There have been similar long dry periods in the past.
- The impact of water resource development is accentuated in dry periods.

In relation to the Barwon- Darling River:

- Modelling indicated that historical water resource development has reduced the flow volumes in the Barwon-Darling River by 40-50 percent compared to without-development conditions. It has also increased the frequency of low flow events.
- Short and medium low flow periods (<6 months) are influenced by climate and development, and longer low flow periods (>1 year) are largely caused by climate – prolonged dry period over the region.
- Analyses of modelled and observed data indicates that the reduced streamflow experienced over 2001–2019, relative to the wetter 1950–2000 period, can be attributed roughly equally to climate variability and to historical water resource development.

[37] Office of the NSW Chief Scientist & Engineer (2023) *Independent review into the 2023 fish deaths in the Darling-Baaka River at Menindee.*

[38] Chiew FHS, Weber TR, Aryal SK, Post DA, Vaze J, Zheng H, Peña-Arancibia JL and Robertson DE (2022) *Evaluation of causes of reduced flow in the northern Murray–Darling Basin*. CSIRO Technical report for the Murray–Darling Basin Authority.

1.6 Previous findings regarding connectivity

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[39, 40] and associated changes in water chemistry, algal blooms and river ecology.[41] They also outline the decline in populations of ecologically and culturally important species such as native fish populations and freshwater mussels and the introduction of pest species like carp.[42]

Box 3 – Previous reports and strategies 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[43]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):[44] examined the water sharing rules that potentially contribute to connectivity between the Barwon–Darling River and its NSW tributaries. This analysis recognised the importance of focusing on inter-valley 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):[45] The Department 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-Class and C-Class licences could have had. The report recommended revised riparian, algal suppression and fish migration targets.

Water sharing plan reviews:[46] 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, which included 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

[39] 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.
[40] 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.
[41] Thoms, M. C. and Delong, M. (2018) *Ecosystem responses to water resource developments in a large dryland river.* Water Resources Research 54, 6643–6655.
[42] Sheldon, F. and McCasker, N. (2020) *Habitat and flow requirements of freshwater mussels in the northern Murray-Darling Basin.*
[43] NSW Government (2021) *NSW Water Strategy*.
[44] Barma Water Resources (2019) *Stocktake of Northern Basin connectivity rules – analysis of implementation and effectiveness.*
[45] Alluvium Consulting (2021) *Review of the Interim Unregulated Flow Management Plan for the North West*
[46] NSW Natural Resources Commission (2019) *Review of the Water Sharing Plan for the Barwon-Darling Unregulated and Alluvial Water Sources – final report*.

on usage and limited gauging stations in these systems. These reviews 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 into fish deaths: these reviews span the mass fish deaths that occurred in the Lower Darling-Baaka over 2004,[47] 2018-19 (Australian Academy of Science[48] and Vertessy reviews)[49, 50] and the 2023 Office of NSW Chief Scientist and Engineer review.[51] 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 River system to avoid catastrophic decline of river condition through dry periods.

The Vertessy review emphasised the impact of the fragmented approach to water management in NSW and how that affects inflows to Menindee Lakes. It outlined that water use in the Barwon-Darling River tributaries had a greater impact on Menindee Lakes inflows compared to extraction along the Barwon–Darling River 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 the Southern Basin. It also recommended prioritisation of changes to Northern Basin water sharing plans to support system scale outcomes.

1.6.1 Climate change could exacerbate connectivity impacts

Climate change analysis completed as part of the Western Regional Water Strategy outlined that under a dry 'worst case' climate change scenario the following could occur:

- **more times when the tributary valleys do not connect with the Barwon-Darling**: median annual NSW and QLD inflows could be 42 percent lower when compared to long-term historical projections.[52]
- **reduction in the number and duration of high-flow events and freshes:** on average, a 37 percent reduction in the number of high-flow events that fill the banks, a 33 percent decrease in the number of freshes occurring every year, and a 19 percent decline in the duration of these freshes flows when they do occur.[53]
- **large increase in the number of years in which a cease-to-flow event occurs**[54]
- **minimum inflows into the Barwon- Darling could be worse than experienced over the 2017-2020 drought**: there could be no inflows into Menindee Lakes for 3 years.[55]

[47] 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*.
[48] 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.
[49] 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*.
[50] 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.
[51] Office of NSW Chief Scientist and Engineer (2023) *Independent review into the 2023 mass fish deaths in the Darling-Baaka River at Menindee.*
[52] DPE Water (2022) *Western Regional Water Strategy* – See page 60.
[53] DPE Water (2022) *Western Regional Water Strategy* – See page 56.
[54] DPE Water (2022) *Western Regional Water Strategy* – See page 56.
[55] DPE Water (2022) *Western Regional Water Strategy* – See page 36.

1.7 Future areas for consideration

The following important issues related to connectivity have not been fully considered by the Panel in this review:

- **Groundwater connectivity:** surface water connectivity can also be impacted by groundwater use in the Northern Basin and further consideration is needed of complementary connectivity rules that should apply to water sharing plans that cover interconnected groundwater systems.
- **Latitudinal floodplain connectivity**: latitudinal connectivity to the adjacent floodplains is another important connectivity outcome that requires further research and model development, in addition to the work already being undertaken by the NSW Government in the Northern Basin[56].
- **Climate change risks:** the potential impact of climate change on water resources in the Northern Basin and associated adaptation strategies to manage these risks (including water management responses related to connectivity) is another area that requires further research and model development. The Panel understands the Department has considerable work going on in this area, which should improve understanding of these risks going forward.

The above issues should be considered further by the Department, once the fundamental issues associated with longitudinal connectivity are addressed and the understanding of climate change risks in the Northern Basin (and associated adaptation strategies) has advanced.

1.8 Summary

The Panel is of the view that the evidence is unequivocal that reduced connectivity in the Northern Basin is having negative impacts on downstream ecosystems and communities. Further, the evidence is clear that a significant portion of this impact is due to rules for sharing water upstream. The following chapters outline the Panel's proposed approach for addressing the current deficiencies in upstream rules to improve outcomes across the NSW Northern Basin.

[56] NSW Government Improving floodplain connections program and Environmental Outcomes Monitoring and Research Program – Floodplain connectivity and inundation

2 A holistic approach to connectivity is needed

Considering the system holistically is fundamental for achieving connectivity outcomes. This systems thinking approach to river management is not new, traditional ecological knowledge is strongly rooted in this sentiment and should be foundational to how we address connectivity across the Northern Basin. Caring for Country means there is a cultural obligation to get water to communities downstream. The Panel has examined the various drivers and barriers for connectivity in the Northern Basin under different climatic conditions and recognise there is a need to address these equitably and consistently across water sources.

To understand what the system needs holistically, the Panel has reviewed the fundamental ecological needs of the system. These needs should be met by rules in relevant water sharing plans, consistent with Section 5(3) of the *Water Management Act 2000*, which requires that in regard to water sharing water sources and their ecosystems must be given priority over other uses.

It is important to note that part of examining the system holistically should ultimately involve consideration of various types of connectivity. As outlined in Chapter 1, the Panel has confined our review to consideration of longitudinal surface water connectivity. Connectivity between groundwater and surface water can also have significant impacts on connectivity. For example, where there is a strong connection between the two, such as in the Namoi valley, depletion of groundwater may impact on surface water levels. The Panel encourages further consideration of groundwater-surface water interactions and how these influence surface water connectivity, noting that these interactions are likely to vary in space and time.

2.1 Key Findings

A holistic approach to connectivity 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 at the system scale.

2 The Panel agreed on ten principles we feel should be followed for the assessment of options and the development of proposed rules and targets to achieve connectivity outcomes. These principles fall into three categories

- Rules need to adhere to the legislation, be clear and implementable
- Rules should be proactive to maintain fundamental ecosystem functions and improve whole-of-system resilience
- Rules need to provide for equitable sharing of water

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 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 rate, 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. Specifically, a subset of baseflow, small fresh and large fresh (considered ecosystem 'maintenance flows') environmental water requirements are necessary to provide for critical needs for maintaining ecosystem health through 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, but improvements are still possible.

2.2 Panel's guiding principles

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

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

1 Rules should adhere to the priorities outlined in the water sharing principles specified in the Act.[57]

2 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 minimise any negative impacts.

3 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.

4 Rules must be implementable. If flow forecasting is not appropriate, possible or too uncertain, then prescriptive rules are needed until such time as forecasting improves.

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

5 Rules should seek to maintain water within the system more often and keep it 'wetter.'

6 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.

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

Rules need to provide for equitable sharing of water

7 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.

8 Rules should provide for restrictions that seek to equitably distribute any impacts to extractive use between users.

9 Rules should be set such that low priority usage upstream should not be allowed when it will impact on baseflows downstream.

10 Rules should seek to achieve targets in a way which minimises impacts on extractive users.

2.3 Challenges for a holistic approach

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 area 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 percent of inflows provided from Northern Basin catchments, the Barwon-Darling River 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 River 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.

2.3.1 Previous steps to improve connectivity have been piecemeal

Some steps have been taken to embed connectivity requirements into the NSW Northern Basin water sharing plans (Box 4). For example, the Western Regional Water Strategy outlined further steps that should be taken to assess proposed rules and opportunities to further enhance connectivity. This expert Panel was convened as the next step in the process, consistent with the water sharing plan clauses.

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 of 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 better able to withstand the variability in inflows that are prevalent in the Northern Basin system.

Box 4 – 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 the Barwon-Darling water sharing plan: 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) in the Barwon-Darling water sharing plan: 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 to the Barwon-Darling water sharing plan area.

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 195 GL. 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 in certain water sources.

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 Darling Basin Plan,[58] 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

[58] 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 an expert panel as this plan has not been amended yet.

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.

2.4 Current connectivity focus is predominantly on recovering from drought

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. 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.[59] It also recognises that improving connectivity during non-drought times may help to build resilience to future extended dry periods.[60] However, despite the evidence included in the Strategy, the proposed actions did not adequately 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 more natural levels of connectivity is likely to be more effective and efficient.

The Panel was asked to consider what flow targets are needed to ensure that the 'critical needs' of the environment, basic landholder rights 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.

2.4.1 Critical ecological needs of the Barwon-Darling System

The health of river systems depends on there being a range of flows. Connectivity is important to fulfill different purposes during all times:[61]

- 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

[59] DPE Water (2022) *Western Regional Water Strategy* – See page 59.
[60] DPE Water (2022) *Western Regional Water Strategy* – See page 58.
[61] DPE Water (2022) *Western Regional Water Strategy* – See Page 57.

- in extreme droughts connectivity helps to avoid irretrievable damage to species, ecological communities and ecosystems.

The NSW Long Term Water Plans identify environmental water needs to achieve various outcomes. They outline how different flow categories contribute to the health of the river and connectivity (see Figure 4 and Table 1).

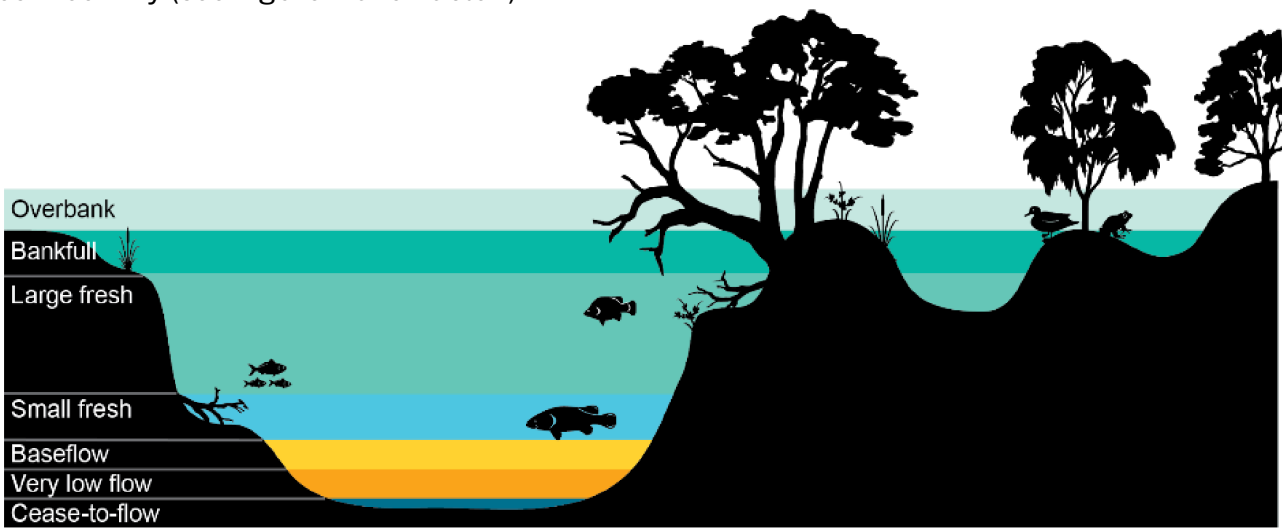

Figure 4. A simplified conceptual model of the role of each flow category[62]

Table 1 Description of the role of each flow category[63]

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.

[62] NSW Government – DPIE (2020) Barwon–Darling Long Term Water Plan Part A.
[63] NSW Government – DPIE (2020) Barwon–Darling Long Term Water Plan Part A.

2.4.2 Department definition of "critical needs" focused on critically dry times

Work undertaken to date by the Department on 'critical needs' assessments has focused on meeting needs during 'critical dry periods.' The *Western Regional Water Strategy* supporting documents[64] 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 focused the analysis on critical human water 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 water needs are the first priority and the environment the second. Whereas, outside these extreme events, the priority is providing water for the environment.[65]

The Panel notes that our understanding is that the 'flipping' of priorities (where human needs take precedence over the environment) 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 reversed, the environment is still the second highest priority and warrants greater consideration. The Panel also notes that this section only relates to the priorities for available water determinations.

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 connectivity analysis undertaken to date as part of the Western Regional Water Strategy has focused on 'critical dry condition triggers' (See Appendix B). These triggers focus 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. Plans typically refer to this as "uncontrolled flow". 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 8.4) make it difficult to assess the 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 rainfall. 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).[66] 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'.

[64] 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.*
[65] DPE Water (2022) *Western Regional Water Strategy* – See page 11.
[66] DPE Water (2022) *Western Regional Water Strategy* – See page 59.

2.5 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.[67], [68] 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. The Department's proposed targets do not address this range of needs.

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.

2.5.1 Benefits of maintaining a "wet" system

There will continue to be extended dry periods, and restoring flows after these periods is important. Work has been completed by the Department to address this. The Panel has additionally focused on what can be done to address the increase in the frequency and duration of short cease-to-flow and low flow events to ensure critical ecosystem functions are achieved under a range of climatic conditions.

In the context of more frequent and extended cease-to-flow events in recent years and of future climate change, there are significant benefits of keeping the system "wetter" more frequently and for longer periods. 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, the more water is soaked up as it flows down the system. The water needed to replenish waterholes and for seepage is much greater if a river has ceased to flow and there are dry antecedent conditions, when compared to when it is still flowing[69].

Keeping the system wetter 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 only on permanent "pools" in an otherwise dry system.

This was demonstrated anecdotally by the 2018 Northern Connectivity Event where the Commonwealth released significant water following an extended dry period, but just after the system had been "wetted up" by an unregulated flow event from rainfall in southern

[67] Sheldon F et al. (2024) *Are environmental water requirements being met in the Murray–Darling Basin, Australia?* Marine and Freshwater Research 75, MF23172. doi:10.1071/MF23172
[68] Wentworth Group of Concerned Scientists (2023) *Are Murray-Darling Basin rivers getting the water they need to stay healthy?*
[69] Department of Agriculture, Water and the Environment (2020) *Final Report on the Northern Connectivity Event (April – July 2018).*

Queensland that flowed to just downstream of Wilcannia earlier in 2018.[70]They achieved significantly more flow downstream, more quickly 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.

Box 5 – Why keep the system wet more often?

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 earlier intervention and additional targets that are focused on ensuring that when water is available in the system, an adequate portion is provided for downstream connectivity and to try to extend the periods where there is water in the system. For example, 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.

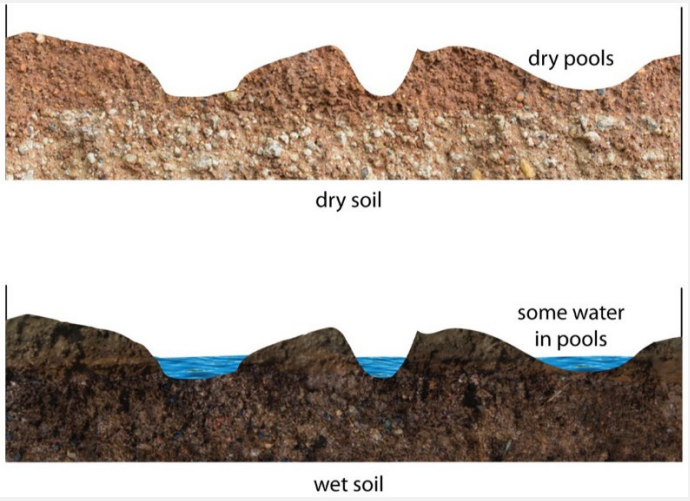

Figure 5. Conceptual figure showing the riverbed acts like a "sponge"

Flows coming down the river bed in the top image would first rewet the system, filling the cracks and pores and pools along the way. Significantly more water would be needed to deliver water downstream in this scenario than if the system is kept wetter – as shown in the lower image.

The impact of the extraction of flows in the tributary rivers on flows in the Barwon-Darling River is conceptualised in Figure 6. 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 demonstrates the important role the end of system wetland complexes play as sponges that absorb water and allow future flows to pass further down the system.

[70] Department of Agriculture, Water and the Environment (2020) *Final Report on the Northern Connectivity Event (April – July 2018).*

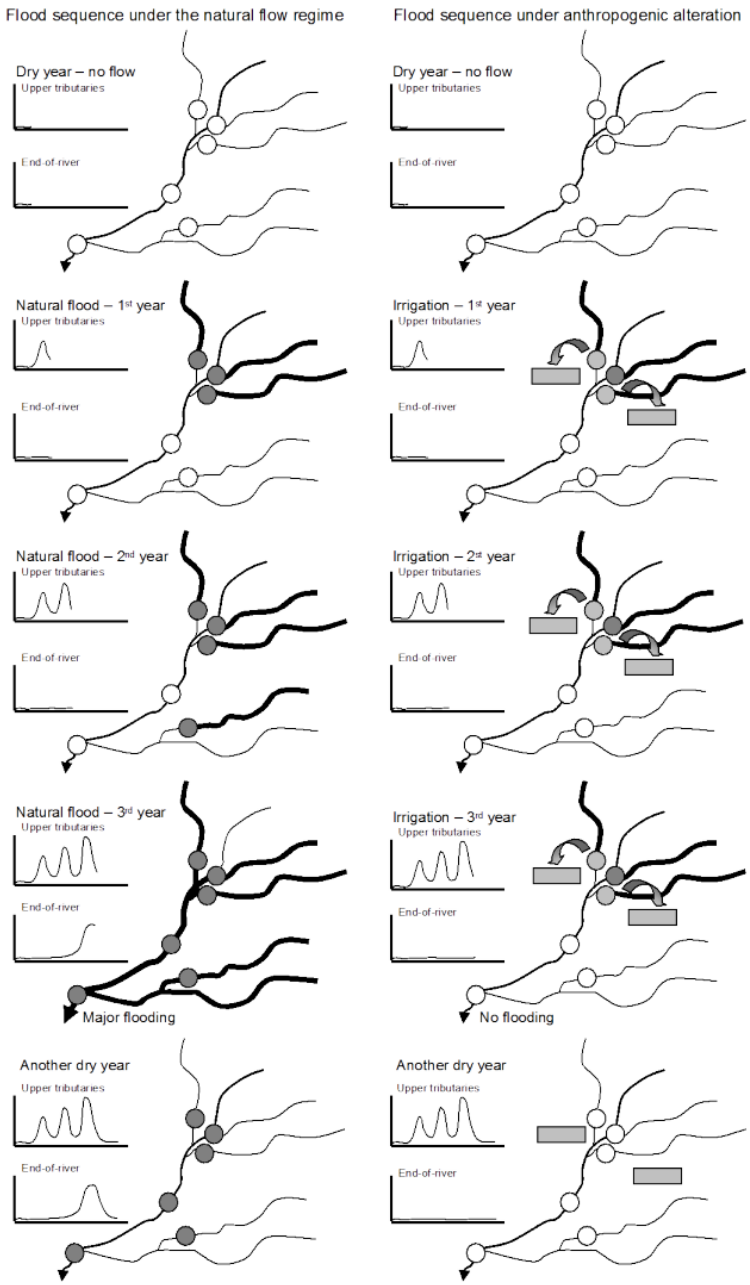

Figure 6 Sequential flooding: conceptual diagram for major tributaries, rivers and wetlands complexes (represented by circles) of a large river system e.g. Murray–Darling Basin (not to scale)[71].

Sequence 1 –Flood sequence under the natural flow regime (left panel from top to bottom): Illustrates a 5-year flow sequence that starts with a dry year, followed by three floods and then another dry year. The flows occur under natural (anthropogenically unmodified) flow conditions, where floodplain and terminal wetlands (closed circles) are progressively wetted and filled from uplands to lowlands (thicker black lines). As the diagram demonstrates, under the natural flow regime the connectivity along channels and between wetlands contributes to flows passing through the system more efficiently resulting in large floods in the third flood year, followed by a year of receding in-channel water levels but sustained aquatic habitat in the wetland refugia. Sequence 2 – Flood sequence under anthropogenic alteration (right panel from top to bottom): Illustrates the same flow sequence. under an irrigation scenario: In this scenario channels and wetlands below storages are filled during the first flood year, but water is removed from channels for irrigation (closed rectangles) so that lower channels and wetlands are not wetted and do not fill and the frequency and duration of flooding of the river system does not eventuate, even after three consecutive years of upland flooding.

[71] 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.

2.5.2 '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).[72] 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.*'[73]

The LTWPs identify a wide range of environmental water requirements for the Barwon-Darling River system and its tributaries. These requirements reflect the hydrological flow regime required to support biodiversity, ecosystem services, some recreational activities, and cultural and spiritual values that depend on healthy aquatic ecosystems.[74]

The Environmental Watering Requirements (EWRs) provide a mechanism for linking flow regimes with environmental outcomes where the flow regimes are based on all water passing a flow gauge in a river, not just what is characterised as 'environmental water' in water sharing plans.[75]

An EWR describes the characteristics of a flow event that are required for that event to achieve identified environmental and ecological outcomes. These include characteristics such as:

- Flow discharge
- Timing
- Duration
- Frequency
- Maximum inter-event period (the longest allowable time period between flow events before a significant decline in the condition, survival, or viability of a specific population is likely to occur).[76]

'Ecosystem Function' Environmental Water Requirements

The Panel has focused on the LTWP's 'Ecosystem Function' EWRs to guide what would be required to meet the critical ecological needs of the system. Collectively, these objectives require variable flows, with periods of low flows alongside a range of flooding flows to maintain ecosystem functions.[77]

Within the 'Ecosystem Function' objectives, the Panel has determined that a sub-set of baseflow, small fresh and large fresh ecosystem function EWRs are necessary to provide what the Panel has identified as critical needs for maintaining ecosystem health through connectivity. See Table 1 for definitions of these flow types.

[72] NSW Government – DPIE (2020) *Barwon–Darling Long Term Water Plan Part A.*
[73] NSW Government – DPIE (2020) *Barwon–Darling Long Term Water Plan Part A.*
[74] Sheldon F et al. (2024) *Are environmental water requirements being met in the Murray–Darling Basin, Australia?* Marine and Freshwater Research 75, MF23172. doi:10.1071/MF23172
[75] ibid
[76] NSW Government – DPIE (2020) *Barwon–Darling Long Term Water Plan Part A.*
[77] NSW Government – DPIE (2020) *Barwon–Darling Long Term Water Plan Part A.*

The definitions for the baseflow, small fresh and large fresh flow categories correlate most closely with the Panel's objective to maintain adequate longitudinal connectivity within the Northern Basin. They fulfill the "ecosystem function" environmental water requirements, which are meant to provide for basic ecosystem function and health of the system including adequate connectivity.[78] More broadly they aim to provide for drought refugia, quality in-stream habitat, movement and dispersal opportunities for aquatic biota (i.e. fish passage), in-stream and floodplain productivity, sediment, carbon and nutrient exchange, and inter-catchment flow contributions.

The Panel views these requirements as the critical connectivity needs of the environment. Ecosystem health and the resilience of the system will continue to decline if these flow requirements not adequately met.

The baseflow, small and large fresh environmental water requirements do not need to be met 100 percent of the time. They each have specific characteristics that need to be met (flow rate, timing, duration, frequency and maximum inter-event period). For example, baseflows are required most of the time, and small and large freshes required periodically – generally at least once every year or two.

2.5.3 Importance of ecosystem maintenance flows

Large freshes, small freshes, baseflows and very low flows are all considered 'ecosystem maintenance flows.'[79] They are essential to keep the ecosystem in a resilient state with healthy flora and fauna populations. In order for ecosystems to maintain health and resilience, periodic "pulses" of small and large flow are important. These pulses are necessary for maintaining movement of nutrients and clearing out of debris, the condition of fish and bird habitat, fish spawning and migration and for maintaining water quality. Maintenance flows must be protected to ensure that the river system can benefit from larger flows that provide for ecosystem productivity (bankfull and overbank flows). The ecological benefits achieved at various flows depends on the interplay between the current flow pulse, recent flow conditions and longer-term climatic cycles. For example, a flow pulse after an extended cease-to-flow period will deliver a different ecological response to a pulse that occurs after a series of flow pulses.[80]

To provide some perspective about what the environmental flow requirements look like, Figure 7 shows the Darling-Baaka River near Wilcannia with a flow of around 1,000 ML/day. For context, baseflow would be about one third of this at 350 ML/day. The flow shown is closer to a small fresh (1,400 ML/day).

[78] NSW Government – DPIE (2020) *Barwon–Darling Long Term Water Plan Part A* – See Page 26.
[79] Sheldon, F. (2017) *Characterising the ecological effects of changes in the 'low-flow hydrology' of the Barwon-Darling River* advice to the Commonwealth Environmental Water Holder Office.
[80] NSW Natural Resources Commission (2019) *Review of the Water Sharing Plan for the Barwon-Darling Unregulated and Alluvial Water Sources – final report*.

Figure 7 Darling River at Wilcannia showing a flow of approximately 1000ML/day. For context, baseflow would be about one third of this at 350 ML/day. The flow shown is closer to a small fresh (1,400 ML/day).

Baseflows

Baseflows can stop the river from drying up by providing the minimum connection of waterholes and allowing some movement of native fish and other animals. These flows can also sustain native plants such as river redgums.

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 River 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.[81] Feedback from Aboriginal stakeholders also indicates that these flows are extremely important culturally.

Very low and cease to flow periods are a normal component of the Barwon-Darling River flow regime. Due to the intermittency of the Barwon-Darling River, a constant baseflow is not consistent with the natural flow regime. However, as periods of cease-to-flow or low flows increase, environmental conditions decline.[82]

[81] 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.

[82] NSW Natural Resources Commission (2019) *Review of the Water Sharing Plan for the Barwon-Darling Unregulated and Alluvial Water Sources – final report*.

Small freshes

Small freshes are flows that connect the river, allowing fish and other species to move longitudinally and improve water quality. 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 – which is 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.[83] 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.[84] 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 be expected to meet the algal suppression requirement outlined in the North-West Flow Plan during these times.

Large freshes

Large freshes are river flows that reach higher up on the riverbank. These flows stimulate some native fish species to migrate and spawn and improve water quality.[85] 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.[86] In many reaches large freshes can breach the sills on localised 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.

Box 6 – What does this mean for the Panel's proposed targets?

The Panel views the environmental water requirements in the Long-Term Water Plans as robust and credible. They represent the best available information on the fundamental connectivity needs of the ecosystems.

It is important to note that the Panel is not recommending that *all* environmental water requirements need to be met to satisfy critical needs. Rather we have focused on a sub-set of requirements that we feel are essential to be met to achieve greater connectivity and therefore help to maintain the fundamental health of the system and ensure basic landholder rights are met.

Given the extensive evidence of the decline of the ecosystem health in the Barwon-Darling River, the Panel views that to meet the Act requirement: *'the sharing of water from a water source must protect the water source and its dependent ecosystems'*[87] at a minimum, targets should seek to restore baseflows, small freshes and large freshes.

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.

[83] 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.
[84] 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.
[85] Sheldon F et al. (2024) *Are environmental water requirements being met in the Murray–Darling Basin, Australia?* Marine and Freshwater Research 75, MF23172. doi:10.1071/MF23172
[86] 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.
[87] *Water Management Act 2000* Section 5(3).

2.6 Recommendations

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, including maintaining connectivity objectives, to ensure the overall health and connectivity of the system.

2 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:

- 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.
- Provide for restrictions earlier in dry times to minimise the length of dry periods and support recovery.

3 Available tools for improving connectivity

Water sharing plans include a range of rules that have the potential to contribute to downstream connectivity. However, most of these rules are not specifically designed to achieve downstream outcomes, such as providing specified volumes of water to downstream systems. Instead, their focus is on in-valley outcomes and providing connectivity through the valley. The exception to this is the North-West Flow Plan rules, which were incorporated into the water sharing plans[88] when they commenced in the 2000s. The rules within the North-West Flow Plan are specifically focused on achieving downstream flows along the Barwon-Darling River. However, as discussed in the section below, despite the rules being established in the water sharing plans, they have generally not been implemented. In their absence, there are no rules specifically designed to ensure the downstream needs of the Barwon-Darling River are adequately provided for.

This does not mean that downstream needs in the Barwon-Darling River are never met, rather the currently implemented rules are not designed to ensure that they are met. Therefore, there are opportunities to improve the achievement of downstream flow targets necessary to maintain ecosystem health.

3.1 Key Findings

Supplementary rules and the North-West Flow Plan

9 Supplementary access rules (other than targets from the North-West Flow Plan) were not, designed to protect downstream needs. North-West Flow Plan targets, which were originally developed in 1992 were maintained as these were recognised as necessary in addition to other supplementary rules to protect flows for downstream needs. The targets from the North-West Flow Plan have not been routinely implemented.

10 While the targets in the North-West Flow Plan are often met without restrictions being implemented they are not always met when there is sufficient supplementary water available that could meet them. Supplementary access is impacting on baseflows, small freshes and large freshes downstream at certain times, generally when there are small to medium flows.

Importance of riparian targets

11 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.

12 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.

[88] Incorporated into the regulated water sharing plans for the Border Rivers, Gwydir and Namoi. Included as a note in the unregulated Barwon-Darling water sharing plan.

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

The Panel considered the range of water sharing plan rules that have the potential to support connectivity consistent with the Panel's Terms of Reference. Table 2 outlines the rules the Panel identified and provides comments regarding their current limitations for supporting downstream connectivity. Appendix C includes the relevant specific rules from each of the northern tributary water sharing plan.

The Panel also acknowledges that there is also a considerable amount of held environmental water that is owned by the Commonwealth Environmental Water Holder (CEWH). Each year the CEWH considers and plans for how they will manage their environmental water. Broadly, the CEWH can either use, trade, or carryover their annual water allocations, under the same rules that apply to all water users. NSW does not control how CEWH chooses to use this water. The Panel understands that the intent behind the majority of the CEWH purchases was to enhance in-valley outcomes. While the Panel has considered where it might be beneficial to work with the CEWH to achieve targets, we have focused on what can be achieved through rules in NSW water sharing plans.

The NSW Government also holds Held Environmental Water[89] licences in the Gwydir and Macquarie catchments. NSW Held Environmental Water can be used to improve connectivity outcomes, but it was primarily purchased for in-valley outcomes. NSW environmental water managers collaborate closely with the Commonwealth to both plan and deliver environmental water events in the NSW Northern Basin.

The *NSW Water Management Act 2000* requires that sharing of water must protect the water source and its dependent ecosystems and basic landholder rights. The Panel is of the view that the water sharing plans are meant to provide adequate water for maintaining river ecosystem health, including for downstream needs, independent of Commonwealth held environmental water. Commonwealth held water is to our understanding meant to provide for additionality on top of basic protections provided for by NSW water sharing plan rules.

Table 2 Rules in Water Sharing Plans that could support 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 decline under future climate change scenarios, less and less water for the environment may be available under this rule. Further, as a large portion of 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

[89] Environmental water, also termed water for the environment, comprises both "planned" and "held" environmental water:
Planned environmental water is water that is provided through rules in water sharing plans (surface and groundwater). Examples include cease-to-pump rules in unregulated water sharing plans and environmental water allowances in regulated river water sharing plans.
Held environmental water is licenced water that is committed for environmental purposes. It may be a statutory or non-statutory commitment. Held environmental water can be recovered via a range of measures e.g. savings from water infrastructure projects, water recovery programs and purchasing of water on the market. Both the NSW and Commonwealth governments are holders of environmental water licences.

Type of Rules	Comments
	'efficient' delivery of water for in-valley use. 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 rules	These rules apply to regulated water sharing plans and require a minimum flow to be released 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 of Plan areas. These flows are not protected beyond the reference point or end of the Plan area. These are often referred to as 'end of system' flow rules – which are minimum flow rules that target a flow at the gauge closest to the end of system. Minimum flow rules at the end of system provide for some connectivity with downstream systems.
North-West Flow Plan Targets	The regulated water sharing plans for the NSW Border Rivers, Gwydir and Namoi and the unregulated Barwon-Darling plan include targets from the North-West Flow Plan that are meant to restrict supplementary access in the northern tributaries and B and C class access in the Barwon-Darling to achieve flow targets in the Barwon-Darling for riparian needs, algal suppression and fish migration. These rules have generally not been implemented. The North-West Flow Plan also included targets for the Macquarie-Cudgegong but these are not currently included in the water sharing plan. In the Barwon-Darling water sharing plan, these targets are included as a note.
Resumption of flow rule (RoF)	The resumption of flow rule currently only applies to the Barwon-Darling unregulated water sharing plan and is designed to protect the critical first flows after an extended low flow or dry period within this Plan area. The rule is triggered when a flow event in the Barwon-Darling River occurs after a continuous period of low or cease to flow. It prevents licence holders in the Barwon-Darling from accessing the first flow until certain targets are forecast to be met. Normal access conditions then apply after flow has been forecast to meet a required target flow. This rule does not protect the first flow in the northern tributaries. In addition, it was designed to support connectivity in the Barwon-Darling through to Wilcannia, not to provide significant inflows to Menindee Lakes and therefore flow requirements for relaxation of restrictions are in a lower flow band as you move further down the system.
Supplementary access rules	Supplementary access is related to uncontrolled flow that is not captured by the major dams and is not needed to fulfill other higher priority needs specified in the water sharing plans. 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 proportion of a supplementary water event within specified reaches for the environment. Supplementary take is subject to announcements 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 (see Section 3.3). Water protected for

Type of Rules	Comments
	the environment through the supplementary access rules is considered planned environmental water.
Floodplain harvesting restrictions	Floodplain harvesting is currently restricted when Menindee Lakes total storage drops below 195 GL and is relaxed based on in-valley triggers (See Chapter 5 for further discussion).
Replenishment flows[90]	These flows provide for releases of larger periodic flows according to the rules in the northern tributary regulated plans. These rules are focused specifically on in-valley outcomes and are usually to provide for basic landholder rights. They are often 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) and environmental flow rules	These are important sources of environmental water for the Macquarie-Cudgegong and Gwydir regulated water sharing plans. Typically, EWAs 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 within the water sharing plan area. EWAs are usually targeted for specific environmental assets within a plan area and are occasionally targeted to support downstream connectivity. EWAs usually have the equivalent of general security protection in the dams. This means that they are allocated water in the same way as general security licences, with reductions in allowances 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.

3.3 Supplementary access rules and the North-West Flow Plan

Supplementary water is uncontrolled flow that cannot be captured in storages such as dams or weirs for future allocation and use. To be considered supplementary flow, the volume of available water must be more than current demands and commitments including environmental provisions of the plan, basic landholder rights and water orders placed by regulated river (general security) access licence holders and higher priority access licences in a water source.

When these conditions are identified for a particular river, a period of supplementary access is announced, and details of the river reaches and time periods where licence holders can extract water are published. The amount of supplementary water available from a flow event depends on the amount and location of rainfall, ensuing streamflow, and the catchment conditions at the time. Supplementary access can be triggered overnight and last for a day or two, a month to six months or more, depending on the river system and nature of the flow event.

The North-West Flow Plan was written in 1992 in recognition that connectivity between river systems was an important consideration for maintaining healthy rivers. The intent of the plan was to limit access to the lower priority supplementary water in upstream valleys (and access to higher flows in the Barwon-Darling) to enable certain flow targets to be met in the Barwon-Darling River.

[90] The NSW Border Rivers water sharing plan for the regulated river includes stimulus flows and translucency rules as well – See Appendix C for full details.

The flow targets in the North-West Flow Plan were subsequently integrated into the northern tributary and Barwon-Darling water sharing plans, other than the Macquarie-Bogan. These water sharing plans require that supplementary access be restricted where necessary to achieve the targets. However, they have generally not been implemented other than two trial attempts in the 1990s prior to the development of the water sharing plans. The Western Regional Water Strategy and the Alluvium review of the North-West Flow Plan[91] indicate that targets were not implemented because of the limitations of flow forecasting. In their absence, there are no rules specifically designed to ensure downstream system needs are adequately provided for.

3.3.1 Implementation of the North-West Flow Plan targets

Feedback on the Panel's Interim Report indicates a lack of clarity about the supplementary rules and the North-West Flow Plan and the extent to which that Plan has been implemented. Some stakeholders were of the view that because targets from the North-West Flow Plan are often met this means that these rules are being fully implemented by WaterNSW. This is not the case, as detailed in the following sections.

Previous reports have highlighted the North-West Flow Plan targets have not been implemented mainly due to limitations of flow forecasting.[92, 93] These reports highlight, for example, that forecasting the shape and size of unregulated flow events entering the Barwon-Darling River from the upper reaches of tributaries many weeks in advance is considerably more challenging than forecasting the movement and active management of regulated releases from headwater storages (such as held environmental water). It is also difficult to forecast the shape and size of unregulated flow events once they enter the Barwon-Darling River. Individual events behave differently in terms of attenuation and losses as they move further down the river system often reflecting the antecedent flow conditions.

Previous reports and water sharing plan amendments have recommended that the North-West Flow Plan targets should be reviewed, revised and then implemented to improve downstream outcomes (See Appendix D for details). The Department and WaterNSW have confirmed that the targets are not routinely implemented (though they may be for example during Section 324 orders).

3.3.2 Other supplementary rules were not intended to replace the North-West Flow Plan

Some stakeholders were of the view that the current supplementary rules in the water sharing plans are adequate to replace the North-West Flow Plan rules.

Supplementary water access rules separate from the North-West Flow Plan rules have been included in the water sharing plans for the northern tributaries since they were originally written in the early 2000s. The supplementary rules vary considerably between plans, as shown in Appendix E.

The Department provided the Panel with limited information about the basis or intent of the supplementary rules. However, we understand many of the rules were taken from historical operational plans, which were negotiated between Government and stakeholders prior to the inception of water sharing plans. The Department advised that water sharing plans were developed by River Management Committees who drew on these operational plans; any

[91] Alluvium Consulting (2021) *Review of the Interim Unregulated Flow Management Plan for the North West.*
[92] Barma, D. (2018) *Stocktake of Northern Basin Connectivity Rules- (review of Implementation and model analysis)* Report to NSW Department of Industry – Water.
[93] Alluvium Consulting (2021) *Review of the Interim Unregulated Flow Management Plan for the North West.*

changes made in the development of the subsequent water sharing plans would have resulted from suggestions by these committees or the Government of the time.

From the documentation available, it is clear that in the development of the current water sharing plans, and in previous operational plans, it was well recognised that there was a need to implement both supplementary rules, to ensure environmental outcomes within the valleys, and the rules from the North-West Flow Plan to provide for downstream connectivity.

The amount of water that each plan allocates to the environment in the supplementary rules varies, but evidence provided indicates the primary consideration in relation to supplementary rules was in-valley outcomes. For example, in the Macquarie-Cudgegong the objective was to enhance the benefits of floodplain inundation and native fish spawning in the Plan area. The paper prepared by the River Management Committee for the Namoi draft water sharing plan outlines a negotiation between additional supplementary access for irrigators and concerns about in-valley environmental outcomes.[94] This paper specifically indicates that the targets from the North-West Flow Plan should be retained in addition to other supplementary rules, stating:

> *'The NWUFP [North-West Unregulated Flow Plan] is aimed at ensuring that critical environmental needs and basic town water supply and domestic and stock water requirements along the Barwon-Darling are not jeopardised by off allocation (supplementary water) extractions of uncontrolled flows along its regulated tributaries.*
>
> *The requirements of the NWUFP will therefore take precedence over all other supplementary water access rules in the Namoi regulated water source.'*

Because they were developed largely to consider differing in-valley needs, supplementary rules vary considerably across plans. In the Namoi and the Border Rivers plans there are specific flow targets that must be forecast to be met in a range of upstream river reaches before supplementary can be announced in those reaches. The Gwydir plan simply requires that other flow rules such as replenishment flows and the environmental flows (generally known as the "3T rule") will be met. Macquarie-Cudgegong has one flow requirement of 5,000 ML/day above orders at Warren Weir forecast to be met. The proportion of supplementary water that is allowed to be taken is also inconsistent across the Plans (see Table 3 and Appendix E for further detail).

Table 3. Summary of supplementary take rules (percentage of take allowed)

Water Sharing Plan	Percentage of supplementary take allowed once supplementary rules are met
Border Rivers	allows for up to 75% to be taken
Namoi	allows for 10% of supplementary water to be taken during certain parts of the year, with 50% allowed at other times
Gwydir	allows for 50% of supplementary water to be taken at all times
Macquarie-Cudgegong	allows 100% to be taken

Given that these rules are largely focused on in-valley outcomes, the Panel did not undertake a detailed analysis of the adequacy of specific rules for each Plan. Instead, we focused on ensuring there are rules in place to adequately provide for downstream needs. However, we

[94] Namoi Regulated River Management Committee (2001) Draft Water Sharing Plan For The Regulated Namoi Water Source Part A- Background documentation provided by DCCEW-Water.

note that the supplementary rules in the Gwydir Plan may provide less protection for potential downstream needs than the Border-Rivers and Namoi Plans and suggest that these rules are reviewed as part of the water sharing plan review.

3.4 Importance of downstream targets

The Panel recognises that the targets in the North-West Flow Plan, as well as the targets the Panel is proposing to replace them with, are frequently met when there are regular high flows in the system. Figure 8 demonstrates how during a period of high flow, supplementary rules are adequate to protect baseflows and freshes.

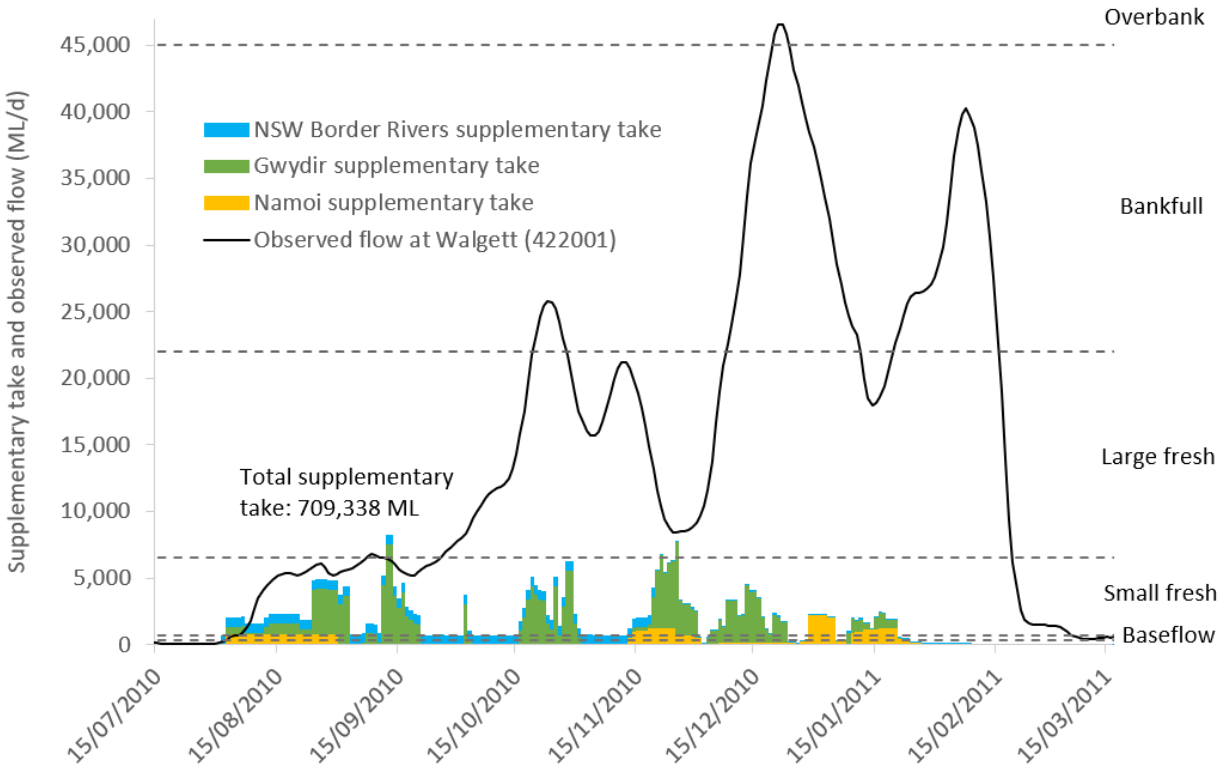

Figure 8 Supplementary take during a large flow event

The Department has indicated in the Western Regional Water Strategy that connectivity rules should target water moving across the landscape 'at important times.' The Panel has identified a gap when supplementary rules do not provide adequate protection of essential downstream needs. This occurs during periods of flow dominated by small to medium flows, where supplementary rules may allow for upstream tributary take, which in turn reduces flows downstream to the extent that baseflow and critical fresh flows are not met.

For example, Figure 9 demonstrates a supplementary event that occurred in November 2015. If supplementary water access had been restricted, the additional flows would likely have provided baseflows in the Barwon-Darling River. Similarly, Figure 10 demonstrates an event where supplementary access in upstream tributaries likely prevented achievement of a small fresh in the Barwon River during the critical summer period.

The Panel acknowledges that the Barwon-Darling A-Class rule changes had not yet been implemented during the time periods covered by these figures. However, it is likely with current rules baseflows and small freshes would still not have been achieved throughout the Barwon-Darling. WaterNSW also confirmed that during times when the system is drying, supplementary restrictions are sometimes inadequate to ensure that end of system flows or downstream targets are met.

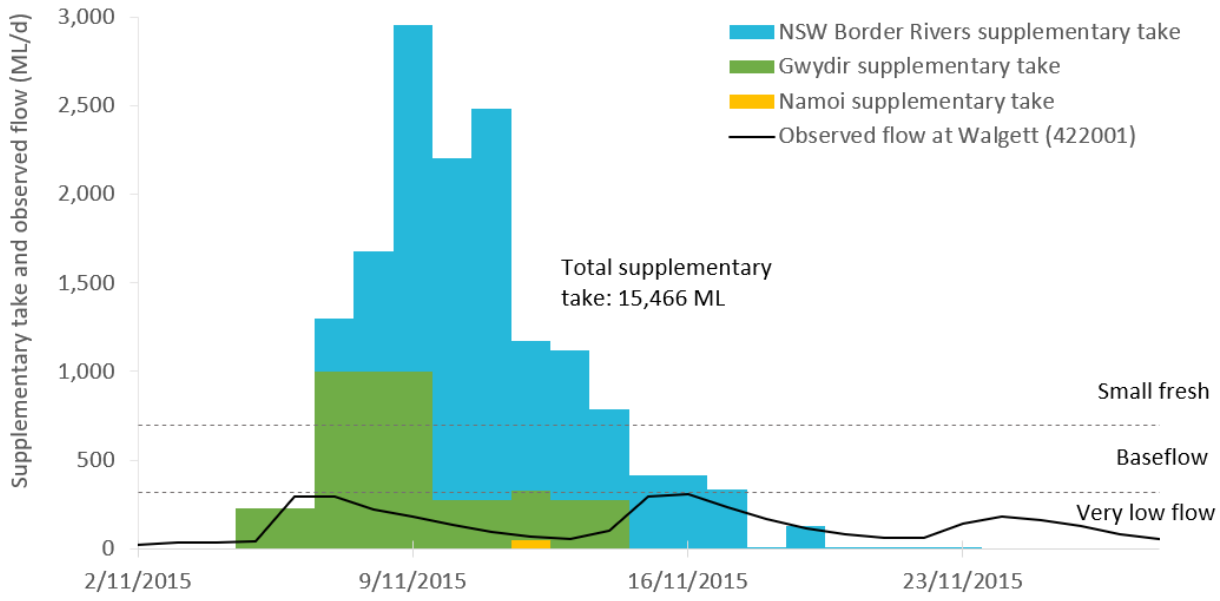

Figure 9 Example supplementary event that likely affected baseflow at Walgett

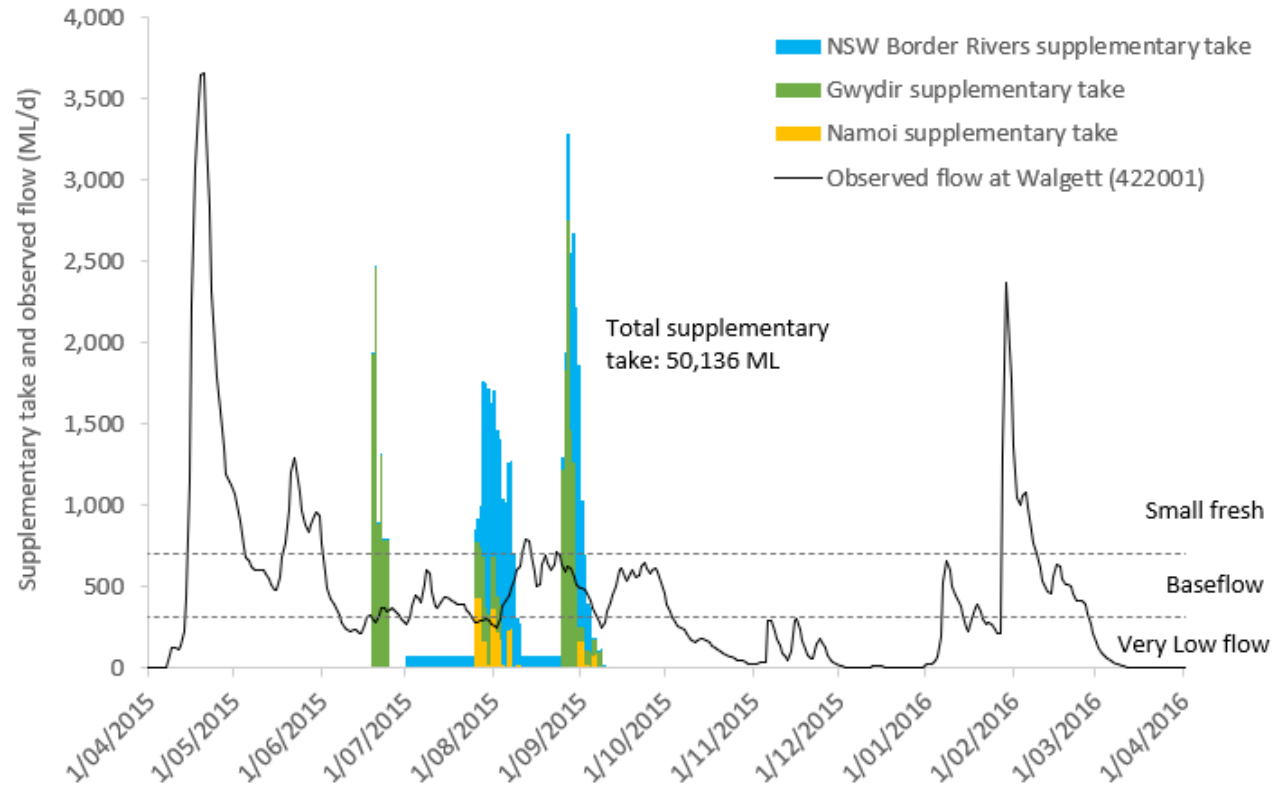

Figure 10 Supplementary events that likely prevented achievement of a small fresh during the critical summer period

As demonstrated by these examples, during smaller supplementary flows, insufficient water may be provided for downstream needs because the supplementary rules are not designed to specifically provide for those downstream needs. Therefore, the Panel is proposing new rules that specifically require achievement of those downstream needs, to provide a safeguard for these critical flows.

The Panel's view is that even if limiting supplementary access would not completely meet the downstream baseflow and small fresh targets, supplementary access should be restricted.

Flows at these times are essential for the environment, for keeping the system wet, and providing a base for future flows to move further down the system. It is also consistent with the Panel's principles that when basic downstream ecosystem and human health needs are not being met, supplementary water should not be taken upstream.

The Panel acknowledges that instances where supplementary is not providing for baseflow or is preventing the achievement of the proposed fresh rules, happen relatively infrequently. However, the times when this does occur are critical for improving connectivity, and therefore these rules are important to ensure critical flows are protected.

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

The Panel's Terms of Reference specifically asked if 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 in the North-West Flow Plan 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, whereas 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 from the tributaries, only to protect it if it is already there.
- 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 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 in the Chapter 4.

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

4 Panel's proposed approach for improving connectivity

The Panel has focused its analysis on trying to gain a sound understanding of the fundamental ecosystem and downstream community connectivity needs. Our aim was to identify 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, 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 upstream water users, it is not appropriate for upstream extraction to put 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.

The Panel has examined the flow conditions necessary to enhance connectivity under different hydrological conditions. The approach taken to support connectivity should be appropriate for the prevailing climate conditions. Currently, the NSW 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 these plans to manage connectivity across the whole system during all climate conditions.

4.1 Key Findings

13 In a system that displays highly variable flows, it is necessary to have different management options for different climatic conditions. Different rules are needed for non-dry compared to dry times, and the transition period in between.

14 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 system connectivity or an adequate "first flush" through to Menindee Lakes following an extended dry period.
- for Menindee Lakes does not adequately represent critically dry conditions and should be reviewed further.

4.2 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. The Panel has proposed management options and rules for three climatic conditions:

- **Non-dry times rules** are intended to provide for adequate downstream flows and maintain the 'wetness' of the system during these times to help the ecosystem to be more resilient and able to withstand drought. The Panel has proposed rules to ensure baseflows, small fresh and large fresh environmental water requirements are met during these times.
- **Transition from non-dry to dry times rules** are intended to provide for when the system begins to enter a "dry" stage as the Panel recognises it would not be efficient or effective to try and maintain baseflow for extended periods where there are minimal inflows into the system. The Panel proposes a trigger for transitioning from the non-dry times rules to the dry times rules be implemented as part of the end of system flow rules. Baseflow would remain protected from "opportunistic take" at all times.
- **Dry times rules** are intended to allow the ecosystem to recover from drought as quickly as possible, and provide for critical needs during extended droughts. The Panel has proposed revised resumption of flow targets and a Connectivity Environmental Water Allowance to address needs during these times.

Figure 11 on the following page depicts how the rules would work together to enhance connectivity across a range of climatic conditions. Importantly the minimum end of system flow rule is intended to apply at all times. During non-dry times this would require releases from the dams, but during other times it would ensure restrictions on uncontrolled flow unless the end of system target it met. The following sections outline in further detail the Panel's proposed rules for different climatic conditions.

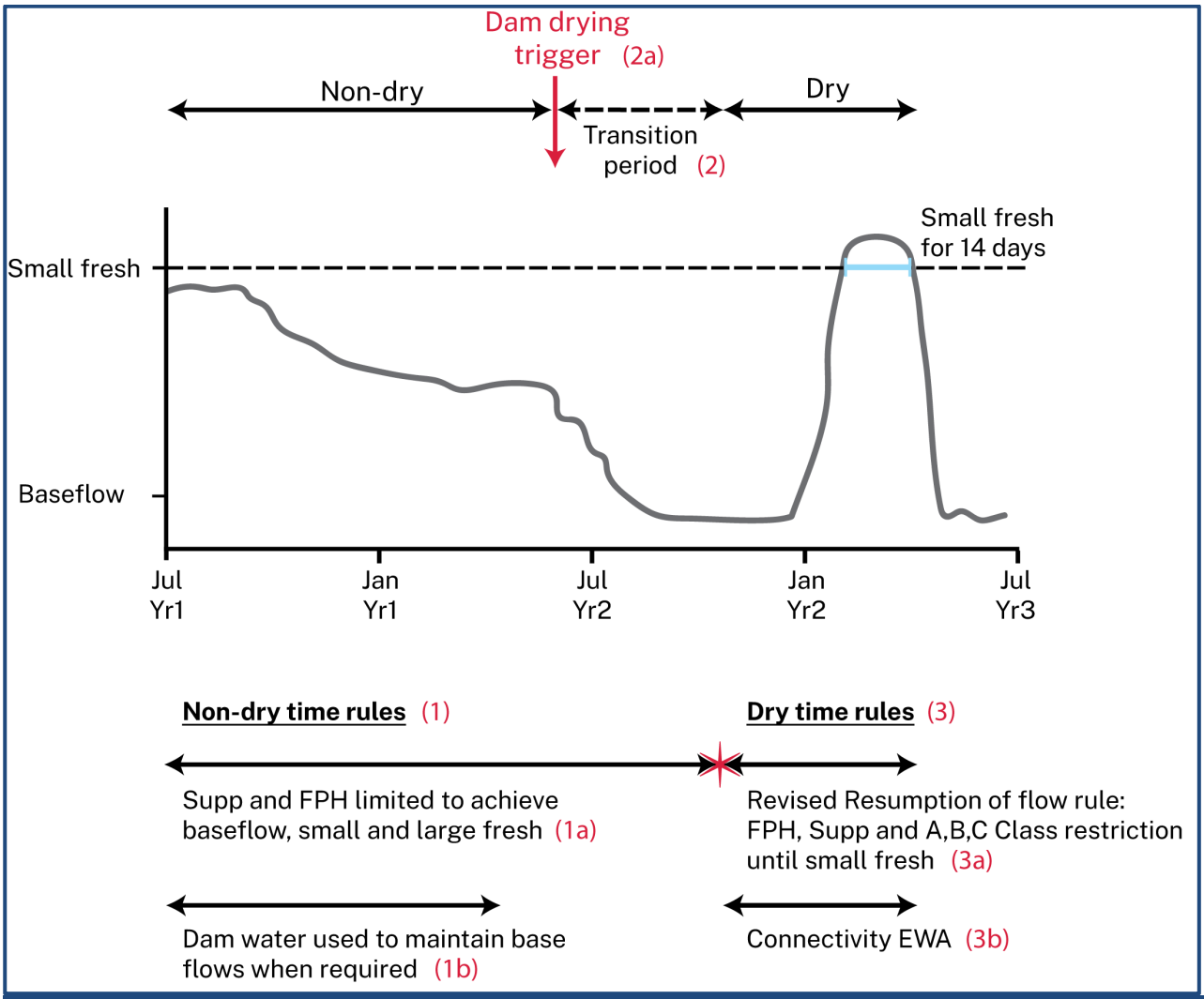

Figure code	Proposed rule as referenced in figure	Relevant Report Chapter Reference
1	**Non-dry times** Baseflow is always protected from opportunistic take of uncontrolled flows. Small/large fresh requirements are met through restrictions on supplementary and floodplain harvesting where necessary	**0**
1a	Supplementary and FPH limited to achieve baseflow, small and large fresh	**4.3.1(baseflows)** **4.3.2(small fresh)** **4.3.3(large fresh)**
1b	Dam water used to maintain baseflows when required	**4.3.1**
2	**Transition from "non dry" to "dry" times**	**4.4**
2a	Dam drying trigger	**4.4**
3	**Dry times**	**4.5**
3a	Revised resumption of flow rule (FPH, supplementary and, A,B,C- class restrictions)	**4.5.1**
3b	Connectivity Environmental Water Allowance	**4.5.2**

Figure 11 Conceptual diagram of proposed rules in the northern tributaries and Barwon-Darling outlining where in this chapter the rule is discussed

4.3 Non-dry time rules

Rules within the northern tributary regulated water sharing plans should be revised to ensure that the baseflow, small fresh and large fresh environmental water requirements are met in non-dry times.

It is critical that baseflow be met when water is readily available in the northern tributaries. Alluvium's review of the North-West Flow Plan[96] indicated that restricting supplementary access could provide improved achievement of downstream baseflows. Our recommendation to protect baseflows in unregulated tributaries could also result in more times when uncontrolled flows are available to achieve end of system baseflows in the regulated system. However, releases from the dams will also be necessary to achieve this objective.

Rules should also be put in place to protect an annual small fresh during the September to April period, and one large fresh event every two years. The Panel recognises the small and large fresh targets are already being met frequently in systems, and therefore the rules will likely not be activated very often. However, they are considered an important safeguard particularly under predicted future climate scenarios.

It may not be feasible to meet these environmental water requirements during times of drought when there is limited water available in the system. It is appropriate during these drier times to have different rules that aim to achieve the best environmental and community outcomes with the water that is available. These dry times rules are outlined in Section 4.5.

4.3.1 To protect baseflows:

The Panel recommends that an end of system minimum flow rule should be added to the Gwydir, Namoi and Border Rivers regulated water sharing plans[97]. This should require an end of system flow equivalent to the bottom of the baseflow EWR be achieved as per the Table 4 below. This should be met where possible from uncontrolled flows and supplemented with releases from the dam if necessary to achieve the target.

The end of system flow rule would require adequate water is provided to achieve the minimum flow requirement. At times this will reduce the amount of water that is available for supplementary take. Supplementary access is provided for after current demands and commitments including environmental provisions of the plan, basic landholder rights and water orders placed by regulated river (general security) access licence holders and higher priority access licences in a water source are fulfilled. The end of system minimum flow rule should be specified as an environmental provision that must be accounted for before water is considered available for supplementary access. In most cases this would not mean that an entire supplementary event is restricted from take, instead it may reduce the volume available.

The proposed end of system flow targets are shown in Table 4 and have been designed to achieve baseflows in the Barwon-Darling during non-dry times as identified in Table 5.

[96] Alluvium Consulting (2021) *Review of the Interim Unregulated Flow Management Plan for the North West*

[97] The Panel has not included a recommendation for an end of system flow rule for the Macquarie-Cudgegong as the end of system flows discharge into the wetlands. Modelling indicated that implementing a similar end of system flow rule as other valleys did not provide a downstream benefit. The Panel has considered potential rules in the unregulated systems between the Macquarie Marshes and the Barwon-Darling that may help contribute to connectivity.

Table 4 Tributary baseflow targets

Location	Baseflow Target*
Border Rivers – Mungindi (416001 Barwon River at Mungindi)	160 ML/d
Namoi - Walgett (419091 Namoi River at U/S Walgett)	30 ML/d
Gwydir – Collarenebri (418055 Mehi Near Collarenebri)	40 ML/d
Gwydir – Galloway (416052 Gil Gil Creek at Galloway)	25 ML/d

* Based on the lower threshold baseflow environmental water requirements from the relevant northern tributary long term water plans[98]

Table 5 Panel proposed baseflow targets in the Barwon-Darling River versus previously proposed targets[99, 100]

Location	Panel Proposed*	Alluvium Review of Riparian Targets[101]	North-West Flow Plan Riparian Target[102]
Mungindi (416001 – Barwon River at Mungindi)	160ML/d	850 ML/d	850 ML/d
Collarenebri (422003 – Barwon River at Collarenebri)	280 ML/d	760 ML/d	760 ML/d
Walgett (422001 – Barwon River at Dangar Bridge)	320 ML/d	N/A	N/A
Bourke (425003 –Darling River at Bourke Town)	500 ML/d	500 ML/d	390 ML/d
Wilcannia (425008 – Darling River at Wilcannia Main Channel)	350 ML/d	350 ML/d	150 ML/d

*Based on the bottom of baseflow environmental water requirements from the Barwon-Darling Long Term Water Plan[103]

[98] NSW Government, (2022), *NSW Border Rivers Long Term Water Plan Parts A and B*; NSW Government, (2020) *Namoi Long-Term Water Plan Part B: Namoi planning units*; NSW Government(2020) *Gwydir Long-Term Water Plan Part B: Gwydir planning units*; NSW Government (2020) *Macquarie-Castlereagh Long-Term Water Plan Part B: Macquarie-Castlereagh planning units*

[99] 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.

[100] Note the riparian targets for Mungindi and Collarenebri from the North-West Flow Plan were not incorporated into the water sharing plans.

[101] Alluvium Consulting (2021) *Review of the Interim Unregulated Flow Management Plan for the North West*

[102] Department of Water Resources (1992) *Interim Unregulated Flow Management Plan for the North-West*

[103] NSW Government (2020) *Barwon-Darling Long-Term Water Plan Part B: Barwon Darling planning units*

The Panel notes that any additional uncontrolled flows that enter the regulated system from the unregulated tributaries would have to be first used to meet the end of system flow rule (or other relevant rules) before being allocated for extractive use. As such, any increase in flows from the unregulated tributaries should contribute to achievement of the end of system flow rules.

In addition to the end of system minimum flow rule the Panel recommends:

1. **Floodplain harvesting restrictions:** Rules should be added to restrict floodplain harvesting at any time that supplementary access is not permitted. The intent of this requirement is that any rainfall runoff that is not exempt cannot be captured when baseflows are not being met.
2. **Dam water used to maintain baseflows when required:** Where uncontrolled flows are not sufficient to meet the end of system flow in each valley, releases should be made from the headwater dams (or water passed through the dam) to ensure the end of system flow is met during non-dry times.

Releases from dams will be necessary to meet the proposed baseflow targets. This is because 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 majority of water necessary to achieve the end of system flow rule through releases could be achieved by passing dam inflows directly downstream. This is because the Panel is only proposing releases from the dams when there are considerable inflows. As such, the Panel does not envision this rule would require a significant amount of water to be stored in the dams on an ongoing basis. The Department should undertake additional analysis to determine how to ensure the end of system flow targets are achieved while minimising impacts on diversions.

It is our understanding that baseflow should be well protected along 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 other than any rule that may be necessary to protect increased flows due to the end of system rules from being subsequently extracted in the Barwon-Darling.

4.3.2 To meet small fresh needs:

Rules should be added to each of the northern tributary plans to support annual small freshes during the September to April period. The rules should 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 small fresh requirements:

Table 6 Proposed small fresh targets

Location (gauge)	Flow rate (ML/day)*	Timing/duration
Mungindi (416001)	540	A minimum of 14 days between September and April every year**.
Collarenebri (422003)	650	14 days must be targeted. However, if an event is targeted with restrictions and the small fresh flow is only achieved for 10 days or more it will be considered as met for that period.
Walgett (419091)	700	
Bourke (425003)	1,550	Restrictions begin at the start of September until the target is achieved, if a small fresh has not been achieved in the previous 12 months.
Wilcannia (425008)	1,400	

*based on the lower threshold small fresh environmental water requirements in the Barwon Darling Long Term Water Plan[104]
** This covers both SF1 and SF2 targets in the Barwon-Darling Long Term Water Plan

The Panel supports the use of forecasting to relax restrictions upstream in the tributaries and upstream in the Barwon-Darling once lower Barwon-Darling targets are forecast to be met. Restrictions should not be relaxed downstream until the flow protected from upstream use has passed. The Panel recommends a rule based on forecasting for achievement of a small fresh as forecasting, even where not perfectly accurate is likely to be more efficient in terms of achieving the targets with minimum impacts, compared to setting "hard and fast" flow rules that must be met before restrictions are lifted.

WaterNSW and the Department have indicated that they have plans to continue to improve forecasting and the more they implement forecasting, the more accurate forecasting will get.

4.3.3 To meet large fresh needs:

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[105].

Access to supplementary, floodplain harvesting and B and C class should be restricted when the operator forecasts that flows are likely to achieve at least 85% of the targets in Table 7.

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

Modelling undertaken for the Panel by the Department indicates that large freshes can be achieved the percentage of years targeted (50% of years). However, the Panel recommends this rule to ensure that a large fresh is targeted when the inter-event duration recommended is exceeded. This requires that a large fresh be met once every two years.

Implementing this rule when there is a reasonable likelihood that a large fresh can be achieved will ensure that opportunistic take does not prevent a large fresh that could have occurred during a critical time for the ecosystem.

[104] NSW Government (2020) *Barwon-Darling Long-Term Water Plan Part B: Barwon Darling planning units*
[105] Alluvium Consulting (2021) *Review of the Interim Unregulated Flow Management Plan for the North West*

Table 7. Proposed large fresh targets

Location (gauge)	Flow rate (ML/day)*	Timing/duration
Mungindi (416001)	3,000	15 days minimum at least once every 2 years
Collarenebri (422003)	4,200	Anytime, but ideally July to September
Walgett (419091)	6,500	15 days must be targeted. However, if an event is targeted with restrictions and the large fresh flow is only achieved for 10 days or more it will be considered as met for that period.
Bourke (425003)	15,000	
Wilcannia (425008)	14,000	Starting in July restrictions begin if a large fresh has not been achieved in the previous 24 months and the operator forecasts that flows are likely to achieve at least 85% of the large fresh targets.

*based on large fresh environmental water requirements from the Barwon-Darling Long Term Water Plan[106]

4.4 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 rules. It would not be efficient or effective to try to maintain baseflow for extended periods where there are minimal inflows to the system. Providing dam releases during this drying period could artificially delay when the resumption of flows rules would be triggered. Therefore, the Panel proposes a trigger for transitioning from the non-dry times rules to the dry times rules be implemented as part of the end of system flow rules.

The Panel proposes that releases from the dam to achieve the end of system flow rule should cease when inflows to the major dams in the individual tributary drops below the 75th percentile on average over a 30 day period. This trigger is based on an estimate of when the inflows are likely to be insufficient to support the end of system flow. The Panel recommends further sensitivity analysis of the specific trigger to assess if a slight change might maintain outcomes but reduce impacts. Once flows in the Barwon-Darling drop below baseflows, the resumption of flow rule 90 day count would begin. There will be a transition period between when releases to achieve the end of system flow rule are suspended and the resumption of flow rule restrictions are triggered. Regardless, the end of system minimum flow rule would remain active at all times. This would ensure that supplementary access and floodplain harvesting would not be able to be taken when baseflows aren't met during this transition period.

[106] NSW Government (2020) *Barwon-Darling Long-Term Water Plan Part B: Barwon Darling planning units*

4.5 Dry time rules

4.5.1 Revised resumption of flow rules

Once the system has transitioned into a dry time then the Panel proposes that the revised resumption of flow targets in Table 8 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 to meet intended outcomes. Further, the Department's documentation indicates that the current resumption of flow rule is not meant to achieve system connectivity, rather it is meant to protect water within the valley down to Wilcannia.[107]

The Panel proposes that the resumption of flow rules should be expanded into the northern 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.

Consistent with the current resumption of flow rules the Panel proposes that restrictions could be lifted when downstream small fresh 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 8.6.

Table 8 Proposed resumption of flow rules versus current resumption of flow rules

Location	Panel Proposed Target (forecasted)	Resumption of flow rule in Barwon Darling WSP	Panel Proposed Target for lifting – (forecasted)	Resumption of flow rule in Barwon Darling WSP (Lifting)
Mungindi (416001)	<160ML/d for 90 consecutive days	N/A	540ML/d for 14 consecutive days	N/A
Collarenebri (422003)	<280 ML/d for 90 consecutive days	N/A	650ML/d for 14 consecutive days	N/A
Walgett – Dangar Bridge (422001)	<320 ML/d for 90 consecutive days	<326 ML/day for 150 consecutive days	700ML/d for 14 consecutive days	>706 ML/d for 10 cons days

[107] 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

Location	Panel Proposed Target (forecasted)	Resumption of flow rule in Barwon Darling WSP	Panel Proposed Target for lifting – (forecasted)	Resumption of flow rule in Barwon Darling WSP (Lifting)
Brewarrina (422002)	<550 ML/d for 90 consecutive days	< 468 ML/day for 150 consecutive days	1,000 for 14 consecutive days	> 1,008 ML/d for 10 consecutive days
Bourke (425003)	<500 ML/d for 90 consecutive days	< 450 ML/day for 120 consecutive days	1,550 for 14 consecutive days	> 972 ML/d for 10 consecutive days or 30 GL past Bourke
Louth (425004)	<450 ML/d for 90 consecutive days	N/A	1500 for 14 consecutive days	N/A
Wilcannia (425008)	<350 ML/d for 90 consecutive days	< 200 ML/day for 90 consecutive days	1400 for 14 consecutive days	> 400 ML/d for 10 consecutive days

4.5.2 Connectivity environmental water allowances

The Panel proposes that additional planned environmental water should be included in the Gwydir, Namoi and Border Rivers regulated water sharing plans for a "connectivity EWA", to provide for replenishment releases during dry times. This water should have the highest level of security in the dam, so that it is available for use it when it's required. Additional work is required to determine the potential volumes necessary, when they would need to be stored and the impact this would have on diversions.

The non-dry rules are intended to provide for adequate downstream flows during non-dry times and maintain the wetness of the system to help the ecosystem be more resilient and able to withstand drought. The resumption of flow rule is intended to allow the ecosystem to recover from drought as quickly as possible. However, there still remains a concern regarding provision of critical needs during extended drought. Action 3.3 in the Western Regional Water Strategy,[108] is to further investigate ways to provide replenishment flows from the northern tributaries during dry periods.[109] The Panel supports this action and suggests it should be achieved through a Connectivity EWA.

Extended dry periods have occurred across the Northern Basin historically. However, the MDBA has identified ecological "thresholds of concern," which they used to develop recommended maximum cease to flow durations. These durations are aimed at preventing cease to flows longer than those identified in the "without development" modelling.[110] The Long-Term Water Plan also identifies maximum cease to flow values. The proposed connectivity EWA would allow releases from dams to mitigate risks during such extended cease to flow periods.

In extreme dry times there may not be any planned environmental water available for use, particularly if general security access has been suspended. While the plans have provisions for planned environmental water that is released from dams, these provisions often do not

[108] DPE Water (2022), *Western Regional Water Strategy - Attachment 5: Analysis on replenishment flows*
[109] DPE Water (2022), *Western Regional Water Strategy*, See page 103
[110] 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*

provide adequate priority for the environment over other users. For example, EWAs are allocated general security status (equivalent to other users in the system), which may not be available during very dry times and many replenishment flows are at the discretion of the operator.

Section 49A and 49B of the Act allows for plan rules to be suspended in extreme dry events or during severe water shortages and Section 60 of the Act indicates that when an order under Section 49B is in place then critical human water needs have first priority in regard to available water determinations. However, the needs of the environment have the next highest priority and are to have priority over other uses other than critical human water needs. The current water allocation methods generally do not allow planned environmental water to be accessed during drought conditions. Some plans such as the Namoi reserve some planned environmental water in the "essential services" account; however, in practice there is insufficient water reserved to deliver this water during droughts.

The "connectivity EWA" should provide adequate water for periodic "pulsing" during extended dry times to maintain connectivity within the valleys for critical ecological and human needs. The Panel recommends that the connectivity 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. This recognises 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.

Given the time constraints and limited access to modelling, the Panel has not been able to fully assess the specific volume and rules that should apply to the proposed connectivity EWA. We propose the following steps to further investigate the appropriate volume, benefits and potential impacts for a connectivity EWA.

1. The NRC should convene a group including at a minimum DEECCW-BCS, DEECCW-water science, Fisheries, and the town water supply group to agree on the targets necessary to maintain critical human water and environmental needs, including maintenance of water quality and refilling and reconnecting essential pools for drought refugia.
2. The Department should undertake modelling to determine the volume necessary to achieve the target flows.
3. Options for storing this volume in the dam should then be modelled and further considered by a range of relevant agency representatives. Considerations should include:
    a. Ability to achieve the intended ecological and human water need outcomes
    b. Whether "carryover" of any unused water should be allowed. Given that the connectivity EWA would presumably be reserved on an annual basis and droughts may last for several years, the Panel recommends that consideration should be given to allowing carryover such that up to 200% of the Connectivity EWA is stored at any given time.
    c. When the volume would be stored and available - the Department has indicated that the connectivity EWA could be designed such that it is not stored until there is a risk of entering a dry time identified. This would help to mitigate impacts on diversions for extractive use while still providing the intended environmental benefit.
    d. Whether the same outcome could be achieved by assigning higher priority to EWAs currently available in the plans (or a portion of those EWAs) such that they are available at all times.

e. Which options provides the best achievement of outcomes while minimising impacts on diversions.

The Department has recognised that there are significant limitations in the current Barwon-Darling model in relation to low flows. In addition, currently the weirs and pools in the system are not included in the model. Therefore, alternative approaches to estimating the volumes of water necessary to refill pools may need to be considered.

The Panel understands that there is additional work planned that may affect the need for, or specifics of, a connectivity EWA. In particular, the Department is reviewing the approach to assessing minimum inflows, including improved consideration of potential future climate scenarios. Plans are also being reviewed under Section 43A by the Natural Resources Commission, who will specifically consider the effectiveness of rules that accommodate water management in extreme low flow drought events. Any results available from these assessments should be considered in development of connectivity EWAs.

4.6 Protection of environmental water

Any water protected through the Panel's proposed rules should be actively managed so that it is protected through to Menindee Lakes. The Panel recommends that once any protected flows reach Menindee Lakes the water should be protected in the Menindee Lakes for use as environmental water. This maintains our principles of equity that upstream users are not restricted so that downstream users can extract. Alternatively, the Panel agrees it may be beneficial for some of the water to be protected through to Menindee Lakes and 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 understands there are ongoing discussions between NSW and the Commonwealth as to how protection of environmental water entering Menindee Lakes could best be achieved.

The Panel recognises the complexities of the governance arrangements for Menindee Lakes and that this recommendation would need to be negotiated with the MDBA and other states to amend the Murray Darling Basin Agreement. We also understand that there is currently a trial underway for "recrediting" held environmental water in the Menindee Lakes from upstream catchments that should be considered in developing solutions which protect environmental water into and through the lakes and ultimately to the South Australian border.

4.7 Assessment of the Department's proposed targets and triggers

The Panel is of the view that the targets outlined in the previous sections of this chapter would achieve improved outcomes over the triggers proposed by the Department in the Western Regional Water Strategy (see Appendix B). The Panel's proposed targets and 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 the Menindee Lakes trigger – which is discussed in Section 5.4 and Chapter 6).

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 be unlikely to 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 analysis for these targets could be helpful in further analysis of the volumes appropriate for the connectivity EWA.

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 195 GL. Chapter 6 outlines the Panel's recommendations in regard to Menindee Lakes. The Panel proposes that once these recommendations have been implemented, further analysis be undertaken on whether a trigger for refilling upper Menindee Lakes is warranted. Any trigger should be based on addressing the specific risk that is being targeted and supported by analysis of whether the trigger is likely to achieve the intended outcome.

4.8 Recommendations

3 The Department should implement rules to achieve the targets and triggers in Table 9 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 outlined in the relevant LTWP. Baseflows should be achieved through minimum daily flow rules at the end of systems, floodplain harvesting access restrictions when supplementary take is not allowed, and dam releases where necessary to achieve the end of system flows.

   b. During dry times – extend the current resumption of flow rules into the Northern Basin tributaries and provide for a small flushing flow following an extended dry period all the way to Menindee Lakes prior to allowing extraction. Baseflow end of system flow targets would remain in place and be met to the extent possible with uncontrolled flows, but dam releases to meet these targets would be suspended.

   c. Establish a "connectivity" environmental water allowance in the Gwydir, Namoi and Border Rivers regulated water sharing plans to provide for replenishment flows during dry times to maintain system health and water quality, following additional analysis of volume needs, benefits and impacts.

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

   - any water protected through these rules should be protected through to Menindee Lakes.
   - once protected flows reach Menindee Lakes the water should be held as an environmental water allowance for use in supplying critical environmental needs for the Lower Darling-Baaka River, or used for translucency flows protected through the Lower Darling-Baaka River.

Table 9-a Summary of Panel's connectivity targets and triggers for non-dry times

Non- Dry times		
Proposal	**Proposed in-valley targets**	**To meet proposed targets in the Barwon Darling**
Protection of baseflow *Regulated water sharing plans should have an end of system flow requirement to enable baseflow targets in the Barwon-Darling to be achieved during non-dry times. This should be achieved through limitations on supplementary and floodplain harvesting access in the first instance, with releases made from storage if these flows are not adequate.*	▪ Mungindi (416001): 160 ML/d ▪ Walgett - Namoi River at U/S Walgett (419091): 30 ML/d ▪ Collarenebri - Mehi Near Collarenebri (418055): 40 ML/d ▪ Galloway (416052): 25 ML/d	▪ Mungindi (416001): 160 ML/d ▪ Collarenebri - Barwon River at Collarenebri (422003): 280 ML/d ▪ Walgett- Dangar Bridge (422001): 320 ML/d ▪ Bourke (425003): 500 ML/d ▪ Wilcannia (425008): 350 ML/d
Proposal	**Proposed Targets**	**Additional details**
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. Restrictions should apply even if targets will not be fully met.*	▪ Mungindi (416001): 540 ML/d ▪ Collarenebri (422003): 650 ML/d ▪ Walgett (419091): 700 ML/d ▪ Bourke (425003) 1,550 ML/d ▪ Wilcannia (425008): 1,400 ML/d	A minimum of 14 days between September and April every year. (Note this covers both SF1 and SF2 targets in the Barwon-Darling 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 10 days or more it will be considered as met for that period. Restrictions begin at the start of September until the target is achieved, if a small fresh has not been achieved in the previous 12 months.

Protect large freshes *Regulated water sharing plans should include restrictions on supplementary and floodplain harvesting, and B and C class licences in the Barwon-Darling to achieve periodic large fresh flows.*	▪ Mungindi (416001) 3,000 ML/d ▪ Collarenebri (422003): 4,200 ML/d ▪ Walgett (419091): 6,500 ML/d ▪ Bourke (425003): 15,000 ML/d ▪ Wilcannia (425008): 14,000 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 10 days or more, it will be considered as met for that period. Starting in July restrictions begin if a large fresh has not been achieved in the previous 24 months and the operator forecasts that flows are likely to achieve at least 85% of the large fresh targets.

Table 10-b Summary of Panel's connectivity targets and triggers for transition periods

Transition arrangements	
Proposal	**Description**
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.*	When the inflows to the major dams in the individual tributary drops below the 75th percentile on average over a 30 day period, then releases from dams to achieve end of system flows are suspended in that tributary. Once flows in the Barwon-Darling drop below baseflows, the resumption of flow rule 90 day count would begin. The Panel recommends further sensitivity analysis of the specific trigger.[111] **Note**: There will be a transition period between when releases to achieve the end of system flow rule are suspended and when the resumption of flow rule restrictions are triggered. During this period the end of system minimum flow rule would still apply to uncontrolled flows. This restriction should apply even if the uncontrolled flows will not fully meet the targets as any contribution to flows downstream at this point is very beneficial for the ecosystems.

[111] The Panel based the selection of the trigger on analysis on historic inflows to the dam and a general principle that when inflows to the dam are no longer supporting the end of system flow, then the releases should be suspended. We recommend that the Department consider further sensitivity analysis to maximise achievement of targeted outcomes while minimising impacts.

Table 11-c Summary of Panel's connectivity targets and triggers for dry times

Dry Times		
Proposal	**Proposed trigger**	**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 forecasted small fresh all the way down the system to ensure flows through to Wilcannia and into Menindee Lakes.* **Note**: The end of system flow rule would still apply to uncontrolled flows during this time but releases from the dam would not be made.	▪ Mungindi: <160 ML/d for 90 days ▪ Collarenebri: <280 ML/d for 90 days ▪ Walgett (Dangar Bridge): <320 ML/d for 90 days ▪ Brewarrina: <550 ML/d for 90 days ▪ Bourke: <500 ML/d for 90 days ▪ Louth: <450 ML/d for 90 days ▪ Wilcannia: <350 ML/d for 90 days	▪ 540 ML/d for 14 consecutive days forecast to be met ▪ 650 ML/d for 14 consecutive days forecast to be met ▪ 700 ML/d for 14 consecutive days forecast to be met ▪ 1,000 ML/d for 14 consecutive days forecast to be met ▪ 1,550 ML/d for 14 consecutive days forecast to be met ▪ 1,500 ML/d for 14 consecutive days forecast to be met ▪ 1,400 ML/d for 14 consecutive days forecast to be met

Table 12-d Summary of Panel's connectivity targets and triggers for all times

All times	
Proposal	**Description**
Menindee Lakes trigger	Chapter 6 outlines the Panel's recommendations in regard to Menindee Lakes. The Panel recommends that once these recommendations have been implemented, further analysis be undertaken on whether a trigger for refilling upper Menindee Lakes is warranted. Any trigger should be based on addressing the specific risk that is being targeted and supported by analysis of whether the trigger is likely to achieve the intended outcome.

Establish 'Connectivity' environmental water allowance *The Gwydir, Namoi and Border Rivers regulated water sharing plans should include a 'connectivity' EWA to 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.*	<u>Further analysis required:</u> The Panel is of the view that the Connectivity EWA should at a minimum provide for reconnecting pools for critical human water needs, environmental needs and water quality needs during severe dry times. The Department's proposed critical dry condition triggers provide a basis for the flows that would be necessary to achieve this. Given time constraints the Panel was unable to fully investigate this option. Further steps necessary to assess this option are provided in Section 4.5.2. **Note**: The "connectivity" EWA should have the highest security status and therefore take precedence in the dam storage so that it can be used when it's required.
Update rules in unregulated water sharing plans (See Chapter 7 for further details)	<u>For non-dry times</u> ▪ Implement cease to pump rules in unregulated water sources identified as important for contributing to connectivity downstream and align rules in water sources adjacent to the Barwon-Darling with the rules in the Barwon-Darling for consistency and equity. ▪ Implement active management where necessary to protect water that is protected for environmental or connectivity purposes in the regulated system and flows into the unregulated system. ▪ Implement restrictions on unregulated water sources when restrictions are triggered in the regulated water sharing plans by the resumption of flow rule, or to achieve a small or large fresh. <u>For dry times</u> ▪ Unregulated users in plans identified as important for contributing to connectivity downstream should be restricted from accessing water while the resumption of flow rule restrictions are in place.

5 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 through floodplain harvesting in the Northern Basin.

5.1 Key Findings

15 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.

16 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.

17 Current rules do very little to restrict floodplain harvesting. Restrictions in regulated plans only apply when Menindee Lakes are below 195 GL total storage and when 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.

18 The objectives of the current and proposed rules for triggering restrictions upstream based on Menindee Lakes volumes, and around how the 60 GL 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 to date been assessed relative to each other.

19 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.

20 Rainfall runoff makes up 44 percent of floodplain harvesting, but 61 percent of this is exempt. The rules for exemption are unclear and difficult to enforce. Rainfall runoff is likely to be available at the same times that supplementary access is allowed and can provide important contributions to connectivity at important times.

5.2 Overview of floodplain harvesting

The take of overland flow in NSW 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 [112] floodplain harvesting is defined as "*the collection, extraction or impoundment of water flowing across designated floodplain including rainfall run-*

[112] *NSW Floodplain Harvesting Policy 2018*

off (external and on-farm rainfall) and overbank flow." [113] Floodplain harvesting activities can occur on sites where all or part of a property lies within a designated floodplain [114]. The definition and the geographical specification of where floodplain harvesting can occur has resulted in several inconsistent rules in some NSW Northern Basin valleys. This is because the floodplain harvesting rules only apply where NSW has declared a floodplain a "designated 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. [115] Also, the most recent fish death events have highlighted that periodic overbank flows / floodplain flows can clear debris and nutrients from floodplains, thereby reducing risk of water quality issues (like algae blooms) in downstream catchments. [116]

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 44 percent of floodplain harvesting is rainfall runoff. However, 61 percent of rainfall runoff is exempt. Therefore, 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 13 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. This could also have implications for longitudinal connectivity, particularly as volumes of water are

[113] 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.
[114] *NSW Floodplain Harvesting Policy 2018, p.4*
[115] 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.
[116] Periodic overbank flows avoids the build up of these organic materials on the floodplains

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" [117]

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."

As previously noted, the implementation of the NSW Floodplain Harvesting Policy means floodplain harvesting should no longer be fully unconstrained. 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.

5.3 Licensing and management of floodplain harvesting

The roll-out of NSW's floodplain harvesting licensing 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, the Department has provided preliminary/draft access rules on its website, which also indicates that the licensing for Namoi is expected in the fourth quarter of 2024. [118]

Associated with the progressive rollout of the NSW floodplain harvesting licensing framework, relevant NSW 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. [119]

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 Office of the Chief Scientist and Engineer report on fish deaths 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. [120]

[117] NSW Legislative Council Select Committee on Floodplain Harvesting (2021) Floodplain harvesting
[118] NSW Government (2023), *Namoi Valley floodplain harvesting licensing and rules*
[119] 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.
[120] 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*

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.

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

Table 14 Rules for issues floodplain harvesting licences

Valley	Issued 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 [121]. 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.

5.3.1 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 195 GL (total storage) **unless** in-valley relaxation targets are being met (see Table 12).

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

Table 15 Restrictions of floodplain harvesting take in relevant Northern Basin Regulated Rivers

Regulated Valley + Barwon Darling River	FPH restricted: Menindee Lake total storage <195 GL	In valley gauge site	Relaxation targets when FPH is permitted: flows remain at or above (ML/d)	Relevant environmental water requirement
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
		Thalaba (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 is very 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 non-exempt floodplain harvesting would occur (i.e. when the river overbanks). As such, the plan rules do not restrict floodplain harvesting if an actual flooding (overbank) flow comes through, apart from restricting some take in upstream areas of valleys that cannot take before the downstream trigger is met. 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.

5.3.2 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 195 GL active storage in the upper lakes.

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.[122] The proposed 'relaxation triggers' to lift these restrictions are:

"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 GL – 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."*

The proposed critical dry condition rule would restrict supplementary, floodplain harvesting and A,B and C class extraction to achieve flow to Menindee Lakes. The Department has indicated that this rule would be intended to override the in-valley floodplain harvesting 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 except in the circumstance where the Lower Darling-Baaka has stopped flowing, and do not provide sufficient guidance as to what the objective is. The Department has indicated the intent is that if the Lower-Darling is not flowing then 195 GL plus the 60 GL to restart the Lower Darling River would be needed. The Panel notes this could require significantly more than 60 GL 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 60 GL restart is still considered necessary in that case.

5.3.3 Current "restart allowance" rule

There is already a rule in the Lower-Darling water sharing plan related to the 60 GL 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 Department has indicated restrictions were intended to be implemented later. The Department website states, "*While the changes to water sharing plan rules to improve connectivity are being finalised, temporary water restrictions may be used to protect the first flows after dry periods to meet critical human and environmental needs. If deemed necessary, these temporary water restrictions would be implemented using Section 324 of the Water Management Act 2000 and may be guided by the critical dry conditions triggers published in the Western Regional water strategy.*"

[122] 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[122] under WaterNSW's Works Approval but this same requirement is not specified in the water sharing plan.

The trigger of 10 days of cease to flow is not logical. The Lower-Darling is highly regulated and the Work Approval and O&O 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, or the operator actively decided to let it stop running to conserve water. 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.

5.4 Menindee Lakes triggers

The Panel was unable to identify a clear logic for why the volume in Menindee Lakes would be used as the primary driver for restrictions on floodplain harvesting in the Northern Basin. Based on the current model limitations (see Section 8.4), the Panel understands there is limited understanding of how much additional water may reach Menindee Lakes through floodplain harvesting restrictions. It 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 Lakes.

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

- **Link between Menindee Lakes volume and FPH is unclear:** Setting restrictions on FPH based solely on the levels in Menindee Lakes is arbitrary. The volumes in Menindee Lakes 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, and the lakes may not be in NSW control. 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 most likely be overridden and would be superfluous.

Further discussion of the Panel's recommendations regarding Menindee Lakes can be found in Chapter 6.

5.5 Proposals for restricting floodplain harvesting

The Panel has considered what restrictions might be necessary or appropriate for restricting floodplain harvesting to contribute to downstream connectivity. Rainfall runoff that is not

exempt should be restricted where possible when supplementary access is restricted. This is because the Panel has proposed restrictions on supplementary access at times we view are most essential for providing additional flow downstream.

5.5.1 Panel's proposed rainfall runoff rules

The Panel is of the view that as a principle, water users should not be allowed to floodplain harvest when supplementary take is not allowed, as these are both considered "opportunistic" take that is lower priority than other forms of take and have potential to provide for downstream connectivity. As the Panel has only recommended supplementary restrictions when we view it is necessary to achieve fundamental needs downstream, it is appropriate that all opportunistic take should be restricted.

The Panel recognises that the restrictions we have recommended are likely to predominantly affect "rainfall runoff" that is floodplain harvested. While there is a significant volume of exempt rainfall runoff, the estimates provided by the Department indicate that approximately 39 percent of rainfall runoff is non-exempt. This equates to approximately 23 percent of all non-exempt floodplain harvesting or approximately 50 GL annually. It is logical to assume that rainfall runoff take will be occurring much of the time that supplementary take is also occurring. This is water that would flow back into the river if it were not captured by on-farm floodplain harvesting infrastructure. Rainfall runoff capture is likely to occur at times that the Panel has identified as important for connectivity – such as when it has been relatively dry and there is some rainfall that provides flow in the rivers.

The Panel has discussed the feasibility of the rules proposed with the Department and with the Natural Resource Access Regulator (NRAR), who is responsible for enforcing rules. Floodplain harvesting regulations are relatively new and it is clear that there remain challenges in fully implementing them. The Panel has identified areas of concern, which should be considered in implementation of our floodplain harvesting recommendations:

- The extent to which landholders can restrict rainfall runoff floodplain harvesting may vary between properties. We understand that for example some have greater ability to block off sections of their infrastructure to prevent it from collecting runoff, whereas others do not.
- There are EPA regulations that prevent landholders from releasing stored water that is rainfall runoff from irrigated land as it may contain pesticides. The extent of the property that is irrigated and the ability to separate runoff from irrigated land and non-irrigated land varies from property to property.

The Panel is of the view that despite these difficulties, rainfall runoff is an important potential source of water for connectivity and recommends that the restrictions we've proposed be introduced and the Department and NRAR continue to work with landholders to ensure that non-exempt runoff is returned to rivers to the maximum extent possible.

5.5.2 Improvements to rainfall runoff exemption are needed

The regulations covering the volume of exempt versus non-exempt rainfall runoff are problematic because they do not provide clarity for the regulator (or the user) as to how much rainfall runoff is allowed to be captured. NRAR indicated this has led to disputes between the regulator and users regarding whether they captured non-exempt runoff -which should be deducted from their allocation, or exempt runoff - which is not deducted from their allocation. In some cases, the users have claimed several times what the regulator estimated should be exempt. In addition, this approach encourages landholders to ensure that as much of the rainfall runoff is exempt as possible. This works counter to the Panel's recommendation that

as much rainfall runoff as possible be returned to the river when floodplain harvesting is restricted.

A simpler, and more equitable approach would be to determine a set volume that is exempt for each property. If the landholder captures more rainfall runoff than that, it should count against their floodplain harvesting allocation. The Panel notes this is consistent with how rainfall runoff is dealt with in unregulated water sharing plans, where users get a set percentage of harvestable rights and anything captured beyond that much is counted against their allocation.

The Panel is of the view that it is appropriate to implement our proposed restrictions on floodplain harvesting, while the Department and NRAR continue to work with landholders to improve regulation of floodplain harvesting. The Panel recommends that regulation for the exemption for rainfall runoff be reviewed to ensure that limits on floodplain harvesting can be readily enforced. Immediate solutions, such as ensuring non-exempt rainfall runoff that is captured is accounted against users allocations would not directly assist with the Panel's objective of returning rainfall runoff to the river. However, the Panel supports a clear cap on the volume of exempt rainfall runoff for each property, so that the total volume of floodplain harvesting that is occurring can be accurately tracked and managed within the limits that are intended to be imposed.

5.5.3 Rules for floodplain harvesting in unregulated plans

As outlined in Section 5.1 the rules for floodplain harvesting in the unregulated system currently do not include any access rule restrictions for floodplain harvesting. This is inequitable particularly as users are often drawing water off the same floodplain during the same events as neighbouring regulated floodplain harvesters. Rules for restricting floodplain harvesting in the regulated water sharing plans and adjacent unregulated water sharing plans with floodplain harvesting licences should be aligned to ensure equity.

5.5.4 Additional steps

There are currently in-valley "relaxation triggers" which override the requirement to restrict floodplain harvesting when Menindee Lakes storage volume is below 195 GL. As noted previously, these triggers would not restrict take during overbank flows when the majority of floodplain harvesting occurs.

The Panel was asked to consider whether the current floodplain harvesting 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 overland flow before it enters the river. This 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 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 downstream connectivity outcomes.

The Department had previously advised the Panel they were considering making the in-valley relaxation triggers “activation triggers”, such that users could not floodplain harvest at any time unless the triggers were met. They have since indicated that the information provided to the Panel was incorrect and this is not their intention. They have indicated that the proposed “critical dry condition” trigger is intended to override the in-valley relaxation triggers, such that upstream take is restricted until the Menindee Lakes target is met. Further discussion of potential triggers for refilling Menindee Lakes is provided in Section 6.7.

The Panel is of the view that in-valley floodplain harvesting activation triggers should be considered. This would be more equitable with supplementary rules, which require a portion of flows be reserved for the environment. However, to be most effective such triggers should consider the in-valley lateral connectivity objectives and how the triggers could be set to ensure that these are met. The Panel considers this beyond our scope but recommends that this is considered by the NRC in their review of water sharing plans, in consultation with relevant agency groups such as BCS, the water science team, the implementation team and the planning team within the Department.

5.6 Recommendations

5 Rainfall runoff floodplain harvesting should be restricted whenever supplementary access is restricted to ensure equity and to contribute to connectivity flows.

6 Rules for exempt rainfall runoff should be reviewed and the Government should consider allocating a fixed volume for each licence that is exempt so that the rules can be adequately enforced. The Department should also work with landholders to improve their ability to return non-exempt rainfall runoff to the river.

7 The NRC should consider whether "activation triggers" for floodplain harvesting are warranted in their reviews of the water sharing plans.

6 Management of Menindee Lakes

Flows from the Barwon-Darling enter Menindee Lakes where they are re-regulated and used to provide for downstream needs. Recent fish deaths have highlighted the need to review the management of Menindee Lakes to improve outcomes for the Lower Darling-Baaka River.

6.1 Key Findings

21 Current minimum flow rules are inadequate for addressing water quality and environmental needs in the Lower Darling-Baaka River, particularly the stretch between the upper lakes and Weir 32. Significantly higher flows are necessary during high risk months to reduce risks of water quality events. The rules also sit outside the water sharing plan and do not specifically require minimum flow releases to be made from the upper lakes.

22 The 30 GL environmental water allowance (EWA) for water quality is not available when the lakes are in NSW control and has been insufficient for mitigating water quality issues in the past two water years. Periodic flow pulses from the EWA are still expected to be necessary to mitigate risk of water quality issues even if minimum daily flows are increased as proposed.

23 Potential changes to rules or operation of the lakes and related agreements would require negotiation and support from the Basin Officials Committee and the Murray-Darling Basin Ministerial Council.

24 The 60 GL restart allowance is supported by operational experience and is likely to be adequate. It is only needed once the Lower Darling-Baaka River has completely stopped flowing. Therefore, it does not need to be continually stored but could be accumulated once the upstream rivers start flowing again. Improved guidance around how to operationally manage the restart is needed.

25 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. 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.

26 Storing water in Menindee Lakes requires careful consideration. They hold significant environmental, cultural and social values that must be considered when making decisions about how they are managed and operated. The lakes are shallow, have a large surface area and are situated in the semi-arid zone, resulting in significant evaporative losses. The upper lakes are more efficient for storing water than the lower lakes as they experience lower evaporative loss. A reasonable estimate of evaporative losses must be included when undertaking any assessment of proposed management rules for the lakes.

27 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. The proposal for storing 195 GL in Menindee Lakes is based on now outdated minimum daily flow requirements and mean evaporation rates. Recommended increases to minimum daily flow rates would require storing additional water in the upper lakes, unless alternative approaches such as translucent flows were implemented.

28 Latest available advice indicates that the total storage volume in the upper lakes should be reserved for priority needs including for supplying minimum daily flows. However, the capacity of the upper lakes is inadequate for supplying critical needs during some

drought conditions. The risk of not being able to supply critical needs to the Lower Darling-Baaka River is higher than the risk in upstream valleys.

6.2 Overview of Menindee Lakes

The Menindee Lakes Storage system comprises several lakes that fill from inflows from the Northern Basin via the Darling River. There are four main lakes including Pamamaroo and Wetherell (upper lakes) and Menindee and Cawndilla (lower lakes), and seven main regulating structures (Figure 12).

The lakes were an ephemeral system and would fill naturally when the Darling River flooded. However, in the 1960s they were augmented to secure water supply for Broken Hill[123] and Menindee township and to increase the volume of regulated water available in the southern connected basin. This water infrastructure is owned by the NSW Government and maintained and operated by WaterNSW.

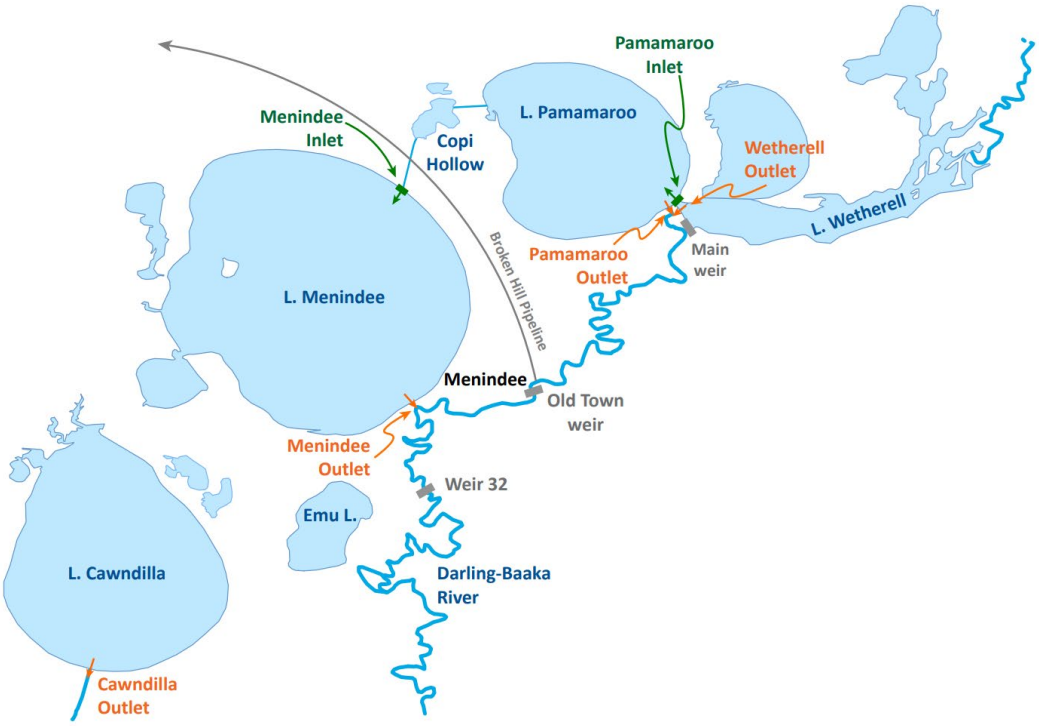

Figure 12 Menindee Lakes system. Key infrastructure regulating storage and distribution of water within the four main interconnected lakes[124]

Management of the lakes is complex and subject to different rules based on whether the lakes are operated as a "NSW resource" or as a "shared resource". The Murray-Darling Basin Agreement requires the lakes to be operated as a shared resource when the combined volume exceeds 640 GL until they fall to 480 GL when the lakes return to NSW control. NSW also has control during flood operations.[125] Operational rules for the shared resource are set out in the *Murray-Darling Basin Agreement*, the *Objectives and Outcomes for river operations for the River Murray System* (O&O) and the WaterNSW Murray-Lower Darling work approval. The MDBA directs operations when managed as a shared resource. Operational rules for the NSW resource are set out in the *Water Sharing Plan for the NSW Murray and Lower Darling Regulated Rivers Water Sources 2016,* the WaterNSW works approval and other state policies (e.g. Extreme Events Policy and Incident Response Guide).

[123] Since 2019 Broken Hill has received its water supply from a pipeline from the Murray River.
[124] 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.*
[125] WaterNSW (2023) Menindee Lakes Flood Operations Review 2021-2023.

Storage capacity: These lakes have active and dead storage (water that cannot be physically delivered downstream via existing infrastructure unless pumped). The combined total storage (at full supply level) is around 1,731 GL, which includes dead storage of around 98 GL. Lakes Menindee and Pamamaroo have the highest dead storage of around 51 GL and 32 GL respectively.[126] At times, the lakes can be "surcharged"[127] to store up to 2,050 GL, generally for the purpose of reducing downstream flood impacts.

High evaporative losses: 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[128] and shallow depth. Historically the lakes have been managed to minimise these losses by preferentially draining Lake Menindee and retaining stored water in the upper lakes. The O&O document includes a specific objective to direct releases of water from the Menindee Lakes Storage in such a way that preferentially conserves water in the most efficient and accessible lakes.

Infrastructure barriers to fish passage: 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).[129, 130] 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.[131]

Changes to release strategy: 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 to maintain water quality and mitigate 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 River is roughly 30 kilometres downstream of Main Weir and are not effective for managing water quality events in this reach.[132]

The Panel has developed a set of targets upstream of Menindee that we feel if met, would achieve a considerable improvement in inflows to the lakes. From a connectivity perspective providing additional flows to Wilcannia and then to Menindee Lakes to provide for the Lower Darling-Baaka River was our objective. Our view is that the Menindee volume trigger seeks to achieve an outcome 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 approaches and proposals aimed at preventing significant water quality problems and fish deaths within the Lower Darling-Baaka River. 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.

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[126] Data provided by DCCEEW Water.
[127] Normal operations of the Menindee Lakes store water within each lake at or below the full supply level. However, the lakes can be "surcharged" to hold more water than the full supply level. Surcharging usually occurs during high inflow or flood mitigation operations. The practice of surcharging may lead to potential environmental, cultural, social and water quality impacts and risks to infrastructure safety that need to be considered.
[128] Excerpt: NRC (2024) *Improving outcomes in the Lower Darling-Baaka River: advice to the Connectivity Expert Panel*
[129] 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.
[130] Office of the NSW Chief Scientist & Engineer (2023) *Independent review into the 2023 fish deaths in the Darling-Baaka River at Menindee.*
[131]Excerpt: NRC (2024) *Improving outcomes in the Lower Darling-Baaka River: advice to the Connectivity Expert Panel*
[132] Excerpt: NRC (2024) *Improving outcomes in the Lower Darling-Baaka River: advice to the Connectivity Expert Panel*

6.3 Natural Resources Commission analysis

In response to the Office of the NSW Chief Scientist and Engineer's report on the March 2023 fish deaths, the Minister requested the Natural Resources Commission (NRC) to undertake detailed analysis of the Murray and Lower-Darling water sharing plan's environmental provisions, including the Lower Darling environmental water allowance and water quality needs in the Lower-Darling to inform its review of the Murray and Lower-Darling regulated water sharing plan. 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-Baaka than was possible for this Panel to undertake.

The NRC agreed to share its preliminary findings with the Panel. Advice provided by the NRC related only to a subset of provisions within the scope of the NRC's Water Sharing Plan review that would be relevant to the Panel.[133] We have considered analysis provided by the NRC in this final report, as reflected in the sections below.

The NRC consulted with independent experts in freshwater ecology and water quality management, as well as the Department, NSW Fisheries, WaterNSW, and NSW Biodiversity, Conservation and Science in developing their findings.

The Panel has reviewed the NRC analysis and consulted with relevant agencies and the NRC's experts. We have adopted much of the analysis and recommendations put forth by the NRC, where we are supportive of them. The following sections include some excerpts from the NRC report – where this is the case it is identified in the footnote.

6.4 Current rules

Chapter 5 outlined that there are several rules either currently in place or proposed in the Western Regional Water Strategy related to upstream restrictions and the volume in Menindee Lakes, including the current floodplain harvesting rules, the Lower-Darling "restart allowance" and proposed "critical dry condition triggers".

The NSW Murray and Lower Darling water sharing plan sets out rules for providing for downstream requirements in the Lower Darling-Baaka River. Some of these affect the amount of water that needs to be stored in Menindee Lakes to provide for critical needs, particularly the upper lakes. However, current rules do not prescribe where releases are to be made from to provide for benefits in the Lower Darling-Baaka River.

6.4.1 Lower Darling Environmental Water Allowance

A 30 GL environmental water allowance (EWA) exists for managing water quality events and algal blooms in the Lower Darling-Baaka River. However, under the NSW water sharing plan, it is currently only available when the lakes are being managed as a shared resource, not when under NSW control. This is problematic given water quality deteriorates during extended low flow conditions, which can occur when the lakes are under NSW control. For example, this allowance was not available at the time of the 2018-2019 fish deaths.

[133] NRC (2024) *Improving outcomes in the Lower Darling-Baaka River: advice to the Connectivity Expert Panel*

The OCSE fish death review report highlighted that the volume of the EWA was inadequate for managing poor water quality associated with the 2022-23 flood recession and 2023 mass fish death event in the Lower-Darling Baaka River.[134, 135]

6.4.2 Minimum Daily Flow Requirements

Minimum daily flows are intended to provide for basic ecosystem needs including maintaining water quality and river health and minimising the occurrence of algal blooms.[136] They are currently specified in the WaterNSW work approval and the O&O document. Current minimum daily flow requirements, which are measured at the gauge directly upstream of Weir 32 (gauge 425 012), have been in place for over two decades.[137]

Current minimum daily flow rules are as follows:

- January – March: 350 ML/day
- April: 300 ML/day
- May – October: 200 ML/day
- November – December: 300 ML/day

The O&O also requires releases of 500 ML/day whenever the Menindee Lakes Storage is above full supply level.

Evidence from the past two decades indicates that current minimum daily flow provisions are inadequate for managing water quality, particularly related to algal blooms and persistent stratification[138] risks and fish deaths.

6.5 Environmental needs for the Lower Darling-Baaka River

There are a range of environmental objectives included in the water sharing plan for the NSW Murray and Lower Darling-Baaka River relating to protecting and enhancing water dependent ecological populations and communities and water quality. Advice provided by the NRC regarding environmental provisions for the Lower Darling Regulated River Water Source indicates that existing plan provisions are not adequate for achieving these objectives, particularly for managing water quality events in the Menindee weir pool, for the reasons outlined below:

- Native fish and other aquatic biota are frequently under stress and face increased mortality due to poor water quality, with some water quality parameters repeatedly outside of target ranges for aquatic ecosystems.
- Murray cod are in much lower numbers upstream of Pooncarie than previous years which is concerning given the population in the Lower Darling-Baaka River was once considered one of the more robust populations in the Murray Darling Basin.[139]
- Poor water quality, particularly low dissolved oxygen, has contributed to several mass fish deaths, particularly in the Menindee weir pool (2018-19 and 2023).

[134] OCSE (2023) *Independent review into the 2023 fish deaths in the Darling-Baaka River at Menindee*.
[135] Excerpt:NRC (2024) *Improving outcomes in the Lower Darling-Baaka River: advice to the Connectivity Expert Panel*
[136] Murray Lower Darling Community Reference Committee (2003) *Guide to the draft water sharing plan for the NSW Murray-Lower Darling Regulated River Water Source*, Appendix 1, unpublished.
[137] Excerpt: NRC (2024): The minimum flow requirements were part of a package of rules recommended by the Murray Lower Darling Community Reference Committeewhich was appointed in January 1999 to develop environmental flow rules for the Murray-Lower Darling River system and again in March 2001 to assist with developing the water sharing plan.
[138] The Panel is referring to thermal stratification whenever we refer to stratification.
[139] Excerpt: NRC (2024) *Improving outcomes in the Lower Darling-Baaka River: advice to the Connectivity Expert Panel*

- There have been a large number of amber and red algal alerts in and downstream of Menindee Lakes, including algal alerts issued in late autumn and winter months which is outside of their typical range. This in turn has impacted on the cultural values and uses of the river and affects Barkandji Traditional Owners and has made water unsafe for community recreation activities and impacted the use of water for domestic and stock purposes.

There are several areas where Plan provisions can be improved to help support basic river health and mitigate perverse water quality events, algal blooms and mass fish deaths in the Lower Darling-Baaka River.[140] The NRC provided advice regarding those provisions relevant to the Panel's scope of work including on the volume of water necessary to store in the upper lakes in order to mitigate risks.

6.5.1 Current minimum daily flow provisions are not adequate

The NRC worked with experts to examine the adequacy of the current minimum daily flow rules. These rules used to be listed in the appendix of the water sharing plan but were removed in 2022 and placed in the WaterNSW work approval. The Panel is of the view that these rules should be provisions in the water sharing plan to provide transparency to users and the community. Minimum flow rules are also included in the O&O document, which sets out arrangements for when the lakes are operated as a shared resource. Therefore, any changes to the rule for when the lakes are operated as a shared resource would need to be negotiated with relevant jurisdictions via the Basin Officials Committee before the O&O document can be updated.

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 River, specifically in the Menindee Weir Pool (upstream of Weir 32), and particularly during summer months. This is based on conditions post-fish death where the effects of the fish deaths 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. These conditions may persist for several years following significant fish deaths.

Until recently, there were limited scientific studies in the Lower Darling-Baaka River, particularly in relation to water quality.[141] After the 2023 fish deaths the water quality monitoring network was expanded in the Lower Darling-Baaka River to better understand responses of water quality parameters to flow rates.[142]

Even before the 2023 fish deaths and improvements to the water quality monitoring network, analysis[143] indicated that a flow rate of up to 750 ML/day was required to mitigate persistent stratification and the risk of mass fish deaths. This knowledge is now informing the current management of releases to the Lower Darling-Baaka River.[144] Data collected during 2023/24 indicate that when this higher flow rate is delivered from Lake Pamamaroo, it is generally effective for limiting persistent stratification in the Menindee weir pool. However, at times, additional flow pulses are still required to disrupt persistent stratification and for managing water quality in the Menindee weir pool.

[140] Excerpt: NRC (2024) *Improving outcomes in the Lower Darling-Baaka River: advice to the Connectivity Expert Panel*
[141] OCSE (2023) *Independent review into the 2023 fish deaths in the Darling-Baaka River at Menindee*
[142] Excerpt: NRC (2024) *Improving outcomes in the Lower Darling-Baaka River: advice to the Connectivity Expert Panel*
[143] Facey, J., Balzer, M., Brooks, A., Westhorpe, D., Williamson, N., Mitrovic, S., (2021) *Minimising persistent thermal stratification and algal blooms using improved flow velocity and discharge targets*, NSW Department of Planning and Environment.
[144] Excerpt NRC (2024): DCCEEW-Water's incident response plan for managing persistent thermal stratification and fish deaths in the Menindee weir pool which recommends releases of 750 ML/day from the upper lakes to minimise the likelihood of persistent thermal stratification from forming.

The NRC and their experts proposed revisions to the minimum daily flow rules based on the latest science. These revisions reflect operations during summer 2024 and are as follows:

- **May – Sep (lower risk period for stratification):** 200 ML/day which is consistent with current minimum flow requirements
- **Nov – Mar (higher risk period for persistent stratification):** 750 ML/day. This contrasts to the current minimum daily flow for this period (300 to 350 ML/day)
- **Apr and Oct (shoulder period and nesting of riverine specialists):** 500 ML/day recognising that the window for persistent thermal stratification can extend to these months, particularly with climate change. The proposed flow rate for October is also intended to help support Murray cod nesting in the Lower Darling-Baaka River.[145]

Feedback from agencies indicates that while the proposed minimum daily flow rules would reduce the burden of the Water Quality Working Group in managing water quality events, there should be some flexibility in provision of minimum daily flows, depending on antecedent climatic and water quality conditions. The Panel understands the NRC will consider this further in its water sharing plan review report.

Table 16 Comparison of current and proposed minimum daily flows (MDF) to improve environmental outcomes in the Lower Darling-Baaka River[146]

Month	Current MDF[a] (ML/day)	Current Volume (ML)	Proposed MDF (ML/day)	Proposed Volume (ML)	Difference between current and proposed volume (ML)
January	350	10,850	750	23,250	12,400
February	350	9,800	750	21,100[b]	11,300
March	350	10,850	750	23,250	12,400
April	300	9,000	500	15,000	6,000
May	200	6,200	200	6,200	0
June	200	6,000	200	6,000	0
July	200	6,200	200	6,200	0
August	200	6,200	200	6,200	0
September	200	6,000	200	6,000	0
October	200	6,200	500	15,500	9,300
November	300	9,000	750	22,500	13,500
December	300	9,300	750	22,500	13,200
Total annual volume		**95,600**		**174,350**	**78,100**

Table notes:

a. Current requirements are set out in the NSW Murray and Lower Darling Work Approval and Objectives and outcomes for river operations in the River Murray System document. Clause 10.3 (d) of the objectives and outcomes document includes an additional requirement of 500 ML/day release when the Menindee Lakes storage is above full supply level.

b. Every four years an additional 750 ML of water will be required when February has a leap year (29 days).

The baseflow for Darling River upstream of Weir 32 (425012) in the Murray-Lower Darling Long Term Water Plan ranges from a minimum of 250 ML/day (April to August) and 1,100 ML/day (December to February) to a maximum of 2,000 ML/day. Proposed minimum daily flows fall within the baseflow range for higher risk periods for stratification and the very low flow range for lower risk periods.[147]

[145] Excerpt NRC (2024): It should be noted that other interventions may be required to support Murray cod nesting.
[146] Table taken from NRC (2024) *Improving outcomes in the Lower Darling-Baaka River: advice to the Connectivity Expert Panel* (minor formatting changes)
[147] Excerpt: NRC (2024) *Improving outcomes in the Lower Darling-Baaka River: advice to the Connectivity Expert Panel*

Additional considerations:

- **Significant volume required**: In order to meet the revised minimum daily flows, significantly more water would be needed on top of existing requirements. The additional volume necessary to meet the revised requirements is 78.1 GL per year not including evaporative losses. The majority of this volume would need to be reserved in the upper lakes as the intent of the releases is to mitigate water quality issues between the upper lakes and Weir 32. Flexibility for reducing flow rates when conditions are not conducive to poor water quality events should be further considered.
- **Releases from the upper lakes**: The majority of the minimum daily flows must be released from the upper lakes as their purpose is to mitigate risks between the upper and lower lakes. Ensuring the quality of releases is also essential to support basic river health in the Menindee weir pool. There needs to be adequate consideration of the ratio of releases from the upper lakes relative to Lake Menindee given the 'blocking' effect of Lake Menindee releases on flow through the Menindee weir pool, which can result in lentic (non-flowing) conditions in the river reach upstream of the junction with Menindee Creek. Flexibility for releasing flows from the lower lakes when conditions are not conducive to poor water quality events requires further consideration.
- **End of system flow requirements at Burtundy:** The proposed minimum flow rules would provide flows to the end of system at Burtundy in most months during normal conditions. They may not provide for end of system flows in all months given losses and lower minimum daily releases outside of high risk periods. Further provisions for supporting connectivity along the length of the Lower Darling-Baaka River may be required. These flows could be met by a combination of releases from the upper lakes and Lake Menindee.
- **Providing for flow variability:** Proposed minimum daily flows on their own will not be adequate to support all of the critical life stages of aquatic organisms or support riparian and floodplain vegetation communities. However, it is anticipated that flow pulses, natural events and informed environmental water deliveries will provide for some variability and contribute towards improved productivity.[148] Rules that allow for daily variability in the flow rate thresholds to avoid constant flow deliveries should be considered further.
- **Rules need to be reasonable to operationalise:** In the lead-up to, during, and in the months following, the fish deaths the Water Quality Working Group was given responsibility for making decisions, often daily, about releases based on water quality. While this provided rapid response to water quality data it is not feasible to maintain this level of staff resourcing for decision-making on an ongoing basis. Therefore, in assessing options the NRC considered the operational feasibility of proposed rules in addition to outcomes.

  It was determined that it is too time intensive for the Water Quality Working Group to collectively monitor and adjust flow rates on a daily basis. A set of rules and processes should be developed and agreed to which establishes responsibilities for monitoring water quality conditions and allow for some flow variability including the release of flow pulses to respond to adverse conditions in consultation with the Water Quality Working Group. The proposed minimum flow rules have been demonstrated to achieve objectives most of the time and are deemed adequate to mitigate risk in combination with response to water quality results using the EWA when necessary.

[148] Excerpt: NRC (2024) *Improving outcomes in the Lower Darling-Baaka River: advice to the Connectivity Expert Panel*

6.5.2 Revised Lower Darling EWA for flow pulses

Advice provided by the NRC indicates that there is a need for making the Lower Darling EWA available when the lakes are under NSW control. This option was examined in the development of the NSW Murray and Lower Darling Water Resource Plan and Western Regional Water Strategy. The revised minimum daily flows outlined above would help to mitigate persistent stratification in the Menindee weir pool and reduce reliance on the EWA. However, flow pulses may still be necessary when minimum daily flows are insufficient for managing water quality and the EWA should provide for these pulses.[149]

The NRC advised that to be effective in managing water quality events in the Menindee weir pool, the Lower Darling EWA would need to be stored and released from the upper lakes and flow pulses up to 1,500 ML/day would be required to disrupt persistent thermal stratification. The EWA would therefore need to be included in the volume reserved in the upper lakes.[150]

The NRC has advised the Panel that if the minimum daily flow requirements are increased, the 30 GL EWA may be adequate in most years to provide for these pulses. However, as conditions are highly variable, there may be years when this is insufficient and therefore recommended "top up" of the EWA which will be further explored. The NRC has also proposed that carryover of the EWA should be considered. The Panel supports these recommendations.

6.5.3 Greater clarity for Lower Darling Restart Allowance

Advice from experts and those involved in a previous restart of the river in March 2020, indicates that the current restart allowance volume of 60 GL is adequate to restart the Lower Darling-Baaka River when it has completely stopped flowing. However, river restarts will require consideration of drought management actions (e.g. removal of block banks that may have been installed in the river for domestic and stock needs) and guidance on water quality and flow related matters (e.g. the restart hydrograph) to mitigate perverse outcomes associated with water quality issues that could arise during a restart.

In the Interim Report, the Panel raised concerns over the Department's logic for when the 60 GL was proposed to begin to be stored in the upper lakes. Our understanding is that this is only needed when the river has completely ceased to flow, in order to 'restart' the river without creating significant water quality issues. As such, it does not need to begin to be stored when the lakes drop below 195 GL. Rather, it can be accumulated once flows begin again after an extended drought.

It would be more efficient to wait until the river upstream is flowing again, and it is feasible to maintain flow in the river, and then accumulate the volume needed to properly restart the river. Short-term storage may be required while an adequate volume for the restart is accumulated for managing water quality risks and to ensure poor quality inflows are not released directly downstream. [151]

6.6 Volumes required to meet critical needs

The NRC provided advice regarding the storage volume required to provide for priority needs in the Lower Darling-Baaka River. The NRC calculated the volume of the priority needs reserve using the water balance approach applied in Department's resource assessment process[152]

[149] Excerpt: NRC (2024) *Improving outcomes in the Lower Darling-Baaka River: advice to the Connectivity Expert Panel*
[150] Excerpt: NRC (2024) *Improving outcomes in the Lower Darling-Baaka River: advice to the Connectivity Expert Panel*
[151] Excerpt: NRC (2024) *Improving outcomes in the Lower Darling-Baaka River: advice to the Connectivity Expert Panel*
[152] Excerpt NRC (2024): Resource assessments, fundamental to water allocations, calculate the volume of water that must be retained in a 'priority reserve' to satisfy future priority needs over a defined planning horizon. These

that underpins the issuing of water allocations in NSW.[153] This includes a consideration of the following factors: planning horizon, commitments, overheads and minimum inflows.

6.6.1 Upper lakes inadequate to guarantee risks are fully mitigated

The Department's water resource assessment process is used in NSW to determine how much water is necessary to reserve in dams to ensure that critical needs are met during extended dry periods. The NRC applied the same approach as used in storages upstream to estimating storage needs in Menindee Lakes.

The results of this analysis indicate that if the minimum daily flow rules proposed are adopted, and a 24-month planning horizon – as used in nearly all valleys upstream – is applied along with reasonable estimates of evaporative losses, it is not physically possible to store the volume of water necessary in the upper lakes. The NRC found that without inflow most of the accessible capacity of the upper lakes (around 450 GL)[154] would be needed to provide priority needs and account for evaporation over a 12-month planning horizon. The NRC noted that a 12-month planning horizon is substantially shorter than the planning horizon generally applied in comparable valleys and that shorter planning horizons increase the risk of insufficient water for priority needs.

Longer term additional flexibility in the revised minimum daily flows should be investigated including the portion that can be released from the lower lakes and options for reducing flow rates when conditions are not likely to contribute to water quality issues. This flexibility may reduce some of the volume required to be stored in the upper lakes to meet priority needs reducing the risk of insufficient water for priority needs.

Ultimately, the Government will need to determine what level of risk is acceptable when determining how much water is stored in the upper lakes for critical needs. This decision-making should be transparent so stakeholders understand the risks and approaches adopted to mitigate these risks.

The NRC undertook additional analysis of the impact on the storage volume arising from varying the key factors. Where possible, the potential risk of insufficient water for priority needs was calculated. They concluded that in order to mitigate risk to the extent possible, the upper lakes should be kept as full as possible, lower priority demands reduced or removed and a mechanism to increase the volume of inflow when needed to top up the lakes be implemented. However, even with this approach, the risk of insufficient water for priority needs will likely be higher than the risk profile established in other plan areas. Broader water reform across the Northern Basin would be needed to align these risk profiles.[155]

6.6.2 Calculating the volume of priority storage reserve required

There are several assumptions that can be varied in the resource assessment, which will impact on the amount of water that needs to be stored, but also the risk that the volume will be inadequate to meet the specified needs.

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assessments seek to maintain adequate reserves even during dry and drought periods. Water exceeding the reserve can be allocated for lower priority needs. This ensures that allocations for lower priority needs are made only when there is a surplus of water for priority needs, in line with the Act's requirements.

[153] Excerpt: NRC (2024) *Improving outcomes in the Lower Darling-Baaka River: advice to the Connectivity Expert Panel*

[154] In the Interim report the Panel reported that 238-290 GL would be needed to meet 12 months critical need. This was based on the assumption that the 195 GL proposed by the Department was adequate to supply needs for 12 months other than additional flows for the increased minimum daily flow. The NRC undertook additional analysis of full needs expected for 12 months and found that the 195 GL estimate was likely insufficient to provide for critical needs and evaporative losses.

[155] Excerpt: NRC (2024) *Improving outcomes in the Lower Darling-Baaka River: advice to the Connectivity Expert Panel*

Planning Horizon: The planning horizon for the Lower Darling-Baaka River is identified in the water allocation methodology[156] and incidence response guide as 24 months.[157] Historically, an 18 to 24-month planning horizon was used. For example, the planning horizon for Broken Hill's priority supply, when sourced from the Menindee Lakes, was 18 months[158] and the Murray-Darling Basin Agreement transition threshold to NSW control (480 GL) was generally considered to secure needs for 18 to 24 months.[159] However, the Western Regional Water Strategy[160] identifies 12 months for critical needs.[161]

The volumes necessary for critical needs are driven predominantly by the environmental requirements. The NRC's analysis assumes that the intent is to provide for the minimum flows for the duration of the planning horizon. As outlined below if the assumptions around the amount of water necessary for environmental (or other needs) are varied, then a longer planning horizon can be sustained.

Commitments: Storage volumes are based on the volume of water required to deliver priority commitments over the planning horizon. The priority commitments for the Lower Darling-Baaka River (Table 14) include water for basic human and environment need as well as regulated river (high security) entitlements. The volume of priority human commitments (including high security entitlements) for the Lower Darling-Baaka River is relatively small totalling 9.5 GL/y. Priority environmental commitments based on revised needs total 204 GL/y. Adding the priority human commitments of 9.5 GL results in a total priority commitment volume of 214 GL. Other commitments, such as general security entitlements and commitments to the shared resource were excluded from the analysis.[162]

Table 17 Volumes of priority water commitments identified in Plan and water allocation methodology[163] and revised environmental commitments.[164]

Priority water commitments	Current volume (ML)[165]	Recommended revised volume (ML)
Basic landholder rights	445#	No change: 445
Domestic and stock licences (100%)	1,341	No change: 1,341
Local water utility (100%)	422	No change: 422
High security (100%)	7,771	No change: 7,771
Minimum daily flows	95,600	174,350
Lower Darling EWA	0 or 30,000*	30,000
Total	**105,579 or 135,579**	**213,884**

Basic landholder rights are considered to be achieved through minimum daily flows and are not considered a commitment as part of the resource assessment
* 0 ML when operated as a NSW resource and 30,000 ML when a shared resource

[156] NSW DPE (2022) *Water Allocation in the Regulated Lower Darling River*
[157] Excerpt NRC (2024): The Incidence Response Guide specifies a 24-month planning horizon; page 19: 'The critical planning period for the Lower Darling regulated river system is two years, consistent with the lowest inflow sequence experienced during the 2013 to 2016 period.'
NSW Department of Planning, Industry and Environment (2019) *BASIN PLAN 2012 NSW Murray and Lower Darling Surface Water Resource Plan Incident Response Guide Schedule G*
[158] NSW DPE (2022) *Water Allocation in the Regulated Lower Darling River*
[159] NSW DPE (2022) *Water Allocation in the Regulated Lower Darling River*
[160] NSW Department of Planning and Environment (2022) *Regional Water Strategy Western December 2022*
[161] Excerpt: NRC (2024) *Improving outcomes in the Lower Darling-Baaka River: advice to the Connectivity Expert Panel*
[162] Excerpt: NRC (2024) *Improving outcomes in the Lower Darling-Baaka River: advice to the Connectivity Expert Panel*
[163] NSW DPE (2022) *Water Allocation in the Regulated Lower Darling River*
[164] Table taken from NRC (2024) *Improving outcomes in the Lower Darling-Baaka River: advice to the Connectivity Expert Panel*
[165] NSW DPE (2022) *Water Allocation in the Regulated Lower Darling River*

Overheads: Storage volumes need to account for system overheads. These account for losses through evaporation, infiltration, conveyance, and system operations. Volumes lost to evaporation represent the largest overhead in the Lower Darling-Baaka River and can reduce the volume of water stored in the lakes by up to 40% over a year.[166] Total evaporation varies based on physical and atmospheric factors and cannot be accurately measured resulting in uncertainty and ranges of evaporation losses.[167] Currently available data on evaporative losses from the lakes are limited. The amount of evaporation will vary considerably based on climatic conditions and the volumes in the lake, which are continually changing. While WaterNSW have various evaporative loss scenarios they are based on estimates with known limitations and large uncertainty, particularly under climate change. To assess evaporative losses more accurately, a model that considers these factors would be needed. The high rates of evaporation substantially increase the storage reserve volume necessary even over shorter planning horizons. Approaches which rely more heavily on inflow may help to reduce the evaporative losses.[168]

Minimum inflow: Resource assessments for the Menindee Lakes assume zero inflow over a 12-month period and would likely assume zero inflow for a 24-month period if including the Millenium Drought. [169] This is consistent with how minimum inflows are assessed in other systems. Assuming higher inflows decreases the storage volume required but carries risks of insufficient water for priority needs if these inflows don't eventuate.[170] The NRC has undertaken some analysis to identify how changes in assumptions around the minimum inflow would vary the risk that the lakes are unable to provide for commitments.

6.7 Proposed approach

The Panel's analysis indicates that the current Menindee trigger of 195 GL for restricting floodplain harvesting to provide for flows when the lakes are low is not adequately supported by evidence. Further, the in-valley "relaxation triggers" mean that very little floodplain harvesting would be restricted by current rules.

The proposed "critical dry condition" trigger for Menindee Lakes would restrict all take upstream when the upper lakes fall below 195 GL active storage in the upper lakes. This would be more effective, but it still not based on an up to date evidence-based assessment of likely needs downstream, or when those needs are likely to be at risk of being met.

The Panel has considered the NRC's analysis and supports an alternative approach to managing volumes in Menindee Lakes as outlined in the following sections, including:

- Separating the upper lakes from the shared resource so that all water available can be used to fulfill environmental and human health needs and managing the upper lakes to keep them as full as possible
- Implementing the revised minimum flow rules proposed by the NRC
- Ensuring the EWA is available at all times, and considering options to allow it to be carried over and/or "topped up" in years when it is depleted
- Further analysis of whether an additional trigger to "refill" the lakes is necessary
- Implement infrastructure solutions

[166] NSW Department of Planning and Environment (2022) *Regional Water Strategy Western December 2022*
[167] Excerpt: NRC (2024) *Improving outcomes in the Lower Darling-Baaka River: advice to the Connectivity Expert Panel*
[168] Excerpt: NRC (2024) *Improving outcomes in the Lower Darling-Baaka River: advice to the Connectivity Expert Panel*
[169] NSW DPE (2022) *Water Allocation in the Regulated Lower Darling River*
[170] Excerpt: NRC (2024) *Improving outcomes in the Lower Darling-Baaka River: advice to the Connectivity Expert Panel*

6.7.1 Separate out the upper lakes from the shared resource

Over the past 18-24 months the operation of the lakes has been revised in recognition of the importance of releasing water from the upper lakes (Pamamaroo and Wetherell) to manage water quality in the Menindee weir pool and mitigate 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 River is roughly 30 kilometres downstream of Main Weir. Therefore releases from Lake Menindee are not effective for managing water quality events in this reach.

The NRC analysis suggests the upper lakes should be reserved for NSW priority needs, and that the upper lakes be kept as full as possible. This would mean separating out the upper lakes from the "shared resource" such that lower priority commitments including regulated river (general security), the shared consumptive pool (including annual dilution flows), and commitments arising from trade would only be released from the lower lakes. This would require agreement from other relevant states and changes to the MDB agreement and O&O document.[171]

The proposed revised environmental provisions require an increased volume of water to be stored and released from the upper lakes. Reducing or removing lower priority demands from the upper lakes would assist in supporting environmental requirements in the Lower Darling-Baaka River. However, when operated as a NSW resource the majority of the lower priority commitments are held by environmental water holders and have been used to manage water quality events. The Panel is of the view that with improved rules the held environmental water would not need to be relied upon to provide basic water quality. It is our understanding that held water can be delivered from any of the lakes. The CEWH should be consulted on any changes to ensure they are fair and equitable.

The Panel understands that current practice is to direct water to the upper lakes before the lower lakes, as they have less evaporative losses, so maintaining the upper lakes as full as possible would be consistent with current practice. Modelling indicates that if the Panel's proposed baseflow and resumption of flow rules were implements around an additional 50 GL/yr of water, on average, should be delivered to Menindee Lakes.

In addition, there is currently a trial ongoing to allow Commonwealth held environmental water to be protected through Menindee Lakes. We understand the volume of water available in this trial is in the order of 40 GL. The Panel supports implementation of rules to ensure that held environmental water is protected through the system. However, we also note that basic water quality is meant to be provided for through water sharing plan rules, or the O&O, and held water is meant to provide additional environmental benefits.

6.7.2 Implement updated minimum daily flows

Table 13 (see Section 6.5.1) compares existing and proposed minimum daily flow requirements and the volumes required to deliver them. Revised minimum daily flows need a significant additional volume of water on top of existing requirements (78.1 GL per year not including evaporative losses).

The proposed revisions to minimum daily flows would increase flow during high risk periods to manage persistent thermal stratification. This period has traditionally been December to March, but recent monitoring indicates this high risk period should be extended, hence a higher flow rate of 750 ML/day is proposed for November to March. They would also increase flows in April and October to provide adequate flows during the "shoulder" period between the historically higher and lower risks months.

[171] Excerpt: NRC (2024) *Improving outcomes in the Lower Darling-Baaka River: advice to the Connectivity Expert Panel*

The Panel's proposed rules to enhance connectivity in the Northern Basin would provide additional flow into the lakes, which could help support the increase in minimum daily flows. Additional water would be necessary from storages in other months to ensure that adequate water is available to deliver the releases. Feedback from agencies on the NRC's analysis indicates that outcomes may be improved if the daily minimum flow rules have some flexibility in them to allow flow variation that is beneficial for ecological outcomes. Additional flexibility regarding release location and flow rates should be considered based on an adaptive management approach.

The proposed minimum daily flow rules are based on evidence collected during the response to the recent fish deaths. Conditions in the river may change over time and the Panel supports adaptive management to reassess minimum flows periodically to ensure they are adequate to achieve outcomes and identify if they can be reduced. The rules should also be revisited if new infrastructure such as permanent fishways are installed or other infrastructure changes occur.

Given that the analysis indicates that the total storage volume of the upper lakes will be unable to provide priority commitments for more than 12 months during very dry times, consideration should be given to alternative operating approaches in these times. The Minister for Water can exercise discretion over the minimum daily flow releases and could do so during drought periods when the lakes are at risk of approaching dead storage. A process should be established for these events that requires concurrence between the NSW Minister for Water and the NSW Minister for the Environment to determine revised volumes of water available for the environment allowing for consideration of critical human water needs. During these events a Water Quality Working Group chaired by NSW DCCEEW-Water should advise on appropriate release rates. A clear process for when to consider shifting operations should also be established.

6.7.3 Revising EWA provisions

Currently the EWA is only available when the lakes are operated as a shared resource. This means in dry times there is no EWA available to help mitigate environmental impacts. Consistent with the NRC's advice, the Panel recommends that the Department should revise the EWA rule to ensure that it is available whenever it may be needed.

There is also evidence that the 30 GL volume of the allowance has been inadequate to meet needs. Increasing the daily minimum flow values should considerably reduce the need to rely on the EWA for meeting water quality needs. However, as noted there will still be times where the EWA is necessary for pulsing to maintain water quality. Given the high variability of inflows to Menindee the NRC has recommended that consideration should be given to "topping up" the EWA if it is forecast to be depleted within a particular year, as well as whether the EWA should be carried over if it is not fully used in any given year.

The Panel recommends that the upper lakes are set aside for storing and providing water for the environment and critical needs. As such our view is that any inflows, from protected planned environmental water or natural inflows, not necessary to meet minimum flow or other commitments under the water sharing plan rules should be allocated to an EWA. We understand there may be benefits to an EWA separate from the current water quality EWA to provide greater flexibility. Alternatively, the rules for the current EWA could be revised to clarify that the main purpose is for water quality, but excess environmental water could be used to achieve other outcomes.

6.7.4 Additional analysis of need for a "Menindee trigger"

The Panel outlined in the Interim Report our view that the volume of water in Menindee lakes is not a good indicator of whether the system is entering a critically dry period. The Panel is recommending that the upper lakes be fully reserved for fulfilling downstream environmental and human health needs and be kept as full as possible. However, there still remains a question of if and when it might be necessary to "top up" the lakes if they start to fall significantly below full storage, which has been determined as necessary to mitigate risk to the extent possible.

The proposed increase in minimum flows will use the water available more quickly than the previous minimum flows. As discussed, the Panel's proposed rules will increase the availability of inflows. However, there may still be a gap between the additional inflows and volumes needed to supply human health and environmental needs and maintain connectivity in the Lower Darling-Baaka River.

Given that the lakes cannot supply the volumes necessary under typical resource assessment processes it will be necessary to take a risk-based approach to determining any triggers. The Panel proposes this should be based on the risk of the lakes actually being depleted and not being able to provide for critical needs. However, the Menindee Lakes model currently has limited ability to assess this risk due to the model inaccuracies associated with low flows, leading to modelled storage rarely if ever depleting to zero.

Once the Government has determined which of the Panel's rules are intended to be implemented and the likely contribution of those rules, as well as any changes to held environmental water, further analysis should be undertaken regarding the potential need for any additional flows into the Menindee Lakes. This should consider:

- When additional water is likely to be needed to provide for a potential drought. The volume of water stored in Menindee Lakes combined with expected inflow could inform a "trigger" for imposing additional restrictions on take in the Northern Basin to provide additional inflows into the lakes.
- Opportunities to provide additional flows when they are most readily available. For example, consideration could be given to a partial restriction on high flows to ensure a larger volume reaches Menindee. The NRC has also recommended further examination of the possibility of "surcharging" the upper lakes to maximise storage when water is available.
- The Government's risk appetite, considering there will be times when the system cannot adequately provide for environmental needs.

6.7.5 Infrastructure solutions should be implemented

The Panel has made recommendations above based on steps we feel are needed in the immediate future. However, 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 and improving fish passage at Weir 32 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.

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.

6.8 Further considerations

The proposed changes to rules and operation of Menindee Lakes could be implemented when the lakes are operated as a NSW resource. However, when operating as a shared resource implementation of proposed changes would require the agreement and cooperation of other states who are members of the operational agreements. The Panel recognises that it may ultimately not be possible to implement the proposed strategies.

If interjurisdictional agreement is not achieved within a reasonable timeframe, the Panel recommends that alternate solutions be further examined, including:

- Other changes to the agreement around how the shared resource is managed from the upper lakes. NSW should continue to encourage management of the shared resource to continue to maximise stored volumes in the upper lakes particularly when transitioning to NSW control and to increase operational flexibility so that some of the shared resource is delivered from the upper lakes at a rate that achieves the revised minimum daily flows.
- The Department has also indicated that the shared resource should be delivered from Lake Cawndilla where possible and infrastructure options should be investigated to link Lake Cawndilla to the Lower-Darling Baaka.
- Further consider the need for a trigger to restrict upstream usage to maintain the volume in the upper lakes, taking into account the operating parameters.

6.9 Recommendations

8 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.

9 In order to improve risk management for the Lower Darling-Baaka River the Panel recommends:

   a. Separating the upper lakes from the shared resource so that all water available can be used to fulfill environmental and priority human needs and managing the upper lakes to keep them as full as possible.

   b. Implementing the revised minimum flow rules proposed in Table 13 of this report.

   c. Ensuring the Lower Darling environmental water allowance is available at all times, and considering options to allow it to be carried over and/or "topped up" in years when it is depleted

   d. Further analysis of whether an additional trigger to "refill" the lakes is necessary.

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

7 Unregulated River Water Sources

The expanded Terms of Reference requires the Panel to consider rules from all Northern Basin water sharing plans (regulated and unregulated) that in our view materially impact on hydrological connectivity. This is a significant task given there are 116 unregulated water sources in the northern Basin, many of which are broken-down even further into management zones[172]. Hence the Panel felt it appropriate to categorise and then prioritise the unregulated water sources it would focus on. The Panel has also drawn on reviews of unregulated river water sharing plans undertaken by the Natural Resources Commission in recent years.

The Panel applied the same principles (outlined in Chapter 2) as those used for the regulated water sharing plan rule analysis. This included the aim of trying to maintain equity between water users and to provide clear rule changes where possible. We have proposed rules to align with the proposed regulated water sharing plan rules, mainly to protect baseflow and occasional freshes during dry times, and to protect the first flush following an extended dry period.

7.1 Key Findings

29 The unregulated water sources of the Northern Basin can provide important contributions for connectivity. The cumulative entitlement across NSW unregulated water sources in the Northern Basin is significant (more than 600 GL not including the Barwon-Darling). 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.

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

31 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). There are risks with extraction limits not being enforced in unregulated plan areas, including uncertainty around LTAAEL exceedance and lack of action to address exceedance.

32 There are several limitations and inequities with current rules that impact on connectivity including the extensive use of “no visible flow” rules, which are inadequate to protect the water sources and their dependent ecosystems, lack of protection of flows protected in the regulated system that flow through the unregulated system and inequities in access rules between unregulated water sources adjacent to the Barwon-Darling and Barwon-Darling licence holders.

33 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 licences create difficulties for equitably restricting unregulated users to achieve connectivity outcomes.

[172] Namoi and Peel Unregulated – 31, Intersecting Streams Unregulated - 6, Barwon-Darling WSP -1, Gwydir Unregulated -28, NSW Border Rivers Unregulated -13, Macquarie-Bogan Unregulated 30, Castlereagh Unregulated - 7.

7.2 Unregulated systems can contribute significantly to connectivity

Unregulated systems provide important links between the regulated water sources and the Barwon-Darling and can contribute significantly to downstream connectivity. The unregulated rivers flowing directly into the Barwon-Darling River contribute around one third of the average inflows to the Barwon-Darling River[173]. In dry years they contribute freshes that may not pass through the adjacent regulated rivers. Daily access rules are therefore important to protect a proportion of these flows. In wet years the proportion can be greater since there are no large on-river dams to regulate the flows. This unregulated flow can contribute greatly to downstream flow variability and connectivity.

The cumulative entitlement across unregulated water sources is significant. At 100 percent allocation[174] the total volume of water available for extraction in the unregulated water sources of the NSW Northern Basin (excluding the Barwon-Darling) is 604,364 ML/y. For comparison, this is higher than the regulated river (general security) entitlement in any of the NSW Northern Basin valleys and is approximately three times the long-term average annual extraction limit for general security in the Gwydir regulated plan area. This extraction can indirectly impact connectivity by impacting flows into, and water allocations in, the regulated rivers. Therefore, managing unregulated river extraction is important for connectivity.

The proportion of entitlement to mean annual flow ranges in unregulated water sources from small in some water sources (less than 1% in the Murra, Culgoa, Moonie and Warrego water sources) to around 44% in the Ottleys Creek water source in the NSW Border Rivers. Other water sources with relatively large entitlements, compared to the mean annual flow, include the Lower Bogan (19%) and Lower Macquarie (25%). The cumulative impact of all this potential extraction cannot be ignored.

7.3 Limitation of current rules and implementation

Inadequate provisions for supporting connectivity and key ecosystem functions:
Current rules for many unregulated water sources do not adequately support connectivity or the health of water sources and their dependent ecosystems. Most unregulated water sources do not have flow-based access rules. Most water license holders in unregulated systems have “no visible flow” rules that allow users to pump water as long as there is visible flow past their pump, or from an in-river pool if there is visible flow from the pool. There is considerable evidence that this is not adequately protective of water sources and their ecosystems as highlighted in several Natural Resource Commission water sharing plan reviews, and risk assessments undertaken by the Department.

Licences carried over from the previous water management act (*Water Act 1912*) retained the former licence conditions, which were typically more restrictive than the “no visible flow” requirements. However, any new users typically receive “no visible flow” conditions. This is inequitable, and generally reduces environmental protection within those unregulated water sources where this occurs.

Lack of data regarding actual extraction in unregulated systems:
Currently, there is very limited information available on how much water is extracted in NSW Northern Basin unregulated plan areas, with the exception of the Barwon-Darling. The availability of data is changing as meters are rolled out under the Non-Urban Metering Strategy, with many of the larger pumps now having meters.

[173] Department of Planning and Environment (2022) *Building the river system model for the Barwon-Darling Valley unregulated river system.* Reference number: INT22/59396.
[174] 100% allocations have been made for each of these plans since they commenced.

Even if all licenced extraction was metered, the water sharing plans lack numeric LTAAELs against which to assess and manage extraction[175]. With the exception of the Barwon-Darling, the Department has not undertaken compliance assessments for unregulated rivers[176]. In the absence of a numeric LTAAEL and compliance system, the Department continues to provide 100% allocations to all unregulated licence holders.

While the Department has indicated they are examining options for undertaking compliance in the unregulated system, this is not yet implemented. Not only does this raise questions about overall levels of take in the unregulated water sources, it also creates potential equity issues between unregulated and regulated licence holders in the same catchment.

Inequity and lack of transparency between users in the same water source:
The variation in rules that govern when unregulated licensees can access their water between users in the same water source is sometimes inequitable. In addition, not all access rules are linked to the access licence stated in the water sharing plan – instead they are placed on the work approval for individual users. This is particularly the case in the Border Rivers water sources. This means that the rules governing take for these licences are not defined in the water sharing plan, resulting in an additional layer of complexity in tracking and enforcing the rules on these licences.

Also, within a water source the rules between management zones can differ from those on the main unregulated river. Access rules for the management zones in tributaries or attached water courses off the main river are less strict. Often the users in these zones only receive a no visible flow rule even though they take the majority of water extracted in the water source. Examples are as follows - in all instances the condition on their works approvals determines their access arrangements.

- Baradine Creek Water Source in the Namoi where 19,023 unit shares (98%) of the water source's 19,409 unit shares are in anabranches of the Namoi River, the largest being Turragulla and Gil Gil Creeks Trading Zone. The water sharing plan rules for Baradine Creek do not apply to these licences.
- Croppa Creek and Whalan Creek Water Source in the Border Rivers where 7,085 unit shares of the water source's 15,674 unit shares are in flood runners flowing from the Macintyre River to the Boomi River. The rule for the water source is visible flow at the pump.
- Pian Creek in the Namoi where 9,130 unit shares (70%) of the water source are not on Pian Creek.

Inequity between water sharing plans:
Many unregulated systems have different access rules to water sharing plans for adjacent and connected unregulated systems allowing some users to extract water when others cannot. The most pronounced example is in the unregulated water sources of the Castlereagh and Macquarie-Bogan that flow into the Barwon-Darling River. In these water sources, water can be extracted until there is 'no visible flow'. This means that while the Barwon-Darling users are restricted by A, B, and C class cease to pump rules and Individual Daily Extraction Components (IDECs)[177], the rivers supplying water directly to the Barwon-Darling have minimal access restrictions. There are even some locations where during higher flows, water

[175] Note that the 6 unregulated WSPs re-made in 2024 (including Border Rivers, Castlereagh & Intersecting Streams) now include a requirement for the Minister to determine and publish numeric LTAAELs to facilitate assessment of compliance, and (by year 6) to have reviewed the LTAAELs to ensure a sustainable level of take.
[176] NRC (2023) *Water Sharing plan reviews issue brief # 2: ensuring LTAAAELs are sustainable*
[177] Individual Daily Extraction Components (IDECs) are a provision of the Water Sharing Plan for the Barwon-Darling Unregulated River Water Source which sets the volume of water that can be extracted by an individual water access licence each day, but only when commence-to-pump thresholds have been reached. IDECs can be adjusted to assist with protecting water for the environment.

may back up from the Barwon-Darling River 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.

In addition, there are cases such as along the Boomi River in the NSW Border Rivers, where water protected in the regulated river flows out into the unregulated system, where it can then be extracted[178]. Any water that is protected for environmental purposes in the regulated system that subsequently flows through the unregulated system should be protected in the unregulated system as well.

Similarly, inconsistent access rules between regulated floodplain harvesting and unregulated access licences need to be addressed to ensure equitable access to water. 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 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.

Box 7 – Case study: Cumulative impact of water access on inflows to the Barwon-Darling

The Gwydir valley includes 28 unregulated river water sources. Some of these water sources provide a significant contribution to inflows entering the Barwon-Darling River. For example, Thalaba Creek is identified as one of three unregulated water sources (the others being Bogan and Castlereagh) that together contribute an estimated 10 percent of inflows to the Barwon-Darling River.[179]

Thalaba Creek has both unregulated access licences and floodplain harvesting (unregulated and regulated) entitlement as shown in Figure 13.[180] The combined entitlement is 8,344.5 ML (not including regulated floodplain harvesting, which may impact on flows).[181] This is currently accounted across both the unregulated and regulated Gwydir water sharing plans. Risks associated with floodplain harvesting (unregulated and regulated) are not reflected in risk assessments developed for Water Resource Plans as these assessments were undertaken prior to issuing of floodplain harvesting licences. The cumulative impact of the combined entitlement has not been assessed further.

Furthermore, floodplain harvesting in adjacent unregulated water sources could potentially impact on inflows to Thalaba Creek and ultimately the Barwon-Darling during higher flow events. Even without floodplain harvesting the large unregulated river entitlement held in Thalaba Creek Water Source was identified in the Gwydir Long Term Water Plan as posing a risk to connectivity with the Barwon-Darling.[182] However, this risk has not to date been addressed.

[178] NRC (2022) NSW Border Rivers Unregulated - Final Report - June 2022 (2).pdf (Sections 4.4 and 4.5). Also, note suggested action (SA 3) regarding upgrade of Neeworra Gauge to real time to allow transparent and enforceable access conditions to be implemented in the Plan area and enable assessment, management, and better modelling of flows in the Boomi River, including discharges to downstream water sources, and to understand connectivity with the Barwon-Darling.
[179] DPE (2022) Building the river system model for the Barwon-Darling Valley unregulated river system. Reference number: INT22/59396
[180] A Thalaba Creek management zone has been created for floodplain harvesting (regulated river) access licences. A total of 89,000 ML of unit shares has been issued for floodplain harvesting (regulated river) access licences in the Gwydir valley.
[181] The combined entitlement for Thalaba Creek Water Source is based on 5,831 ML of floodplain harvesting (unregulated river) access licence entitlement, 2,492 ML unregulated river access licence entitlement, 21.5 ML of domestic and stock access licences. The entitlement does not include regulated floodplain harvesting.
[182] DPIE (2020) *Gwydir Long Term Water Plan Part B: Gwydir planning units*

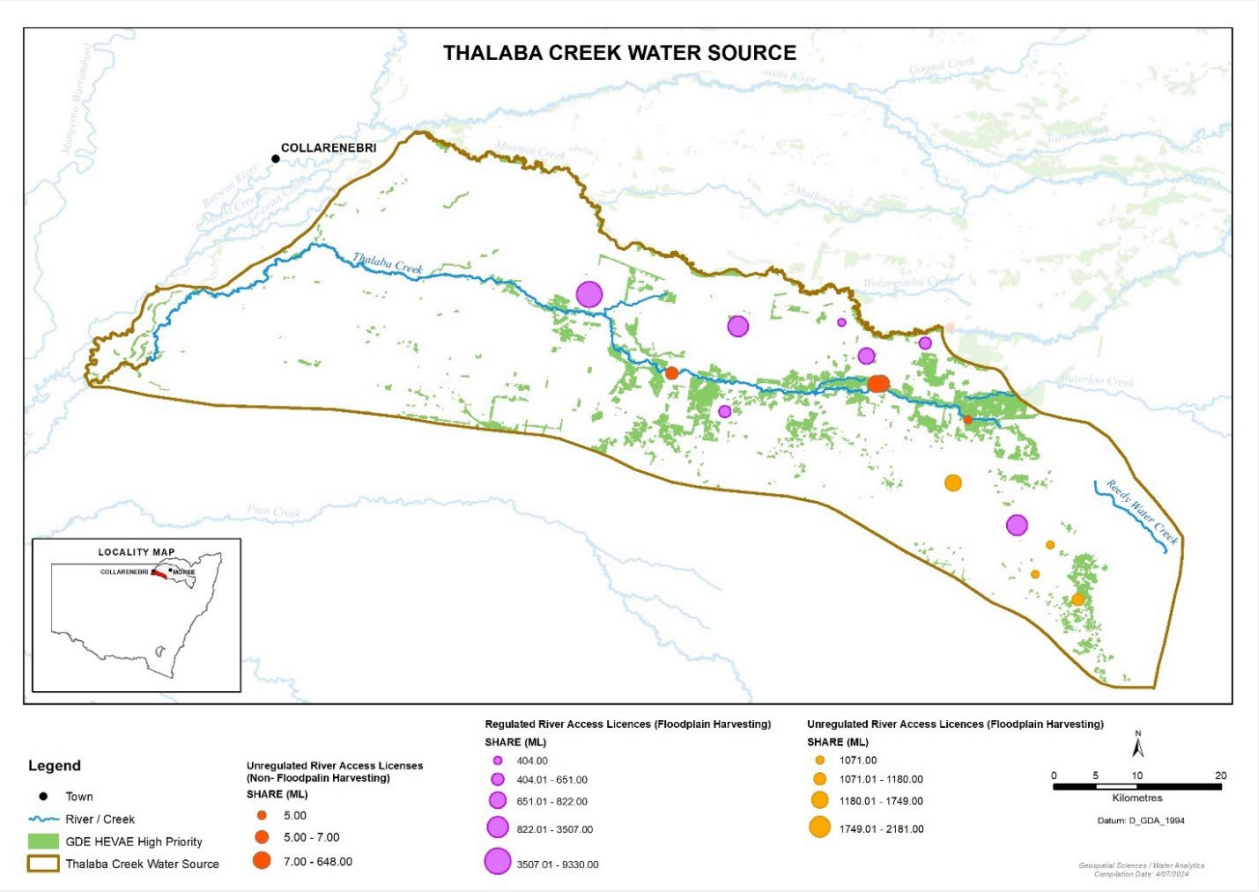

Figure 13 Location of unregulated access licences and floodplain harvesting (regulated and unregulated) licences in the Gwydir valley

7.4 Determining appropriate and equitable rules for connectivity

Setting rules for the unregulated rivers to provide for system connectivity requires several steps. First, deciding which water sources are considered a priority; second, categorising where the unregulated river is located relative to other rivers and thus how it affects connectivity; and third, applying consistent principles across water sources. Since the situations can be different, equity does not require the same rule is applied to all unregulated water sources, rather, that the same rule is applied for the same circumstances. These steps are set out below.

Priority unregulated river water sources for assessing connectivity

For this assessment the Panel adopted a shortlist of priority unregulated river water sources based on the Panel's amended Terms of Reference. The Panel understands the list in the Terms of Reference is based on advice from the Department and other NSW government agencies. The Terms of Reference included the Gwydir water source, but the Panel's review indicated the entitlements are largely upstream of the Lower Gwydir wetlands and so the restrictions we are proposing are unlikely to contribute significantly to downstream connectivity into the Barwon River. Hence, this water source was removed from the shortlist. The Panel also considered advice from the Department on which water sources were considered priority for potential 324 orders, as well as entitlement and flow data. Additional water sources were added to this list that were considered significant for connectivity with the Barwon-Darling (Figure 14).

At 100 percent allocation the total water available for extraction in these priority water sources is estimated to have an entitlement of 197,800 ML/y. This is comparable to extraction limits of 214,000 ML/year for the Barwon-Darling River. These priority water sources cover one third of total unregulated entitlement (excluding the Barwon-Darling) in the NSW Northern Basin.

Categories of water sources for setting access rules
Within the NSW Murray-Darling Basin there are five broad types of unregulated water sources identified for the purpose of understanding connectivity and setting access rules. These are:

1. **Upstream of major storages:** these water sources provide inflows to major storages and can directly affect water available in the regulated river and hence water allocations. For example, Tenterfield Creek in the NSW Border Rivers. They are not the focus of the Panel's advice on access conditions.

2. **Flow into regulated rivers downstream of major storages**: Flows generated in these water sources can influence connectivity in downstream regulated rivers. They can contribute flows that lead to announcements of supplementary events in downstream regulated rivers and influence the reliability of water allocations downstream. They can also be used to fulfill rules in the Plans such as end of system minimum flow rules.

3. **Anabranch or distributary channels that are connected to the regulated rivers:** extraction from these rivers can directly affect how much water leaves the regulated rivers system and then re-enters the regulated river system, and inflows to the Barwon-Darling. e.g. Pian Creek in the Namoi valley, Boomi River in the NSW Border Rivers.

4. **Unregulated rivers that directly flow into the Barwon-Darling:** rivers and streams that drain freely into the Barwon-Darling River (e.g. Intersecting Streams Unregulated Water Sources, Bogan River in the Macquarie-Bogan catchment).

5. **Unregulated water sources downstream of regulated rivers that flow into the Barwon-Darling:** water sources that drain into the Barwon-Darling but are located downstream of regulated river reaches (e.g. Lower Macquarie water source in the lower Macquarie catchment).

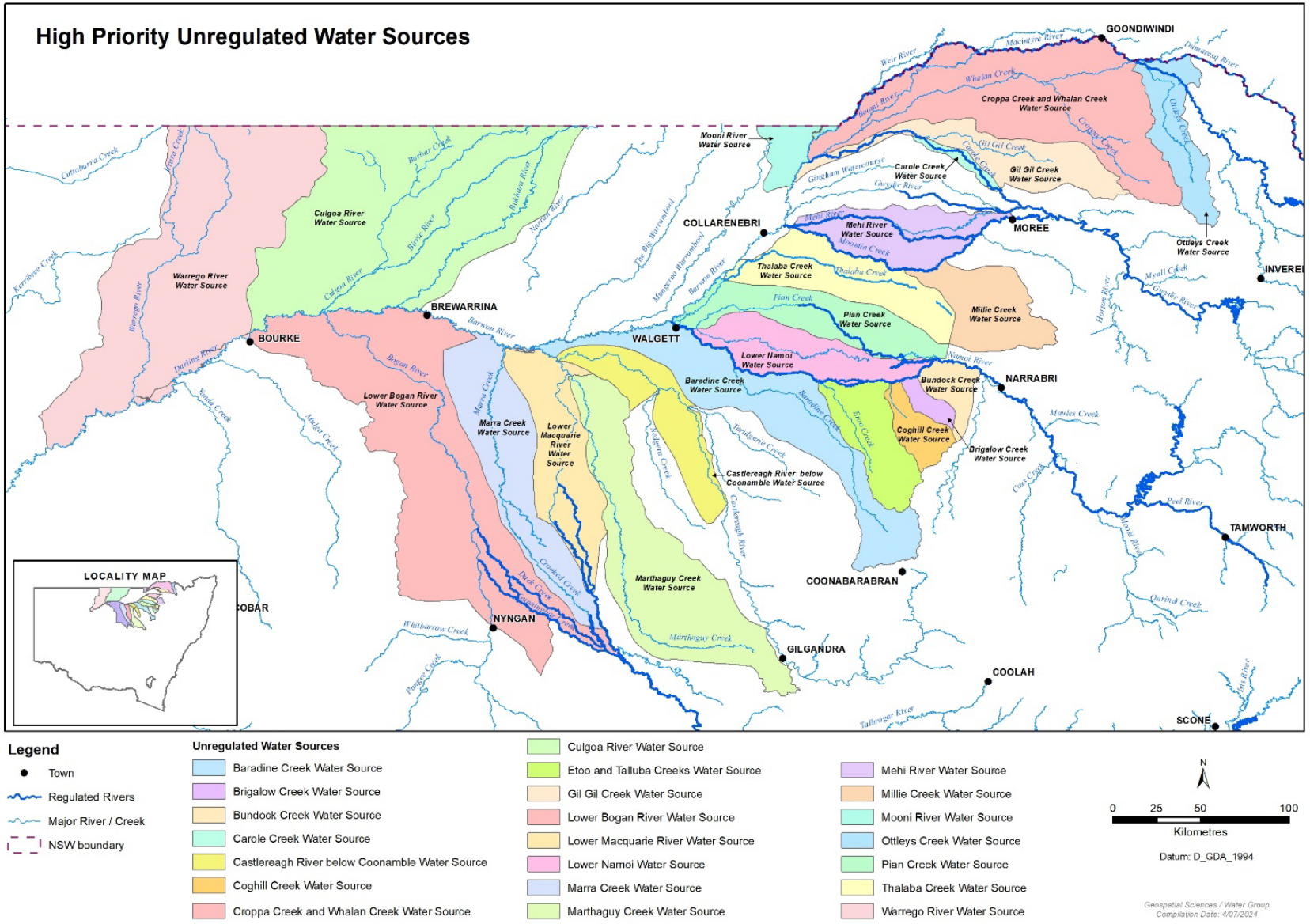

Figure 14 Priority unregulated river water sources for assessing connectivity

The Panel has considered categories 2-5 in its prioritisation of unregulated water sources relevant to system connectivity. The priority water sources together with their category are listed in Table 15. For each category a different set of water sharing rules is required. The timing of extraction is important. For example, those unregulated rivers between the regulated rivers and the Barwon-Darling should allow environmental water, specifically released or protected water from upstream water sources to pass through. Other rivers may directly contribute flows into the Barwon-Darling, so a portion of those flows should be protected for downstream connectivity consistent with regulated rivers.

Table 18 Categorised priority unregulated water sources for improving connectivity with the Barwon-Darling

Water sharing plan	Water Source	Category of unregulated water source
NSW Border Rivers Unregulated	Croppa and Whalan Creeks	3
	Ottleys Creek	4
Gwydir	Mehi	5
	Millie	4
	Thalaba	4
	Gil Gil	4
	Carole	3
Namoi and Peel Unregulated	Baradine	3
	Lower Namoi	3
	Brigalow	2
	Bundook	2
	Coghill	2
	Etoo and Talluba Creeks	2
	Pian	3
Macquarie-Bogan Unregulated	Lower Bogan	4
	Lower Macquarie	5
	Marra	5
	Marthaguy Creek	3
Castlereagh Unregulated	Castlereagh below Coonamble	4
Intersecting streams	Culgoa River	5
	Warrego	4
	Moonie	4

7.5 Proposed changes to rules for priority unregulated river water sources

The Panel offers the following recommendations when specifying rules for unregulated water sources to support system connectivity. These rules should apply to unregulated water access licences (not stock and domestic or local water utility licences).

Generally:

- Where rules in adjacent unregulated systems differ, they should be aligned to maintain consistency and equity and maintain environmental protections. Specifically, rules for water sources adjacent to the Barwon-Darling River should be subject to similar cease-to-pump rules as the Barwon-Darling, that protect baseflows. Alternatively, the Department should consider whether these water sources should be incorporated into the Barwon-Darling water sharing plan.
- The distribution and function of the gauging network across the unregulated catchments should be improved (as recommended in previous NRC water sharing plan reviews). The DEECCW-Planning team has indicated that currently established gauges in many water sources are inadequate to support flow-based cease-to-pump rules. However, other agency representatives were of the view that gauges deemed inadequate are adequate enough to implement cease to pump rules. A precautionary approach should be taken when assessing adequacy of gauges for implementing rules, which prioritises protection of environmental flows, including connectivity flows. In reviewing the gauging network:
    - Assessment should be made of whether it is possible to repair or recalibrate the gauges rather than replacing them.
    - If a cease to pump rule is not adopted due to poor gauging this should be clearly stated. The criteria for considering what would be adequate gauging and decision making processes should also be made transparent. This information should be publicly available.
    - The Panel notes there are several newer and less expensive technologies that should be considered if a gauge is difficult to implement or inaccurate.
- The Department should develop a plan for ensuring that any of the water sources identified as high risk for impacting connectivity (Table 15) have adequate gauging or employ alternative, new technologies to support the Panel's proposed rules within the next two years.

To provide improved flows during non-dry times:

- The Department should implement improved cease-to-pump rules in water sources identified as important for contributing to downstream connectivity (type 2-5). This would include:
    - Seeking to establish cease-to pump conditions using appropriate and transparent flow classes based on environmental and basic landholder needs and applying these consistently to licence holders of the same licence type within the same water source or management zone.
    - The rules should be based on flows past nearest appropriate gauge.
    - Rules should ensure a flow equivalent to baseflow at the bottom of the water source to help maintain connectivity through the system. Ideally these rules should be informed by baseflow EWRs from Long Term Water Plans (where available). Where baseflow EWRs are not available, more site-specific analysis may be required with advice from NSW DCCEEW-Water Science team, BCS, DPI-Fisheries and any other relevant groups within DCCEEW. Selection of the targets should be overseen by an independent body such as the NRC or the Panel.
- The DCCEEW Water Science team presented a hydrological risk assessment approach to the Panel that they have used to assess cease-to-pump rules for water sharing plan remakes in unregulated systems. Many of the water sources identified by the Panel have already been assessed by Water Science using this risk

assessment approach. The risk assessment process combines information on the degree of hydrological change in the water source (the 'likelihood') with the ecological values within the water source (the 'consequence'), to provide an overall risk rating for components of the flow regime. Based on the limited information available to the Panel, we found the risk assessment to be a reasonable approach.

  - The Panel recommends that the risk assessment process for water sharing plan remakes be reviewed by BCS, DPI-Fisheries and the NRC to ensure it addresses the risks appropriately, including cumulative risks of all forms of water take. The agreed upon risk assessment process should be made public (for transparency purposes) and, if necessary, assessments already completed should be updated to reflect any changes to the process.
  - In order to prioritise which water sources are considered first to improve system connectivity, the risk assessment approach undertaken by NSW DCCEEW-Water Science should be used once reviewed as per above. The Panel recommends that water sources with a medium or high risk rating for zero flow, baseflow and fresh flow components should be prioritised in the first instance.

- Implement restrictions on extraction in unregulated tributaries that drain directly into the Barwon-Darling (type 3-5) whenever there are restrictions in the regulated water sharing plan areas to achieve an annual small fresh or large fresh flow every other year, as outlined in the Panel's recommendations for regulated catchments.
- Implement active management where necessary to protect environmental or connectivity water (including held environmental water) that is protected in the regulated system and which subsequently flows into the unregulated system. This would also apply to environmental water protected in Queensland that flows through the Intersecting Streams unregulated water sharing plan area.

To provide for improved flow during dry times:

- Unregulated users should be restricted from accessing water while the resumption of flow rule restrictions are in place in the regulated water sharing plan areas and the Barwon-Darling (type 2-5).

A summary of these suggested approaches to rule setting in unregulated water sources and which water sources these apply to is provided in Table 16.

Table 19 Suggested approaches for setting rules in unregulated water sources to support connectivity

Water source type		Water sources	Additional access rule for connectivity
1	Upstream of major storages	Multiple	▪ Access rules not covered in this report. Compliance with LTAAEL is important for cumulative impact and reliability of regulated river end of system flows.
2	Unregulated rivers that flow into regulated river downstream of major storages	Brigalow Bundook Coghill Etoo and Talluba Gil Gil Ottleys Creek Baradine(part[183])	▪ Review cease-to-pump rules and in-stream pool drawdown rules to support downstream connectivity. ▪ During dry times, apply resumption of flow rule restrictions for unregulated access and floodplain harvesting licences
3	Anabranch or distributary channels that are connected to the regulated rivers	Croppa and Whalan Creeks Baradine (part[184]) Mehi Carole Lower Namoi Pian (part)	▪ Review cease-to-pump rules and in-stream pool drawdown rules to support downstream connectivity. ▪ During dry times, apply resumption of flow rule restrictions for unregulated access and floodplain harvesting licences ▪ During non-dry times implement restrictions to achieve an annual small fresh and periodic large fresh as outlined for regulated catchments.
4	Unregulated rivers that directly flow into the Barwon-Darling	Thalaba - Millie Castlereagh below Coonamble Lower Bogan Warrego Moonie	▪ Review cease-to-pump rules and in-stream pool drawdown rules to support downstream connectivity. ▪ During dry times, apply resumption of flow rule restrictions for unregulated access and floodplain harvesting licences ▪ During non-dry times implement restrictions to achieve an annual small fresh and periodic large fresh as outlined for regulated catchments.
5	Unregulated water sources downstream of regulated rivers	Lower Macquarie Marra Marthaguy Creek Culgoa River	▪ Review cease-to-pump rules and in-stream pool drawdown rules to support downstream connectivity. ▪ During dry times, apply resumption of flow rule restrictions for unregulated access and floodplain harvesting licences ▪ During non-dry times implement restrictions to achieve an annual small fresh and periodic large fresh as outlined for regulated catchments. ▪ Implement active management consistently to protect water that is protected for environmental or connectivity purposes in the regulated system which flows into the unregulated system.

[183] Turragulla and Gil Gil Creeks Trading Zone of Baradine Creek
[184] Remainder of Baradine Creek Water Source

7.6 Recommendations

11 In order to improve equity of rules between plans:

a. Rules for water sources adjacent to the Barwon-Darling River should be subject to similar cease-to-pump rules as the Barwon-Darling, that protect baseflows. Alternatively, the Department should consider whether these water sources should be incorporated into the Barwon-Darling water sharing plan.

b. Align the floodplain harvesting rules in the unregulated and regulated water sharing plans.

12 Improve the distribution and function of the gauging network across the unregulated catchments. The Department should develop a plan for ensuring that any of the water sources identified as high risk for impacting connectivity have adequate gauging to support necessary rules within the next two years.

13 Implement cease-to-pump rules in water sources identified by the Panel as important for contributing to downstream connectivity. This includes establishing cease-to pump conditions using appropriate flow classes based on environmental and basic landholder needs and applying these consistently to licence holders of the same licence type within the same water source or management zone. The rules should be based on flows past specified gauges and ensure a flow equivalent to baseflow at the bottom of the water source to help maintain connectivity through the system. These conditions should replace existing no visible flow and instream pool draw down rules. Issues related to gauge reliability should be considered along with the precautionary principle, prioritising protection of flows that help improve connectivity.

14 The existing hydrological risk assessment approach developed by DCCEEW Water Science team should be reviewed and revised if necessary to fully address connectivity risks and then used to prioritise water sharing plans for rule changes and determine appropriate cease to pump rules.

15 Implement restrictions on extraction in unregulated tributaries that drain directly into the Barwon-Darling whenever there are restrictions in the regulated water sharing plan areas to achieve an annual small fresh or large fresh flow every other year, as outlined in the Panel's recommendations for regulated catchments.

8 Modelling Results and Impacts

A preliminary assessment of the downstream flow benefits and diversion impacts of key connectivity rules proposed by the Panel has been undertaken using the Department's river system models. These models were developed by the Department as tools for: guiding water management policy decisions; developing and reviewing water sharing plans; and monitoring and reporting of annual average diversions and environmental outcomes.

To assist the Panel with estimating the potential benefits and impacts associated with the proposed connectivity rules, the Department undertook scenario modelling utilising the following river system models:

- Border Rivers regulated river system model (Source)[185]
- Gwydir Valley regulated river system model (IQQM)[186]
- Namoi Valley regulated river system model (Source)[187]
- Macquarie Valley regulated river system (IQQM)[188]
- Barwon-Darling Valley unregulated river system model (IQQM)[189]
- River Murray and Lower-Darling River systems model (Source – MDBA)[190]

The modelling that was undertaken by the Department for the Panel was preliminary in nature due to the limited timeframe available for modelling and the complexities associated with running six different river system models.[191] The models that were used to assess the Panel's proposed rules were generally consistent with the models utilised in the recently completed Western Regional Water Strategy. However, it is understood that further refinement of the models (including the redevelopment of the Namoi Source Model) has been undertaken by the Department in recent times and these updated models are expected to be utilised by the Department to further assess the proposed connectivity rules as part of the formal water sharing plan review process.

As the modelling undertaken for the Panel was preliminary in nature, the proposed connectivity rules have not been fully optimised to maximise benefits and/or minimise impacts. In particular, further refinement of the rules may (in some cases) lead to the Panel's proposed connectivity objectives being largely met with lesser impact on water users.

It should be noted that, for the purposes of the Final Report, the Panel specified the scenarios to be modelled by the Department and requested key outputs (average annual statistics and daily timeseries data) be provided. As such, the Panel did not directly access the models and verification of model setup and outputs was undertaken by the Department.

[185] NSW Government DPIE (2020) Building the river system model for the Border Rivers Valley regulated river system
[186] NSW Government DPE (2022) Building the river system model for the Gwydir Valley regulated river system
[187] NSW Government – DPE (2022) Building the river system model for the Namoi regulated river system
[188] NSW Government – DPE (2023) Building the river system model for the Macquarie Valley regulated river system
[189] NSW Government – DPE (2022) Building the river system model for the Barwon-Darling Valley unregulated river system
[190] Types of water modelling | Murray–Darling Basin Authority (mdba.gov.au)
[191] In undertaking the model scenarios, the EOS flow outputs from the four major tributary models are used as key inputs to the Barwon-Darling model, and the EOS flow output from the Barwon-Darling model is used as a key input to the River Murray and Lower-Darling model.

8.1 Key Findings

34 Modelling results indicate that the Panel's proposed baseflow and resumption of flow rules combined are likely to largely achieve the expected baseflow, small fresh and large fresh targets the Panel has identified. Proposed rules for the unregulated water sharing plans and floodplain harvesting, which cannot be accurately modelled would further contribute to fully meeting the targets.

35 Modelling results indicate that on average the combined baseflow and resumption of flow rules proposed by the Panel have a less than a four percent impact on diversions across the Northern Basin, with around six percent average impact in the three upper valleys. For comparison, the current rules in the water sharing plans taken from the North-West Flow Plan if implemented would have at least a three percent impact on diversions in the three upper valleys based on modelling using "perfect forecasting".

Limitations of the Department's surface water modelling

36 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 downstream benefits of rule changes.

37 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

38 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.

39 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.

40 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.

41 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. WaterNSW has indicated that with more experience forecasting will improve.

8.2 Modelled Scenarios

The following Connectivity Panel scenarios were modelled by the Department at the Panel's request:

Scenario 1: EOS Flow Targets	▪ End of system (EOS) flow targets in the major tributaries (in isolation)
Scenario 2: Revised RoF Rule	▪ Expanded Resumption of flow (RoF) rule, including restrictions in the major tributaries (in isolation) without FPH restrictions
Scenario 3: Combined Rules	▪ Combined connectivity rules (EOS flow targets and revised RoF rule) without FPH restrictions ▪ The benefits to Menindee Lakes due to increased EOS flows was also assessed

Several sub-scenarios were also considered, including different EOS flow targets and a limited analysis of the combined rules with FPH restrictions, with restrictions only applying to overbank harvesting (due to model limitations) and 100 % of the savings returned to the end of system. These are listed in Appendix F, along with summary results. Different EOS flow targets were explored to assess the potential impacts across the tributaries as evenly as possible.

The Panel focused on modelling the EOS flow targets and revised RoF rule, as these were expected to have the most significant impact on supporting the key connectivity objectives of improving baseflows, small freshes and large freshes. While the other proposed connectivity rules are also considered to be important, further modelling was unable to be undertaken at this stage due to time constraints and model limitations. Additional modelling that is proposed by the Panel to complete the analysis of the proposed rules is discussed in Section 8.5.

8.3 Model Results

Modelling results indicate that the Panel's proposed baseflow and resumption of flow rules are likely to largely achieve the expected baseflow, small fresh and large fresh targets the Panel has identified. This would provide substantial ecological, social and cultural benefits to downstream communities. These flows are vital for the long-term maintenance of ecosystem health in the Northern Basin rivers with baseflows enhancing water quality through reaches and providing flows to connect more permanent sections of the river. Small and large in-channel freshes are significant for fish movement as well as the spawning and recruitment of a range of species. These in-channel flows provide the healthy ecological background that allows the entire system to boom during periods of extensive over-bank floods, which occur less frequently. The baseflow results indicate over an additional month of baseflow on average in the Barwon-Darling, which will also provide important cultural benefits for communities.

The results indicate that on average the Panel's combined baseflow and resumption of flow rules have a less than 4% impact on diversions across the Northern Basin, with around 6% average impact in the three upper valleys. The Panel notes that this is likely to be on the high end of likely impacts as discussed further in Section 8.4.2. We also note that modelling indicates that if the North-West Flow Plan rules currently in the water sharing plans were being implemented that they would have over a 3% impact on diversions in the three upper valleys and approximately a 2% impact across the Northern Basin. As such the

difference in impacts on diversions from what should be experienced under current rules versus the Panel rules is likely less than 2-3% across the Northern Basin.

8.3.1 Flow benefits of modelled proposed rules

A summary of the downstream flow benefits that were achieved by the key connectivity scenario (i.e. Scenario 3: Combined Rules without FPH restrictions) are shown below in Table 17 and Table 18. Also included in the tables are:

- Base Case Scenario: which represents current conditions and water sharing plan rules (excluding the North-West Flow Plan rules, which have not been implemented)
- Without Development Scenario: which represents near-natural conditions, with all water infrastructure, water extractions, water management and operating rules removed from the model

Summary results for all scenarios are included in Appendix F.

The Panel has recommended that baseflow should be achieved during non-dry times. It is assumed prior to development that baseflow would have occurred most, if not all, of the time during non-dry times. As such, we've estimated that achieving baseflow at approximately the "without development" scenario levels would achieve our target of baseflow during non-dry times. Therefore, results are compared to the without development scenario as an indicator of our target percentage for baseflow achievement.

Table 20 Summary of Model Results for Combined Rules (Scenario 3) – Baseflow Outcomes: the percentage of time flows achieve or exceed the baseflow target under the Base Case, Combined Rules and Without Development modelling scenarios

Location	Baseflow Target ML/d	Base Case Scenario (Current Conditions)	Combined Rules (Scenario 3)	Without Development Scenario
Mungindi	160	58%	**74%**	68%
Collarenebri	280	49%	**59%**	66%
Walgett	320	55%	**63%**	74%
Bourke	600	69%	**75%**	75%
Wilcannia	350	66%	**72%**	78%

The modelled EOS flow targets significantly improve the proportion of time that baseflows are achieved, with an average increase of around 10% of the time (representing an increase of >1 month per year on average) across the five Barwon-Darling River gauge locations. Baseflows are now being achieved 69% of the time across the Barwon-Darling, compared to without development levels of 72%, and base case levels of 59%.

More refinement of the EOS flow rules could be used to further close this gap; however, the Panel expects there would be additional contributions from the unregulated systems, and non-exempt rainfall runoff floodplain harvesting to help achieve targets if recommendations for the unregulated water sources and floodplain harvesting rules are adopted (see Chapters 5 and 7). Given this, and the limitations of the modelling, the Panel is of the view there is a high likelihood that our proposed suite of rules will achieve the intended baseflow outcomes.

Table 21 Summary Model Results for Combined Rules (Scenario 3) – Small / Large Fresh Outcomes: showing the percentage of years the small fresh (14 days / Sept to Apr) and large fresh (15 days/ anytime) are achieved

Location	SF Target ML/d	SF Base Case Scenario	SF Combined Rules (Scenario 3)	LF Target ML/d	LF Base Case Scenario	LF Combined Rules (Scenario 3)
Mungindi	540	84%	**90%**	3,000	36%	**38%**
Collarenebri	650	86%	**90%**	4,200	58%	**61%**
Walgett	700	92%	**96%**	6,500	60%	**65%**
Bourke	1,550	82%	**90%**	15,000	52%	**52%**
Wilcannia	1,400	82%	**90%**	14,000	51%	**51%**

SF=Small fresh, LF=Large fresh

The combination of EOS flow targets and the revised RoF rule has resulted in significant improvements in the annual achievement of small freshes across all gauge locations, with more modest improvements in large freshes. The revised RoF rule is prioritising the achievement of a small fresh after an extended period of drought (where flows have fallen below baseflow for more than 90 days) and in some cases, protecting a full large fresh, as evidenced by the improvement in the achievement of large freshes in the upstream gauge locations.

This is further illustrated in the Figure 15 below, which demonstrates the combined rules in action and clearly shows the modelled improvement in flows at Wilcannia over a sample climatic period (July 2001 to July 2005). Figure 15 shows two small fresh events that would have been protected (in April 2003 and October 2004 – red peaks) by the revised RoF rule and improvements in baseflows in the non-dry periods, due to EOS flow targets. Note, a small fresh at Wilcannia is 1,400ML/d. The figure also demonstrates improved outcomes during small freshes that weren't protected by the revised RoF rule, but were supported by the improvement in baseflows, as shown in the inset figure.

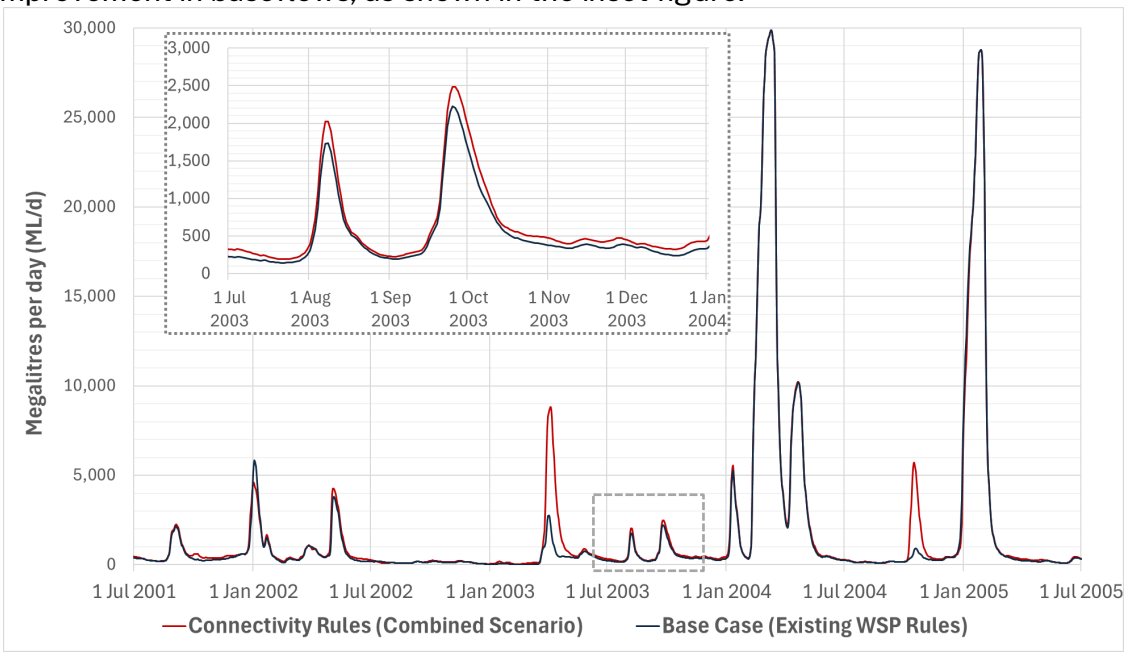

Figure 15 Modelled outcomes of proposed connectivity rules at Wilcannia (EOS flow targets and revised RoF Rule)

Results also indicate that the proposed rules would considerably improve inflows to Menindee Lakes, providing approximately 50 GL of additional annual flow on average in the Darling River at Wilcannia. This would assist with meeting the environmental and community needs of the Lower-Darling. The impact of increased inflows to Menindee Lakes is demonstrated in Figure 16, which shows the proportion of time the upper two lakes (Lake Wetherall and Lake Pamamaroo) exceed various volumes. For example, the proposed connectivity rules would increase the proportion of time the top two lakes exceed 200 GL total storage from around 85% to around 90%.

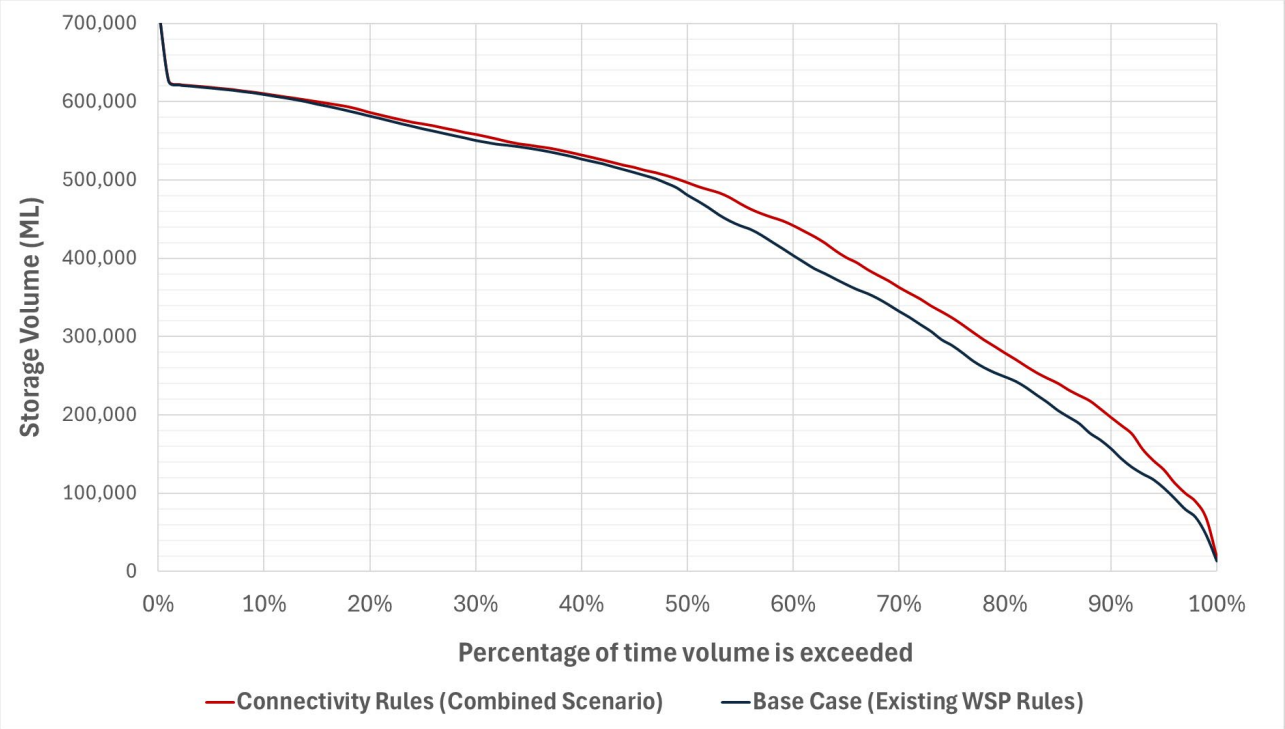

Figure 16 Modelled outcomes of proposed connectivity rules at Menindee Lakes (total storage volume in upper lakes – i.e. Lake Wetherall and Lake Pamamaroo)

8.3.1 Analysis of environmental water requirements achievement

A preliminary assessment of key model outputs was undertaken using the EWR assessment code[192] (EWR_tool), which was developed by the MDBA with input from NSW DCCEEW Biodiversity, Conservation and Science (BCS) Group[3][193]. The preliminary assessment of EWRs using the EWR_tool was undertaken with the assistance of the BCS Group, using model outputs provided by the Water Group modelling team outlined above[194].

The assessment focused on the achievement of baseflow and small fresh EWRs in the Barwon-Darling for various model scenarios, including the Base Case Scenario, the Combined Rules Scenario and the Without Development Scenario.

The long-term average achievement of baseflow and small fresh EWRs at key locations in the Barwon-Darling is summarised in Appendix F. The analysis shows that the Combined Rules Scenario generally results in significant improvements in baseflow outcomes, particularly for the BF1_b EWR, which seeks to ensure minimum baseflow requirements in

[192] https://github.com/MDBAuth/EWR_tool
[193] NSW long-term water plans environmental water requirement assessment code description
[194] BCS Group assisted in running the EWR tool to produce the EWR achievement metrics presented in Appendix F, while analysis and interpretation was undertaken by the Panel.

all years (particularly dry years). It also demonstrates a significant improvement in the number of years the small fresh is achieved within the inter-event period targeted.

BCS undertook post-processing of previous model outputs to improve the assessment of EWR achievement for baseflow, very low flow and cease to flow events because the current Barwon-Darling IQQM is prone to overestimating low flows. Due to time limitations, post-processing of model outputs was not undertaken for the EWR results provided for the Panel. However, the Panel supports such post-processing analysis to address the known low flow issues with the model.

8.3.2 Impact on diversions of modelled proposed rules

The estimated impact of the proposed connectivity rules on diversions within each valley, based on the Department's preliminary modelling, is shown in Table 19.

Table 22 Preliminary Estimate of Average Annual Impact on Diversions from Connectivity Rules

Valley	EOS Flow Targets (Scenario 1)	Revised RoF Rule (Scenario 2)	Combined Rules without FPH Restrictions (Scenario 3)
Border Rivers	-5.7%	-3.0%	**-8.0%**
Gwydir	-5.2%	-2.3%	**-5.6%**
Namoi	-1.7%	-2.6%	**-3.8%**
Macquarie[195]	0%	0%	**0%**
Barwon-Darling	1.4%*	-0.3%	**0.5%***
TOTALS	-2.7%	-1.7%	**-3.6%**

*Note: *Preliminary modelling of rules has resulted in some increases in diversions in the Barwon-Darling due to increased flows from the major tributaries. Further refinement of the rules will need to be considered to ensure increased flows are protected through the Barwon-Darling and don't lead to increased diversions.*

The EOS flow targets have 2.7% impact on diversions across the Northern Basin, with around 4.5% average impact in the three upper valleys (Border Rivers, Gwydir and Namoi). While the revised RoF rule has around a 1.7% impact on total diversions, with around 2.5% average impact in the three upper valleys.

The combined connectivity rules have a less than 4% impact on diversions across the Northern Basin, with around 6% average impact in the three upper valleys. The modelled impact in the Border Rivers is as high as 8% (for Scenario 3). The Panel proposes that further refinement of the proposed rules should consider options to ensure a more equitable distribution of the impacts across the valleys.

Further refinement of the connectivity rules has the potential to reduce the above estimated diversion impacts, including the use of forecasting to determine when sufficient flows have been protected and allow restrictions to be lifted. While the models are unable to accurately estimate the downstream benefits of FPH restrictions (particularly non-exempt rainfall runoff components), the actual downstream flow benefits due to FPH restrictions have the potential to further reduce the period of time that restrictions are required. Similarly proposed revisions to rules in the unregulated systems could contribute to achieving baseflows and reduce the need for dam releases.

[195] Due to the location of the Macquarie Marshes and the lack of regulated flows below the marshes, the proposed rules have minimal impacts on both flows and diversions in the Macquarie Valley.

The Panel acknowledges that the end of system flow rules proposed would have some impact on general security due to dam releases. Due to the preliminary nature of the modelling, we have not attempted to examine the breakdown between types of usage as there would be a high level of uncertainty in these results. We also note the limitations of the models in being able to provide this breakdown. For example, the contribution from unregulated systems is fixed and restriction of rainfall runoff cannot be adequately modelled, therefore the model will not pick up any benefit from restrictions in the unregulated system or rainfall runoff (floodplain harvesting) that would contribute to end of system flows and reduce the need for dam releases.

8.3.3 Impact of implementing the North-West Flow Plan rules

The Department undertook modelling that incorporated implementation of the North-West Flow Plan rules that are currently in the water sharing plans. The description of this modelling provided by the Department indicated:

"This has been undertaken by including restrictions to supplementary access, floodplain harvesting and A/B/C Class access to achieve fish passage and algal suppression flow targets. The restrictions have been based on the "perfect forecasting" approach used for the Western Regional Water Strategy (Western RWS). This involves use of a "bookend" model scenario in each valley where supplementary, floodplain harvesting, and A/B/C Class access are fully suspended for the entire model simulation, and identifying those years where restrictions have resulted in additional flow events exceeding the fish passage and algal suppression targets in the North-West Flow Plan. For each year where additional events occur in the bookend scenario, restrictions have been introduced into the base case model for September-February in that year (the approach taken for modelling to support the Western RWS)."

It should be noted that this approach underestimates the impact of implementing the rules. In practice, WaterNSW would need to forecast whether it was necessary to restrict supplementary access and they would not be able to do this "perfectly" as was done in this modelling scenario. However, the modelling results provide a minimum estimate of the potential impact of implementing the rules that are currently in place from the North-West Flow Plan.

Table 23 Modelled change in total long-term average annual diversions with implementation of the North West Flow Plan rules

Location	Average Annual Impact on Diversions North — West Flow Plan Rules
Border Rivers	-3.2%
Gwydir	-2.3%
Namoi	-2.6%
Macquarie	0.0%
Barwon-Darling	-1.6%
TOTAL	-1.8%

The results indicate an average reduction in diversions of 2% across the four tributary valleys and the Barwon Darling and an average reduction in diversions of 3% across the three upper valleys. It's important to reiterate that the estimate of impact on diversions for the North-West Flow Plan is an underestimate of impacts, so that actual difference in

impacts between the Panel's proposed baseflow and resumption of flow rules and implementation of the North-West Flow Plan would be lower than this.

The Panel has proposed that the rules from the North-West Flow Plan that are currently in the water sharing plans should be replaced by the Panel's proposed rules. Therefore, the impact from the Panel rules should not be viewed as additional to the potential implementation of the North-West Flow Plan rules, but as an alternative.

8.4 Limitations of modelling

In the Interim Report, the Panel outlined several concerns with limitations of modelling. The Department has indicated that despite these limitations, the models should still be reasonably accurate for comparing the relative connectivity benefit of different rules but may not be as accurate for assessing the exact magnitude of the benefits.

Based on our limited review of the most recent model development reports (referenced in Section 8.1), the Panel is of the view that the models are, on average, reasonably accurate for the flow ranges we are focusing on – i.e. baseflows through to large freshes. However, there are still some concerns with model accuracy when assessing environmental water requirements on an individual event achievement basis – i.e. when assessing the achievement of a specific flow threshold for a specific minimum duration. It is likely that the model will overestimate peak flows and/or durations sometimes, while underestimating at other times. This needs to be taken into consideration when assessing environmental water requirement achievements on an event-by-event basis.

The models are generally less accurate when simulating low flows and this impacts the assessment of environmental water requirements below baseflow, including periods of cease-to-flow. Consequently, the Panel has generally not focused on these. However, inflows to Menindee Lakes are impacted by low flow inaccuracies, particularly when simulating extended periods of low flows, making it difficult to estimate the likelihood of reaching critically low storage volumes, with or without the Panel's proposed connectivity rules. The Panel understands BCS has developed some methods for post-processing model results to account for low flow inaccuracies. These should be used where analysis involves flows below baseflow in particular.

The NSW 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 used to undertake the assessments have limitations, particularly at low flows.[196] There are known limitations with the Barwon-Darling IQQM, particularly the simulation of dry period flows. In addition, the current approach requires taking the simulated output of the tributary models and inputting them into the

[196] 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 low flow analysis due to known issues of the model.

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.

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 that overbank 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. The inability to model floodplain harvesting restrictions limits our ability to assess potential options for restricting floodplain harvesting, and the downstream benefits they may provide using the models.
- **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 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 rule changes targeting downstream outcomes onerous as the effect of rule changes in the valleys must be assessed, then input into downstream models, with 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 which will result in models being integrated so that analyses can be run across the entire Northern Basin.

In addition to the limitations outlined above, the Department indicated they used the same models as were used for the Western Regional Water Strategy for consistency in assessing connectivity options. However, they have several updated models, which they have indicated are more accurate and that they will use to rerun the modelling of the Panel's proposed rules. Most significantly the Namoi Source model has been further developed, which should provide more accurate assessment of impacts and benefits in the Namoi. The Panel notes that there were some disparities in model results for the Namoi which were raised with the Department and should be more fully considered in any further modelling.

The Department also used model simulated inflows for the modelling undertaken for the Panel. The Panel understands for further evaluation of potential rules they will use gauged inflow data, where available, which the Panel supports as this is likely to be more accurate.

We note that generally these limitations mean that the model most likely overestimates the impacts on diversions and underestimates the benefits to downstream flows. The Panel has focused on achieving specific flow targets. When there are restrictions, then downstream targets should be achieved more quickly, but the model does not necessarily pick up on this and may overestimate the time in restriction, which increases impact on diversions. For example:

- The model cannot return flows from restricting unexempt rainfall runoff floodplain harvesting to river system and so no benefit is shown in the model from doing this. However, it is able to estimate impacts to users from doing this.

- The model does not change inflows from the unregulated system based on changes to rules in unregulated system. As such, any improvement in flows from the unregulated system are not reflected in the model results.
- Evidence of actual flows and extraction indicates there are times when additional restriction on supplementary and floodplain harvesting will be sufficient to achieve baseflow targets. The models largely indicate any additional achievement of baseflow requires releases from dams, which has a larger impact on overall diversions than restriction of supplementary or floodplain harvesting.

The Panel recognises the abovementioned model limitations lead to a level of uncertainty with the benefits and impacts associated with the proposed connectivity rules. However, the Panel also recognises the critical need to take immediate actions to improve connectivity and is of the view that the models provide a reasonable estimate of approximate benefits and impacts to assist with decision-making. Going forward, the proposed connectivity objectives and rules should be assessed using the best available models and supplementary evidence sources where necessary. Continuous improvement of the river system models along with adaptive management, should support the fine tuning of connectivity rules over time.

8.5 Additional modelling needed

The results provided by the Department are preliminary but give a reasonably accurate assessment of the scale of impact and benefits likely from implementing the existing and proposed rules. Further refinement of the river system models and further modelling of connectivity scenarios will need to be undertaken by the Department to support a more detailed assessment of the benefits and impacts of the proposed rules and principles.

As was discussed, the Department has indicated that they intend to re-run necessary scenarios using the latest models and gauged inflow data. All river system models in the NSW Northern Basin should be updated to the latest available version and include the use of gauged inflow data, particularly where it is considered to be a more accurate representation of system inflows (compared to 100% simulated inflows).

In undertaking this modelling there are additional refinements that should be included, which will result in more accurate estimates, but which the Panel did not have time to consider. These include:

- **Forecasting**: Use of forecasting to reduce the impacts on water users by lifting restrictions once downstream flow targets are forecast to be achieved. This requires several iterations of modelling as the models are not currently linked and was therefore not possible in the time available to the Panel.
- **Protection of flows:** Full protection of 'connectivity flows' (through the Barwon-Darling) that have been achieved through restrictions in the major tributaries, including consideration of the progressive lifting of restrictions. The Panel has proposed that any additional flow achieved from upstream restrictions should not be available for extraction downstream, but to date this has not been added to the modelling. As such, current model results indicate a slight increase in diversions for Barwon-Darling users which the Panel views as inappropriate.
- **Further refinement of the end of system flow rules:** The Department has indicated that they will need to work with WaterNSW to determine how water for the end of system flow that is released from the dam is accounted for in the resource assessment. This may require reserving some water in the dam, which would affect the impact on diversions. The Panel has recommended rules for releases that are

dependent on in-flows to the dam. As such, releases would not be required when inflows are low (below 75th percentile for 30 days on average).

We recognise that some water will be set aside in the resource assessment process to provide for these rules. However, we do not anticipate that a large amount of water would need to be reserved in the dams, because the majority of the time the end of system rule should be largely met by inflows and uncontrolled flows (or the requirement to make releases would be suspended). Therefore, a portion of inflows could be passed through the dam to achieve the targets the majority of the time.

The Panel encourages the Department to undertake a risk-based assessment of the volume that needs to be set aside in the resource assessment to ensure minimum impact on licence holders while maintaining a high likelihood of achieving the targets. The Panel also notes that the models will not pick up any improved flows from restrictions in unregulated systems or from floodplain harvesting. As such, if the Panel's full recommendations are taken up the model is likely to overestimate the volume necessary to release from the dams. This should be considered in the resource assessment.

- **Further refinement of the transition trigger:** It may be appropriate to further refine the transition triggers (suspension of releases to support EOS flow targets) proposed for the major tributaries, taking into consideration the operational practicalities and the achievement of downstream flow targets. The Panel supports this, provided achievement of the downstream flow targets is maintained.
- **Further assessment of equity across valleys**: The current modelling predicts a larger impact on the Border Rivers users than the other valleys. The Panel expects this is because the combined dam inflows in the Border Rivers is small relative to the other valleys, and the end of system flow target is high relative to other valleys. The Department has also indicated that current modelling assumes reductions are shared across the system meaning Queensland users would also have a reduction, but this would have to be negotiated and the Intergovernmental Agreement revised. There may be merit in considering refinement of the end of system rules to better balance the impacts across the valleys. This would require, for instance, increasing the end of system flow in valleys with lower impacts and lowering it in the Border Rivers to maintain the same level of achievement of downstream flows. The Panel recommends the rules are first modelled with the latest available models, as it is possible more accurate models may show a different balance of impacts across the valleys.
- **Lifting of resumption of flow restrictions**: The Panel has proposed that in principle the restrictions for the resumption of flow rule should be lifted from upstream to downstream based on forecasted flow at the target locations. The intent is that downstream users should not be allowed to take water that was protected upstream. However, stakeholders have raised that given the complexity of the system, there may be scenarios where more refined lifting of restrictions is appropriate to maintain equity. The Panel recommends this is discussed further with stakeholders and, if necessary, rules for lifting restrictions are refined, again provided that achievement of targets is maintained.

There are also rules that the Panel is proposing that have not yet been modelled. These include:

- **Connectivity EWA**: As discussed in Section 6.7.3 the Panel has not developed a specific volume recommendation for the EWA but has identified the intent of the connectivity EWA and recommended next steps to further assess this option. This includes modelling to assess volumes necessary to be stored to achieve various outcomes, and to assess the benefits and impacts of various options.

- **Rules to protect small and large fresh**: the modelling results indicate that small and large freshes are achieved across the approximate target percentage of years. However, the inter-event duration is also important. The Panel has recommended that a small fresh should be achieved every year between September and April and a large fresh every other year. The analysis of EWR achievement indicates that there are times that these timeframes are not met. Therefore, the Panel has recommended that rules be included to protect these events in the targeted timeframes. Analysis indicates this does not occur frequently and as such is unlikely to have a significant impact on the long-term average annual diversions. The Panel understands that it may also be quite difficult to model these rules. Given the likely limited impact on diversions and resource requirements to model the rules it may be sensible to implement the rules as a precautionary measure without modelling them and reassess them in the future, as part of an adaptive management approach.

In addition to these additional modelling steps, it is important that in assessing any results, the potential benefits and impacts of any changes to floodplain harvesting and unregulated water sharing plans are estimated to the extent possible. However, inability to accurately estimate these or model them should not prevent steps from being taken until better information is available. In the longer term, the models should be updated to enable floodplain harvesting restrictions (of all forms of floodplain harvesting) and changes to unregulated rules to be modelled.

8.6 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[197] recommending that steps be taken to improve forecasting.

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 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

[197] 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

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.

8.7 Further refinement of rules

The Panel has tried to be as clear as possible regarding the intended outcome from our proposed rules. It is entirely appropriate that the Department will undertake its usual steps for developing specific rules for water sharing plans, including additional modelling and engagement with stakeholders. There is no doubt that additional analysis and engagement with stakeholders is necessary to fully refine the specifics of how these rules could be implemented most effectively and efficiently. In order to operationalise the rules, further consultation is required with the water users (particularly irrigators), river operators (WaterNSW) and river managers (Department's Water Planning Implementation Team). The water users in these systems have a great deal of knowledge about how the systems operate and should be consulted on how the rules can best be designed to ensure the outcomes are met, with minimal negative impacts on diversions.

While it is recognised that the proposed connectivity rules may need further refinement, it is essential that the connectivity principles and targeted outcomes outlined in this report are maintained. The Panel is of the view that in order to ensure that the intent of the rules

and targets are maintained in any further analysis, it is appropriate for the Panel to continue to have a role in reviewing the modelling results and approach to rule refinement. The Panel (or relevant Panel members) should review Department analysis and provide advice to the Minister as to whether it adequately meets the intent of the Panel's recommendations (See Chapter 9 for further discussion of oversight recommendations).

8.8 Recommendations

16 In undertaking any additional modelling to assess final rules the Department should:

a. Use the latest river system models available and include the use of gauged inflow data, particularly where it is considered to be a more accurate representation of system inflows.

b. Undertake additional analysis of the benefits and impacts of forecasting, protection of flows generated through proposed rules, refinement of end of system rules to account for the resource assessment process and evaluate options to improve equity across valleys.

c. Model connectivity EWA options once developed and consider whether small and large fresh rules require modelling.

d. Work with DEECCW-BCS to undertake a more detailed assessment of the achievement of baseflow, small fresh and large fresh EWRs using the EWR assessment tool, including post-processing of model results to account for low flow inaccuracies.

Limitations of the Department's surface water modelling

17 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.

18 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

19 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.

20 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.

21 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.

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

9 Implementation considerations

While the Panel has attempted to answer as many outstanding questions as we could for the final report, we recognise that finalising rules and implementing our recommendations will take considerably more work. This chapter outlines important considerations for implementation of any agreed recommendations, as well as recommendations for governance arrangements we feel are necessary to ensure any adopted reforms are a success.

9.1 Key Findings

42 Limitations of forecasting, modelling and available data have led to some previously identified actions for improving connectivity from being implemented, despite evidence of declining ecosystem health.

43 Assumptions in the hydrological models that are input into the economic studies to date are flawed as they do not accurately reflect actual irrigator behaviour and are not undertaken at the most appropriate scale.

44 There is a need for integrated governance at the whole of Northern Basin system 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 inter-valley connectivity within the system as a whole.

9.2 Adaptive management and precautionary approach

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 generally not 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. However, 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.

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 water sharing plan rule changes. A 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.

For example, the Panel has recommended that supplementary and floodplain harvesting should be restricted unless end of system baseflow requirements are met. The modelling does not show a significant impact on supplementary access from doing this and is not able to assess impact on floodplain harvesting. However, actual flow data suggests that these rules are likely to provide baseflow at some times, particularly in extending how long baseflow can be met during a supplementary event, especially in situations where the system is drying. The Panel firmly believes these rules are appropriate and necessary to ensure that possible opportunistic take is not adversely affecting downstream fundamental flows. Implementing these rules is consistent with the precautionary approach and the principles adopted by the Panel.

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, and to manage the uncertainties of climate change.

9.3 Socio-Economic Analysis

The Terms of Reference specifically asks the Panel to consider the potential impact on long-term average annual extraction limits, which is discussed in Chapter 8. However, much of the feedback from stakeholders on the Interim Report was related to concerns about what broader socio-economic studies would be undertaken. The Department has indicated they will undertake additional socio-economic analysis as part of the assessment of the Panel's recommendations.

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 these analyses and some recommendations for improvements we think should be considered for any final socio-economic analysis completed to assess our proposed rules.

The Panel has concerns about the adequacy and suitability of the economic analysis carried out to date for 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. However, this should not preclude them from investing in additional economic and social analyses, which are needed to fully assess the Panel's proposed connectivity rule changes, and which are necessary for meeting the requirements for delivering an appropriate cost-benefit analysis. This would include improvements to the modelling of irrigated production area and irrigator response to changing availability of water and using data from greater than a 10-year period in analysis to account for likely periods of wet and dry. The Panel acknowledges this would require additional resources.

Modelling irrigated production (area and yield): Each of the previous 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 are meant to examine how changes to diversions impact on overall yield. However, they do not appear to be sensitive enough to represent the true variability in irrigated production. For example, with reference to irrigated cotton production in the four northern tributaries plus the Barwon-Darling, the area was estimated by the Department to vary between 138,000 hectares and 249,000 hectares. Yet in reality, the area of irrigated cotton production has been between 25,000 hectares (mostly using groundwater) and almost 200,000 hectares. [198]

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. The Department should ensure they have the latest industry data and that this is reflected in their modelling.

Improved water use modelling assumptions: The models used by the Department are based on water availability and daily crop water use. However, these models are unable to adequately represent the area planted decision-making of water users. The models have static assumptions about how available water is used by irrigators. They do not have the capability to adapt to potential changes in how irrigators may use their water under different rules. As the proposed changes would lead to a substantial change to current rules, water users will face a significant adjustment to new risks with respect to water management. These changes in water management decision-making mean it is less likely that the current models will reliably estimate the effects of the connectivity proposals.

The existing models are used to also estimate crop yields from the irrigated area planted. They depend on a water balance approach, using a crop water demand function and keep meeting the daily demands until the water runs out. However, these models do not appear to accurately represent the behaviour of irrigators. 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 applications for the crops which have been planted. Without this understanding of how irrigators utilise the various types and volume of water available to them, it would be difficult for the existing models to assess how the proposed connectivity rule changes might impact on yields and any subsequent estimation of gross value of production or farm profitability.

It is therefore recommended, in the first instance, that irrigated agriculture production models, whose outputs of planted area and yield would be used as inputs to local community and larger regional 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 (or implementation of the Panel's recommendations) 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

[198] Based on Expert Panel member experience and knowledge of industry data.

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 water users to review such new risks to water availability and to internalise 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 utilise the findings of the analyses provided to the Panel of the Department's proposed rules, 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, as the Panel has attempted to do to the extent possible with our recommendations.

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. Similarly, improved hydrologic forecasting should improve the timing of applying and lifting restrictions on access to minimise the effects on water users.

Floodplain harvesting and unregulated contributions have not been considered: As detailed in Chapter 8 the Department's models are not able to accurately assess the impacts and benefits of floodplain harvesting restrictions or changes to rules in the unregulated water sharing plans. The potential impacts of these issues should be considered in interpreting any results from socio-economic analyses.

9.3.1 Options for improved analysis

The Panel recommends that when looking more extensively at economic impacts the Department consider these impacts at multiple levels.

Level 1: Direct impact on irrigated agriculture production

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. This will require new crop area and yield models (as identified above) developed with industry input.

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 irrigated 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. The Department has indicated that the hydrological modelling is down to the scale of individual irrigator nodes. However, we understand for economic analyses this data was only provided at the valley scale. 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 decisions and crop yields.

Level 2: Local community analysis - flow on effects to agricultural and other sectors
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 individual 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 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, with differing potential effects of water restrictions in Goondiwindi, Mungindi, Moree and Collarenabri. Each of these communities is supported by different sets of water entitlements and potential access restrictions associated with improving connectivity. They also have very different economic structures, meaning irrigated production has differing flow-on effects to social and economic conditions in these respective communities. As such, the impacts should be modelled separately for the separate locations.

Level 3: Large regional scale analysis
A third level of impact analysis should include a broader, large region analysis such as employing computable general equilibrium (CGE) modelling. This modelling could look at the tributaries and Barwon-Darling as five separate regions within the whole of Australia.

Level 4: Location-based analysis of costs, benefits and trade-offs for connectivity recommendations
The full economic analysis needs to include a valuation of the social, cultural and environmental outcomes arising from these recommendations in addition to the economic impacts of restricting water access to meet the connectivity objectives. Given the potential for the connectivity proposals to have far-reaching social and economic costs as well as benefits distributed across the Northern Tributary valleys and the Barwon-Darling, studies should be undertaken to fully evaluate those outcomes. 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, cultural and social effects of the proposed connectivity rule changes should be derived from purpose-built models relying on data collected from the location being assessed.

Economic assessments are often incorrectly viewed as measuring just impacts and benefits in dollar terms. Economic assessments require an examination of the changes in four dimensions – the financial, social, cultural and environmental outcomes within an economy arising from an intervention. It is this level of understanding which the Panel believes will be required to support effective implementation of the connectivity proposals.

A sound socio-economic assessment would provide a baseline and could be used to track the implementations of the rules over time to determine if they have adequately achieved the benefits they aim to achieve and that the impacts are in line with those expected. The Panel recognises that a full assessment of socio-economic impacts would require time and resources; however, we view this to be a worthwhile investment.

Economic tools for examining connectivity proposal trade-offs
A consistent framework to assess the trade-offs for different connectivity options is required. With respect to the connectivity recommendations proposed by the Panel, some of the outcomes will not be directly measurable in dollar terms but still require representation to assess the bounds of the trade-offs which are anticipated to occur. For example, the extent of decreased production (in hectares and dollars) relative to environmental and cultural benefits against the background of the challenging socio-economic conditions within Northern Basin communities. This information will quantify changes but within the context of understanding the relative difficulties those communities face in terms of adapting to changes in water availability and use.

There are adequate tools available to allow such comparisons of outcomes as a means of supporting and guiding implementation of the Panel's recommendations. Two options which could be employed to assist this process are:

1. Optimization

The financial, social, cultural and environmental trade-offs arising from improving connectivity could be examined using an optimizing platform such as GAMS (General Algebraic Modelling System). This approach precludes any requirement to reduce all social, cultural and environmental outcomes to dollar values.

2. Choice modelling – the stated preference technique

Choice modelling is designed to elicit the preferences of stakeholders across a choice set. That is, to reveal their preferences for different outcomes when presented with a number of scenarios for achieving improved connectivity. Across the choice set, the multiple scenarios would include a case of no change (business as usual) plus a series of changes which vary by only one element. In presenting each related connectivity scenario, a monetary value would be assigned to one of the choices. For this approach to be effective, it is important that a sample of people who are likely to benefit from, or be impacted by, the proposed changes are the ones who should participate in the choice modelling data collection. It is the local representatives who would be best placed to reveal the trade-offs which might be expected from improving connectivity.

Limitations of a direct "willingness to pay" approach
There has been some suggestion that a 'willingness to pay" approach may be an appropriate way to determine broader socio-economic implications. However, the Panel does not support this as a suitable approach.

Simply using a direct willingness to pay approach to derive 'values' on these parameters, based on asking people (especially those outside of the region) what they would be willing to pay for an outcome will not adequately represent the nature and extent of the potential costs and benefits from the outcomes arising from implementing the Panel's proposed recommendations.

Further to this, a willingness to pay approach to finalising and implementing the connectivity proposals is not relevant to understanding the trade-offs between multiple connectivity options. More specifically, no one is purchasing environmental outcomes,

cultural improvement or social changes, but these are the trade-offs which need to be considered. It will be necessary to reveal (and quantify) the scale of the trade-offs which the Panel's (or alternative) connectivity implementation measures might create. For example, how much water diversion is foregone as a consequence of delivering different levels of improved connectivity? What are the social and cultural adjustments expected from those changes?

9.3.2 Economic activities effected by Panel recommendations

It is important that economic analysis is designed to address the question at hand. There are at least three different types of activity associated with water management activities that need to be assessed from an "economic" perspective. Each activity requires their own processes and approaches to examine the potential outcomes and the type of analysis should be carefully considered.

- **Trade-offs from proposals to improve connectivity:** The changed timing of access to water (in addition to changes in the volumes of water that could be diverted) for irrigation would be expected to alter the management of farming production. The economic costs of this foregone production would need to be considered with respect to the benefits of improved connectivity. In this case, "economic" analysis refers to examining a more complete suite of the total of irrigated production, local economy, social, cultural and environmental changes associated with the recommendations of the Panel (the Level 4 analysis described above). The Panel expects this is the analysis most relevant to the majority of our recommendations.
- **Government investment in water way management infrastructure** – some of the Panel's proposed recommendations might include the placement of new gauging stations to help improve the measurement of end-of-system flow volumes and the development of modelling capabilities which support improved forecasting of when to apply and lift restrictions on water access. This investment would be part of a broader approach which shifts the emphasis from within-valley management to better represent the connectivity aspects of water management, and costs and benefits should be properly assessed in this context.
- **Purchase of water**: Under some circumstances governments might choose to purchase water entitlements to reduce the availability of water extracted for irrigated production and enhance environmental benefits. However, this does not require economic analysis. Any approach to acquire water in this way would be based on a process of negotiation between the buyer and seller of entitlements.

The impacts of the first of these three activities should include assessing the direct effects on irrigated production and the flow-on effects to the local economies. This would require developing a modelling capability which accurately reflects the changing area of irrigated production. As mentioned in the section above, for the four northern tributaries plus the Barwon-Darling, the area of irrigated production actually ranges from approximately 25,000 hectares up to almost 200,000 hectares (depending on the prevailing climate), not the range of 138,000 to 250,000 hectares suggested in scenarios provided to the Panel.

Working with industry to more correctly represent the area of irrigated production each year would better inform the regional economic (input-output) modelling for better understanding the localised effects of changes in access to water. Similarly, working with the water-dependent sectors of the northern tributaries and the Barwon-Darling should help to inform considerations of the investments required to support the second activity above.

Most attention is required to assess the trade-offs from improving connectivity (which also depends on the outcomes from the second and third activities above). The suggested frameworks for supporting such an assessment would be an optimisation approach or choice modelling (as outlined previously). Use of one of these frameworks for understanding the impacts and the trade-offs between different connectivity-improving proposals is required. It must be one that examines the combined financial, social, cultural and environmental outcomes, and relies on local input to inform the trade-offs and implementation decisions.

The results from all these analyses will be necessary to interpret the regional-level (CGE) modelling outputs. In this way, the modelling will provide the best means for examining the local effect of improving connectivity in conjunction with the broader flow-on effects to the regional, state and national economies.

9.4 Northern Basin governance arrangements

The Panel is of the view that some of the connectivity problems persist because recommendations from previous reviews have not been successfully implemented to achieve their intended outcomes. Without clear accountability for tracking and managing connectivity outcomes it is unlikely that reforms will be successful.

Currently, consistent with the water sharing plans, water is managed predominantly to meet in-valley water sharing plan requirements. 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. It will also require consideration of a range of scientific inputs and monitoring and evaluation from various agencies.

While the Panel has based its recommendations on best available information, that information has considerable limitations. Where data is uncertain the Panel has taken a suitably precautionary approach, making recommendations we feel will likely achieve the intended outcomes. Connectivity is complex and must be adaptively managed to be efficient and effective. As better information becomes available through implementation and testing of the rules, opportunities to improve outcomes and efficiency are likely. Stakeholder concerns, experiences and input will be important in order to make connectivity efforts successful.

Such coordination and adaptive management requires strong and objective oversight. 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. Implementing any rule changes will also require focus and effort to ensure that necessary analyses and consultation are undertaken in a timely manner. Specifically, the Panel recommends that the Government implement the following governance arrangements.

- **Shorter term:** It will be important in finalising rules that the intended outcomes are not compromised. In the shorter term (for the next 18 months) the Panel recommends that the Minister establish independent oversight for finalisation of any of the Panel's recommendations that are supported for implementation or further analysis. It would likely be most efficient to continue to engage with current Panel members overseen by the NRC to review any further analysis. Those responsible for independent oversight should:
  - provide input into and review of any further analysis by the Department
  - provide advice to the Minister as to the adequacy of further analysis or rule development and whether they adhere to the Panel's intent

- provide regular assessment of progress towards agreed recommendations and whether progress is in line with any timelines agreed with the Minister.
- seek open and transparent input on any further analysis from other relevant Government groups including BCS, DPI-Fisheries, WaterNSW, the water science, planning and implementation teams as appropriate to ensure that full expertise available within the Government is leveraged.

- **Longer term:** Over the next 12-18 months the Panel recommends that the Government develop longer term governance arrangements for overseeing connectivity in the Northern Basin to ensure more enduring solutions to connectivity problems. New governance arrangements should provide for coordination of connectivity efforts across the Northern Basin and ensure independent oversight for review of the implementation of any agreed longer term connectivity recommendations and monitoring.

  This body should be independent of the Water Group. The NRC may again be a logical organisation to oversee the group as they are independent of the various Government agencies that would provide input.

  Key functions of this body should be:

  - driving improved data collection and modelling to support connectivity issues
  - ensuring that a monitoring and evaluation program is in place so that connectivity initiatives are fully informed by the latest data and science and adaptively managed over time
  - ensuring that decision-making and evidence is transparently shared with the community
  - ensuring stakeholder experience and concerns are incorporated into decision-making as appropriate

  There is already a cross-agency connectivity stakeholder group. There may be merit in revising this group such that it is independently led and provides advice to Government regarding connectivity initiatives.

  At a minimum the governance arrangements should include representatives from:

  - DEECCW – Water Group – water science team
  - DEECCW – Water Group – implementation team
  - DEECCW – Water Group – planning team
  - DEECCW – BCS
  - DPI Fisheries
  - DPI Agriculture
  - CEWH
  - MDBA

- The Panel recommends that this Governance body be supported by 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. This group could for example meet quarterly to provide community input on progress and issues related to connectivity. The Panel notes that there is currently a Northern Basin Environmental Watering Group[199] that could perhaps be leveraged for this

[199] https://www.dcceew.gov.au/water/cewo/nbew-group

purpose; although the Panel recognises this group does not currently include community stakeholders.

9.5 Recommendations Roadmap

The Panel recognises that there are a significant number of recommendations. However, many of them could be implemented in conjunction with one another. We have mapped out the phases that we anticipate would be required to implement the various recommendations to provide further clarity about expected timing for completion and priorities.

9.5.1 Phase 1: Immediate (0-6 months)

In the immediate term there are several steps that need to be taken to begin advancing any recommendations the Minister chooses to implement or investigate further. The Panel understands some of these steps are already occurring, such as further modelling of proposed rules, which may impact which rules advance to the full implementation stage.

Recommendations requiring immediate action include:

Additional modelling - Recommendation 16(a-d) & 17: these recommendations require undertaking additional modelling of proposed rules to ensure the latest models and gauged inflow data are used, that refinements of proposed rules are assessed and that further analysis of benefits are assessed with the EWR tool. This work should take into account potential limitations of models and where other sources of data should be used to supplement model analysis.

Protection of environmental water - Recommendation 4: This requires further assessment of options for ensuring that flows generated through any implemented rules are protected through to Menindee Lakes and are able to be used as environmental water in the Lower Darling-Baaka. This should feed into the modelling discussed above.

Socio-economic analysis: Recommendation 24: the initial socio-economic analysis should support assessment of rule options further assessed in recommendations 16 and 17 above.

Develop unregulated plan rules - Recommendation 14: this recommendation requires implementing a reviewed risk assessment process to assess appropriate cease to pump rules to protect baseflows in high priority unregulated water sources. The Panel notes the DEECCW-Water Science team has already undertaken the risk assessment for many of the water sources identified and so we anticipate this recommendation could be completed fairly rapidly.

Upgrade the Pamamaroo inlet – Recommendation 10: The Panel recommends that the inlet regulator be replaced as a matter of urgency.

Assign independent oversight – Recommendation 23a: The Panel recommends that the Minister assign oversight independent of the Department to ensure the intent of the recommendations and the holistic approach is maintained.

9.5.2 Phase 2: Updating rules and processes (0-18 months)

Phase 1 would support a number of steps necessary to design rules and processes for recommendations in Phase 2. Some work on implementing these recommendations could begin straight away, which is why the time frame overlaps with the immediate phase. Recommendations for this phase include:

Improving forecasting - Recommendations 19, 20, 21: these require steps be taken to improve forecasting including identification of additional gauging needs, development of transparent guidelines for how forecasting decisions are made, and continued use of a precautionary approach to forecasting such that targets have a high likelihood of being met. This work could begin right away but will take time to implement.

Improved management of Menindee Lakes - Recommendation 9 a-c: these recommendations relate to changes to the Murray Lower-Darling water sharing plan. Some changes would require negotiation with other states and the Commonwealth to implement changes to various agreements. Further analysis is also required of some options and may be informed by the NRC report on the water sharing plan review due later in 2024.

Water sharing plan rules changes - Recommendations 3a-c, 5, 11a-b, 13, 15, 22: these require changes to water sharing plan rules to implement any of the connectivity rules ultimately adopted for the regulated and unregulated water sharing plans to address protection of baseflows and freshes, the resumption of flow rule, connectivity EWAs, unregulated water sharing plan cease to pump and active management rules, and floodplain harvesting restrictions.

This would require developing the specific amendments to water sharing plans and undertaking consultation with stakeholders. This timing is consistent with the commitments made in the recent Government response to the OSCE report on the fish deaths. The Panel understands that the Department would seek to make changes to all plans simultaneously for equity. We generally agree with this approach but are of the view that changes to cease to pump rules for unregulated water sharing plans that are due to be remade in 2025 should be incorporated at that time or at a minimum, amendment provisions should indicate the intent to implement changes to the cease to pump rules to improve connectivity.

Long-term governance – Recommendation 23(b-c): this requires development and adoption of a longer term independent governing body to oversee ongoing implementation and consideration of connectivity.

9.5.3 Phase 3: Investigation / Further Analysis (0-24 months)

Review rainfall runoff exemptions – Recommendation 6: This requires review of the rainfall runoff regulations to ensure that they are enforceable and adequately restrict floodplain harvesting.

In-valley floodplain harvesting triggers – Recommendation 7: This requires the NRC to review in-valley floodplain harvesting triggers as part of their water sharing plan reviews. This would be ongoing as water sharing plans come up for review. Most northern tributary water sharing plan reviews will be completed in the next two years.

Further analysis of Menindee triggers – Recommendation 9d: once decisions are made around other recommendations to Menindee Lakes operations, further analysis of the need for an additional trigger for upstream restrictions should be undertaken. This cannot be accurately completed until decisions are made around whether to implement other rules which would contribute to volumes available in Menindee Lakes.

Improve gauging in the unregulated systems – Recommendation 12: The Department should develop a plan for ensuring that any of the water sources identified as high risk for impacting connectivity have adequate gauging to support necessary rules within the next two years.

Socio-economic analysis – Recommendation 24: The Panel has recommended proper socio-economic assessment of costs and benefits. This full analysis will require further development of methodology and additional resourcing to be implemented and should underpin decision-making going forward.

9.5.4 Phase 4: Long-term (1-4 years) / Ongoing

Monitor floodplain harvesting (ongoing) – Recommendation 8: This requires ongoing assessment of whether floodplain harvesting rules and restrictions are adequately providing for downstream needs.

Improve modelling (long-term) – Recommendations 18a-b: This requires that the models are updated to address the limitations identified in this report and independently reviewed.

Continue to improve forecasting (long-term) – Recommendation 20: This requires continuous improvement and adaptive management of forecasting so that it improves over time.

Assessment of connectivity (ongoing) – Recommendations 1 & 2: these recommendations require an ongoing commitment to implementation of a holistic approach to connectivity across the Norther Basin, ensuring adequate water is protected for downstream at all times.

9.5.5 Summary of implementation phases and oversight suggested

Table 21 outlines the phases, recommendations and proposed oversights for each recommendation.

Table 24 Recommended timing and independent oversight for recommendations

Phase/ Timing	Recommendation	Recommendation ID	Oversight recommended
Phase 1: Immediate Phase (0-6 months)	Additional modelling	16(a-d)	NRC/Panel
		17	NRC/Panel
	Protection of environmental water	4	NRC/Panel
	Socio-economic analysis	24	NRC/Panel
	Develop unregulated plan rules	14	NRC/Panel
	Upgrade the Pamamaroo inlet	10	NRC/Panel
	Assign independent oversight	23a	NRC/Panel
Phase 2: Updating rules and processes (0-18 months)	Improving forecasting	19	NRC/Panel
		20 (initial)	NRC/Panel

		21	NRC/Panel
	Improved management of Menindee Lakes	9 (a-c)	NRC/Panel
	Water sharing plan rule changes	3 (a-c)	NRC/Panel
		5	NRC/Panel
		11 (a-b)	NRC/Panel
		13	NRC/Panel
		15	NRC/Panel
		22	NRC/Panel
	Long term governance	23b-c	NRC/Panel
Phase 3: Investigation/ Further analysis (0-24 months)	Review rainfall runoff exemptions	6	Department, WaterNSW & NRAR
	In-valley floodplain harvesting triggers	7	NRC
	Further analysis of Menindee triggers	9d	NRC / Panel
	Improve gauging in the unregulated systems	12	NRC / Panel
	Socio-economic analysis	24	NRC / Panel
Phase 4: Long-term/ ongoing	Monitor floodplain harvesting	8	Longer term independent governance body
	Improve modelling	18 (a-b)	Longer term independent governance body
	Continue to improve forecasting	20 (ongoing)	Longer term independent governance body
	Ongoing assessment of connectivity	1 2	Longer term independent governance body

9.6 Recommendations

23 To improve accountability for system-wide connectivity the NSW Government should:

a. ensure there is independent oversight of the further assessment and implementation of any agreed recommendations over the next 18 months to ensure the intent of the recommendations and holistic focus are not lost.

b. In the longer-term, assign a governance body responsible for reviewing the ongoing 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.

c. create a community advisory group including representatives from the Aboriginal community, industry stakeholders from upstream and downstream, and local community groups to advise the longer-term governance body described above regarding on-ground experiences and issues.

24 Assumptions in the hydrological models that are input into the economic studies to date should be reviewed for any future analyses to ensure they reflect actual irrigator behaviour and are at the appropriate scale. The socio-economic analysis should consider the full range of benefits and impacts likely to be experienced and the Department should consider the four levels of analysis recommended in Chapter 9 of this report when designing their socio-economic assessment.

Appendix A – 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

Appendix B – Western Regional Water Strategy Proposed Critical Dry Condition Triggers

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 of options to improve connectivity 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 22. The Panel's assessment of these triggers is discussed in Section 4.7.

Table 25. 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.
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.	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.

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 Lower Darling River 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.

Appendix C – Details of water sharing plan rules

The Interim Unregulated Flow Management Plan for the North-West of NSW (North-West Flow Plan) was released in 1992 in response to the significant algal bloom in the Barwon-Darling River in late 1991. The primary objective of the North-West Flow Plan was to: 'revise the management of unregulated flows to achieve immediate gains in the health of the river systems, without causing severely adverse consequences for water users.'

The North-West Flow Plan set out conditions under which access to supplementary flow events in tributary water sources could be restricted or prohibited to protect flows into the Barwon Darling River. In addition, B and C Class licenced access in the Barwon-Darling River could also be restricted or prohibited to achieve various flow targets at downstream locations.

The North-West Flow Plan provides flow targets to achieve riparian, algal suppression and fish migration flows as outlined in Table 23. These targets initially informed the Valley Management Plans and were then included in the first water sharing plans for the Gwydir, Border Rivers and Namoi regulated water sources. The majority of these targets are still included in the plans as detailed in Table 24**.**

Table 26 Objectives and flow targets of the Interim Unregulated Flow Management Plan for the North

Flow	Objective	Flow Target
Riparian flows	The need to protect the low flow regime primarily to maintain the security of town and rural domestic and stock supplies.	Achieve a flow of: (i) 150 ML per day in the Darling River at Wilcannia (ii) 280 ML per day in the Darling River at Louth (iii) 390 ML per day in the Darling River at Bourke (iv) 550 ML per day in the Darling River at Brewarrina (v) 700 ML per day in the Barwon River at Walgett (vi) 760 ML per day in the Barwon River at Collarenebri (vii) 850 ML per day in the Barwon River at Mungindi. To apply at all times
Algal suppression	Seasonal flow requirements to 'flush' the system with smaller flows and sufficient to replace water in weirs to minimise the conditions for algal growth.	Achieve a flow of at least 2,000 ML per day in the Darling River at Wilcannia for 5 consecutive days during the period October to April, inclusive, providing flows of this quantity have not already been reached. during the preceding three months within the October to April period.
Fish migration	The requirement to protect fish migration flows to 'drown out' the weirs (Brewarrina and Bourke)	Achieve: • a flow of 14,000 ML per day in the Darling River at Brewarrina for 5 consecutive days, and/or

	deemed to be the main impediments to migration.	• a flow of 10,000 ML per day in the Darling River at Bourke for 5 consecutive days During the period September to February inclusive, providing two such flow events have not already occurred during that period in that water year.

Table 27 Where and how the North-West Flow Plan targets are mentioned in current water sharing plans

Plan	Section	Rule
Gwydir Regulated River Water Source 2016	Announcement of supplementary events [48 (4)] Schedule 2 –Flow Targets	A supplementary water event for supplementary water access licences nominating water supply works on the Mehi River, Carole Creek or on rivers which receive effluent flows from the Mehi River or Carole Creek is not to be announced, or is to be restricted if, in the Minister's opinion, this is required to ensure outflows from the water source contribute to meeting the requirements of the Barwon-Darling River Flow Targets specified in Schedule 2.
Upper Namoi and Lower Namoi Regulated River Water Sources 2016	Taking of water under supplementary water licences in the Lower Namoi Regulated River Water Source [48(5) & (6)]	Taking of water under supplementary water access licences in the Lower Namoi Regulated River Water Source shall not be permitted, or shall be restricted, when this is required to ensure outflows from the Lower Namoi Regulated River Water Source contribute to meeting the requirements of the Interim Unregulated Flow Management Plan for the North West. Subclause 6 outlines the requirements of the Interim Unregulated Flow Management Plan.
NSW Border Rivers Regulated Water Source 2021	Announcement of supplementary water event (general) [45(2)] Schedule 1 (2) – The Baron Darling Flow Targets	A supplementary water event is not to be announced, or is to be limited, for supplementary water access licences nominating water supply works on the Macintyre River when in the Minister's opinion it is necessary to do so to ensure that outflows from the water source contribute to meeting the requirements of the flow targets under clause 2 of Schedule 1 (the Barwon Darling Flow Targets).
Barwon-Darling Unregulated River Water Source 2012	Note in: Access rules for unregulated river (A class), (B class) and (C class) access licences [46] Note 1	An order under Section 324 of the Act may be made by the Minister to restrict or prohibit the taking of water under unregulated river (B Class) access licences and/or unregulated river (C Class) access licences if the Minister is satisfied that is it necessary to do so in the

		public interest to meet the following requirements — *The riparian flows, algal suppression and fish migration North-West Flow Plan targets are then listed*

Tributary end of system flows

End-of-system flow rules require minimum flows to pass through the end of a water source or river system or a specified point or gauge. This ensures that flow is maintained below the areas of major extraction and can assist in providing for hydrological connectivity into the downstream water source. End-of-system flow rules vary between valleys as outlined in Table 25.

Table 28 End of system flow rules

Rule	Plan	Section	Rule
End of System related to supplementary access	NSW Border Rivers Regulated River	S47 Announcement of supplementary water events downstream of the Macintyre River and Dumaresq River junction (Table B Notes)	Border Rivers WSP notes that the supplementary water event finish flow volume for upstream of Goondiwindi was developed to ensure an end of system flow consistent with Section 23 of the New South Wales –Queensland Border Rivers Intergovernmental Agreement 2008[200]: requires NSW and Queensland water plans to produce an average end of system flow of at least 60.8% of the predevelopment flow pattern
		S45 (4c) Announcement of supplementary water event (general)	During the period from 1 September of each year to 31 March of each following year, the amount of uncontrolled volume that can be taken does not cause the flow in the Barwon River at Mungindi to be 100 ML/day or less. This rule is outlined in the IGA (Section 32) which has the objective of improving low flows at the end of the Border Rivers system to support a healthy riverine environment.
Other End of system rules	Namoi Regulated Water Sharing Plan	Part 3 Environmental water provisions Clause 14 Planned environmental water	In the months of June, July and August, a minimum daily flow which is equivalent to 75% of the natural 95th percentile daily flow for each month shall be maintained in the Namoi River at Walgett.

[200]NSW and Queensland Government (2009) *New South Wales –Queensland Border Rivers Intergovernmental Agreement 2008.*

			The above shall not apply when the sum of the water stored in Keepit Dam and Split Rock Dam is less than 120,000 megalitres This is mainly achieved through regulated releases. Historically this has not always been met.
	Gwydir Regulated Water Sharing Plan	Clause 61	Specifies minimum flow requirements to ensure planned environmental water for the Ramsar listed Gwydir wetlands but not further downstream.
	Macquarie Regulated Plan	Clause 84	Does not have minimum daily flows at a specific location, but includes replenishment flows for different water sources if sufficient water is available. These replenishment flows are also at the operator's discretion.

Appendix D – Recommendations from previous reports regarding the North-West Flow Plan

Table 29 Recommendations related to implementing the North-West Flow Plan

Key findings/ recommendation	Report
The hydrologic analysis indicated that the rules associated with the North-West Flow Plan, if able to be implemented, can potentially deliver meaningful connectivity improvements to the Barwon – Darling River beyond those that currently exist. However, supporting hydrologic forecasting tools need to be developed along with further analysis on the potential benefits and impacts of implementing the rules. Furthermore, the combination of implementing the targets with targeted use of HEW as illustrated by the Northern Connectivity Event of April 2018 also creates opportunities for substantial improvements in connectivity.	Stocktake of Northern Basin connectivity rules – analysis of implementation and effectiveness (Final Report), May 2019 (Barma Resources)
To enhance connectivity in the Northern Basin to better achieve Plan outcomes: a. Include, update and implement provisions in the Plan to enable an updated Interim Unregulated Flow Management Plan for the North-West to be implemented and protect flows from extraction by all licence classes. These provisions should be clear and transparent and not require a Section 324 order under the *Water Management Act 2000*. b. Revise Plan provisions as necessary to contribute to Plan objectives in the 2023 remake based on best available information. To enhance connectivity in the Northern Basin to better achieve Plan outcomes: a. update the Interim Unregulated Flow Management Plan for the North-West based on best available information. b. improve consideration of connectivity across the Northern Basin by updating and implementing provisions of all relevant water sharing plans enabling an updated Interim Unregulated Flow Management Plan for the North-West. c. undertake necessary enhancements including gauging and tools for estimating losses as required to facilitate implementation.	Final report - Review of the Water Sharing Plan for the Barwon-Darling Unregulated and Alluvial Water Sources 2012 September 2019 (Natural Resources Commission) Recommendation 13; Suggestion G
The analysis demonstrated that limiting access to supplementary flows and B- and C-class access does	Review of the Interim Unregulated Flow Management Plan for the North-West

contribute to meeting the existing North-West Flow Plan targets, though this impact may be limited. The Review of the existing North-West Flow Plan targets, drawing on contemporary practice, science and knowledge, recommended that some of the individual targets should be revised to ensure that the desired outcomes of the North-West Flow Plan are being achieved. This would involve raising the flow target at three of the gauge points (Bourke, Louth, and Wilcannia) and modifications to the fish migration and algal suppression targets. In order for the North-West Flow Plan to be implemented effectively, the Review recommends a number of operational and procedure related considerations.	November 2021 (Alluvium Consulting)
Amendments made to the Border Rivers water sharing plan in 2021 require a review of the targets in North-West Flow Plan. As required under this amendment, in 2023 the Department initiated the coordination of an independent expert panel to review and recommend proposed changes to the North-West Flow Plan targets.	2021 Border Rivers Regulated Water Sharing Plan Amendment
Action 3.2: Finalise the review of the North-West Flow Plan to identify the best way to support algal suppression and fish migration. This action will finalise a review on the best way to support algal suppression and fish migration, and confirm if restricting supplementary licences, B Class and C Class licences at important times should be progressed to suppress algal blooms and support fish migration. The review will inform the remake of the *Barwon– Darling Water Sharing Plan in 2024* and be informed by independent advice from an expert panel, additional technical analysis and stakeholder feedback. The report states that, it was not proposed to maintain the riparian rights targets in the North-West Flow Plan as the original riparian targets were surpassed by water sharing plan rules. Instead, the Strategy recommends relying on the critical dry conditions targets to meet critical human and environmental needs (these critical dry conditions triggers were addressed in Action 3.1 Publish critical dry condition triggers and seek to implement them in water sharing plans).	Western Regional Water Strategy 2022 (DPE Water)

Appendix E – Supplementary Flow Access Conditions Summary

Table 30 Supplementary Flow Access Conditions Summary

Plan	Where	Rule (general)	Specifics
Water Sharing Plan for the NSW Border Rivers Regulated River Water Source 2021	Announcement of supplementary water event (general) (clause 45) Division 2 Supplementary water events Supplementary water downstream of the Macintyre River and Dumaresq River junction (clause 46)	General	Access is to be shared between NSW and QLD – sharing is provided for in the IGA - in relation to the Dumaresq River, ensure the volume of uncontrolled flow will be shared equally between NSW and Queensland (as per the IGA) Defining at ▪ which flow event take can start and when it must stop (supp water event start flow, and supp water event finish flow). Note there is seasonal variation in these flows (summer/ winter)
		Volume taken	▪ Ensure the amount specified under subclause (5) does not allow the extraction of over 75% of the uncontrolled flow volume in the Barwon River at Mungindi gauge (416001) ▪ Between, and including, 1 September and 31 March, ensure that the amount that may be taken under subclause (4) (c) does not cause the uncontrolled flow in the Barwon River at Mungindi gauge (416001) to be less than or equal to 100 ML/day. The maximum volume of water that can be taken during each supp announcement must not exceed the volume of flow occurring between the start and finish flows, plus the volume of water required to: meet the environmental provisions of the plan, satisfy downstream domestic and stock rights and native title rights, satisfy the total NSW and Queensland water orders

placed by access licences including associated losses, provide any required replenishment flows as specified in clause 58 and satisfy the Queensland share for water harvesting licences.

Commence and cease flows

Dates	Supplementary water event start flow (ML/day)	Supplementary water event finish flow (ML/day)	As measured at
Pindari Dam to the Macintyre River and Dumaresq River junction			
1 Sep–31 Mar	500	150	Ashford
	1000	250	Holdfast
1 Apr–31 Aug	100	50	Ashford
	150	50	Holdfast
Dumaresq River and Pike Creek junction to the Dumaresq River and Macintyre River junction			
1 Sep–31 Mar	750	250	Glenarbon
1 Apr–31 Aug	150	50	Glenarbon
Downstream of Macintyre River and Dumaresq junction			
Upstream of Goondiwindi (over 2 consecutive days)			
	10000	3650	Goondiwindi gauge
Downstream of Goondiwindi (over 2 consecutive days)			
	2000	1550	Combined flow from Macintyre River at Kanowna gauge

			and Weir River at Mascot gauge
		Other	The water take must only be used for direct irrigation and not pumped into farm storages and a maximum extraction rate of 6ML/day per diversion pump is to apply
Water Sharing Plan for the Gwydir Regulated River Water Source 2016	Division 2 Supplementary water events Clause 48	Volume of water available	No more than 50% of the supplementary water event volume may be permitted to be taken under supplementary water access licences during a supplementary water event.
		Commence and cease flows	Whenever flows in the river system are above those required to: i) meet the environmental provisions of the Plan, (ii) satisfy downstream domestic and stock rights and native title rights, (iii) satisfy the water orders placed by regulated river (general security) access licences and higher priority access licences, and (iv) provide any required replenishment flows specified in clause 58.
Water Sharing Plan for the Upper Namoi and Lower Namoi Regulated River Water Sources 2016	Lower Namoi Regulated River Water Source Division 3 Extraction conditions Clause 48	Volume	The volume of water that may be made available for extraction under supplementary water access licences in the Lower Namoi Regulated River Water Source prior to 1 July 2019, should not exceed 50% of the supplementary event volume, and after 30 June 2019, should not exceed: (i) 10 % of the supplementary event volume between 1 July and 31 October, and (ii) 50 % of the supplementary event volume between 1 November and 30 June.
		Commence and Cease flows	There are different rules depending on total volume of water allocations in regulated river(general security) access licence accounts. **Narrabri and downstream of Narrabri**

Supplementary Start flow and finish flow will be 500 ML/day when the total volume of water allocations in regulated river (general security) access licence accounts is less than or equal to 90,000 megalitres, and those specified in the following table, when the total volume of water allocations in regulated river (general security) access licence accounts is greater than 90,000 megalitres:

Date	Supplementary water event start flow (ML/day)	Supplementary water event finish flow (ML/day)	As measured at
At Narrabri			
1 August – 31 December	5000	3000	Narrabri Creek at Narrabri plus Namoi River at Narrabri
1 January–31 January	4000	2000	Narrabri Creek at Narrabri plus Namoi River at Narrabri
1 February–31 July	2000	1000	Narrabri Creek at Narrabri plus Namoi River at Narrabri
Downstream of Narrabri			
1 August – 31 December	5000	3000	Namoi River at Mollee
	4000	2500	Namoi River at Gunidgera Weir
	3000	2000	Namoi River at Weeta Weir
1 January–31 January	4000	2000	Namoi River at Mollee
	3000	2000	Namoi River at Gunidgera Weir
	2000	1500	Namoi at River Weeta Weir
1 February–31 July	2000	1000	Namoi River at Mollee
	2000	1000	Namoi River at Gunidgera Weir
	1500	1000	Namoi River at Weeta Weir

		Other	Clause 12 further details rules around the event volume Clause 13- 15 further rules around when water can be taken once the event start flow has been reached – incorporating travel times between Narrabri and the location of water supply works. Clause 16 provides specific rules for when uncontrolled flows are arising from inflows to the Lower Namoi Regulated River Water Source downstream of Weeta Weir and the taking of water for water supply works downstream of Weeta Weir: Take may be permitted after uncontrolled flows have increased to a rate sufficient to: - (a) ensure a flow of 200 ML/day for 5 days would be achieved in the Namoi River at Walgett, when the total volume of water allocations in regulated river (general security) access licence accounts is greater than 90,000 megalitres, or - (b) ensure a flow of 10 ML/day when the total volume of water allocations in regulated river (general security) access licence accounts is less than 90,000 megalitres. Clause 17 provides rules for the taking of water under supplementary water access licences nominating water supply works on the Gunidgera/Pian system.
Water Sharing Plan for the Macquarie and Cudgegong Regulated Rivers Water Source 2016	Division 3 Supplementary water events Section 54 Announcement of supplementary water event	Commence flows	**Downstream of the upper limit to Burrendong Dam water storage** Announced when uncontrolled flows or a release of water from the FMZ (or both) exceed: - (i) releases made from the Macquarie EWA specified in Division 3 of Part 10, - (ii) flows required for domestic and stock rights, native title rights and water orders for access licences downstream of Burrendong Dam water storage, - (iii) replenishment flows as specified in clause 84 The flows need to exceed the requirements above by 5,000 ML per day or more at Warren Weir (421004). **Upstream of Burrendong Dam water storage** Announced when uncontrolled flows or a release of water from the FMZ (or both) exceed: - (i) releases made from the Cudgegong EWA specified in Division 1 and 2 of Part 10, - (ii) flows required for domestic and stock rights, native title rights and water orders for access licences upstream of Burrendong Dam water storage

	The flows need to exceed the requirements above by 5,000 ML per day or more at Warren Weir (421004). And water needs to be spilling from Burrendong Dam or water is being released from the FMZ. FMZ= flood mitigation zone of Burrendong Dam.

Appendix F – Modelling

Model Scenarios

The model scenarios that were considered by the Panel are summarised in Table 28.

Table 31 List of key model scenarios considered by the Panel

Scenario	Final Report Scenario	Panel Model Reference	Description
Base Case	Base Case	n/a	• Current conditions scenario based on model versions adopted for the Western Regional Water Strategy (as at December 2020). • Contains current levels of development and existing water sharing plan rules (without North-West Flow Plan rules, as they have not been implemented). • Inflows are 100% simulated.
Without Development	Without Development	n/a	• Without development model scenarios sourced from SEED[201] (edition 1). • This scenario represents near-natural conditions, with all water infrastructure, water extractions, water management and operating rules removed from the model.
EOS Flow Targets	*Not specifically referenced*	CP1A	• Modify base case to include EOS flow targets in Border Rivers, Gwydir and Namoi valleys. Flow targets were suspended whenever dam inflows fell below 75th percentile monthly inflow. • No change to resource assessment calculations. • EOS flow targets set at the top of baseflow EWR for Gwydir and Namoi, and bottom of baseflow EWR for Border Rivers (to test sensitivity).
	Scenario 1: EOS Flow Targets	CP1B	• Similar to CP1A, with EOS flow targets set at the bottom of baseflow EWR (in line with Panel's proposed rules).
	Not specifically referenced	CP1C	• Similar to CP1A, with EOS flow targets set at the top of baseflow EWR for Gwydir, bottom of baseflow EWR for Namoi, and below baseflow (100 ML/d) for Border Rivers (to test sensitivity).

[201] https://www.seed.nsw.gov.au/

Revised RoF Rule	Scenario 2: Revised RoF Rule	CP4A	• Modify base case to include a revised RoF rule (previously only active in the Barwon-Darling) that restricts supplementary water access in the major tributaries based on flows falling below baseflow for 90+ days in the Barwon-Darling, and lifts restrictions based on the achievement of a small fresh in the Barwon-Darling (as proposed by the Panel). • Triggers for each tributary valley were taken from Barwon-Darling river sections (defined for existing RoF rule) that they flow into – i.e. Mungindi to Walgett section for Border Rivers and Gwydir valleys, and Walgett to Brewarrina section for Namoi and Macquarie valleys. • No restrictions to FPH.
Combined Rules	*Not specifically referenced*	CP6A	• Combination of EOS flow targets (Scenario 1 / CP1B) and Revised RoF Rule (Scenario 2 / CP4A). • Restriction periods for RoF rule were based on the results of Scenario 2 (CP4A), as a first iteration. • FPH restrictions (with no return flows) were included in this model run to support calculations required for scenario CP6B (which included limited FPH restrictions and return flows).
	Scenario 3: Combined Rules	CP6A2	• Similar to CP6A, with restrictions based on the results of the CP6A, as a second iteration. Restriction periods were generally reduced compared to CP6A.
	Not specifically referenced	CP6B	• Similar to CP6A, with adjustment to include FPH restrictions (to overbank flow harvesting only) and estimated return flows (100% of restricted FPH returned to EOS in each tributary).

Model Summary Results

Each of the model scenarios listed in Table 29 were modelled by the DCCEEW Modelling Group using a 125-year historical climate sequence: i.e. 1 July 1895 to 30 June 2020. Key model results were provided by the Modelling Group and are summarised in the tables below.

Table 32 Model Summary Results – Baseflow Outcomes – Percentage of days flows achieve or exceed baseflow target

Location	Baseflow Target ML/d	Base Case Scenario	Without Development Scenario	EOS Flow Targets (High) CP1A	EOS Flow Targets (Low) CP1B	EOS Flow Targets (Mixed) CP1C	Revised RoF Rule CP4A	Combined Rules CP6A/CP6A2/CP6B
Barwon-Darling								
Mungindi[202]	160	58%	68%	74%	74%	65%	58%	74%
Collarenebri	280	49%	66%	70%	59%	66%	49%	59%
Walgett	320	55%	74%	70%	63%	67%	55%	63%
Bourke	600	69%	75%	79%	75%	78%	69%	75%
Wilcannia	350	66%	78%	75%	72%	74%	67%	72%
Major Tributaries (end of system)								
Gwydir (Mehi)[203]	40	44%	77%	75%	68%	75%	44%	68%
Gwydir (Gil Gil Ck)[204]	25	43%	17%	74%	67%	74%	43%	67%
Namoi[205]	30	63%	81%	71%	68%	68%	63%	68%
Macquarie[206]	65	36%	44%	38%	36%	36%	36%	36%

[202] Barwon River at Mungindi is used at the most upstream location in the Barwon-Darling and also the end of system location for the Border Rivers
[203] Mehi River near Collarenebri
[204] Gil Gil Creek at Galloway
[205] Namoi River at Walgett
[206] Macquarie River at Carinda

Table 33 Model Summary Results – Small Fresh Outcomes: Percentage of years small fresh target is achieved (14 days / Sept to Apr)

Location	Small Fresh Target ML/d	Base Case Scenario	EOS Flow Targets (High) CP1A	EOS Flow Targets (Low) CP1B	EOS Flow Targets (Mixed) CP1C	Revised RoF Rule CP4A	Combined Rules (1st iteration) CP6A	Combined Rules (2nd iteration) CP6A2	Combined Rules (with FPH) CP6B
Barwon-Darling									
Mungindi	540	84%	89%	89%	88%	88%	91%	90%	91%
Collarenebri	650	86%	92%	90%	90%	90%	91%	90%	91%
Walgett	700	92%	94%	93%	94%	94%	97%	96%	97%
Bourke	1,550	82%	86%	85%	86%	88%	90%	90%	90%
Wilcannia	1,400	82%	83%	82%	84%	87%	89%	90%	89%
Major Tributaries (end of system)									
Gwydir (Mehi)	90	87%	99%	96%	99%	92%	100%	100%	100%
Gwydir (Gil Gil Ck)	45	87%	99%	95%	99%	89%	96%	97%	96%
Namoi	200	93%	92%	92%	92%	93%	92%	92%	92%
Macquarie	140	61%	65%	62%	62%	62%	62%	62%	62%

Table 34 Model Summary Results – Large Fresh Outcomes: Percentage of years large fresh target is achieved (15 days / anytime)

Location	Large Fresh Target ML/d	Base Case Scenario	EOS Flow Targets (High) CP1A	EOS Flow Targets (Low) CP1B	EOS Flow Targets (Mixed) CP1C	Revised RoF Rule CP4A	Combined Rules (1st iteration) CP6A	Combined Rules (2nd iteration) CP6A2	Combined Rules (with FPH) CP6B
Barwon-Darling									
Mungindi	3,000	36%	36%	36%	36%	41%	41%	38%	41%
Collarenebri	4,200	58%	59%	58%	59%	62%	62%	61%	62%
Walgett	6,500	60%	62%	61%	62%	65%	64%	65%	64%
Bourke	15,000	52%	52%	52%	52%	52%	52%	52%	52%
Wilcannia	14,000	51%	51%	51%	51%	51%	51%	51%	51%
Major Tributaries (end of system)									
Gwydir (Mehi)	800	68%	74%	71%	74%	77%	78%	80%	78%
Gwydir (Gil Gil Ck)	750	46%	46%	47%	46%	49%	48%	49%	48%
Namoi	2,250	86%	86%	86%	86%	90%	89%	89%	89%
Macquarie	700	41%	42%	42%	42%	42%	42%	42%	42%

Table 35 Model Summary Results – Estimated Diversion Impacts: Average Annual Diversions (GL/a)

Valley	Base Case Scenario	EOS Flow Targets (High) CP1A	EOS Flow Targets (Low) CP1B	EOS Flow Targets (Mixed) CP1C	Revised RoF Rule CP4A	Combined Rules (1st iteration) CP6A / CP6B	Combined Rules (2nd iteration) CP6A2	Combined Rules (2nd iteration excl. FPH restrictions^) CP6A2
Border Rivers+	203.1	191.5	191.5	198.5	197.0	183.3	185.5	186.8
Gwydir	449.5	404.3	426.2	404.3	439.1	417.7	422.2	424.4
Namoi	236.6	231.5	232.5	232.5	230.5	223.9	225.8	227.7
Macquarie	337.1	330.0	337.1	337.1	337.0	337.1	337.1	337.1
Barwon-Darling	**161.2**	**164.4***	**163.4***	**164.1***	**160.7**	**159.5**	**160.5**	**162.1***
TOTALS	**1,387.5**	**1,321.7**	**1,350.7**	**1,336.5**	**1,364.3**	**1,321.5**	**1,331.0**	**1,338.2**

Notes: *+ Border Rivers EOS flow targets are assumed to be borne equally by NSW and QLD storage resources*

** Barwon-Darling diversion increases are due to increased flows from major tributaries and not modelling the protection of these flows*

^ Impact on diversions from FPH restrictions was removed from these results via a post-modelling adjustment

Preliminary Assessment of Environmental Watering Requirements (EWR)

A preliminary assessment of key model outputs was undertaken using the EWR assessment code[207] (EWR_tool), which was developed by the MDBA with input from NSW DCCEEW Biodiversity, Conservation and Science (BCS) Group[208]. The preliminary analysis of EWRs using the EWR_tool was undertaken with the assistance of the BCS Group, using model outputs provided by the DCCEEW Modelling Group. BCS Group assisted in running the EWR_tool to produce the EWR achievement metrics presented below. Analysis and interpretation was undertaken by the Panel.

The assessment focused on the achievement of baseflow and small fresh EWRs in the Barwon-Darling for various model scenarios, including the Base Case Scenario, the Combined Rules Scenario (CP6A2) and the Without Development Scenario. The specific EWRs considered are from the Barwon-Darling Long Term Water Plan[209], on which the Panel's recommended flow rules were based.

Previous assessments of EWR outcomes in the Barwon-Darling using modelled outputs have attempted to take into consideration known model inaccuracies associated with the simulation of low flows. As the current Barwon-Darling IQQM is prone to overestimating low flows[210], post-processing of previous model outputs has previously been undertaken by the BCS Group to inform the development of EWRs for baseflow, very low flow and cease to flows. This could be considered for the future refinement of EWR assessment when modelled data is used. However, due to time limitations, post-processing of model outputs was not undertaken for the EWR results summarised below.

The long-term average achievement of baseflow and small fresh EWRs at key locations in the Barwon-Darling is summarised in the two tables below.

[207] https://github.com/MDBAuth/EWR_tool
[208] NSW long-term water plans environmental water requirement assessment code description
[209] Barwon Darling Long Term Water Plan
[210] Murray-Darling Basin Authority (2018) Ecological needs of low flows in the Barwon-Darling - Technical Report

Table 33 summarises EWR results for baseflows and shows the Combined Rules Scenario generally results in significant improvements in baseflow outcomes, particularly for the BF1_b EWR, which seeks to ensure minimum baseflow requirements in all years (particularly dry years).

Table 36 Preliminary EWR Assessment – Long Term Average Achievement of Baseflow EWRs: Percentage of years Baseflow BF1_a and BF1_b are achieved under different modelling scenarios

Baseflow EWR	Location	Flow Rate ML/d	Duration Requirements	Target Freq. (% yrs)	Base Case Scenario	Combined Rules Scenario	Without Development Scenario
BF1_a	Mungindi	>160	*BF >220 days (typical year)*	50%	46%	**76%**	61%
BF1_a	Collarenebri	>280	*BF >245 days (typical year)*	50%	20%	**35%**	50%
BF1_a	Walgett	>320	*BF >285 days (typical year)*	50%	14%	**26%**	51%
BF1_a	Bourke	>600	*BF >270 days (typical year)*	50%	42%	**56%**	56%
BF1_a	Wilcannia	>350	*BF >290 days (typical year)*	50%	34%	**45%**	56%
BF1_b	Mungindi	>160	*BF >110 days (dry year)*	100%	89%	**98%**	94%
BF1_b	Collarenebri	>280	*BF >120 days (dry year)*	100%	73%	**85%**	91%
BF1_b	Walgett	>320	*BF >130 days (dry year)*	100%	73%	**90%**	93%
BF1_b	Bourke	>600	*BF >120 days (dry year)*	100%	90%	**94%**	95%
BF1_b	Wilcannia	>350	*BF >120 days (dry year)*	100%	88%	**91%**	94%

Table 34 summarises EWR results for small freshes and shows the Combined Rules Scenario also results in meaningful improvements in small fresh outcomes, with improvements in the achievement of 10-day small freshes on an annual basis (at any time; SF1_s) and the achievement of 14 days small freshes at critical times (Sept to April; SF2).

Table 37 Preliminary EWR Assessment – Long Term Average Achievement of Small Fresh EWRs: Percentage of years Small Fresh SF1_s and Small Fresh SF2 are achieved under different modelling scenarios

Small Fresh EWR	Location	Flow Rate ML/d	Duration Requirements	Target Freq. (% yrs)	Base Case Scenario	Combined Rules Scenario	Without Development Scenario
SF1_s	Mungindi	>540	*SF >10 days (any time)*	100%	98%	**99%**	100%
SF1_s	Collarenebri	>650	*SF >10 days (any time)*	100%	97%	**98%**	99%
SF1_s	Walgett	>700	*SF >10 days (any time)*	100%	95%	**99%**	100%
SF1_s	Bourke	>1,550	*SF >10 days (any time)*	100%	91%	**95%**	100%
SF1_s	Wilcannia	>1,400	*SF >10 days (any time)*	100%	88%	**96%**	100%
SF2	Mungindi	540 - 3,000	*SF >14 days (Sept to April)*	75%	82%	**90%**	88%
SF2	Collarenebri	650 - 4,200	*SF >14 days (Sept to April)*	75%	81%	**84%**	94%
SF2	Walgett	700 - 6,500	*SF >14 days (Sept to April)*	75%	91%	**94%**	100%
SF2	Bourke	1,550 - 15,000	*SF >14 days (Sept to April)*	75%	78%	**84%**	96%
SF2	Wilcannia	1,400 - 14,000	*SF >14 days (Sept to April)*	75%	78%	**86%**	98%

Further small fresh EWR metrics (specifically related to SF1) for Wilcannia, across the 125-year historical climate sequence, are shown in the two figures below.

Figure 17 shows the rolling 10-year frequency for the achievement of SF1 (on an annual basis, at any time) at Wilcannia, with the target being 100% (i.e. achievement of SF1 all years in a 10-year period). For the Base Case Scenario, the 10-year frequency drops to 70% several times and as low as 60%. In other words, in some 10 year periods the SF1 EWR is only met in 6 or 7 years out of 10. For the Combined Rules Scenario, the 10-year frequency rarely falls below 90%, with the lowest being 80%, at the end of the climate sequence. This suggests the proposed connectivity rules should lead to improved outcomes in dry periods, when ecosystems are particularly vulnerable to prolonged periods without adequate flows.

Figure 18 shows the rolling maximum inter-event period for the achievement of SF1 at Wilcannia, with the target maximum being 365 days. There is a significant improvement in

inter-event periods previously exceeding 365 days, reducing from 23% of years under the Base Case Scenario to 9% of years under the Combined Rules Scenario. This suggests that while the Panels rules (that have been modelled) reduce the frequency of maximum inter-event periods being exceeded, there will still be some times when this flow doesn't occur within the maximum timeframe that it is required (i.e. in extended dry times).

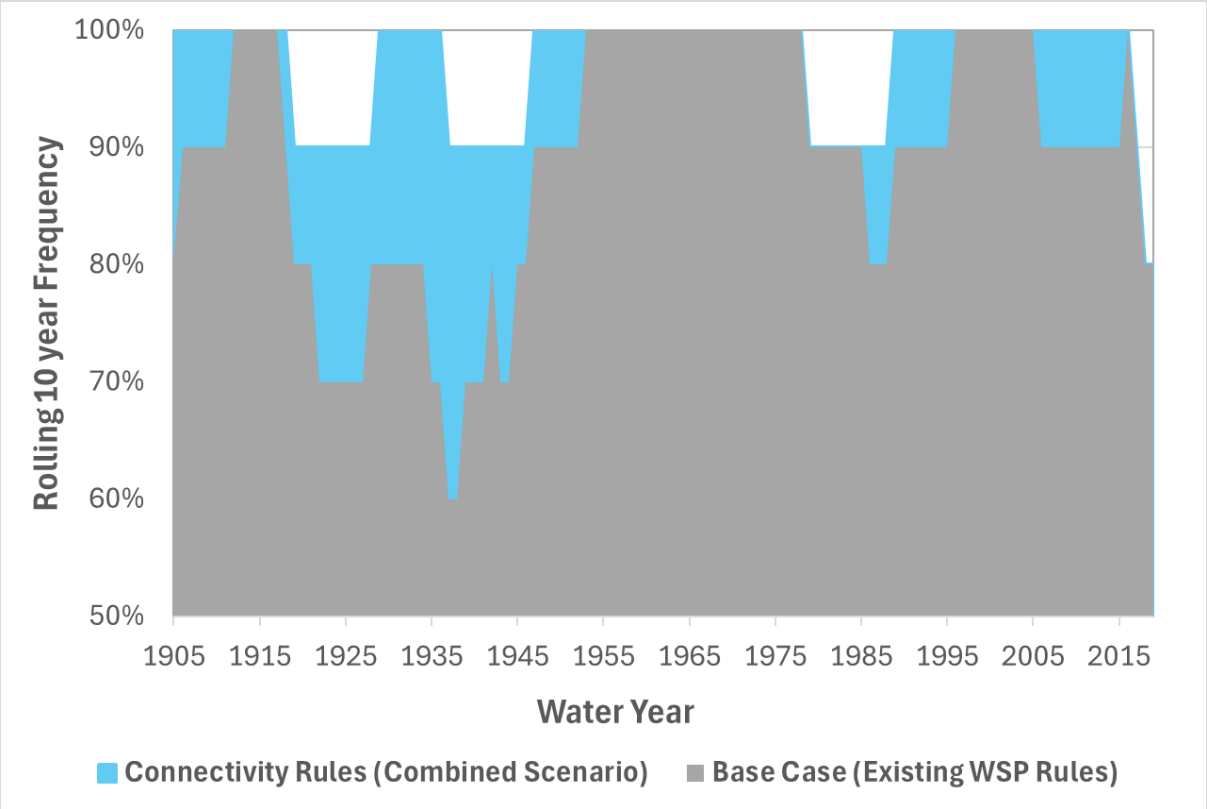

Figure 17 Rolling 10-year frequency for achievement of SF1 (any time) at Wilcannia (target 100%)

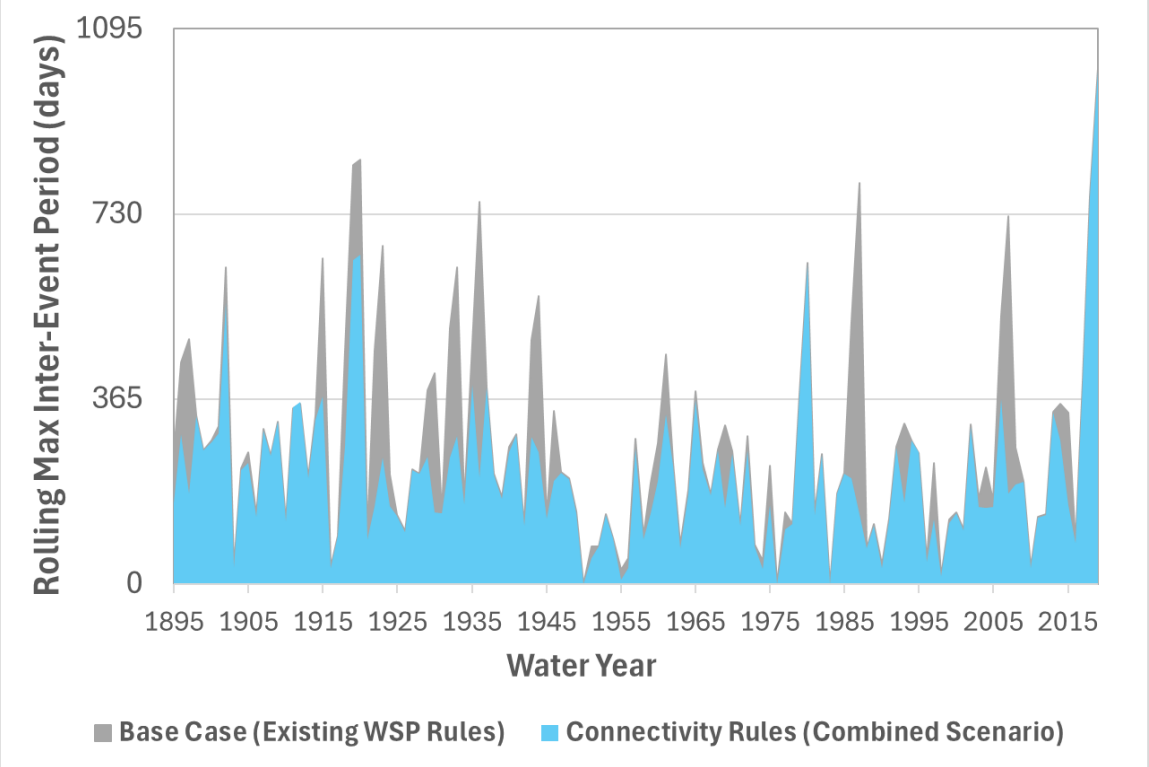

Figure 18 Rolling Maximum Inter-Event Period for achievement of SF1 (any time) at Wilcannia (target 365 days max)