WATER MANAGEMENT

DRAFT Critical dry condition triggers to reduce risk to environmental and human water needs

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Acknowledgment of Country

The Department of Planning, Industry and Environment acknowledges the Traditional Owners and Custodians of the land on which we live and work and pays respect to Elders past, present and future.

Contents

Purpose of this paper

The Water Group within the NSW Department of Planning, Industry and Environment has developed draft triggers for initiating temporary water restrictions under section 324 of the *Water Management Act 2000.* This paper provides information on how the draft temporary water restriction triggers have been developed to seek feedback from key stakeholders before broader public consultation.

The draft triggers at a glance

The draft triggers are designed to reduce the risk of critical water shortages leading to severe damage to water-dependent environments or communities. The triggers are a signal that management action should be undertaken to reduce the risks.

It is proposed that temporary water restrictions on commercial access may be issued under Section 324 of the *Water Management Act 2000* across the northern NSW Murray–Darling Basin if rainfall and flows are predicted to occur in response to the following triggers:

- a cease-to-flow period of 120 days at Wilcannia
  or
- Menindee Lakes fall below 195 gigalitres capacity
  or
- the northern valleys and/or Barwon–Darling River system is classified as Drought Stage 4 criticality.

These are proposed as initial triggers that will be refined through further remote sensing of refuge pools and weirs along the Barwon–Darling River to assess when critical dry conditions thresholds are forecast.

In addition to temporary water restrictions, a flushing flow release in the lower Baaka–Darling River may be initiated if:

- differences between dissolved oxygen levels at different depths within refuge pools indicate that stratification is occurring
  or
- dissolved oxygen levels drop below 5 milligrams per litre and evidence suggests that they will continue to fall
  or
- blue–green algal densities exceed 4 cubic millimetres per litre and evidence suggests that they will continue to increase.

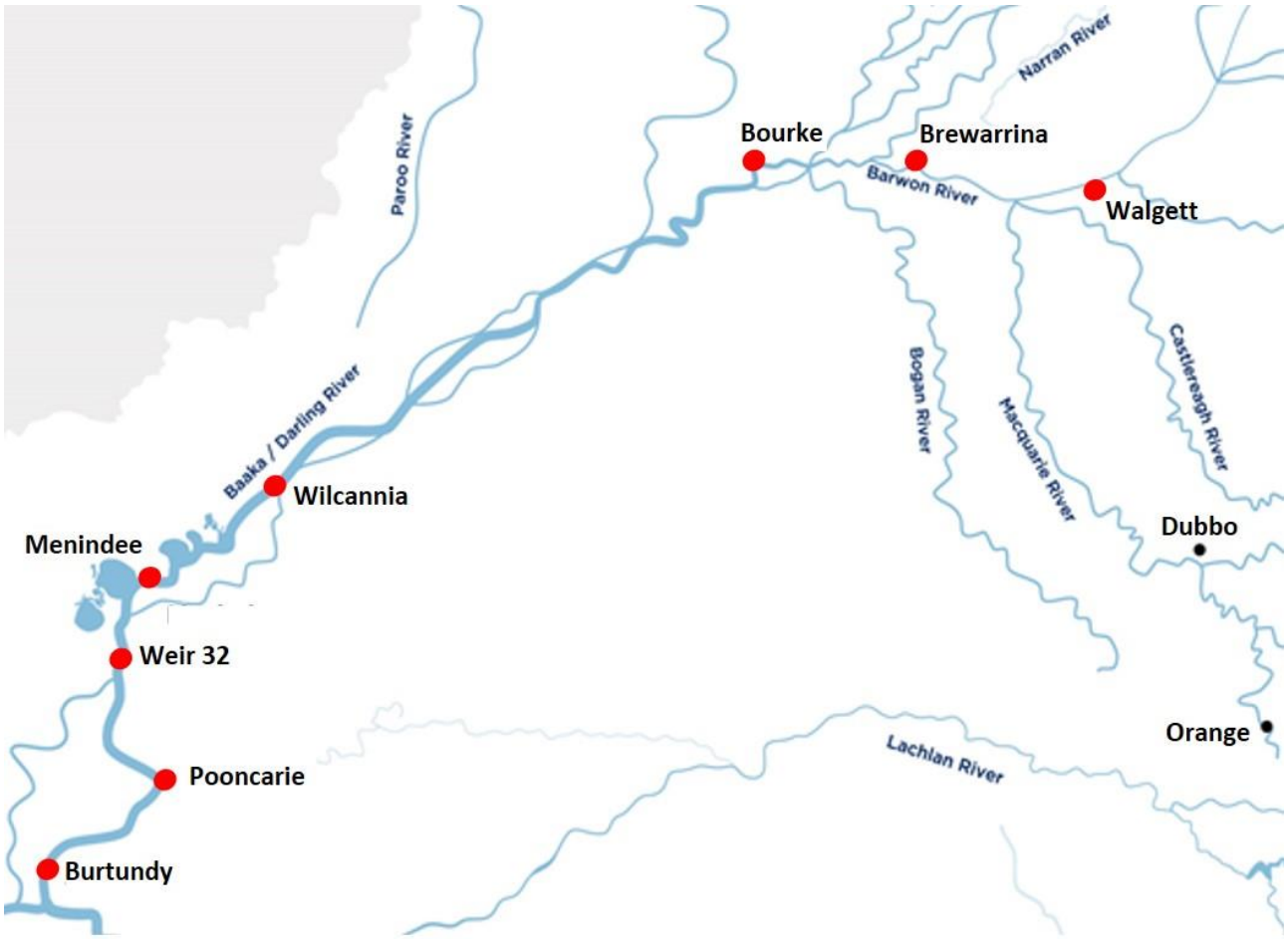

Figure 1. Location of draft trigger sites for the Barwon–Darling River, Menindee Lakes and lower Baaka–Darling River

Background

Between 2017 and early 2020, northern inland NSW experienced record drought conditions that severely impacted water availability for human and environmental needs. The drought broke in the first months of 2020 when significant rain fell in the northern Murray–Darling Basin.

From 17 January 2020 to 28 February 2020, the Department of Planning, Industry and Environment restricted commercial water access in the northern Basin by issuing temporary water restriction section 324 orders. The protected flows enabled reconnection of the Barwon–Darling River through to the Menindee Lakes and the restart of releases from the lower Baaka–Darling River to Wentworth. Thousands of kilometres of rivers across the northern Basin and lower Baaka–Darling flowed for the first time in many months.

The 2020 northern flow event marked the first time that temporary water restrictions had been applied across such a large area and range of commercial water extraction (general security, high security, unregulated river, floodplain harvesting and supplementary access). The restrictions were lifted progressively as flows passed, or were forecast to pass, to meet specific targets set along the rivers and for Menindee Lakes.

The department has produced several reports and assessments to evaluate the effectiveness of the 2020 event (available from the North-west flows in early 2020 pages of the department's website).

An independent panel was appointed by the Minister to review the event and provide recommendations on future temporary water restrictions. The panel published its findings in the Independent Panel Assessment of the Management of the 2020 Northern Basin First Flush Event (PDF 522 KB).

Key recommendations for the department were to:

- develop a clear definition and quantification of critical water needs during dry conditions
- develop clear triggers that will determine when first-flush management arrangements start and when they cease to apply (reverting to water sharing rules)
- ensure that the methods for first-flush management are evidence-based, scientific and made publicly available.

Temporary water restrictions and priorities under the Water Management Act

The NSW *Water Management Act 2000* sets out the general priorities for access to water. This involves promoting the protection of the water source and its dependent ecosystems as well as basic landholder rights to water.

During severe water shortages, the focus shifts towards securing critical domestic water needs. When managing extractions at these times, domestic needs for essential town services and individual landholders are considered first followed by the needs of the environment. Water for stock and high-security access licences are the next highest priority.

In addition to these priorities, section 324 of the Act allows temporary water restrictions to be implemented if it is in the public interest, such as:

- to cope with water shortages
- where there are threats to public health and safety
- to protect flows for environmental purposes.

Temporary water restrictions are intended to meet needs or circumstances that fall outside of the normal water sharing plan rules and are not 'business as usual' instruments.

Figure 2. A refuge pool near Tilpa on the Baaka–Darling River in March 2018

What we mean by critical dry conditions

Critical dry conditions for the environment

During extended dry periods, refuge pools evaporate and contract. Large pools fragment into smaller pools and conditions for water ecosystems become crowded, leading to increased predation and a build-up of toxic waste, including harmful blue-green algal blooms. Pools can become stratified, separating into layers of different temperatures and oxygen concentrations. The bottom layers can have too little oxygen for fish to survive in.

The NSW Government has produced a fact sheet, Defining 'needs of the environment' during extended dry events (PDF 340 KB), to outline the legislative and policy background for protecting the environment during extreme dry periods. It details strategies that can be used to avoid loss of native species, communities and ecosystems, and prevent irretrievable damage that would stop ecosystems from recovering.

Vertessy et al. (2019) investigated the catastrophic fish kills on the Darling -Baaka River over the summer of 2018–19. The authors found that the events were most likely caused by a rapid cool change that led to surface water mixing with deoxygenated water at the bottom of the stratified pools. Oxygen levels would have crashed throughout the pool, leaving fish with nowhere to escape to.

The authors also concluded that the pools had been in a critical and unstable condition for several months beforehand. This meant that the fish kill could have happened at any time over that period if the weather had changed sooner. Similarly, Baldwin (2019) discussed a wide range of interventions that could be used to reduce the impact of toxic water conditions, especially low oxygen and algal blooms, but none of these are as effective as preventing the conditions developing in the first place. The critical time for intervention is before water conditions reach a tipping point.

We define critical dry conditions for the environment as the point when the risk of a catastrophic event has sharply escalated. Conditions that can signal this risk include where:

- evaporation has broken large refuge pools into smaller pools that can deteriorate at a faster rate
- dissolved oxygen levels and temperature vary significantly at different depths, indicating that the pools are beginning to stratify. Oxygen levels at the bottom that begin to approach 2 to 3 milligrams per litres can be lethal for many fish, forcing them to gulp for air at the surface (Ellis & Meredith 2004, Baldwin 2019)
- blue–green algal biovolume exceeds the 'amber alert' concentration of 4 cubic millimetres per litre and is approaching 10 cubic millimetres per litre, which is a 'red alert' concentration under the NSW *Public Health Act 2010.*

Critical dry conditions for human water use

Towns along the Barwon–Darling are supplied by town weir pools. Weir pool conditions can deteriorate in the same way as natural pools, leading to problems with high salinity, blue–green algae or other toxins requiring additional treatment. Almost all Barwon–Darling towns had to access groundwater during the recent drought and at times were largely or fully reliant on the bore supplies because of insufficient and/or poor-quality surface water. With concerns about the quality of the bore supply, bottled water was provided to some communities and water was also carted to several towns including Pooncarie and Menindee.

We define critical dry conditions for human water use as the point when the risk of insufficient water for high priority domestic supply for towns and individual landholders is escalated. Conditions that can signal this risk include where:

- evaporation has broken large weir pools into smaller pools that are harder to extract water from and can deteriorate at a faster rate
- conditions are approaching Stage 4 critical drought and town water use is subject to high levels of council restrictions, or there are real risks of towns running out of surface water
- blue–green algal biovolume has exceeded the 'amber alert' concentration of 4 cubic millimetres per litre and is approaching 10 cubic millimetres per litre, which is a 'red alert' concentration under the NSW *Public Health Act 2010*.

Draft critical dry condition triggers

Where possible, the draft triggers proposed in this paper use real-time information collected during an extended dry period rather than trigger values based on predictions or statistical estimates. This allows us to respond more directly to conditions at the time. For example, if the river has ceased to flow over autumn and winter, conditions are relatively cool, and it will take longer to reach critical conditions than it would during hotter months.

Using triggers based on real-time data means that management responses are proportional to the variation in risk. However, real-time triggers are still in development for the upper Barwon–Darling, so we have proposed an alternative as the first option.

We have also proposed draft triggers that allow water managers to respond with realistic options and time frames. For example, temporary water restrictions can be an effective mechanism for responding to a critical dry condition trigger on the Barwon–Darling River or the Menindee Lakes, but management must allow for the possibility that it could take several weeks for a flushing flow to arrive. Potential triggers on the Barwon–Darling River must therefore be a reliable indicator of conditions well before they become critical, to allow for conveyance time. If refuge pools in the lower Darling–Baaka River reach a critical condition, these could be mitigated more rapidly through water releases from the Menindee Lakes. These triggers can be based on real-time monitoring of refuge pool conditions rather than antecedent conditions.

Draft Barwon–Darling River initial triggers based on historic and modelled cease-to-flow durations

Environmental critical dry condition triggers

Alteration of the Barwon–Darling River's natural flow regime has affected the magnitude, frequency, duration and timing of all flows, but especially the low flows and cease-to-flow periods (MDBA 2018, Mallen-Cooper and Zampatti 2020). NSW and federal agencies have identified maximum cease-to-flow periods in the Barwon–Darling. These are intended to set the limit on what the environment can cope with without risking severe damage. Studies have guided the draft triggers for critical dry environmental conditions.

The Murray–Darling Basin Authority (MDBA) has recommended maximum cease-to-flow durations at Bourke and Wilcannia that are based on ecological 'thresholds of concern' (MDBA 2018). These were cease-to-flow durations that were outside the range of 'without development' flow models (models that estimated what flow conditions would be without human water extraction). The authors considered that if recorded cease-to-flow durations were longer than those in the 'without development' model, then they were likely to significantly increase the risk of environmental impacts.

The MDBA used flow data from 1990 to 2016 at five locations along the river but acknowledged that the Barwon–Darling hydrology models provide less accurate representations of low flow conditions than higher flows. In response, the report uses other sources of evidence alongside flow models, including ecological studies, salinity management and blue–green algal management guidelines.

The Barwon–Darling Long Term Water Plan (LTWP) (DPIE-EES 2020a) also recommended maximum cease-to-flow durations between Mungindi and Wilcannia. These were based on analyses of modelled and historical flow records. Maximum cease-to-flow durations were based on the 95th percentile of recorded dry periods but flow data in the analyses was restricted to a period from 2000 to 2014 to maintain a consistent approach across all the planning units. This was necessary because many of the flow gauges on the Barwon–Darling River started operation in 1999.

We have used the MDBA 2018 maximum cease-to-flow durations to inform the draft triggers because they are broadly consistent with the LTWP triggers in the same locations (Table 1), as they were derived from longer sequences of historical data and are publicly available.

Disadvantages with using the MDBA 2018 triggers are that they are not available for other key locations such as Walgett and Brewarrina. Additionally, there is limited flexibility around climate and on-ground conditions, which may lead to the trigger durations being shorter or longer than appropriate. For this reason, we will undertake further work on real-time remote monitoring of refuge pools.

The draft trigger for Wilcannia is proposed to be based on the MDBA (2018) recommendation, which is 120 days without flows. A trigger for Bourke will not be defined until we have completed more analyses. We need to understand how frequently the trigger would be activated, especially in relation to the resumption of flow trigger for Bourke that was recently introduced into the Barwon–Darling Unregulated River Water Sharing Plan.

Table 1. Comparison of recommended maximum duration of cease-to-flow periods in the Barwon–Darling LTWP (2020a) and 'Ecological needs of low flows in the Barwon-Darling: Technical Report' (2018)

River section	Flow reference gauge	Maximum cease-to-flow duration (MDBA 2018)	Maximum cease-to-flow duration (Barwon–Darling LTWP 2020a)
Brewarrina to Bourke	Darling River at Bourke 425003	60 days of flows <1 ML/day	90 days
Bourke to Wilcannia	Darling River at Wilcannia 425008	120 days of flows <20 ML/day[1]	160 days

Human water use critical dry condition triggers

Town weirs along the Barwon–Darling generally provide between 6 and 9 months' supply. Bourke Weir, with a capacity of over 4,000 megalitres, provides around 6 months' supply with no inflows and Wilcannia Weir (currently 3,000 megalitres capacity and proposed to be doubled in the upgrade to be commenced in late 2022) provides 4 to 5 months' supply with no inflows.

The MDBA (2018) recommended that event-based management should be implemented to limit no and very low flow periods at Wilcannia from exceeding 120 to 150 days. A cease-to-flow period approaching or forecast to approach 120 days at Wilcannia (Table 1) has been considered as an appropriate signal for restrictions.

Under the NSW Extreme Events Policy (PDF 718.67 KB) which sets out the framework for managing extreme events such as drought, a critical drought or water shortage is where the focus is on preserving water for essential town water, stock and domestic demands only. This is classified as Drought Stage 4 Criticality. Drought Stage 3 Criticality occurs when high priority and general irrigation demands are restricted, or major adjustments are needed to treat or provide raw

[1] WaterNSW has advised that 20 ML/day is considered to be a cease-to-flow measure because gauge 425008 Darling River at Wilcannia becomes unreliable below that flow rate.

water to the minimum quality requirement. Once a valley is in Drought Stage 4 Criticality, future inflows will need to be protected for critical human and environmental needs. You can find more information on drought stages on the Drought stages and measures implemented during the 2017-20 drought page of the department's website.

Over time, the remote sensing project will investigate whether monitoring of major weirs can identify a critical trigger point when human water supply is compromised. However, in the interim, we propose the following initial critical dry condition triggers for human needs:

- if Wilcannia is forecast to be without flows for more than 120 days
  or
- when the Barwon-Darling moves to Drought Stage 4 Criticality
  or
- when northern Basin tributaries are classified as Drought Stage 4 Criticality
  or
- draft triggers for the Baaka–Darling River.

The Menindee Lakes are a naturally occurring series of shallow wetlands located along the lower Baaka–Darling River near the town of Menindee that were modified during the 1950s and 1960s to provide water storage for Broken Hill and the southern Murray–Darling Basin. Broken Hill is no longer reliant on the Menindee Lakes as it is now supplied by a pipeline from the Murray River.

Water flows into the lakes system through Lake Wetherell, which is a ponded weir pool created by Menindee Main Weir on the Darling–Baaka River. Other lakes in the system are filled sequentially once Lake Wetherell reaches a sufficient depth to connect either via natural sill levels (Lakes Tandure, Balaka, Bijiji and Malta) or via regulator gates (Lake Pamamaroo, Menindee and Cawndilla). You can find more information about the lakes' operation in the MDBA's Menindee Lakes fact sheet.

When the lakes are full or inflows have ceased, the lakes' emptying sequence is the reverse of the filling sequence, meaning that Lake Wetherell is usually the preferred storage during extended dry periods and the source of flows into the lower Darling -Baaka. We have therefore proposed a Lake Wetherell trigger in this paper that will maintain:

- aquatic refuges and habitat within the lake
- an adequate reserve to respond to critical dry condition requirements in the lower Darling-Baaka River
- at least 12 months' supply for critical human water needs in the lower Darling-Baaka River.

During extended drought conditions, Lake Wetherell is an important refuge because of its depth and volume. The Murray–Lower Darling Long Term Water Plan (DPIE-EES 2020b) and the MDBA (2012) recommend maintaining a minimum water level of 58.9 metres AHD (Australian height datum), equivalent to 50 gigalitres of storage, distributed between Lake Wetherell and Lake Tandure. The 58.9 metres height supports drought refugia and fish survival by connecting pools, backwaters and fringing habitat in the 2 lakes (MDBA 2012, Baldwin 2020).

The lower Darling-Baaka River has ceased to flow on several occasions including in the last two decades and we have learned important lessons about how best to deliver flows that mitigate the risks when releases are restarted. In 2004, a flushing flow inadvertently resulted in fish kills because discharge volumes were too low to mix oxygen through stagnant pools or safely move the accumulation of organic material downstream (Ellis & Meredith 2004, Baldwin 2021). Later flushing events in 2016 and 2020 had higher flow rates and did not report any fish kills. You can find more information about the 2020 flushing flow in the information sheet Lower Darling release—water quality monitoring (PDF 207 KB).

We recommend maintaining the same strategy used for the 2020 flushing flow to restart flows. This was to:

- maintain a flushing peak at 3,000 megalitres per day at Weir 32 for 7 days
- gradually decrease flows down to 500 megalitres per day at Weir 32 after 21 days and then return to normal releases.

Approximately 55 gigalitres in total volume would have to be reserved in Lake Wetherell to provide for this strategy.

WaterNSW has recently estimated that 195 gigalitres in storage at Menindee Lakes would be required to provide 12 months' supply for Darling–Baaka critical needs (towns, domestic and stock and basic landholder rights). This estimate assumes a summer start, average evaporation and no inflows to provide continuous flow along the river under the minimum water sharing plan rule monthly releases (which total 96 gigalitres per year and vary from 200 megalitres per day in winter to 350 megalitres per day).

Based on combined critical human and environmental needs, we recommend that the critical drought trigger for Menindee Lakes be set at **195 gigalitres** for initiating temporary water restrictions on upstream access.

We have also considered a draft trigger of 450 gigalitres, which would provide up to 2 summers' or 18 months supply in Menindee Lakes under no inflows, but still with required water sharing plan releases which meet town, domestic and stock and commercial needs. However, we did not progress this because 450 gigalitres provides normal supply rather than critical supplies. General security allocations start at 300 to 350 gigalitres.

Dead storage levels and the lower Darling restart allowance

The 195 gigalitres proposed as a drought trigger includes retaining a volume of 50 gigalitres (which includes dead storage) in Lake Wetherell for a fish drought refuge.

We have proposed that a Darling-Baaka restart allowance of 60 gigalitres is included in the next lower Darling water sharing plan. The allowance will apply whenever the total storage in the Lakes falls below 480 gigalitres. The first 60,000 megalitres of inflow to the Menindee Lakes that occurs after the Darling River at Weir 32 has ceased to flow for 10 consecutive days will be credited to the restart allowance. This will be used to restart the river through managed releases to minimise risks to water quality and aquatic species and may also be used to meet water orders along the lower Darling-Baaka. Water remaining in the restart allowance at the end of the water year will be carried over to the next water year, until the lakes exceed 640 gigalitres.

The restart allowance will work in concert with any 324 restriction targets and arrangements to manage releases from the lakes.

Figure 3. The Baaka–Darling River upstream of Lake Wetherell after the restart of flows, March 2020

Accounting for flow travel times to reach Barwon–Darling and Lake Wetherell trigger sites

Flushing flows will be most effective before or shortly after a refuge pool reaches the critical dry condition threshold. However, if temporary water restrictions are triggered at the time when the threshold is reached, there may be a considerable delay before flows actually arrive.

For example, the WaterNSW operations update for February 2020 showed that flows took about 50 days to travel from the end of the Border Rivers at Mungindi to Wilcannia (as detailed in the Operations Update February 2020 rainfall event. (PDF 1406kb). However, rainfall in the lower Namoi or Condamine–Culgoa rivers may take as little as 14 to 18 days. During the 2020 northern Basin flow event, multiple flow events took place in different valleys. Both actual and forecast flows were carefully tracked and managed by the department's Water team and WaterNSW.

Management actions will need to take account of forecast rainfall locations. If rainfall is forecast, temporary restrictions may need to be in place several weeks before the critical dry condition trigger is reached, to allow for travel times. The department's Water Group and WaterNSW will work together to develop a framework that will help ensure decisions around forecast flow travel times can be predictable and clearly explained.

Research to develop remote monitoring of refuge pool extent and condition

NSW Department of Primary Industries – Fisheries (2015) and the Queensland Department of Science, Information Technology and Innovation (DSITI2015) have extensively mapped natural pools and weir pools along the Barwon–Darling River. DSITI also used a combination of remote sensing and statistical modelling to estimate how refuge pools could persist without flows in the lower Balonne and Barwon rivers. These approaches have the potential to be used for critical dry condition triggers, but more research is needed.

The department's Water team is undertaking a feasibility study to determine how readily the existing techniques can be applied to developing dry condition triggers on the Barwon–Darling River. We are investigating whether remote sensing data can be used to map how surface water contracts in refuge pools during droughts (Figure 4). Our aim is to identify the points when important refuge and water supply pools begin to fragment into smaller pools that are at greater risk of critical conditions. If this approach is feasible, we will develop a remote monitoring program that commences when flows cease at any one of the key locations of Brewarrina, Walgett, Bourke and Wilcannia. This program should be able to provide regular updates to the public as we continue to track conditions.

Figure 4. Satellite image of the Barwon–Darling River upstream of Brewarrina in February 2020. Blue indicates the presence of surface water. Orange is dry riverbed. Small orange patches indicate that large pools have fragmented into smaller pools due to evaporation.

Draft operational triggers for the lower Baaka–Darling River

Water is released into the lower Baaka–Darling River from the Menindee Lakes. Flows can be delivered to key locations on the Baaka–Darling quickly, provided there is available water in storage. This means water managers can monitor and respond to real-time updates of water quality condition, especially any indications that thermal stratification is occurring in refuge pools and weirs.

We have proposed water quality thresholds as the draft critical dry period triggers for three key locations along the Darling-Baaka River (Table 2). The draft triggers are intended to guide releases of water from Menindee Lakes and not to trigger restrictions on upstream water use. If any of the trigger conditions are met, a flushing flow should be released as quickly as possible.

Water quality triggers are proposed for dissolved oxygen and blue–green algae. Water temperature should also be measured as it can provide a second line of evidence of thermal stratification. However, we are not proposing that water temperature be used as a trigger because daily variation can make interpretation difficult. Daily variation in dissolved oxygen can indicate stratification and blue–green algae blooms, so it is a signal that should be considered when monitoring for critical conditions.

Monitoring for water quality triggers should be conducted throughout the warmer, higher-risk months when low flows and poor conditions are most likely to occur. October to March is generally regarded as the highest risk period for thermal stratification.

Table 2. Draft critical dry condition operational triggers for the lower Baaka–Darling River

River Section	Flow reference gauge	Dissolved oxygen trigger[2]	Blue–green algae trigger[3]	Monitoring duration and frequency
Weir 32	Darling River upstream Weir 32 425012	Initial alert notification at 50% saturation or 5 mg/L Critical ecological threshold alert level 3 mg/L	Amber Alert algae recreation guideline of 0.4 to 4 cubic millimetre per litre or announcement of an Amber alert warning	October–March Real-time continuous monitoring of dissolved oxygen and water temperature at multiple depths. Weekly monitoring of blue–green algae4
Pooncarie	Darling River at Pooncarie 425005	Initial alert notification at 50% saturation or 5 mg/L Critical ecological threshold alert level 3 mg/L	Amber Alert algae recreation guideline of 0.4 to 4 cubic millimetre per litre or announcement of an Amber alert warning	October–March Real-time continuous monitoring of dissolved oxygen and water temperature at multiple depths. Weekly monitoring of blue–green algae
Burtundy	Darling River at Burtundy 425007	Initial alert notification at 50% saturation or 5 mg/L Critical ecological threshold alert level 3 mg/L	Amber Alert algae recreation guideline of 0.4 to 4 mm3/L or announcement of an Amber alert warning	October – March Real-time continuous monitoring of dissolved oxygen and water temperature at multiple depths. Weekly monitoring of blue–green algae4

It is essential that dissolved oxygen and temperature monitors are installed at several depths in key monitoring locations so that stratification is easily detected. Baldwin (2019, 2021) recommended measuring dissolved oxygen and temperature at 10 cm, 50 cm and then every

[2] Native fish and other large aquatic organisms requiring at least 2 mg/L of dissolved oxygen to survive but may begin to suffer at levels below 4 to 5 mg/L (Gerhke 1988).

[3] This is based on Chapter 6 of the National Health and Medical Research Council guidelines for managing risk in recreational water (NHMRC 2008).

[4] Based on the recommendations for effective monitoring of pool stratification outlined in Baldwin (2019, 2020)

50 cm from the bottom of the deepest part of the pool. This will provide data with enough frequency and resolution to confidently detect stratification.

The triggers listed in Table 2 apply to both critical human and critical environmental needs.

Implementing and lifting temporary water restrictions

Large-scale, coordinated use of temporary water restrictions was first undertaken during the 2020 Northern Flow event to protect first flows after a prolonged drought. This gives us a body of experience to draw on. The following discussion shows how Section 324 orders might be used.

A, B and C class access in the Barwon–Darling water sharing plan, floodplain harvesting in the Barwon–Darling and in northern valleys, supplementary access in the northern tributaries and large unregulated river access on the lower northern valleys would be restricted when:

- there is likely to be a cease-to-flow period of 120 days at Wilcannia, especially in spring-summer
- Menindee Lakes falls below 195 gigalitres
- the Barwon–Darling River is classified as Drought Stage 4 Criticality.

If any of the above conditions is met, access would be restricted if:

- flows are forecast to occur
- forecast flows will meaningfully contribute to meeting the targets.

If the northern tributaries are in Drought Stage 4 Criticality (regardless of whether the above triggers are met), a section 324 restriction may also be placed in these systems until flow recovers.

During a severe drought there may not be flows sufficient to temporarily restrict access to meet targets at Wilcannia or Menindee Lakes. For example, the recent drought was the worst on record for the northern NSW Basin and the lower Darling-Baaka River. From late 2017 to late 2019, there were no supplementary access periods in the northern valleys and B-class pump thresholds in the Barwon–Darling were not or rarely met. However, at times when some small inflows occurred in the Barwon–Darling, flows were embargoed to meet local needs. It was not until 2020 that substantial flows occurred that were able to provide a flow through the northern valleys and into Menindee Lakes. Restrictions on accessing initial flows assisted in ensuring that flows extended downstream earlier than if pumping had been permitted.

Proposed targets for lifting restrictions

The initial target for Menindee Lakes for lifting restrictions during the 2020 event was 70 gigalitres of additional inflows. In practice, this applied to the restrictions on access in the northern valleys. With subsequent tributary inflows from Queensland, the target was increased to 200 gigalitres. This helped deliver social, environmental and cultural outcomes for the lower Darling-Baaka and allowed a flushing flow to be sent down the lower Darling-Baaka initially to improve the poor water quality and aquatic habitat before a return to more normal releases.

With a drying climate, it is appropriate to take a precautionary approach and adopt the 195 gigalitres as the target for lifting restrictions as well as initiating restrictions.

As a volume target, restrictions would be lifted once flows were forecast to reach Menindee Lakes and increase capacity above 195 gigalitres. This should ensure adequate flows at Wilcannia.

However, if Menindee Lakes is above 195 gigalitres but the Wilcannia trigger of no flow for 120 days is likely to occur without an imminent flow event, then the upstream restrictions would be lifted once a flow of 4,000 megalitres is forecast to reach Wilcannia. This is consistent with the Barwon–

Darling water sharing plan resumption of flow lifting target of 400 megalitres for 10 days. A flow of this size would also result in the filling of the existing Wilcannia town weir.

Lifting of restrictions would occur:

- progressively as flows move through the systems
- if there is high confidence in downstream flow predictions meeting targets
- in consideration of travel times and antecedent conditions that will impact on river losses.

However, if flow forecasting indicates the flows in localised upstream sections will not meaningfully contribute to downstream targets regardless of whether access is allowed or not, then restrictions may be temporarily lifted.

Continued research and next steps

We are seeking feedback from the Connectivity Stakeholder Reference Group on the initial draft triggers.

We will continue working on remote sensing triggers for the Barwon–Darling River. We will undertake more analysis and in-depth modelling to make sure that the draft triggers integrate well with other low flow protection rules. In particular, we will be closely examining how the critical dry condition triggers on the Barwon–Darling River interact with the resumption of flow rules in the Barwon–Darling water sharing plan.

The resumption of flow rules are designed to protect low flows after an extended dry period in the Barwon–Darling, but do not necessarily influence the frequency and duration of cease-to-flow events. They also only apply to water users covered by the Barwon–Darling water sharing plan. We expect that the critical dry condition triggers will complement the water sharing plan rules by focussing on conditions that are outside the water sharing plan's intended rules, and by initiating management responses across the broader northern Basin.

We also need to undertake further work to understand cultural needs in the context of an extended drought and first flush.

Community consultation will be undertaken in 2022 through the Western Regional Water Strategy and the Barwon-Darling Water Sharing Plan remake.

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