



Australian Government

Commonwealth Environmental Water Office

Commonwealth Environmental Water Office

Water Management Plan

Chapter 3.6 – Macquarie River

2020–21



This document represents a sub-chapter of 'Commonwealth Environmental Water Office Water Management Plan 2020-21, Commonwealth of Australia, 2020'.

Please visit: <https://www.environment.gov.au/water/cewo/publications/water-management-plan-2020-21> for links to the main document.

Acknowledgement of the Traditional Owners of the Murray–Darling Basin

The Commonwealth Environmental Water Office respectfully acknowledges the Traditional Owners, their Elders past and present, their Nations of the Murray–Darling Basin, and their cultural, social, environmental, spiritual and economic connection to their lands and waters.

© Copyright Commonwealth of Australia, 2020.



Commonwealth Environmental Water Office Water Management Plan 2020-21 is licensed by the Commonwealth of Australia for use under a Creative Commons Attribution 4.0 International licence with the exception of the Coat of Arms of the Commonwealth of Australia, the logo of the agency responsible for publishing the report, content supplied by third parties, and any images depicting people. For licence conditions see: <https://creativecommons.org/licenses/by/4.0/>

This report should be attributed as 'Commonwealth Environmental Water Office Water Management Plan 2020-21, Commonwealth of Australia, 2020'.

The Commonwealth of Australia has made all reasonable efforts to identify content supplied by third parties using the following format '© Copyright' noting the third party.

The views and opinions expressed in this publication are those of the authors and do not necessarily reflect those of the Australian Government or the Minister for the Environment.

While reasonable efforts have been made to ensure that the contents of this publication are factually correct, the Commonwealth does not accept responsibility for the accuracy or completeness of the contents and shall not be liable for any loss or damage that may be occasioned directly or indirectly by, or reliance on, the contents of this publication.

For more information about Commonwealth environmental water, please contact us at:

1800 803 772

ewater@awe.gov.au

www.environment.gov.au/water/cewo

@theCEWH

GPO Box 858, Canberra ACT 2601

3.6 Macquarie River Valley

3.6.1 Region overview

(a) River valley

The Macquarie River forms above Bathurst in Central Western New South Wales (NSW), where the Campbells and Fish rivers join, and flows into Burrendong Dam, south east of Wellington (Figure 1). Below the dam, tributary flows are provided by the Bell, Little and Talbragar rivers, and Wambangalong and Coolbaggie creeks. As the land flattens further west of Dubbo, the Macquarie River provides flows to distributary creeks, wetlands and rich alluvial river flats associated with braided channels, and can connect with the Barwon–Darling River.

Macquarie River flows are heavily influenced by large rainfall events in the upper catchment and flows in tributary systems. Two major storages, Windamere Dam (capacity 368 gigalitres) on the Cudgegong River, and Burrendong Dam on the Macquarie River (storage capacity of 1 188 gigalitres, with additional storage capacity of 489 gigalitres in the flood mitigation zone), regulate catchment water supplies.

(b) Traditional Owners

The rivers and wetlands of the Macquarie River Valley hold significant spiritual and cultural importance for Aboriginal people. In the upper and middle Macquarie valley, the Aboriginal people are the Wiradjuri, while on the plains the Bogan River forms the boundary between the Ngemba and Ngiyampaa Nations to the west and the Wayilwan Nation to the east. Wayilwan country includes most of the Castlereagh catchment, except the north-east corner, which is the traditional land of the Kamilaroi.

(c) Important sites and values

The valley includes the Macquarie Marshes complex on the lower reaches of the Macquarie River, of which, parts of the northern, southern and eastern Marshes are listed as a Wetland of International Importance under the Ramsar Convention. Parts of the Macquarie Marshes were recognised under the Ramsar Convention for being a unique example of a wetland type in the region in terms of their size and their diversity of wetland types, supporting species of conservation significance and biological diversity, providing refuge during adverse conditions, and regularly supporting large numbers of waterbirds. This includes those listed under international migratory agreements (JAMBA, ROKAMBA, CAMBA). The Ramsar site contains a range of habitats including core areas of semi-permanent wetlands, such as forests and woodlands, reed beds, marshes, rushlands and open lagoons. These vegetation types have been identified as critical components of the Ramsar site.

Other assets in the valley include the Macquarie River channel, the unregulated components of the lower Macquarie River and the distributary creek system to the west of the Marshes.

The Macquarie Marshes and Macquarie River support numerous species listed as endangered or vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999*, for example, the Australian painted snipe, Australasian bittern, Murray cod, trout cod and spike rush. The aquatic community of the Macquarie also forms part of the Lowland Darling River aquatic ecological community, which is listed as endangered under the *NSW Fisheries Management Act 1994*.

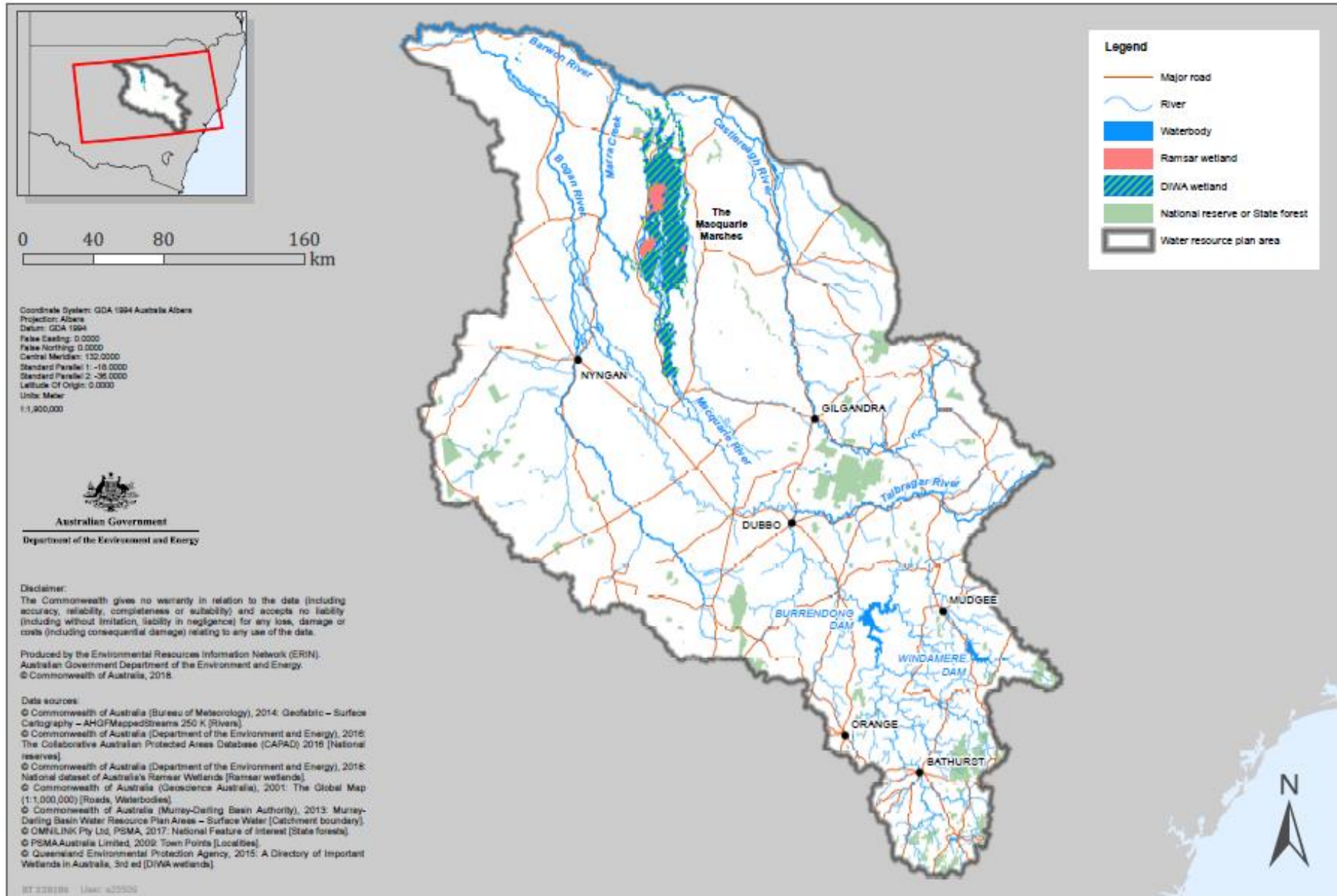


Figure 1: Map of the Macquarie River Valley (produced by the Department of the Environment and Energy, June 2018.)

(d) Stakeholder engagement

In the Macquarie River Valley, the planning, management, and delivery of Commonwealth water for the environment is undertaken in conjunction with a range of partners and stakeholder groups. Key stakeholders in the Macquarie include the NSW Department of Planning, Industry and Environment (DPIE), the Department of Primary Industries (DPI) – Fisheries, WaterNSW, and the Macquarie Cudgegong Environmental Flow Reference Group (EFRG), who provide advice to water managers on priorities for water use.

Local Engagement Officers from the Commonwealth Environmental Water Office (CEWO) also work with different stakeholders as part a broader program of engagement around the management of the Commonwealth environmental water entitlements. As part of this work, Local Engagement Officers have been engaging directly with members of the local Aboriginal community.

3.6.2 Environmental objectives

Based on long-term environmental objectives in the Basin Plan, draft state long-term watering plans, site management plans (including Ramsar site ecological character descriptions), and best available knowledge, the following objectives are relevant for environmental watering in the Macquarie River Valley.

The objectives targeted in a particular year may vary, depending on available water, catchment conditions, operational feasibility, and demand for environmental water. These objectives will continue to be revised as part of the CEWO's commitment to adaptive management.

Vegetation: Maintain the condition, growth and survival of riparian, in-channel, floodplain and wetland vegetation.

Waterbirds: Increase waterbird abundance and maintain species diversity by supporting naturally triggered breeding events, and maintaining suitable refuge, feeding and breeding habitat.

Native fish: Prevent loss of native fish species and improve population structure and distribution, by supporting opportunities for movement, dispersal, reproduction, and recruitment.

Other vertebrates: Support opportunities for the reproduction and recruitment of other native aquatic species, including frogs and turtles.

Connectivity: Support longitudinal connectivity, including with the Barwon River, and lateral connectivity between the river and floodplain.

Processes/water quality/resilience: Support key ecosystem functions and promote productivity; maintain water quality in channels and pools; and maintain drought refuge habitat.

3.6.3 First Nations environmental objectives

Representatives of the First Nations peoples of the Macquarie valley have identified environmental objectives for their country for 2020–21 (Table 1 and Table 2). These objectives were developed through the First Nations Environmental Guidance project undertaken by the Northern Basin Aboriginal Nations (NBAN) and the Murray Lower Darling Rivers Indigenous Nations (MLDRIN) organisations, as well as directly from local Ngiyampaa, Wayilwan and Wiradjuri Aboriginal community members.

Some of these objectives sit outside the scope of water for the environment to influence, while for others, the link between water for the environment and the site or issues is not well understood. The CEWO will use environmental flows to contribute to these objectives where possible and where this is consistent with the Commonwealth Environmental Water Holder's statutory responsibility of protecting and restoring environmental assets in the Basin.

The Commonwealth Environmental Water Holder is committed to continuing to work with the local Aboriginal community to better understand their objectives.

Table 1: First Nations environmental objectives for the Macquarie Valley for 2020–21 from NBAN (NBAN Ltd. 2020)

River flows and Connectivity
<i>Priority sites:</i> Macquarie River: needs to provide flow to the marshes at all times. Castlereagh River*: the flow that comes from rain needs to be protected. Other flows and connectivity: Macquarie and Castlereagh Rivers need to flow at all times to sustain cultural and heritage sites. Local advice is needed to inform this objective.
Native Vegetation
<i>Indicator species:</i> Redgum, bulrush, stringy bark ⁱ , iron bark ⁱ are all important for culture. Redgum and bulrush are important for habitat, and bulrush for weaving.
Native Birds
<i>Indicator species:</i> Wood duck, kingfisher, black cockatoo ⁱ . Wood Duck are used for food. The kingfisher has cultural significance.
Native Animals
<i>Indicator species:</i> Cod, yellowbelly, turtles, Macquarie perch (missing). These are important for providing food.
Connecting with Country
Wayilwan people are and need to be connected with Country across the Wayilwan Nation.

ⁱ Water for the environment targeting other environmental outcomes may influence this species or objective

Table 2: First Nations environmental objectives for the Macquarie Valley for 2020–21 from MLDRIN (MLDRIN 2020)

Waterways and Places in Need of watering
Major rivers; Wetlands, Billabongs and Floodplains; Other places, parks, forests, islands; All on Country; Macquarie River; Macquarie Marshes
River Flows and Connectivity
Improve flows and quantity (rivers and general); Improve timing and seasonality of flows; Improve tributary flows; Improve water quality; Remove barriers and constraints.
Vegetation
Nardoo, phragmites, sheoaks ⁱ .
Fish
Catfish, Murray cod, silver perch, yellowbelly,
Waterbirds
Darters, ducks, swan.
Other species
Platypus ⁱ , cockatoos ⁱ .

ⁱ Water for the environment targeting other environmental outcomes may influence this species or objective

* The Castlereagh River is currently out of scope for use of environmental water entitlements.

3.6.4 Recent conditions and seasonal outlook

(a) *Recent conditions and environmental water use*

The Macquarie River Valley has experienced very hot and dry conditions since 2017–18, with rainfall being well below average, and highest on record temperatures. Inflows to Burrendong Dam have been extremely low during this time, with the lowest inflows on record.

With new drought of record conditions in the Macquarie River Valley, access to general security and planned environmental water accounts was restricted to 70 per cent of the 1 July 2018 carryover balance. This limited the volume of NSW and Commonwealth water for the environment that was delivered to support wetland vegetation and native fish in 2018–19.

Further restrictions were put in place in 2019–20, with all allocations of water for the environment being held in a drought sub-account (along with other general security water). Consequently, no water for the environment was able to be delivered as the extreme drought continued.

The mid-Macquarie River was shut off downstream of Warren in late August 2019, resulting in cease to flow conditions, necessitating the rescue of native fish from drying refuge pools over summer. Ongoing very hot and dry conditions affected the condition of vegetation in the Macquarie Marshes. During the spring and summer large areas had little or no ground cover. A fire in spring 2019 also burnt large areas of the north marsh reedbed (part of the Ramsar site).

Late summer and autumn rainfall and flows provided much needed water to parts of the Macquarie Marshes. Commonwealth and NSW supplementary water entitlements were used to ensure some additional water was left instream to help support recovery in the Macquarie River and Marshes. Some areas of the Marshes such as the north marsh reedbed have responded well. However, areas that haven't received sufficient water are in poorer condition. A range of bird species such as spoonbills, magpie geese, ibis and whistling ducks have been observed in increasing numbers in the Marshes.

As of 29 June 2020, Burrendong Dam was at 23 per cent capacity, up from ~1.5 per cent in February. However, further significant inflows are required before there is sufficient water available to meet all system requirements in 2020–21 or announce any new allocations.

Details of previous Commonwealth environmental use in the Macquarie River Valley are available at: <http://www.environment.gov.au/water/cewo/catchment/macquarie/history>.

(b) *Seasonal outlook*

According to the Bureau of Meteorology outlook in July, above median rainfall is forecast across the Macquarie River Valley from late winter through spring. While this forecast suggests that the recent severe dry conditions may ease somewhat, several months of above average rainfall are needed to see a recovery from the current severe drought. Stream flows may be less than expected during the recovery. However, wetter conditions can return suddenly in the northern Basin. Maximum temperatures are also forecast to remain above average over the coming months.

(c) *Water availability*

The volume of Commonwealth environmental water carried over in the Macquarie River Valley for use in 2020–21 is 22.7 gigalitres. However, given current drought restrictions only 40 per cent of this volume (9.08 gigalitres) is available for use. The remaining volume continues to be quarantined in the drought sub-account until conditions improve further. No new allocations are expected unless resource availability significantly improves, and quarantined water has been made available.

Based on the expected available volume of water held by the Commonwealth and other water holders, as well as recent and forecast catchment conditions, it is expected that the overall resource availability will be very low to low in 2020–21.

(d) Environmental demands

Considering the prolonged drought and need to support recovery and avoid further damage to key assets, there are a number of environmental demands that require water urgently in 2020–21.

The environmental water demands for assets in the Macquarie River Valley in 2020–21 are represented in Table 3. Note that the capacity to contribute to many of these environmental demands is contingent on a substantial improvement in water availability in the catchment.

Table 3: Environmental demands, priority for watering in 2020–21 and outlook for coming year in the Macquarie River Valley.

Environmental assets	Target values	Indicative demand (for all sources of water in the system) ⁶		Watering history ⁷ (from all sources of water)	2020–21		Implications for future demands
		Flow/Volume	Required frequency (maximum dry interval)		Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020–21
Mid-Macquarie River (Burrendong – Marebone Weir)¹ Native fish habitat and spawning including threatened species such as Murray cod, freshwater catfish In-stream aquatic ecosystems Riparian vegetation	Fish refuge: all guilds Aquatic ecosystems	Baseflows[*]: small (>200 ML/d), very regular flows through to end of system, wetting waterholes and in-stream storages. Ideally depth >0.3 m above commence to flow level, to allow some movement and prevent pool stratification.	Ideally: continuous flow (Max interval: continuous flow)	Demand expected to be met by essential regulated supplies in all but the most extreme dry years. Minimum baseflows have been achieved in all years, other than in 2019–20 when extreme dry flow conditions meant that the Macquarie River was shut off downstream of Warren Weir in late August 2019 until tributary flows improved conditions in February 2020. Baseflows are ideally required continuously to maintain in-stream habitat, and will be required again in 2020–21, particularly in the river between Warren and Marebone where there were cease to flow conditions. Therefore, the environmental demand has been assessed as high to critical.	High to Critical	High priority for use of CEW under very low water availability scenario, subject to environmental water being available for delivery. However, there is a risk in 2020–21 that baseflows won't be met should extreme dry conditions continue. Expected to be met by essential regulated supplies under low to very high water resource availability scenarios.	High
	Fish spawning–flow generalists (e.g. Australian smelt, carp gudgeon) + in-channel specialists (e.g. Murray cod, freshwater catfish)	Small freshes: Small fresh 1(SF1) >500 ML/d anytime (but ideally Oct–Apr) for 10 days. Small fresh 2 (SF2) >500–6 000 ML/day for at least 14 days at Baroona in Sep–Apr (Sep–Dec for Murray cod spawning); and conditioning flow in winter (July to mid-August).	Ideally: SF 1: annually (Max interval: 3 years for large-bodied generalists; 5 years in-channel specialists; 1 year for small-bodied) SF2: 5–10 years in 10	Small freshes were achieved between 2015–16 and 2018–19 but had only been partially met in 2019–20 as of mid-April 2020. SF1 and SF2 were likely met in February and April downstream of tributaries (Bell, Little rivers), but not upstream to Burrendong Dam. No winter priming flow was achieved. These flows are ideally provided annually, particularly for small bodied fish, so are required again in 2020–21. Therefore, the environmental demand has been assessed as high.	High	Potential use under low to high water resource availability scenarios, subject to natural tributary flows and water temperature.	Moderate to High
	Flow specialists guild movement and breeding [†]	Priming flow: >5 000 ML total flows at Baroona over 3 days with approx. 7 day recession (tributary pulse). Spawning pulse: initial peak ≥ 5 000 ML/day at Baroona for >2 days with event lasting for >7 days. (35–40 day total event) Dispersal flow: Initial pulse >3 000 ML total flows over 3 days at Baroona. Second pulse min. 2 000 ML/day peak with recession. Approx 10d duration total events. (Oct–March) Water temperature for all pulses ≥19°C.	Ideally: 3–5 years in 10 (up to twice per year) (Max interval: 4 years)	Flows for native fish flow specialists were likely last fully met in 2012–13 (Nov–Jan). Tributary flows to Baroona in February 2020 likely provided priming and spawning flows, followed by a dispersal flow in March. Another potential spawning pulse occurred in April 2020. However, this demand was not met to Marebone, and supplementary access, and channel breakouts/floodrunners and operation of creeks impacted on achievement of required flows. The maximum interval between events for these flows has been exceeded by three years. Also, in consideration of the extreme drought conditions, and recent fish kills, it is unlikely that the flows in 2019–20 were sufficient to support the longer-term recovery of native fish flow specialists in the mid-Macquarie River. Therefore, the environmental demand for water in 2020–21 has been assessed as critical.	Critical	Although the demand for water is very high, water available to meet this demand is insufficient under a very dry scenario. The capacity to target spawning pulses using regulated environmental water is also limited in most years. Possible use of CEW (e.g. supplementary) under moderate to high water resource availability scenarios to augment freshes and support movement. Subject to natural tributary flows, water temperature, and significant river rises that will cue movement and possibly spawning of flow specialists.	Critical
	Fish movement In stream + riparian vegetation	Large freshes and bankfull: 10 000–20 000 ML/day at Baroona for a minimum of 3 days (to drown out key weirs). (Gin Gin drowns out at 18 000 ML)	Ideally: 2 in 10 years (Max interval: 2–4 years)	Large freshes were last achieved in 2016–17, when flows >10 000 ML/day were achieved at Baroona on three occasions, for 6, 3 and 28 days respectively in Sept–Oct 2016, and in 2011–12 before that. These flows were partially met in 2019–20, having exceeded 10 000 ML/d at Baroona for 2 days in February and 3 days in April. However, these flow rates were not reached in other sections of the river, and supplementary access impacted on the achievement of this demand. To meet the desired frequency of these flows, water is required in 2020–21 or 2021–22. Therefore, the environmental demand has been assessed as moderate.	Moderate	A low priority for CEW in 2020–21 and only able to contribute to this demand when coordinated with major tributary flow event.	Moderate

^{*} Very low flows in the mid-Macquarie River have the same flow rate and requirements as baseflows (>200 ML/day). Cease to flow events should be avoided because they no longer occur, and fish, plant and animal communities are dependent on regular flows.

[†] There are still knowledge gaps related to spawning requirements and hotspots in the Macquarie catchment for flow specialists.

Environmental assets	Target values	Indicative demand (for all sources of water in the system) ⁶		Watering history ⁷ (from all sources of water)	2020–21		Implications for future demands
		Flow/Volume	Required frequency (maximum dry interval)		Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020–21
Macquarie Marshes <small>3,4‡</small> Includes areas of Ramsar listed wetlands [§] Nationally significant wetlands Waterbird breeding and habitat Habitat and breeding ground for frogs Native fish habitat	Blue and Purple inundation zones (4 000 to 9 000 ha)	30–60 GL at Marebone over 3 months between June and April to inundate reed beds, lagoons, mixed marsh, and water couch.	Ideally: annually (Max interval: 2 years)	Demand has been met in most parts of the Marshes in most years since 2012–13. This demand was likely met in the Northern and Southern Marshes in 2019–20, based on the flow volume, inundation extent and duration. Rainfall and supplementary events contributed flows (~132 GL of water was recorded at Marebone over three months to late April, with 106 GL being available to the Marshes). Approximately 49 GL reached Pillicawarrina and the Northern Marshes. However, in the Eastern Marshes, despite good rainfall, lower inflows were received. Overall, the demand for water in 2020–21 has been assessed as high, to support the recovery and growth of core wetland vegetation, and to provide habitat for a range of aquatic species. This is based on the annual need for water, the prolonged extreme dry conditions preceding inflows in autumn 2020, and inflows occurring later in the growing season when temperatures were cooler. Encroachment of dryland species and high grazing pressure also intensifies the need for water in 2020–21, to aid recovery of wetland vegetation.	High	A high priority for CEW under very low to high water resource availability scenarios.	High
	Pink inundation zone (19 000 ha)	100 GL at Marebone over 3 months between June and April to inundate reeds, water couch, mixed marsh, river red gum forest, river cooba.	Ideally: 8 in 10 years (Max interval: Groundcover – 2 years; trees 4–7 years)	Demand met in 2012–13, 2016–17 and again in 2017–18 in all areas of the Marshes, excluding the Eastern Marshes in 2017–18, which was not inundated for the target duration. Demand was either partially met or not met in years in between, including in 2019–20. Although ~132 GL of flow passed Marebone Weir over three months to the end of April, 106 GL of which was available to the Marshes, this demand has not yet been met. Extreme dry conditions preceding these flows has meant this volume has been insufficient to adequately support all vegetation types in the pink zone. Lateral connectivity has not been achieved between channels, beyond the reedbeds into areas of river red gum forest and river cooba. Inundation outside the prime growing season may also impact on the ability to fully meet these requirements. Low groundcover and high grazing pressure have also intensified the need for water to aid recovery. Requires water in 2020–21 to contribute to 8 in 10 year frequency, avoid damage, and to build resilience, including in Ramsar sites. Therefore, this environmental demand has been assessed as high.	High	A high priority for CEW under low to high water resource availability scenarios. Unlikely to have sufficient water to target this demand, unless there is a substantial improvement in water availability.	High
	Red inundation zone (50 000 ha)	250 GL at Marebone over 3–5 months between June and April to inundate river red gum woodland, river cooba, inner coolibah woodland	Ideally: 1 in 3 years (Max interval: 4–7 years)	Demand met in 2016–17 and 2012–13 in all areas of the Marshes. However, as this flow has now not been met in the last three years (ideal frequency), water is needed in 2020–21. Therefore, the demand is considered high.	High	Possible use under high or very high water resource availability scenarios. Would require other water sources to meet.	High
	Orange and green inundation zones (81 000 to 145 000 ha)	400 to 700 GL at Marebone over 5 months between June and April to inundate outer river red gum (RRG) woodland, coolibah, and black box	Ideally: 1 in 4 years (RRG), or 1 in 8 years (other veg) (Max interval: 7 years (RRG) 20 years (other veg))	Demand last met in 2016–17 in all areas of the Marshes and previously in 2010–11. Some minor inundation occurred in 2011–12 and 2012–13. The condition of this area may be affected by low inflows and below average rainfall during extreme drought conditions. Demand is considered moderate to high, requiring water in 2020–21 or 2021–22, particularly to maintain river red gum woodland.	Moderate to High	Low priority for use of CEW in 2020–21 and only able to contribute to this demand when coordinated with major flow event.	Moderate to High

‡ Volume required to meet demands may vary depending on antecedent conditions.

§ Vegetation types/communities that are identified as critical components of the Ramsar site include water couch, river red gum forest and woodland, reed beds, cumbungi, mixed marsh, coolibah and blackbox woodland. By maintaining this wetland vegetation, other critical components of the Ramsar site may be supported, including frogs, fish, waterbird breeding and foraging habitat.

Environmental assets	Target values	Indicative demand (for all sources of water in the system) ⁶		Watering history ⁷ (from all sources of water)	2020–21		Implications for future demands
		Flow/Volume	Required frequency (maximum dry interval)		Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2021–22 if watering occurred as planned in 2020–21
Lower Macquarie River (Marshes – Barwon River)^{1,2} Native fish habitat and dispersal Provides connectivity between Macquarie and Barwon catchments In-stream aquatic ecosystems and floodplain vegetation	In-stream aquatic ecosystems Fish Connectivity	In-channel flows: Minimum 20 ML/day at Bells Bridge for 45 days.	Ideally: annually (Max interval: 1–2 years)	Small in-channel flows were met in the lower Macquarie in each year between 2016–17 and 2018–19 (usually between Aug and Dec/Jan). However, cease to flow conditions have persisted in the lower Macquarie River in 2019–20, with the exception of small flows above 20 ML/d (S&D) in March, April and again in May 2020. These flows ideally occur annually and are required again in 2020–21. Therefore, the environmental demand has been assessed as high.	High	Possible use under low to moderate water resource availability scenarios, subject to tributary flows. Needs may be partially met by other flows (e.g. environmental water delivered to the Marshes).	High
	Fish Connectivity	System connectivity between the Macquarie and Barwon catchments: † for example in-channel flow targeting minimum rates of 140 ML/day at Bells Bridge (minimum depth of 50 cm) to connect the lower Macquarie River and the Barwon River for a minimum of 28 days.	Opportunistic (Max interval: 4 years)	Based on flows at Bells Bridge, suitable connection was achieved in spring 2016, autumn 2017, and again in spring/summer 2017. Note that these flows in 2016–17 occurred during wetter conditions and the autumn flow was specifically targeting connectivity to the Barwon River. However, flows in 2017–18 occurred in drier conditions and were likely subject to extraction downstream of Bells Bridge, meaning suitable connection may not have been achieved. This demand was also partially met in 2018–19, with environmental water providing a low flow connection to the Barwon River during spring 2018. Flows from the Castlereagh and Marthaguy provided good connectivity in the lower reaches in early 2020. However, cease to flow conditions persisted through much of 2019–20, and flows remained well below 140 ML/d at Bells Bridge. Therefore, this demand was not met and water required in 2020–21.	High	High priority for CEW under moderate to very high water resource availability scenarios only, subject to suitable conditions and operational feasibility.	Moderate to High
	Floodplain vegetation Connectivity	15–30 GL at Bells Bridge to inundate floodplain and lower reach of Macquarie River.	Ideally: 1 in 3 years (Max interval: 7 years)	Good connectivity was achieved with the lower reach and floodplain of the Macquarie River in 2016–17 and previously in 2012–13. ~15.3 GL of flow also passed Bells Bridge between July and mid-Dec 2017. However, this water was likely subject to unregulated flow extraction in the lower Macquarie, so this demand may not have been fully met since 2016–17. Therefore, the environmental demand has been assessed as high.	High	Unlikely to be a priority under continuing very dry conditions. Possible use under high to very high water resource availability scenarios only, subject to suitable conditions and operational feasibility.	High
Unregulated Distributary creeks⁵ (Marra Creek Lower Crooked Creek^{**}) Native fish habitat In-channel and riparian habitat In-channel and riparian habitat Connectivity with Barwon–Darling catchment	Fish In channel and riparian vegetation Increased frequency and duration of connectivity to Barwon–Darling	Baseflows and freshes to Marra Creek and/or the lower Crooked Creek. Volumes required dependent on which creeks are targeted. Some connectivity may be provided by replenishment flows.	Required frequency unknown (1 in 1–3 years based on key vegetation)	Demand was met in 2016–17 and 2012–13, with stock and domestic replenishment flows partially contributing to demand in some creeks in years in between. Some flows were recorded in Crooked and Marra creeks following rainfall, tributary flows and delivery of stock and domestic water between February and April 2019–20. Marra Creek also connected with the Barwon. Following these flows, this demand is considered to have been met in Marra Creek (total 16 138 ML at the Carinda gauge Feb–Apr). However, flows only partially met this demand in Crooked Creek (total 5 350 ML at the Profile gauge Feb–Apr). Overall, water is required in the next 1–2 years, so the environmental demand has been assessed as moderate to high.	Moderate to High	Possible use under moderate to very high water resource availability scenarios, subject to suitable water availability and operational feasibility.	High

^{**} Broader system connectivity may be achieved by other flows in the system and operational management of environmental/other water (e.g. via the Bogan River, Gunningbar Creek, the Castlereagh River, and Marthaguy Creek (including through the Gum Cowl)).

Environmental assets	Target values	Indicative demand (for all sources of water in the system) ⁶		Watering history ⁷ (from all sources of water)	2020–21		Implications for future demands Likely urgency of demand in 2021–22 if watering occurred as planned in 2020–21
		Flow/Volume	Required frequency (maximum dry interval)		Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	
<p>Prioritised critical refuge habitat – various locations as required in exceptional circumstances</p> <p>Refuge habitat</p> <p>Native fish (e.g. olive perchlet), water rat and tortoise survival</p> <p>Water quality</p>	<p>Fish (all guilds) and other aquatic dependent biota refuge</p> <p>Aquatic ecosystems</p>	<p>Baseflows to replenish significant refuge pools at high risk of drying down in exceptionally dry circumstances.</p> <p>Volumes required are likely to be relatively small, but dependent on which refuge pools are targeted.</p>	<p>As required only during extremely dry conditions</p>	<p>Demand expected to be met by essential regulated supplies in all but the most extreme dry years.</p> <p>Environmental water was provided to two important refuge pools in 2018–19 (Lower Nyngan Weir Pool and at Methalibar Reserve on Ewenmar Creek) to help prevent them from drying out.</p> <p>Extreme dry conditions persisted for much of 2019–20, and generally no environmental water was available to deliver. Some native fish and turtles were rescued and relocated or moved to hatcheries to form insurance populations. However, tributary flows between February and April 2020 provided relief to refuge pools downstream of Warren Weir. Other refuge pools have been replenished by rainfall, stock and domestic and/or tributary flows. Considering the prolonged dry conditions, and overall decline in the condition of many refuge pools, the demand for water to maintain critical refuge habitat has been assessed as moderate to high. The urgency for water to maintain refuges in 2020–21 will depend on catchment conditions and water availability in the coming months.</p>	<p>Moderate to High</p>	<p>Expected to be met by essential regulated supplies. However, there is a risk in 2020–21 that some critical refuge habitat will dry out and decline in quality if conditions remain dry.</p> <p>Potential use under very low water availability scenario, subject to environmental water being available for delivery.</p>	<p>Variable depending on climatic conditions:</p> <p>If extreme dry conditions persist, demand may be Critical;</p> <p>Should conditions become significantly wetter, demand may reduce to Low or Very Low</p>

Note: contributions to meet Barwon–Darling environmental requirements may be considered subject to water availability, antecedent conditions, and environmental demands. Refer to CEWO’s Water Management Plan 2020-21 Chapter 3.7: Barwon–Darling.

References:

- Sourced from information and advice provided by NSW DPI Fisheries (Sam Davis and Rod Price, pers. comm. 2015– 2020).
- Sourced from Barma Water Resources et al. (2011).
- Sourced from advice from NSW Department of Planning, Industry and Environment (Tim Hosking, Paul Keyte and Debbie Love, pers. comm. 2015–2020), NSW Department of Environment, Climate Change and Water (2010), and MDBA (2012).
- Based on inundation zones as mapped by Thomas et al. (2015).
- Sourced from Torrible et al. (2011).
- Information on flow/volume and required frequency of indicative demands drawn from the draft Macquarie-Castlereagh Long Term Water Plan (NSW OEH 2018a and b), as appropriate.
- All watering history sourced from advice from NSW Department of Planning, Industry and Environment (Tim Hosking, Paul Keyte and Debbie Love, pers. comm. 2015–2020), NSW DPIE Statement of annual environmental watering priorities, WaterNSW Water Balance Reports, and data from the following gauges (WaterNSW 2020):

421090: Macquarie River at d/s Marebone Weir	421088: Marebone Break at d/s regulator	421127: Macquarie River at Baroona
421001: Macquarie River at Dubbo (in the absence of available data at Wellington)	421107: Marra Creek at Billybongbone Bridge	421016: Crooked Creek at Profile
421147: Macquarie River at Pillicawarrina	421097: Marra Creek at Carinda Road	421012: Macquarie River at Carinda (Bells Bridge)
	421146: Gum Cowal at Bifurcation	421022: Macquarie River at Oxley Station
	421907: Macquarie at Brewon	421152: Gum Cowal at Oxley

Key - potential watering in 2020-21

	High priority for Commonwealth environmental watering (likely to receive water even under low water resource availability)
	Secondary priority for Commonwealth environmental watering (watering to occur only if natural trigger is met, or under moderate - high water resource availability); or water demand likely to be met via other means
	Low priority for Commonwealth environmental watering (under high - very high water resource availability)
	Unable to provide Commonwealth water because of constraints or insufficient water

Key - environmental demands

	Critical demand i.e. urgent need for water in that particular year to manage risk of irretrievable loss or damage
	High demand for water i.e. needed in that particular year
	Moderate demand for water i.e. water needed that particular year and/or next
	Low demand for water i.e. water generally not needed that particular year
	Very low demand for water i.e. water generally not needed that particular year or the following year

Note that demand is considered at a generalised scale; there may be specific requirements that are more or less urgent within the flow regime

3.6.5 Water delivery in 2020–21

Based on the demand for water for the environment, water availability (supply), and catchment conditions, the overall purpose for managing Commonwealth water for the environment in the Macquarie River Valley in 2020–21 is to avoid damage and protect the health and resilience of aquatic ecosystems in the Macquarie River and Marshes, and other important sites in the valley as required.

Consistent with the demands and purpose identified, the CEWO is considering supplying water for the environment to the following actions in 2020–21.

Using water for the environment carried over into 2020–21, deliver water to the Macquarie Marshes to target the inundation of 4 000–9 000 ha (blue and purple inundation zones – Figure 2) of core wetland vegetation (reeds, water couch, lagoons and mixed marsh). Inundation of the core wetlands is required for 3–6 months over the warmer spring growing period, particularly for reedbeds and mixed marsh. Delivery of water for the environment at this time would help support wetland recovery and avoid irretrievable loss or damage in the Marshes.

To help prime the system ready for this delivery, tributary flows and NSW translucent water may be used, if available, to maintain moisture in the marshes over winter. This would build on the benefits of recent rainfall and flows and help boost the response to water delivered in spring.

Delivery of water for the environment to the Macquarie Marshes is scalable, depending on the volume of water available and catchment conditions. Should conditions and water availability improve, there may be opportunities to target the inundation of a larger area of the Marshes, although not at the expense of meeting the required duration target in core areas.

Depending on the volume of water available, delivering environmental water to the Macquarie Marshes may also:

- meet baseflow and small fresh requirements in the mid-Macquarie River
- support native fish condition, movement and spawning opportunities in the mid-Macquarie River by managing the hydrograph to provide suitable flows
- support values of the Ramsar site within the Marshes as defined by its ecological character, such as maintaining core areas of semi-permanent wetlands (including reeds, water couch and red gum forest), providing habitat for migratory waterbirds and native fish, and promoting biological diversity.

Another priority is to provide a connection flow to the Barwon River via the Marshes and lower Macquarie River. A suitable connection flow has not occurred since 2016–17 and would provide an opportunity for native fish to move and disperse between the two systems. This may include juvenile golden perch observed moving in the Barwon–Darling system in autumn 2020. Delivering a native fish connection flow is dependent on sufficient water being available at a time best suited for fish to move and disperse.

There is a critical demand to provide flows to support native fish flow specialist movement and breeding in the mid-Macquarie River. Similarly, there is a high demand for water to inundate up to 50 000 ha of the Macquarie Marshes, and to support floodplain vegetation in the lower Macquarie. However, a significant increase in the availability of water for the environment (and other water sources) is required to support these demands. Meeting the demand for native fish flow specialists is also dependent on the occurrence of suitable tributary flows to cue movement and breeding.

As in previous years, the use of Commonwealth and NSW environmental water in the Macquarie River Valley will be adaptively managed together throughout 2020–21, in response to changing water resource availability and environmental conditions and demands.

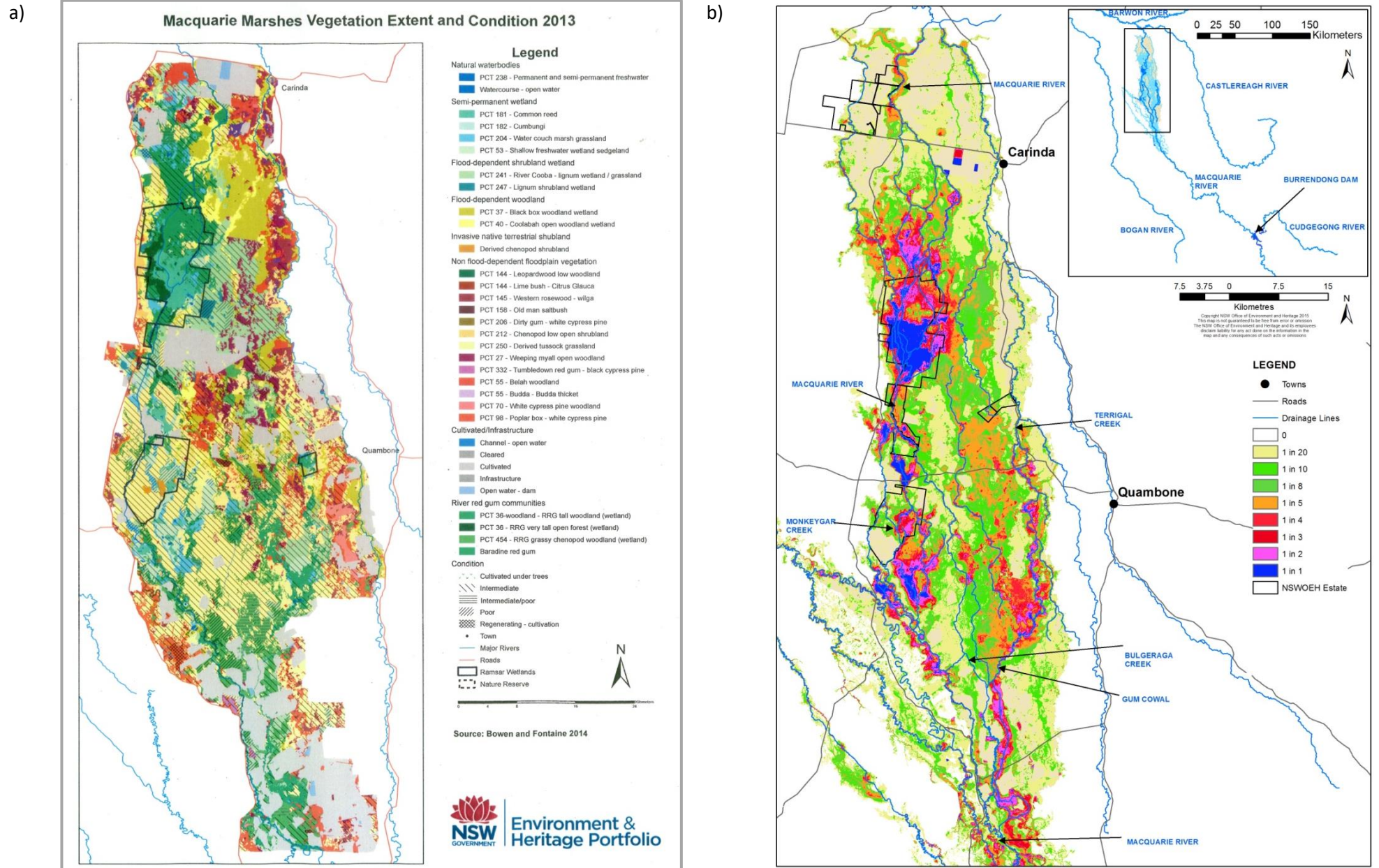


Figure 2: a) Macquarie Marshes vegetation mapping (Bowen & Fontaine 2014); b) Inundation frequencies: Macquarie Marshes 1988–2008 (Thomas et al. 2015)

3.6.6 Monitoring and Lessons learned

(a) Monitoring

In the Macquarie River Valley, monitoring is primarily undertaken by NSW agencies including NSW DPIE (vegetation, waterbirds and frogs), NSW DPI – Fisheries (native fish), and WaterNSW (hydrology and flow delivery data). The CEWO has also funded a number of short-term intervention monitoring projects to evaluate the environmental responses of native fish, waterbirds, and freshwater mussels.

Details of monitoring activities funded by the CEWO in the Macquarie River Valley can be found at: <http://www.environment.gov.au/water/cewo/catchment/macquarie/monitoring>

(b) Lessons learned

Outcomes from monitoring and lessons learned in previous years are a critical component for the effective and efficient use of Commonwealth water for the environment. These learnings are incorporated into the way environmental water is managed.

Key findings from fish⁶, flow⁷, frog⁸ and waterbird⁹ monitoring in the Macquarie River Valley are summarised in Table 4.

Table 4: Key lessons learned in the Macquarie River Valley

Theme	Lesson learned
Native fish	<ul style="list-style-type: none"> Spring/early summer delivery has been associated with peaks in breeding of some small-bodied opportunistic fish species (e.g. Australian smelt, un-specked hardyhead, Murray-Darling rainbowfish), particularly on the receding tail of flows, or during sustained periods of increased flow. Spring/early summer delivery is also likely to support recruitment of native species such as Murray cod and freshwater catfish, by increasing flows and boosting in-stream productivity in the river.
Frogs	<ul style="list-style-type: none"> Local weather and inundation extent influence the activity of some species. Increased inundation increases the number of sites with conditions suitable for breeding, and the calling of flow-responsive species. Flooding events are very important for increasing overall abundance of flow-responsive species, by supporting breeding and enabling frogs to move between wetlands. Longer duration of inundation is important for frogs to complete metamorphosis. Maintaining water levels in the Marshes into late November increases frog recruitment.
Waterbirds	<ul style="list-style-type: none"> Delivery in winter/spring (into summer if possible) provides suitable wetland habitat for nationally threatened and internationally recognised migratory species and coincides with warmer temperatures and peak activity for waterbirds and their food supplies. A slow steady contraction of inundated area is preferable, particularly for wading species. Delivery to parts of the Marshes during dry conditions helps support a diverse range of waterbirds and provides important feeding and refuge habitat.
Connectivity	<ul style="list-style-type: none"> Connectivity between Macquarie and Barwon rivers can be achieved using water for the environment and is important for allowing the movement of native fish between rivers for spawning, dispersal and recruitment.

⁶ Stocks et al. 2015, Davis et al. 2017

⁷ WaterNSW 2017

⁸ NSW OEH 2017, Ocock and Spencer 2017, NSW OEH 2019a

⁹ Spencer et al. 2016, McGinness et al. 2017, Brandis 2017, NSW OEH 2019b

3.6.7 Bibliography

Barma Water Resources in association with IRPEC Pty Ltd and Paul Wettin (2011). *Environmental Water Delivery: Macquarie River*. Prepared for the Commonwealth Environmental Water Office, Canberra. Unpublished.

Bowen, S. and Fontaine, K. (2014). *Vegetation Communities of the Macquarie Marshes*. NSW Office of Environment and Heritage, Sydney.

Brandis, K. (2017). *High resolution monitoring of waterbird colonies in the Macquarie Marshes*. Draft final report, May 2017. Centre for Ecosystem Science, University of NSW.

Bureau of Meteorology (2020). *Rainfall—The chance of above median for July to September 2020*. <http://www.bom.gov.au/climate/outlooks/#/rainfall/median/seasonal/0>

Bureau of Meteorology (2020). *Rainfall—The chance of above median for August to October 2020*. <http://www.bom.gov.au/climate/outlooks/#/rainfall/median/seasonal/1>

Bureau of Meteorology (2020). *Temperature—The chance of above median maximum temperature for June to August 2020*. <http://www.bom.gov.au/climate/outlooks/#/temperature/maximum/median/seasonal/0>

Bureau of Meteorology (2020). *Temperature—The chance of above median maximum temperature for July to September 2020*. <http://www.bom.gov.au/climate/outlooks/#/temperature/maximum/median/seasonal/1>

Bureau of Meteorology (2020). *Thirty-six monthly rainfall deciles for New South Wales / ACT*. <http://www.bom.gov.au/jsp/awap/rain/index.jsp?colour=colour&time=latest&step=0&map=decile&period=36month&area=ns>

Commonwealth Environmental Water Office (2014). *Commonwealth environmental water use options 2014–15: Macquarie River Valley*. Commonwealth of Australia 2014.

Davis, S., Asmus, M.W. and Stocks, J.R. (2017). *Making the connection: Designing, delivering and monitoring flows between catchments. A case study in the Macquarie and Barwon rivers April–June 2017*. Report to the Commonwealth Environmental Water Office, December 2017. <http://www.environment.gov.au/water/cewo/publications/making-the-connection>

Jenkins, K., Kingsford, R., Wolfenden, B., Shiquan, R., and Driver, P. (2012). *Invertebrate monitoring and modelling in the Macquarie Marshes*. NSW Department of Primary Industries, Sydney.

McGinness, H., Martin, J., Robinson, F., Davies, M., Piper, M., Keyte, P., Suter, S., Spencer, J., Rees, J., Webster, E., Brandis, K., Kingsford, R., Doerr, V., Mac Nally, R. (2017). *Waterbird movements and breeding success in the Macquarie Marshes, NSW 2016–17*. Progress Report May 2017, submitted to the Commonwealth Environmental Water Office (CEWO), Department of Environment and Energy. CSIRO, Canberra. <http://www.environment.gov.au/water/cewo/publications/waterbird-movements-breeding-success-macquarie-marshes-final-report-2017>

Murray–Darling Basin Authority (2012). *Assessment of environmental water requirements for the proposed Basin Plan: Macquarie Marshes*. <http://www.mdba.gov.au/sites/default/files/archived/proposed/EWR-Macquarie-Marshes.pdf>

Murray–Darling Basin Authority (2014). *Basin-wide environmental watering strategy*. <http://www.mdba.gov.au/sites/default/files/pubs/Final-BWS-Nov14.pdf>

Murray–Darling Basin Authority (2019). *People, industry and water use*. <https://www.mdba.gov.au/discover-basin/catchments/macquarie-castlereagh>

Murray Lower Darling Rivers Indigenous Nations (MLDRIN) (2020). *First Nations Environmental Water Guidance Project. MLDRIN Member Nations 2020-21 Priorities*. Report provided to Commonwealth Environmental Water Office.

Northern Basin Aboriginal Nations (NBAN) Ltd. (2020) *First Nations Environmental Water Guidance Report*. Provided to the Commonwealth Environmental Water Office.

NSW Department of Environment, Climate Change and Water (2010). *Macquarie Marshes Adaptive Environmental Management Plan*. Synthesis of information projects and actions. DECCW, June 2010.

NSW Department of Industry – Water (2019). *Temporary water restrictions: Macquarie Regulated River Water Source*. <https://www.industry.nsw.gov.au/water/allocations-availability/temporary-water-restrictions/macquarie-regulated-river-water-source>

NSW Department of Planning, Industry and Environment (2020). Water Allocation Statement – NSW Regulated Rivers Water Sources 1 July 2020. NSW Department of Planning, Industry and Environment INT20/75956. https://www.industry.nsw.gov.au/_data/assets/pdf_file/0012/313032/WAS-Regulated-Rivers-20200701.pdf

NSW Office of Environment and Heritage (2019a). *Frog and tadpole surveys in the Macquarie Marshes, spring 2018*. NSW Office of Environment and Heritage, February 2019.

NSW Office of Environment and Heritage (2019b). *Waterbird surveys in the Macquarie Marshes, spring 2018*. NSW Office of Environment and Heritage, February 2019.

NSW Office of Environment and Heritage (2018a). *Macquarie-Castlereagh Long Term Water Plan Part A: Macquarie-Castlereagh catchment. Draft for exhibition*. <https://www.environment.nsw.gov.au/research-and-publications/publications-search/macquarie-castlereagh-long-term-water-plan-part-a>

NSW Office of Environment and Heritage (2018b). *Macquarie-Castlereagh Long Term Water Plan Part B: Macquarie-Castlereagh planning units. Draft for exhibition*. <https://www.environment.nsw.gov.au/research-and-publications/publications-search/macquarie-castlereagh-long-term-water-plan-part-b-planning-units>

NSW Office of Environment and Heritage (2017). *Summary of observations from two years of monitoring frogs in the Macquarie Marshes*. NSW Office of Environment and Heritage, February 2017.

Ocock, J. and Spencer, J. (2017). *Results from spring frog surveys in the Macquarie Marshes (2011–2017)*. NSW Office of Environment and Heritage, November 2017.

Spencer, J., Hosking, T., Ocock, J. and Suter, S. (2016). *OEH waterbird surveys in the Macquarie Marshes – spring 2015*. NSW Office of the Environment and Heritage, February 2016.

Stocks, J.R., Scott, K.F., Rodgers, M.P., Walsh, C.T., van der Meulen, D.E., and Gilligan, D. (2015). *Short-term intervention monitoring of a fish community response to an environmental flow in the mid and lower Macquarie River: 2014/2015 watering year*. NSW Department of Primary Industries, Batemans Bay.

Thomas, R. F., Kingsford, R. T., Lu, Y., Cox, S. J., Sims, N. C. and Hunter, S. J. (2015). Mapping inundation in the heterogeneous floodplain wetlands of the Macquarie Marshes, using Landsat Thematic Mapper. *Journal of Hydrology*, 524, 194–213.

Torrible, L., Wettin, P., Barma, D., Wilson, G., Hobcroft, D., and O’Cock, J. (2011). *Post flood assessment and determination of environmental water requirements for Gunningbar Creek, Lower Crooked Creek, Marra Creek and the lower Macquarie River*. Prepared by IRPEC Pty for BWR on behalf of the Australian Government Department of Sustainability, Environment, Water, Population and Communities.

WaterNSW (2020). *Regional water availability report – Weekly edition 27 April 2020*. https://www.waternsw.com.au/_data/assets/pdf_file/0005/156146/Water-Availability-Report-27-April-2020.PDF?utm_source=Swift&utm_medium=Email&utm_campaign=NSW_availability

WaterNSW (2020). *Real time data: 421 – Macquarie River Basin*. <https://realtimedata.watarnsw.com.au/>

WaterNSW (2017). *Lower Macquarie Catchment Temporary Water Monitoring 2017*. Report to Commonwealth Department of Environment and Energy, October 2017.

WaterNSW (2018). *Burrendong Dam – facts and history*.
<http://www.watarnsw.com.au/supply/visit/burrendong-dam>

WaterNSW (2018). *Windamere Dam – facts and history*.
<http://www.watarnsw.com.au/supply/visit/windamere-dam>