



Australian Government

Commonwealth Environmental Water Office

**Commonwealth Environmental Water**

Portfolio Management Plan

# Macquarie River Valley

2016–17



Front cover image credit: White necked heron and glossy ibis at U Block. Photo by Commonwealth Environmental Water Office

Back cover image credit: Macquarie River at Dubbo. Photo by Commonwealth Environmental Water Office

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.

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# Commonwealth environmental water portfolio management planning

## Commonwealth environmental water

The Commonwealth Environmental Water Holder is an independent statutory position established by the *Water Act 2007* to manage the Commonwealth environmental water holdings. The Commonwealth Environmental Water Holder leads and is supported by the Commonwealth Environmental Water Office (the Office), a division of the Australian Government Department of the Environment.

Under the *Water Act 2007*, Commonwealth environmental water must be managed to protect or restore environmental assets, so as to give effect to relevant international agreements. The *Water Act 2007* also requires that the Commonwealth Environmental Water Holder perform its functions and exercise its powers consistently with and in a manner that gives effect to the Basin Plan and that Commonwealth environmental water is managed in accordance with the Basin Plan's environmental watering plan.

## Purpose of the document

This document sets out the plans for managing the Commonwealth environmental water portfolio in the Macquarie River Valley for 2016–17. Efficient and effective management of Commonwealth environmental water requires the utilisation of all portfolio management options, including water delivery, carryover and trade. To support improved outcomes from water use over time, carryover provides the opportunity to optimise water use across water years and to improve water availability early in a water year, while trade provides further capacity to optimise use over the long-term as well as across catchments.

By taking a multi-year approach to planning, portfolio management tools such as use, carryover and trade can be managed for maximising environmental outcomes. The portfolio management plans support transparent, coordinated and adaptive management of the Commonwealth environmental water portfolio, consistent with Basin Plan obligations including the expected outcomes in the Basin-wide environmental watering strategy and the Basin annual environmental watering priorities.

To learn more about the portfolio management planning approach see *Portfolio Management Planning: Approach to planning for the use, carryover and trade of Commonwealth environmental water 2016–17* (available at: <http://www.environment.gov.au/water/cewo/publications>).

## Delivery partners

Commonwealth environmental water is managed in conjunction with and delivered by a range of partners. In the Macquarie River Valley, our partners include the New South Wales Office of Environment and Heritage (NSW OEH), Department of Primary Industries – Water, Department of Primary Industries – Fisheries, and Water NSW.

This portfolio management plan has been developed in consultation with our delivery partners and the Macquarie Cudgong Environmental Flows Reference Group.

## Your input

The management of Commonwealth environmental water relies on considerable advice and assistance from local organisations, state governments and others. Individuals and groups within the Murray-Darling Basin community are encouraged to submit suggestions for the management of Commonwealth environmental water. Please contact the Office via: [ewater@environment.gov.au](mailto:ewater@environment.gov.au).

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# 1.Environmental watering in the Macquarie River Valley

## 1.1. The Macquarie River Valley

Macquarie River flows are heavily influenced by large rainfall events in the upper catchment and flows in tributary systems. The river is formed when the Campbells and Fish rivers join above Bathurst in Central Western New South Wales (NSW) followed by tributary flows from the Winburndale River, Turon River and Pyrmul Creek. The Macquarie River then drains into Burrendong Dam, south east of Wellington (Figure 1). Below the dam, tributary flows are provided by the Bell River, which enters at Wellington; Little River and Wambangalong Creek, which enter upstream of Dubbo; and the Talbragar River and Coolbaggie Creek, which enter just downstream of Dubbo. Subsequently, 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. At this point, water flows are slow resulting mainly from extensive silt deposits and high attenuation.

Two major storages, Windamere Dam (capacity 368 gigalitres (GL)) on the Cudgegong River, and Burrendong Dam on the Macquarie River (storage capacity of 1 188 GL, with additional storage capacity of 489 GL in the flood mitigation zone), regulate catchment water supplies. Commonwealth environmental water delivery is gravity fed from Burrendong Dam into the Macquarie River to downstream environmental assets such as the Macquarie Marshes and distributary creeks. Regulating structures are utilised to manage the diversion of water into distributary creeks at lower rates, or overbank at high flow rates onto floodplains and wetlands.

The primary environmental asset in the catchment is the Macquarie Marshes complex on the lower reaches of the Macquarie River. Other assets in the catchment include the Macquarie River channel, the unregulated component of the lower Macquarie River downstream of Warren Town Weir and the distributary creek system to the west of the Marshes.

The *Water Sharing Plan for the Macquarie and Cudgegong Regulated Rivers Water Source (2003)* provides for planned environmental water and stock and domestic (replenishment) flows. Such releases offer opportunities to align Commonwealth environmental water deliveries to increase the potential for environmental objectives to be achieved and assist with delivery efficiency.

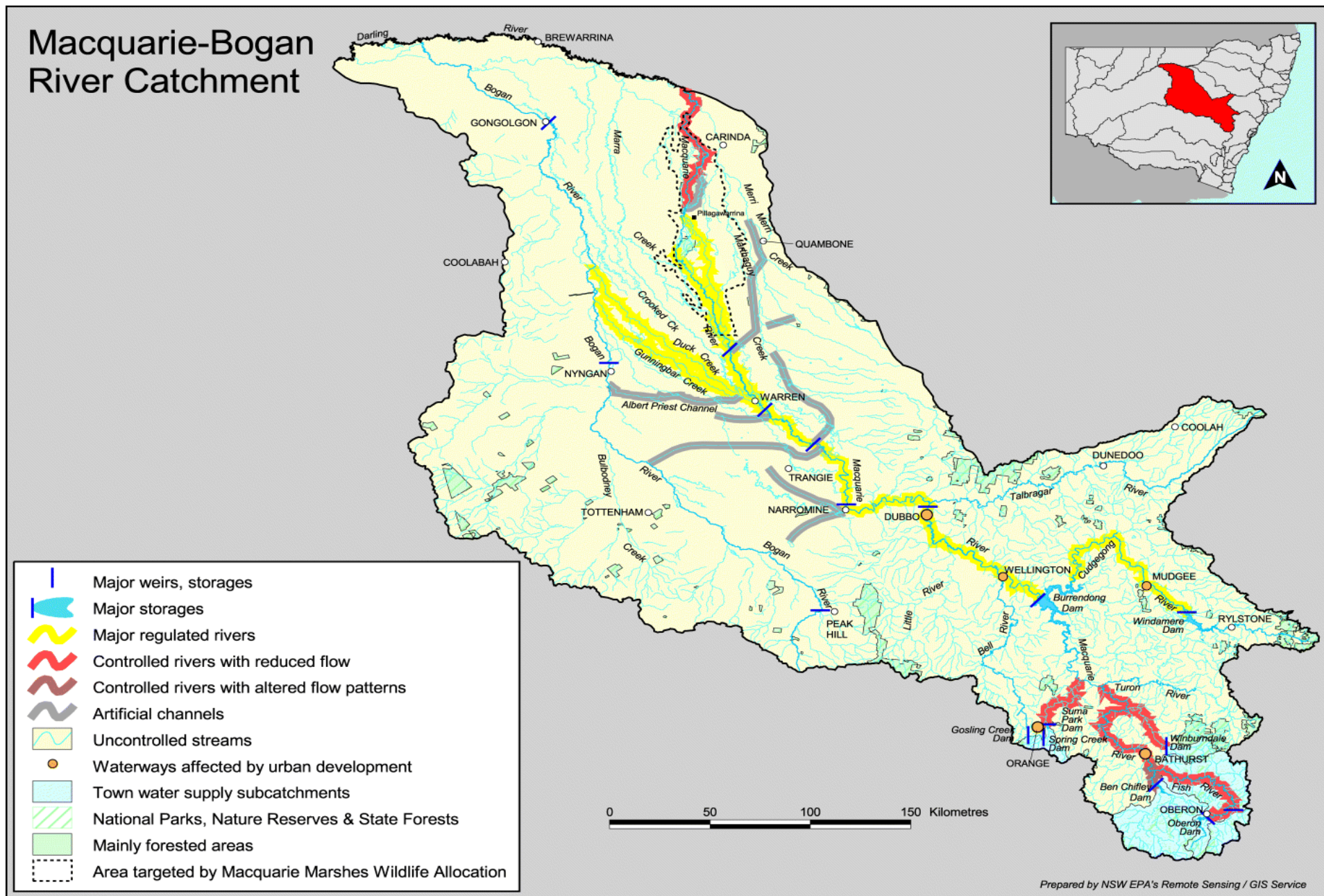


Figure 1: Map of the Macquarie River Valley (produced by the NSW Office of Environment and Heritage).

## 1.2. Environmental objectives and outcomes in the Macquarie River Valley

The long-term environmental objectives and expected outcomes for the Murray-Darling Basin are described in the Basin Plan's environmental watering plan and the Basin-wide environmental watering strategy. The Basin-wide environmental watering strategy includes quantified environmental outcomes at both a Basin-scale and for each catchment. Outcomes relevant for the Macquarie River Valley are described in [Attachment A](#).

Basin state governments are also developing long-term watering plans for each catchment. These plans will identify the priority environmental assets and ecosystem functions in the catchment, the objectives and targets for these assets and functions, and their watering requirements. Once developed, these plans will provide the key information on the long-term environmental water demands in the catchment. Before the development of long-term watering plans, the Office will continue to draw on existing documentation on environmental water demands developed by state governments, local natural resource management agencies and the Murray-Darling Basin Authority.

Based on these strategies and plans, and in response to best available knowledge drawing on the results of environmental watering monitoring programmes, the outcomes being targeted by environmental watering in the Macquarie River Valley are summarised in Table 1 below. The objectives and targeted outcomes for water-dependent ecosystems will continue to be revised as part of the Commonwealth Environmental Water Office's commitment to adaptive management.

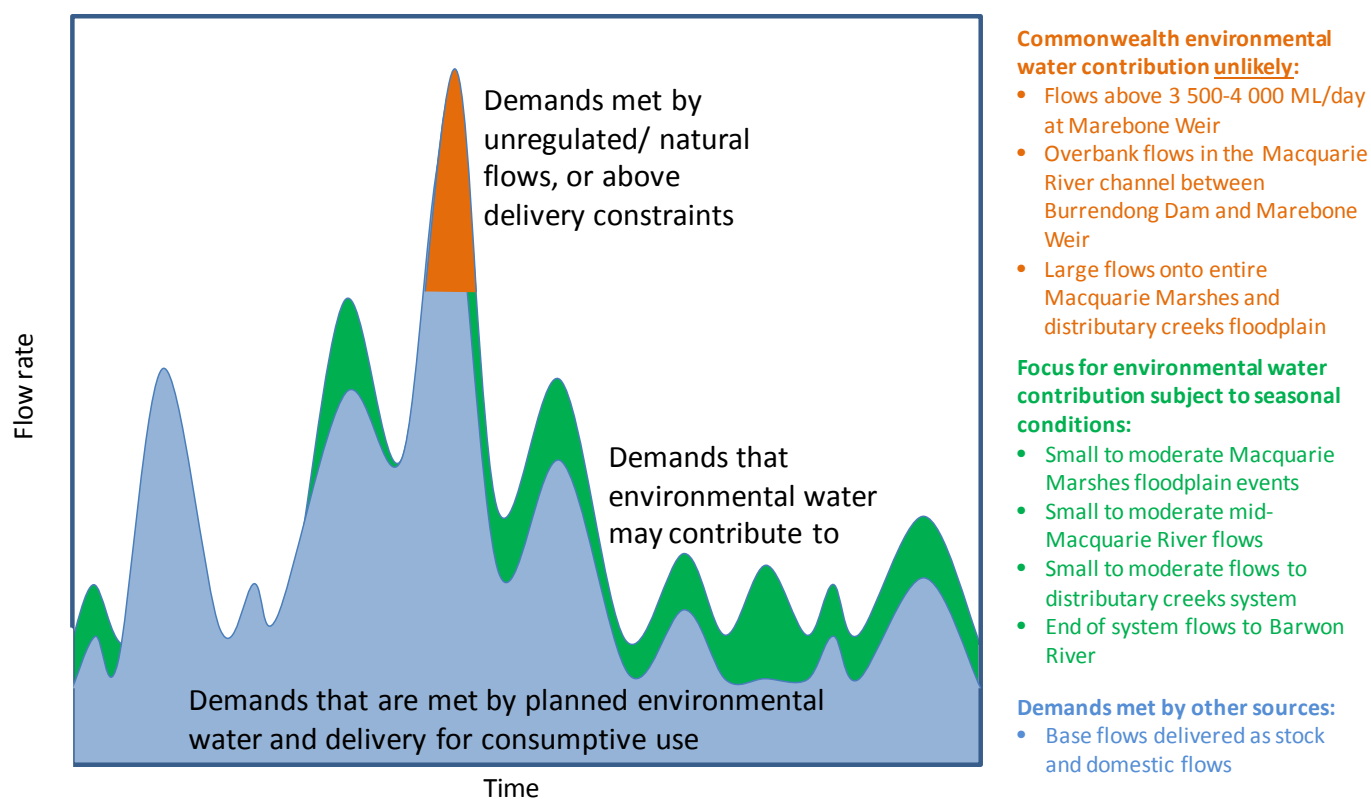
**Table 1:** Summary of outcomes being targeted by environmental watering in the Macquarie River Valley

BASIN-WIDE OUTCOMES (Outcomes in red link to the Basin-wide environmental watering strategy)	EXPECTED OUTCOMES FOR MACQUARIE ASSETS		
	IN-CHANNEL ASSETS	OFF-CHANNEL ASSETS	
	Macquarie River	Macquarie Marshes	Distributary creeks
<b>VEGETATION</b>	Maintain riparian and in-channel vegetation condition, growth and survival (extent)	Maintain, and in some cases improve, floodplain and wetland vegetation condition, growth and survival	Support the condition, growth and survival of riparian and in-channel vegetation
<b>WATERBIRDS</b>		Provide suitable habitat to increase waterbird abundance and reproduction, and maintain current species diversity	
<b>FISH</b>	Support opportunities for the movement and increased distribution, reproduction and recruitment of native fish		Support the movement and habitat requirements of native fish
<b>MACROINVERTEBRATES</b>	Support recruitment and maintain macroinvertebrate diversity and habitat		
<b>OTHER VERTEBRATES</b>	Support opportunities for the reproduction and recruitment of other native aquatic species, including frogs and turtles		Support the reproduction of other native aquatic species including frogs
<b>CONNECTIVITY</b>	Support longitudinal connectivity, in particular increase connectivity with the Barwon-Darling	Support connectivity, particularly lateral between the river and floodplain	Support connectivity, particularly with the lower Macquarie River and Barwon River
<b>PROCESSES</b>	Support key ecosystem functions and promote productivity, including on the floodplain		
<b>WATER QUALITY</b>	Maintain water quality within channels and pools		
<b>RESILIENCE</b>	Provide drought refuge habitat (particularly for fish)		

Information sourced from: Murray-Darling Basin Authority (2012); Murray-Darling Basin Authority (2014); Barma Water Resources in association with IRPEC Pty Ltd and Paul Wettin (2011); Torrible et al. (2011); Commonwealth Environmental Water Office (2014); and Jenkins et al. (2012).

### 1.3. Environmental flow requirements

Not all environmental demands can and will be met through the use of held environmental water. Some demands are met by regulated water deliveries for consumptive purposes, while others are met by large unregulated flows events or are beyond what can be delivered within operational constraints. Figure 2 shows the broad environmental demands that are in scope for Commonwealth environmental water. Importantly, these are broad, indicative demands and individual watering actions may contribute to particular opportunities, such as using infrastructure to deliver water to individual wetlands that would otherwise not be possible because of constraints. Also, there may be opportunities for Basin state governments to remove or modify constraints, which will improve the efficiency and/or effectiveness of environmental watering. Further information on delivery constraints are described in [Attachment B](#).



**Figure 2:** Scope of demands that environmental water may contribute to in the Macquarie River Valley

Based on the above outcomes sought and delivery constraints, specific watering requirements (flow magnitude, duration, timing and frequency) have been identified as being in scope for Commonwealth environmental water. These water requirements are described in Table 3. As with the objectives and targeted outcomes, the environmental water requirements will continue to be reviewed and revised in response to new knowledge.

### 1.4. Monitoring and adaptive management

Operational monitoring is undertaken for all Commonwealth environmental watering actions and involves collecting on ground data with regard to environmental water delivery such as volumes delivered, impact on the river systems hydrograph, area of inundation and river levels. It can also include observations of environmental outcomes.

The outcomes from these monitoring activities are used to inform portfolio management planning and decision-making.

## 2. Portfolio management in 2016–17

In planning for the management of Commonwealth environmental water, the Commonwealth Environmental Water Office aims to maximise the outcomes achieved from the available water. This includes consideration of the urgency of demands (based on targeted outcomes and watering requirements, watering history and asset condition watering) and the available supply under different resource scenarios. Plans for water delivery, trade and carryover are then made in a multi-year context, with an assessment also undertaken of need for water in future years.

This planning process is outlined in full in Table 3 below and summarised in the sections below.

### 2.1. Antecedent and current catchment conditions and the demand for environmental water in 2016–17

Despite some good rainfall in the catchment in winter 2015, hot and dry conditions have generally prevailed in the Macquarie catchment since spring 2012, with average to very much below average rainfall and above average to very much above average maximum temperatures across the region, and very much below average surface water availability. These warmer and drier conditions have slowed the recovery of wetland vegetation that showed improvements during wetter conditions between 2010 and 2012, and has resulted in significant drying of the floodplains. A combination of NSW and Commonwealth environmental water has been delivered to the Macquarie River and Macquarie Marshes during these drier years, which has helped to support the inundation of core wetland areas. However, with reduced resource availability many of the environmental demands for water remain high. A fire that occurred in the reed beds of the Northern Macquarie Marshes Nature Reserve in March 2016 has also increased the environmental demand for water in the Macquarie Marshes.

Environmental water demands for environmental assets in the Macquarie catchment in 2016–17 are represented in Table 3 and are summarised below:

**Mid-Macquarie River (Burrendong – Marebone Weir):** Varied demand, relative to the flow class (size of flow). Should regulated flows from Burrendong Dam cease as a consequence of prolonged dry conditions, there will be a high demand for water to provide small flows to maintain refugia for native fish. Flows of this type are required continuously and are often met by other sources. There is also a high demand for water in 2016–17 to contribute to freshes that will support the movement and breeding of native fish (flow specialists). Large freshes and bank full flows to drown out weirs and allow for movement of native fish is considered to be a low demand (required approximately twice in ten years).

**Lower Macquarie River (Marshes – Barwon River):** High demand. With increasingly dry conditions over the past three years, there has been a reduction in connectivity between the Macquarie Marshes and the lower Macquarie River and the Barwon-Darling system. While there is uncertainty about the required frequency of flows and connectivity in the lower Macquarie, small flow events in 2013 and 2014 have led to partial connectivity with the Barwon River, however, there have not been significant flows since early 2012. If adequate connectivity is not achieved in 2016–17, it is expected that the urgency for meeting this demand will remain high in 2017–18.

**Macquarie Marshes (reed beds, lagoons, mixed marsh, water couch):** High demand. Ideally annual wetting is required to maintain these communities. Some species such as water couch were showing signs of improvement in 2013, but have not recovered to previously observed conditions and are being replaced by other species in some parts of the Marshes. Despite receiving water in 2015–16, reed beds in the Northern Marshes were burnt in a fire in March 2016, and inundation in 2016–17 would support their recovery.

**Macquarie Marshes (reeds, water couch, mixed marsh, river red gum forest, river cooba):** High demand. With conditions continuing to dry since 2012–13, some areas have not been adequately watered, particularly in the North Marsh. Some species have maximum dry intervals of two to three years, so wetting is required to sustain these communities and prevent further loss.

**Macquarie Marshes (river red gum woodland, river cooba, inner coolibah woodland):** High demand. Some species such as river red gum woodland are not recovering well in parts of the Marshes, particularly in the Southern Marshes. These areas have not been inundated since spring 2012–13. River red gum woodlands in the Northern Marshes are showing signs of stress. Some vegetation species require water every three to four years and will require wetting in the next one to two years to maintain condition.

**Macquarie Marshes (outer river red gum woodland, coolibah and black box):** Low to moderate demand. These areas have not been sufficiently inundated since 2010–11, with only minor wetting in 2011–12 and 2012–13. There has been a decline in river red gum trees further away from watercourses. Some species require water every four to five years and will require wetting in the next one to two years to maintain condition.

**Distributary creeks:** Varied demand, depending on the creek. Demands in the unregulated distributary creeks are considered to only have been partially met by stock and domestic flows over the last three years (e.g. Marra Creek) and were last partially met in the Lower Crooked Creek in 2013–14. Dry conditions and low water availability has made it difficult to provide environmental water to these assets. Small to medium flows may be required in the next one to two years to Marra and Lower Crooked creeks to provide benefits for vegetation, and to provide connectivity with the Barwon-Darling system. Regulated distributary creeks of Duck, upper Crooked and Gunningbar are provided with base flows, and larger flows in 2010 and 2012, so known environmental demands are low.

### ***Murray-Darling Basin 2016–17 environmental watering priorities***

In contributing to these demands, the Commonwealth Environmental Water Office will have regard for the following 2016–17 Basin annual environmental watering priorities for the Macquarie catchment:

- support viable populations of threatened native fish species by protecting drought refuges and maintaining instream habitats
- contribute to the long-term recovery of silver perch by improving the viability of existing populations and enhancing conditions for recruitment and dispersal to suitable habitats
- in moderate conditions, contribute to the long-term recovery of threatened species, (including silver perch), through range expansion and the establishment of new populations
- in moderate conditions, capitalise on opportunities to support waterbird breeding
- in moderate conditions, support waterbird populations by watering critical breeding and feeding habitats at the important Basin environmental assets for waterbirds and coordinate watering at ecologically linked systems, particularly at the Macquarie Marshes and Narran Lakes.

Note that there may be limited ability to contribute to coordinated watering at ecologically linked systems in 2016–17 but this could be considered as part of long-term planning.

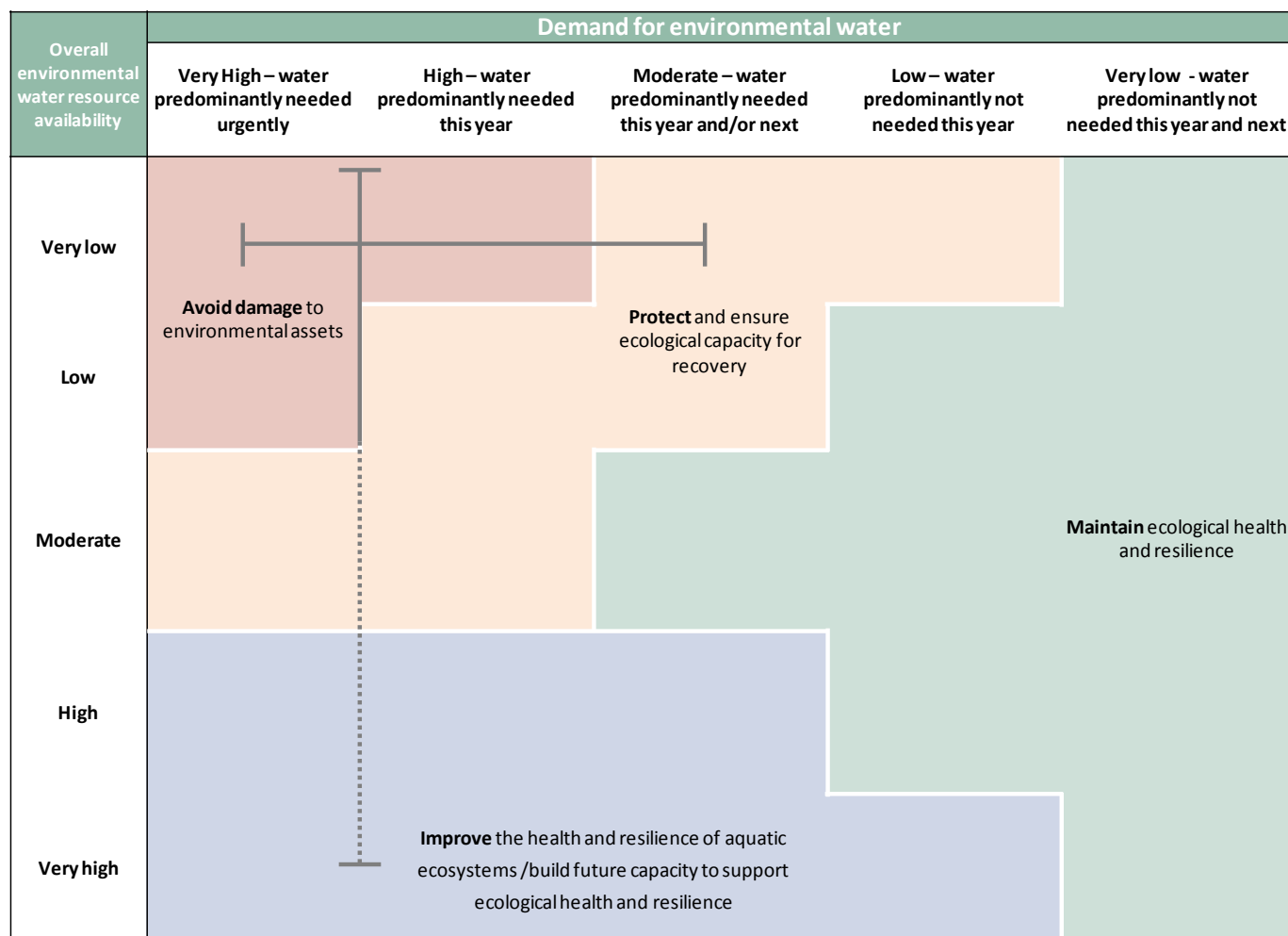
## **2.2. Water availability in 2016–17**

### *Forecasts of Commonwealth water allocations*

The volume of Commonwealth environmental water likely to be carried over in the Macquarie River Valley for use in 2016–17 is estimated to be 8 GL.

Allocations against Commonwealth water entitlements in the Macquarie are determined by state governments and will vary depending on inflows. The following forecasts in Table 2 are based on the best available information including state forecasts and historical inflow scenarios:





**Figure 3:** Determining a broad purpose for portfolio management in the Macquarie River Valley for 2016–17. Note: grey lines represent the likely range in demand and resource availability for the 2016–17 water year.

Further detail on how the overall purpose for portfolio management changes under different supply and demand scenarios is provided in *Portfolio Management Planning: Approach to planning for the use, carryover and trade of Commonwealth environmental water 2016–17* (available at: <http://www.environment.gov.au/water/cewo/publications>).

## 2.4. Water Delivery in 2016–17

Consistent with the demands and purpose described above, the Office is considering supplying environmental water to the following watering actions for 2016–17 (see also Table 3 for supporting information regarding the basis for determining these watering intentions).

Should very dry conditions persist into 2016–17 and no further allocations become available, available water will be used in combination with suitably sized tributary (natural) flows to avoid critical damage within the Macquarie Marshes and to help maintain connectivity and critical drought refuge in the Macquarie River, benefitting native fish. This would produce a flow of approximately 30 GL, with inundation of 4 000–10 000 hectares of the Macquarie Marshes (depending on the natural flow and timing). If no tributary flows occur, the volume would be carried over to add water to future flows for habitat maintenance and core wetland areas.

Should conditions improve and further Commonwealth environmental water become available, water delivery (in conjunction with NSW environmental water) would be targeted at semi-permanent wetland vegetation in the core areas of the Macquarie Marshes. This would require between 30 and 60 GL of water during spring or autumn, to contribute to maintaining wetland vegetation, and provide habitat for waterbirds, fish and frogs. This action is scalable depending on the volume of water available, with a minimum of 30 GL required to reach the core areas of both the North and South Marshes, particularly targeting areas of the Northern Macquarie Marshes Nature Reserve, which were burnt in March 2016. The Eastern Marsh may also be targeted should water availability increase during 2016–17.

Under a moderate to high water resource availability scenario, Commonwealth environmental water (in conjunction with NSW environmental water) could be targeted at contributing to flows in the Macquarie River that will benefit native fish (flow specialists), by promoting fish movement, reproduction and recruitment. The volume of Commonwealth environmental water would be dependent on the volume of other water in the system, with a minimum total (all water sources) of 60 GL required. This watering action would also water wetland vegetation in the Macquarie Marshes, and could be linked with the action described above.

There is also a high demand for water in the lower Macquarie River in 2016–17, both in-channel, and to connect with the floodplain. Delivery of environmental water to the lower Macquarie River could be undertaken in conjunction with other actions to deliver water to the mid-Macquarie River and Macquarie Marshes. However, delivery of environmental water to this part of the system will be dependent on water availability.

## Stakeholder Feedback

The Macquarie Cudgegong Environmental Flows Reference Group (EFRG) has recommended that in the event of ongoing dry conditions and in the absence of additional allocations, the low volumes of environmental water available should be used in conjunction with a suitably-sized (~23 GL) tributary flow event in either Spring 2016 or Autumn 2017. Should such a tributary flow of this magnitude not occur, the volume should be carried over to 2017–18 for use to provide refuge or avoid critical damage. Should water availability increase or in the event of significant tributary inflows, environmental water delivery in 2016–17 should target the inundation of semi-permanent wetland vegetation (reeds, water couch, mixed marsh, river red gum forest and river cooba). This action could target reed beds in the Northern Marshes and support their recovery following fire in March 2016. Targeting these species and communities in the Northern Marshes would provide a number of benefits in the Southern Marshes as well, and provide some in-channel benefits for fish and other native aquatic species.

The Office is working to improve engagement with the Traditional Owners about environmental water planning in the Macquarie. In May 2016, representatives of the Ngilyampaa-Wailwan elders journeyed along the Macquarie River and the Macquarie Marshes with representatives from the Office, the Department of Primary Industries, NSW Office of Environment and Heritage, and the NSW National Parks and Wildlife Service. During the journey, participants discussed ideas for improving Traditional Owner engagement in the planning process and opportunities for providing feedback on the use of Commonwealth environmental water in future.

## 2.5. Trading water in 2016–17

Planning for water trade considers supply and demand within the catchment, and across the Basin. As part of the planning process, the Commonwealth Environmental Water Office undertakes a Basin-wide analysis to identify opportunities to use allocation trade to better match differing demands across catchments (see *Commonwealth Environmental Water Portfolio Management: Basin-wide analysis 2016–17* available at: <http://www.environment.gov.au/water/cewo/publications>).

The Commonwealth Environmental Water Office is investigating the potential for purchases to augment water for the environment in a number of catchments in the northern Murray-Darling Basin to meet high environmental water demands (particularly in the Macquarie Marshes, Lower Balonne/Narran Lakes and Border Rivers). Further information will be provided to the market ahead of any trade of Commonwealth environmental water at: <http://www.environment.gov.au/water/cewo/trade/current-trading-actions>.

For more information on the rules and procedures governing the trade of Commonwealth environmental water, see the *Commonwealth environmental water Trading Framework* available at: <http://www.environment.gov.au/water/cewo/publications/water-trading-framework-dec2014>.

## 2.6. Carrying over water for use in 2017–18

The volume of water carried over for use in 2017–18 will depend upon resource availability and demand throughout the year. In the Macquarie River Valley, unless sufficient tributary flows occur or further water allocations become available during 2016–17, the current allocations may be carried over to 2017–18 for critical drought refuge if required, or to build volumes to levels that can address demands in 2017–18. As documented in Table 3 below, potential demands in 2017–18 include:

- Small flows between spring and autumn, and/or during winter as fish conditioning/maintenance flows in the Macquarie River
- Spring flows in the Macquarie River, targeting native fish (flow specialists) movement and breeding
- Instream flows in the lower Macquarie River, providing connectivity to the Barwon-Darling
- Winter or spring watering in the Macquarie Marshes in the blue and purple, pink and red inundation zones
- Baseflows and freshes to unregulated distributary creeks, such as Marra and Lower Crooked creeks.

Carryover volumes will be adjusted throughout the year as the season unfolds in response to both current and future demands and the water available to meet these demands.

**Table 3a:** Environmental demands, priority for watering in 2016–17 and outlook for coming years in the Macquarie River Valley – VERY LOW / LOW WATER RESOURCE AVAILABILITY IN 2016–17

Environmental assets	Values	Indicative demand (for <u>all sources of water</u> in the system)	Required frequency (maximum dry interval)	Watering history (from all sources of water) <sup>6</sup>			2016–17			Implications for future demands		
				2013–14	2014–15	2015–16	Predominant urgency of environmental demand for water	Purpose under <u>very low</u> / <u>low</u> resource availability	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2017–18 if watering occurred as planned in 2016–17	2018–19 Range of likely demand	Met in 2017–18
				(drying)	(dry)	(dry)						Not met in 2017–18
Mid-Macquarie River (Burrendong – Marebone Weir) <sup>1</sup>	Fish refuge: all guilds Aquatic ecosystems	<b>Baseflows:</b> small very regular flows through to end of system, wetting holes and in-stream storages	Ideally: continuous flow (Max interval: continuous flow)				HIGH Minimum baseflows required if releases from Burrendong Dam cease in extreme dry.	<b>Avoid damage</b>	Intervention is only required if baseflows suspended.	High	High	
	Fish spawning–flow generalists + in-channel specialists	<b>Small freshes:</b> up to 1 000 ML/day for at least 14 days at Wellington <sup>†</sup> in spring (Oct-Nov) and autumn; and conditioning flow in winter (July to mid-August).	Ideally: annually (Max interval: 3 years generalists and 5 years in-channel specialists)		Met in spring but not winter	Met in winter and early spring. River drying down over summer	MODERATE Respond to natural tributary flows and water temperature.	<b>Avoid damage / Protect</b>	Possible use subject to tributary flows and water availability. Needs may be partially met by spring/summer irrigation flows.	Moderate to High	Moderate	
	Flow specialists guild movement and breeding	<b>Freshes:</b> 6 000–7 000 ML/day at Wellington, (> 1 000 ML/day at Barooka) during spring (Oct-Nov). Include priming flow (>20 cm rise) and recession, followed by a large spike (>40 cm rise).	Ideally: 1 in 3 years (up to twice per year) (Max interval: 5 years)	Not met downstream of Burrendong, but partially met for 2 days at Barooka	Not met	Not met	HIGH Respond to natural tributary flows, water temperature, and significant river rises that will cue movement and spawning of flow specialists.	<b>Avoid damage/ Protect</b>	Insufficient water available under a very low and low water availability scenario. Use of supplementary entitlement relevant.	Critical	Low	
	Fish movement In stream + riparian vegetation	<b>Large freshes and bankfull:</b> 10 000–20 000 ML/day at Barooka for a minimum of 3 days (to drown out key weirs).	Ideally: 2 in 10 years (Max interval: Unknown)	For one day only in September	Not met	Flows above 10 000 ML/day at Barooka for 3 days in June	LOW Based on flows at Dubbo, achieved 5 times since March 2005. Drown out 2010–11 and 2011–12.	<b>Protect / Maintain</b>	Insufficient water. Only able to contribute to this demand when coordinated with major tributary flow event.	Low	Low	
											Low to Moderate	
Lower Macquarie River (Marshes – Barwon River) <sup>2</sup>	Instream aquatic ecosystems Fish Connectivity	<b>Seasonal freshes:</b> in-channel flows Minimum 20 ML/day at Bells Bridge for 45 days.	Ideally: annually (Max interval: Unknown, possibly 2 years)	Short-term connection only (84 days spring 2013; 36 days autumn 2014)	Minimal connection (26 days autumn 2015)	Short-term connection only (25 days autumn 2016)	HIGH Limited connectivity achieved since 2012–13.	<b>Avoid damage/ Protect</b>	Possible use subject to tributary flows and water availability. Needs may be partially met by other flows.	High	Moderate	
	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)	7 111 ML	1 929 ML	2 727 ML	HIGH Limited connectivity achieved since 2012–13.	<b>Avoid damage/ Protect</b>	Insufficient water under a very low and low water availability scenario to contribute to this demand.	High	Low	
Macquarie Marshes <sup>3,4</sup> (Refer to Figure 4 for inundation map)	Blue and Purple inundation zones (4 000 to 9 000 ha)	30–60 GL at Marebone over 5 months between June and April to inundate reed beds, lagoons, mixed marsh, and water couch.	Ideally: annually (Max interval: 2 years)	Autumn 2014	Met in South and East Marshes, but not North Marsh	Met in South and North Marshes, but not East	HIGH Dry antecedent conditions and fire in the North Marsh in March 2016 have increased demand.	<b>Avoid damage / Protect</b>	Possible use subject to tributary flows and water availability. A lower volume could be used to target specific area/s of the Marshes.	High	Moderate	
	Pink inundation zone (19 000 ha)	100 GL at Marebone over 5 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)	Autumn 2014	Not met	Partially – 1 000 ha (including some areas of inner river red gum) inundated	HIGH Dry antecedent conditions have increased demand.	<b>Avoid damage / Protect</b>	Insufficient water available to contribute to this demand.	High	Moderate	
											Critical	

<sup>†</sup> Targets for water delivery (e.g. Wellington vs Barooka vs Marebone) are contingent on water availability – further work is required to provide more prescriptive targets

Environmental assets	Values	Indicative demand (for <u>all sources of water</u> in the system)	Required frequency (maximum dry interval)	Watering history (from all sources of water) <sup>6</sup>			2016–17			Implications for future demands		
				2013–14	2014–15	2015–16	Predominant urgency of environmental demand for water	Purpose under <u>very low</u> / <u>low</u> resource availability	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2017–18 if watering occurred as planned in 2016–17	2018–19 Range of likely demand	Met in 2017–18
				(drying)	(dry)	(dry)						Not met in 2017–18
Macquarie Marshes <sup>3,4</sup> (Continued) (Refer to Figure 4 for inundation map)	Red inundation zone (50 000 ha)	250 GL at Marebone over 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)	117 GL	Not met	Not met	HIGH Last large-scale inundation in spring 2012.	Avoid damage / Protect	Insufficient water available to contribute to this demand	High	Low	
	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))	Not met	Not met	Not met	LOW-MODERATE Last inundated in 2010–11, with some inundation in 2011–12 and 2012–13.	Protect	Insufficient water available to contribute to this demand	Moderate	Very Low	
Unregulated Distributary creeks <sup>5</sup> Marra Creek Lower Crooked Creek <sup>†</sup>	Fish In channel and riparian vegetation	Baseflows and freshes to Marra Creek and/or the lower Crooked Creek. Volumes required dependent on which creeks are targeted.	Required frequency unknown (1 in 1–3 years based on key vegetation)	Stock and domestic replenishment flows only (Marra and lower Crooked creeks)	Stock and domestic replenishment flows only (Marra Creek)	Stock and domestic replenishment flows only (Marra Creek). Very small events. No connectivity	MODERATE-HIGH Some distributary creeks, such as Marra Creek, may have an increased need for baseflows and small freshes to provide connectivity and support riparian vegetation.	Avoid damage / Protect	Insufficient water available to contribute to this demand. Needs may be partially met by stock and domestic replenishment flows.	High	Low	
	Increased frequency and duration of connectivity to Barwon-Darling	Some connectivity may be provided by replenishment flows.									High	
<div>1. Sourced from information and advice provided by NSW DPI Fisheries (Sam Davis, pers. comm. 2015, 2016)</div> <div>2. Sourced from Barma Water Resources et al. (2011)</div> <div>3. Sourced from advice from NSW Office of Environment and Heritage (Tim Hosking and Debbie Love, pers. comm. 2015, 2016), and MDBA (2012)</div> <div>4. Based on inundation zones as mapped by Thomas et al. (2015).</div> <div>5. Sourced from Torrible et al. (2011)</div> <div>6. All watering history sourced from advice from NSW Office of Environment and Heritage (Tim Hosking and Debbie Love, pers. comm. 2015, 2016), NSW OEH Statement of annual environmental watering priorities, WaterNSW Water Balance Reports, and data from the following gauges (WaterNSW 2016):<div><div><div>• 421090: Macquarie River at d/s Marebone Weir</div><div>• 421040: Macquarie River d/s Burrendong Dam (in the absence of available data at Wellington)</div></div><div><div>• 421001: Macquarie River at Dubbo</div><div>• 421107: Marra Creek at Billybongbone Bridge</div><div>• 421166: Gunningbar Creek at Fairview Dam</div></div><div><div>• 421164: Duck Creek at Napali</div><div>• 421012: Macquarie River at Carinda (Bells Bridge)</div></div></div></div>								Carryover potential	Low proportion of allocations carried into 2017–18.	Low to moderate proportion of allocations may be carried over to 2018–19.	Level of carryover will depend on environmental demands and resource availability.	
								Trade potential	Potential for purchases to augment water for the environment in a number of catchments in the northern Murray-Darling Basin to meet high environmental water demands (particularly in the Macquarie Marshes, Lower Balonne/Narran Lakes and Border Rivers). Further information will be provided to the market ahead of any trade of Commonwealth environmental water.			

Key - events in previous years

Key - events in previous years

	means demand was met by Commonwealth environmental water or any other source
	means demand was partially met by Commonwealth environmental water or any other source (may be used to indicate infrastructure assisted delivery)
	means water not provided (or not required)

Note that not all demands require water every year; drying phases are important for floodplains and temporary wetlands or streams

Key - potential watering in 2016-17

	means a high priority for Commonwealth environmental watering (full or partial contribution, and subject to seasonal and operational considerations)
	means a secondary priority for Commonwealth environmental watering, likely to be met via other means (other water holders, or natural flows)
	means a low priority for Commonwealth environmental watering

Key - urgency of environmental demands

	means critical demand i.e. urgent need for water in that particular year to manage risk of irretrievable loss or damage
	means high demand for water i.e. needed in that particular year
	means moderate demand for water i.e. water needed that particular year and/or next
	means low demand for water i.e. water generally not needed that particular year
	means 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

<sup>†</sup> Note: Gunningbar, Duck and the Upper Crooked creeks are not currently a target for environmental watering

**Table 3b:** Environmental demands, priority for watering in 2016–17 and outlook for coming years in the Macquarie River Valley – **MODERATE WATER RESOURCE AVAILABILITY IN 2016–17**

Environmental assets	Values	Indicative demand (for <u>all sources of water</u> in the system)	Required frequency (maximum dry interval)	Watering history (from all sources of water) <sup>6</sup>			2016–17			Implications for future demands		
				2013–14	2014–15	2015–16	Predominant urgency of environmental demand for water	Purpose under <u>moderate</u> resource availability	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2017–18 if watering occurred as planned in 2016–17	2018–19 Range of likely demand	Met in 2017–18
				(drying)	(dry)	(dry)						Not met in 2017–18
<b>Mid-Macquarie River (Burrendong – Marebone Weir) <sup>1</sup></b>	Fish refuge: all guilds Aquatic ecosystems	<b>Baseflows:</b> small very regular flows through to end of system, wetting holes and in-stream storages.	Ideally: continuous flow (Max interval: continuous flow)				HIGH Minimum baseflows required if releases from Burrendong Dam cease in extreme dry.	Protect	This demand would be met by other water sources under a moderate scenario.	High	High	
	Fish spawning–flow generalists + in-channel specialists	<b>Small freshes:</b> up to 1 000 ML/day for at least 14 days at Wellington* in spring (Oct–Nov) and autumn; and conditioning flow in winter (July to mid-August).	Ideally: annually (Max interval: 3 years generalists and 5 years in-channel specialists)		Met in spring but not winter	Met in winter and early spring. River drying down over summer	MODERATE Respond to natural tributary flows and water temperature.	Protect	Potential use subject to tributary flows and sufficient water availability.	Moderate	Moderate	
	Flow specialists guild movement and breeding	<b>Freshes:</b> 6 000–7 000 ML/day at Wellington, (> 1 000 ML/day at Baroona) during spring (Oct–Nov). Include priming flow (>20 cm rise) and recession, followed by a large spike (>40 cm rise).	Ideally: 1 in 3 years (up to twice per year) (Max interval: 5 years)	Not met downstream of Burrendong, but partially met for 2 days at Baroona	Not met	Not met	HIGH Respond to natural tributary flows, water temperature, and significant river rises that will cue movement and spawning of flow specialists.	Protect	High priority for watering depending on tributary inflows and available water. Use of supplementary entitlement relevant.	Low	Low	
	Fish movement In stream + riparian vegetation	<b>Large freshes and bankfull:</b> 10 000–20 000 ML/day at Baroona for a minimum of 3 days (to drown out key weirs).	Ideally: 2 in 10 years (Max interval: Unknown)	For one day only in September	Not met	Flows above 10 000 ML/day at Baroona for 3 days in June	LOW Based on flows at Dubbo, achieved 5 times since March 2005. Drown out 2010–11 and 2011–12.	Maintain	Insufficient water. Only able to contribute to this demand when coordinated with major tributary flow event.	Low	Low	
<b>Lower Macquarie River (Marshes – Barwon River) <sup>2</sup></b>	Instream aquatic ecosystems Fish Connectivity	<b>Seasonal freshes:</b> in-channel flows Minimum 20 ML/day at Bells Bridge for 45 days.	Ideally: annually (Max interval: Unknown, possibly 2 years)	Short-term connection only (84 days spring 2013; 36 days autumn 2014)	Minimal connection (26 days autumn 2015)	Short-term connection only (25 days autumn 2016)	HIGH Limited connectivity achieved since 2012–13.	Protect	Possible use subject to tributary flows and sufficient water availability. Needs may be partially met by other flows	Moderate to High	Moderate	
	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)	7 111 ML	1 929 ML	2 727 ML	HIGH Limited connectivity achieved since 2012–13.	Protect	Insufficient water to contribute to this demand.	High	Low	
<b>Macquarie Marshes <sup>3,4</sup> (Refer to Figure 4 for inundation map)</b>	Blue and Purple inundation zones (4 000 to 9 000 ha)	30–60 GL at Marebone over 5 months between June and April to inundate reed beds, lagoons, mixed marsh, and water couch.	Ideally: annually (Max interval: 2 years)	Autumn 2014	Met in South and East Marshes, but not North Marsh	Met in South and North Marshes, but not East	HIGH Dry antecedent conditions and fire in the North Marsh in March 2016 have increased demand.	Protect	Possible use subject to tributary flows and water availability. A lower volume could be used to target specific area/s of the Marshes.	High (depending on whether demand met in all areas of the Marshes or not)	Moderate	
	Pink inundation zone (19 000 ha)	100 GL at Marebone over 5 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)	Autumn 2014	Not met	Partially – 1 000 ha (including some areas of inner river red gum) inundated	HIGH Dry antecedent conditions have increased demand.	Protect	Possible use subject to tributary flows and water availability. A lower volume could be used to target specific area/s of the Marshes.	Moderate to High (depending on whether demand met in all areas of the Marshes or not)	Moderate	
<b>Macquarie</b>	Red inundation	250 GL at Marebone over 5 months between June and	Ideally: 1 in 3	117 GL	Not met	Not met	HIGH	Protect	Insufficient water available to contribute	High	Low	

Environmental assets	Values	Indicative demand (for <u>all sources of water</u> in the system)	Required frequency (maximum dry interval)	Watering history (from all sources of water) <sup>6</sup>			2016–17			Implications for future demands		
				2013–14	2014–15	2015–16	Predominant urgency of environmental demand for water	Purpose under <u>moderate</u> resource availability	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2017–18 if watering occurred as planned in 2016–17	2018–19 Range of likely demand	Met in 2017–18
				(drying)	(dry)	(dry)						Not met in 2017–18
<b>Marshes</b> <sup>3,4</sup> (Continued) (Refer to Figure 4 for inundation map)	zone (50 000 ha)	April to inundate river red gum woodland, river cooba, inner coolibah woodland	years (Max interval: 4–7 years)				Last large-scale inundation in spring 2012.		to this demand		High to Critical	
	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: 1in 4 years (RRG), or 1 in 8 years (other veg) (Max interval: 7 years (RRG) 20 years (other veg))	Not met	Not met	Not met	LOW-MODERATE Last inundated in 2010–11, with some inundation in 2011–12 and 2012–13.	Maintain	Insufficient water available to contribute to this demand	Moderate	Very Low	High
<b>Unregulated Distributary creeks<sup>5</sup></b> <b>Marra Creek</b> <b>Lower Crooked Creek</b>	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)	Stock and domestic replenishment flows only (Marra and lower Crooked creeks)	Stock and domestic replenishment flows only (Marra Creek)	Stock and domestic replenishment flows only (Marra Creek). Very small events. No connectivity	MODERATE-HIGH Some distributary creeks, such as Marra Creek, may have an increased need for baseflows and small freshes to provide connectivity and support riparian vegetation.	Protect / Maintain	Possible use, depending on water available and recent watering in the Macquarie Marshes.	Moderate to High	Low	High

See references at Table 3a

Key - events in previous years

	means demand was met by Commonwealth environmental water or any other source
	means demand was partially met by Commonwealth environmental water or any other source (may be used to indicate infrastructure assisted delivery)
	means water not provided (or not required)

Note that not all demands require water every year; drying phases are important for floodplains and temporary wetlands or streams

Key - potential watering in 2016-17

	means a high priority for Commonwealth environmental watering (full or partial contribution, and subject to seasonal and operational considerations)
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Key - urgency of environmental demands

	means critical demand i.e. urgent need for water in that particular year to manage risk of irretrievable loss or damage
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Note that demand is considered at a generalised scale; there may be specific requirements that are more or less urgent within the flow regime

Carryover potential	Low to moderate proportion of allocations carried into 2017–18.	Low to moderate proportion of allocations may be carried over to 2018–19, but will depend on resource availability and demands.	Level of carryover will depend on environmental demands and resource availability.
Trade potential	Potential for purchases to augment water for the environment in a number of catchments in the northern Murray-Darling Basin to meet high environmental water demands (particularly in the Macquarie Marshes, Lower Balonne/Narran Lakes and Border Rivers). Further information will be provided to the market ahead of any trade of Commonwealth environmental water.		

**Table 3c: Environmental demands, priority for watering in 2016–17 and outlook for coming years in the Macquarie River Valley – HIGH / VERY HIGH WATER RESOURCE AVAILABILITY IN 2016–17**

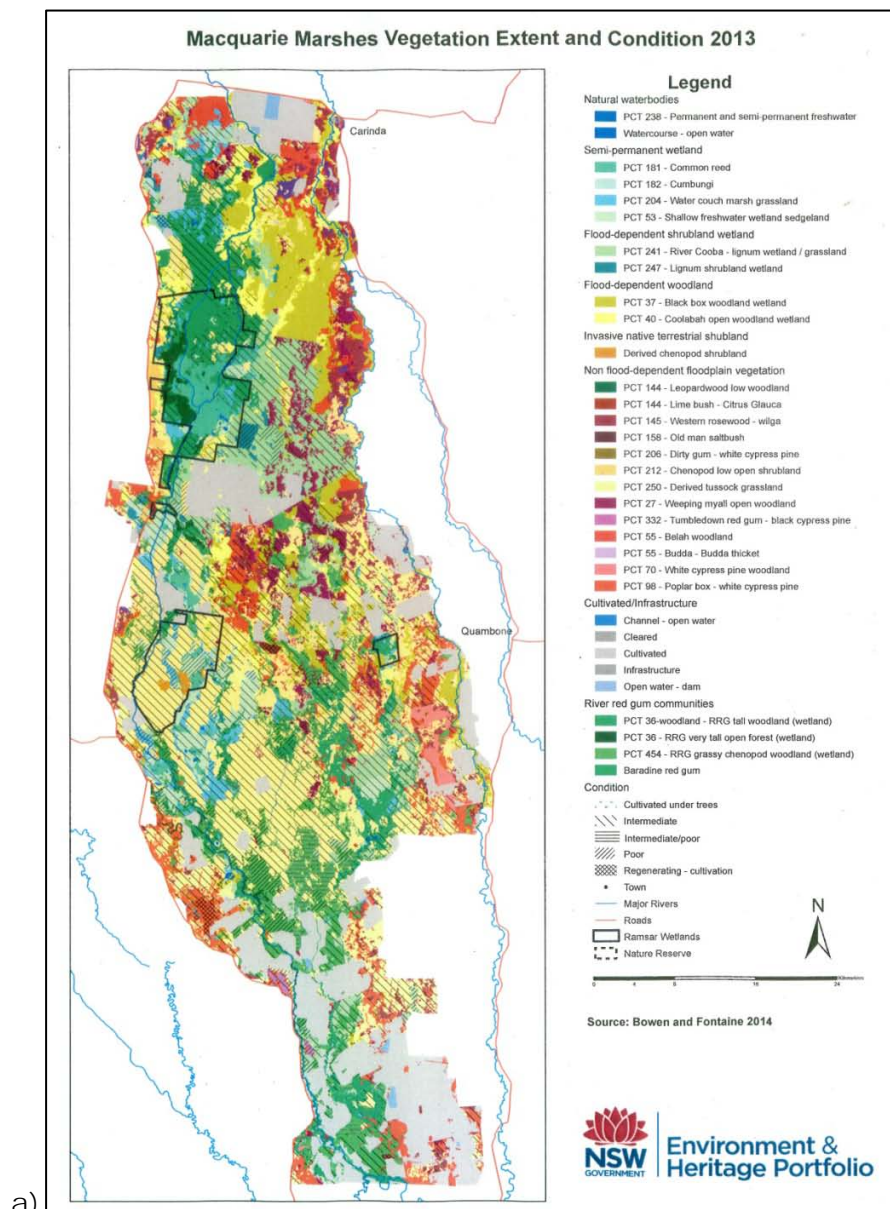
Environmental assets	Values	Indicative demand (for <u>all sources of water</u> in the system)	Required frequency (maximum dry interval)	Watering history (from all sources of water) <sup>6</sup>			2016–17			Implications for future demands		
				2013–14	2014–15	2015–16	Predominant urgency of environmental demand for water	Purpose under <u>high</u> / <u>very high</u> resource availability	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2017–18 if watering occurred as planned in 2016–17	2018–19 Range of likely demand	Met in 2017–18
				(drying)	(dry)	(dry)						Not met in 2017–18
<b>Mid-Macquarie River (Burrendong – Marebone Weir) <sup>1</sup></b>	Fish refuge: all guilds Aquatic ecosystems	<b>Baseflows:</b> small very regular flows through to end of system, wetting holes and in-stream storages.	Ideally: continuous flow (Max interval: continuous flow)				HIGH Minimum baseflows required if releases from Burrendong Dam cease in extreme dry.	Improve	This demand would be met by other water sources under a moderate scenario.	High	High	
	Fish spawning–flow generalists + in-channel specialists	<b>Small freshes:</b> up to 1 000 ML/day for at least 14 days at Wellington* in spring (Oct-Nov) and autumn; and conditioning flow in winter (July to mid-August).	Ideally: annually (Max interval: 3 years generalists and 5 years in-channel specialists)		Met in spring but not winter	Met in winter and early spring. River drying down over summer	MODERATE Respond to natural tributary flows and water temperature.	Improve	Potential use subject to tributary flows and water availability. Needs may be met by other flows.	Moderate to High	Moderate to High	
	Flow specialists guild movement and breeding	<b>Freshes:</b> 6 000–7 000 ML/day at Wellington, (> 1 000 ML/day at Baroona) during spring (Oct-Nov). Include priming flow (>20 cm rise) and recession, followed by a large spike (>40 cm rise).	Ideally: 1 in 3 years (up to twice per year) (Max interval: 5 years)	Not met downstream of Burrendong, but partially met for 2 days at Baroona	Not met	Not met	HIGH Respond to natural tributary flows, water temperature, and significant river rises that will cue movement and spawning of flow specialists.	Improve	High priority for watering depending on tributary inflows and water availability. Use of supplementary entitlement relevant.	Low	Low	
	Fish In stream + riparian vegetation	<b>Large freshes and bankfull:</b> 10 000–20 000 ML/day at Baroona for a minimum of 3 days (to drown out key weirs).	Ideally: 2 in 10 years (Max interval: Unknown)	For one day only in September	Not met	Flows above 10 000 ML/day at Baroona for 3 days in June	LOW Based on flows at Dubbo, achieved 5 times since March 2005. Drown out 2010–11 and 2011–12.	Maintain / Improve	Possible use dependent on available water. Subject to major tributary event.	Low	Low	
<b>Lower Macquarie River (Marshes – Barwon River) <sup>2</sup></b>	Instream aquatic ecosystems Fish Connectivity	<b>Seasonal freshes:</b> in-channel flows Minimum 20 ML/day at Bells Bridge for 45 days.	Ideally: annually (Max interval: Unknown – possibly 2 years)	Short-term connection only (84 days spring 2013; 36 days autumn 2014)	Minimal connection (26 days autumn 2015)	Short-term connection only (25 days autumn 2016)	HIGH Limited connectivity achieved since 2012–13.	Improve	High priority for watering depending on tributary inflows and water availability. Needs may be met by other flows.	Moderate	Moderate	
	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)	7 111 ML	1 929 ML	2 727 ML	HIGH Limited connectivity achieved since 2012–13.	Improve	High priority for watering depending on tributary inflows and water availability. Use of supplementary entitlement relevant.	Low	Low	
<b>Macquarie Marshes <sup>3,4</sup> (Refer to Figure 4 for inundation map)</b>	Blue and Purple inundation zones (4 000 to 9 000 ha)	30–60 GL at Marebone over 5 months between June and April to inundate reed beds, lagoons, mixed marsh, and water couch.	Ideally: annually (Max interval: 2 years )	Autumn 2014	Met in South and East Marshes, but not North Marsh	Met in South and North Marshes, but not East	HIGH Dry antecedent conditions and fire in the North Marsh in March 2016 have increased demand.	Improve	High priority for watering in 2016–17.	Moderate	Moderate	
	Pink inundation zone (19 000 ha)	100 GL at Marebone over 5 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)	Autumn 2014	Not met	Partially – 1 000 ha (including some areas of inner river red gum) inundated	HIGH Dry antecedent conditions have increased demand.	Improve	High priority for watering in 2016–17.	Moderate	Moderate	

Environmental assets	Values	Indicative demand (for <u>all sources of water</u> in the system)	Required frequency (maximum dry interval)	Watering history (from all sources of water) <sup>6</sup>			2016–17			Implications for future demands		
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	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: 1in 4 years (RRG), or 1 in 8 years (other veg) (Max interval: 7 years (RRG) 20 years (other veg))	Not met	Not met	Not met	LOW-MODERATE Last inundated in 2010–11, with some inundation in 2011–12 and 2012–13.	Maintain / Improve	Possible use depending on water availability and other higher urgency demands having been met.  Water may be provided on the tail of an unregulated flow, depending on flow rates and duration of flows.	Low	Very Low	
Unregulated Distributary creeks <sup>5</sup> Marra Creek Lower Crooked Creek	Fish In-channel and riparian vegetation	Baseflows and freshes to Marra Creek and/or the lower Crooked Creek.  Volumes required dependent on which creeks are targeted.	Required frequency unknown (1 in 1–3 years based on key vegetation)	Stock and domestic replenishment flows only (Marra and lower Crooked creeks)	Stock and domestic replenishment flows only (Marra Creek)	Stock and domestic replenishment flows only (Marra Creek).  Very small events. No connectivity	MODERATE-HIGH  Some distributary creeks, such as Marra Creek, may have an increased need for baseflows and small freshes to provide connectivity and support riparian vegetation.	Improve	Possible use depending on water availability and other higher urgency demands having been met.  Use of supplementary entitlement relevant. May be met by tributary flows.	Low to Moderate	Low	
	Increased frequency and duration of connectivity to Barwon-Darling	Some connectivity may be provided by replenishment flows.									Moderate	
See references at Table 3a								Carryover potential	Low proportion of allocations carried into 2017–18.	Low to moderate proportion of allocations may be carried over to 2018–19, but will depend on resource availability and demands.	Level of carryover will depend on environmental demands and resource availability.	
<b>Key - events in previous years</b> <div><div></div> means demand was met by Commonwealth environmental water or any other source <div></div> means demand was partially met by Commonwealth environmental water or any other source (may be used to indicate infrastructure assisted delivery) <div></div> means water not provided (or not required)</div> Note that not all demands require water every year; drying phases are important for floodplains and temporary wetlands or streams												
<b>Key - potential watering in 2016-17</b> <div><div></div> means a high priority for Commonwealth environmental watering (full or partial contribution, and subject to seasonal and operational considerations) <div></div> means a secondary priority for Commonwealth environmental watering, likely to be met via other means (other water holders, or natural flows) <div></div> means a low priority for Commonwealth environmental watering</div>								Trade potential	Potential for purchases to augment water for the environment in a number of catchments in the northern Murray-Darling Basin to meet high environmental water demands (particularly in the Macquarie Marshes, Lower Balonne/Narran Lakes and Border Rivers). Further information will be provided to the market ahead of any trade of Commonwealth environmental water.			

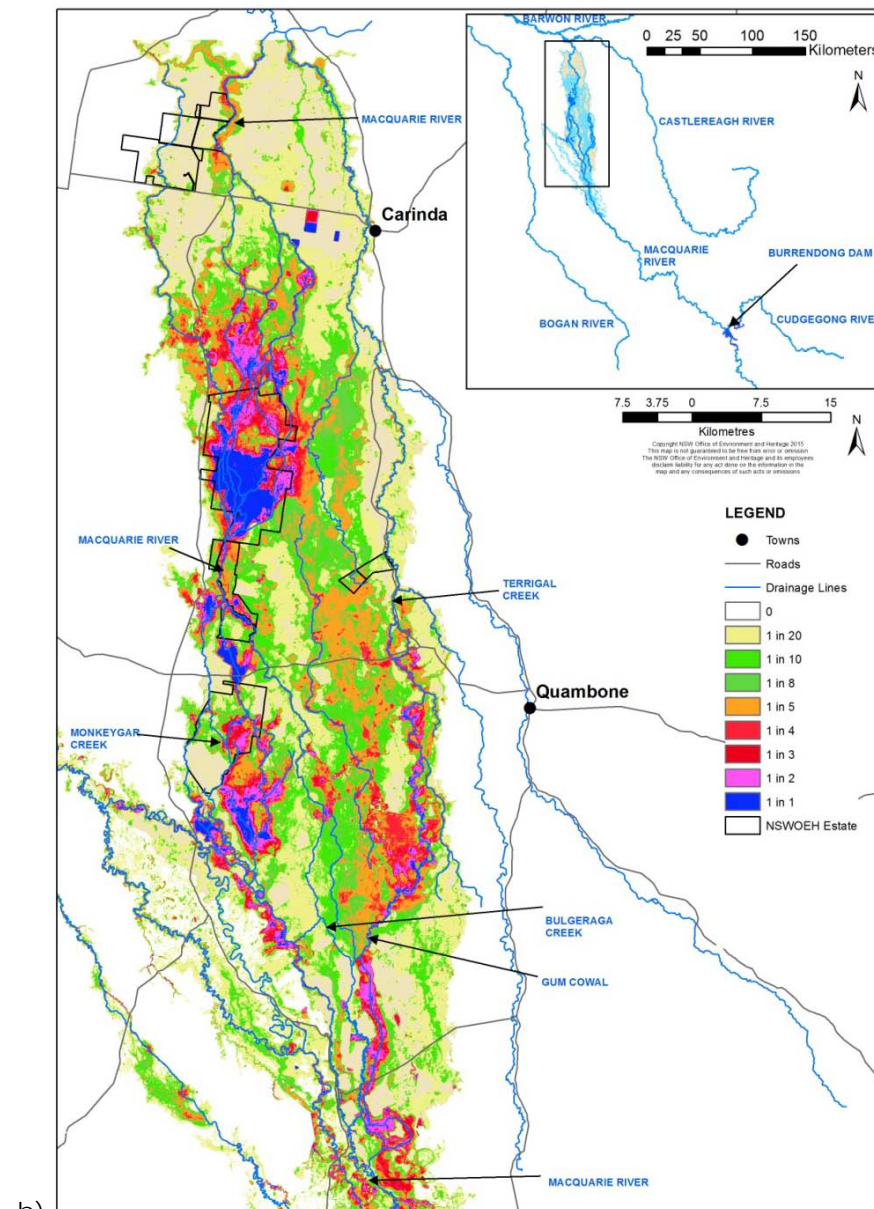
**Key - urgency of environmental demands**

means critical demand i.e. urgent need for water in that particular year to manage risk of irretrievable loss or damage  
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Note that demand is considered at a generalised scale; there may be specific requirements that are more or less urgent within the flow regime



a)



b)

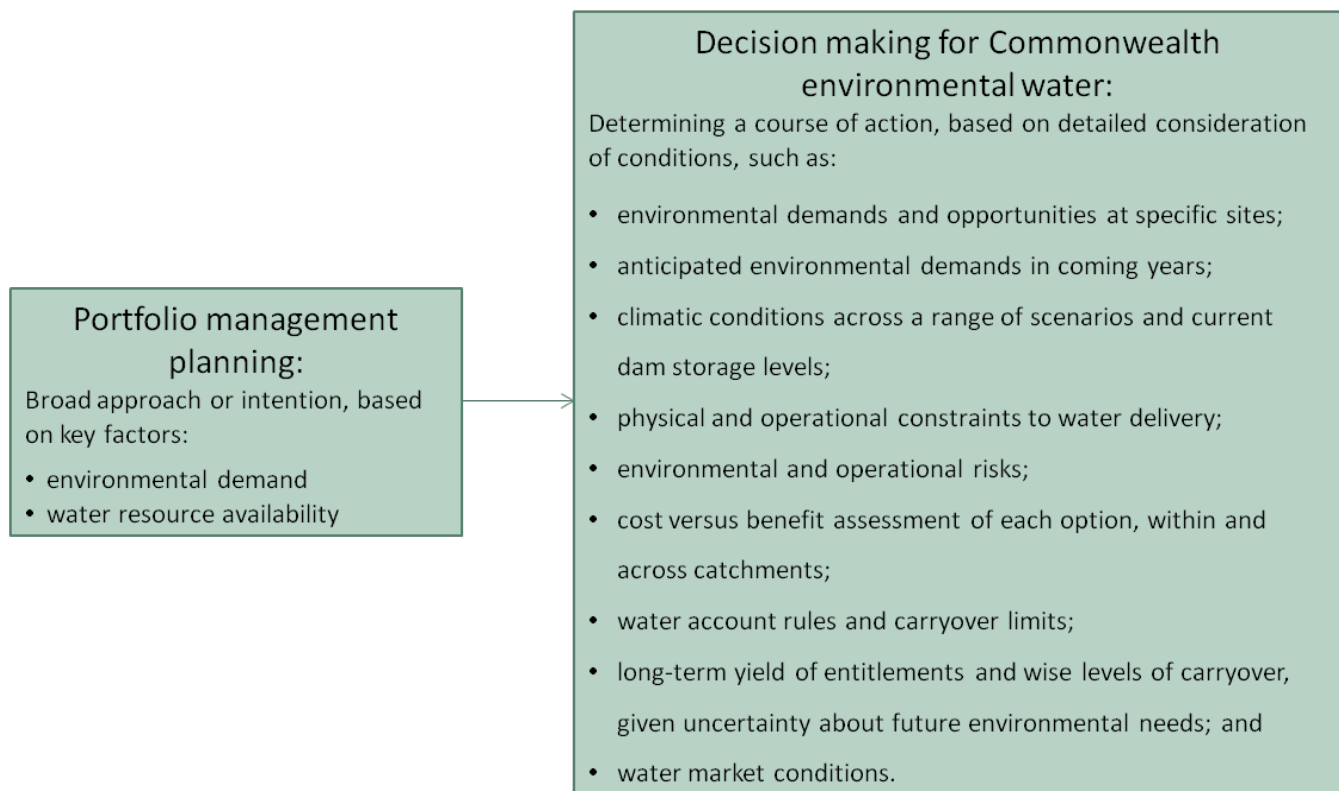
**Figure 4:** a) Vegetation mapping of the Macquarie Marshes (Bowen and Fontaine 2015) and b) Inundation mapping of the Macquarie Marshes 1988–2008 (Thomas et al. 2015).

## 3. Next steps

### 3.1. From planning to decision making

It is important to distinguish between planning and operational decision making. As shown in Figure 5, planning allows the Office to manage the environmental water portfolio in a holistic manner and is an exercise in developing a broad approach or intention, based on the key drivers (demand and supply).

Decision making throughout each year builds on the intention by considering in more detail the specific prevailing factors and additional factors such as costs, risks and constraints to water delivery and market conditions.



**Figure 5:** Planning and decision making for Commonwealth environmental water use

### 3.2. Further information

For further information on how the Office plans for water use, carryover and trade, please visit our web site <http://www.environment.gov.au/water/cewo>

- Water use: [www.environment.gov.au/topics/water/commonwealth-environmental-water-office/assessment-framework](http://www.environment.gov.au/topics/water/commonwealth-environmental-water-office/assessment-framework)
- Carryover: <http://www.environment.gov.au/topics/water/commonwealth-environmental-water-office/portfolio-management/carryover>
- Trade: *Discussion Paper – Trade of Commonwealth Environmental Water and Commonwealth Environmental Water Trading Framework*: <http://www.environment.gov.au/water/cewo/trade/trading-framework>

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# Attachment A – Expected outcomes from the Basin-wide environmental watering strategy

Expected outcomes from the Basin-wide environmental watering strategy (MDBA 2014) that are relevant to the Macquarie River Valley are described below.

## RIVER FLOWS AND CONNECTIVITY

Baseflows are at least 60 per cent of the natural level

Contributing to a 10 per cent overall increase in flows in the Barwon–Darling

A 10–20 per cent increase in the frequency of freshes and bankfull flows

## VEGETATION

Maintain the current extent of water-dependent vegetation near river channels and on low-lying areas of the floodplain.

No decline in the condition of river red gum, black box and coolibah across the Basin

Improved recruitment of trees within black box, river red gum and coolibah communities

Improve condition of lignum shrublands in the Macquarie Marshes

Increased periods of growth for non-woody vegetation communities that closely fringe or occur within the river and creek channels, and for common reed and cumbungi in the Macquarie Marshes.

### Vegetation extent

Area of river red gum (ha)	Area of black box (ha)	Area of coolibah (ha)	Shrublands	Non-woody water dependent vegetation
58 200	57 100	32 200	Lignum in the Macquarie Marshes	Closely fringing or occurring within the Bogan, Castlereagh, Macquarie and Talbragar rivers; and common reed, cumbungi and water couch in the Macquarie Marshes

## WATERBIRDS

Maintain current species diversity

Increase Basin-wide abundance of waterbirds by 20–25 per cent by 2024

A 30–40 per cent increase in nests and broods (Basin-wide) for other waterbirds

Up to 50 per cent more breeding events (Basin-wide) for colonial nesting waterbird species

## Important Basin environmental assets for waterbirds in the Macquarie

Environmental asset	Total abundance and diversity	Drought refuge	Colonial waterbird breeding	Shorebird abundance	In scope for C'th e-watering
Macquarie Marshes	Yes	Yes	Yes	Yes	Yes

## FISH

No loss of native species

Improved population structure of key species through regular recruitment, including:

- Short-lived species with distribution and abundance at pre-2007 levels and breeding success every one to two years
- Moderate to long-lived with a spread of age classes and annual recruitment in at least 80 per cent of years

Increased movements of key species

Expanded distribution of key species and populations

**Key species for the Macquarie include:**

Species	Specific outcomes	In-scope for C'th water in the Macquarie?
Flathead galaxias ( <i>Galaxias rostratus</i> )	Considered extinct. Reintroduction using southern populations may be an option in the longer term, with the Macquarie a potential candidate site.	Possibly (Once widespread. Current extent unknown in Macquarie. Potential for re-introduction)
Freshwater catfish ( <i>Tandanus tandanus</i> )	Expand the core range of existing populations in the Macquarie	Yes
Golden Perch ( <i>Macquaria ambigua</i> )	A 10–15 per cent increase of mature fish (of legal take size) in key populations	Yes
Murray cod ( <i>Maccullochella peelii peelii</i> )	A 10–15 per cent increase of mature fish (of legal take size) in key populations	Yes
Olive perchlet ( <i>Ambassis agassizii</i> )	Establish additional populations in the Macquarie	Possibly (Once widespread. Current extent unknown in Macquarie. Potential for re-introduction)
Silver perch ( <i>Bidyanus bidyanus</i> )	Expand the core range in the Macquarie catchments	Yes
Southern purple-spotted gudgeon ( <i>Mogurnda adspersa</i> )	Expand the range (or core range) of populations in the Macquarie. Establish additional populations	Yes
Trout cod ( <i>Maccullochella</i> )	The distribution of trout cod in the	Yes

Species	Specific outcomes	In-scope for C'th water in the Macquarie?
<i>macquariensis</i> )	Northern Basin is limited to the Macquarie catchment downstream of Burrendong Dam. Range expansion of the current population is a priority. Establish additional populations	

#### Important Basin environmental assets for native fish in the Macquarie

Environmental asset	Key movement corridors	High Biodiversity	Site of other Significance	Key site of hydrodynamic diversity	Threatened species	Dry period / drought refuge	In-scope for C'th water
Macquarie River – below Burrendong Dam to Warren	Yes	Yes			Yes	Yes	Yes
Macquarie Marshes to Barwon, including lateral connectivity at the marshes	Yes				Yes	Yes	Yes
Lower Bogan River to junction with the Darling River	Yes				Yes	Yes	Yes

# Attachment B – Library of watering actions

## Operational considerations in the Macquarie River Valley catchment

The delivery of environmental water in the Macquarie River Valley is currently constrained by the release capacities from storages, channel capacities, and system constraints.

Watering actions will be developed in consideration of the following constraints:

- Burrendong Dam storage capacity of 1 188 000 ML and outlet capacity of 8 200 ML/day (WaterNSW 2015)
- South Dubbo weir drown out at > 14 385 ML/day
- Marebone Choke – third party impact at prolonged flows > 4 000 ML/day
- Crooked Creek off take capacity of 100 ML/day
- structures such as banks, weirs, regulators and diversion channels in the Macquarie Marshes.

The Commonwealth Environmental Water Office will develop watering options within existing water delivery and channel capacity constraints unless the agreement of all affected parties has been obtained for an alternative delivery approach.

## Potential watering actions under different levels of water resource availability

Under certain levels of water resource availability, watering actions may not be pursued for a variety of reasons, including that environmental demand may be met by unregulated flows and that constraints and/or risks may limit the ability to deliver environmental water. Table 4 identifies the range of potential watering actions in the Macquarie River Valley and the levels of water resource availability that relate to these actions.

**Table 4:** Summary of potential watering actions for the Macquarie River Valley

Broad Asset	Indicative demand	Applicable level(s) of resource availability				
		Very Low	Low	Moderate	High	Very High
Mid-Macquarie River	Baseflows: small, very regular flows through to end of system, wetting holes and instream storages.	1. <i>Minimum baseflows</i> : contribute to flows to maintain connectivity during extreme dry conditions to provide native fish refuge if regulated flows cease				
	Small freshes: up to 1 000 ML/day for at least 14 days at Wellington in spring (Oct-Nov) and autumn; and conditioning flow in winter (July to mid-August).	2. <i>Native fish maintenance flow</i> : contribute to flows (baseflows and freshes) in the mid-Macquarie River for the maintenance and conditioning of native fish (flow generalists and in-channel specialists) (July to mid-August)*				
		3. <i>Native fish flow (flow generalists)</i> : contribute to river flows (baseflows and freshes) in the mid-Macquarie River to provide habitat for native fish (all guilds) and to provide spawning opportunities for flow generalists (spring)*				
	Freshes: 6 000–7 000 ML/day at Wellington, during spring (Oct-Nov). Include priming flow (>20 cm rise) and recession, followed by a large spike (>40 cm rise).			4. <i>Native fish flow (flow specialists)</i> : contribute to river flows (freshes) in the mid-Macquarie River to support native fish populations (flow specialists), including movement, reproduction and recruitment*		
	Large freshes and bankfull: 10 000–20 000 ML/day at Barooka for a minimum of 3 days (to drown out key weirs).				5. <i>Native fish passage flow</i> : contribute to river flows (freshes) in the mid-Macquarie River to drown key weirs and provide movement, spawning and recruitment opportunities for flow specialists and generalists *	
Lower Macquarie River	Seasonal freshes: in-channel flows Minimum 20 ML/day at Bells Bridge for 45 days.	6. Contribute to flows (seasonal freshes) to provide connectivity to the lower Macquarie River and through to the Barwon-Darling, maintain aquatic ecosystems, and provide opportunities for native fish*				

Lower Macquarie River (continued)	15–30 GL at Bells Bridge to inundate floodplain and lower reach of Macquarie River				7. Contribute to flows to inundate floodplain and the lower reach of the lower Macquarie River through to the Barwon-Darling, provide connectivity, and support floodplain vegetation*
Macquarie Marshes	Flows between 60 and 700 GL at Marebone over five months between June and April  (wetland inundation action scalable depending on water resource availability scenario and target extent)	8. <i>Wetland inundation</i> : Contribute to flows to the Macquarie Marshes to inundate wetland vegetation and provide habitat and recruitment opportunities for waterbirds, fish and frogs			
				9. <i>Waterbird breeding contingency</i> : Contribute to flows to the Macquarie Marshes to maintain inundation in key waterbird reproduction areas to support a naturally triggered breeding event	
Distributary creeks	Baseflows and freshes targeting fish, vegetation and connectivity with the Barwon River			10. <i>Restoring natural flow variability</i> : Contribute to flows (baseflows and freshes) in Marra Creek and/or Lower Crooked Creek to support hydrological connectivity, vegetation and native fish populations	

Note: Under certain resource availabilities, options may not be pursued for a variety of reasons including that environmental demand may be met by unregulated flows and that constraints and/or risks may limit the ability to deliver environmental water.

\* Could be coordinated with environmental water delivery to the Macquarie Marshes, depending on timing and/or volumes. Providing connectivity via Marthaguy Creek may be achieved by coordinating with water delivered to the East Marsh.

## Potential watering actions – standard operating arrangements

Table 4 above identifies the range of potential watering actions in the Macquarie River Valley that give effect to the long-term demands and flow regime identified as being in scope for the Office to contribute environmental water to in any given year. The standard considerations associated with these actions are set out below.

### 1. Mid-Macquarie River minimum baseflows

*Watering action:* Contribute to flows to maintain connectivity during extreme dry conditions to provide native fish refuge if regulated flow releases from Burrendong Dam cease.

*Standard operational considerations:* Target flow rates would be dependent on conditions in the system, the volume of water available to be delivered and operational considerations.

*Typical extent:* This watering action would contribute flows to the mid-Macquarie River downstream of Burrendong Dam to downstream of Warren.

*Approvals:* Consult with NSW agencies (Water NSW, OEH and DPI Fisheries) before implementing this action.

### 2. Native fish maintenance flow

*Watering action:* Contribute to flows (small freshes) in the mid-Macquarie River for the maintenance and conditioning of native fish (flow generalists and in-channel specialists) (July to mid-August).

*Standard operational considerations:*

- The flow limit for this action is 4 000 ML/day at Marebone Weir
- The timing of the flow is very important. Flows should ideally be delivered before mid-August to avoid favouring carp and providing a competitive advantage over native fish species.
- This action would take advantage of in-stream flows by supplementing tributary flows and/or consumptive orders to create the desired flow increase and recession .
- This action could be coordinated with environmental water delivery to the Macquarie Marshes, depending on appropriate timing and volumes.

*Typical extent:* This watering action would be targeted at contributing flows to the mid-Macquarie River downstream of Burrendong Dam, but would also provide flows into the Macquarie Marshes.

*Approvals:* Consult with NSW agencies (Water NSW, OEH and DPI Fisheries) before implementing this action.

### 3. Native fish flow (flow generalists)

*Watering action:* Contribute to river flows (small freshes) in the mid-Macquarie River to provide habitat for native fish (all guilds) and to provide spawning opportunities for flow generalists.

*Standard operational considerations:*

- The flow limit for this action is 4 000 ML/day at Marebone Weir.
- This action would take advantage of in-stream flows by supplementing tributary flows and/or consumptive orders to create the desired flow increase and recession.
- This action could be coordinated with environmental water delivery to the Macquarie Marshes, depending on appropriate timing and volumes.
- Commonwealth supplementary entitlements could contribute to meeting this demand.

*Typical extent:* This watering action would be targeted at contributing flows to the mid-Macquarie River downstream of Burrendong Dam, but would also provide flows into the Macquarie Marshes.

*Approvals:* Consult with NSW agencies (Water NSW, OEH and DPI Fisheries) before implementing this action.

#### **4. Native fish flow (flow specialists)**

*Watering action:* Contribute to river flows (freshes) in the mid-Macquarie River to support native fish populations (flow specialists), including movement, reproduction and recruitment.

*Standard operational considerations:*

- The flow limit for this action is 4 000 ML/day at Marebone Weir.
- This action would take advantage of in-stream flows by supplementing tributary flows and/or consumptive orders to create the desired flow increase and recession. A flow rise of approximately 2 metres may be required.
- This action could be coordinated with environmental water delivery to the Macquarie Marshes, depending on appropriate timing and volumes.
- Commonwealth supplementary entitlements could contribute to meeting this demand.

*Typical extent:* This watering action would be targeted at contributing flows to the mid-Macquarie River downstream of Burrendong Dam, but would also provide flows into the Macquarie Marshes.

*Approvals:* Consult with NSW agencies (Water NSW, OEH and DPI Fisheries) before implementing this action.

#### **5. Native fish passage flow**

*Watering action:* Contribute to river flows (large freshes and bankfull) in the mid-Macquarie River to drown out key weirs and provide movement, spawning and recruitment opportunities for flow specialists and generalists.

*Standard operational considerations:*

- The flow limit for this action is 4 000 ML/day at Marebone Weir.
- A total of 15 000 ML/day at Dubbo is required to drown out weirs on the Macquarie River at Dubbo and Narromine.
- This action would take advantage of in-stream flows by supplementing tributary flows and/or consumptive orders to create the desired flow increase and recession .
- This action could be coordinated with environmental water delivery to the Macquarie Marshes, depending on appropriate timing and volumes.
- Commonwealth supplementary entitlements could contribute to meeting this demand.

*Typical extent:* This watering action would be targeted at contributing flows to the mid-Macquarie River downstream of Burrendong Dam, particularly at major weirs at Dubbo and Narromine to enable fish passage. The action would also provide flows into the Macquarie Marshes.

*Approvals:* Consult with NSW agencies (Water NSW, OEH and DPI Fisheries) before implementing this action.

## 6. Lower Macquarie River in-channel freshes

*Watering action:* Contribute to flows (baseflows and freshes) to provide connectivity to the lower Macquarie River and Barwon-Darling, maintain aquatic ecosystems and riparian vegetation, and provide opportunities for native fish. The action would help support floodplain vegetation along the lower Macquarie River during periods of higher resource availability.

*Standard operational considerations:*

- The flow limit for this action is 4 000 ML/day at Marebone Weir.
- Target flow rates would be dependent on conditions in the system, the volume of water available to be delivered and operational considerations.
- This action could be coordinated with environmental water delivery to the Macquarie Marshes or other flows, depending on appropriate timing and volumes.
- Flows above 50 ML/day at Carinda may be at risk of extraction.

*Typical extent:* This watering action would be targeted at contributing flows to the lower Macquarie River downstream of the Macquarie Marshes. If water is being provided to the Eastern Marshes it may also be possible to deliver additional water to the lower Macquarie River via Marthaguy Creek. Depending on water availability, this action would also provide flows to the Barwon-Darling system. This action would provide additional benefits to the mid-Macquarie River and Marshes en route to the lower Macquarie.

*Approvals:* Consult with NSW agencies (Water NSW, OEH and DPI Fisheries) before implementing this action.

## 7. Lower Macquarie floodplain inundation

*Watering action:* Contribute to flows to inundate floodplain and the lower reach of the lower Macquarie River through to the Barwon-Darling, provide connectivity, and support floodplain vegetation.

*Standard operational considerations:*

- The flow limit for this action is 4 000 ML/day at Marebone Weir.
- Target flow rates would be dependent on conditions in the system, the volume of water available to be delivered and operational considerations.
- This action could be coordinated with environmental water deliveries to the Macquarie Marshes or other flows, depending on appropriate timing and volumes.
- Flows above 50 ML/day at Carinda may be at risk of extraction, so consideration is required as to how environmental water would be protected to the end of system.

*Typical extent:* This watering action would be targeted at contributing to flows to the lower Macquarie River and floodplain downstream of the Macquarie Marshes. It is expected that this action would provide connectivity to the Barwon-Darling system. This action would provide additional benefits to the mid-Macquarie River and Marshes en route to the lower Macquarie.

*Approvals:* Consult with NSW agencies (Water NSW, OEH and DPI Fisheries) before implementing this action. This action would also require close collaboration with relevant landholders to manage any potential third party impacts.

## 8. Wetland inundation

*Watering action:* Contribute to flows to the Macquarie Marshes to inundate wetland vegetation, and provide habitat and recruitment opportunities for waterbirds, fish and frogs.

*Standard operational considerations:*

- The flow limit for this action is 4 000 ML/day at Marebone Weir.
- Commonwealth environmental water would be delivered via rivers flows from Burrendong Dam to Marebone Weir (accounting point), taking up to 11 days to reach the weir.
- Commonwealth supplementary entitlements could contribute to meeting this demand.

*Typical extent:*

- Depending on water availability, specific areas of the Marshes system may be targeted (e.g. within the Northern, Southern and/or Eastern Marshes) rather than the entire inundation zone.
- The extent targeted varies across demands and water resource availability scenarios and will vary depending on delivery design and flow rates. Approximate inundation extents are provided below:
  - Contribute to inundating up to 9 000 ha of reed beds, lagoons and water couch in the Macquarie Marshes (60 GL: Very Low to Low scenario).
  - Contribute to inundating up to 19 000 ha of reeds, water couch, mixed marsh, river red gum forest and river cooba in the Macquarie Marshes (100 GL: Very Low to Moderate scenario).
  - Contribute to inundating up to 50 000 ha of river red gum woodland, mixed marsh and river cooba in the Macquarie Marshes (250 GL: Low to High scenario).
  - Contribute to inundating between 81 000 and 145 000 ha of outer river red gum forest, coolibah, myall and black box in the Macquarie Marshes (400–700 GL: Moderate to High scenario).

*Approvals:* Consult with NSW agencies (Water NSW, OEH and DPI Fisheries) before implementing this action.

## 9. Waterbird breeding contingency

*Watering action:* Contribute to flows to the Macquarie Marshes to maintain inundation in key waterbird reproduction areas to support a naturally triggered breeding event.

*Standard operational considerations:*

- The flow limit for this action is 4 000 ML/day at Marebone Weir.
- Delivery of Commonwealth environmental water will be triggered by a shared recognition with NSW OEH and other key agencies that catchment conditions and short term future flows into the Marshes will be insufficient to maintain the conditions required to successfully complete a bird breeding event.
- Delivery of Commonwealth environmental water will be adaptively managed to maintain inundation at an appropriate depth and duration, and to avoid a rapid flow recession in known breeding areas.
- This action may not be operationalised if other flows (e.g. irrigation, unregulated, replenishment flows) are deemed sufficient to support the breeding event to completion.
- Commonwealth environmental water would be delivered via rivers flows from Burrendong Dam to Marebone Weir (accounting point), taking up to 11 days to reach the weir.

*Typical extent:* Key waterbird breeding sites across the Macquarie Marshes. Specific sites will depend on where the waterbird breeding event takes place at that time.

*Approvals:* Consult with NSW agencies (Water NSW, OEH and DPI Fisheries) before implementing this action. In particular, to determine whether environmental water can be delivered to the precise location of the bird breeding event.

## 10. Restoring natural flow variability

*Watering action:* Contribute to flows (baseflows and freshes) in Marra Creek and/or Lower Crooked Creek to support hydrological connectivity, vegetation and native fish populations.

*Standard operational considerations:*

- Target flow rates will be dependent on prevailing flow conditions, target assets and operational considerations.
- Commonwealth environmental water would be delivered as in-stream flows, which are gravity fed from Burrendong Dam and diverted from the Macquarie River channel into the distributary creeks system.
- Commonwealth environmental water could be provided to the distributary creeks using either General Security or Supplementary entitlements, depending on conditions and water availability. Flows may be provided in addition to replenishment or unregulated flows, and depending on conditions.
- Delivery to the Lower Crooked Creek is constrained by the capacity of the Crooked Creek channel, regulator and Mumblebone Weir.
- Commonwealth supplementary entitlements could contribute to meeting this demand.

*Typical extent:* The likely target of this action would be the unregulated parts of the distributary creeks system such as Marra Creek and the Lower Crooked Creek. Flows may also contribute to achieving connectivity with the Bogan River and/or Barwon-Darling. Other distributary creeks such as Duck and Gunningbar creeks are not likely to be targeted for the delivery of Commonwealth environmental water. Further investigation and consultation regarding the regulated distributary creeks may be undertaken in the future.

*Approvals:* Close collaboration with landholders in the distributary creeks system would be required to deliver environmental water to the system. Consultation with NSW agencies (Water NSW, OEH and DPI Fisheries) would be required before implementing this action.

# Attachment C – Long-term water availability

## Commonwealth environmental water holdings

The Commonwealth holds the following entitlements in the Macquarie River Valley:

- General security
- Supplementary

The full list of Commonwealth environmental water holdings can be found at <http://www.environment.gov.au/water/cewo/about/water-holdings> and is updated monthly.

## Other sources of environmental water

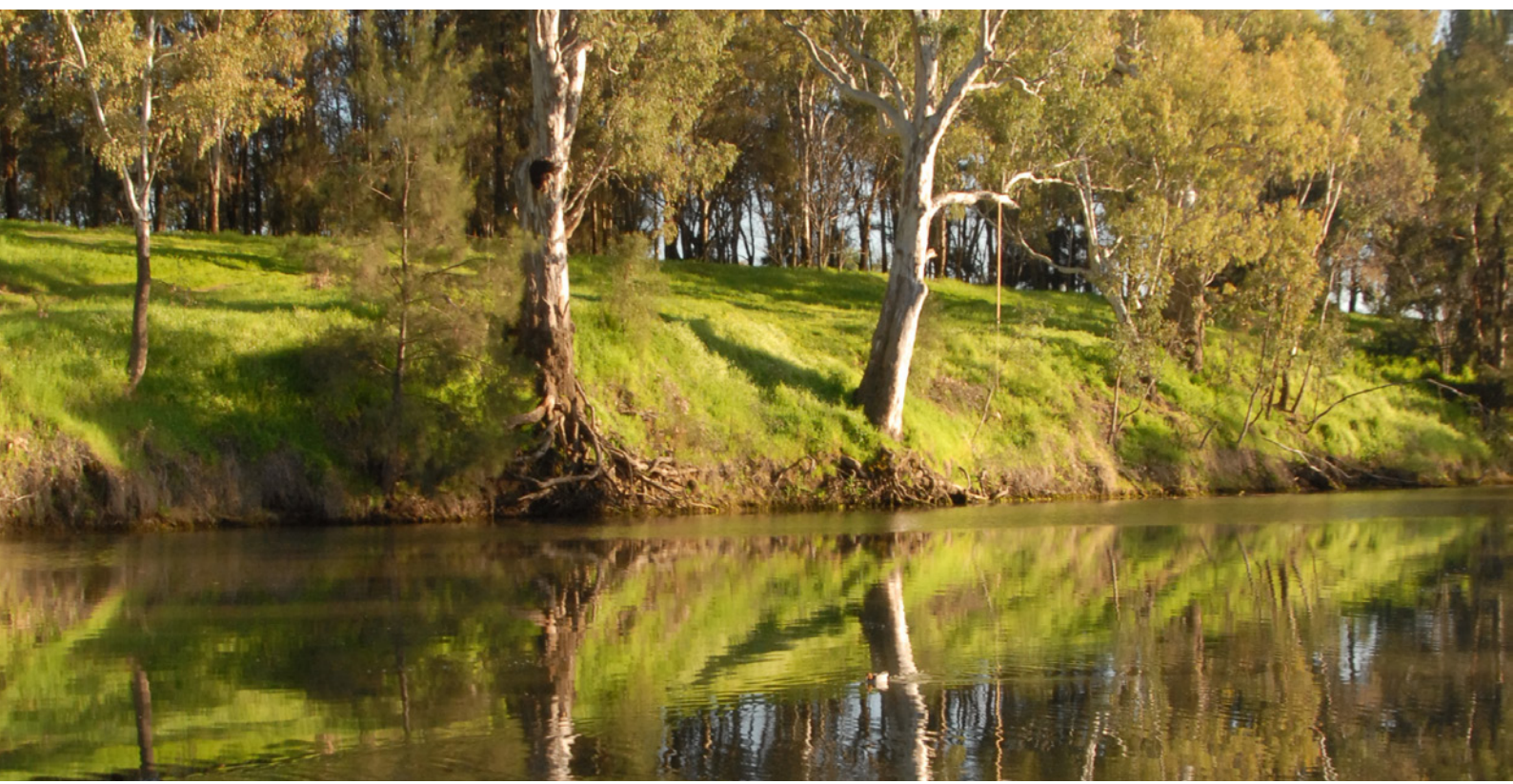
Other potential sources of held environmental water that may be used to complement Commonwealth environmental water delivery in the Macquarie River Valley include:

- General Security (New South Wales Office of Environment and Heritage)
- Supplementary (New South Wales Office of Environment and Heritage)

## Planned environmental water

In addition to water entitlements held by environmental water holders, environmental demands may also be met via natural or unregulated flows and water provided for the environment under rules in state water plans (referred to as 'planned environmental water').

The Macquarie Water Sharing Plan allocates 160 GL of planned environmental water for use in the Macquarie River Valley. To date, this allocation has largely been used to provide flows to the Macquarie Marshes in conjunction with environmental water entitlements held by the Commonwealth Environmental Water Holder and NSW Riverbank. A further 'environmental translucency' allocation of 10 GL is stored in the Windamere Dam for the Cudgegong system.



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