Department of Planning and Environment

NSW Border Rivers Long Term Water Plan Parts A and B

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Acknowledgement of Traditional Owners

The Department of Planning and Environment pays its respects to the Traditional Owners and their Nations of the Murray–Darling Basin. The contributions of earlier generations, including the Elders, who have fought for their rights in natural resource management are valued and respected.

In the NSW Border Rivers catchment, the Department of Planning and Environment pays its respects and acknowledges the Gomeroi (also known as Gamilaraay and the Kamilaroi), Kambuwal, Githabul, Bigambul, Kwiambul and Ngarabal Traditional Owners, past, present and emerging. We recognise their role as custodians of country and the deep cultural connections and spiritual significance of these riverine environments. We look forward to building new and strengthening existing relationships to improve the health of our rivers, wetlands and floodplains.

Figure 1 Barwon River at Mungindi
Photo: E Wilson

Summary

Rivers, creeks, wetlands and floodplains play a vital role in sustaining healthy communities and economies. They provide productivity and connections across the landscape for people, plants and animals with benefits that extend well beyond the riverbank and floodplains.

Over the past 200 years, many rivers, wetlands and floodplains in New South Wales (NSW) have had their natural flow regimes disrupted because of dams, weirs, floodplain development, and water regulation and extraction. This includes changes to low flows, which are vital to the survival and condition of aquatic biota.

The NSW Border Rivers Long Term Water Plan (LTWP) is an important step to describing the flow regimes required to maintain or improve environmental outcomes in the NSW Border Rivers. The plan identifies water management strategies for maintaining and improving the long-term health of the NSW Border Rivers riverine and floodplain environmental assets and the ecological functions they perform. This includes detailed descriptions of ecologically important river flows and risks to water for the environment.

Importantly, the LTWP does not prescribe how environmental water should be managed in the future but looks at management of all water to promote environmental outcomes in the catchment. The LTWP will help water managers make decisions about where, when and how water can be used to achieve agreed long-term ecological objectives. This recognises that the Murray–Darling Basin Plan (Basin Plan) (MDBA 2012a) specifically requires environmental water managers to act adaptively by making timely decisions based on the best-available knowledge, and from monitoring and evaluating the outcomes of water use.

Background to Long Term Water Plans

The Basin Plan (Chapter 8, part 4) establishes a framework for managing environmental water at the Basin and catchment scale. The framework is designed to ensure environmental water managers work collaboratively to prioritise water use to meet the long-term needs of native fish, water-dependent native vegetation and waterbirds whilst coordinating water use across multiple catchments to achieve Basin-scale outcomes.

The Basin-wide environmental watering strategy (BWS) (MDBA 2014) and LTWPs are central features of this framework. The BWS establishes long-term environmental outcomes and targets for the whole Basin and its catchments. LTWPs, which apply to catchment-scale water resource plan areas (WRPAs), must contribute to the achievement of the BWS by identifying:

- priority environmental assets and functions in a WRPA
- ecological objectives and ecological targets for those assets and functions
- environmental water requirements (EWRs) needed to meet those targets and achieve the objectives.

Water resource plans (WRPs) must have regard to LTWPs.

The NSW Border Rivers Long Term Water Plan

The NSW Border Rivers LTWP is one of 9 plans being developed by the Department of Planning and Environment, Biodiversity and Conservation Division (DPE–BC) to cover the NSW portion of the Murray–Darling Basin. Development of the LTWP has involved 6 main steps:

1. undertaking a comprehensive **stocktake** of water-dependent native fish, birds and plant species and the river processes that underpin a healthy river system across the catchment to identify priority environmental assets and priority ecosystem functions
2. determining specific and quantifiable **objectives and targets** for the priority assets and functions in the NSW Border Rivers catchment
3. determining the **environmental water requirements** (including volume, frequency, timing and duration) needed to sustain and improve the health and/or extent of priority environmental assets and ecosystem functions
4. identifying the **risks and constraints** to meeting the long-term water requirements of priority environmental assets and ecosystem functions
5. identifying potential **management strategies** to meet environmental water requirements
6. identifying **complementary investments** to address the **risks and constraints** to meeting the long-term water requirements of priority environmental assets and ecosystem functions.

This LTWP presents this information in 9 chapters in 2 parts, with appendices.

Environmental values of the NSW Border Rivers catchment

The NSW Border Rivers catchment supports a range of water-dependent ecosystems, including instream aquatic habitats, riparian forests, and floodplain watercourses, woodlands and wetlands. Notably, the Morella Watercourse/Boobera Lagoon/Pungbougal Lagoon complex is nationally recognised in the Directory of Important Wetlands (Environment Australia 2001). These ecosystems benefit many water-dependent species, including state and federally listed threatened ecological communities (TECs), threatened, endangered and migratory waterbirds, and threatened native fish species, by providing habitat and food resources.

The ecological condition of the NSW Border Rivers water-dependent environmental assets is largely driven by flows that connect the instream benches, cut-off channels, anabranches, floodplains and wetlands. Flows that provide these connections support organic carbon transfer and nutrient cycling, trigger movement and breeding of native fish and waterbirds, and directly impact vegetation condition and habitat availability.

Information to support this LTWP was sourced from local, traditional and scientific sources – collected in partnership with water managers, natural resource managers and experts, and environmental water holders. Information about the NSW Border Rivers environmental values closely aligns with material in DPE’s *NSW Border Rivers Surface Water Resource Plan – Risk Assessment* (DPIE–Water 2019a).

Water for the environment

The NSW Border Rivers LTWP contains ecological objectives and targets for priority environmental assets and ecosystem functions in the NSW Border Rivers catchment. Priorities are defined by the Basin Plan as those assets and functions that can be managed with planned and held environmental water. The objectives and targets have been identified for native fish, native vegetation, waterbirds and ecosystem functions. As noted in the BWS, each of these themes is a good indicator of river and wetland health and is responsive to flow.

The objectives express the current understanding of environmental outcomes that might be expected from implementation of the Basin Plan in the rivers, wetlands, floodplains and watercourses of the NSW Border Rivers. The targets for each ecological objective provide a transparent means of evaluating progress towards their achievement and the long-term success of management strategies.

Table 1 Summary of the environmental outcomes sought in the NSW Border Rivers

Broad outcomes	Overarching objectives	Example uses of water for the environment to achieve LTWP outcomes and objectives
Maintain the diversity and improve the population of native fish in the catchment	Increase native fish distribution and abundance, and ensure stable population structures	• Ongoing use of the Stimulus Flow to boost productivity and, where possible, promote spawning • In dry times, replenish refuge waterholes for native fish to increase chances of fish survival
Maintain the extent and improve the health of water-dependent native vegetation and wetlands	Maintain and improve the viability and extent of river red gum, black box and coolibah communities, lignum shrublands and non-woody wetland vegetation	• Limit any reduction in flood size, frequency and changes to flow paths
Maintain the diversity of waterbird species and increase their numbers across the catchment	Restore habitat for waterbirds to contribute to recovery of waterbird populations across the Murray–Darling Basin	• Maintain connection and disconnection of anabranches • Coordinate consumptive flows and held environmental water (HEW) releases to meet EWRs at higher flow categories
Improve connections along rivers and between rivers and their floodplains for improved river system health	Improve ecosystem functioning to provide healthy ecosystems capable of supporting native biota	• Maintain connection and disconnection of anabranches • Coordinate consumptive flows and HEW releases to meet a variety of EWRs at different magnitudes to mimic natural flow regimes

Management strategies and complementary investments

There are complementary measures that may be required to ensure the LTWP's objectives and targets are achieved (see Chapter 7). These include addressing cold water pollution caused by water releases from Pindari and Glenlyon dams, addressing major barriers to fish movement, providing incentives to landholders to conserve riparian, wetland and floodplain vegetation, and screening irrigation pumps to protect fish.

Currently, many in-channel EWRs are being met by consumptive flows. There is potential to achieve additional EWRs from cooperative and coordinated river operations. It will be necessary to coordinate the use of held environmental water (HEW) with planned environmental water (PEW) and consumptive flows to maximise environmental efficiency and enable the best possible achievement of EWRs.

In addition, in the Border Rivers there is PEW committed through intergovernmental agreement with Queensland and the Border Rivers Commission (BRC) (DPI 2008). This includes an uncontrolled flow target at Mungindi of 100 ML/day between 1 September and 31 March. Coordination among water managers is required to ensure this flow target is not met by HEW, to avoid held water substituting for the PEW.

Monitoring and evaluation of the Long Term Water Plan

Over the 20-year duration of this LTWP, NSW and Commonwealth agencies will, where possible and funded, undertake monitoring of the health of rivers, wetlands and floodplains within the NSW Border Rivers to:

- monitor and demonstrate progress towards the objectives and targets identified in the LTWP
- inform and support the management of environmental water
- provide early information to test the assumptions and conditions that underpin the plan.

Review and update of the LTWP

As knowledge and evidence of ecological processes in the Border Rivers improves, it may be necessary to review and update the LTWP. To ensure the information in this LTWP remains relevant and up-to-date, this plan will be reviewed and updated no later than 5 years after it is first published. Additional reviews may also be triggered by:

- accreditation or amendment to the water sharing plan (WSP) or WRP for the NSW Border Rivers catchment
- revision of the BWS that materially affects this LTWP
- a sustainable diversion limit (SDL) adjustment
- new information arising from evaluating responses to environmental watering
- new knowledge about the water-dependent cultural values and assets of the catchment
- new knowledge about the ecology of the catchment that is relevant to environmental watering
- improved understanding of the effects of climate change and its impacts on the catchment, EWRs and water management
- changes to the river operating environment or the removal of constraints that affect watering strategies
- material changes to river and wetland health, not considered within this LTWP.

PART A: NSW Border Rivers catchment

1. Introduction

The Border Rivers catchment straddles NSW and QLD. It has a total area of approximately 49,500 km^2, with 24,500 km^2 in NSW (Green et al. 2012). The NSW Border Rivers catchment stretches east to west between the western slopes of the Great Dividing Range across to the township of Mungindi. Major townships in the region include Inverell, Glen Innes, Tenterfield and the cross-border communities of Goondiwindi and Mungindi.

Water storages in the Border Rivers catchment include Glenlyon Dam on Pikes Creek (QLD), Coolmunda Dam on Macintyre Brook (QLD) and Pindari Dam on the Severn River (NSW). Major tributaries include Tenterfield Creek in NSW and the QLD Severn River, which merge to become the Dumaresq River. The NSW Severn River joins the Macintyre River below Pindari Dam, which links to the Dumaresq River upstream of Goondiwindi. A map of the catchment is shown in Figure 4.

Downstream, the catchment is characterised by numerous anabranches and distributary channels including the Boomi River and Whalan Creek. The Macintyre River continues its cross-country journey, meeting the Weir River and becoming the Barwon River, north-east of Mungindi.

Characterised by its many waterholes, billabongs and wetlands, the NSW Border Rivers catchment supports the iconic Murray cod and 15 other species of native fish. The threatened purple-spotted gudgeon, silver perch and eel-tailed catfish have all been recorded in the catchment (DPI 2015a).

The various wetlands and waterholes also support internationally and nationally significant waterbirds including brolgas, bar-tailed godwit, black-necked stork and magpie geese. The aquatic community of the NSW Border Rivers forms part of the endangered ecological community (EEC) known as the *Aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River*.

Remnant native vegetation in the tablelands to the east of the catchment includes New England grassy woodlands and Northern Tableland dry sclerophyll forests. The vegetation communities on the slopes of the middle catchment are remnants of large expanses of forest and woodland, with grassy white-box woodlands, kurrajong, cypress pine, Blakely's red gum, yellow box and silver ironbark. In these areas of less disturbed vegetation, there are significant cultural heritage sites.

To the west on the floodplains, extensive areas have been cleared for agriculture. Remnants of coolibah floodplain woodlands remain, with occasional myall woodlands, and whitewood and belah woodlands with lignum and mimosa. The western plains once supported significant areas of Mitchell and plains grass communities; however, these are now greatly reduced.

Threatened ecological communities (TECs) found in the catchment include McKies Stringybark Blackbutt Open Forest, New England Peppermint Woodland, White Box Yellow Box Blakely's Red Gum Woodland, Coolibah-Black Box Woodlands, Carbeen Open Forest, Myall Woodland and Inland Grey Box Woodland.

Traditional owners have longstanding and continuing ties to country and hold the many billabongs/Warrambool along the rivers in this catchment in high regard. Of particular importance is the Morella Watercourse/Boobera Lagoon/Pungbougal Lagoon complex, with Boobera Lagoon having special cultural significance. Aboriginal nations and communities in the region include the Kamilaroi/Gomeroi, Kambuwal, Githabul, Bigambul, Kwiambul and Ngarabal groups.

River flows in the NSW Border Rivers, like many Murray–Darling Basin catchments, have been altered by headwater dams, weirs, river and creek modifications, and large-scale irrigation development of the floodplain. With the development of large-scale irrigation industries, patterns and total volumes of flows, as well as the regularity of small to moderate-sized events have reduced. Plans and rules have been developed that specify how water is to be shared between users and the environment. The condition of the catchment's riverine and floodplain ecosystems, and the plants and animals they support, has declined considerably because of development.

Figure 2 Upper Macintyre River
Photo: M Miles

1.1 Approach to developing the NSW Border Rivers Long Term Water Plan

The NSW Border Rivers LTWP applies to the NSW Border Rivers surface water resource plan area (WRPA) and is one of 9 catchment-based plans covering the NSW portion of the Murray–Darling Basin. The LTWP has been developed to be consistent with the requirements of the Basin Plan (MDBA 2012a).

The NSW Border Rivers LTWP is the product of best-available information and engagement with water managers, natural resource managers, environmental water holders and community members. It draws together local, traditional and scientific knowledge to identify the catchment's priority environmental assets and ecosystem functions to guide the management of water to protect and restore condition over the long term.

Development of the NSW Border Rivers LTWP has involved 6 main steps:

1. undertaking a comprehensive **stocktake** of water-dependent native fish, birds and plant species and the river processes that underpin a healthy river system across the catchment to identify priority environmental assets and priority ecosystem functions
2. determining specific and quantifiable **objectives and targets** for the priority assets and functions in the NSW Border Rivers catchment
3. determining the **environmental water requirements** (including volume, frequency, timing and duration) needed to sustain and improve the health and/or extent of priority environmental assets and ecosystem functions
4. identifying the **risks and constraints** to meeting the long-term water requirements of priority environmental assets and ecosystem functions
5. identifying potential **management strategies** to meet environmental water requirements
6. identifying **complementary investments** to address the **risks and constraints** of meeting the long-term water requirements of priority environmental assets and ecosystem functions.

1.1.1 Implementing the Long Term Water Plan

Implementation of the LTWP requires strong partnerships and coordination between all land managers and water users. The LTWP provides the foundation to support future coordination efforts by:

- informing and guiding annual and longer-term water management deliberations and planning by the Department of Planning, Industry and Environment – Biodiversity and Conservation Division (DPE–BC) and the Commonwealth Environmental Water Office (CEWO)
- informing planning processes that influence river and wetland health outcomes, including development of WSPs and WRPs
- identifying opportunities for more strategic river operations and strengthening collaboration between holders of environmental water
- helping target investment priorities for complementary actions that will effectively contribute to progressing the outcomes sought by this LTWP
- building broad community understanding of river and wetland health issues.

1.2 The Long Term Water Plan document structure

The NSW Border Rivers LTWP is presented in 9 chapters with accompanying appendices. It is divided into Part A (catchment-scale information) and Part B (planning unit-scale specifics, including localised EWRs).

Part A: The whole NSW Border Rivers catchment

- **Chapter 1** explains the background and purpose of the LTWP.
- **Chapters 2** and **3** identify the NSW Border Rivers water-dependent environmental assets and ecosystem functions, and articulate the environmental outcomes that are expected from implementation of the LTWP through ecological objectives and targets.
- **Chapter 4** describes the EWRs needed to achieve the ecological objectives over the next 5, 10 and 20 years.
- **Chapter 5** describes the risks and constraints that may limit water managers' capacity to achieve the EWRs and their associated ecological objectives in the NSW Border Rivers. This chapter also outlines potential management strategies.

- **Chapter 6** identifies the possible ways to use HEW and PEW, and other system flows that support flow regimes, to meet the EWRs of the Border Rivers NSW environmental assets under different water resource availability scenarios (RAS).
- **Chapter 7** outlines the workplan going forward to progress towards the objectives. This includes potential cooperative arrangements between government agencies.

Part B: NSW Border Rivers planning units

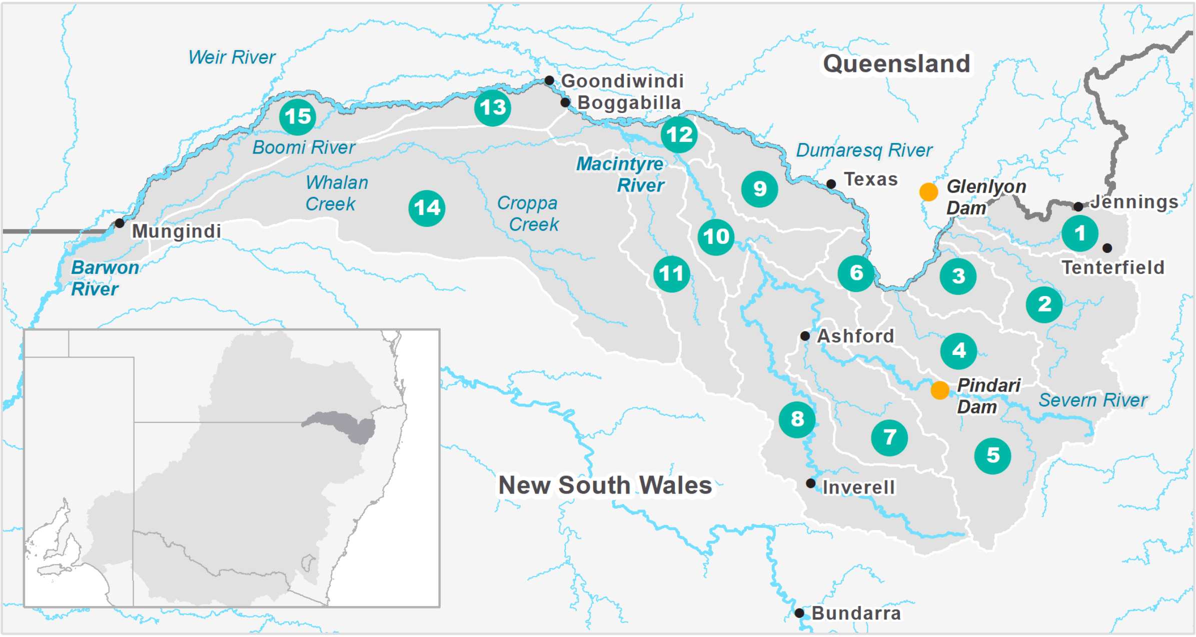
- **Chapter 8** introduces Part B of the LTWP and the planning unit-scale specifics provided in this section.
- **Chapter 9** presents the detail of the LTWP at a finer scale of management areas and planning units. This includes a summary of the priority environmental assets and values each planning unit supports, and EWRs with flow rates attributed to specific gauges.

Appendices

- **Appendix A** details the ecological objectives relevant to each planning unit.
- **Appendix B** provides further details on the relevance of RAS to water management decision-making.
- **Appendix C** collates data on environmental assets across the catchment.

Figure 3 Lemon Tree Flat, Severn River
Photo: N Foster

1.3 Planning units



Legend

Planning Units

0 35 70
Kilometers

Planning Units

1. Tenterfield Creek
2. Mole River
3. Reedy Creek
4. Beardy River
5. Glenn Innes
6. Bonshaw
7. Kings Plains
8. Inverell
9. Campbells and Camp Creeks
10. Yetman Creek
11. Ottleys Creek
12. Confluence of Macintyre River and Dumaresq River
13. Macintyre River floodplain upstream of Boomi River
14. Whalan & Croppa Creeks Subcatchment
15. Macintyre River & Boomi River floodplain

Figure 4 NSW Border Rivers showing the location of planning units in the LTWP

The planning units shown in Figure 4 are referred to in most chapters. The planning units in the NSW Border Rivers were derived from water sources in the 2012 *Water Sharing Plan for the NSW Border Rivers Unregulated and Alluvial Water Sources*. A few adjustments were made for the purpose of the LTWP to reflect various features of river operations and the landscape. The end result is planning units that are relatively uniform within, with boundaries that recognise ecologically relevant differences to other planning units:

- Campbells Creek and Camp Creek water sources have been merged as there is only one gauge within this section on which to set EWRs
- the Ottleys Creek water source has been split to recognise the aquatic differences between the Macintyre and Dumaresq rivers in the lower northern part from the more ephemeral nature of Ottleys Creek. NSW (Mitchell) landscapes (Mitchell 2002) were used to identify a relevant boundary
- a number of new planning units were created downstream of the junction between the Macintyre and Dumaresq rivers:

- planning unit 14 – Whalan Creek and Croppa Creek sub-catchment distinguishes the unregulated and ephemeral Croppa and Whalan creeks from the Macintyre and Boomi rivers. The trade boundary in the unregulated WSP was adopted
- the division created above Terrewah on the Macintyre River to form planning units 13 – Macintyre River floodplain upstream of Boomi River, and 15 – Macintyre River and Boomi River floodplain, recognises the change in the geomorphology of the river channel that occurs in this section of river. NSW (Mitchell) landscapes were again used to identify a relevant boundary.

Figure 5 Dumaresq River from Bonshaw Weir
Photo: L Cameron and J St Vincent-Welch

2. Environmental assets of the NSW Border Rivers

The NSW Border Rivers catchment supports a variety of water-dependent ecosystems, including instream aquatic habitats, riparian forests, and floodplain woodlands and wetlands. These ecosystems are located throughout the catchment and each has its own water requirements depending on the plants, animals and ecosystem functions it contains.

2.1 Priority environmental assets in the NSW Border Rivers

In addition to the assets identified in the BWS, Schedule 8 of the Basin Plan outlines criteria for identifying water-dependent ecosystems that should be recognised as environmental assets in the Murray–Darling Basin. The criteria are designed to identify water-dependent ecosystems that are internationally important, natural or near-natural, provide vital habitat for native water-dependent biota, and/or can support threatened species, TECs or significant biodiversity.

The water-dependent ecosystems in NSW Border Rivers were assessed against the Schedule 8 criteria. Significant Aboriginal water-dependent cultural sites, such as Aboriginal ceremony and dreaming sites, fish traps, scar trees, and waterholes that are registered in the Aboriginal Heritage Information Management System (AHIMS) were also included as water-dependent assets in the LTWP. Results of the assessment are presented in Figure 7.

Priority environmental assets in LTWPs are the assets that have been identified using Schedule 8 criteria that can be managed through NSW's PEW, NSW's and CEWO's HEW, and/or through implementation of the WSP rules. Priority environmental assets may be, for example, a reach of river channel and its floodplain features at a geographic location, or a wetland complex or anabranch.

Figure 6 Macintyre river at Yetman February 2021
Photo: D Preston

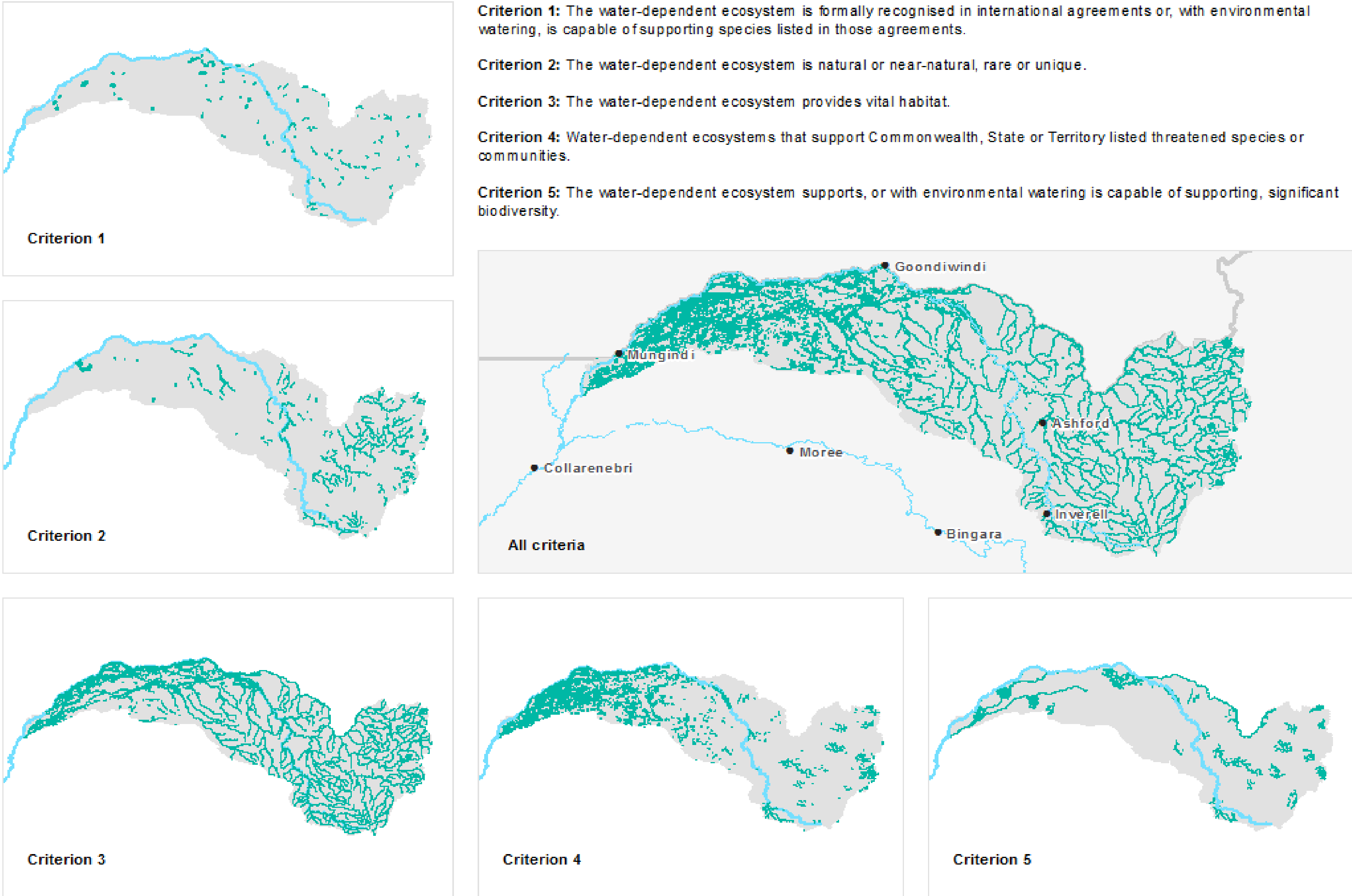


Figure 7 Five criteria for identification of environmental assets applied to NSW Border Rivers

3. Ecological objectives and targets

Ecological objectives and targets have been established for priority environmental assets and values in the NSW Border Rivers (sections 3.1–3.4). Consistent with the BWS (MDBA 2014), the objectives are grouped into 4 themes: native fish, native vegetation, waterbirds and ecosystem functions. The water requirements of indicator species, or functional groups of species or ecosystem functions within each theme are also representative of those needed by other water-dependent species such as frogs and turtles. Achievement of the objectives will also contribute to the landscape and Basin-scale environmental outcomes sought by the BWS, and benefit other water-dependent species.

The 5, 10 and 20-year targets for each ecological objective provide a transparent means of evaluating progress towards their achievement and the long-term success of the LTWP's management strategies and their implementation. If met, the targets will indicate that the environment is responding positively to water management. Failure to meet targets should trigger reassessment of the related flow regime and whether the LTWP is being implemented as intended, to determine if changes are needed. It is important to note that the 20-year targets in the LTWP assume the relaxation or removal of constraints to allow more flexibility in water delivery.

The ecological objectives for the NSW Border Rivers as they relate to individual planning units are listed in Appendix A.

3.1 Native fish values and objectives

The fish community of the NSW Border Rivers includes up to 16 native species recorded or expected to occur (including flat-headed gudgeon) and up to 5 alien species (DPI 2015a). In general, the NSW Border Rivers fish community is rated in moderate condition with some rivers such as the Dumaresq, mid-lower Macintyre, Boomi and Upper Barwon, and Whalan Creek rated as good. Other waterways – Tenterfield Creek, Deepwater River, upstream reaches of the Severn River, upper Macintyre and some tributaries of Whalan Creek – are rated as being in poor condition (see Figure 8).

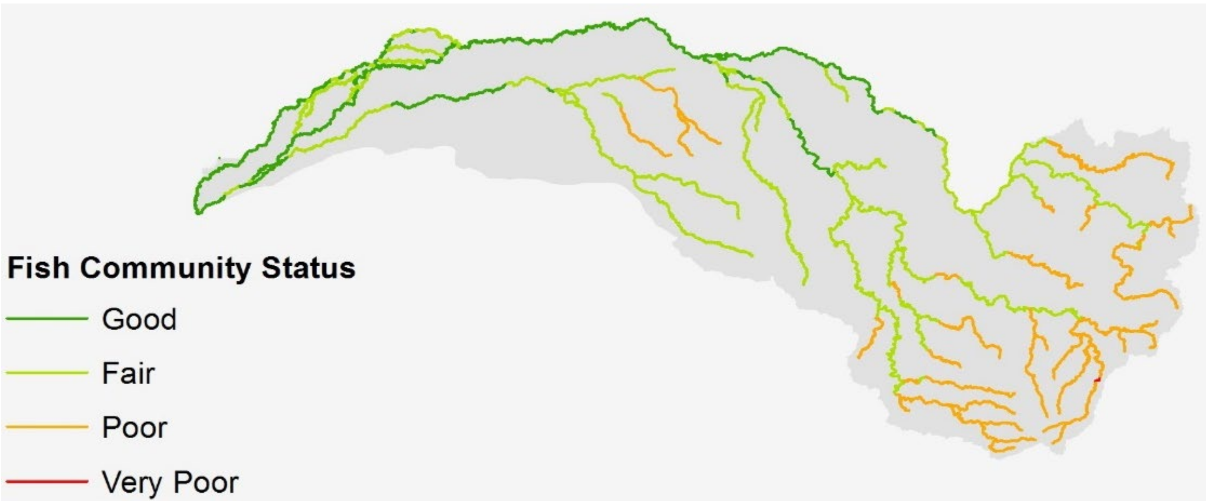


Figure 8 The current status of fish communities in NSW Border Rivers (DPI 2016b)

Priority drought refuge sites are located along the Severn and Dumaresq rivers with these sites known to support purple-spotted gudgeon, mountain galaxias, river blackfish, silver perch, olive perchlet, freshwater catfish, Murray cod, and unspecked hardyhead (McNeil et al. 2013). In addition, the BWS (MDBA 2014) has identified 3 key rivers in the Border Rivers as important environmental assets for native fish:

- Barwon–Darling River (Menindee to Mungindi) – values include 'key movement corridor', 'high biodiversity', 'key site of hydrodynamic diversity', 'threatened species' and 'dry spell/drought refuge'
- Macintyre River – Mungindi to Severn in NSW – values include 'key movement corridor', 'high biodiversity', 'key site of hydrodynamic diversity', 'threatened species' and 'dry spell/drought refuge'
- Severn River within Sundown National Park – values include 'high biodiversity', 'key site of hydrodynamic diversity', 'threatened species' and 'dry spell/drought refuge'.

Other important assets in the Border Rivers include large areas of aquatic habitat – large woody debris and fallen timber on bench platforms and inset floodplain areas – along the Macintyre, Weir, Boomi and Barwon river reaches downstream of Goondiwindi (Boys 2007; MDBA 2012b). The Dumaresq River supports large aggregations of aquatic macrophytes providing considerable habitat for native fish (DoE 2016). Below Pindari Dam, the NSW Severn River sustains high fish diversity and provides good quality refuges for native fish (DoE 2016).

Four of the NSW Border Rivers native fish species are listed as vulnerable, threatened or endangered in NSW Murray–Darling Basin waters under the *Fisheries Management Act 1994* (FM Act). These include the purple-spotted gudgeon, freshwater catfish, olive perchlet and silver perch, with the indicative distribution of these species shown in Figure 10 (for detail on the method used, see DPI 2016a). In addition, the Darling River snail is listed as critically endangered. Parts of the NSW Border Rivers and its associated aquatic biota, including parts of the Macintyre River, Severn River and the Dumaresq River have also been listed under the FM Act as part of the Lower Darling EEC.

Figure 9 Purple-spotted gudgeon and freshwater catfish
Photos: G Schmida

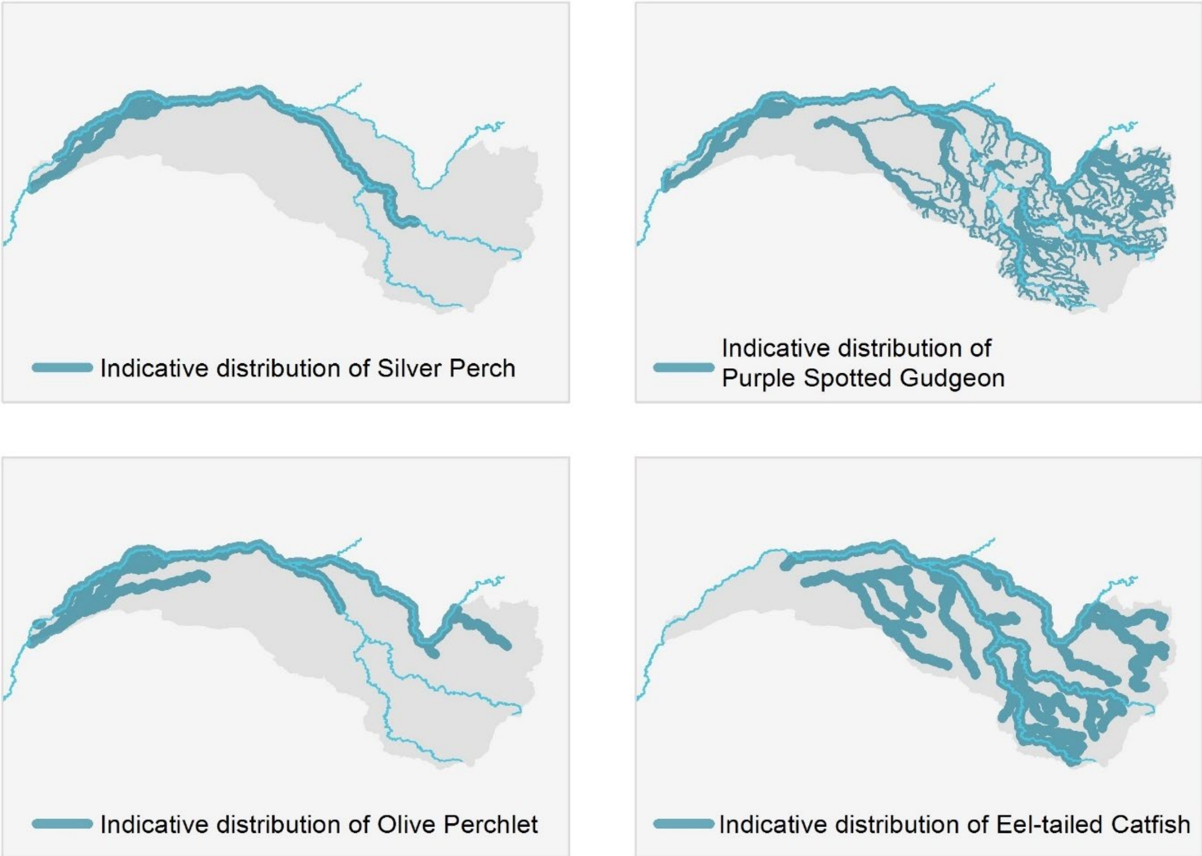


Figure 10 Maps of indicative distribution of 4 key native fish species in the NSW Border Rivers (DPI 2016b)

Table 2 Native fish (NF) ecological objectives and targets

Ecological objectives		Target fish species	Targets 5 years (2024)	Targets 10 years (2029)	Targets 20 years (2039)
NF1	No loss of native fish species	All recorded fish species	All known species detected annually		
				Fish community status improved by one category compared to 2014 assessment[1]	
NF2	Increase the distribution and abundance of short to moderate-lived generalist native fish species	Australian smelt, carp gudgeon, western carp gudgeon, bony herring, Murray–Darling rainbowfish, unspecked hardyhead	Increased distribution and abundance of short to moderate-lived species compared to 2014 assessment No more than one year without detection of immature fish (short-lived) No more than 2 years without detection of immature fish (moderate-lived species)		
NF3	Increase the distribution and abundance of short to moderate-lived floodplain specialist native fish species	Olive perchlet[2]			
NF4	Improve native fish population structure for moderate to long-lived flow pulse specialist native fish species	Golden perch, silver perch, spangled perch	Juvenile and adult fish detected annually No more than 2 consecutive years without recruitment in moderate-lived species No more than 4 consecutive years without recruitment in long-lived species		
			Minimum of 1 significant recruitment event in 5 years[3]	Minimum of 2 significant recruitment events in 10 years	Minimum of 4 significant recruitment events in 20 years

[1] Assessment of fish abundance and distribution pre-2014, aligned with the BWS and DPI 2016a

[2] Purple-spotted gudgeon and olive perchlet may occur in both floodplain wetlands and in-channel (riverine lentic). EWRs should be managed to cater for these species in both habitats in accordance with species distributions and riverine/floodplain characteristics.

[3] Young-of-year comprise more than 30% of the population

Ecological objectives		Target fish species	Targets		
			5 years (2024)	10 years (2029)	20 years (2039)
NF5	Improve native fish population structure for moderate to long-lived riverine specialist native fish species	Murray cod, river blackfish, freshwater catfish, purple-spotted gudgeon[2]	Juvenile and adult fish detected annually No more than 2 consecutive years without recruitment in moderate-lived species No more than 4 consecutive years without recruitment in long-lived species		
			Minimum of 1 significant recruitment event in 5 years[4]	Minimum of 2 significant recruitment events in 10 years	Minimum of 4 significant recruitment events in 20 years
NF6	A 25% increase in abundance of mature (harvestable-sized) golden perch and Murray cod	Golden perch, Murray cod	Length–frequency distributions include size classes of legal take size for golden perch and Murray cod 25% increase in abundance of mature golden perch and Murray cod		
NF7	Increase the prevalence and/or expand the population of key short to moderate-lived floodplain specialist native fish species into new areas (within historical range)	Olive perchlet[5]	Adults detected annually in specified planning units No more than 1 year without detection of immature fish in specified planning units (short-lived)		
				Increased distribution and abundance in specified planning units	Increased distribution and abundance in specified planning units
NF8	Increase the prevalence and/or expand the population of key moderate to long-lived riverine specialist native fish species into new areas (within historical range)	Freshwater catfish, purple-spotted gudgeon[5]	Adults detected annually in specified planning units No more than 2 years without detection of immature fish in specified planning units (moderate-lived species) No more than 4 years without detection of immature fish in specified planning units (long-lived species)		
				Increased distribution and abundance in specified planning units	Increased distribution and abundance in specified planning units

[4] Young-of-year comprise more than 30% of the population
[5] Purple-spotted gudgeon and olive perchlet may be considered either floodplain specialists or riverine specialists depending on geographical location.

3.2 Native vegetation values and objectives

The NSW Border Rivers catchment supports a range of water-dependant vegetation communities. River red gum is found throughout the catchment in areas closely fringing the main river channels and many of the tributaries. The total area of river red gum is approximately 30,000 ha (OEH 2015). Black box and coolibah are generally limited to the lower floodplain. Black box (approximately 400 ha) occurs in the Macintyre River and Boomi River floodplain planning unit while more extensive areas of coolibah (600,000 ha in total) occur throughout the lower part of the catchment from the confluence of the Dumaresq and Macintyre rivers to Mungindi and in the Whalan and Croppa creek sub-catchments. Small areas of lignum shrublands (approximately 4,000 ha in total) also occur in the lower part of the catchment and Whalan and Croppa creek sub-catchments (Figure 11).

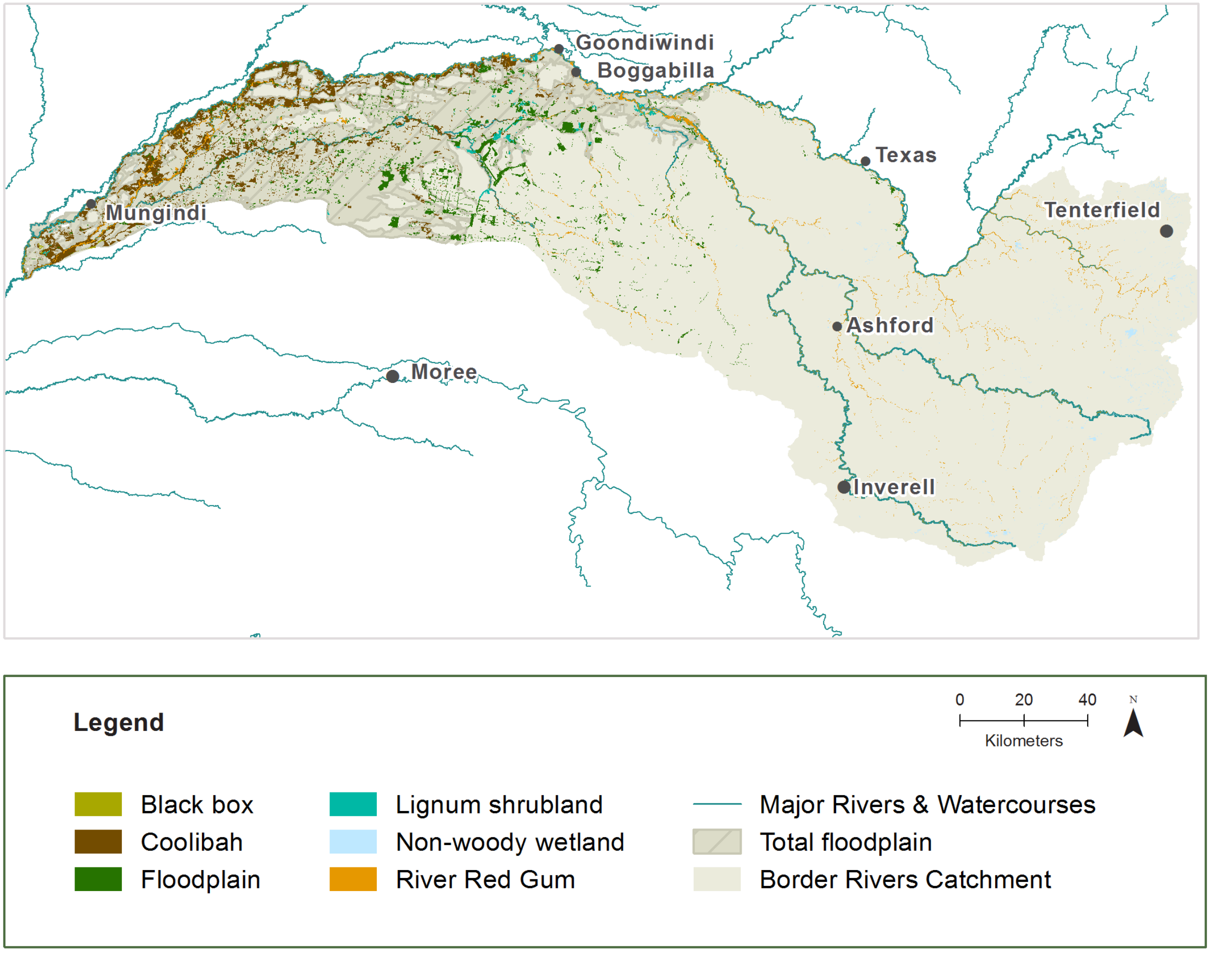


Figure 11 Map of native vegetation assets in the NSW Border Rivers (compiled by DPIE in 2016 based on OEH 2015)

The availability of water across the landscape affects plant germination, survival and reproduction, and ultimately influences the position of species in the landscape (Casanova 2015). The native vegetation species and communities identified by the BWS have been grouped based on their watering requirements and their position and extent on the floodplain. In the NSW Border Rivers, river red gum is predominantly found in riparian zones and requires more frequent watering. Coolibah and black box remnants can be found on the floodplain and require less frequent surface water to maintain condition and extent (Roberts and Marston 2011; Casanova 2015). Across these patches of remnant vegetation there is also a gradient of vegetation condition, often related to the frequency of inundation across landscape components, with vegetation closer to the river channels having more frequent access to water and generally being in better condition. Flooding is often required for recruitment of floodplain communities (Roberts and Marston 2011; Casanova 2015).

It may not be possible to increase the extent of woody vegetation due to agricultural land development. The objectives and targets of this plan aim to maintain the current extent. This requires native vegetation of good condition to limit tree mortality and will require recruitment to replace any losses.

Objectives and targets for within channel vegetation, lignum shrublands and non-woody wetland recognise the ongoing need for vegetative growth and regular seed setting to ensure ongoing population viability of these short-lived species (Roberts and Marston 2011; Casanova 2015).

Figure 12 Macintyre River at Holdfast
Photo: N Foster

Table 3 Native vegetation (NV) ecological objectives and targets

Ecological objectives		Targets: 5 years (2024)	Targets: 10 years (2029)	Targets: 20 years (2039)
NV1	Maintain the extent and viability of non-woody vegetation communities occurring within channels	Increase the cover of non-woody, inundation-dependent vegetation within or closely fringing river channels following inundation events		
NV2	Maintain or increase the extent and maintain the viability of non-woody vegetation communities occurring in wetlands and on floodplains	Over a 5-year rolling period, water couch and marsh club-rush to flower and set seed at least 2 years in 5 Maintain the total area of non-woody wetland vegetation communities occurring on actively managed floodplains and floodplains influenced by PEW[6]		
NV3	Maintain the extent and improve the condition of river red gum communities closely fringing river channels	Maintain the 2016 mapped extent[7] of river red gum woodland communities closely fringing river channels		
		Over a 5-year rolling period: • maintain the extent and proportion of river red gum communities closely fringing river channels that are in moderate or good condition[8] • no further decline in the condition of river red gum communities closely fringing river channels that are in poor or degraded condition		Over a 5-year rolling period: • increase the proportion of river red gum communities closely fringing river channels that are in moderate or good condition • improve the condition score of river red gum communities closely fringing river channels that are in poor, degraded or severely degraded condition by at least one condition score

[6] Unregulated areas where river flows and off-channel pools are protected by the Water Sharing Plan for the NSW Border Rivers Unregulated and Alluvial Water Sources 2012

[7] Extent based on compiled native vegetation plant community type (PCT) mapping. Map compiled by DPIE from best-available PCT mapping as at 2016 (State Vegetation Type Map for the Border Rivers, Gwydir and Namoi region, OEH 2015)

[8] Condition score according to the MDBA Stand Condition tool (Cunningham et al. 2009)

Ecological objectives			Targets		
			5 years (2024)	10 years (2029)	20 years (2039)
NV4a	Maintain or increase the extent and maintain or improve the condition of native woodland and shrubland communities on floodplains	River red gum forest	Maintain the 2016 extent of river red gum forest		
NV4b		River red gum woodland	Over a 5-year rolling period: • maintain the extent and proportion of woodlands and shrublands in moderate or good condition • no further decline in the condition of woodlands and shrublands in poor or degraded condition • increase the abundance of woodland seedlings and saplings in degraded communities on the actively managed floodplain		Over a 5-year rolling period: • increase the proportion of woodlands and shrublands in moderate or good condition • improve the condition score of woodlands and shrublands in poor, degraded or severely degraded condition by at least one condition score Support successful recruitment of trees in the long term by increasing the abundance of young adult trees (10–30 cm diameter at breast height) compared to the previous 10-year period
NV4c		Black box woodland			
NV4d		Coolibah woodland			
NV4e		Lignum shrublands	Maintain the 2016 extent of lignum shrubland communities		Increase the total area of lignum shrublands occurring within the actively managed floodplain by 10%

3.3 Waterbird values and objectives

Waterbirds are useful indicators of the health of water-dependent ecosystems (Amat and Green 2010). In the 30 years to 2012, annual waterbird surveys revealed a 72% decline in average waterbird abundance in the Murray–Darling Basin (MDBA 2014). This is a critical observation because waterbirds are an important indicator of wetland health as their abundance and diversity are related to the total area of wetland available, the health of wetland vegetation and the abundance of food resources; for example, microcrustacea, fish and aquatic vegetation (Kingsford 1999). Wetlands in good condition with vegetation in good health, and a variety of habitats with varying water depths, tend to support the greatest diversity of waterbird species and highest waterbird abundance (Kingsford and Norman 2002).

Waterbirds are a group of highly mobile species and can respond to flows over large spatial scales (Kingsford and Norman 2002; Amat and Green 2010). Improvements in waterbird populations across the Murray–Darling Basin is one of the main ecological objectives of the Basin Plan. With more water available for the environment through the Basin Plan, increases in frequency, duration and extent of inundation of wetland areas are expected to provide more habitat for waterbirds and other water-dependent species (MDBA 2014).

Sixty-one waterbird species have been recorded in the NSW Border Rivers (ALA 2017; DPIE 2017; Porter et al. 2016), including 6 threatened species and 8 species protected under international agreements (Table 4). Overall, there is limited waterbird monitoring in the NSW Border Rivers.

Table 4 Waterbird species in the NSW Border Rivers listed as threatened or protected under international agreements

Functional waterbird group	Species and status[9]
Ducks	Blue-billed duck (V), freckled duck (V)
Herbivores	Magpie goose (V)
Large waders	Black-necked stork (E), brolga (V)
Piscivores	Caspian tern (J), white-winged black tern (C, J, K)
Shorebirds	Bar-tailed godwit (C, J, K, CE, V), common greenshank (C, J, K), Latham's snipe (J, K), marsh sandpiper (C, J, K), pectoral sandpiper (J, K), sharp-tailed sandpiper (C, J, K)

More than 100 waterbird species have been recorded in the NSW portion of the Murray–Darling Basin and these species can be split into functional groups that reflect differences in their habitat requirements. The 5 waterbird functional groups described by Bino et al. (2014) and used in the BWS are: ducks and grebes, herbivores, piscivores (fish-eating waterbirds), large waders, and shorebirds (or small waders). Knowledge of the water requirements of different waterbird species informs watering strategies and can be used to evaluate whether these strategies have met the timing, duration and frequency requirements for different waterbird groups. These functional groups are reflected in the objectives and targets in this LTWP and the BWS. In addition, the objectives recognise the differences between colonial and non-colonial waterbirds. Colonial waterbirds gather in large numbers when their breeding and feeding habitats are inundated. Although there are historic records, there are no known current colonial waterbird breeding sites in the NSW Border Rivers and consequently objective WB4 is not included in this LTWP.

[9] V = listed as vulnerable on NSW threatened species list, CE = critically endangered in the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) Act or NSW BC Act, E = endangered in EPBC Act or BC Act, C = CAMBA listed, J = JAMBA listed, K = RoKAMBA listed

The total number of waterbird species and total number of individuals can change rapidly in response to flows, specifically increases in total wetland area and the diversity of wetland habitats inundated. When inundated, floodplain habitats can provide feeding and breeding habitat for a range of waterbird species. Waterbird species richness is greatest when there are varying water depths across a range of wetland types (Taft et al. 2002). This is because there is a mosaic of wetland types with varying water depths that can provide deeper wetlands for fish-eating waterbirds and diving ducks, and vegetated shallower wetlands that provide feeding habitat for dabbling ducks and large waders. Emergent aquatic vegetation on the edge of waterbodies also provides habitat for cryptic crakes, rails and bitterns. As wetlands dry, exposed mudflats can form providing feeding habitat for resident and migratory shorebird species.

Table 5 Waterbird (WB) ecological objectives[10] for NSW Border Rivers

Ecological objectives		Targets		
		5 years (2024)	10 years (2029)	20 years[11] (2039)
WB1	Maintain the number and type of waterbird species	Maintain a 5-year rolling average of 6[12] or more waterbird species in the NSW Border Rivers		
			Identify at least 52 waterbird species in the NSW Border Rivers in a 10-year period	Identify at least 59 waterbird species in the NSW Border Rivers in a 20-year period
WB2	Increase total waterbird abundance across all functional groups	Total abundance of the 5 functional groups maintained in the NSW Border Rivers compared to the 5-year 2012–16 baseline period		
WB3	Increase opportunities for non-colonial waterbird breeding	Total abundance of non-colonial waterbirds in the waterbird area maintained compared to the 5-year 2012–16 baseline period		
WB5	Maintain the extent and improve condition of waterbird habitats	Maintain or increase extent and improve condition of waterbird foraging and breeding locations in the waterbird area (to be evaluated under targets set for native vegetation)		

3.4 Ecosystem function values and objectives

The NSW Border Rivers catchment is comprised of streams and rivers, anabranches with semi-permanent lagoons and wetlands, and floodplain features (DPI 2015a). Within these broad habitat types, niche habitats such as deep channels, pools and riffles, gravel beds, instream benches, snags, aquatic vegetation and riparian vegetation are available to the catchment's aquatic species. Flows that connect within and between these niche habitats can enable biological, geochemical and physical processes that provide ecosystem function, as needed to support healthy ecosystems (Bunn and Arthington 2002).

[10] Objective WB4 relates to colonial waterbird breeding and is not relevant for the NSW Border Rivers LTWP.

[11] 20-year targets will be further refined following additional data collection

[12] This value is low and represents an absolute minimum target. There is limited waterbird survey coverage for NSW Border Rivers and the BWS does not identify any waterbird assets in this valley.

Ecosystem functions include the maintenance of vital habitats such as refugia during drought, the transportation of nutrients and organic matter to provide food and resources, the movement of sediment for the maintenance of riparian channels, movement of water-dependent species, and maintenance of water quality suitable for the persistence of flora and fauna (see Schedule 9, Basin Plan (MDBA 2012a)).

Ecosystem functions have been grouped into objectives based on the broad processes involved. Collectively, the objectives require variable flows, with periods of low flows alongside a range of higher flows to maintain ecosystem functions such as in-channel complexity (e.g. benches) (Boulton et al. 2000; Thoms and Sheldon 2002).

The anabranches in the Border Rivers are known to make a significant contribution to ecosystem health within the catchment, and also more broadly to the Murray–Darling Basin (McGinness 2007). Flows required to maintain these habitats, and contribute to the health of the catchment and Basin, are considered under the broader objectives of quality instream habitat, instream and floodplain productivity and sediment, carbon and nutrient exchange.

3.4.1 Drought refugia

Refugia can occur within the main river channels, as instream pools, or in off-channel habitat where water persists after disconnection from the channel, such as in the anabranches, or where maintained by groundwater inflows such as in Boobera Lagoon (Reid et al. 2012). The refugia can contain different types of habitat, such as logs, wet undercut banks, riffles, sub-surface stream sediments and riparian vegetation. The range of habitat available can inform assessment of the quality of the refugia.

Refugia are critical to the survival of many aquatic species during dry spells and drought, and act as source populations for subsequent recolonisation and population growth (Adams and Warren 2005; Arthington et al. 2010). In the Border Rivers, establishing and maintaining off-channel drought refugia occurs during higher connective flows that occur in wetter years. Water quality of pools is also considered under this objective.

3.4.2 Quality instream habitat

Processes grouped in this objective include water quality, flow variability, appropriate wetting and drying cycles, geomorphic processes that create and maintain diverse physical habitat, large woody debris and rates of rise and fall that can influence bank erosion. The physical form of instream habitats, including the location of riparian and instream vegetation, channel shape and bed sediment, is influenced by river flow (Bunn and Arthington 2002). For example, fresh and bankfull flows with sufficient velocity are required to maintain pool depth and riffles by scouring out bed material and initiating material transportation downstream (Davie and Mitrovic 2014). Changes to the rates of rise and fall of river levels can also impact on the quality of instream habitat.

3.4.3 Movement and dispersal opportunities for aquatic biota

Longitudinal and lateral connectivity allows organisms to move and disperse between environments. It can be essential for maintaining population viability (Amtstaetter et al. 2016) by allowing individuals to move to different habitat types for breeding and conditioning, and recolonisation following disturbances like flood and drought. Flow pulses can promote dispersal of early life stages from the breeding site for a range of species and promote genetic diversity among catchments (Humphries and King 2004).

3.4.4 Instream and floodplain productivity

The supply of organic material underpins all river food webs by providing the food energy needed to drive life. The sources of organic material, the timing of its delivery and how long it remains in a section of river depends on the flow regime and the nature of the riparian vegetation. Instream productivity can be gained by wetting higher surfaces and higher velocity flows that scour and break down filamentous algae (Davie and Mitrovic 2014).

In the Border Rivers the extent of productivity gained from the wetting and drying cycles of the anabranches differs to that of the floodplain (McGinness 2007). It is known that regular drying and wetting of the anabranches can maintain a base level of productivity between overbank flow events that provides greater levels of productivity. River flow management can be used to increase carbon and nutrient sources in-channel by increasing the frequency of anabranch connection and floodplain inundation (McGinness 2007).

3.4.5 Groundwater-dependent biota

While this LTWP is primarily focused on the management of surface water, there are interactions with groundwater and groundwater-dependent ecosystems. Recharge to groundwater is considered under this objective.

3.4.6 Sediment, carbon and nutrient exchange

This objective addresses the processes of sediment delivery to downstream reaches and the mobilisation of carbon and nutrients to and from anabranches, floodplains and wetlands. The flows, and processes, required to meet this objective overlap with those required for instream and floodplain productivity and quality instream habitat.

3.4.7 Inter-catchment flow contributions

Connectivity between key planning units and between the NSW Border Rivers catchment and the Barwon River during critical spawning periods will support native fish outcomes and contribute to improved outcomes in the NSW Border Rivers and Barwon–Darling catchments. Hydrological connectivity is required at a planning unit scale throughout the catchment, as contributing to end-of-system flows. End-of-system flows requires assessment of flows at Mungindi and further downstream due to inflows from the Boomi River.

Figure 13 Severn River
Photo: N Foster

Table 6 Priority ecosystem function (EF) ecological objectives and targets

<table>
<tr><th colspan="3" rowspan="2">Ecological objectives</th><th rowspan="2">Description and key contributing processes</th><th colspan="3">Targets</th></tr>
<tr><th>5 years (2024)</th><th>10 years (2029)</th><th>20 years (2039)</th></tr>
<tr><td>EF1</td><td colspan="2">Provide and protect a diversity of refugia across the landscape</td><td>Water depth and quality in pools (in-channel), core wetlands and lakes
Condition of vegetation in core wetlands and riparian zones</td><td colspan="3">Maintain dissolved oxygen (DO) and salinity levels in key refuge pools at ecologically tolerable levels</td></tr>
<tr><td>EF2</td><td colspan="2">Create quality instream, floodplain and wetland habitat</td><td>Regulation of DO, salinity and water temperature
Flow variability and hydrodynamic diversity
Provision of diverse wetted areas
Appropriate wetting and drying cycles
Geomorphic (erosion/deposition) processes that create and maintain diverse physical habitats
Appropriate rates of fall to avoid excessive bank erosion
Control of woody-vegetation encroachment into river channels and wetlands</td><td colspan="3">Rates of rise and fall do not exceed the 5th and 95th percentiles (respectively) of natural rates during regulated water deliveries</td></tr>
<tr><td rowspan="2">EF3</td><td rowspan="2">Provide movement and dispersal opportunities within, and between, catchments for water-dependent biota to complete lifecycles and disperse into new habitats</td><td>a. within catchments</td><td rowspan="2">Dispersal of eggs, larvae, propagules and seeds downstream and into off-channel habitats
Migration to fulfil life-history requirements
Foraging of aquatic species and recolonisation following disturbance</td><td colspan="3" rowspan="2">Protect or improve frequency of events that allow fish passage in target planning units/gauges
Annual detection of species and life stages representative of the whole fish community through key fish passages in specified planning units
Increase in passage of key moderate to long-lived riverine and moderate to long-lived flow pulse specialists through key fish passages in the Border Rivers compared to passage rates detected in 2014–19
Protect or improve the number of events that enable movement of fish between catchments within 12 months of major breeding events and dry spells</td></tr>
<tr><td>b. between catchments</td></tr>
</table>

Ecological objectives		Description and key contributing processes	Targets		
			5 years (2024)	10 years (2029)	20 years (2039)
EF4	Support instream and floodplain productivity	Aquatic primary productivity (algae, macrophytes, biofilms, phytoplankton) Terrestrial primary productivity (vegetation) Aquatic secondary productivity (zooplankton, macroinvertebrates, fish larvae, adult fish) Decomposition of organic matter	Enhance riverine productivity to support increased food availability for aquatic food webs by increasing the supply of autochthonous & allochthonous carbon & nutrients Maintain soil nitrogen, phosphorus and carbon levels at long-term natural levels Maintain/improve the abundance and distribution of decapod crustaceans		
			No decline in key native fish species condition metrics (e.g. weight:length ratio)	Improve key native fish species metrics (e.g. weight:length ratio)	
EF5	Support nutrient, carbon and sediment transport along channels, and exchange between channels and floodplains/wetlands	Sediment delivery to downstream reaches and to/from anabranches, floodplains and wetlands Mobilisation of carbon and nutrients from in-channel surfaces (e.g. benches/banks), floodplains and wetlands and transport to downstream reaches and off-channel habitats Dilution of carbon and nutrients that have returned to rivers	Maintain nutrient and dissolved organic carbon (DOC) pulses at multiple locations along a channel during freshes, bankfull and overbank events Maintain extent and condition of floodplain vegetation Maintain soil nitrogen, phosphorus and carbon levels at long-term natural levels		
EF6	Support groundwater conditions to sustain groundwater-dependent biota	Groundwater recharge and discharge Dilution of saline/acidic groundwater Salt export from the Murray–Darling Basin	Maintain the 2016 mapped extent of groundwater-dependent vegetation communities Maintain groundwater levels within the natural range of variability over the long term		
EF7	Increase the contribution of flows into the Murray and Barwon–Darling from tributaries	Provision of end-of-system flows to support ecological objectives in downstream catchments	No reduction in rolling 5-year average flows at each planning unit gauge and end of catchment gauge. No increase in the long-term average number of days of cease-to-flow conditions.		

4. Environmental water requirements

Flow and inundation regimes drive the ecological characteristics of rivers and floodplain wetlands (Poff and Zimmermann 2010). A flow regime represents the sequence of flow events over time, and it is this sequence of different flow magnitudes that produce flooding and drying patterns. Flow regimes govern river channel and wetland formation, their configuration and connectivity with the floodplain. Flow regimes prompt key ecological processes such as nutrient cycling and energy flow, breeding and migration, and dispersal of plants and animals.

The sequence of flows over time can be considered as a series of discrete events. These events can be placed into different flow categories (e.g. baseflows, freshes, bankfull, overbank and wetland flows) according to the magnitude of flow discharge or height within a watercourse, and the types of outcomes associated with the events (e.g. inundation of specific features such as channel benches, riparian zones or the floodplain).

Each flow category can provide for a range of ecological functions; for example, a small fresh might inundate river benches that provide access to food for native fish and support in-channel vegetation. Similarly, an overbank flow may support carbon exchange between the river and its floodplain and improve river red gum condition. Flow categories describe the height or level of a flow within a river channel or its extent across a floodplain (Figure 14 and Table 7). Flow rates for flow categories at sites across the NSW Border Rivers catchment are shown in Table 9.

An EWR is the flow or inundation regime that a species, or community, needs to ensure its survival and persistence. It can also be the flow regime needed to meet the water requirements of a range of species in a defined geographic area. EWRs are based on knowledge of a species' biological and ecological needs, such as what it needs to feed, breed, disperse and migrate.

Meeting the full life-history needs of an aquatic organism (plant or animal) typically requires a combination of several different flow categories over time; for example, a native fish species may require a 'small fresh' as a 10-day pulse in late winter to cue spawning, followed by a relatively stable flow for 2–4 weeks in early spring to support nesting. Once the fish reaches maturity (1–3 years) it may require a 'bankfull' fast-flowing river in combination with 'overbank' flows to trigger dispersal and migration.

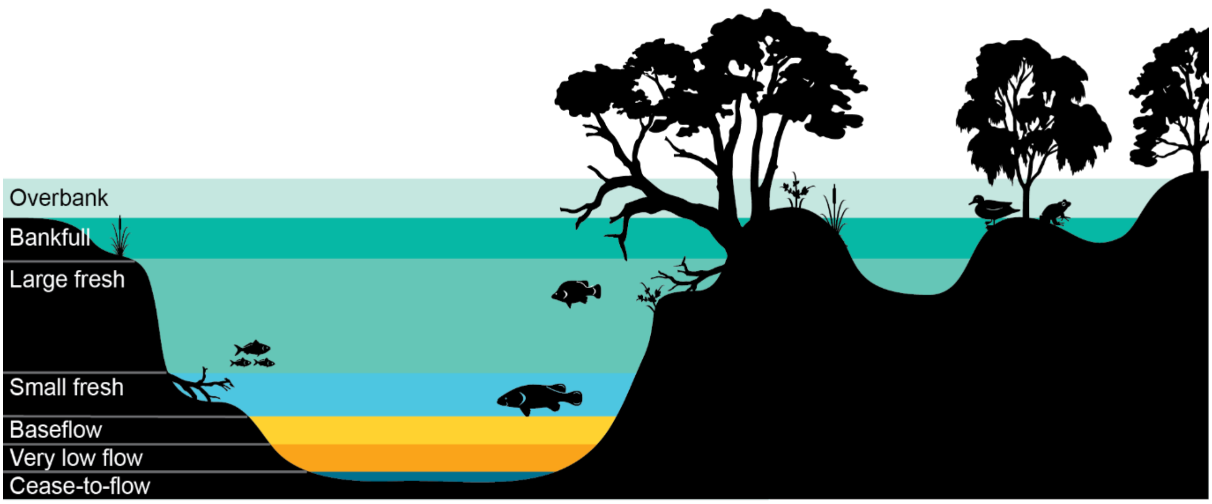


Figure 14 Flow categories shown as river level stages on the cross-section of a river channel

Table 7 Description of the role provided by each flow category shown in Figure 14

Flow category	Description
Overbank / wetland inundating flow (OB)	Broad-scale lateral connectivity with the floodplain and wetlands. Supports nutrient, carbon and sediment cycling between the floodplain and channel. Promotes large-scale productivity.
Bankfull flow (BK)	Inundates all in-channel habitats and connects many low-lying wetlands and anabranches. Partial or full longitudinal connectivity. Drowns out most in-channel barriers (e.g. weirs).
Large fresh (pulse) (LF)	Inundates benches, snags and inundation-tolerant vegetation higher in the channel. Supports productivity and transfer of nutrients, carbon and sediment. Provides fast-flowing habitat. Drowns out some smaller in-channel barriers. Begins to wet off-channel habitat and provides connectivity along anabranches and low-lying wetlands with commence-to-flow thresholds lower than bankfull.
Small fresh (pulse) (SF)	Improves longitudinal connectivity. Inundates lower banks, bars, snags and in-channel vegetation. Trigger for aquatic animal movement and breeding. Flushes pools. May stimulate productivity/food webs.
Baseflow (BF)	Provides connectivity between pools and riffles and along channels. Provides sufficient depth for fish movement along reaches.
Very low flow (VF)	Minimum flow in a channel that prevents a cease-to-flow. Provides hydrological connectivity between some pools.
Cease-to-flow (CF)	Partial or total drying of the channel. Stream contracts to a series of disconnected pools. No surface flows.

4.1 Developing environmental watering requirements to support ecological objectives

Development of EWRs for LTWPs draws on the best-available information from water managers, ecologists, scientific publications and analysis of gauged and modelled flows. The process started with an assessment of the water requirements of individual species, then of guilds or functional groups. Where water requirements (flow category, duration, timing, etc.) overlapped between species or groups, the individual requirements were combined to provide a single EWR that supported the relevant group of environmental objectives.

At the planning unit scale, EWRs are informed by an understanding of the channel morphology and hydrology. This included an analysis of channel cross-sections, floodplain inundation data, observed flow data, modelled flow data and operational experience.

Each EWR is expressed as a flow category that has been assigned a flow rate or volume, an ideal timing, duration and frequency, and a maximum inter-event period based on the suite of plants, animals and functions it supports (see Table 8 for full description of EWR terms). Complete EWRs for each planning unit in the NSW Border Rivers, including flow rates and total volumes, can be found in Part B.

A summary of flow rates for flow categories at sites in the NSW Border Rivers are shown in Table 9. The timing, duration and frequency components of EWRs, grouped by flow category, for all biota and functions in the NSW Border Rivers catchment and the objectives they support, are presented in Table 10. Some of these details are consistent across the NSW Border Rivers, while some details, such as the duration and frequency, are tailored to planning units. Planning unit-specific EWRs are presented in Part B. Important flow regime characteristics to meet life-history needs and each of the LTWP objectives are described in Table 11.

Table 8 Definition of terms and guide for interpreting EWRs

Term	Explanation
EWR code	Each EWR is given a specific code to shorten the EWR name (e.g. SF1 for small fresh 1). This code is used to link ecological objectives and EWRs.
Ecological objectives	The LTWP ecological objectives supported by the EWR. Includes reference to codes of all LTWP objectives supported (e.g. NF1 = objective 1 for native fish), and a short description of key objectives and life stages being targeted (e.g. spawning or recruitment). Bold text indicates the primary objectives of each EWR. See Tables 2, 3, 5 and 6 for full objectives.
Gauge	The flow gauging station that best represents the flow within the planning unit, for the respective EWR and associated ecological objective(s). Flow recorded at this gauge should be used to assess the achievement of the EWR.
Flow rate or flow volume	The flow rate (typically ML/day) or flow volume (typically GL over a defined period of time) required to achieve the relevant ecological objective(s) for the EWR. Most EWRs are defined using a flow rate, whilst flow volumes are used for EWRs that represent flows into some large wetland systems.
Timing	The required timing (or season, typically expressed as a range of months within the year) for a flow event to achieve the specified ecological objective(s) of the EWR. In some cases, a preferred timing is provided, along with a note that the event may occur at 'any time'. This indicates that ecological objectives may be achieved outside the preferred timing window, but perhaps with sub-optimal outcomes. In these instances, for the purposes of managing and delivering environmental water, the preferred timing should be used to give greater confidence in achieving ecological objectives. Natural events may occur at other times and still achieve ecological objectives. For testing EWR achievement, 'any time' should be the standard test, whilst the preferred season should be considered as an additional test to assess ecological consequences.
Duration	The duration for which flows must be above the specified flow rate for the flow event to achieve the specified ecological objective(s) of the EWR. Typically, this is expressed as a minimum duration (except for cease-to-flow EWRs). Longer durations will often be desirable and deliver better ecological outcomes. Some species may suffer from extended durations of inundation, and where relevant a maximum duration may also be specified. Flows may persist on floodplains and within wetland systems after a flow event has passed. Where relevant a second duration may also be specified, representing the duration for which water should be retained within floodplain and wetland systems. Low flow durations (very low flows and baseflows) are not intended to be consecutive days (i.e. these days do not have to be consecutive and can occur throughout the water year). Durations for small fresh EWRs upwards are required to be consecutive days (all EWRs above baseflows are designed as events with minimum event durations).
Frequency	The frequency at which the flow event should occur to achieve the ecological objective(s) associated with the EWR. Frequency is expressed as the number of years the event should occur within a 10-year period. In most instances, more frequent events will deliver better outcomes, and maximum frequencies may also be specified, where relevant. Clustering of events over successive years can occur in response to climate patterns. Clustering can be ecologically desirable for the recovery and recruitment of native fish, vegetation and waterbirds populations; however, extended dry periods between clustered events can be detrimental. Achieving

Term	Explanation
	ecological objectives will require a pattern of events over time that achieves both the frequency and maximum inter-flow period, and the 2 must be considered together when evaluating outcomes or managing systems. Where a range of frequencies is indicated (e.g. 3–5 years in 10), the range reflects factors including the natural variability in population requirements, uncertainty in the knowledge base, and variability in response during different climate sequences (e.g. maintenance of populations during dry climate sequences at the lower end of the range, and population improvement and recovery during wet climate sequences at the upper end of the range). The lower end of the frequency range (when applied over the long term) may not be sufficient to maintain populations and is unlikely to achieve any recovery or improvement targets. As such, when evaluating EWR achievement over the long term through statistical analysis of modelled or observed flow records, DPE–BC recommends that the average of the frequency range is used as the minimum long-term target frequency.
Long-term average (LTA) frequency	Minimum long-term average target frequency.
Maximum inter-flow or inter-event period	The maximum time between flow events before a significant decline in the condition, survival or viability of a particular population is likely to occur, as relevant to the ecological objective(s) associated with the EWR. This period should not be exceeded wherever possible. Annual planning of environmental water should consider placing priority on EWRs that are approaching (or have exceeded) the maximum inter-event period, for those EWRs that can be achieved or supported using environmental water or management.
Additional requirements and comments	Other conditions that should occur to assist ecological objectives to be met; for example, rates of rise and fall in flows. Also comments regarding limitations on delivering environmental flows and achieving the EWR.

Figure 15 Dumaresq River upstream of Riverton
Photo: L Cameron and J St Vincent Welch

4.2 Flow category thresholds

The flow rates that define each flow category (baseflows, small freshes, etc.) and associated EWRs will vary between catchments and river reaches. Table 9 presents the range of flow rates for each flow category at representative gauge sites in the NSW Border Rivers catchment (Figure 16). The environmental outcomes associated with each flow category are expected to begin occurring at the bottom end of the flow ranges. Greater and sometimes substantially increased outcomes are likely to occur (e.g. for wetland connecting large freshes and overbank flows) as flows increase in size within the flow band. While the flow rates for each flow category are expressed as ranges in Table 9, flow rates for the EWRs presented in Part B are expressed as minimum flow rates (i.e. the bottom end of the range) in most cases, meaning that an EWR may also be met by higher flows in other categories.

Table 9 Flow threshold estimates (ML/day) for flow categories in planning units in the NSW Border Rivers catchment[13][14]

Planning unit	Gauge	Low flows			Freshes			Overbank[15]	
		Cease-to-flow	Very low flow	Baseflow	Small	Large	Bankfull	Small	Large
Planning unit 1: Tenterfield Creek									
Tenterfield Creek at Clifton	416003	>1	3–40	40–100	100–1,500	1,500–5,000	5,000–14,000	>14,000	
Planning unit 2: Mole River									
Mole R. at Donaldson	416032	>1	10–50	50–230	230–720	720–8,000	8,000–26,000	>26,000	
Planning unit 3: Reedy Creek									
Dumaresq R. Roseneath	416011	>1	71–250	250–500	500–2,400	2,400–19,000	19,000–40,000	>40,000	>66,000
Planning unit 4: Beardy River									
Beardy R. at Haystack	416008	>1	10–50	50–100	100–700	700–5,000	5,000–15,200	>15,200	>30,000
Planning unit 5: Glen Innes									
Severn R. at Strathbogie	416039	>1	22–58	58–110	110–1,200	1,200–8,500	>8,500	N/A	
Planning unit 6: Bonshaw									
Dumaresq R. U/S Bonshaw	416007	>1	72–250	250–500	500–2,400	2,400–24,000	24,000–53,000	>53,000	
Planning unit 7: Kings Plains									
Severn R. at Ashford	416006	>1	48–65	65–245	245–1,520	1,520–15,000	15,000–20,000	>20,000	
Planning unit 8: Inverell									
Macintyre River at Wallangra	416010	>1	11–40	40–140	140–2,000	2,000–12,500	12,500–26,000	>26,000	

[13] See definitions table for explanations. Note the full set of EWRs for each gauge can be found in Part B. This is a summary of threshold estimates only.

[14] While the flow rates for each flow category are expressed as ranges in this table, flow rates for the EWRs presented in Part B are expressed as minimum flow rates (i.e. the bottom end of the range) in most cases, meaning that an EWR may also be met by higher flows in other categories. Only small fresh 2 EWRs have banded flow threshold estimates (i.e. flow should remain in the band to support native fish breeding requirements).

[15] Ideally these EWRs will also include ideal total event volumes. These values are yet to be determined.

Planning unit	Gauge	Low flows			Freshes			Overbank[15]	
		Cease-to-flow	Very low flow	Baseflow	Small	Large	Bankfull	Small	Large
Planning unit 9: Campbells Creek and Camp Creek									
Dumaresq R. at Glenarbon	416040	<1	50–140	140–500	500–2,400	2,400–30,000	30,000–45,000	>45,000	
Planning unit 10: Yetman									
Macintyre at Holdfast	416012	<1	92–250	250–1,000	1,000–7,400	7,400–43,000	43,000–53,000	>53,000	
Planning unit 11: Ottleys Creek									
Ottleys Creek at Coolatai	416020	<1	4–200	N/A	200–400	400–3,900	3,900–4,500	>4,500	
Planning unit 12: Confluence of Macintyre River and Dumaresq River									
Refer to Macintyre at Goondiwindi gauge 416201A									
Planning unit 13: Macintyre River floodplain upstream of Boomi River									
Macintyre at Goondiwindi[16]	416201A	<1	166–450	450–1,500	1,500–8,000	8,000–15,000	15,000–20,000	20,000–60,000	>60,000
Macintyre River at Terrewah	416047	<1	40–50	50–330	330–2,200	2,200–7,900	7,900–10,500	>10,500	
Planning unit 14: Whalan and Croppa creeks sub-catchment									
Whalan at Euraba[17]	416072	<4	N/A	N/A	>240	N/A	>850	>2,000	
Macintyre at Goondiwindi	416201A								>73,000[18]
Planning unit 15: Macintyre River and Boomi River floodplain									
Boomi Weir Offtake	416037	<1	3–25	25–75	75–365	365–1,000	1,000–2,000	>2,000	
Macintyre at Kanowna	416048	<1	73–210	210–400	400–900	900–3,300	3,300–4,900	>4,900	
Barwon River at Mungindi	416001	<1	45–160	160–540	540–3,000	3,000–7,900	7,900–10,000	10,000–13,000	>13,000

[16] See the EWR table in Part B for the distinction in flow magnitudes required for bankfull flows upstream and downstream of Goondiwindi.

[17] Note only certain EWRs were able to be developed for Whalan Creek at Euraba due to deficiencies of data.

[18] This magnitude of flow at Goondiwindi gauge assists in the overbank EWR at Whalan Creek at Euraba being met (along with tributary inflows from Croppa Creek to Whalan Creek).

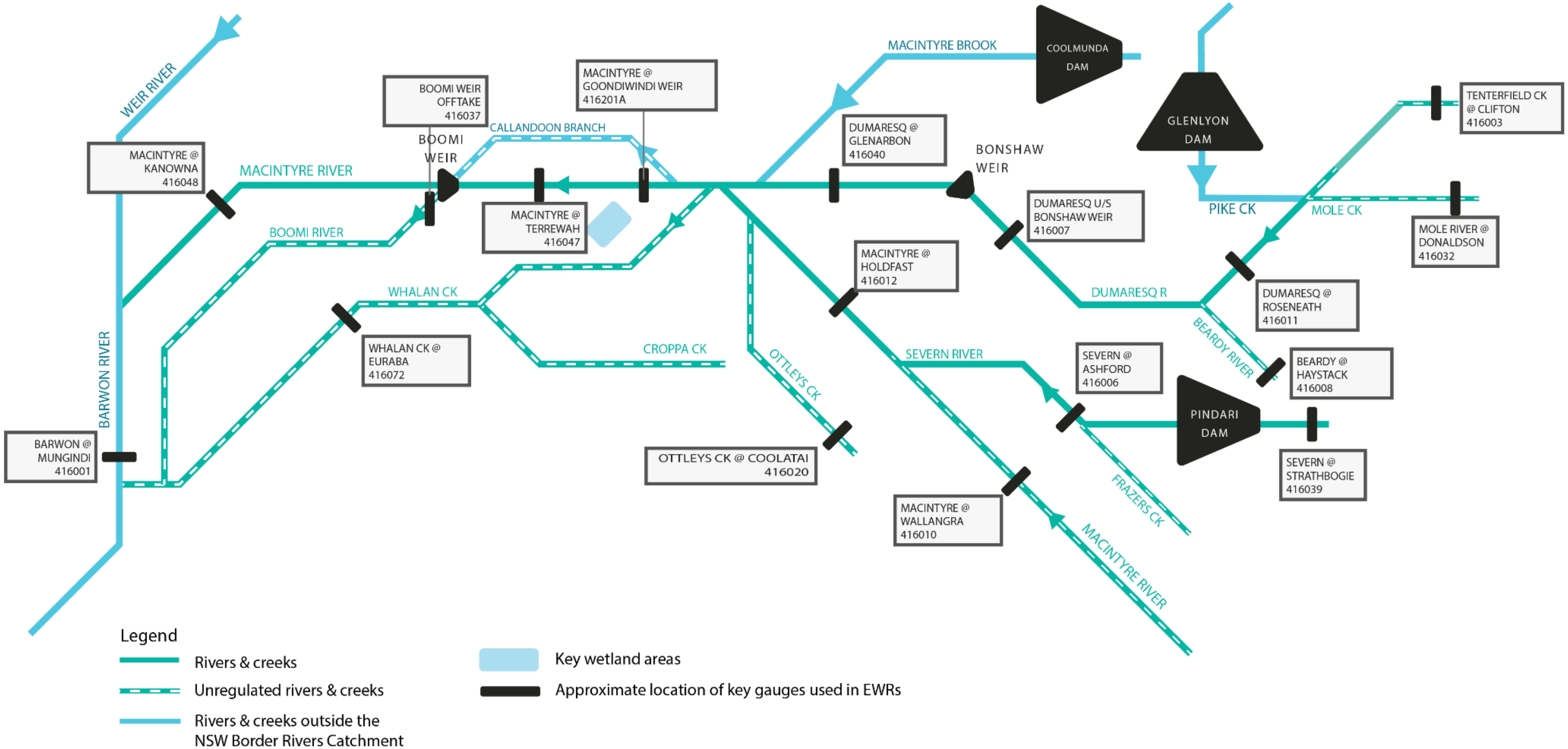


Figure 16 Schematic diagram showing river gauge locations on the main watercourses in the NSW Border Rivers catchment

4.3 Catchment-scale environmental water requirements

Table 10 Catchment-scale EWRs and the ecological objectives they support[19]

Flow category and EWR code[20]		Ecological objectives[20]	Timing[20]	Duration[20]	Frequency (LTA frequency)[20]	Maximum inter-event period[20]
Cease-to-flow	CFa	Native fish: NF1 – Survival (all species) Ecosystem functions: EF1, 2 – refuge habitat	Any time	In line with natural[21] Part B outlines the maximum duration of cease-to-flow events that should occur in no more than 50% of years (5 in 10 years, i.e. typical years)		N/A
	CFb	Native fish: NF1 – Survival (all species) Ecosystem functions: EF1, 2 – refuge habitat	Any time	In line with natural Part B outlines the maximum duration of cease-to-flow events that should occur in no more than 5% of years (5 in 100 years, i.e. the driest years)		N/A
	CFc	Native fish: NF1 – Survival (all species) Ecosystem functions: EF1, 2 – refuge habitat	Any time	In line with natural Part B outlines the maximum percentage of years that should have cease-to-flow events of any duration		N/A
Very low flows	VFa	Native fish: NF1– Survival and condition (all species) Waterbirds: WB1 – Survival (all species) Ecosystem functions: EF1, 2 – refuge habitat	Any time	In line with natural[21]	5 in 10 years (50%) minimum	In accordance with cease-to-flow requirements
	VFb	Native fish: NF1– Survival and condition (all species) Waterbirds: WB1 – Survival (all species) Ecosystem functions: EF1, 2 – refuge habitat	Any time	In line with natural[21]	Every year (100%)	In accordance with cease-to-flow requirements

[19] This is a high-level overview of the objectives each EWR will contribute to and the general parameters. For specific details of each EWR parameter, refer to Part B.

[20] See Table 8 for definitions of terms and explanatory text for EWRs; most are minimum durations, except for cease-to-flow.

[21] Durations determined using modelled ‘without development’ and observed data

Flow category and EWR code[20]		Ecological objectives[20]	Timing[20]	Duration[20]	Frequency (LTA frequency)[20]	Maximum inter-event period[20]
Baseflows	BF1a	Native fish: NF1, 2, 3, 4, 5, 6, 7, 8 – Survival, condition and movement (all species) Waterbirds: WB1 – Survival (all species) Ecosystem functions: EF1, 2, 3a – refuge habitat, within catchment dispersal	Any time	In line with natural[21]	5 in 10 years (50%) minimum	95th percentile of duration of spells between events[22].
	BF1b	Native fish: NF1, 2, 3, 4, 5, 6, 7, 8 – Survival, condition and movement (all species) Waterbirds: WB1 – Survival (all species) Ecosystem functions: EF1, 2, 3a – refuge habitat, within catchment dispersal	Any time	In line with natural[21]	Every year (100%)	95th percentile of duration of spells between events[22].
	BF2a	Native fish: NF1, 2, 3, 5, 6, 8 – Recruitment (riverine specialists, generalists) Waterbirds: WB1 Native vegetation: NV1 – in-channel non-woody vegetation Ecosystem functions: EF1	Sep to Mar	In line with natural[21]	5 in 10 years (50%) minimum	2 years
	BF2b	Native fish: NF1, 2, 3, 5, 6, 8 – Recruitment (riverine specialists, generalists) Waterbirds: WB1 Native vegetation: NV1 – in-channel non-woody vegetation Ecosystem functions: EF1	Sep to Mar	In line with natural[21]	Every year (100%)	2 years

[22] Modelled ‘without development’ flow data has been used for this analysis.

Flow category and EWR code[20]		Ecological objectives[20]	Timing[20]	Duration[20]	Frequency (LTA frequency)[20]	Maximum inter-event period[20]
Small freshes	SF1	Native fish: NF1, 6, 8 – Dispersal/condition (all species) Native vegetation: NV1 – in-channel non-woody vegetation Ecosystem functions: EF3a, 3b, 4 – within and between catchment biotic dispersal	Ideally Oct to Apr (but can occur any time)	Ideally 10 days minimum but varies by location[23]	Ideally annually[24] but varies by location[23]	1 year
	SF2	Native fish: NF2, 3, 5 – spawning and recruitment (generalists, river and floodplain specialists)	Oct to Apr[25]	Ideally 14 days minimum[26] but varies by location[23]	Ideally 5–10 years in 10 (75%)[24] but varies by location[23]	2 years
Large freshes	LF1	Native fish: NF1, 6, 9 – dispersal and condition (all species); recruitment (flow pulse specialists) Native vegetation: NV3 – fringing river red gum Ecosystem functions: EF1, 2, 3a, 4, 6 – channel maintenance; nutrient, sediment and carbon transport; productivity	Ideally Jul to Sep (but can occur any time)	Ideally 5 days minimum but varies by location[23]	Ideally 5–10 years in 10 (75%) but varies by location[23]	2 years
	LF2	Native fish: NF2, 4 – spawning (flow pulse specialists)	Oct to Apr	Ideally 5 days minimum but varies by location[23]	Ideally 3–5 in 10 years (42%) but varies by location[23]	4 years

[23] See specific EWRs for each planning unit at representative gauges in Part B.

[24] Recommended ideal frequency is linked to providing conditions that protect and improve native fish populations in heavily impacted systems.

[25] Recommended ideal timing is linked to maximising spawning and recruitment outcomes based on known spawning seasons for native fish. Ideal timing for objectives related to dispersal and/or productivity have also been recommended; however, these may occur any time with a movement and/or condition outcome still expected from native fish. September to December for Murray cod.

[26] Recommended minimum durations for flows associated with spawning and recruitment outcomes are based on known egg hatch time and morphology; these may be able to be increased based on flow data analysis and/or real time monitoring of fish larval presence, but they should not be reduced (e.g. extending the SF2 duration would reduce the likelihood of nests being disturbed or abandoned during the critical 14-day incubation period).

Flow category and EWR code[20]		Ecological objectives[20]	Timing[20]	Duration[20]	Frequency (LTA frequency)[20]	Maximum inter-event period[20]
	LF3	Native fish: NF1, 3, 7 – spawning and dispersal (floodplain specialists) Native vegetation: NV1, 2 – non-woody vegetation in and fringing anabranches and low-lying wetlands, NV3 – fringing river red gum Ecosystem functions: EF2, 4 -geomorphic processes and productivity	Ideally Oct to Apr but depends on local conditions	Varies by location[23]	Ideally 5–10 years in 10 (75%) but varies by location[23]	4 years
Bankfull	BK1	Native fish: NF6, 9 – dispersal and condition (flow pulse specialists) Waterbirds: WB1, 2, 5 – condition, breeding, habitat Native vegetation: NV1, 2, 3 – non-woody vegetation in-channel, wetlands, and anabranches; fringing river red gum Ecosystem functions: EF2, 3a, 3b, 4, 5, 6 – nutrient, sediment and carbon transfer; biotic dispersal; productivity	Any time	Ideally 5 days minimum but varies by location[23]	Ideally 5–10 years in 10 (75%) but varies by location[23]	5 years
	BK2	Native fish: NF3 – spawning (floodplain specialists Waterbirds: WB1, 3 – condition, breeding, habitat Native vegetation: NV1, 2, 4a, 4b, 4e – non-woody vegetation in-channel, wetlands and anabranches; lignum	Oct to Apr	Ideally 10 days minimum but varies by location[23]	Ideally 2-5 years in 10 but varies by location[23]	4 years

Flow category and EWR code[20]		Ecological objectives[20]	Timing[20]	Duration[20]	Frequency (LTA frequency)[20]	Maximum inter-event period[20]
Small overbank	OB1	Native fish: NF1, 9 – condition and dispersal (all species); recruitment (flow pulse specialists) Waterbirds: WB1, 3, 5 – condition, breeding and habitat Native vegetation: NV2, 3, 4a, 4b, 4c, 4e – non-woody vegetation in wetlands and anabranches; river red gum; black box and lignum Ecosystem functions: EF2, 4, 5, 7 – lateral connectivity with floodplain habitats, nutrient, carbon and sediment transfer; productivity; longitudinal connectivity and contribution of flow to Barwon–Darling system	Any time	Ideally 5 days minimum, but varies by location[23]	Ideally 2–3 years in 10 (25%) but varies by location[23]	5 years
Large overbank	OB2	Waterbirds: WB1, 3, 5 – condition, breeding and habitat Native vegetation: NV2, 3, 4a, 4b, 4c 4d, 4e – non-woody vegetation in wetlands and anabranches; river red gum; black box; coolibah and lignum Ecosystem functions: EF2, 4, 5, 6, 7 – lateral connectivity with floodplain habitats; nutrient, carbon and sediment transfer; productivity; groundwater recharge; longitudinal connectivity and contribution of flow to Barwon–Darling system	Ideally Oct to Apr but depends on local conditions	Ideally 10 days minimum but varies by location[23]	Ideally 5 years in 10 (50%) but varies by location[23]	4 years but depends on local conditions

Table 11 Important flow regime characteristics to deliver ecological objectives

Ecological objective	Important flow regime characteristics[27]
Native fish objectives[28]	
NF1: No loss of native fish species	• Cease-to-flow: No increase in the frequency or duration of cease-to-flow periods is required to minimise the loss of refuge pools, beyond levels of ecosystem tolerance. • Very low flows (VF) in dry times may maintain or minimise loss of pools, as critical for fish survival and maintenance. A very low flow can provide some hydrological connection. A flow depth of 10–30 cm above cease-to-flow is considered a low flow for the purposes of stable low flow spawning fish (Kerr and Prior 2018). • Baseflows (BF1) are required for the survival and maintenance of native fish condition as these flows maintain adequate water quality (DO, salinity and temperature) in refuge pools and sufficient flow depth to allow fish movement [at least 0.3 m above cease-to-flow for small and moderate bodied fish (Gippel 2013; O'Conner et al. 2015). In wide channels, habitat mapping and/or local knowledge is used to determine the appropriate flow rate. • A baseflow (BF2) preferably between September and March with an annual or biannual frequency and maximum interflow period of 2 years enhances recruitment outcomes of river specialist and generalist fish. Baseflows can be beneficial for stable low flow spawning fish. These species require less than 10 cm fluctuation of a low flow for 7–21 days, with up to 60 days for recruitment (Kerr and Prior 2018). Spawning and recruitment flows for riverine specialists require a minimum of 24 days flow (DPI 2018a). • Small freshes (SF1) (at least 0.5 m above cease-to-flow) support movement and dispersal opportunities for large bodied fish (Fairfull and Witheridge 2003; Gippel 2013; O'Conner et al. 2015). • Large fresh (LF1): An annual large fresh that wets higher in-channel surfaces and some anabranches and wetlands with low commence-to-flow/fill thresholds (ideally between July and September) and ideally for at least 5 days, releases carbon and nutrients and provides for fish condition. The large fresh should trigger some primary productivity that will provide food resources and hence improve fish condition prior to the spring/summer spawning season. Flow velocities of >0.3 m/s are ideal to trigger fish movement. In upland valley confined settings, flows are naturally faster passing events and a shorter duration event is relevant (Poff et al. 1997). • In some locations a large fresh (LF3) or a bankfull flow (BK1 and BK2) can fill deep pools in the anabranches providing a higher variability of habitat types. These pools can persist for several years (Reid et al. 2012) and provide some drought refuge and promote instream productivity. • A bankfull (BK1 and BK2) that inundates low-lying off-channel habitat for 10 days supports the spawning and recruitment of floodplain specialists. The ideal timing is October to April with a maximum interflow period of 4 years. • Overbanks (OB1 and OB2) and floodplain wetland inundating flows, ideally from August to February, for at least 3 days and occurring 2–

[27] See Table 8 for definitions of terms and explanatory text for EWRs.

[28] Important flow regime characteristics for all native fish objectives are based on NSW DPI 2015a and Ellis et al. 2018.

<table>
<tr><th>Ecological objective</th><th>Important flow regime characteristics[27]</th></tr>
<tr><td></td><td>3 years in 10 years (with a maximum inter-event period of 5 years) are also required to support condition and movement/dispersal outcomes of all native fish groups. Larger flows that inundate off-stream habitat can also promote growth and recruitment through increased floodplain productivity and habitat availability. To achieve productivity, overland flows need to return to the main channels (Baldwin et al. 2016). Larger flows that connect low-lying billabongs provide important habitat to support strong survivorship and growth of juveniles.</td></tr>
<tr><td>NF2: Increase the distribution and abundance of short to moderate-lived generalist native fish species</td><td>In addition to the flows listed above for all native fish species, other important aspects of the flow regime for generalists are listed below.
Regular (ideally annual) spawning and recruitment events for the persistence of short-lived species.
• A baseflow (BF2), preferably between September and March with an annual or biannual frequency and maximum interflow period of 2 years enhances recruitment outcomes of river specialist and generalist fish. This is also required for stable low flow spawning fish that require less than 10 cm fluctuation of a low flow for 7–21 days, with up to 60 days for recruitment (Kerr and Prior 2018). Spawning and recruitment flows for riverine specialists require a minimum of 24 days flow (DPI 2018a).
• Although spawning often occurs independent of flow events, spawning is enhanced by small freshes (SF2) during the warmer months of October to April. At a minimum, events should occur 5–10 years in 10 with a minimum event duration of 14 days for egg development and hatching. Providing multiple freshes during the spawning season provides flexibility in species response and opportunities for multiple spawning events. A slow recession is beneficial for recruitment.
• Large freshes (LF2) occurring 2–3 weeks after spawning will enhance recruitment of larvae and juveniles by aiding dispersal and access to habitat and suitable prey. Larger flows that inundate off-stream habitat (such as anabranch connecting flows) can also promote growth and recruitment (i.e. increased productivity and habitat availability).</td></tr>
<tr><td>NF3: Increase the distribution and abundance of short to moderate-lived floodplain specialist native fish species</td><td>In addition to the flows listed above for all native fish species, there are other important aspects of the flow regime for floodplain specialists, specifically the olive perchlet. The flow category that results in off-channel habitat or in-channel low velocity niches being inundated varies with the ecological features found at a planning unit scale. The most ideal habitat is off-channel as this provides a more stable velocity and water height for spawning. In planning units where this habitat is not available, or where this habitat can be accessed at lower flows, lower flow categories are applied to the EWR to support this objective.
• Small fresh, large fresh and bankfull flows (BF2, SF2, LF3, BK1/2) during the warmer months of October to April provide low velocity spawning habitat and productivity benefits to support fish growth. These flows should inundate habitats for at least 10 days to allow for egg development and occur at least 5 years in 10, with a maximum inter-event period of 4 years. This period will depend on the persistence of off-channel habitats and time between reconnection to mainstem waterways. Flows should be of a long enough duration to support isolated populations. Water temperatures should be above 22°C. The flow category required to connect with off-channel and other low velocity habitat varies with the landscape features in each planning unit.</td></tr>
</table>

Ecological objective	Important flow regime characteristics[27]
	• Recruitment is enhanced by subsequent flow events that boost productivity (large fresh and bankfull flows) 2–4 weeks after spawning flows. Most floodplain specialist species require spawning and recruitment every 1–2 years for population survival. • Stable low flow spawning fish can also respond to long periods of stable low flows that maintain partial wetting of in-channel vegetation. A baseflow (BF2) for a minimum of 7 days, with 21 days considered more ideal, between September and March at least every second year can be beneficial to the survival of these species (Kerr and Prior 2018).
NF4: Improve native fish population structure for moderate to long-lived flow pulse specialist native fish species	In addition to the flows listed above for all native fish species, other important aspects of the flow regime for flow pulse specialists include: • Spawning of flow pulse specialists is triggered by a rapid rise or fall in flow (relative to natural rates) between spring and summer when temperatures are greater than 17°C. In lowland systems, spawning responses are enhanced by substantial flow rises of at least 2 m to cover instream features and high flow velocities of greater than 0.3 m/s. • A large fresh (LF2) between October and April for a minimum of 5 days and a rapid rate of rise should meet these spawning requirements. This is needed 3–5 years in 10 with a maximum inter-event period of 4 years. A rapid rise with temperatures greater than 17°C, ideally 2–3 weeks before SF2 will enhance spawning outcomes. Rate of fall no faster than 5th percentile of natural. Integrity of flow events needs to be maintained over long distances (10s to 100s of km) to maximise the capacity for instream spawning, downstream dispersal by drifting eggs and larvae and movements by adults and juveniles.
NF5: Improve native fish population structure for moderate to long-lived riverine specialist native fish species	In addition to the flows listed above for all native fish species, other important aspects of the flow regime for riverine specialists include: • A baseflow (BF2), preferably between September and March with an annual or biannual frequency and maximum interflow period of 2 years enhances recruitment outcomes of river specialist and generalist fish. Stable baseflows are required for recruitment of low flow spawning fish, with less than 10 cm fluctuation of a low flow for 7–21 days, with up to 60 days (Kerr and Prior 2018). Spawning and recruitment flows for riverine specialists require a minimum of 24 days flow (DPI 2018a). • Spawning of riverine specialists usually occurs annually, independent of flow events; however, spawning may be enhanced by small freshes (SF2) between October and April to promote ecosystem productivity and inundate additional spawning habitat. Event duration should be a minimum of 14 days with an average frequency of 5–10 years in 10 and maximum inter-event period of 2 years. Water temperatures should be >20°C. River blackfish may spawn in lower water temperatures of >16°C and Murray cod in >18°C. Murray cod have a narrower spawning window of September to December. • Small freshes (SF2) are required for nesting species (e.g. Murray cod and freshwater catfish). Preventing rapid drops in water level (that exceed natural rates of fall) during, and for a minimum of 14 days after spawning is important for preventing fish nests from drying. • Recruitment is enhanced by an immediately following secondary flow pulse (large fresh, bankfull or overbank) for dispersal and access to nursery habitat in low-lying wetland and billabong habitats.

Ecological objective	Important flow regime characteristics[27]
	• Overall, riverine specialists prefer hydraulically complex flowing streams containing submerged structures (snags and benches) that provide cover and spawning habitat. Flow variability through the delivery of small and large freshes, bankfull and overbank flows enhances the availability of diverse habitat, enhances growth and condition of larvae and juveniles and provides connectivity for dispersal between habitats.
NF6: A 25% increase in abundance of mature (harvestable sized) golden perch and Murray cod	The flow requirement of golden perch (flow pulse specialist) and Murray cod (riverine specialist) are outlined above under NF4 and NF5, respectively. An increase in mature (harvestable size) fish will be particularly dependant on recruitment success and supporting improved population structure. Baseflows (BF) support the maintenance of populations, while recruitment for both species benefits from fresh events and larger flows that boost productivity (bankfull, overbank and in some cases large freshes). Small and large freshes provide dispersal opportunities and access to sheltered and productive nursery habitat.
NF7: Increase the prevalence and/or expand the population of key short to moderate-lived floodplain specialist native fish species into new areas (within historical range)	These floodplain specialist fish spawn in low velocity habitats such as off-channel wetlands, billabongs, at stable low flows or edge habitat in-channel. The flow category most relevant for this objective varies with the landscape and habitat features of each planning unit. • Baseflow (BF1/2) is required for stable low flow spawning fish that require less than 10 cm fluctuation of a low flow for 7–21 days, with up to 60 days for recruitment (Kerr and Prior 2018). Spawning and recruitment flows for riverine specialists require a minimum of 24 days flow (DPI 2018a). • Small fresh, large fresh and bankfull flows (SF3, LF3, BK2) during the warmer months of October to April provide low velocity spawning habitat and productivity benefits to support fish growth. These flows should inundate habitats for at least 10 days to allow for egg development and occur at least 5 years in 10, with a maximum inter-event period of 4 years. This period will depend on the persistence of off-channel habitats and time between reconnection to mainstem waterways. Flows should be of a long enough duration to support isolated populations. Water temperatures should be above 22°C. The flow category required to connect with off-channel and other low velocity habitat varies with the landscape features in each planning unit. • Recruitment is enhanced by subsequent flows events that boost productivity (large fresh, bankfull, anabranch connecting or overbank flows) 2–4 weeks after spawning flows. Most floodplain specialist species require spawning and recruitment every 1–2 years for population survival.
NF8: Increase the prevalence and/or expand the population of key moderate to long-lived riverine specialist native fish species into new areas (within historical range)	Flow requirements of riverine specialists are outlined for NF5. A small fresh or greater is required to enable movement and increased distribution of these species. This can occur any time of the year for a minimum duration of 10 days.

Ecological objective	Important flow regime characteristics[27]
NF9: Increase the prevalence and/or expand the population of key moderate to long-lived flow pulse specialists native fish species into new areas (within historical range)	Flow requirements of flow pulse specialists are outlined for NF4. Expanding populations into new areas will be particularly dependant on dispersal flows, particularly large freshes (LF1–3), bankfull (BK1) and overbank flows (OB1, OB2).
Native vegetation objectives[29]	
NV1: Maintain the extent and viability of non-woody vegetation communities occurring within and closely fringing channels	Non-woody, inundation tolerant plants occurring on the channel bed, banks, bars and benches require regular wetting and drying to complete their lifecycle. Variable size and duration of flows including baseflows, variable size freshes and bankfull flows throughout the year will promote diverse communities. Regular inundation will also encourage a dominance of native species over exotic species, as the latter tend to be less tolerant of inundation (Catford et al. 2011). Increased cover of non-woody, inundation tolerant vegetation on banks is likely to stabilise bank material and therefore reduce the risk of excessive bank erosion. • Baseflow (BF1 and 2): It is known that the same stable low flows that support stable low flow spawning fish, also support in-channel vegetation. Aquatic plants establish beds and increase in species richness at flows of up to 0.3 m/s, and then decline as velocity further increases (Kerr and Prior 2018). Ideal season is late winter and spring (Kerr and Prior 2018). • Small freshes in summer and autumn are important for replenishing soil moisture in riverbanks to ensure survival and maintenance. • Bankfull: Inundation of banks during late winter and early spring by freshes and bankfull flows is required to replenish soil moisture to promote growth during spring. Prolonged submergence of some amphibious species (especially if there are continuous high flows during the irrigation season) may have detrimental impacts on survival. • Large freshes and bankfull flows (LF3, BK1 and 2): Hydrological connection of anabranches and low-lying wetlands increases the diversity of plant species, with shallower, higher connectivity billabongs having more diverse niche habitats, such as muddy margins and greater recruitment (Reid et al. 2015). The natural pattern of connection with distinct wet and dry phases creates a mosaic of habitat and benefits wetland vegetation. This is particularly important for shallower off-channel habitats with greater vegetation diversity (Reid et al. 2015). The duration of connection and disconnection are also important factors in the movement of organic carbon and nutrients (McGinness 2007; McGinness and Arthur 2011).
NV2: Maintain the extent and viability of non-woody vegetation communities occurring in wetlands and on floodplains	A flow that inundates lignum at least every 18 months is ideal for high condition shrubs that are capable of supporting bird breeding (Thoms et al. 2007). Long periods of inundation, of between 3 and 7 months from late summer are preferable and may also support breeding of waterbirds (Brandis and Bino 2016). In between floods, drying is required for soil aeration and to preserve crack habitat (Casanova 2015).

[29] Important flow regime characteristics for all native vegetation objectives are based on Casanova (2015), Roberts and Marston (2011), and Rogers and Ralph (2011).

Ecological objective	Important flow regime characteristics[27]
	A flow that inundates lignum every 3–5 years will sustain shrubs in a lesser condition (Casanova 2015). After 7 years condition drops and regular (annual) watering is required for several years to regain condition (Casanova 2015). Overall it requires greater volumes of water to restore condition as opposed to a maintenance regime. Flood sequences, with multiple higher flow events within shorter timeframes provide sufficient wetting longer term (Leigh et al. 2010). In Border Rivers, non-woody vegetation is also found in wetlands and billabongs located along the anabranches and low-lying wetlands. A larger flow event will provide greater connection to wetlands and billabongs in anabranches (Reid et al. 2015). • Large fresh and bankfull flows (LF3, BK1, BK2) will support non-woody wetland vegetation instream and in some low-lying wetlands with low commence-to-flow thresholds. The pattern of connective flows influences the structure of wetland plant communities, with impacts to diversity and abundance (Reid et al. 2015). The required duration and frequency varies widely by species. Highly water-dependant, amphibious species such as water couch, spike-rush and cumbungi require inundation for 5–8 months, 8–10 years in 10. The maximum period between events is 2 years. • Large fresh or bankfull flows and above: To support non-woody, inundation-tolerant vegetation, habitat should be inundated for 2–8 months. Hydrological connection increases the diversity of plant species, with shallower, higher connectivity billabongs having more diverse niche habitats, such as muddy margins and greater recruitment (Reid et al. 2015). Small but frequent anabranch/low-lying wetland connection events (e.g. LF1–3, BK1–2) will be important for maintaining the extent and viability of these species. • Small and larger overbank flows (OB1 and OB2) will support amphibious damp species such as floodplain herbs, grasses and sedges that require less frequent (3–10 years in 10) and shorter duration (2–4 months) inundation.
NV3: Maintain the extent and maintain or improve the condition of river red gum communities closely fringing river channels	• Large freshes and bankfull (BK1): River red gum fringing river channels will be supported by this range of flows, which inundate the upper channel and can wet the root zone of fringing riparian vegetation. Flows that recharge alluvial aquifers and soil moisture in the riparian zone are also important for maintaining deep rooted vegetation between inundation events. • Overbank (OB1): A small overbank that inundates river red gum to a depth of 20–30 cm for 4–6 weeks is required for recruitment (Casanova 2015). The most beneficial timing is between August and December to coincide with flowering. The maximum interflow spell is 7 years with a frequency of every 3 years preferable (Casanova 2015). Longer spells lead to loss in condition (Casanova 2015). A follow-up flood or local rainfall to supply soil moisture in the following spring or early summer will assist survival of seedlings (Roberts and Marston 2011). • Overbank (OB2): Vigorous growth of river red gum woodlands requires flooding every 2–4 years, with inundation persisting for 2–4 months. This longer duration of inundation is more likely to occur during larger events, or when small overbanks are clustered (i.e. more than one event in a short period) as in (BK2) in low-lying areas.

Ecological objective		Important flow regime characteristics[27]
NV4: Maintain the extent and maintain or improve the condition of native woodland and shrubland communities on floodplains	NV4a and NV4b: River red gum woodland	Maintaining the condition of river red gum forests and woodlands on the floodplain requires overbank flows that inundate vegetation for between 2 and 7 months during September to February. • Overbank (OB1): For river red gum communities located on lower parts of the floodplain, inundation needs to occur every 2–4 years with a maximum period between events of 4 years. • Overbank (OB2): Maintenance of river red gum communities located higher on the floodplain requires larger overbank events, but these can occur less frequently; a little more than once in 10 years, with a maximum inter-event period that is no more than natural. It is likely that river red gum persisting further from the main channel may be supported by rainfall and groundwater.
	NV4c: Black box woodland and NV4d: Coolibah woodland	• Overbank (OB1 and OB2) are required to create conditions for germination and maintain condition of coolibah and black box, with recruitment following flood recession (Casanova 2015). Flood duration of 4 weeks is ideal, unless seedlings are less than 2 months of age (Casanova 2015). Recession of floodwaters from September to February is considered most favourable for germination, with a follow-up flood or local rainfall increasing survival of seedlings. Ideal frequency is one in 3–7 years, with a critical spell duration of 10 years (Casanova 2015).
	NV4e: Lignum shrubland	The condition of lignum is strongly related to flood frequency and duration of inundation. Once condition is lost, it requires additional flows to restore. The flow category required to inundate lignum depends on its location in the landscape with low-lying areas inundated at bankfull and higher areas requiring overbank flows to connect. • Large fresh and bankfull (LF3, BK1–2): Maintaining past inundation patterns of billabongs and wetlands located along the anabranches will ensure the continued survival of lignum in these parts of the landscape. Regeneration requires more frequent inundation (ideally annual), for 1–12 months between August and March (September to February for vegetative expansion). • Overbank (OB1 and OB2) flows can inundate wetlands to maintain lignum shrublands and coolibah wetland woodland. Inundation is required for 3–7 months at a frequency of 5–10 years in 10 and a maximum period between events of 5 years (OB1).
 **Waterbird objectives[30]**		
WB1: Maintain the number and type of waterbird species		A variety of foraging habitat including deep pools, muddy edges and riparian vegetation is maintained by a range of flows from very low flow and above. Dry spells no greater than experienced historically are required to support refugia during drought. Breeding requires inundation of lignum, reeds and cumbungi and forested wetlands with tree hollows at least every 1–2 years. Ideal duration is between 2 and 6 months, depending on the species. Small overbank events in summer are ideal, with opportunistic breeding in autumn and spring. • Baseflows (BF1–2) that create muddy edges may be favourable for shorebirds. • Bankfull (BK1–2): Riparian and low-lying wetland vegetation condition is needed for foraging and breeding habitat. This requires

[30] Important flow regime characteristics for all waterbird objectives are based on Brandis (2010), Brandis and Bino (2016), Rogers and Ralph (2011), and Spencer (2017).

Ecological objective	Important flow regime characteristics[27]
	bankfull or greater flows, as defined in the native vegetation objectives. At these flow rates, the inundation of anabranches may create deep pools that can serve as refugia in drier times. • Bankfull (BK1–2): Regular connection of off-channel habitat creates a complex mosaic of semi-permanent and permanent waterholes. These billabongs can retain water for several years providing drought refuge for waterbirds and other fauna during extended periods of low flow (Reid et al. 2012). High connectivity billabongs below Goondiwindi have commence-to-flow thresholds of 7,000 ML/d at Goondiwindi, with these flows having an average recurrence interval of one year, while low connectivity billabongs may require overbank flows of up to 60,000 ML/d (Reid et al. 2015). • Overbank (OB1): Overbank flows will increase foraging and breeding area, with longer duration providing greater benefit to vegetation, waterbird condition and potential for breeding. These floods are required at least every 5 years (Brandis and Bino 2016). Overbank and wetland inundating flows, preferably in spring–summer, that inundate a mosaic of floodplain habitats including non-woody floodplain vegetation, open shallow waterbodies, and deep lakes and lagoons, will provide feeding habitat for a range of waterbird species including open water foragers, herbivores, emergent vegetation-dependent species, large waders, wetland generalists and small waders (including migratory shorebird species). Where there is gradual drawdown of habitats over late summer–autumn this can extend feeding habitat available for migratory and resident shorebird species (small waders). • Overbank (OB2): A larger overbank event will increase foraging and breeding area, with longer duration providing greater benefit to vegetation, waterbird condition and potential for breeding (Brandis and Bino 2016).
WB2: Increase total waterbird abundance across all functional groups	As in WB1, provide seasonal (spring–summer) flooding with gradual drawdown over summer into autumn to provide feeding habitat for waterbird species and maintain the condition of waterbird breeding and feeding habitats (WB5). • Bankfull (BK1–2): Regular connection of off-channel habitat and low-lying wetlands creates a complex mosaic of semi-permanent and permanent waterholes. These billabongs can retain water for several years providing drought refuge for waterbirds and other fauna during extended periods of low flow (Reid et al. 2012). High connectivity billabongs below Goondiwindi have commence-to-flow thresholds of 7,000 ML/d at Goondiwindi while low connectivity billabongs may require overbank flows of up to 60,000 ML/d (Reid et al. 2015). • Overbank flows (OB1–2) at the same time as those to neighbouring catchments provide benefits to waterbird populations by providing habitat across a larger area of the Murray–Darling Basin. Follow-up overbank and wetland inundating flows (OB1–2, AC1–2) in years following large breeding events in the other catchments may also promote the survival of juvenile birds and contribute to increased waterbird populations. Increasing total waterbird abundance will also rely on maintaining (and in some cases) improving the condition of key native vegetation types that provide breeding and foraging habitats (see WB5). In the Border Rivers these include river red gum, river cooba, common reed, lignum and cumbungi. Overbank and wetland inundating flows are critical to maintaining the extent and condition of these breeding habitats (see WB5 for more details).

Ecological objective	Important flow regime characteristics[27]
WB3: Increase opportunities for non-colonial waterbird breeding	• Breeding habitat includes lignum, reeds and cumbungi, and sometimes flood-dependent trees standing in water. Large fresh (LF1–3), bankfull (BK1–2) and small overbank (OB1) flows that connect anabranches may create deep pools and provide appropriate conditions. • Overbank (OB1–2) flows will increase foraging and breeding area, with longer duration providing greater benefit to vegetation, waterbird condition and potential for breeding (Brandis and Bino 2016).
WB5: Maintain the extent and improve condition of waterbird habitats	Riparian and low-lying wetland vegetation condition is needed for foraging and breeding habitat. This requires bankfull flows, as defined in the native vegetation objectives. Waterbirds depend on a wide variety of breeding and foraging habitats, which are maintained through a range of bankfull (BK1–2) and overbank flows (OB1–2). Important habitat includes sites that provide nesting habitat consisting of river red gum, river cooba, belah, lignum and/or cumbungi. Flows of sufficient duration are needed to maintain the extent and condition of these vegetation communities across the catchment. This ensures sites are in event-ready condition when large overbank events (OB1–2) initiate large-scale colonial waterbird breeding events across the wider Murray–Darling Basin. Bankfull (BK1–2) and overbank flows (OB1–2) will also support a broader range of foraging habitats in the Border Rivers, including spike-rush sedgelands, marsh grasslands, lignum shrublands, open lagoons and lakes. The required duration and frequency of overbank flows to support these vegetation types are outlined under the native vegetation objectives.
Priority ecosystem functions objectives[31]	
EF1: Provide and protect a diversity of refugia across the landscape	• Cease-to-flow periods of durations that are not longer than the persistence of water of sufficient volume and quality in key larger river pool refuges is vital for survival of native plants and animals. No increase in the duration or frequency of cease-to-flow periods of less than 10 ML/d at Mungindi (CEWO 2018), as compared to historical. Small flows can replenish pools while a larger event may be required to end an extended dry period. Further work is required to identify higher habitat variability and quality refuge pools (DPI 2015b; DPI 2018a). • Very low flows (VF) can maintain the volume of in-channel pools as refugia for native fish and other biota, minimising the loss of pools. These flows are unlikely to improve water quality. • Baseflow (BF1–2): The flow rate used to replenish pools needs to be of sufficient velocity and for sufficient duration to de-stratify the pools. In lowland areas (e.g. below Goondiwindi) a flow above 0.3–0.5 m/s for 12 days de-stratifies pools and minimises risk of blue-green algae outbreaks. Algal blooms are more likely in October to March and if thermal stratification persists more than 5 days (Mitrovic et al. 2003). Baseflows are required every year for most of the year (no less than natural) and are especially important during dry times. Water quality (e.g. DO, temperature and salinity) may inform timing and urgency of response.

[31] Important flow regime characteristics for all priority ecosystem function objectives are based on Alluvium (2010).

Ecological objective	Important flow regime characteristics[27]
	• Large fresh (LF1): When restarting flows after a cease-to-flow event, larger magnitude flows (e.g. large fresh or above) may be required to dilute poor water quality, and minimise the risk of ecological disturbances (such as fish kills) as water from the bottom of pools is mixed through the water column. • Large fresh (LF1–3): In cobble dominated riffle sections higher velocities of approximately 1.2 m/s scour and reduce filamentous algae (Davie and Mitrovic 2014). • Bankfull (BK1–2): Regular connection of off-channel habitat creates a complex mosaic of semi-permanent and permanent waterholes. These billabongs can retain water for several years providing drought refuge for waterbirds and other fauna during extended periods of low flow (Reid et al. 2012). High connectivity billabongs below Goondiwindi are inundated on average once a year while low connectivity billabongs should be inundated approximately every 4 years (Reid et al. 2015).
EF2: Create quality instream and floodplain and wetland habitat	The full range of in-channel and overbank flows are required to maintain quality instream and floodplain habitat. Variable in-channel flows (baseflows – bankfull flows) will provide a diversity of physical and hydraulic habitats. With increasing magnitude of flows, greater areas of the channel are inundated (e.g. benches, bars, snags and banks at different elevations in the channel). Baseflows and small freshes provide areas of slackwater (slow flowing) habitat, while large freshes provide deeper and faster flowing habitats. Small and large freshes are important for flushing fine sediment from pools, de-stratifying pools and maintaining geomorphic features such as benches and bars. Bankfull flows are important for geomorphic maintenance of all channel features. To protect banks from excessive erosion it is important to maintain rates of fall that do not exceed natural rates of fall for all regulated deliveries. Slow rates of fall allow water to drain from the bank slowly, reducing the risk of mass failure of the banks. Maintaining slow rates of fall is particularly important when flows are in the lower third of the channel, to protect the 'toe' of the bank, which supports the rest of the bank above. Rapid drawdown can cause excessive bank slumping, more likely in areas with higher pumping capacities. Rapidly rising river levels when banks are dry can also lead to bank slumping and erosion. This is particularly relevant in the regulated water source, prioritised to higher fragility reaches. Operation of weirs may also result in damaging rates of rise and fall if water is quickly released at the end of the irrigation season. Bank notching can be avoided by varying flows (avoiding holding flows constant for too many consecutive days) and targeting different peak heights for freshes. • Baseflows (BF1–2) are required to promote growth of in-channel vegetation, creating quality habitat. • Large fresh (LF): Higher velocities will scour, move sediment and maintain geomorphology of the channels. Flows greater than 80% of channel capacity for a minimum duration of 3 days with gradual rates of fall contribute to channel conservation (Gippel 2002). • Bankfull (BK1–2) and overbank flows (OB1–2) are required to provide essential floodplain and wetland habitat for native fish, waterbirds and other aquatic fauna.

Ecological objective	Important flow regime characteristics[27]
EF3: Provide movement and dispersal opportunities within and between catchments for water-dependent biota to complete lifecycles and disperse into new habitats	Providing longitudinal connectivity is critical for migration, recolonisation following disturbance events, allowing species to cross shallow areas, and dispersal of larvae to downstream habitats. In-channel flows of adequate depth and duration (baseflows and freshes) are important to allow for the movement of aquatic and riparian fauna and flora along rivers and creeks. For example, flows of at least 0.3 m are needed to allow medium sized native fish to move along a channel. The achievement of native fish objectives requires productivity flows for fish condition and movement of fish. A small fresh or greater is required to enable movement and increased distribution. • A small fresh or greater at each of the lower Macintyre River floodplain gauges and Mungindi is required for dispersal of fish into the NSW Border Rivers. A flow within one year of an LF2 in the Barwon–Darling is ideal. • Large fresh (LF): Upstream dispersal of fish requires drown out of physical barriers, such as dams and weirs. In the lower Macintyre there are known barriers at Boggabilla Weir (7,610 ML/d) and Goondiwindi Weir (4,330 ML/d) (DPI 2018a). These drown outs occur within the large fresh flow range. • Bankfull (BK) and overbank (OB1): Drown out of physical barriers is particularly important following major breeding events and to reconnect populations after dry times. The largest 2 barriers are thought to be Cunningham Weir at 44,500 ML/d and Glenarbon Weir at 26,200 ML/d both in planning unit Campbells and Camp creeks. Further upstream on the Dumaresq River, Bonshaw Weir has an estimated drown out of 19,300 ML/d (DPI 2018a). Glenarbon and Bonshaw Weir drown outs are within bankfull flows, while the Cunningham Weir is drowned out by small overbank flows.
EF4: Support instream and floodplain productivity	No increase in the cease-to-flow duration or frequency at Mungindi and Goondiwindi gauges to support downstream productivity. • Small fresh (SF), large freshes (LF1–3) and bankfull (BK1) flows may drive significant pulses of productivity that can maintain ecosystem function between overbank events. Carbon and nutrients are released when benches and higher-level in-channel surfaces are wet after a dry period. The rate of release peaks quickly (in the first day), and then tapers (Southwell 2008). Flows that target high-level surfaces provide particularly significant contributions to river productivity between flood events (McGinness 2007). • Large fresh (LF1–3) and bankfull (BK1–2) flows provide a significant pulse in productivity between overbank events. Productivity from the complex arrangement of anabranches in Border Rivers can sustain ecosystem functions between flood events (McGinness 2007). Productivity requires pulse connections, as opposed to continuous flows. Dry periods allow for organic matter to build up that can then release organic carbon when connected. Increased time between connections also increases the risk of blackwater (deoxygenated water) when flows reconnect (McGinness and Arthur 2011). • Overbank flows (OB1–2) that inundate the floodplain are the most critical flow categories for supporting large-scale productivity, which in turns drives aquatic food webs both on the floodplain and in-stream. Primary productivity includes growth of algae, macrophytes, biofilms and phytoplankton, which in turn drives secondary productivity (zooplankton, macroinvertebrates, fish larvae, etc.).

Ecological objective	Important flow regime characteristics[27]
EF5: Support nutrient, carbon and sediment transport along channels, and between channels and floodplains/wetlands	Freshes and bankfull flows are important for mobilising organic matter and sediment from in-channel surfaces (e.g. leaf litter that has accumulated on bars, benches and banks during low flows). This material is transported downstream or deposited in other parts of the channel where it is utilised, in the case of nutrients and carbon, to drive primary productivity, or in the case of sediment, for channel maintenance (e.g. to replenish banks and benches). • Bankfull (BK1–2) flows: Cycles of connection and disconnection create off-channel billabong refuges and lentic habitats (Mallen-Cooper and Zampatti 2018). No increase in the duration of anabranch cease-to-flow periods, as defined by the ratio of time below commence-to-flow thresholds to time above commence-to-flow thresholds, is required to maintain natural wetting and drying cycles, and associated nutrient processes. In turn, this may impact on plant diversity (Reid et al. 2015). Productivity requires pulse connections, as opposed to continuous flows. Dry periods allow for organic matter to build up that can then release organic carbon when connected. Increased time between connections also increases the risk of blackwater (deoxygenated water) when flows reconnect (McGinness and Arthur 2011). • Overbank flows (OB1–2) are essential for transferring nutrients and carbon from the floodplain to the channel. A larger overbank flood and above will provide greater connection between anabranches, billabongs, the floodplain and river, with increased nutrient transfer. A flushing flow at least every 8–10 years is expected to minimise build-up of organic carbon on the floodplains and limit the risk of blackwater events (McGinness 2007).
EF6: Support groundwater conditions to sustain groundwater-dependent biota	• Recharge to groundwater is more likely at higher flows when downwards pressure is greater. Large freshes (LF1–3), bankfull flows (BK1–2) and overbank (OB1–2) will contribute to recharging shallow groundwater aquifers in areas where there is a surface–groundwater connection. This recharge can reduce the salinity of shallow aquifers and raise water tables, providing critical soil moisture for deep-rooted vegetation in the riparian zone and on low-lying floodplains. • Overbank (OB2): A large overbank flood or greater allows recharge of groundwater-dependent ecosystems that are further from the river, and this may contribute to persistence of deep-rooted woody vegetation such as coolibah and black box.
EF7: Increase the contribution of flows into the Murray–Darling from tributaries; that is, into the Barwon–Darling from the Border Rivers catchment	• Hydrological connection: Total flow diversion is the most important threatening process. Australian studies on the percentage of flows required to maintain a low risk of environmental degradation report that between two-thirds and 80–92% of natural mean annual flow is required (Arthington and Pusey 2003). Hydrological connection occurs at very low flows and above (Mallen-Cooper and Zampatti 2015). The intergovernmental agreement (DPI 2008), Basin Plan and BWS all include considerations for long-term flow. The BWS is seeking to keep baseflows at least 60% of the natural level and an overall 10% increase of flows in the Barwon–Darling. Specific targets for Border Rivers include a 10–20% increase in freshes and bankfull events. To increase contribution of flows to the Barwon–Darling requires no loss in flows at Mungindi and Presbury gauges (end-of-system), Terrewah and Kanowna (inflows from QLD), and no loss in flows at end of planning unit gauges (contributing flows). Minimum volumes for hydrological connection are calculated at 60% of average annual flow pre-development (averaged modelled and observed). Future monitoring of hydrological connection may require assessment of a 5-year rolling average to account for climatic variation.

Ecological objective	Important flow regime characteristics[27]
	• Flows from the Border Rivers to provide movement and dispersal opportunities between catchments (see EF3) will also contribute to important EWRs in the Barwon–Darling WRPA. • Protecting overbank flows (OB1, 2) will also provide important flows and transfer nutrients and carbon from floodplains in the Border Rivers to the Barwon River.

4.4 Changes to the flow regime

Dams were built in the Border Rivers catchment in the 1960s and 1970s for flood mitigation and irrigation water supply to the plains. Since that time, river flows in the catchment have been highly regulated.

The major water storages are located in the headwaters of each of the major rivers and include Pindari Dam (312,000 ML capacity) located on the Severn River, the Glenlyon Dam (261,000 ML capacity) on Pike Creek, which connects to the Dumaresq River, and Coolmunda Dam (69,000 ML capacity) on the headwaters of the Macintyre Brook River for Macintyre Brook water users. System inflows are mainly regulated by Glenlyon and Pindari dams. Flows from these dams are regulated to Mungindi which is the downstream boundary of the Border Rivers region (Green et al. 2012). Glenlyon Dam on the Pike Creek, in the upper Dumaresq catchment, regulates 88% of inflows, and Pindari Dam on the Severn River (NSW) regulates 70% of inflows (MDBA 2021).

CSIRO (2007) calculated that for the Border Rivers, the average long-term water availability (under historical climate conditions) is around 1,208 GL/year. Of this amount, around 34% is extracted (around 411 GL/year) under development conditions. This is high compared with other catchments in the Basin (CSIRO 2008). The actual level of extractions and systems flows is highly variable from year to year, depending on volumes held in dams and then the natural flows in the system. In very high flows and/or flood years, the volumes extracted as a percentage of flows can be lower, while in other years the percentage can be higher; for example, if most flows are deliveries for irrigation from water storage dams.

There are also 15 main channel weirs constructed to assist in providing water for irrigation, urban, stock and domestic purposes, as well as numerous small weirs on tributaries and anabranch channels. This includes weirs at Bonshaw, Goondiwindi, Mungindi and Boggabilla. Boggabilla Weir located 20 km upstream of Goondiwindi was constructed in 1991 and is the largest of the main channel weirs. This is the main regulating structure for the lower sections of the Macintyre River, controlling flows during the main irrigation season from October to March.

Regulation of the river has had the greatest impact on the lowland region of the Border Rivers system, due to reduced flows and changes in the patterns and sizes of flows, with extractions, including floodplain harvesting reducing flows progressively towards the end of the catchment. Dams and weirs have also changed the timing and size of flows. Baseflows and small fresh-sized flows have increased in size and frequency in areas downstream of major dams and upstream of the major extraction points, while larger freshes and bankfull events have decreased in frequency. Timing of flows has shifted to the main periods of irrigation releases from October to February. Natural downstream flows are also reduced due to extraction under supplementary access licences or rules, and for overbank events from floodplain harvesting.

A shift towards using unregulated rivers for irrigation and water harvesting, including harvesting of on-farm overland flow, occurred in the 1990s with on-farm storage increasing. In 2007, on-farm ring tanks that pump floodwaters from a nearby watercourse accounted for around 40% of constructed storage capacity in the region (MDBC 2007).

There have been several studies investigating changes to parts of the flow regime:

- Crossman et al. (2011) found that water resource development has resulted in a decrease in the average frequency of flows that connect the lagoons and wetlands of the Macintyre River floodplain by around 22%, with an ~8% reduction in event volumes (Crossman 2011).
- High amounts of groundwater development around the Dumaresq River are likely to reduce future groundwater security for the Border Rivers Alluvium and the groundwater management units across the broader Border Rivers. This may have significant impacts to stream flows, with reductions of up to 9.6 GL/year, as over half of the groundwater recharge is from stream flows / river leakages (CSIRO 2007).
- Davies et al. (2012) for the Sustainable Rivers Audit found that hydrological condition at the Border Rivers audit sites declines from the upland zone upstream of regulation and diversion, through the slopes zone downstream of the storages, to the lowland zone. By the time most flows enter the Barwon–Darling downstream of Mungindi, the gross volume of annual flow and high flow events at the lowland zone are generally rated as ‘poor’ to ‘very poor’ condition.
- Gippel (2006) also undertook a comparison of flows under current (baseline) arrangements and natural (without-development) conditions. The analysis was based on flows predicted by IQQM (Integrated Quantity and Quality Model) for an 80-year period between 1922 and 2002 and indicated that based on modelled flows at Mungindi, there has been a significant change in bankfull flows in the Lower Border Rivers system as a result of water resource development.
- MDBA (2012b) analysis of modelled flow data for 1895–2009 at Goondiwindi and Mungindi showed that when compared with flow patterns at Goondiwindi, a significant alteration of flows under baseline (current) conditions is apparent for predicted flows at Mungindi when compared to pre-development conditions. The impact of development on flows at Mungindi has been to reduce average daily flows throughout the year, with a less defined seasonal peak.

Planning units and gauges upstream of major water storages, or in tributaries, can be impacted by unregulated licences and other factors that can impact on inflows. Planning units downstream of major water storages and weirs can also be impacted by the operation of such infrastructure and water delivery patterns. Further analysis of the observed flow data is required to determine if the EWRs are being impacted by insufficient flow volumes, duration of flow events, seasonality of flow events or some other factor.

4.5 Planned and held environmental water in Border Rivers

The following describes the planned and held environmental water arrangements as per the existing WSPs. Any currently proposed revisions to these plans, such as changes to the long-term average annual extraction, are not reflected in the details below. If/once these changes to the WSP are confirmed, this section of the LTWP will require updating, along with any subsequent changes to the risks, constraints and/or potential management strategies.

Water resources in the NSW Border Rivers catchment are managed under 2 WSPs:

- Water Sharing Plan for the NSW Border Rivers Regulated River Water Source 2021 (WSP 2021)
- Water Sharing Plan for the NSW Border Rivers Unregulated and Alluvial Water Sources 2012 (WSP 2012).

4.5.1 Planned environmental water (PEW)

PEW is committed by the WSP for fundamental ecosystem health or other specified environmental purposes. This applies generally, or at specified times, or in specified circumstances. This water is not able to be taken or used for any other purpose. The following rules in the regulated WSP define the PEW within that plan.

Continuous low flow rule

The continuous low flow rule is aimed at providing riparian flow, connectivity of downstream pools and riffles, and curtail problems associated with extended flow recession (WSP 2021). A minimum daily release of 10 ML is made from Pindari Dam, except when a greater volume is released to meet basic landholder rights and licensed extractions.

Translucency rule

This rule refers to the immediate release of specified inflows into the dam, intended to provide some reflection of the natural flows downstream of the dam to the point of the next significant inflow (from Frazers Creek near Ashford). It requires that:

- from September to May inflows into Pindari Dam are released, up to a limit of 50 ML/day unless a greater volume is released to meet basic landholder rights and licensed extractions
- from June to August inflows into Pindari Dam are released, up to a limit of 200 ML/day, unless a greater volume is released to meet basic landholder rights and licensed extractions.

Stimulus Flow rule

The Stimulus Flow rule is intended to provide a flow in the river that mirrors a naturally occurring hydrograph, add benefit to any translucency environmental health releases, provide targeted pre-season cues to fish breeding, and regularly wet and inundate the interconnected riparian areas primarily in the river downstream of Pindari Dam to the confluence with the Dumaresq and Macintyre rivers, after which the flow is no longer protected from extraction. This rule requires that at the start of each water year, 4,000 ML is set aside in Pindari Dam. To trigger release of the stimulus flow, an inflow to Pindari Dam of greater than 1,200 ML/day is required between 1 April and 31 August. Water set aside but not released can be carried over to the next water year to a maximum of 8,000 ML. The timing, rate, volume and duration of the Stimulus Flow released is determined by DPE–BC, in collaboration with other stakeholders such as DPE–Water, Department of Primary Industries Fisheries (DPIF) and CEWO.

Mungindi flow rule

This flow rule is also outlined in the intergovernmental agreement (DPI 2008). Each year between 1 September and 31 March, take of uncontrolled stream flow is not permitted if, after taking into account stream losses, the uncontrolled stream flow would result in a flow in the Barwon River at Mungindi of 100 ML/day or less (WSP 2021).

Cease-to-pump rules

Water for the environment is protected in unregulated water sources through licence volumes and conditions, such as access restrictions on days when flows are low. This is achieved by establishing cease-to-pump rules that require users to stop taking water when flow declines below a set level. Currently, in rivers and creeks, users must cease-to-pump when there is no visible flow at the pump site. In pools, pumping is not permitted when the water level is lower than its full capacity.

4.5.2 Held environmental water (HEW)

HEW is the water that is committed by the conditions of access licences for specified environmental purposes. In the WSP it is termed ‘adaptive environmental water’. Currently NSW does not have any environmental water holdings in the NSW Border Rivers, while the Commonwealth Environmental Water Holder holds 39,769 ML of entitlements (as at February 2022) across the NSW and QLD Border Rivers, with a long-term average annual yield of 15,283 ML. The Northern Basin Review recommended further water recovery in QLD Border Rivers and NSW Border Rivers to reach total reductions of 29 GL in QLD and 7 GL in NSW. Full recovery of these volumes has the potential to significantly contribute to achievement of NSW Border Rivers EWRs.

5. Risks, constraints and strategies

The Border Rivers LTWP is focused on managing water, where possible, to maximise ecological outcomes in a heavily modified landscape. There are a number of factors that could potentially impact how the plan is implemented, or how the environment responds to management under this plan. These are either risks to river and wetland health, or constraints on our capacity to manage water in the most appropriate and effective way.

The DPIE–Water risk assessment for the NSW Border Rivers (DPIE–Water 2019a) was undertaken to inform water resource planning in the NSW Border Rivers. It identifies risks to areas of conservation value based on the degree of hydrological change, and several areas at high risk of insufficient water. This chapter complements that risk assessment and addresses the specific risks and constraints that may affect the implementation of the LTWP.

This chapter focuses on risks to meeting the EWRs of priority environmental assets and functions in the NSW Border Rivers catchment (Table 12). It also outlines the risks and constraints that affect our capacity to achieve the ecological objectives of this LTWP (Table 13). This risk assessment has assisted with identifying investment opportunities for improving the likelihood that EWRs can be achieved in the short and long term (Table 26).

Figure 17 Boomi Regulator
Photo: E Wilson

5.1 Risks and constraints to meeting environmental water requirements

Table 12 Risks and constraints to meeting EWRs in the NSW Border Rivers catchment and strategies to address them

Type of risk	Description or example of risk	Potential impact(s)	Potential management strategies	Potential project partners
Insufficient water for the environment	There is a relatively small volume of HEW. There is a small volume of PEW associated with the Pindari stimulus flow. This is only protected from Pindari Dam to the confluence with the Dumaresq and Macintyre rivers.	Many EWRs cannot be met with existing planned and held environmental water. Any further development of water storages is likely to further exacerbate this current shortage of water. Associated objectives are unlikely to be achieved.	No reduction in PEW, explore options for additional water recovery and protect natural inflows from unregulated tributaries	DPE–BC, DPE–Water and CEWO
	Flows in NSW Border Rivers are influenced by rainfall, flows and extraction in QLD.	Increased take from unregulated rivers in QLD, such as the Weir River and Boomi River will reduce flows in the lower floodplain area of NSW Border Rivers. Flows in anabranches and ephemeral streams in the floodplain are at risk. Inflows from QLD are managed under the 2008 NSW–QLD Border Rivers intergovernmental agreement and *NSW–QLD Border Rivers Act 1947*. The current business plan for the Border Rivers Commission (BRC) is to shift responsibilities to each state's respective water infrastructure managers. Mechanisms for compliance and accountability remain unclear.	Ensure transparent public reporting of flows and extraction in both QLD and NSW	BRC, NRAR

Type of risk	Description or example of risk	Potential impact(s)	Potential management strategies	Potential project partners
	The most recently available General Purpose Water Accounting Report for NSW Border Rivers identifies 855 GL of unaccounted difference between inflows and extraction in the catchment in 2016–17 (Burrell et al. 2018).	The unaccounted difference between inflows and extraction is after system 'losses' such as rewetting and evaporation are accounted for. The volume in 2016–17 is approximately 10 times higher than the previous year. The unaccounted difference represents less PEW (water not extracted under licence) and less water available for downstream catchments.	Refer to the Natural Resources Access Regulator (NRAR) water compliance policy and strategy	NRAR
	Inadequate commence and cease-to-pump rules in unregulated water sources can place pools at risk and limit the volume that tributaries are able to provide to downstream environments.	There is potential for direct impact on ecosystem functions objectives, and also fish objectives including those pertaining to purple-spotted gudgeon and other threatened species.	Investigate extent of impact and explore options such as changes to rules, improved metering and trade out of high risk areas	DPE–BC and DPE–Water
Take of environmental water delivery	The likelihood of water loss is related to the pressure for consumptive water and a perceived lack of monitoring and/or enforcement of water extraction conditions.	This may prevent flows from reaching the flow thresholds and event duration required by EWRs, and subsequently prevent objectives from being achieved.	Refer to the NRAR water compliance policy and strategy	NRAR
Knowledge gaps and uncertainties	There are significant knowledge gaps in the Border Rivers, including: • relationship between ground and surface water • location of high quality habitat drought refugia • location and watering needs of cultural assets • ongoing fish tagging to monitor movement of species and populations • confirmation of flow requirements of stable low flow spawning fish.	As regionally specific knowledge is gained, revision to the objectives and EWRs will be required.	As funding permits, undertake research activities such as habitat mapping and monitoring of LTWP outcomes	DPE–BC, DPIF

Type of risk	Description or example of risk	Potential impact(s)	Potential management strategies	Potential project partners
Floodplain structures and barriers	Construction (e.g. levees, diversion channels, sediment blockage of culverts) has caused barriers to delivering water to wetland and floodplain areas. These will be identified by the hotspots project.	Changes to overland flows that redirect water away from environmental assets may limit achievement of native vegetation, waterbird and functions objectives associated with overbank EWRs.	Implement the Border Rivers Floodplain Management Plan and if funding permits, undertake remedial work	DPE–Water, DPE–BC
Instream barriers and structures	The largest 3 barriers are thought to be Cunningham Weir with a drown out of 44,500 ML/d, Glenarbon Weir with a drown out of 26,200 ML/d and Bonshaw Weir with a drown out of 19,300 ML/d. Upstream fish movement is limited by these structures and sections are only connected during bankfull flows.	This directly limits the dispersal of fish across the whole of the Border Rivers after major breeding events and dry spells. Remediation to add suitable fish ways would enable this objective to be achieved at lower flow rates.	Refer to NSW DPIF Fish for the Future: Action in the Northern Basin – NSW proposal for Northern Basin Toolkit (DPI 2017). Seek funding to remove barriers	DPIF
			Remove priority illegal barriers	NRAR
Take of environmental water delivery	The likelihood of water loss is related to the pressure for consumptive water and a perceived lack of monitoring and/or enforcement of water extraction conditions.	This may prevent flows from reaching the flow thresholds and event duration required by EWRs, and subsequently prevent objectives from being achieved.	Refer to the NRAR water compliance policy and strategy	NRAR
Insufficient channel capacity	In some catchments there is insufficient channel capacity for both environmental water and consumptive water delivery. Given that the volume of environmental water held in Border Rivers is minimal, it is unlikely this constraint is present.	Considered unlikely. Further investigation is needed to determine if this constraint is relevant and its potential impacts.	Investigate extent of risk and explore options for addressing	DPE–BC

Type of risk	Description or example of risk	Potential impact(s)	Potential management strategies	Potential project partners
Insufficient release rates from storages	The maximum daily release from storages may not be sufficient to create events that peak in higher flow categories, such as large fresh and bankfull flows.	This would prevent achievement of certain EWRs.	Coordinate dam releases with unregulated tributary flows to promote higher peaking events	DPE–BC and CEWO
			Ensure no further development of unregulated tributaries, including no further construction of dams	DPE–Water and WaterNSW
Unsympathetic river operations	In drier times block releases are used to deliver consumptive water. These blocks can cause unnatural rates of rise and fall, short pulses in flow that do not meet durations required for EWRs, or extended periods of steady flow that lack the cues for ecological responses such as spawning. The extent to which block releases are limiting the achievement of EWRs or causing negative environmental impacts requires further investigation.	There is potential for direct impacts on ecosystem functions objectives and the durations of EWRs.	Investigate extent of risk and explore options for increasing environmental effectiveness of consumptive water releases	DPE–BC and WaterNSW
	Inappropriate rate and timing of release can mean that river levels rise and fall rapidly.	This directly impacts on achievement of some ecosystem functions objectives.		

5.2 Non-flow related risks and constraints to meeting Long Term Water Plan objectives

The risks and constraints to meeting the ecological objectives include external factors that could potentially impact on achieving the targets outlined in this plan. These may be water related, such as cold water pollution downstream of major water storages (DPI 2015a); or consequences of inappropriate land-use practices, such as the reduction of groundcover over large areas in upper catchments and the clearing of native vegetation. While managing these risks and constraints is outside the scope of this LTWP, they have been included to draw attention to their influence on river and wetland health, and to highlight the importance of linking this LTWP with natural resource management.

Table 13 Risks and constraints to meeting ecological objectives in the Border Rivers catchment

Type of risk	Description or example	Potential impact(s)	Potential management strategies	Potential project partners
Unsuitable water quality / poor water quality	Water quality affects the ecology and survival of aquatic organisms. Unfavourable water quality can be caused by natural processes, such as during hypoxic blackwater events after dry or low-flow periods. This occurs from the build-up of organic material in channels and on floodplains and leads to low DO levels and potential fish kills. Total nitrogen, total phosphorus, DO, pH and turbidity have been assessed at 12 monitoring stations, with a medium or high likelihood on at least one of these parameters reported at 5 stations. Salinity was rated as a high likelihood (only assessed at Mungindi). Blue-green algae likelihood is high at Pindari Dam, on the Severn River downstream of Pindari and the Macintyre River at Boggabilla. Glenlyon Dam is also prone to blue-green algae.	Poor water quality may reduce ecosystem resilience to disturbances and reduce the extent of ecological response from watering. The ideal season for EWRs that pertain to fish spawning is the warmer months of spring–summer. The use of HEW may be limited to less ideal timings, such as autumn and winter, to minimise risk of fish kills associated with turnover of stratified pools in summer. Potential direct and indirect impacts on the objectives. Recovery may require increased frequency of environmental flows to encourage species recruitment and a return to stable populations.	Implement recommendations detailed in the water quality management plan and the incident response guide (DPIE–Water 2019b, c) to promote prevention of water quality incidents.	DPE–BC and DPE–Water

Type of risk	Description or example	Potential impact(s)	Potential management strategies	Potential project partners
Poor condition of water-dependent ecosystems	There are non-water related factors impacting on the condition of water-dependent ecosystems. This includes land management practices, native vegetation clearing, invasive species and erosion.	Poor condition of ecosystems may reduce ecosystem resilience to disturbances and reduce the extent of ecological response from watering. A higher frequency of environmental watering and reduced spell duration between events may be required to enable recovery.	Encourage improvement in land management	LLS with landholders
			Implement the *Local Land Services Act 2016* and *Biodiversity Conservation Act 2016* (BC Act)	DPE–BC, LLS, Biodiversity Conservation Trust (BCT), DPE–Water
Altered hydrograph due to climate change	Increased extremes of temperature and rainfall may increase the flashiness of flows and reduce the persistence of water in inundated areas. Longer and more frequent cease-to-flow periods, coupled with increased dry sequences may put pressure on maximum interflow periods and increase demand for environmental water.	It may become more difficult to meet the minimum durations of EWRs, particularly in unregulated streams. Frequencies of EWRs in moderate and wet conditions may need to increase to enhance ecosystem recovery and sufficient resilience for dry times.	No further construction of regulating structures on unregulated tributaries. Revision of pumping rules may be required	DPE–Water
			Monitor changes and adjust use of HEW and PEW in response	DPE–BC
Knowledge gaps and uncertainties	There are significant knowledge gaps in the Border Rivers, including: • relationship between ground and surface water • location of high quality habitat drought refugia • location and watering needs of cultural assets • ongoing fish tagging to monitor movement of species and populations • confirmation of flow requirements of stable low flow spawning fish.	As regionally specific knowledge is gained, revision of the objectives and EWRs will be required.	As funding permits, undertake research activities such as habitat mapping and monitoring of LTWP outcomes	DPE–BC and DPIF

Type of risk	Description or example	Potential impact(s)	Potential management strategies	Potential project partners
Social willingness and adequacy of governance structures	Community acceptance and support for a healthy environment is important for the achievement of this LTWP. Establishment of a regional body to provide local knowledge is needed for regionally specific water management and ownership. Social understanding and acceptance of environmental water will also promote protection of environmental water.	A lack of social willingness for environmental protection may increase the need for compliance actions. Local knowledge may improve development of appropriate management strategies to achieve the EWRs and associated objectives.	Establish mechanisms for gaining regional input to environmental water decisions to build knowledge and understanding and foster ownership	DPE–BC and DPE–Water
Floodplain structures and barriers	Construction (e.g. levees, diversion channels, sediment blockage of culverts) has caused barriers to delivering water to wetland and floodplain areas. These will be identified by the hotspots project.	Changes to overland flows that redirect water away from environmental assets may limit achievement of native vegetation, waterbird and functions objectives associated with overbank EWRs.	Implement the Border Rivers Floodplain Management Plan and if funding permits, undertake remedial work	DPE–Water and DPE–BC
Fish entrainment	Native fish can be removed, injured or killed when sucked into irrigation pumps	This directly impacts on all the native fish objectives. Mortality or removal of native fish due to entrainment places additional pressure on successful spawning and recruitment events to maintain populations.	Refer to the fisheries management plan for screens on pumps	DPIF and DPE–Water
Land management practices	Grazing practices can alter soil cover and damage native vegetation cover. Cropping practices can cause soil degradation and alter soil cover. Land degradation and erosion can impact the geomorphology of channels. Water runoff and water quality can also be impacted.	Potential impacts on the achievement of objectives, through indirect processes. Degradation of water quality and riparian zones may require increased frequency of environmental flows to enable the system to compensate.	Encourage improvement in land management	LLS with landholders

Type of risk	Description or example	Potential impact(s)	Potential management strategies	Potential project partners
Native vegetation clearing	Native vegetation clearing has direct impacts on vegetation objectives and the availability of waterbird habitat. Changes to riparian vegetation can impact on water quality, erosion rates and instream habitat.	Potential direct and indirect impacts on objectives. Native vegetation clearing may prevent achievement of native vegetation targets and objectives. Degradation of water quality and riparian zones may require increased frequency of environmental flows to enable the system to compensate.	Implement the Local Land Services Act and BC Act	DPE–BC, LLS, BCT, DPE
Invasive species	Invasive plants and pest animal species may invade watercourses, make use of water features and impact on habitat quality. For example, azolla outbreaks in the Severn River may blanket the water surface, reduce DO and result in ecosystem damage.	Potential direct and indirect impacts on objectives. Recovery from in-channel invasive species may require increased environmental flows. Impacts of invasive species may directly affect species populations and achievement of targets and objectives.	Encourage improvement in land management	LLS with landholders
			Monitor introduction and spread of invasive species. Implement the NSW Invasive Species Plan 2018–2021 (DPI 2018b)	LLS, DPE–BC, DPIF and DPI
Biosecurity	Flows and water-dependent biota can carry disease and toxins through the landscape. In cases such as the carp herpes this may be a positive outcome, in other cases this may cause significant loss of environmental values and assets.	Potential direct and indirect impacts on objectives. Recovery from disease may require increased frequency of environmental flows to encourage species recruitment and a return to stable populations.	Implement the NSW *Biosecurity Act 2015* and NSW Biosecurity Strategy	LLS, DPE–BC, DPIF and DPI
Cold water pollution	Cold water pollution was rated as a high likelihood for downstream of Pindari Dam, Glenlyon Dam and Coolmunda Dam in the risk assessment for the NSW Border Rivers WRPA (DPIE–Water 2019a). Cold water pollution from Pindari Dam extends to Boggabilla, and Glenlyon Dam cold water pollution extends to the junction with Macintyre Brook (Lugg and Copeland 2014)	Cold water limits achievement of objectives related to fish spawning and recruitment, due to metabolic changes in native fish and absent spawning cues. Flow events of sufficient volume and duration may be achieved but ecological responses may be prevented due to water temperature.	Implement the NSW Cold Water Pollution Strategy	DPE–Water and WaterNSW

Type of risk	Description or example	Potential impact(s)	Potential management strategies	Potential project partners
Dam stratification and destratification	In 2018, turnover (destratification) of Pindari Dam has resulted in large fish kills across all major fish guilds. At Glenlyon Dam, only minor fish kills of bony bream were reported.	This potentially impacts on all native fish objectives, creating additional pressure on successful fish spawning and recruitment to replace losses.	Monitor and explore opportunities for adaptive management of EWRs to encourage resilience	DPIF, DPE–BC and CEWO

5.3 Climatic change

Climate change is a key long-term risk to river, wetland and floodplain health. It will exacerbate the natural seasonal variability that exists in NSW, making it more difficult to manage our landscapes and ecosystems and the human activities that depend on them. The Murray–Darling Basin Sustainable Yields project investigated the potential impacts of climate change on water resources and flows to key environmental sites across the Basin, including the Border Rivers catchment (CSIRO 2007). The project predicts the following for the Border Rivers:

- 9% reduction in average annual runoff to rivers in the catchment by 2030 (best estimate median)
- 9% reduction in water availability and 12% reduction in end-of-system flows by 2030
- 26% increase in the average period between inundation events for the anabranches and billabongs of the Macintyre.

Best-available climate change projections for the New England and NSW North West indicate a significant change to climatic patterns in the future. The NARCliM model (scenario 2)[32] projects the changes shown in Table 14 by 2030 and 2070. See the 'More information' section for links to NARCliM projections.

There are uncertainties with these climate change projections, and the projected changes are unlikely to occur in isolation. Rather, they will occur alongside other changes owing to water resource development, land use, and environmental water management. Accordingly, it is currently unclear what impacts these changes will have on the environmental assets of the NSW Border Rivers catchment.

Table 14 Potential climate related risks in the New England and NSW North West

Potential risk due to climate change	Description of risk		NARCliM projection (scenario 2)	
			2020–39	2060–79
Change in rainfall	By 2030 there will be little change in annual rainfall. Rainfall will increase across the region during autumn. Rainfall will decrease across the region during summer and winter.	Summer	–3.3%	+9.8%
		Autumn	+14.9%	+16.8%
		Winter	–7.6%	–0.7%
		Spring	+2.6%	–0.7%
Change in average temperature	Mean temperatures are projected to rise by 0.7°C by 2030. The increases are occurring across the region, with the greatest increase during summer and spring.	Summer	+0.89°C	+2.28°C
		Autumn	+0.72°C	+2.20°C
		Winter	+0.48°C	+1.92°C
		Spring	+0.80°C	+2.33°C
Change in number of hot days (max. temp. >35°C)	Hots days are projected to increase across the region by an average of 7 days per year by 2030. The greatest increases are seen in the west of the region around Moree, with a projected 10–20 hot days per year.	Annual	+7.1	+23.4

[32] The NARCliM projections have been generated from 4 global climate models (GCMs) dynamically downscaled by 3 regional climate models (RCMs).

Potential risk due to climate change	Description of risk		NARCliM projection (scenario 2)	
			2020–39	2060–79
Change in number of cold nights (min. temp. <2°C)	Cold nights are projected to decrease by an average of 9 fewer days per year by 2030. The greatest decreases are seen around Glen Innes, which is projected to experience 10–20 fewer cold nights per year.	Annual	–8.8	–26.1
Bushfires – changes in number of days a year with FFDI>50[33]	Overall, severe fire weather is projected to increase (slightly) across the region by 2030. Increased severe fire weather is expected in the north-west part of the region during spring (the prescribed burning season) and summer (peak fire risk season).	Annual	+0.2	+0.9
Hillslope erosion	Changes are expected in soil erosion and rainfall erosivity. Soil organic carbon stocks are projected to decline to 2030.	Mean percent increase	10–20%	20–30%
Biodiversity	Species composition will likely be impacted by rising temperatures, increased fire frequency, changing fire regimes, storm damage and (potentially) drought.			

5.4 Strategies for mitigating climate related risks

WRPs and environmental water managers will need to adapt to changes in climate and flows when and if they occur. In striving to respond to the environmental demands of rivers, wetlands and floodplains, environmental water managers consider the range of priorities and strategies at their disposal on a 1–3-year timeframe.

Water managers currently examine the outcomes of climate change research and monitor outcomes against existing objectives and targets using real-time data, such as rainfall, to inform their understanding of the impacts of climate change at the catchment scale. This information will assist in answering questions such as:

- How will the volume of water stored in Pindari and Glenlyon dams be affected by climate change?
- How will water quality be affected by climate change?
- Will the flow pathways across the landscape change as our climate changes?
- Will the duration of floodplain inundation decrease due to higher evaporation rates, which will likely come with increased temperatures caused by climate change?
- How will changes in rainfall, runoff and evaporation impact soil chemistry in a changing climate?
- How will changes in weather attributed to climate change, including increased air temperatures, flow seasonality due to changes in rainfall or severe weather events, affect the plants and animals of the Border Rivers area and the wider Murray–Darling Basin?
- How will changes in consumptive water use influence the use of water for the environment?

[33] The Forest Fire Danger Index (FFDI) is used in NSW to quantify fire weather. It combines observations of temperature, humidity and wind speed. Fire weather is classified as severe when the FFDI is >50.

Environmental water managers will continue to respond to the environmental demands of rivers, wetlands and floodplains, considering the range of priorities and strategies at their disposal. Climate change will be another important variable in this decision-making process.

Figure 18 Dumaresq River, NSW Border Rivers
Photo L Cameron and J St Vincent Welch

6. Water management under different water resource availability scenarios

6.1 Prioritisation of ecological objectives and watering in regulated river reaches or those affected by regulated flows

In addition to the longer-term climate related risks outlined above, environmental water managers consider antecedent conditions and seasonal predictions. Environmental water managers consider a range of factors when determining where and when discretionary water for the environment should be delivered. Some of these considerations include the current condition of the plants and animals, the recent history of connectivity of river channels to their floodplain systems, rainfall history and predictions, and water availability (DECCW 2011). The EWRs, and specifically the maximum inter-event period, provide additional information to guide ecological demand and use of environmental water on a shorter-term basis.

Planning for the management of water-dependent environmental assets amid this variability means that plans must be adaptive. Watering activities need to range from building resilience and promoting ecological restoration by maximising environmental outcomes from flow events when water is abundant, to minimising losses or damage by maintaining drought refuges when resources become scarce. Ecological resilience can be gained through:

- maintaining healthy condition of water-dependent ecosystems, including species' populations
- maintaining environmental flows within the boundaries of wetting and drying cycles
- maintaining spell durations within tolerance thresholds to prevent irreversible change
- protection of refugia during drought and other disturbances
- facilitating repopulation and/or recolonization following drought or other disturbances
- minimising human-induced threats (e.g. invasive species, habitat fragmentation).

This section sets out a framework to help inform annual water management decisions in river reaches which are regulated or affected by regulated water. This information is presented in terms of a water resource availability scenario (RAS) as proposed by MDBA (2012b). In Tables 15–22 below each RAS is described in 2 tables covering:

- broad priorities to guide management under the particular scenario
- potential management strategies for achieving these priorities
- priority LTWP objectives for each scenario and target flow categories (marked with an X).

Some of the wording of the LTWP objectives has been adjusted to highlight the most relevant aspect of the objective under the scenario. For example, an LTWP objective that over 20 years seeks to 'improve' may only seek to 'maintain' under a dry scenario. Some of the objectives have been summarised or combined for better presentation. The full list of objectives can be found in Chapter 3. More information about RAS and how it is defined is outlined in Appendix B.

6.1.1 Water RAS: Very dry – protect

In very dry conditions, the broad priority of water management is to protect and avoid irretrievable damage, such as the critical loss of species, communities and ecosystems. This may require preventing or minimising unnaturally prolonged dry periods and the maintenance of refuges. The priority LTWP objectives, and if relevant, refocused objectives for very dry conditions are shown in Table 16.

Table 15 Broad management priorities and potential strategies for a very dry RAS

	Broad water management priorities	Key management strategies for consideration
Very dry	Avoid critical loss of species, communities and ecosystems Maintain refuges Avoid irretrievable damage or catastrophic events Avoid unnaturally prolonged dry periods between flow events Support targeted longitudinal connectivity within catchment for functional processes and a range of flora and fauna Prevent 2 consecutive years of extreme dry to core wetland areas	Focus on limiting exceedance of maximum inter-flow periods through the following strategies: • provide very low flows to replenish in-channel pools with high habitat value, particularly during and after a hot summer. This may require alternative watering actions (e.g. pumping) to support anabranch/floodplain habitats to ensure no loss of species for floodplain specialists (e.g. to prevent wetlands with threatened fish species from drying out) • explore options to maximise environmental outcomes from weir replenishment flows • explore options to maximise environmental outcomes from long block releases • review cease-to-pump rules in unregulated sections If a critical water shortage or similar critical incident restricts the use of water for the environment, DPE–BC as part of the Critical Water Advisory Panel, will work to minimise exceedances of maximum inter-flow periods for important areas.

Table 16 Priority LTWP objectives and target flow categories for a very dry RAS

Priority LTWP objective	Flow categories							
	Cease-to-flow	Very low flow	Baseflow	Small fresh[34]	Large fresh	Bankfull	Small overbank	Large overbank
NV1: Maintain the extent and viability of non-woody vegetation communities occurring within channels			X					
NV2: Maintain the extent and maintain the viability of non-woody vegetation communities occurring in wetlands and on floodplains					X	X		
NV3: Maintain the extent of river red gum communities closely fringing river channels						X		
NV4e: Maintain the extent of native woodland and shrubland communities on floodplains – lignum shrublands						X		

[34] Small freshes may be important and achievable in a very dry scenario to protect core wetland habitats and avoid critical habitat loss.

Priority LTWP objective	Flow categories							
	Cease-to-flow	Very low flow	Baseflow	Small fresh[34]	Large fresh	Bankfull	Small overbank	Large overbank
WB1: Maintain the number and type of waterbird species		X	X			X		
NF1: No loss of native fish species			X		X			
EF1: Provide and protect a diversity of refugia across the landscape	X	X	X		X	X		
EF2: Create quality instream, floodplain and wetland habitat	X	X	X			X		

6.1.2 Water RAS: Dry – maintain

In dry conditions, the broad management priority is to maintain environmental assets and ecosystem functions. This may include seeking to provide flow connectivity and movement opportunities for aquatic biota, enabling species to move to more favourable habitats and refuges. In these conditions management remains focused on limiting exceedance of maximum inter-flow periods, as opposed to maintaining the long-term ideal frequency of events. EWRs aimed at spawning may be in high demand if the boundaries of species' lifecycles are being tested, but otherwise creation of spawning events may be deferred until conditions are more favourable for recruitment. Similarly, objectives that seek to maintain habitat or refugia and require higher flows for anabranch connection and bankfull may not be triggered as requiring action if these flows have occurred prior to dry conditions and the associated EWRs are within maximum inter-flow periods. The priority LTWP objectives, and if relevant, refocused objectives for dry conditions are shown in Table 18.

Table 17 Broad management priorities and potential strategies for a dry RAS

	Broad water management priorities	Key management strategies for consideration
Dry	Support the survival and viability of threatened species and communities Maintain refuges Maintain environmental assets and ecosystem functions Avoid unnaturally prolonged dry periods between flow events Support longitudinal connectivity for functional processes and a range of flora and fauna Explore options for Stimulus Flow to provide a small fresh through the system Protect tributary inflows Review cease-to-pump rules in unregulated sections	Explore option for Stimulus Flow to provide a small fresh through the system Protect tributary inflows Review cease-to-pump rules in unregulated sections

Table 18 Priority LTWP objectives and target flow categories for a dry RAS

Priority LTWP objective	Flow categories							
	Cease-to-flow	Very low flow	Baseflow	Small fresh	Large fresh	Bankfull	Small overbank	Large overbank
NV1: Maintain the extent and viability of non-woody vegetation communities occurring within channels		X	X					
NV2: Maintain the extent and maintain the viability of non-woody vegetation communities occurring in wetlands and on floodplains					X	X		
NV3: Maintain the extent and the condition of river red gum communities closely fringing river channels						X		
NV4e: Maintain the extent and maintain the condition of native woodland and shrubland communities on floodplains – lignum shrublands						X		
WB1: Maintain the number and type of waterbird species		X	X	X		X		
WB2: Maintain total waterbird abundance across all functional groups		X	X	X		X		
WB5: Maintain the extent and condition of waterbird habitats						X		
NF1: No loss of native fish species			X	X				
NF2: Maintain the distribution and abundance of short to moderate-lived generalist native fish species				X				
NF3: Maintain the distribution and abundance of short to moderate-lived floodplain specialist native fish species				X	X			
NF4: Maintain native fish population structure for moderate to long-lived flow pulse specialist native fish species				X				
NF5: Maintain native fish population structure for moderate to long-lived riverine specialist native fish species				X				
NF7: Maintain the prevalence of key short to moderate-lived floodplain specialist native fish species in core population areas				X	X	X		
NF8: Maintain the prevalence of key moderate to long-lived riverine specialist native fish species in core population areas				X				
EF1: Provide and protect a diversity of refugia across the landscape	X		X	X				

Priority LTWP objective	Flow categories							
	Cease-to-flow	Very low flow	Baseflow	Small fresh	Large fresh	Bankfull	Small overbank	Large overbank
EF2: Create quality instream, floodplain and wetland habitat	X		X				X	
EF3a: Provide movement and dispersal opportunities for water-dependent biota to complete lifecycles and disperse into new habitats – within catchments					X			
EF4: Support instream and floodplain productivity	X			X			X	
EF7: Increase the contribution of flows into the Murray and Barwon–Darling from tributaries		X	X	X	X	X		

6.1.3 Water RAS: Moderate – recover

In moderate conditions, the broad management priority is to promote recovery of environmental assets and ecosystem functions. This includes enabling growth, reproduction and small-scale recruitment for a diverse range of flora and fauna. If moderate conditions are following a dry period, activation of low-lying off-channel habitat such as anabranches may be required to increased productivity. It may also be necessary to increase the number of events, to restore the longer-term frequency to ideal. If moderate conditions are following a wet period, productivity of the system may be sufficient due to recent floodplain connection. This may change the relative emphasis between objectives and flows required. In moderate conditions, particularly if following wet conditions, it may be possible to carry over water for use in dry years. The priority LTWP objectives for moderate conditions are shown in Table 20.

Table 19 Broad management priorities and potential strategies for a moderate RAS

	Broad water management priorities	Key management strategies for consideration
Moderate	Enable growth, reproduction and small-scale recruitment for a diverse range of flora and fauna Promote low-lying floodplain–river connectivity Seek to meet ideal event frequencies Support medium flow river and floodplain functional processes Support longitudinal connectivity within and between catchments for functional processes and a range of flora and fauna Support low flow lateral connectivity and end-of-system flows Set aside water for use in drier years	Management strategies for achieving these broad priorities will remain limited by the volume of HEW and PEW available: • explore options for Stimulus Flow to contribute to EWRs • continue cooperative water with Water NSW and CEWO to maximise outcomes from consumptive water deliveries and coordinated releases of HEW • consider carry over of HEW and PEW for drier times

Table 20 Priority LTWP objectives and target flow categories for a moderate RAS

Priority LTWP objective	Flow categories							
	Cease-to-flow	Very low flow	Baseflow	Small fresh	Large fresh	Bankfull	Small overbank	Large overbank
NV1: Improve the extent and viability of non-woody vegetation communities occurring within channels		X	X					
NV2: Increase the extent and viability of non-woody vegetation communities occurring in wetlands and on floodplains					X	X	X	
NV3: Maintain the extent and improve the condition of river red gum communities closely fringing river channels						X	X	
NV4c: Increase the extent and improve the condition of native woodland and shrubland communities on floodplains – black box woodland							X	
NV4d: Increase the extent and improve the condition of native woodland and shrubland communities on floodplains – coolibah woodland							X	
NV4e: Increase the extent and improve the condition of native woodland and shrubland communities on floodplains – lignum shrublands						X	X	
WB1: Maintain the number and type of waterbird species		X	X	X	X	X	X	
WB2: Increase total waterbird abundance across all functional groups					X	X	X	
WB3: Increase opportunities for non-colonial waterbird breeding					X	X	X	
WB5: Maintain the extent and improve condition of waterbird habitats					X	X	X	
NF1: No loss of native fish species			X	X	X	X		
NF2: Increase the distribution and abundance of short to moderate-lived generalist native fish species				X				
NF3: Increase the distribution and abundance of short to moderate-lived floodplain specialist native fish species				X	X	X	X	
NF4: Improve native fish population structure for moderate to long-lived flow pulse specialist native fish species					X			

Priority LTWP objective	Flow categories							
	Cease-to-flow	Very low flow	Baseflow	Small fresh	Large fresh	Bankfull	Small overbank	Large overbank
NF5: Improve native fish population structure for moderate to long-lived riverine specialist native fish species				X				
NF6: A 25% increase in abundance of mature (harvestable sized) golden perch and Murray cod				X	X			
NF7: Increase the prevalence and/or expand the population of key short to moderate-lived floodplain specialist native fish species into new areas					X			
NF8: Increase the prevalence and/or expand the population of key moderate to long-lived riverine specialist native fish species into new areas				X				
EF1: Provide and protect a diversity of refugia across the landscape	X	X	X		X			
EF2: Create quality instream, floodplain and wetland habitat	X	X	X			X		
EF3a: Provide movement and dispersal opportunities for water-dependent biota to complete lifecycles and disperse into new habitats – within catchments					X	X		
EF3b: Provide movement and dispersal opportunities for water-dependent biota to complete lifecycles and disperse into new habitats – between catchments			X	X				
EF4: Support instream and floodplain productivity	X			X		X	X	
EF5: Support nutrient, carbon and sediment transport along channels, and exchange between channels and floodplains/wetlands					X	X	X	
EF6: Support groundwater conditions to sustain groundwater-dependent biota					X	X	X	
EF7: Increase the contribution of flows into the Murray and Barwon–Darling from tributaries		X	X	X	X	X	X	

6.1.4 Water RAS: Wet – improve

In wet conditions, the broad management priority is to promote improvements in condition, increases in populations and population expansion of environmental assets and ecosystem functions. In wet conditions, natural events may provide lateral and longitudinal connectivity as larger volume events occur. The priority LTWP objectives, and if relevant, refocused objectives for wet conditions are shown in Table 22.

Table 21 Broad management priorities and potential strategies for a wet RAS

	Broad water management priorities	Key management strategies for consideration
Wet	Enable growth, reproduction and large-scale recruitment for a diverse range of flora and fauna Support longitudinal connectivity within and between catchments for functional processes and a range of flora and fauna Support high flow lateral connectivity and end-of-system flows Set aside water for use in drier years	Management strategies for achieving these broad priorities will remain limited by the volume of HEW and PEW available: • consider short-term versus longer-term environmental need for Stimulus Flow • continue cooperative water with WaterNSW and CEWO to maximise outcomes from consumptive water deliveries and coordinated releases of HEW • consider carry over of HEW and PEW for drier times

Table 22 Priority LTWP objectives and target flow categories for a wet RAS

Priority LTWP objective	Flow categories							
	Cease-to-flow	Very low flow	Baseflow	Small fresh	Large fresh	Bankfull	Small overbank	Large overbank
NV1: Improve the extent and viability of non-woody vegetation communities occurring within channels		X	X					
NV2: Increase the extent and maintain the viability of non-woody vegetation communities occurring in wetlands and on floodplains					X	X	X	
NV3: Maintain the extent and improve the condition of river red gum communities closely fringing river channels						X	X	
NV4c: Increase the extent and improve the condition of native woodland and shrubland communities on floodplains – black box woodland						X	X	X
NV4d: Increase the extent and improve the condition of native woodland and shrubland communities on floodplains – coolibah woodland						X	X	X
NV4e: Increase the extent and improve the condition of native woodland and shrubland communities on floodplains – lignum shrublands					X	X	X	X

Priority LTWP objective	Flow categories							
	Cease-to-flow	Very low flow	Baseflow	Small fresh	Large fresh	Bankfull	Small overbank	Large overbank
WB1: Maintain the number and type of waterbird species						X	X	X
WB2: Increase total waterbird abundance across all functional groups						X	X	X
WB3: Increase opportunities for non-colonial waterbird breeding					X	X	X	X
WB5: Maintain the extent and improve condition of waterbird habitats					X	X	X	X
NF1: No loss of native fish species			X	X	X	X	X	X
NF2: Increase the distribution and abundance of short to moderate-lived generalist native fish species				X				
NF3: Increase the distribution and abundance of short to moderate-lived floodplain specialist native fish species				X	X			
NF4: Improve native fish population structure for moderate to long-lived flow pulse specialist native fish species				X				
NF5: Improve native fish population structure for moderate to long-lived riverine specialist native fish species				X				
NF6: A 25% increase in abundance of mature (harvestable sized) golden perch and Murray cod				X	X	X	X	X
NF7: Increase the prevalence and expand the population of key short to moderate-lived floodplain specialist native fish species into new areas				X	X	X	X	
NF8: Increase the prevalence and expand the population of key moderate to long-lived riverine specialist native fish species into new areas				X				
EF1: Provide and protect a diversity of refugia across the landscape	X		X	X				
EF2: Create quality instream, floodplain and wetland habitat	X		X					X
EF3a: Provide movement and dispersal opportunities for water-dependent biota to complete lifecycles and disperse into new habitats – within catchments					X	X	X	
EF3b: Provide movement and dispersal opportunities for water-dependent biota to complete lifecycles and disperse into new habitats – between catchments					X	X	X	

Priority LTWP objective	Flow categories							
	Cease-to-flow	Very low flow	Baseflow	Small fresh	Large fresh	Bankfull	Small overbank	Large overbank
EF4: Support instream and floodplain productivity	X			X		X	X	X
EF5: Support nutrient, carbon and sediment transport along channels, and exchange between channels and floodplains/wetlands					X	X	X	X
EF6: Support groundwater conditions to sustain groundwater-dependent biota							X	X
EF7: Increase the contribution of flows into the Murray and Barwon–Darling from tributaries		X	X	X	X	X	X	X

6.2 Water management during extreme conditions and ecologically critical water quality incidents

The quantity and quality of water are important drivers of ecological processes and contribute to the overall health of a waterway. Physical and chemical properties such as temperature, pH, electrical conductivity, algal blooms, heavy metals, pesticides and DO affect the biology and ecology of aquatic plants and animals, especially when outside tolerable levels (Watson et al. 2009).

Insufficient water or water of poor quality can impact all water users, including water used for crops or livestock, recreational activities, and drinking. The responsibility for managing water to prevent or reduce the severity of water quality issues or during extreme conditions therefore lies with all users.

The effective management of water quality incidents relies on timely access to monitoring information at key sites and the identification of risk factors. Whilst environmental water may be used in certain instances to provide refuge habitat, there is insufficient environmental water to avoid, mitigate or offset water quality issues in NSW rivers, nor is it the responsibility of environmental water managers to do so. The NSW Extreme Events Policy (DoI 2018b) provides a framework for making decisions during extreme events. It is designed to facilitate early intervention and delay the need to suspend certain water sharing arrangements.

Table 23 and Table 24 describe critical water quality incidents and extreme conditions respectively, and recommended management strategies for environmental water managers. In these 2 instances, the management priorities of water managers are to:

1. avoid irretrievable damage or catastrophic events
2. avoid critical loss of species, communities and ecosystems
3. protect critical refuges
4. maximise the environmental benefits of all water in the system.

For a more detailed description of the roles and responsibilities for each critical incident stage, please refer to the incident response guide for the NSW Border Rivers Surface Water WRPA (DPIE–Water 2019c).

Table 23 Priorities and strategies for managing water during extreme conditions

Extreme condition description	Identifying features	Management strategies for achieving priorities
A critical drought and/or water shortage where only restricted town water supply, stock and domestic and other restricted high priority demands can be delivered	Very low to no natural or regulated flows resulting in disconnected pools Limited water held in storages Limited ability to deliver water for critical human needs WSP may be suspended	DPE–BC will develop priority environmental water needs in consultation with the key stakeholders to ensure these needs are considered in the management of all water Sustain critical in-channel refuge pools and core wetland areas Work with WaterNSW to protect, or if possible, provide very low flows or replenishment flows[35] to relieve severe unnatural prolonged dry periods and support suitable water quality in critical refuge pools[36]

Table 24 Priorities and strategies for managing water during critical water quality incidents

Critical water quality incident description	Identifying features	Management strategies for achieving priorities
Water quality does not meet Australian and New Zealand Guidelines for Fresh and Marine Water Quality, and is causing or is likely to cause significant impact on aquatic ecosystems[37]	Weir/refuge pools are stratified Water quality sampling and analysis demonstrates unfavourable conditions: • lack of DO[38] • unnatural change in temperature • unnatural change in pH • unnatural change in salinity • excess suspended particulate matter[39] • elevated levels of nutrients[40] • chemical contamination[41]	DPE–BC will develop priority environmental water needs in consultation with the key stakeholders to ensure these needs are considered in the management of all water Work with WaterNSW to protect, or if possible, provide baseflows and very low flows[35] to support suitable water quality in rivers and critical refuge pools[36] Sustain critical in-channel refuge pools and instream habitat Limit exceedance of maximum inter-event periods for floodplain inundating flows to reduce the risk of hypoxic blackwater events

[35] As described in the relevant EWRs in the LTWP

[36] Natural flows, operational water, PEW and water quality allowances (where they exist) should be used in the first instance before considering the use of HEW.

[37] Descriptions of the types of water quality degradation, their main causes, and where they are likely to occur in the NSW Border Rivers catchment can be found in the water quality management plan for the NSW Border Rivers water resource plan area (DPIE–Water 2019b).

[38] DO levels should be high enough to prevent the asphyxiation of respiring organisms, typically >4 mg/L.

[39] Excess particulate matter may be identified through poor optical properties of waterbodies, the smothering of benthic organisms, or the reduction in photosynthesis (which will inhibit primary production).

[40] May lead to nuisance growth of aquatic plants

[41] Diffuse or point source pollutants may have lethal or sub-lethal effects on aquatic biota.

6.3 Protection of ecologically important flow categories in unregulated areas

In areas where water cannot be delivered through a regulating structure (unregulated streams), the only means of protecting environmentally important flows is through rules in the WSP 2012. Table 25 sets out potential management strategies that could be implemented in the WSPs to ensure important flows are protected during very dry through to wet times. Many of these strategies are consistent with the NSW macro planning approach for pools (NOW 2011), which recommends water access rules for in-river and off-river (wetland) pools be reviewed and alternative rules considered where moderate or high risks to instream environmental values are identified. For any of these strategies to be successful, adequate compliance measures need to be in place, and in some areas, improved water metering and gauging is also required.

Table 25 Potential management strategies to protect ecologically important flows in unregulated rivers and creeks

Flow category	Potential management strategies	Most relevant RAS
Cease-to-flow	Consider rostering landholder water access during low flow months or when flows begin to approach the cease-to-pump flow rate Consider reviewing cease-to-pump rules to reduce the length of cease-to-flow periods Consider implementing a first flush rule to ensure cease-to-flow periods are broken at ecologically relevant times and with events of sufficient magnitude to avoid adverse water quality incidents	Very dry Dry
Low flows and baseflows	Consider rostering landholder water access during low flow months or when flows begin to approach the cease-to-pump flow rate Consider reviewing cease-to-pump rules to better protect low flows and baseflows, especially during dry times or ecologically important months	Very Dry Dry
Freshes	Consider implementing a first flush rule to protect freshes at ecologically relevant times Consider implementing extraction limits[42],[43]	Very dry Dry Moderate
Entire flow regime, including overbank and wetland inundating flows	Consider installing water level gauges at or near extraction sites, or river flow gauges if none exist in the planning unit Ensure compliance with water access licence conditions Consider rostering landholder water access during low flow months or when flows begin to approach the cease-to-pump flow rate	All weather scenarios

[42] Individual daily extraction limits or total daily extraction limits for a particular flow class may be considered to reduce extraction pressure on ecologically important flow categories.

[43] Recommended ideal frequency is linked to providing conditions that protect and improve native fish populations in heavily impacted systems.

Flow category	Potential management strategies	Most relevant RAS
	Consider implementing individual and/or total daily extraction limits (IDELS / TDELS)	
	Consider introducing cease-to-pump and commence-to-pump rules (and any associated required amendments to water access licence conditions) that protect HEW and PEW[44]	
	Maintain no trade into water source rules in the WSP	
	Consider targeted water access licence purchases from willing sellers where flows are acutely impacted	
	Monitor for changes in land use, floodplain harvesting, and water demand and review access rules if current usage is high or if the pattern changes	

[44] In-line with the Basin Plan requirement for implementation of prerequisite policy measures that provide for delivered environmental water to be protected

7. Going forward

7.1 Cooperative arrangements

7.1.1 River operations to benefit the environment

All water, including natural events and consumptive water, has the potential to contribute to improving the ecological condition of rivers, wetlands and floodplains (MDBA 2014). It may be possible for controlled river flows for consumptive deliveries to meet many EWRs, without any contribution of HEW. Preliminary investigation indicates that this is the current case for several EWRs. Further analysis is required to determine the gaps in flow regime and EWRs that are not achieved through consumptive flows or current PEW.

In the Border Rivers the relatively small volume of HEW increases reliance on environmentally effective operating practices to maximise the achievement of EWRs. There may be cases where the losses used in river operations could be adjusted to improve rates of rise and fall, or in drier times block releases can be grouped to meet minimum event durations. In long block releases, as can occur in moderate to wet years, a lack of rising and falling river levels is environmentally detrimental as variability in flows is needed to cue certain ecological functions. In these water delivery patterns, flow rates may be within the range required to inundate required features, but ecological outcomes may be limited due to the absence of flow variability or rising and/or falling cues. River operations can limit or prevent the achievement of ecological outcomes from the delivery of consumptive water, resulting in greater volumes of HEW required to maintain the environment.

The actual impact of unsympathetic water delivery practices on achievement of the EWRs requires further investigation. Pending the findings, it may be possible for increased collaboration between DPE and WaterNSW to strike a balance between operational efficiency and environmental effectiveness. This may require:

- adjustment of delivery of irrigation orders to more closely mimic natural flow events
- refinement of water releases from Pindari Dam to mimic natural rates of fall
- consideration of environmental needs in the management and release of weir pools; for example, using the end of season release of weir pools to achieve baseflows or ecologically guided timing of the Boomi River replenishment flow.

7.1.2 Cooperative water management arrangements

Managing water for the environment at the catchment scale requires cooperation between stakeholders. Such cooperative arrangements ensure all water in the system can be managed in a coordinated way that maximises environmental outcomes, and that the receiving environment is accessible and supported by appropriate management.

Water for the environment in NSW is managed cooperatively by 2 government agencies: DPE and CEWO. Together these agencies manage NSW and Commonwealth HEW portfolios (DPE–BC and CEWO), and the WSPs that provide PEW throughout the system (DPE–Water).

This management is supported by the water rule set – the WSP as part of the WRP – developed and managed by DPE–Water with implementation of river operations under licence to WaterNSW. DPIF is also integral to several processes, such as fish passage and instream structures compliance.

Agencies should consider establishing a multi-agency, intergovernmental working group to collaboratively scope and develop an ongoing program to implement the LTWP for the NSW Border Rivers.

Discussions are underway between government agencies and key stakeholders on the most appropriate mechanism to gain regional input and build regional ownership of environmental water management in the NSW Border Rivers. Any mechanism established will need to recognise the interactions between northern systems and function across catchments. Implementation of Northern 'Toolkit measures' may also be a focus of work at a regional level.

7.1.3 Strategic use of environmental water

One approach to achieving EWRs in regulated portions of the catchment is through direct intervention, with release of HEW. Currently, NSW does not hold any water entitlements in the NSW Border Rivers. The use of environmental water holdings to achieve the LTWP objectives will require cooperation with CEWO. Coordinating deliveries of HEW with consumptive deliveries can help to achieve greater flow volumes from the use of all water. Such arrangements might enable larger in-channel and anabranch connecting flows that would not be possible with HEW alone. This may require establishing more flexible channel sharing arrangements by permitting environmental water to build on consumptive or stock and domestic deliveries to achieve a greater proportion of EWRs for improved environment outcomes.

The 2021 WSP provides for PEW. Of the various rules for PEW, only the Pindari Stimulus Flow can be used with some discretion. The timing (between 1 August and 1 December), rate, volume and duration of the Stimulus Flow released is determined by DPE–BC and DPE–Water. Fish monitoring of environmental uses of the Pindari Stimulus Flow shows that benefits can extend the full length of Border Rivers. In 2017 the late August release contributed to a small fresh at Terrewah and a baseflow at Mungindi. It is possible that the Stimulus Flow has contributed to the improvement in EWRs since 2009. Further investigation is required to confirm these results and determine the extent to which the Stimulus Flow has contributed to recent positive fish monitoring results.

In the past, strategic use of PEW coordinated with HEW has enabled desired flow events to be achieved while minimising the use of HEW. For example, activation of translucency rules during release of HEW should contribute to the volume released, forming part of the environmental event and reducing the volume of HEW required.

A broad strategy for environmental water use in the NSW Border Rivers should also seek to:

- **Create, protect and maintain refuge pools**

In wetter years and years with sufficient HEW, this will require higher flows in the lower part of the Macintyre River to create pools in the anabranches and fill low-lying wetlands. The establishment of these pools in wetter years and persistence of pools as conditions dry will result in off-channel refuges being available in drier conditions.

In drier years, protecting and maintaining pools may involve the use of HEW from Glenlyon Dam to replenish and maintain pools in-channel along the Dumaresq River. Releases from Coolmunda, Glenlyon and Pindari dams may contribute to maintaining pools in the lower Macintyre River.

- **Maintain disconnection and reconnection of the anabranches**

To establish and maintain refugia in the anabranches, regular periods of hydrological connection during moderate years is required to build the condition of these off-channel habitats. Productivity gains from these anabranches can support in-channel ecosystems between larger flood events, with the productivity benefits extending into the Barwon–Darling (DPI 2015a). In addition, it is thought that the lower Macintyre River and associated waterways provides critical spawning habitat for golden perch and other flow pulse specialists, with this contributing significantly to fish populations through the length of the Barwon–Darling (DPI 2015a). The higher flows required to connect the anabranches, if permitted to continue to end-of-system flows, can provide meaningful connectivity to the Barwon–Darling.

- **Ensure regular small freshes below Pindari Dam**

Growing experience with the use of the Pindari Stimulus Flow indicates that it can provide a small fresh sufficient to promote fish recruitment. The Stimulus Flow provides an important opportunity to maintain EWRs that would otherwise be missing from the current flow regime. The protection of native fish and enhancement of recruitment outcomes can be improved by opening the seasonal window of use for the Stimulus Flow from August – December to all year round under certain circumstances, and with Ministerial approval, to ensure native fish and river health can be supported during potentially critical summer and autumn periods.

The size of flow that can be released from Pindari Dam limits the creation of large fresh events below the dam. Where it is possible to coordinate the Stimulus Flow with other tributary inflows, such as from Frazers Creek and the upper Macintyre River, it may be possible to create a large fresh. The timing and pattern of flow pulses achieved will impact on the extent to which productivity gains can also be made from the breakup of filamentous algae.

In addition to the above approach, the following strategies will significantly contribute to achievement of this LTWP:

- protect inflows from unregulated water sources, including preventing any further development of regulating structures such as dams and weirs
- investigate opportunities to improve environmental effectiveness of river operations
- prevent growth in floodplain harvesting, and ensure floodplain developments do not change flows to and around environmental assets
- ensure supplementary flow events provide end-of-system connectivity to the Barwon–Darling, maintaining the natural pattern of sequential flooding as required to restore ecosystems in both Border Rivers and downstream catchments.

7.1.4 Complementary natural resource management

To achieve the watering required to support the LTWP's ecological objectives, it is necessary to ensure priority environmental assets and functions on private land can be accessed for management. This includes arrangements with landholders for these assets to be inundated at the required timing, frequency and duration. Access to these assets to evaluate how they are responding to management over time is also vital.

Complementary management of water-dependent environmental assets will assist achievement of the LTWP objectives. Degradation of assets through poor land management practices and inadequate legislative protection for assets such as native vegetation, may undermine environmental water management. Cooperative arrangements between government agencies such as Local Land Services, private industry groups, individual landholders and community groups that ensure adequate stewardship of environmental assets are essential to the success of this LTWP. A priority action from this LTWP is to secure and formalise the continuity of these arrangements with relevant landholders and agencies.

7.1.5 Cooperative investment opportunities

There are many opportunities in the NSW Border Rivers catchment to improve the way the LTWP is implemented (Table 26). Some of these are through joint projects or investments. Identification of key project partners, funding opportunities and subsequent implementation of projects to address these priorities would contribute significantly to the ecological objectives identified in this plan.

Through the life of the plan, DPE will seek opportunities to build links and partnerships to support implementation of projects that will contribute to the ecological objectives of the LTWP.

Table 26 Forward workplan and investment opportunities to improve environmental outcomes in the NSW Border Rivers catchment

Project idea or investment	Actions required	Potential project partners
Support and guide implementation of the 'Toolkit' measures	Contribute to identification, planning and assessment of relevant Northern Basin Toolkit measures. This may include analysis of the expected impacts of various Toolkit measures on the achievement of EWRs	DPI Fisheries, DPE–BC, DPE–Water, WaterNSW, CEWO
Cooperative water management	Ongoing collaboration with CEWO, DPE–Water, DPI Fisheries and WaterNSW to plan and implement releases of HEW and PEW and monitoring in NSW Border Rivers	CEWO, DPI Fisheries, DPE–Water, WaterNSW
	Investigate opportunities to achieve EWRs with consumptive flows	WaterNSW, irrigation community, DPI Fisheries, DPE–BC
	Identify opportunities to achieve EWRs from refined river operations	
	Identify and maintain rules in the WSP and current river operations that are contributing to current achievement of EWRs	DPE–Water, DPE–BC
Complete hydrological assessment of the EWRs	Identify which EWRs are currently being met by PEW and/or HEW and the gaps in the flow regime. Determine which criteria of the unmet EWRs is limiting (flow volume, duration, timing and/or spell duration) to inform targeted management strategies	DPE–BC, DPI Fisheries
Risks and constraints	Determine impacts of risks and constraints on specific EWRs and identify targeted management options	DPE–BC, DPI Fisheries, DPE–Water
Climate change impacts	Investigate and monitor impacts of climate change, such as: • How will the volume of water captured and stored be affected? • How will water quality be affected? • How will changes to rainfall intensity change the shape of natural flow events (e.g. duration, rates or rise and fall)? • Will overland flow paths change as our climate changes? • How will the persistence of floodplain inundation change? • How will climate change affect native and non-native plants and animals?	DPE–BC, DPI Fisheries, DPE–Water
Floodplain harvesting	Assess the impacts of floodplain harvesting on EWRs and condition of floodplain ecosystems	DPE–BC, DPI Fisheries, DPE–Water, CEWO
Prioritisation of ecological objectives and watering	Prioritise ecological objectives and watering based on the: • extent of environmental assets that can be watered using PEW and HEW • ecological demand for water (time since last event and interflow thresholds) • condition of environmental values and assets • Basin-scale importance of values and assets	DPE–BC, DPI Fisheries

Project idea or investment	Actions required	Potential project partners
Knowledge gaps in the LTWP	Identify any changes to the LTWP required in response to findings from research currently underway	DPE–BC
	Monitor resource condition and impacts of flows to further build an evidence base for watering actions and inform adaptive management of annual EWR priorities	DPE–BC, CEWO, DPI Fisheries, DPE–Water
	Establish a process to identify and incorporate cultural values and assets	DPE–BC
Addressing knowledge gaps and further research into EWRs	There is growing evidence and knowledge of water-dependent ecosystems and environmental flows in the NSW Border Rivers. The Short Term Intervention Monitoring project for fish, funded by CEWO and undertaken by NSW and QLD, has made a significant contribution to informing the objectives and EWRs in this plan. As experience in environmental watering builds, and recently detected outcomes such as improved population resilience of Murray cod, silver perch spawning aggregation and improved populations of carp gudgeon can be linked to specific flow events, the evidence base for EWRs will strengthen. Other research such as habitat mapping in Dumaresq River has been used to inform the spatial prioritisation of objectives and EWRs and research undertaken in QLD to inform WRPs has informed the definition of specific flow categories, such as the baseflow. To determine the most effective and efficient protection and restoration of EWRs, greater knowledge is needed on the underlying reasons why particular EWRs are no longer occurring. It is not known if EWRs have not been achieved due to missing flow categories (flow thresholds not reached), inappropriate timing of flows, or insufficient event durations. In the absence of such investigation, it is difficult to propose relevant and targeted management solutions to protect or improve the achievement of EWRs.	DPE–BC, CEWO, DPI Fisheries, DPE–Water
Environmental water advisory group	DPE–BC has been working with local communities over many years through environmental water advisory groups (EWAGs). These groups draw on the expertise and experience of community members to help inform the decision-making process. EWAGs may include water managers, recreational fishers, landholders, Aboriginal groups, independent scientists, local government representatives and a variety of partner agencies. The groups meet regularly to discuss proposed or upcoming watering events, any issues or concerns, the results of watering events and future opportunities. They help decide which sites to target for watering as well as the best timing to maximise outcomes for rivers and wetlands and the plants and animals that depend on them. They also help to develop strategies for various weather scenarios and provide advice on how to minimise disruption to farmers and communities. Opportunities to establish a Border Rivers EWAG should be investigated.	DPE–BC

Project idea or investment	Actions required	Potential project partners
Improved gauging of Boomi River	The Boomi River and its floodplain is an important environmental asset of the Border Rivers catchment. Currently there is only one NSW gauge situated at the junction of the Macintyre and Boomi rivers. This junction is currently regulated, and water is predominantly managed to meet stock and domestic licences further down the river. DPE–BC recommends the addition of another gauge further down the Boomi River to better inform environmental management of this area.	

7.2 Measuring progress

Monitoring, evaluating and reporting are integral components of adaptive water management. Monitoring how water moves through the landscape and how the environment responds informs ongoing improvements to planning and operational decisions. This information will also assist in determining whether the LTWP is meeting its objectives and targets, and will inform revisions of this LTWP.

The NSW Government works with key agencies (the CEWO, MDBA and Queensland Government) and the community in the Border Rivers catchment to implement monitoring programs that inform and improve water management.

Monitoring programs can provide essential insights to water managers. An example of such a program was a study in the catchment between 2015 and 2018 into native fish populations, their distributions and responsiveness to environmental water management (DoEE 2019). This study was able to confirm the presence and distribution of Murray cod, freshwater catfish, purple-spotted gudgeon and olive perchlet in key rivers across the catchment. The study also detected that recruitment of native fish species was lacking, which enabled adaptive management of environmental flows in 2017 to target and trigger productivity and fish recruitment to recover native fish populations in the Border Rivers catchment.

The NSW Border Rivers Monitoring, Evaluation and Reporting Plan (NSW MERP) coordinates NSW Government agencies' approach to MER to consistently deliver on Basin Plan and NSW requirements and avoid duplication between agencies (DoI 2018a). The NSW MERP includes the objectives of this LTWP, along with the WSP and water quality management plan objectives to investigate how water resource management protects and enhances native frog, native vegetation, waterbird and frog communities (where possible). Current MER activities in the northern Basin include:

- hydrologic monitoring of low flows and flow variability at identified refuge assets using selected gauges and remote sensing
- condition and extent of native water-dependent vegetation communities using the Basin-wide vegetation stand condition tool
- waterbird species richness, abundance and breeding through the long-running Aerial Waterbird Surveys of Eastern Australia (from 1983 onwards) covering limited locations in the Border Rivers
- hydrologic monitoring of flow connectivity between and within water sources at selected gauges including cross-border flow connectivity between QLD and NSW
- MDBA Basin-scale Acoustic Telemetry Fish Tracking coordination project to record fish movement, migration and expanded distribution of key species
- annual fish community sampling

- water quality monitoring for several variables and multiple sites, including turbidity, total nitrogen, total phosphorus, DO and pH
- upland river and stream surveys for Booroolong frog populations.

Pending the provision of funding for expanded MER programs, other monitoring and research programs will be carried out in the NSW Border Rivers catchment through the 20-year life of this LTWP.

7.3 Review and update

This LTWP brings together the best-available information from a range of community, traditional and scientific sources. To ensure the information remains relevant and up-to-date, this LTWP will be reviewed and updated no later than 5 years after it is implemented. Additional reviews may also be triggered by:

- accreditation or amendment of the WSP or WRP
- revision of the BWS that materially affects this LTWP
- an SDL adjustment
- new information arising from evaluating responses to environmental watering
- new ecological knowledge that is relevant to environmental watering
- improved understanding of the effects of climate change and its impacts on the objectives and EWRs
- changes to the river operating environment or the removal of constraints that affect watering strategies
- material changes to river and wetland health, not considered within this LTWP.

PART B: NSW Border Rivers planning units

8. Introduction

To manage the complexity of the NSW Border Rivers WRPA, the NSW Border Rivers LTWP has been divided into 15 planning units (Figure 19). Planning units delineate areas with a unique set of mechanisms for managing water for environmental outcomes.

Planning units in the NSW Border Rivers catchment have largely been derived from the water source boundaries in the WSP 2012. A few adjustments were made to the water source boundaries to reflect various features of river operations and the landscape. Overall these adjustments aim to create planning units that are somewhat uniform within, and distinct from other planning units. Adjustments included:

- Campbells Creek and Camp Creek have been merged as there is only one gauge within this section on which to set EWRs
- the Ottleys Creek water source has been split to recognise the differences between the Macintyre and Dumaresq rivers in the lower northern part from the more ephemeral nature of Ottleys Creek. NSW (Mitchell) landscapes were used to identify a relevant boundary
- a number of new planning units were created downstream of the junction between the Macintyre and Dumaresq rivers:
    - planning unit 14 – Whalan Creek and Croppa Creek sub-catchment distinguishes the unregulated and ephemeral Croppa and Whalan creeks from the Macintyre and Boomi rivers. The trade boundary in the unregulated WSP was adopted
    - the division created above Terrewah on the Macintyre River to form planning units 13 – Macintyre River floodplain upstream of Boomi River, and 15 – Macintyre River and Boomi River floodplain, recognises the change in the geomorphology of the river channel that occurs in this section of river. NSW (Mitchell) landscapes were again used to identify a relevant boundary.

For each planning unit the following local-scale information is provided:

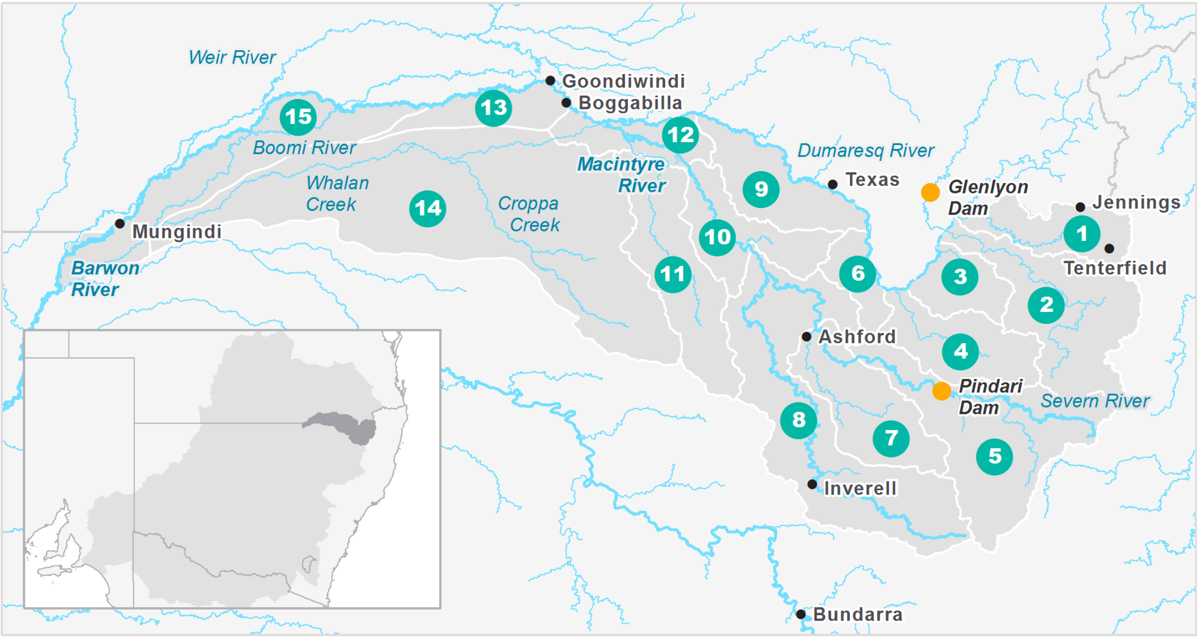
- locations of priority environmental assets identified as part of the plan's development
- ecological values, including native fish, waterbird species, native vegetation communities and water-dependant cultural assets that occur within the planning unit's priority environmental assets
- EWRs to support key ecological values and related LTWP objectives and targets that are presented for representative gauge/s in the planning unit.

EWRs are defined for representative gauges in each planning unit. These EWRs describe the flow (or inundation regime, in the case of large lake systems) to support ecological objectives and targets for all priority environmental assets in each planning unit. A guide to interpreting EWRs is provided in Table 8 (Part A). The location of representative gauges is shown in Figure 16 (Part A).

EWRs may be met with discretionary environmental water, consumptive deliveries, operational flows (e.g. conveyance flows or bulk water transfers between storages), unregulated flows (i.e. tributary flows and spills from dams), or a combination of these.

The EWR tables bring together the catchment-scale EWR details provided in Table 10 (Part A) and the flow thresholds in Table 9 (Part A) with the refined planning unit-scale details, where relevant. EWRs that are irrelevant to the planning unit are not shown. For most EWRs any flow above the stated flow threshold is regarded as contributing to that

EWR; for example, flows that are above bankfull or overbank are also considered as meeting the objectives associated with baseflow EWRs. The only exception is SF2 where only flows within the band specified will meet the objectives associated with SF2.



Legend

Planning Units

N

0 35 70

Kilometers

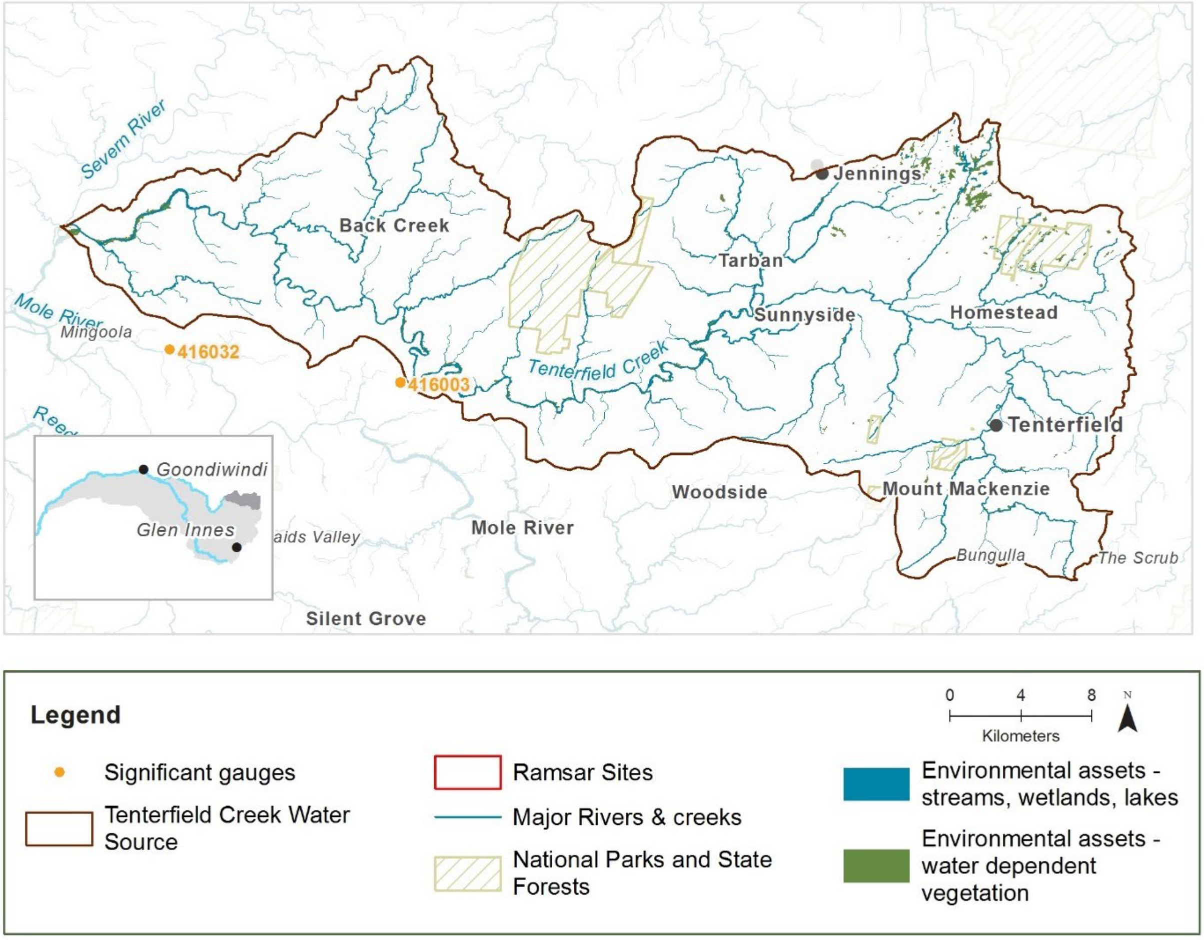
Planning Units

1. Tenterfield Creek
2. Mole River
3. Reedy Creek
4. Beardy River
5. Glenn Innes
6. Bonshaw
7. Kings Plains
8. Inverell
9. Campbells and Camp Creeks
10. Yetman Creek
11. Ottleys Creek
12. Confluence of Macintyre River and Dumaresq River
13. Macintyre River floodplain upstream of Boomi River
14. Whalan & Croppa Creeks Subcatchment
15. Macintyre River & Boomi River floodplain

Figure 19 Planning units in the NSW Border Rivers LTWP

9. Planning unit report cards

9.1 Tenterfield Creek (Tenterfield Creek at Clifton 416003)



Priority environmental assets	
Rivers, creeks, wetlands and their associated floodplains and water-dependant native vegetation, including (but not limited to): • Tenterfield Creek • Back Creek • Garden Creek • Horse Creek • Gosling Swamp • Green Gully • Log Hut Creek • Teatree Creek • Instream habitat, including refuge pools and fringing vegetation communities • Unaltered flows contribute to persistence of refugia and a natural flow regime downstream. Any further loss or interruption of natural flows needs to be prevented to minimise ongoing decline in fish assets	
Native fish[45]	• golden perch X+Y • spangled perch X • Murray cod (V) X+Y • freshwater catfish (E)X+Y • southern purple spotted gudgeon (E) X+Y • olive perchlet (E) X+Y • Darling River hardyhead X • Australian smelt X+Y • carp gudgeon X+Y • mountain galaxias X+Y • Murray–Darling rainbowfish X+Y • bony herring X • unspecked hardyhead X+Y

45 Native fish species marked with an X recorded in the planning unit via catch records and/or Australian Museum records where they exist. Species marked with a Y are expected to occur in the planning unit based on Maxent modelling with a minimum 33% probability of occurrence (Richies et al. 2016). CE = critically endangered, E = endangered, V = vulnerable.

Priority environmental assets	
Waterbirds	38 water-dependent bird species recorded, including the listed[46] waterbird species: magpie goose (V), white-winged black tern (C,J), bar-tailed godwit (C,J,K) and Latham's snipe (J,K)
Native vegetation	7 water-dependent PCTs, with: • 951 ha of river red gum woodland • 408 ha of non-woody wetland • 225 ha of flood-dependent shrubland wetland
Cultural assets	Significant cultural history but with limited recorded sites in water-dependent areas: • modified trees

[46] Listed as Commonwealth or NSW threatened (vulnerable [V], endangered [E] or critically endangered [CE]) or under international migratory bird agreements (JAMBA [J], CAMBA [C], ROKAMBA [K])

Table 27 EWRs for Tenterfield Creek planning unit (Tenterfield Creek at Clifton 416003)[47]

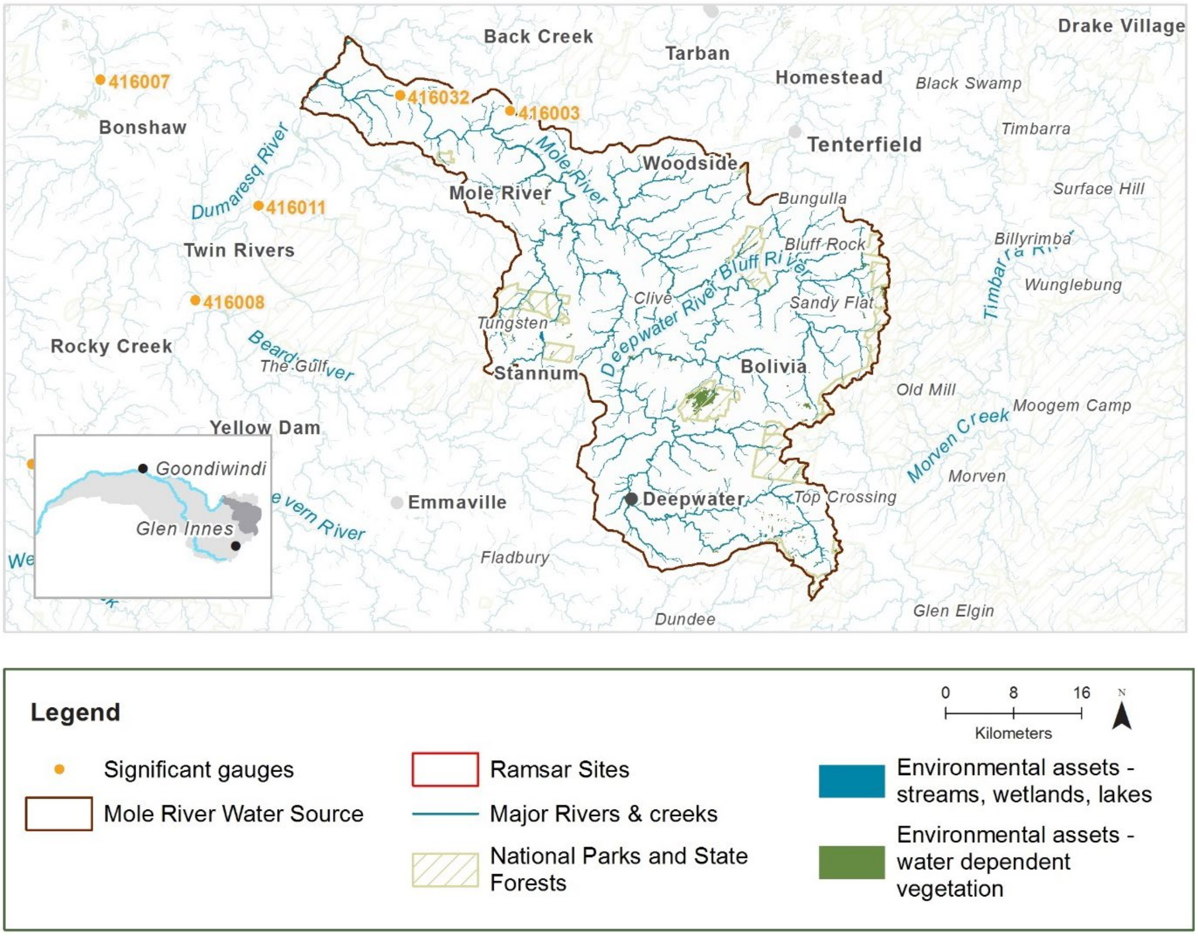
Flow category and EWR code		Flow threshold	Timing	Duration[48]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Cease-to-flow	CFa	<1 ML/d	Any time	4 days maximum	No more than 5 years in 10 (50% of years)	N/A	
	CFb	<1 ML/d	Any time	47 days maximum	No more than 5 years in 100 (5% of years)	N/A	
	CFc	<1 ML/d	Any time	Any duration	No more than 77% of years	N/A	
Very low flow	VFa	>3 ML/d	Any time	275 days per year minimum	5 years in 10 (50%) minimum	In accordance with cease-to-flow requirements	
	VFb	>3 ML/d	Any time	115 days per year minimum	Every year (100%)	In accordance with cease-to-flow requirements	
Baseflow	BF1a	>40 ML/d	Any time	94 days per year minimum	5 years in 10 (50%) minimum	139 days	
	BF1b	>40 ML/d	Any time	19 days per year minimum	Every year (100%)	139 days	
	BF2a	>40 ML/d	September to March	62 days per year minimum	5 years in 10 (50%) minimum	223 days	
	BF2b	>40 ML/d	September to March	13 days per year minimum	Every year (100%)	223 days	

[47] Refer to Table 8 in Part A for definitions of terms and explanatory text for EWRs

[48] Durations can be non-consecutive days for very low flow and baseflows. All other durations are expressed as consecutive days.

Flow category and EWR code		Flow threshold	Timing	Duration[48]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Small fresh	SF1	>100 ML/d	Ideally October to April but can occur any time	4 days minimum	Every year (100%)	1 year	Ideal timing is based on preferred temperature range for fish spawning of >20°C for most native fish and >18°C for Murray cod SF1 ideally shortly after LF2 for increased likelihood of successful recruitment of fish, productivity and dispersal
	SF2	100–1,500 ML/d	August to April	7 days minimum (ideally 14 days)	5–10 years in 10 (75%) minimum	2 years	
Large fresh	LF1	>1,500 ML/d	Ideally July to September but can occur any time	2 days minimum	5 years in 10 (50%) minimum	4 years (ideally 2 years)	This flow in Jul to Sep will improve pre-spawning fish condition
	LF2	>1,500 ML/d	October to April	2 days minimum (Ideally 5 days)	3 years in 10 (30%) minimum	4 years	Commencing as a rising flow only Temp preferably >17°C to maximise spawning outcomes Ideally shortly before SF1
Bankfull	BK1	>5,000 ML/d	Any time	1 day minimum	4 years in 10 (40%) minimum	5 years	
	BK2	>5,000 ML/d	October to April	1 day minimum	3–4 years in 10 (35%) minimum	7 years (ideally 4 years)	
Overbank	OB1	>14,000 ML/d	Any time	1 day minimum	1–1.5 years in 10 (12.5%) minimum	15 years	

9.2 Mole River (Mole River at Donaldson 416032)



Priority environmental assets			

Rivers, creeks, wetlands and their associated floodplains and water-dependant native vegetation, including (but not limited to):

- Mole River
- Deep Water River
- Bluff River
- Oaky Creek
- Pyes Creek
- Instream habitat, including refuge pools, and non-woody wetland and fringing vegetation communities
- Unaltered flows contribute to persistence of refugia and a natural flow regime downstream
- Any further loss or interruption of natural flows needs to be prevented to minimise decline in fish assets

Native fish[49]	• golden perch X+Y • spangled perch X • Murray cod (V) X+Y • freshwater catfish (E) X+Y • bony herring Y • unspecked hardyhead X+Y	• southern purple-spotted gudgeon (E) X+Y • olive perchlet (E) X+Y • Darling River hardyhead X • Australian smelt X+Y	• carp gudgeon X+Y • mountain galaxias X+Y • Murray–Darling rainbowfish X+Y

[49] Native fish species marked with an X recorded in the planning unit via catch records and/or Australian Museum records where they exist. Species marked with a Y are expected to occur in the planning unit based on Maxent modelling with a minimum 33% probability of occurrence (Richies et al. 2016). CE = critically endangered, E = endangered, V = vulnerable.

Priority environmental assets	
Waterbirds	23 water-dependent bird species recorded, including the listed[50] waterbird species: magpie goose (V) and Latham's snipe (J,K)
Native vegetation	9 water-dependent PCTs, with: • 2,740 ha of river red gum woodland • 1,021 ha of non-woody wetland • 1,289 ha of flood-dependent shrubland wetland
Threatened other species	• Bell's turtle (V) • glandular frog (V)
Cultural assets	Significant cultural history but with limited recorded sites in water-dependent areas: • modified trees

[50] Listed as Commonwealth or NSW threatened (vulnerable [V], endangered [E] or critically endangered [CE]) or under international migratory bird agreements (JAMBA [J], CAMBA [C], ROKAMBA [K])

Table 28 EWRs for Mole River planning unit (Mole River at Donaldson 416032)[51]

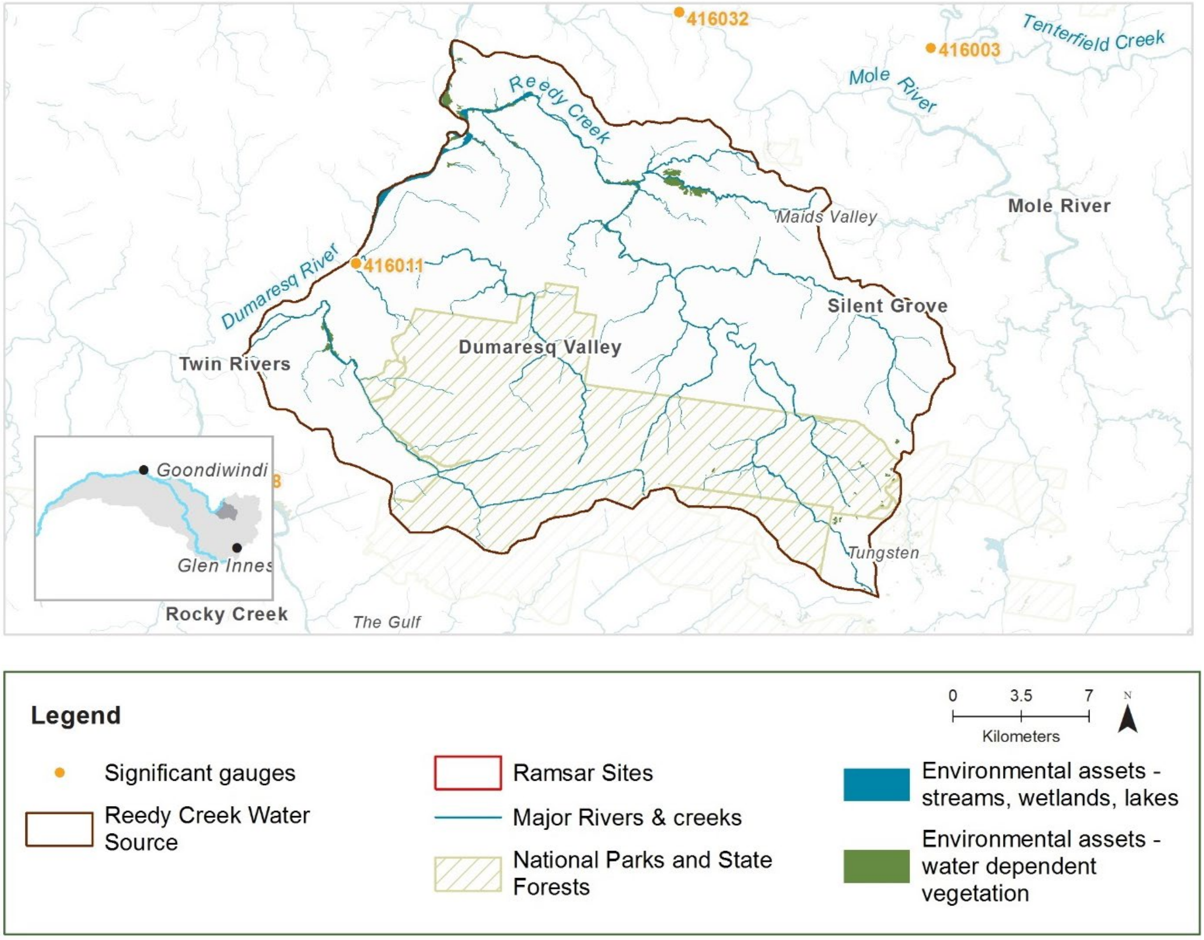
Flow category and EWR code		Flow threshold	Timing	Duration[52]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Cease-to-flow	CFa	<1 ML/d	Any time	10 days maximum	No more than 5 years in 10 (50% of years)	N/A	
	CFb	<1 ML/d	Any time	90 days maximum	No more than 5 years in a 100 (5% of years)	N/A	
	CFc	<1 ML/d	Any time	Any duration	No more than 53% of years	N/A	
Very low flow	VFa	>10 ML/d	Any time	277 days per year minimum	5 years in 10 (50%) minimum	In accordance with cease-to-flow requirements	
	VFb	>10 ML/d	Any time	138 days per year minimum	Every year (100%)		
Baseflow	BF1a	>50 ML/d	Any time	189 days per year minimum	5 years in 10 (50%) minimum	123 days	
	BF1b	>50 ML/d	Any time	72 days per year minimum	Every year (100%)	123 days	
	BF2a	>50 ML/d	September to March	126 days per year minimum	5 years in 10 (50%) minimum	192 days	
	BF2b	>50 ML/d	September to March	43 days per year minimum	Every year (100%)	192 days	

51 Refer to Table 8 in Part A for definitions of terms and explanatory text for EWRs

52 Durations can be non-consecutive days for very low flow and baseflows. All other durations are expressed as consecutive days.

Flow category and EWR code		Flow threshold	Timing	Duration[52]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Small fresh	SF1	>230 ML/d	Ideally October to April but can occur any time	10 days minimum	8–9 years in 10 (88%) minimum	1 year	Ideal timing is based on preferred temperature range for fish spawning of >20°C for most native fish and >18°C for Murray cod SF1 ideally shortly after LF2 for increased likelihood of successful recruitment of fish, productivity and dispersal
	SF2	230–720 ML/d	September to April	14 days minimum	3 years in 10 (33%) minimum (ideally 5–10 years in 10 (75%))	7 years (ideally 2 years)	
Large fresh	LF1	>720 ML/d	Ideally July to December but can occur any time	8 days minimum	5 years in 10 (50%) minimum	2 years	This flow in Jul to Sep will improve pre-spawning fish condition
	LF2	>720 ML/d	October to April	5 days minimum	6 years in 10 (60%) minimum	3 years	Commencing as a rising flow only Temp preferably >17°C to maximise spawning outcomes Ideally shortly before SF1
	LF3	>2,200 ML/d	Any time	3 days minimum	4–5 years in 10 (45%) minimum	4 years	EWR will contribute to channel maintenance and connectivity
Bankfull	BK1	>8,000 ML/d	October to April	1 day minimum	3–4 years in 10 (36%) minimum	5 years	
	BK2	>8,000 ML/d	Any time	1 day minimum	4–5 years in 10 (46%) minimum	4 years	
Overbank	OB1	>26,000 ML/d	Any time	1 day minimum	1 year in 10 (11%) minimum	9 years	

9.3 Reedy Creek (Dumaresq River at Roseneath 416011)



Priority environmental assets			
Rivers, creeks, wetlands and their associated floodplains and water-dependant native vegetation, including (but not limited to): • Reedy Creek • Silent Grove Creek • Black Swamp Gully • Gulf Creek • Dingo Gully • Bald Rock Creek • Instream habitat in this section of the Dumaresq River includes instream vegetation and benches that may provide suitable spawning habitat and therefore require maintenance • Several connected wetlands off the Dumaresq River provide critical ecosystem function, wetland vegetation and low velocity fish spawning habitat • Unaltered flows contribute to persistence of refugia and a natural flow regime downstream			
Native fish[53]	• golden perch X+Y • spangled perch Y • Murray cod (V) X+Y • freshwater catfish (E) X+Y	• southern purple-spotted gudgeon (E) X+Y • olive perchlet (E) Y • Australian smelt X+Y • carp gudgeon X+Y	• mountain galaxias Y • Murray–Darling rainbowfish X+Y • bony herring X+Y • unspecked hardyhead X+Y
Waterbirds	19 water-dependent bird species recorded		

[53] Native fish species marked with an X recorded in the planning unit via catch records and/or Australian Museum records where they exist. Species marked with a Y are expected to occur in the planning unit based on Maxent modelling with a minimum 33% probability of occurrence (Richies et al. 2016). CE = critically endangered, E = endangered, V = vulnerable.

Priority environmental assets	
Native vegetation	4 water-dependent PCTs, with: • 847 ha of river red gum woodland • 30 ha of non-woody wetland • 196 ha of flood-dependent shrubland wetland
Cultural assets	Significant cultural history but with limited recorded sites in water-dependent areas: • modified trees

Table 29 EWRs for Reedy Creek planning unit (Dumaresq River at Roseneath 416011)[54]

Flow category and EWR code		Flow threshold	Timing	Duration[55]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Cease-to-flow	CFa	<1 ML/d	Any time	3 days maximum	No more than 5 years in 10 (50% of years)	N/A	
	CFb	<1 ML/d	Any time	8 days maximum	No more than 5 years in a 100 (5% of years)	N/A	
	CFc	<1 ML/d	Any time	Any duration	No more than 1 year in 10 (10% of years)	N/A	
Very low flow	VFa	>71 ML/d	Any time	292 days per year minimum	5 years in 10 (50%) minimum	In accordance with cease-to-flow requirements	
	VFb	>71 ML/d	Any time	175 days per year minimum	Every year (100%)	In accordance with cease-to-flow requirements	
Baseflow	BF1a	>250 ML/d	Any time	160 days per year minimum	5 years in 10 (50%) minimum	95 days	
	BF1b	>250 ML/d	Any time	43 days per year minimum	Every year (100%)	95 days	
	BF2a	>340 ML/d	September to March	102 days per year minimum	5 years in 10 (50%) minimum	206 days	Supports fish recruitment and is underpinned by habitat mapping (DPI 2018a)
	BF2b	>340 ML/d	September to March	29 days per year minimum	Every year (100%)	206 days	

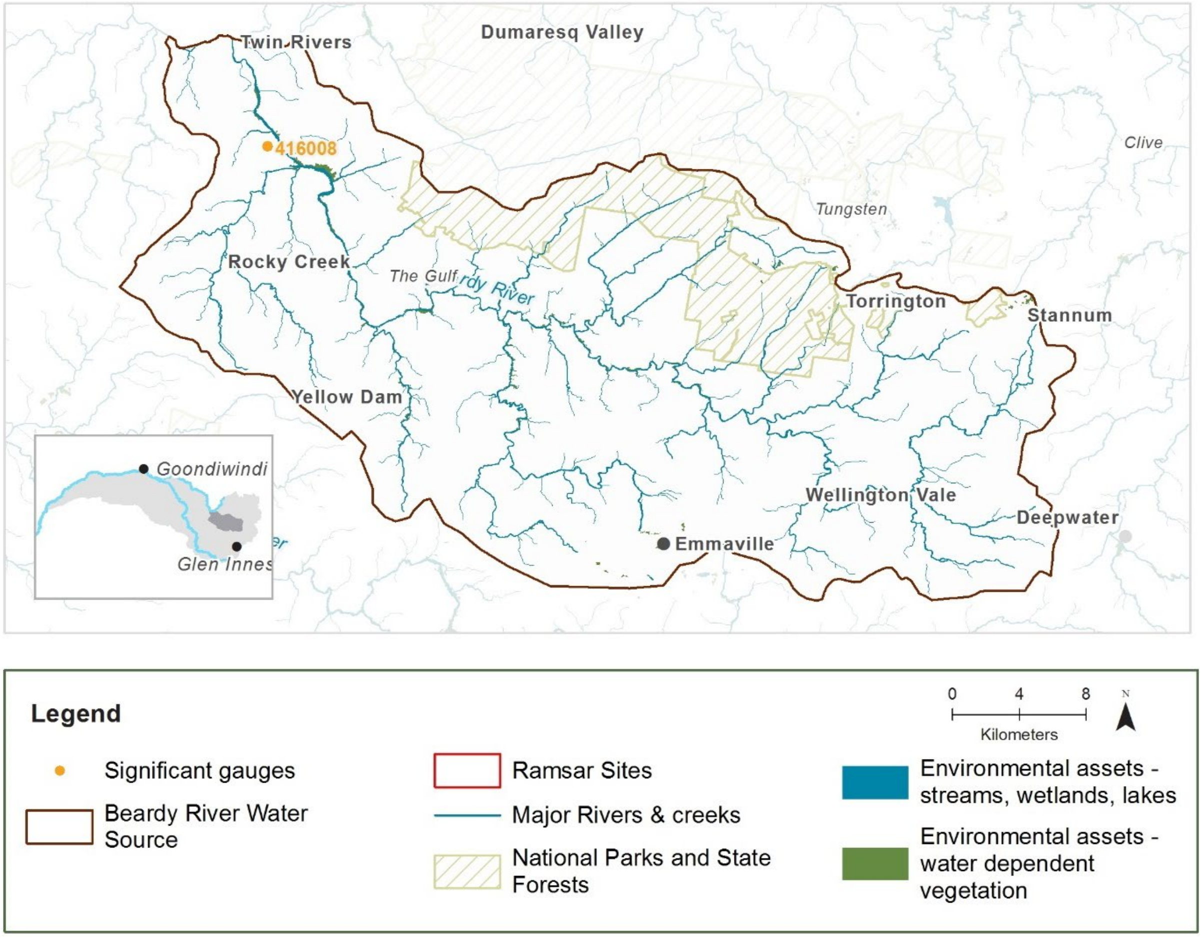
54 Refer to Table 8 in Part A for definitions of terms and explanatory text for EWRs

55 Durations can be non-consecutive days for very low flow and baseflows. All other durations are expressed as consecutive days.

Flow category and EWR code		Flow threshold	Timing	Duration[55]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Small fresh	SF1	>500 ML/d	Ideally October to April but can occur any time	10 days minimum	Every year (100%)	1 year	Ideal timing is based on preferred temperature range for fish spawning of >20°C for most native fish and >18°C for Murray cod SF1 ideally shortly after LF2 for increased likelihood of successful recruitment of fish, productivity and dispersal
	SF2	1,000–2,400 ML/d	August to April	11 days minimum (ideally 14 days or above)	2–3 years in 10 (25%) minimum (ideally 5–10 years in 10 (75%))	8 years (ideally 2 years)	Higher flow threshold compared to SF1 based on ideal magnitude for Murray cod spawning in the area (pers. comms. DPIF)
Large fresh	LF1	>2,400 ML/d	Ideally July to September but can occur any time	5 days minimum	5–10 years in 10 (75%) minimum	2 years	This flow in Jul to Sep will improve pre-spawning fish condition
	LF2	>2,400 ML/d	October to April	5 days minimum	6 years in 10 (60%) minimum	3 years	Temp. preferably >17°C to maximise spawning outcomes Ideally shortly before SF1
	LF3	>6,250 ML/d	Any time	3 days minimum	6 years in 10 (60%) minimum	4 years	Designed to contribute to ecosystem function objectives, including sediment transport and flushing of cobble beds. Corresponds to optimal flow for enhanced native fish condition through improved habitat inundation and connectivity (DPI 2018a)

Flow category and EWR code		Flow threshold	Timing	Duration[55]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Bankfull	BK1	>19,000 ML/d	Any time	Minimum of 1 day	5 years in 10 (50%) minimum	4 years	
	BK2		October to April	2 days minimum	3 years in 10 (30%) minimum	6 years (ideally 4 years)	
Overbank	OB1	>40,000 ML/d	Any time	1 day minimum	2 years in 10 (20%) minimum	8 years	
	OB2	>66,000 ML/d	Any time	1 day minimum	1.5 years in 10 (15%) minimum	N/A	

9.4 Beardy River (Beardy River at Haystack 416008)



Priority environmental assets

Rivers, creeks, wetlands and their associated floodplains and water-dependant native vegetation, including (but not limited to):

- Beardy River
- Rocky Creek
- Dry Creek
- Bark Hut Creek
- Highland Home Creek
- Vegetable Creek
- Instream habitat and fringing vegetation communities, including wetland vegetation
- Unaltered flows contribute to persistence of refugia and a natural flow regime downstream, any further loss or interruption of natural flows needs to be prevented to minimise further decline in fish assets
- Torrington State Conservation Area is the largest protected area in Border Rivers, providing an important biodiversity corridor

Native fish[56]

- golden perch Y
- spangled perch X+Y
- freshwater catfish (E) X+Y
- southern purple-spotted gudgeon (E) X+Y
- olive perchlet (E) Y
- Darling River hardyhead X
- Australian smelt X+Y
- carp gudgeon X+Y
- mountain galaxias Y
- Murray–Darling rainbowfish X+Y
- bony herring Y
- unspecked hardyhead Y

[56] Native fish species marked with an X recorded in the planning unit via catch records and/or Australian Museum records where they exist. Species marked with a Y are expected to occur in the planning unit based on Maxent modelling with a minimum 33% probability of occurrence (Richies et al. 2016). CE = critically endangered, E = endangered, V = vulnerable.

Priority environmental assets	
Waterbirds	23 water-dependent bird species recorded
Native vegetation	7 water-dependent PCTs, with: • 1,227 ha of river red gum woodland • 77 ha of non-woody wetland • 25 ha of flood-dependent shrubland wetland
Cultural assets	Significant cultural history but with limited recorded sites in water-dependent areas: • modified trees

Table 30 EWRs for Beardy River planning unit (Beardy River at Haystack 416008)[57]

Flow category and EWR code		Flow threshold	Timing	Duration[58]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Cease-to-flow	CFa	<1 ML/d	Any time	14 days maximum	No more than 5 years in 10 (50% of years)	N/A	
	CFb	<1 ML/d	Any time	143 days maximum	No more than 5 years in a 100 (5% of years)	N/A	
	CFc	<1 ML/d	Any time	Any duration	No more than 72% of years	N/A	
Very low flow	VFa	>10 ML/d	Any time	168 days per year minimum	5 years in 10 (50%) minimum	In accordance with cease-to-flow requirements	
	VFb	>10 ML/d	Any time	64 days per year minimum	Every year (100%)	In accordance with cease-to-flow requirements	
Baseflow	BF1a	>50 ML/d	Any time	85 days per year minimum	5 years in 10 (50%) minimum	169 days	
	BF1b	>50 ML/d	Any time	25 days per year minimum	Every year (100%)	169 days	
	BF2a	>50 ML/d	September to March	51 days per year minimum	5 years in 10 (50%) minimum	228 days	
	BF2b	>50 ML/d	September to March	13 days per year minimum	Every year (100%)	228 days	

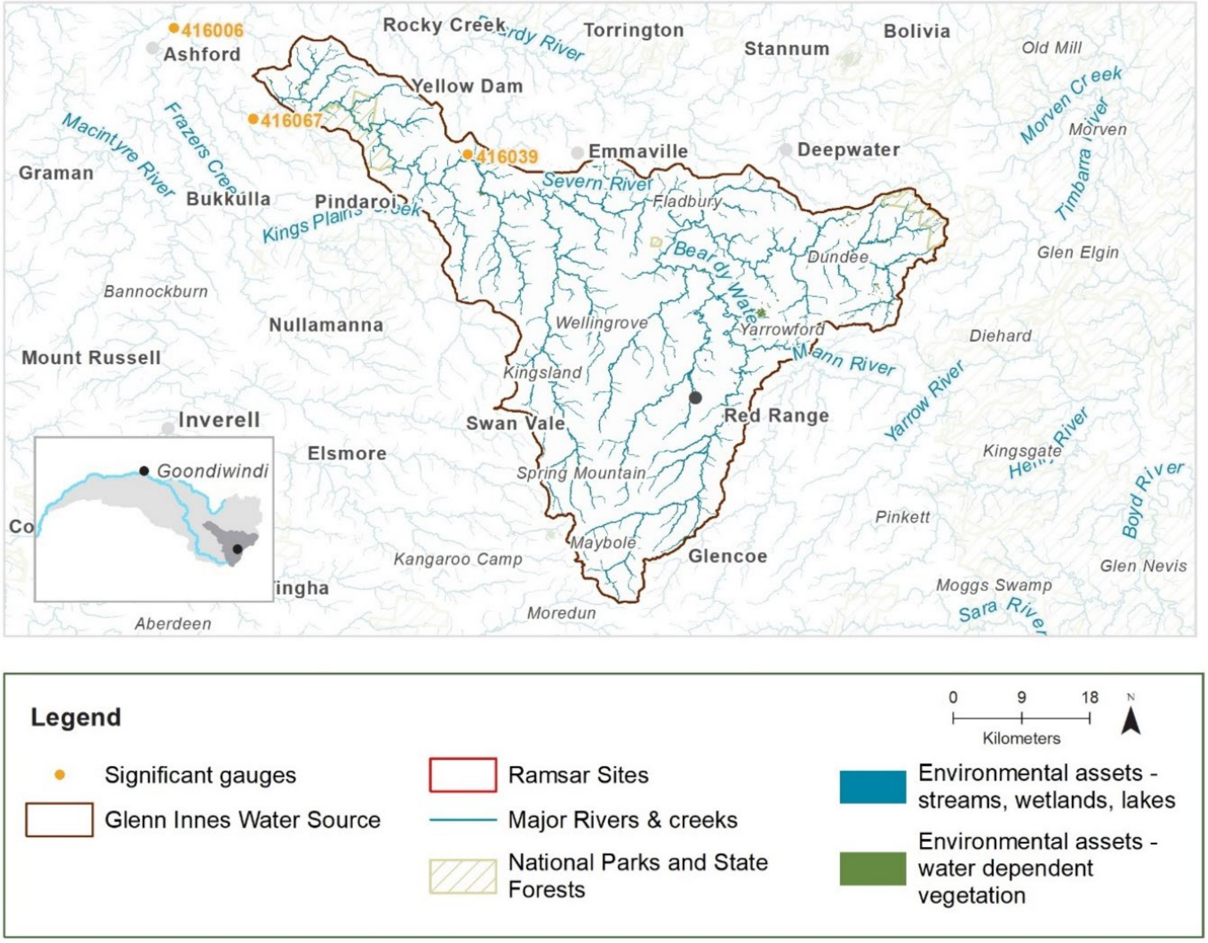
[57] Refer to Table 8 in Part A for definitions of terms and explanatory text for EWRs

[58] Durations can be non-consecutive days for very low flow and baseflows. All other durations are expressed as consecutive days.

Flow category and EWR code		Flow threshold	Timing	Duration[58]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Small fresh	SF1	>100 ML/d	Ideally October to April but can occur any time	7 days minimum	Every year (100%)	1 year	Ideal timing is based on preferred temperature range for fish spawning of >20°C for most native fish and >18°C for Murray cod SF1 ideally shortly after LF2 for increased likelihood of successful recruitment of fish, productivity and dispersal
	SF2	100–700 ML/d	September to April	9 days minimum (ideally 14 days)	4–5 years in 10 (45%) minimum (ideally 5–10 years in 10 (75%))	3 years (ideally 2 years)	
	SF3	100–270 ML/d	August to April	14 days minimum	0.5 years in 10 (5%) minimum (ideally 5–10 years in 10 (75%))	N/A	This EWR has been designed to specifically support Murray cod and freshwater catfish breeding conditions with a limit on velocities
Large fresh	LF1	>700 ML/d	Ideally July to December but can occur any time	4 days minimum	6 years in 10 (60%) minimum	2 years	This flow in Jul to Sep will improve pre-spawning fish condition
	LF2	>700 ML/d	October to April	5 days minimum	5 years in 10 (50%) minimum	4 years	Flow velocity ideally 0.3–0.4 m/s (depending on channel form) Temp. preferably >17°C to maximise spawning outcomes Ideally shortly before SF1
Bankfull	BK1	>5,000 ML/d	October to April	1 day minimum	4–5 years in 10 (45%) minimum	4 years	
	BK2	>5,000 ML/d	Any time	2 days minimum	2–3 years in 10 (25%) minimum	7 years (ideally 5 years)	

Flow category and EWR code		Flow threshold	Timing	Duration[58]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Overbank	OB1	>15,200 ML/d	Ideally October to April but can occur any time	1 day minimum	2 years in 10 (20%) minimum	10 years (ideally 4 years)	
	OB2	>30,000 ML/d	Any time	1 day minimum	1 in 20 years (5%) minimum	–	Designed to contribute to larger flows downstream along the Dumaresq River

9.5 Glen Innes (Severn River at Strathbogie 416039)



Priority environmental assets			
Rivers, creeks, wetlands and their associated floodplains and water-dependant native vegetation, including (but not limited to): • Severn River • Beardy Waters • Wellingrove Creek • Ironbark Creek • Arrawatta Creek • Camerons Creek • Cam Creek • Nine Mile Creek • Furracabad Creek • Reddestone Creek • Instream habitat and fringing vegetation communities, including wetland vegetation • Unaltered flows contribute to persistence of refugia within the planning unit			
Native fish[59]	• golden perch X+Y • silver perch (CE) Y • Murray cod (V) X+Y • river blackfish Y • Australian smelt Y	• freshwater catfish (E) X+Y • southern purple-spotted gudgeon (E) Y • Darling River hardyhead X	• carp gudgeon X+Y • mountain galaxias X+Y • Murray–Darling rainbowfish Y • unspecked hardyhead Y

59 Native fish species marked with an X recorded in the planning unit via catch records and/or Australian Museum records where they exist. Species marked with a Y are expected to occur in the planning unit based on Maxent modelling with a minimum 33% probability of occurrence (Richies et al. 2016). CE = critically endangered, E = endangered, V = vulnerable.

Priority environmental assets		
Waterbirds	43 water-dependent bird species recorded, including the listed[60] waterbird species: blue-billed duck (V), black-necked stork (E), Latham's snipe (J,K), marsh sandpiper (C,J,K) and pectoral sandpiper (J,K)	
Native vegetation	9 water-dependent PCTs, with: • 1,430 ha of river red gum woodland • 612 ha of non-woody wetland	• 630 ha of flood-dependent shrubland wetland
Threatened other species	• Bell's turtle (V) • southern myotis (V)	• glandular frog (V)
Cultural assets	• Aboriginal ceremony and dreaming • Aboriginal resource and gathering • modified trees	• ceremonial ring • stone quarry

[60] Listed as Commonwealth or NSW threatened (vulnerable [V], endangered [E] or critically endangered [CE]) or under international migratory bird agreements (JAMBA [J], CAMBA [C], ROKAMBA [K])

Table 31 EWRs for Glen Innes planning unit (Severn River at Strathbogie 416039)[61]

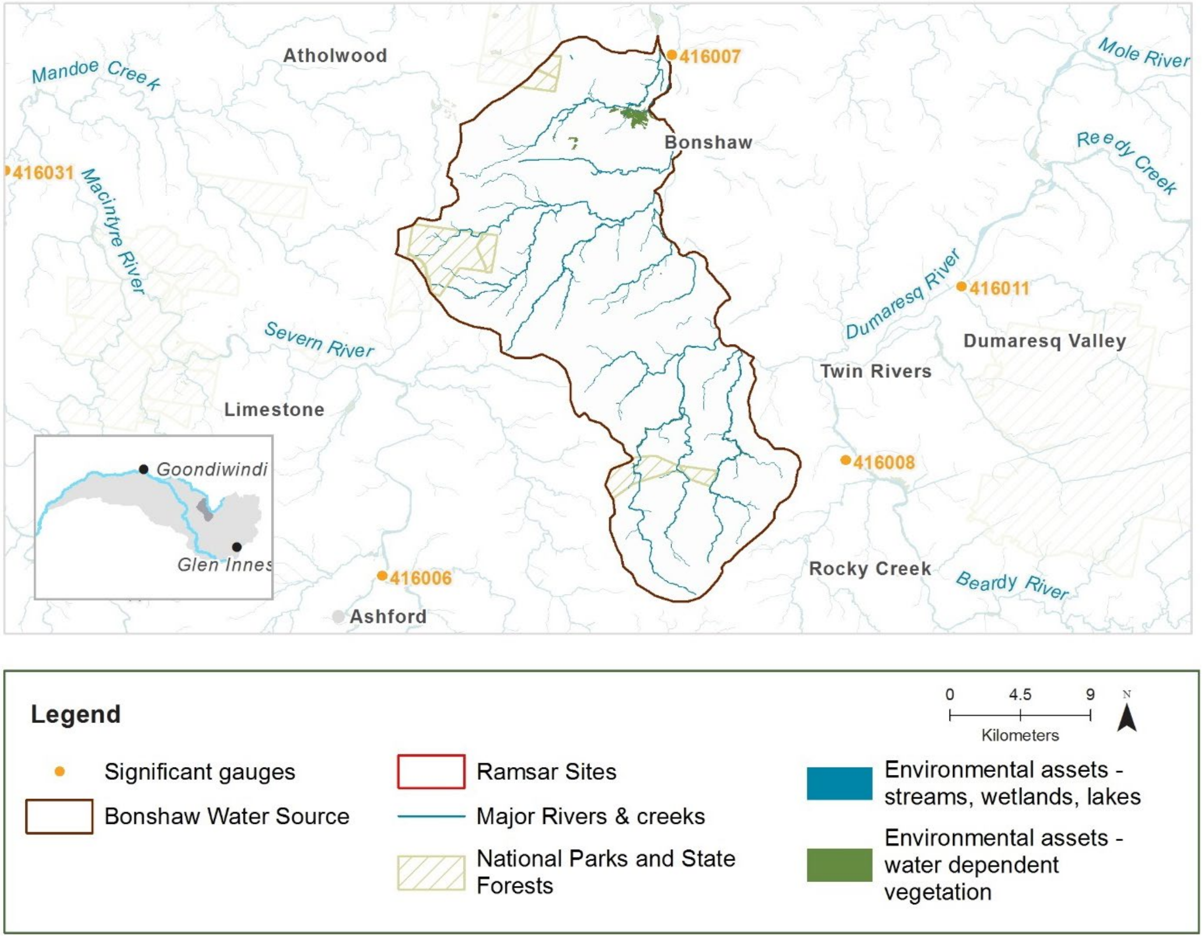
Flow category and EWR code		Flow threshold	Timing	Duration[62]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Cease-to-flow	CFa	<1 ML/d	Any time	13 days maximum	No more than 5 years in 10 (50% of years)	N/A	
	CFb	<1 ML/d	Any time	72 days maximum	No more than 5 years in a 100 (5% of years)	N/A	
	CFc	<1 ML/d	Any time	Any duration	No more than 33% of years	N/A	
Very low flow	VFa	>22 ML/d	Any time	277 days per year minimum	5 years in 10 (50%) minimum	In accordance with cease-to-flow requirements	
	VFb	>22 ML/d	Any time	120 days per year minimum	Every year (100%)	In accordance with cease-to-flow requirements	
Baseflow	BF1a	>58 ML/d	Any time	180 days per year minimum	5 years in 10 (50%) minimum	92 days	
	BF1b	>58 ML/d	Any time	57 days per year minimum	Every year (100%)	92 days	
	BF2a	>58 ML/d	September to March	117 days per year minimum	5 years in 10 (50%) minimum	186 days	
	BF2b	>58 ML/d		35 days per year minimum	Every year (100%)	186 days	

[61] Refer to Table 8 in Part A for definitions of terms and explanatory text for EWRs.

[62] Durations can be non-consecutive days for very low flow and baseflows. All other durations are expressed as consecutive days.

Flow category and EWR code		Flow threshold	Timing	Duration[62]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Small fresh	SF1	>110 ML/d	Ideally October to April but can occur any time	10 days minimum	Every year (100%)	1 year	Ideal timing is based on preferred temperature range for fish spawning of >20°C for most native fish and >18°C for Murray cod SF1 ideally shortly after LF2 for increased likelihood of successful recruitment of fish, productivity and dispersal
	SF2	110–560 ML/d	September to April	14 days minimum	6 years in 10 (60%) minimum (ideally 5–10 years in 10 (75%))	2 years	
Large fresh	LF1	>1,900 ML/d	Ideally July to December but can occur any time	4 days minimum	5 years in 10 (50%) minimum	4 years (ideally 2 years)	This flow in Jul to Sep will improve pre-spawning fish condition
	LF2	>1,900 ML/d	October to April	4 days minimum	3–5 years in 10 (42%) minimum	5 years (ideally 4 years)	Temp. preferably >17°C to maximise spawning outcomes Ideally shortly before SF1
	LF3	>1,200 ML/d	October to April	5 days minimum	5 years in 10 (50%) minimum	4 years	Does not have the ideal 2 m depth, but meets the life history requirements for fish in terms of duration and frequency
Bankfull	BK1	8,500 ML/d	October to April	1 day minimum	6 years in 10 (60%) minimum	3 years	
	BK2	>8,500 ML/d	Any time	3 days minimum	2 years in 10 (20%) minimum	13 years (ideally 5 years)	
Overbank							Steep gorge topography: bankfull EWR should wet higher benches and habitat. No overbank EWR at this gauge

9.6 Bonshaw (Dumaresq River upstream Bonshaw 416007)



Priority environmental assets

Rivers, creeks, wetlands and their associated floodplains and water-dependant native vegetation, including (but not limited to):

- Myall Creek
- Spring Creek
- Log Creek
- Crooked Creek
- Little Oaky Creek
- Boughyard Creek
- Instream habitat includes vegetation and benches that may provide suitable spawning habitat
- Several connected wetlands off the Dumaresq River provide critical ecosystem function, instream vegetation and low velocity fish spawning habitat
- Unaltered flows contribute to persistence of refugia and a natural flow regime downstream

Native fish[63]

- golden perch X+Y
- spangled perch X+Y
- Murray cod (V) X+Y
- freshwater catfish (E) X+Y
- southern purple-spotted gudgeon (E) X+Y
- olive perchlet (E) X+Y
- Australian smelt X+Y
- carp gudgeon X+Y
- bony herring X+Y
- flat-headed gudgeon Y
- Murray–Darling rainbowfish X+Y
- unspecked hardyhead X+Y

[63] Native fish species marked with an X recorded in the planning unit via catch records and/or Australian Museum records where they exist. Species marked with a Y are expected to occur in the planning unit based on Maxent modelling with a minimum 33% probability of occurrence (Richies et al. 2016). CE = critically endangered, E = endangered, V = vulnerable.

Priority environmental assets	
Waterbirds	19 water-dependent bird species recorded
Native vegetation	7 water-dependent PCTs, with: • 533 ha of river red gum woodland • 38 ha of non-woody wetland • 417 ha of floodplain vegetation
Threatened other species	• southern myotis
Cultural assets	Significant cultural history but with limited recorded sites in water-dependent areas: • Aboriginal ceremony and dreaming, artefacts • modified trees
Other	• Bonshaw Weir is a high priority for fish passage remediation

Table 32 EWRs for Bonshaw planning unit (Dumaresq River upstream Bonshaw 416007)[64]

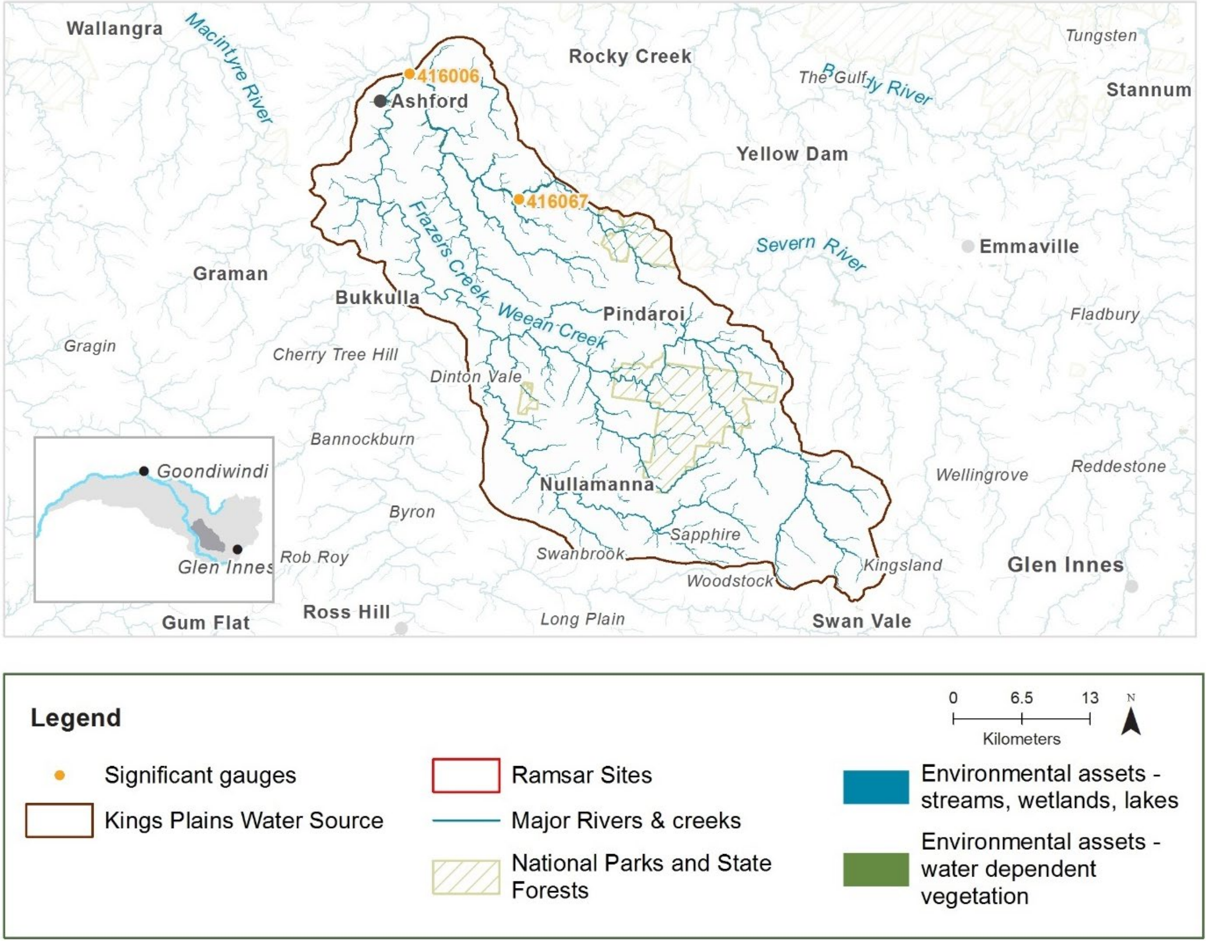
Flow category and EWR code		Flow threshold	Timing	Duration[65]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Cease-to-flow	CFa	<1 ML/d	Any time	3 days maximum	No more than 5 years in 10 (50% of years)	N/A	
	CFb	<1 ML/d	Any time	27 days maximum	No more than 5 years in a 100 (5% of years)	N/A	
	CFc	<1 ML/d	Any time	Any duration	No more than 15% of years	N/A	
Very low flow	VFa	>72 ML/d	Any time	306 days per year minimum	5 years in 10 (50%) minimum	In accordance with cease-to-flow requirements	
	VFb	>72 ML/d	Any time	161 days per year minimum	Every year (100%)	In accordance with cease-to-flow requirements	
Baseflow	BF1a	>250 ML/d	Any time	177 days per year minimum	5 years in 10 (50%) minimum	102 days	
	BF1b	>250 ML/d	Any time	58 days per year minimum	Every year (100%)	102 days	
	BF2a	>250 ML/d	September to March	137 days per year minimum	5 years in 10 (50%) minimum	186 days	
	BF2b	>250 ML/d	September to March	38 days per year minimum	Every year (100%)	186 days	

64 Refer to Table 8 in Part A for definitions of terms and explanatory text for EWRs.

65 Durations can be non-consecutive days for very low flow and baseflows. All other durations are expressed as consecutive days.

Flow category and EWR code		Flow threshold	Timing	Duration[65]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Small fresh	SF1	>500 ML/d	Ideally October to April but can occur any time	10 days minimum	Every year (100%)	1 year	Higher threshold for this EWR based on specific Murray cod preferences in this area Ideal timing is based on preferred temperature range for fish spawning of >20°C for most native fish and >18°C for Murray cod SF1 ideally shortly after LF2 for increased likelihood of successful recruitment of fish, productivity and dispersal
	SF2	1,000–2,400 ML/d	September to April	14 days minimum	2–3 years in 10 (25%) minimum (ideally 5–10 years in 10 (75%))	2 years	
Large fresh	LF1	>2,400 ML/d	Ideally July to September but can occur any time	5 days minimum	5–10 years in 10 (75%) minimum	2 years	This flow in Jul to Sep will improve pre-spawning fish condition
	LF2	>2,400 ML/d	October to April	5 days minimum	6–7 years in 10 (65%) minimum	3 years	Temp. preferably >17°C to maximise spawning outcomes Ideally shortly before SF1
	LF3	>6,750 ML/d	Any time	3 days minimum	6 years in 10 (60%) minimum	4 years	
Bankfull	BK1	>24,000 ML/d	October to April	1 day minimum	2–3 years in 10 (25%) minimum	4 years	
	BK2	>24,000 ML/d	Any time	1 day minimum	4 years in 10 years (40%) minimum	5 years	
Overbank	OB1	>53,000 ML/d	Any time	1 day minimum	1.5 years 10 years (15%) minimum	12 years (ideally 4 years)	

9.7 Kings Plains (Severn River at Ashford 416006)



Priority environmental assets

Rivers, creeks, wetlands and their associated floodplains and water-dependant native vegetation, including (but not limited to):

- Severn River
- Frazers Creek
- Weean Creek
- Oaky Creek
- Dingo Creek
- Kings Plains Creek
- Pindari Creek
- Five Mile Creek
- Instream habitat of high conservation value with rare or rare and threatened river styles
- Fringing vegetation communities
- Unaltered flows contribute to persistence of refugia and a natural flow regime downstream
- Quality of aquatic ecosystems in Frazers Creek is high and requires conservation

Native fish[66]

- golden perch [X]
- silver perch (CE) [X+Y]
- Murray cod (V) [X+Y]
- freshwater catfish (E) [X+Y]
- southern purple-spotted gudgeon (E) [X+Y]
- Australian smelt [X+Y]
- carp gudgeon [X+Y]
- Murray–Darling rainbowfish [X+Y]
- unspecked hardyhead [Y]
- mountain galaxias [Y]

[66] Native fish species marked with an X recorded in the planning unit via catch records and/or Australian Museum records where they exist. Species marked with a Y are expected to occur in the planning unit based on Maxent modelling with a minimum 33% probability of occurrence (Richies et al. 2016). CE = critically endangered, E = endangered, V = vulnerable.

Priority environmental assets	
Waterbirds	29 water-dependent bird species recorded, including the listed[67] waterbird species: brolga (V) and common greenshank (C,J,K)
Native vegetation	5 water-dependent PCTs, with: • 1,492 ha of river red gum woodland • 12 ha of non-woody wetland • 6 ha of flood-dependent shrubland wetland
Cultural assets	• Aboriginal ceremony and dreaming • burial sites • modified trees

[67] Listed as Commonwealth or NSW threatened (vulnerable [V], endangered [E] or critically endangered [CE]) or under international migratory bird agreements (JAMBA [J], CAMBA [C], ROKAMBA [K])

Table 33 EWRs for Kings Plains planning unit (Severn River at Ashford 416006)[68]

Flow category and EWR code		Flow threshold	Timing	Duration[69]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Cease-to-flow	CFa	<1 ML/d	Any time	Cease-to-flow events have not occurred in observed data post regulation (1969–2017) in this planning unit. They should therefore be avoided to protect the fish community. The resilience of this community is likely to have been compromised by development.			
	CFb	<1 ML/d	Any time				
	CFc	<1 ML/d	Any time	Any duration	0% of years	N/A	
Very low flow	VFa	>48 ML/d	Any time	258 days per year minimum	5 years in 10 (50%) minimum	In accordance with cease-to-flow requirements	
	VFb	>48 ML/d	Any time	132 days per year minimum	Every year (100%)	In accordance with cease-to-flow requirements	
Baseflow	BF1a	>65 ML/d	Any time	224 days per year minimum	5 years in 10 (50%) minimum	66 days	
	BF1b	>65 ML/d	Any time	114 days per year minimum	Every year (100%)	66 days	
	BF2a	>65 ML/d	September to March	149 days per year minimum	5 years in 10 (50%) minimum	180 days	
	BF2b	>65 ML/d	September to March	79 days per year minimum	Every year (100%)	180 days	

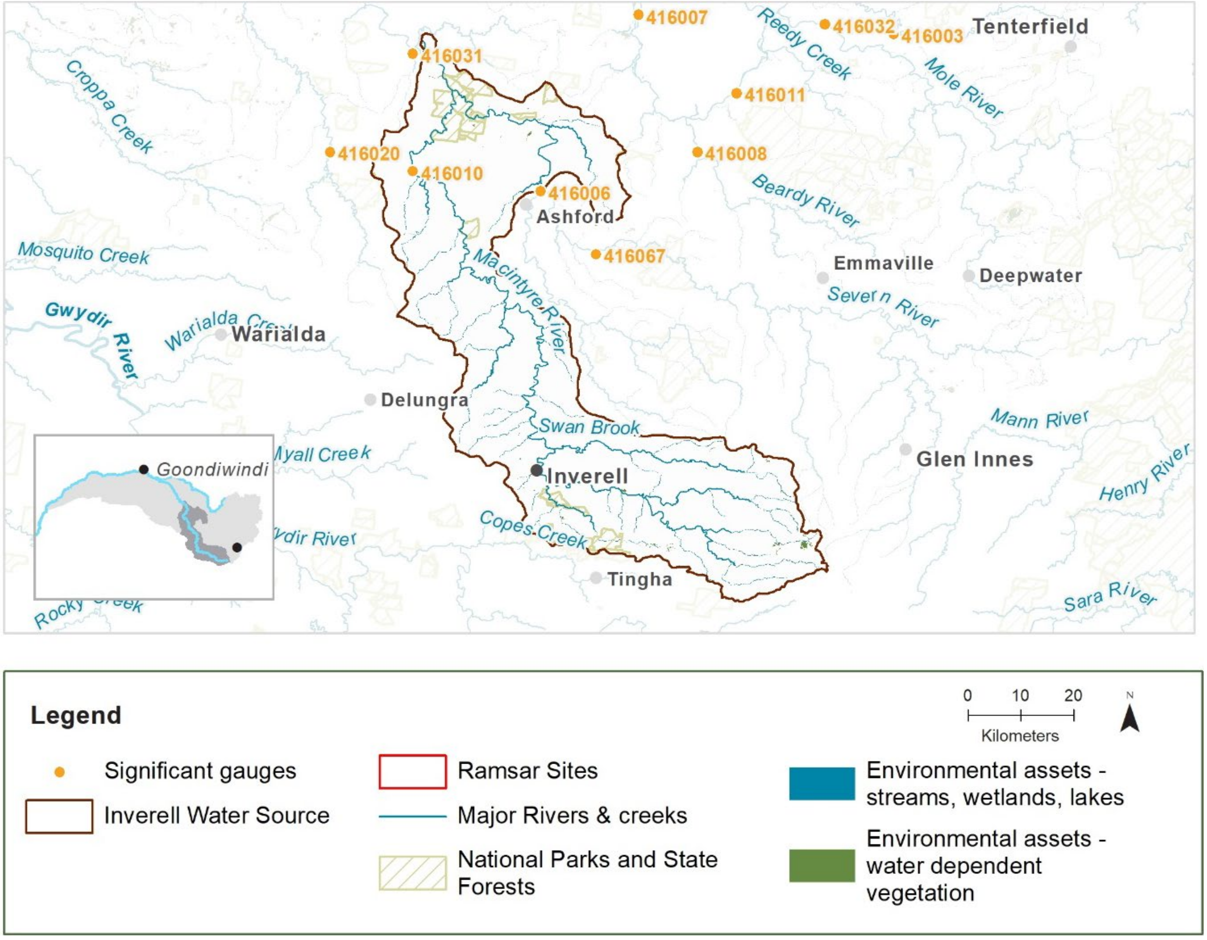
[68] Refer to Table 8 in Part A for definitions of terms and explanatory text for EWRs.

[69] Durations can be non-consecutive days for very low flow and baseflows. All other durations are expressed as consecutive days.

Flow category and EWR code		Flow threshold	Timing	Duration[69]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Small fresh	SF1	>245 ML/d	Ideally October to April but can occur any time	10 days minimum	Every year (100%)	1 year	Ideal timing is based on preferred temperature range for fish spawning of >20°C for most native fish and >18°C for Murray cod SF1 ideally shortly after LF2 for increased likelihood of successful recruitment of fish, productivity and dispersal
	SF2	245–1,520 ML/d	September to April	14 days minimum	7–8years in 10 (75%) minimum	2 years	
Large fresh	LF1	>1,520 ML/d	Ideally July to December but can occur any time	5 days minimum	8 years in 10 (80%) minimum	2 years	This flow in Jul to Sep will improve pre-spawning fish condition This magnitude will assist with ecosystem function and vegetation objectives as well
	LF2	>1,520 ML/d	October to April	7 days minimum	4–5 years in 10 (45%) minimum	4 years	Temp. preferably >17°C to maximise spawning outcomes Ideally shortly before SF1
	LF3	>4,200 ML/d	October to April	4 days minimum	4–5 years in 10 (45%) minimum	4 years	This EWR will contribute to the life-history trigger for fish to spawn (close to a 2 m height rise) and will contribute to ecosystem functions, including flushing sediment
Bankfull	BK1	>15,000 ML/d	October to April	1 day minimum	5–6 years in 10 years (55%) minimum	5 years (ideally 4 years)	
	BK2	>15,000 ML/d	Any time	2 days minimum	4 years in 10 (40%) minimum	5 years	

Flow category and EWR code		Flow threshold	Timing	Duration[69]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Overbank	OB1	>20,000 ML/d	October to April	1 day minimum	3–5 years in 10 (35%) minimum	6 years (ideally 4 years)	
	OB2	>20,000 ML/d	Any time	2 days minimum	3 in 10 years (30%) minimum	7 years (ideally 5 years)	

9.8 Inverell (Macintyre River at Wallangra 416010)



Priority environmental assets

Rivers, creeks, wetlands and their associated floodplains and water-dependant native vegetation, including (but not limited to):

- Macintyre River
- Myall Creek
- Severn River
- Reedy Creek
- Swamp Creek
- Graman Creek
- Cherry Tree Creek
- Bannockburn Creek
- Swan Brook
- Middle Creek
- Rob Roy Creek
- Jessies Gully
- Macintyre River is a key movement corridor with high biodiversity, instream habitat and fringing vegetation communities, including a large area of river red gum, hydrodynamic diversity, occurrence of threatened species and dry period/drought refuge
- Unaltered flows contribute to persistence of refugia and a natural flow regime downstream

Native fish[70]

- golden perch X+Y
- silver perch (CE) X+Y
- spangled perch Y
- Murray cod (V) X+Y
- flat-headed gudgeon Y
- river blackfish Y
- freshwater catfish (E) X+Y
- southern purple-spotted gudgeon (E) Y
- olive perchlet (E) X
- Murray–Darling rainbowfish X+Y
- Darling River hardyhead X
- Australian smelt X+Y
- carp gudgeon X+Y
- mountain galaxias X+Y
- bony herring Y
- unspecked hardyhead X+Y

[70] Native fish species marked with an X recorded in the planning unit via catch records and/or Australian Museum records where they exist. Species marked with a Y are expected to occur in the planning unit based on Maxent modelling with a minimum 33% probability of occurrence (Richies et al. 2016). CE = critically endangered, E = endangered, V = vulnerable.

Priority environmental assets	
Waterbirds	40 water-dependent bird species recorded, including the listed[71] waterbird species: blue-billed duck (V) and Latham's snipe (J,K)
Native vegetation	9 water-dependent PCTs, with: • 2,948 ha of river red gum woodland • 350 ha of non-woody wetland • 292 ha of flood-dependent shrubland wetland
Cultural assets	Significant cultural history but with limited recorded sites in water-dependent areas: • Aboriginal ceremony and dreaming • modified trees

[71] Listed as Commonwealth or NSW threatened (vulnerable [V], endangered [E] or critically endangered [CE]) or under international migratory bird agreements (JAMBA [J], CAMBA [C], ROKAMBA [K])

Table 34 EWRs for Inverell planning unit (Macintyre River at Wallangra 416010)[72]

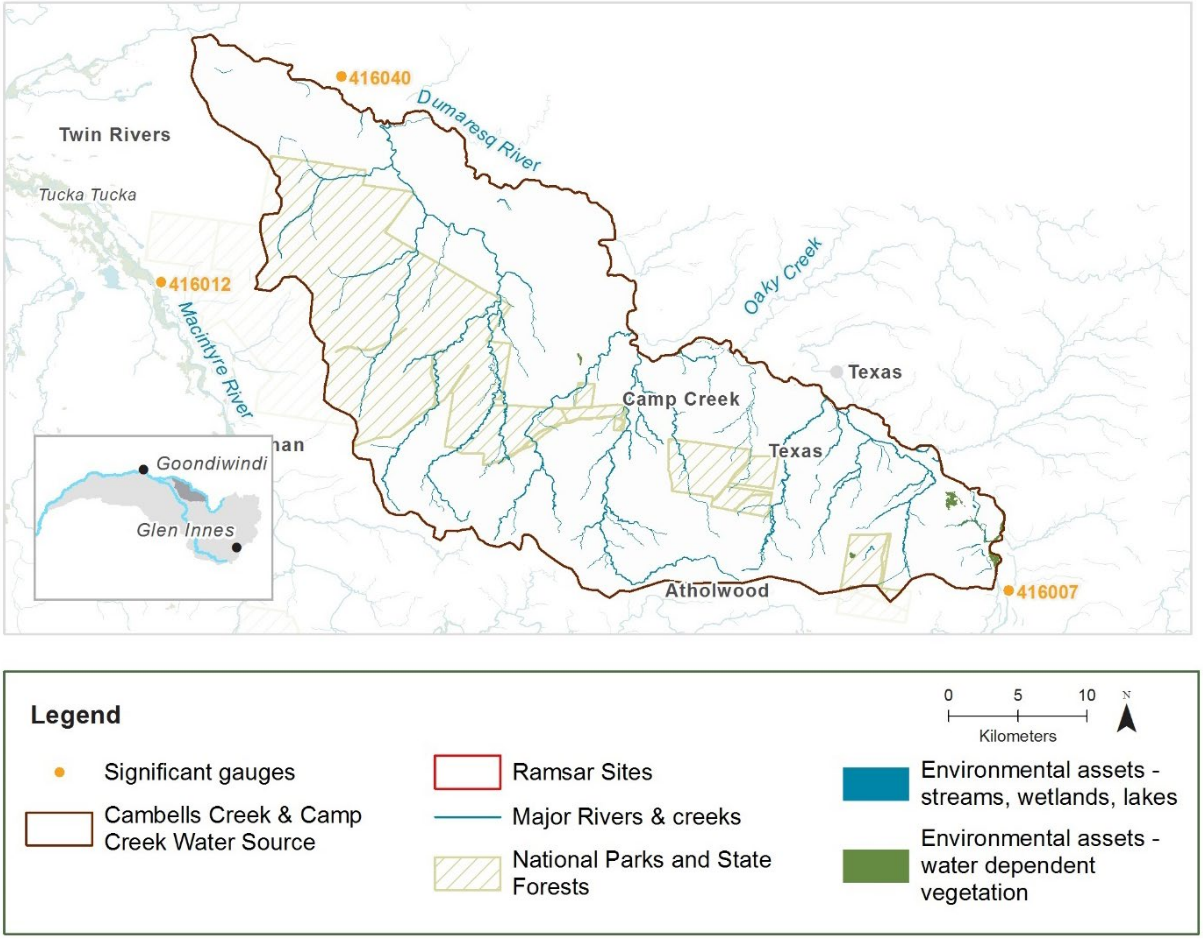
Flow category and EWR code		Flow threshold	Timing	Duration[73]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Cease-to-flow	CFa	<1 ML/d	Any time	21 days maximum	No more than 5 years in 10 (50% of years)	N/A	
	CFb	<1 ML/d	Any time	106 days maximum	No more than 5 years in a 100 (5% of years)	N/A	
	CFc	<1 ML/d	Any time	Any duration	No more than 64% of years	N/A	
Very low flow	VFa	>11 ML/d	Any time	256 days per year minimum	5 years in 10 (50%) minimum	In accordance with cease-to-flow requirements	
	VFb	>11 ML/d	Any time	99 days per year minimum	Every year (100%)	In accordance with cease-to-flow requirements	
Baseflow	BF1a	>40 ML/d	Any time	224 days per year minimum	5 years in 10 (50%) minimum	140 days	
	BF1b	>40 ML/d	Any time	43 days per year minimum	Every year (100%)	140 days	
	BF2a	>40 ML/d	September to March	119 days per year minimum	5 years in 10 (50%) minimum	212 days	
	BF2b	>40 ML/d	September to March	24 days per year minimum	Every year (100%)	212 days	

[72] Refer to Table 8 in Part A for definitions of terms and explanatory text for EWRs

[73] Durations can be non-consecutive days for very low flow and baseflows. All other durations are expressed as consecutive days.

Flow category and	EWR code	Flow threshold	Timing	Duration[73]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Small fresh	SF1	>140 ML/d	Ideally October to April but can occur any time	10 days minimum	9 years in 10 (90%) minimum	1 year	Ideal timing is based on preferred temperature range for fish spawning of >20°C for most native fish and >18°C for Murray cod SF1 ideally shortly after LF2 for increased likelihood of successful recruitment of fish, productivity and dispersal
	SF2	140–2,000 ML/d	September to April	14 days minimum	5 years in 10 (50%) minimum (ideally 5–10 years in 10 (75%))	2 years	
Large fresh	LF1	>2,000 ML/d	Ideally July to December but can occur any time	4 days minimum	4–5 years in 10 (45%) minimum	4 years (ideally 2 years)	This flow in Jul to Sep will improve pre-spawning fish condition
	LF2	>2,000 ML/d	October to April	5 days minimum	3–4 years in 10 (35%) minimum	8 years (ideally 4 years)	Temp. preferably >17°C to maximise spawning outcomes Ideally shortly before SF1
Bankfull	BK1	12,500 ML/d	October to April	1 day minimum	3–4 years in 10 (35%) minimum	4 years	
	BK2	>12,500 ML/d	Any time	2 days minimum	3 years in 10 (30%) minimum	6 years (ideally 5 years)	
Overbank	OB1	>26,000 ML/d	Any time	2 days minimum	1 in 10 years (10%) minimum	10 years (ideally 5 years)	

9.9 Campbells Creek and Camp Creek (Dumaresq River at Glenarbon 416040)



Priority environmental assets

Rivers, creeks, wetlands and their associated floodplains and water-dependant native vegetation, including (but not limited to):

- Campbells Creek
- Camp Creek
- Browns Creek
- Texas Creek
- Stony (Middle) Creek
- Instream habitat in this part of the Dumaresq River has greater complexity, quality and drought refugia
- Connected wetlands provide critical productivity, wetland vegetation and low velocity fish spawning habitat
- Unaltered flows contribute to persistence of refugia and a natural flow regime downstream

Native fish[74]

- golden perch X+Y
- spangled perch X+Y
- Murray cod (V) X+Y
- freshwater catfish (E) X+Y
- bony herring X+Y
- southern purple-spotted gudgeon (E) Y
- olive perchlet (E) X+Y
- Darling River hardyhead X
- Australian smelt X+Y
- carp gudgeon X+Y
- flat-headed gudgeon Y
- Murray–Darling rainbowfish X+Y
- unspecked hardyhead X+Y

[74] Native fish species marked with an X recorded in the planning unit via catch records and/or Australian Museum records where they exist. Species marked with a Y are expected to occur in the planning unit based on Maxent modelling with a minimum 33% probability of occurrence (Richies et al. 2016). CE = critically endangered, E = endangered, V = vulnerable.

Priority environmental assets	
Waterbirds	29 water-dependent bird species recorded, including the listed[75] waterbird species: black-necked stork (E)
Native vegetation	6 water-dependent PCTs including the BC Act listed Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions • 1,238 ha of river red gum woodland • 60 ha of non-woody wetland • 617 ha of floodplain vegetation
Threatened other species	• Booroolong frog (E)
Cultural assets	• Aboriginal ceremony and dreaming, artefacts, conflict • habitation structure • waterhole • modified trees
Other	Glenarbon Weir is a high priority for fish passage remediation

[75] Listed as Commonwealth or NSW threatened (vulnerable [V], endangered [E] or critically endangered [CE]) or under international migratory bird agreements (JAMBA [J], CAMBA [C], ROKAMBA [K])

Table 35 EWRs for Campbells Creek and Camp Creek planning unit (Dumaresq River at Glenarbon 416040)[76]

Flow category and EWR code		Flow threshold	Timing	Duration[77]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Cease-to-flow	CFa	<1 ML/d	Any time	9 days maximum	No more than 5 years in 10 (50% of years)	N/A	
	CFb	<1 ML/d	Any time	24 days maximum	No more than 5 years in a 100 (5% of years)	N/A	
	CFc	<1 ML/d	Any time	Any duration	No more than 35% of years	N/A	
Very low flow	VFa	>50 ML/d	Any time	261 days per year minimum	5 years in 10 (50%) minimum	In accordance with cease-to-flow requirements	
	VFb	>50 ML/d	Any time	145 days per year minimum	Every year (100%)	In accordance with cease-to-flow requirements	
Baseflow	BF1a	>140 ML/d	Any time	192 days per year minimum	5 years in 10 (50%) minimum	104 days	
	BF1b	>140 ML/d	Any time	96 days per year minimum	Every year (100%)	104 days	
	BF2a	>140 ML/d	September to March	132 days per year minimum	5 years in 10 (50%) minimum	181 days	
	BF2b	>140 ML/d	September to March	77 days per year minimum)	Every year (100%)	181 days	

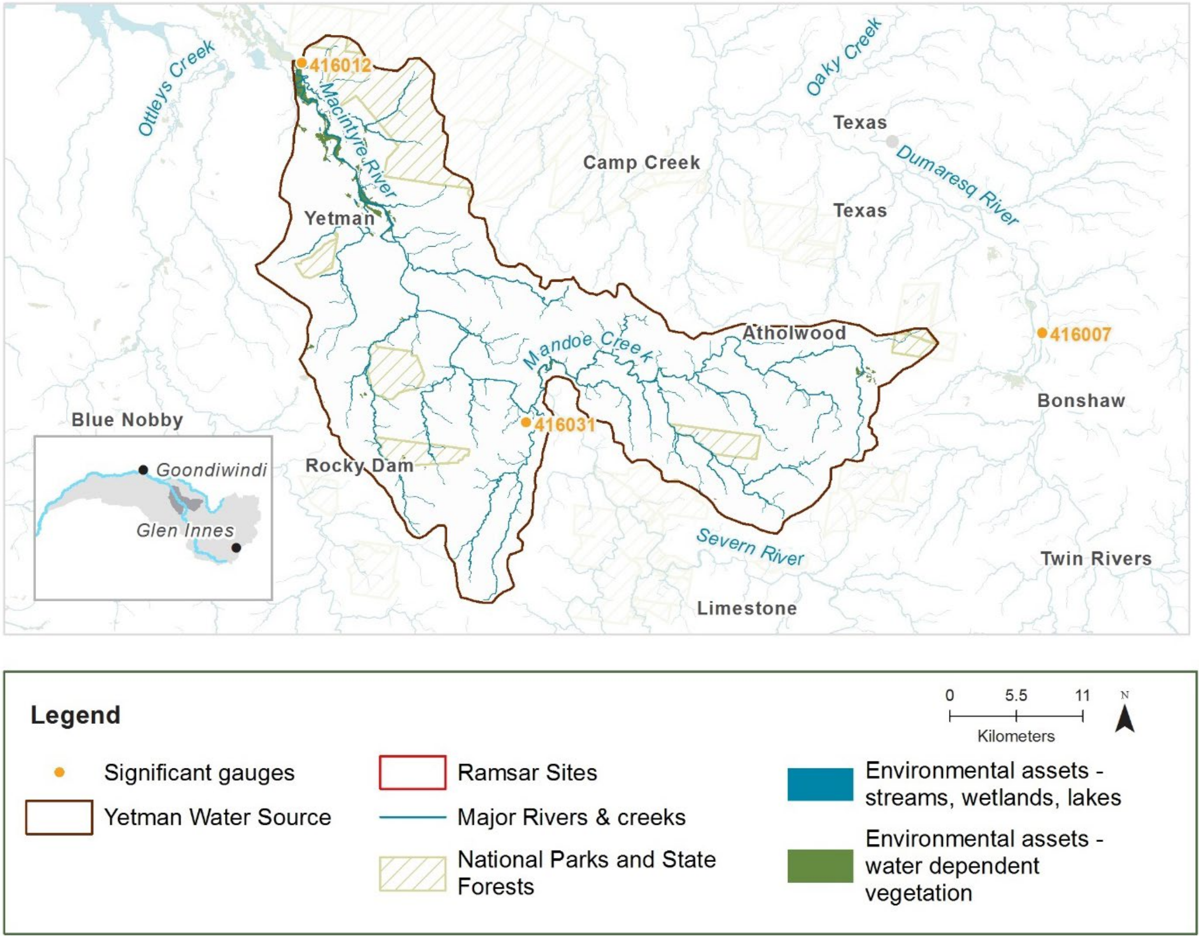
[76] Refer to Table 8 in Part A for definitions of terms and explanatory text for EWRs.

[77] Durations can be non-consecutive days for very low flow and baseflows. All other durations are expressed as consecutive days.

Flow category and EWR code		Flow threshold	Timing	Duration[77]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Small fresh	SF1	>500 ML/d	Ideally October to April but can occur any time	10 days minimum	Every year (100%)	1 year	Ideal timing is based on preferred temperature range for fish spawning of >20°C for most native fish and >18°C for Murray cod SF1 ideally shortly after LF2 for increased likelihood of successful recruitment of fish, productivity and dispersal
	SF2	1,000–2,400 ML/d	August to April	Ideally 14 days minimum	2 years in 10 minimum (ideally 5–10 years in 10 (75%))	7 years (ideally 2 years)	SF2 has a higher threshold at this location due to local evidence of Murray cod breeding Ideal timing is based on preferred temperature range for fish spawning of >20°C for most native fish and >18°C for Murray cod
Large fresh	LF1	>2,400 ML/d	Ideally July to December but can occur any time	5 days minimum	5–10 years in 10 (75%) minimum	2 years	This flow in Jul to Sep will improve pre-spawning fish condition
	LF2	>2,400 ML/d	October to April	5 days minimum	3–3.5 years in 10 (32%) minimum	4 years	Temp. preferably >17°C to maximise spawning outcomes Ideally shortly before SF1
	LF3	7,300 ML/d	Any time	4 days minimum	5 years in 10 (50%) minimum	4 years	Magnitude guided by habitat mapping in the Dumaresq River

Flow category and EWR code		Flow threshold	Timing	Duration[77]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Bankfull	BK1	>30,000 ML/d	Any time	1 day minimum	3 years in 10 (30%) minimum	8 years (ideally 4 years)	
	BK2	>30,000 ML/d	October to April	1 day minimum	2 years in 10 (20%) minimum	9 years (ideally 5 years)	
Overbank	OB1	>45,000 ML/d	Preferably October to April but can occur any time	1 day minimum	2 in 10 years (20%) minimum	9 years (ideally 4 years)	

9.10 Yetman (Macintyre at Holdfast 416012)



Priority environmental assets

Rivers, creeks, wetlands and their associated floodplains and water-dependant native vegetation, including (but not limited to):

- Macintyre River
- Simpsons Creek
- Morell Creek
- Oaky Creek
- Reedy Creek
- Pine Creek
- Back Creek
- Ena Creek
- Bunal Creek
- Branch Creek
- Mandoe Creek
- Macintyre River is a key movement corridor with high biodiversity, hydrodynamic diversity, occurrence of threatened species and dry period/drought refuge
- Instream habitat and fringing vegetation communities, with water-dependent listed PCTs
- Rare or rare and threatened river styles requiring protection from hydrological stress

Native fish[78]

- golden perch $^{X+Y}$
- silver perch (CE) $^{X+Y}$
- spangled perch $^{X+Y}$
- Murray cod (V) $^{X+Y}$
- bony herring $^{X+Y}$
- freshwater catfish (E) $^{X+Y}$
- southern purple-spotted gudgeon (E) ^{Y}
- olive perchlet (E) $^{X+Y}$
- Australian smelt $^{X+Y}$
- carp gudgeon $^{X+Y}$
- flat-headed gudgeon ^{Y}
- Murray–Darling rainbowfish $^{X+Y}$
- unspecked hardyhead $^{X+Y}$

[78] Native fish species marked with an X recorded in the planning unit via catch records and/or Australian Museum records where they exist. Species marked with a Y are expected to occur in the planning unit based on Maxent modelling with a minimum 33% probability of occurrence (Richies et al. 2016). CE = critically endangered, E = endangered, V = vulnerable.

Priority environmental assets	
Waterbirds	24 water-dependent bird species recorded, including the listed[79] waterbird species: black necked stork (E)
Native vegetation	9 water-dependent PCTs, including the BC Act listed Weeping Myall open woodland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion • 1,485 ha of river red gum woodland • 299 ha of floodplain vegetation • 105 ha of non-woody wetland • 24 ha of coolibah
Cultural assets	Significant cultural history but with limited recorded sites in water-dependent areas: • grinding grooves • modified trees

[79] Listed as Commonwealth or NSW threatened (vulnerable [V], endangered [E] or critically endangered [CE]) or under international migratory bird agreements (JAMBA [J], CAMBA [C], ROKAMBA [K])

Table 36 EWRs for Yetman planning unit (Macintyre at Holdfast 416012)[80]

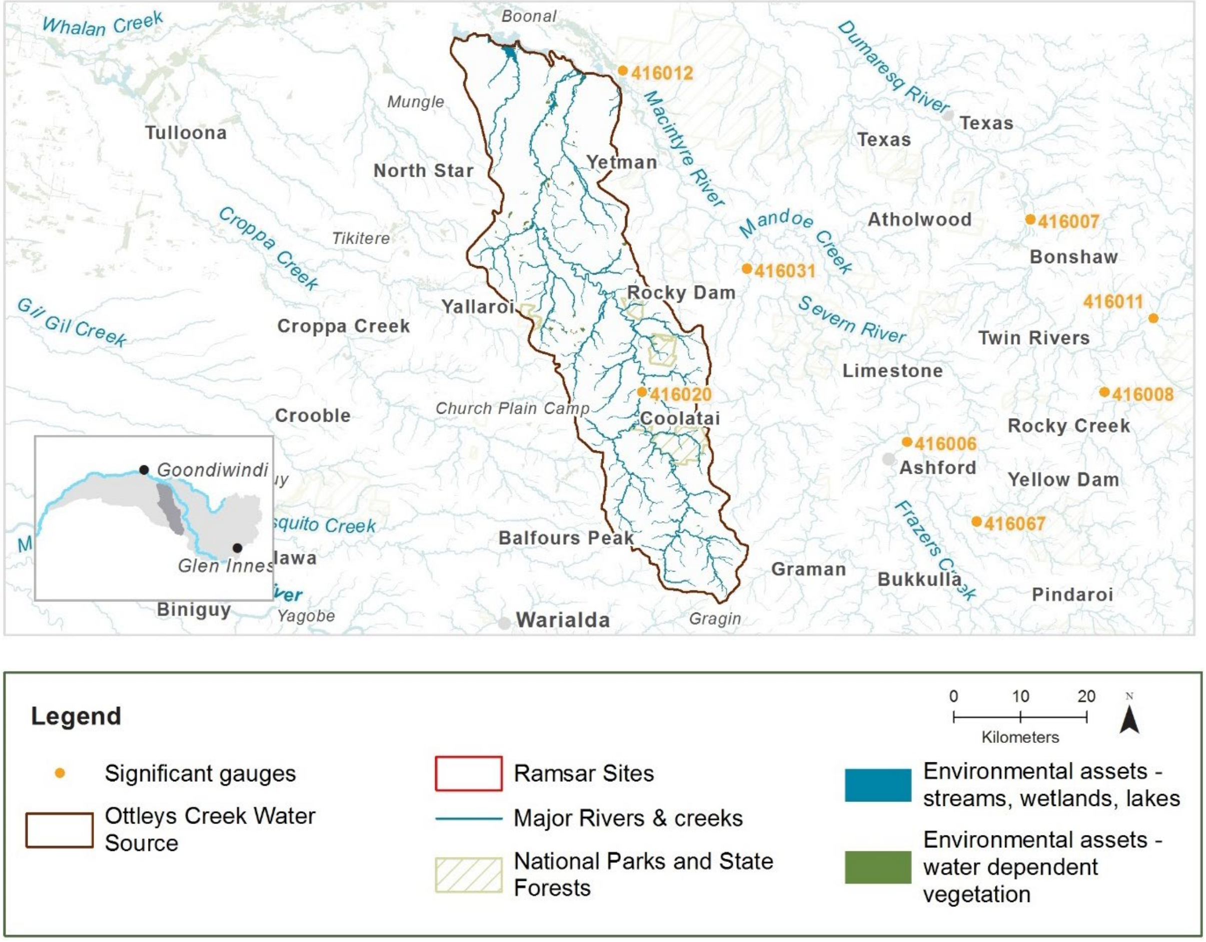
Flow category and EWR code		Flow threshold	Timing	Duration[81]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Cease-to-flow	CFa	<1 ML/d	Any time	6 days maximum	No more than 5 years in 10 (50% of years)	N/A	
	CFb	<1 ML/d	Any time	24 days maximum	No more than 5 years in a 100 (5% of years)	N/A	
	CFc	<1 ML/d	Any time	Any duration	No more than 6% of years	N/A	
Very low flow	VFa	>92 ML/d	Any time	266 days per year minimum	5 years in 10 (50%) minimum	In accordance with cease-to-flow requirements	
	VFb	>92 ML/d	Any time	111 days per year minimum	Every year (100%)	In accordance with cease-to-flow requirements	
Baseflow	BF1a	>250 ML/d	Any time	162 days per year minimum	5 years in 10 (50%) minimum	120 days	
	BF1b	>250 ML/d	Any time	61 days per year minimum	Every year (100%)	120 days	
	BF2a	>250 ML/d	September to March	111 days per year minimum	5 years in 10 (50%) minimum	192 days	
	BF2b	>250 ML/d	September to March	34 days per year minimum	Every year (100%)	192 days	

[80] Refer to Table 8 in Part A for definitions of terms and explanatory text for EWRs.

[81] Durations can be non-consecutive days for very low flow and baseflows. All other durations are expressed as consecutive days.

Flow category and EWR code		Flow threshold	Timing	Duration[81]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Small fresh	SF1	>1,000 ML/d	Ideally October to April but can occur any time	8 days minimum	9 years in 10 (90%) minimum	1 year	Ideal timing is based on preferred temperature range for fish spawning of >20°C for most native fish and >18°C for Murray cod SF1 ideally shortly after LF2 for increased likelihood of successful recruitment of fish, productivity and dispersal
	SF2	1,000–7,400 ML/d	September to April	10 days minimum (ideally 14 days)	5 years in 10 (50%) minimum (ideally 5–10 years in 10 (75%))	2 years	
Large fresh	LF1	>7,400 ML/d	Ideally July to December but can occur any time	4 days minimum	5 years in 10 (50%) minimum	3 years (ideally 2 years)	This flow in Jul to Sep will improve pre-spawning fish condition
	LF2	>7,400 ML/d	October to April	5 days minimum	3–4 years in 10 (35%) minimum	6 years (ideally 4 years)	Temp. preferably >17°C to maximise spawning outcomes Ideally shortly before SF1
	LF3	>11,500 ML/d	October to April	4 days minimum	3 years in 10 (30%) minimum	4 years	
Bankfull	BK1	>43,000 ML/d	October to April	1 day minimum	2–3 years in 10 (25%) minimum	4 years	
	BK2	>43,000 ML/d	Any time	1 day minimum	2–3 years in 10 (25%) minimum	5 years	
Overbank	OB1	>53,000 ML/d	October to April	1 day minimum	1–2 years in 10 (15%) minimum	4 years	
	OB2	>53,000 ML/d	Any time	1 day minimum	2–3 years in 10 (25%) minimum	5 years	

9.11 Ottleys Creek (Ottleys Creek at Coolatai 416020)



Priority environmental assets			

Rivers, creeks, wetlands and their associated floodplains and water-dependant native vegetation, including (but not limited to):

- Ottleys Creek
- Seereys Creek
- Long Plain Creek
- Scrubby Creek
- Jardines Creek
- Middle Creek
- Flaggy Creek
- Blue Nobby Creek
- Ephemeral flows provide significant pulses of productivity to downstream areas
- Unaltered flows contribute to persistence of refugia and a natural flow regime downstream
- Water-dependent listed PCTs

Native fish[82]	• golden perch Y • spangled perch X+Y • Murray cod (V) Y • freshwater catfish (E) Y	• southern purple-spotted gudgeon (E) Y • Australian smelt Y • carp gudgeon Y • flat-headed gudgeon Y	• Murray–Darling rainbowfish Y • bony herring Y • unspecked hardyhead Y
Waterbirds	22 water-dependent bird species recorded		

[82] Native fish species marked with an X recorded in the planning unit via catch records and/or Australian Museum records where they exist. Species marked with a Y are expected to occur in the planning unit based on Maxent modelling with a minimum 33% probability of occurrence (Richies et al. 2016). CE = critically endangered, E = endangered, V = vulnerable.

Priority environmental assets	
Native vegetation	9 water-dependent PCTs, including the BC Act listed Weeping Myall open woodland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion and Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions • 839 ha of river red gum woodland • 254 ha of non-woody wetland • 1,188 ha of floodplain vegetation • 523 ha of coolibah
Cultural assets	Significant cultural history but with limited recorded sites in water-dependent areas: • modified trees

Table 37 EWRs for Ottleys Creek planning unit (Ottleys Creek at Coolatai 416020)[83]

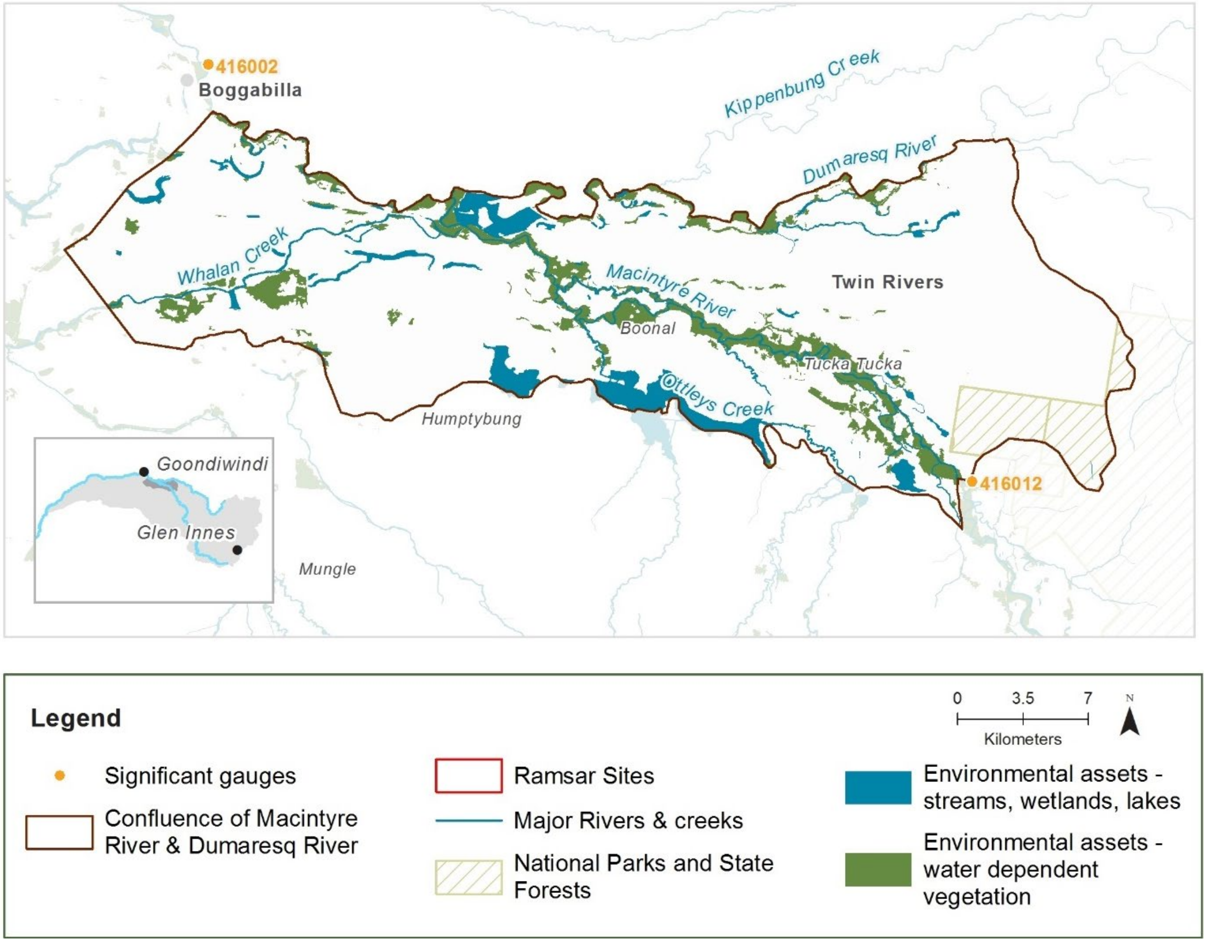
Flow category and EWR code		Flow threshold	Timing	Duration[84]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Cease-to-flow	CFa	<1 ML/d	Any time	4 days maximum	No more than 5 years in 10 (50% of years)	N/A	
	CFb	<1 ML/d	Any time	119 days maximum	No more than 5 years in a 100 (5% of years)	N/A	
	CFc	<1 ML/d	Any time	Any duration	No more than 43% of years.	N/A	
Very low flow*	VFa	>4 ML/d	Any time	186 days per year minimum	5 years in 10 (50%) minimum	In accordance with cease-to-flow requirements	*no baseflow at this gauge
	VFb	>4 ML/d	Any time	22 days per year minimum	Every year (100%)	In accordance with cease-to-flow requirements	
Small fresh	SF1	>200 ML/d*	Ideally October to April but can occur any time	2 days minimum	6–7 years in 10 (65%) minimum	2 years (ideally 1 year)	Ideal timing is based on preferred temperature range for fish spawning of >20°C for most native fish and >18°C for Murray cod SF1 ideally shortly after LF2 for increased likelihood of successful recruitment of fish, productivity and dispersal
	SF2	>200 ML/d*	August to April	2 days minimum (ideally 14 days)	6 years in 10 (60%) minimum (ideally 5–10 years in 10 (75%))		

[83] Refer to Table 8 in Part A for definitions of terms and explanatory text for EWRs

[84] Durations can be non-consecutive days for very low flow and baseflows. All other durations are expressed as consecutive days.

Flow category and EWR code		Flow threshold	Timing	Duration[84]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
							*No upper band required for catfish and Murray cod breeding at this location
Large fresh	LF1	>400 ML/d	Ideally July to September but can occur any time	3 days minimum	2 years in 10 (20%) minimum	5 years (ideally 2 years)	This flow in Jul to Sep will improve pre-spawning fish condition
	LF2	>400 ML/d	October to April	2 days minimum	4–5 years in 10 (47%) minimum	5 years (ideally 4 years)	Temp. preferably >17°C to maximise spawning outcomes Ideally shortly before SF1
Bankfull	BK1	>3,900 ML/d	October to April	1 day minimum	1.5 years in 10 (15%) minimum	4 years	
	BK1	>3,900 ML/d	Any time	1 days minimum	2–3 years in 10 (25%) minimum	5 years	
Overbank	OB1	>4,500 ML/d	October to April	1 day minimum	1 year in 10 (10%) minimum	7 years (ideally 4 years)	Clustered events (i.e. multiple events over 2–3 years) will provide improved conditions for native vegetation recruitment. Multiple events in close proximity will also improve the condition of native veg. communities
	OB2	>4,500 ML/d	Any time	1 day minimum	2 years in 10 (20%) minimum	6 years (ideally 5 years)	

9.12 Confluence of Macintyre River and Dumaresq River (Macintyre River at Goondiwindi 416201A)



Priority environmental assets

Rivers, creeks, wetlands and their associated floodplains and water-dependant native vegetation, including (but not limited to):

- Macintyre River
- Dumaresq River
- Tucka Tucka Creek
- Malgarai Lagoon
- Whalan Creek
- Borah Creek
- Maynes Lagoon
- Ottleys Creek
- Seereys Creek
- Bora Wetland
- Gobbooyallana Lagoon
- Macintyre River is a key movement corridor and has high biodiversity, hydrodynamic diversity, occurrence of threatened species and dry period/drought refuge
- Large areas of river red gum, coolibah and lignum and water-dependent listed PCTs
- Significant area of vital habitat providing drought refuge and rare river styles

Native fish[85]	• golden perch X+Y • silver perch (CE) Y • spangled perch X+Y • Murray cod (V) X+Y	• freshwater catfish (E) X+Y • southern purple-spotted gudgeon (E) Y • olive perchlet (E) X+Y • Australian smelt X+Y	• carp gudgeon X+Y • Murray–Darling rainbowfish X+Y • bony herring X+Y • unspecked hardyhead X+Y

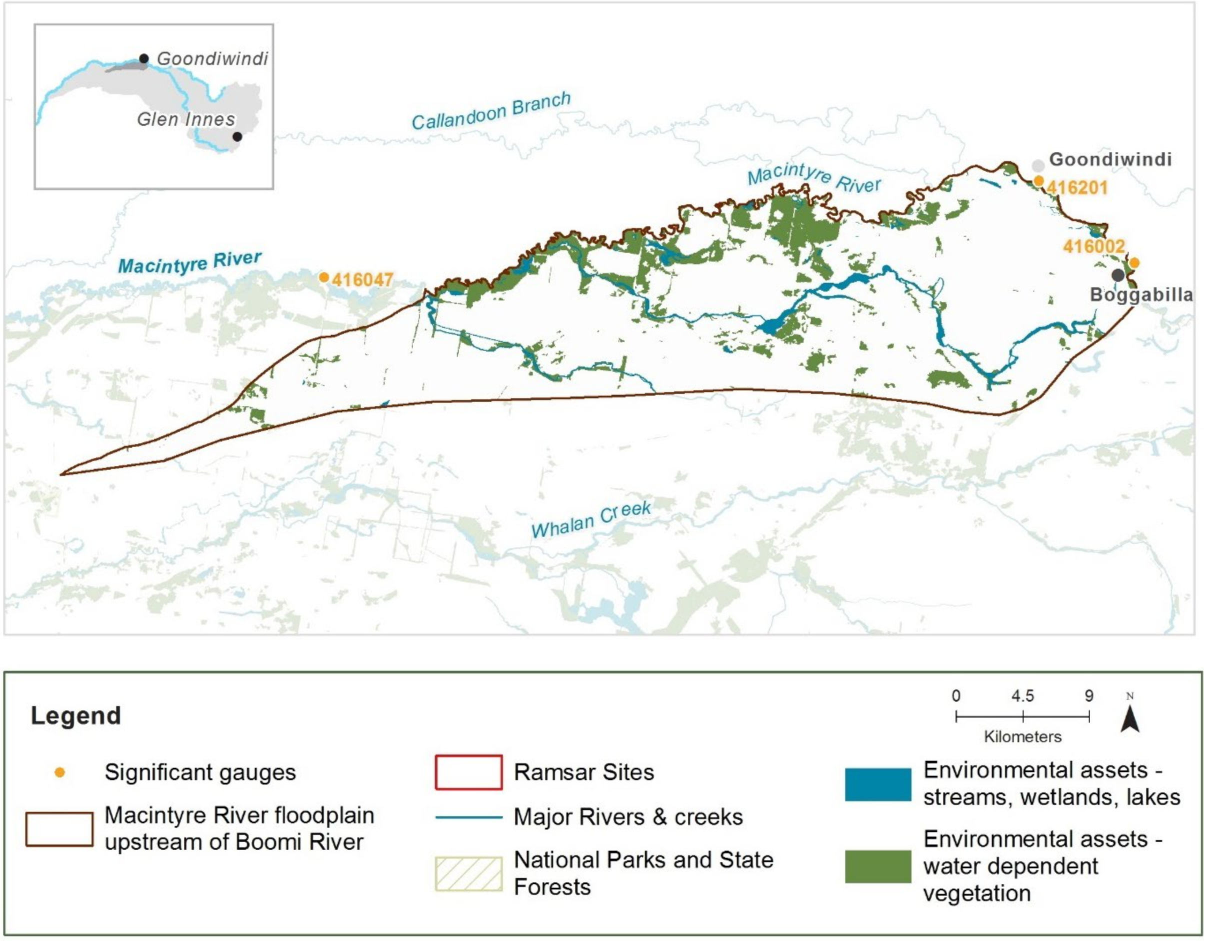
[85] Native fish species marked with an X recorded in the planning unit via catch records and/or Australian Museum records where they exist. Species marked with a Y are expected to occur in the planning unit based on Maxent modelling with a minimum 33% probability of occurrence (Richies et al. 2016). CE = critically endangered, E = endangered, V = vulnerable.

Priority environmental assets	
Waterbirds	41 water-dependent bird species recorded, including the listed[86] waterbird species: freckled duck (V) and Latham's snipe (J,K)
Native vegetation	12 water-dependent PCTs, including the BC Act listed Weeping Myall open woodland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion and Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions • 3,419 ha of river red gum woodland • 790 ha of coolibah • 1,222 ha of floodplain vegetation • 240 ha of non-woody wetland • 740 ha of lignum
Cultural assets	Boobera Lagoon has significant Aboriginal heritage value. The Gamilaraay (Kamilaroi) people believe the lagoon is the resting place of the rainbow serpent Garriya. The site is estimated to contain millions of stone artefacts as well as scar trees and canoe trees. • 2 culturally significant wetlands • Aboriginal resource and gathering, artefacts • Aboriginal ceremony and dreaming • artefacts, shells • modified trees
Other	Cunningham Weir is a high priority for fish passage remediation

EWRs for this planning unit are represented at the Macintyre River at Goondiwindi (416201A) gauge located in planning unit #12 immediately downstream. These EWRs are presented in Section 9.13: Macintyre River floodplain upstream of Boomi River.

[86] Listed as Commonwealth or NSW threatened (vulnerable [V], endangered [E] or critically endangered [CE]) or under international migratory bird agreements (JAMBA [J], CAMBA [C], ROKAMBA [K])

9.13 Macintyre River floodplain upstream of Boomi River (Macintyre River at Goondiwindi 416201A and Terrewah 416047)



Priority environmental assets

Rivers, creeks, wetlands and their associated floodplains and water-dependant native vegetation, including (but not limited to):

- Macintyre River
- Boobera Watercourse
- Boobera Lagoon
- Morella Watercourse
- Pungbougal Lagoon
- Poopoopirby Lagoon
- Uathery Lagoon
- Significant anabranches with billabongs and wetlands provide drought refugia and productivity pulses between floods that maintains ecosystem functions
- Billabongs and wetlands are known to provide habitat variability for a range of water-dependent species, including protected waterbirds such as brolga and black-necked stork
- Large areas of river red gum, coolibah, floodplain vegetation, lignum and water-dependent listed PCTs
- Macintyre River and floodplain lagoons are a key movement corridor with high biodiversity, hydrodynamic diversity, threatened species and dry period/drought refuge
- Morella Watercourse/Boobera Lagoon/Pungbougal Lagoon is a wetland of national importance, a naturally occurring permanent waterhole and one of the most important Aboriginal places in eastern Australia

Priority environmental assets	
Native fish[87]	• golden perch [X+Y] • silver perch (CE) [Y] • spangled perch [X+Y] • Murray cod (V) [X+Y] • freshwater catfish (E) [X+Y] • southern purple-spotted gudgeon (E) [Y] • olive perchlet (E) [X+Y] • Australian smelt [X+Y] • carp gudgeon [X+Y] • Murray–Darling rainbowfish [X+Y] • bony herring [X+Y] • unspecked hardyhead [X+Y]
Waterbirds	45 water-dependent bird species recorded, including the listed[88] waterbird species: black-necked stork (E), brolga (V), Australian gull-billed tern (C), Latham's snipe (J,K), marsh sandpiper (C,J,K) and sharp-tailed sandpiper (C,J,K)
Native vegetation	12 water-dependent PCTs, including the BC Act listed Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions • 1,359 ha of river red gum woodland • 4,724 ha of coolibah • 2,536 ha of floodplain vegetation • 107 ha of non-woody wetland • 428 ha of lignum
Cultural assets	Significant cultural history but with limited recorded sites in water-dependent areas: • Aboriginal ceremony and dreaming • modified trees

[87] Native fish species marked with an X recorded in the planning unit via catch records and/or Australian Museum records where they exist. Species marked with a Y are expected to occur in the planning unit based on Maxent modelling with a minimum 33% probability of occurrence (Richies et al. 2016). CE = critically endangered, E = endangered, V = vulnerable.

[88] Listed as Commonwealth or NSW threatened (vulnerable [V], endangered [E] or critically endangered [CE]) or under international migratory bird agreements (JAMBA [J], CAMBA [C], ROKAMBA [K])

Table 38 EWRs for the Macintyre River floodplain upstream of Boomi River (Macintyre at Goondiwindi 416201A)[89]
These EWRs also apply to planning unit 12: Confluence of Macintyre River and Dumaresq River.

Flow category and EWR code		Flow threshold	Timing	Duration[90]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Cease-to-flow	CFa	<1 ML/d	Any time	4 days maximum	No more than 5 years in 10 (50% of years)	N/A	
	CFb	<1 ML/d	Any time	31 days maximum	No more than 5 years in a 100 (5% of years)	N/A	
	CFc	<1 ML/d	Any time	Any duration	No more than 39% of years	N/A	
Very low flow	VFa	>166 ML/d	Any time	300 days per year minimum	5 years in 10 (50%) minimum	In accordance with cease-to-flow requirements	
	VFb	>166 ML/d	Any time	142 days per year minimum	Every year (100%)	In accordance with cease-to-flow requirements	
Baseflow	BF1a	>450 ML/d	Any time	213 days per year minimum	5 years in 10 (50%) minimum	99 days	
	BF1b	>450 ML/d	Any time	72 days per year minimum	Every year (100%)	99 days	
	BF2a	>450 ML/d	September to March	142 days per year minimum	5 years in 10 (50%) minimum	188 days	
	BF2b	>450 ML/d	September to March	57 days per year minimum	Every year (100%)	188 days	

89 Refer to Table 8 in Part A for definitions of terms and explanatory text for EWRs

90 Durations can be non-consecutive days for very low flow and baseflows. All other durations are expressed as consecutive days.

Flow category and EWR code		Flow threshold	Timing	Duration[90]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Small fresh	SF1	>1,500 ML/d	Ideally October to April but can occur any time	10 days minimum	Every year (100%)	1 year	Ideal timing is based on preferred temperature range for fish spawning of >20°C for most native fish and >18°C for Murray cod SF1 ideally shortly after LF2 for increased likelihood of successful recruitment of fish, productivity and dispersal
	SF2	1,500–8,000 ML/d	September to April	14 days minimum	5–10 years in 10 (75%) minimum	2 years	
Large fresh	LF1	>8,000 ML/d	Ideally July to September but can occur any time	5 days minimum	5–10 years in 10 (75%) minimum	2 years	Flows above 7,000 ML/d will start to fill around half of the anabranches in the reach This flow in Jul to Sep will improve pre-spawning fish condition
	LF2	>8,000 ML/d	October to April	6 days minimum	3–5 years in 10 (42%) minimum	4 years	Commencing as a rising flow only Temp. preferably >17°C to maximise spawning outcomes Ideally shortly before SF1
Bankfull for downstream	BK1_ds	>15,000 ML/d	Any time	5 days minimum	5 years in 10 (50%) minimum	5 years	Flows of this magnitude will start to produce overbank flows downstream of Goondiwindi
	BK2_ds	>15,000 ML/d	October to April	4 days minimum	5 years in 10 (50%) minimum	4 years	
Bankfull for upstream	BK1_us	>34,000 ML/d	Any time	3 days minimum	4–5 years in 10 (45%) minimum	5 years	These bankfull EWRs have been designed to meet ecological objectives upstream of Boggabilla and the surrounding areas of low-lying floodplain. Flows at this magnitude will start to inundate Whalan Creek
	BK2_us	>34,000 ML/d	October to April	2 days minimum	4 years in 10 (40%) minimum	6 years (ideally 4 years)	

Flow category and EWR code		Flow threshold	Timing	Duration[90]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Overbank[91]	OB1	>20,000 ML/d	September to April	5 days minimum	5 years in 10 (50%) minimum	4 years	Flow to support spawning
	OB2	>60,000 ML/d	Ideally October to April but can occur any time	3 days minimum	2 years in 10 (20%) minimum	5 years	This EWR provides for ecological outcomes both upstream and downstream of Goondiwindi along the connected floodplain
	OB2_Whalan	>73,000	Ideally October to April but can occur any time	2 days minimum	2–3 years in 10 (25%) minimum	5 years	This magnitude of flow at Goondiwindi assists in the overbank EWR at Whalan Creek at Euraba being met (along with tributary inflows from Croppa Creek to Whalan Creek). Flows at this magnitude will provide for ecological benefits on the floodplain between the Macintyre River and Whalan Creek
	OB3	>100,000 ML/d	Any time	2 days minimum	1–1.5 in 10 years (15%) minimum	TBD	Flows above this magnitude lead to extensive inundation of the floodplain around the Macintyre River and where it connects to Whalan Creek and Ottley's Creek and lagoons throughout that system (including the significant Boobera Lagoon). Flows greater than this have been observed (up to 150,000 ML/d)

[91] Clustered overbank events (i.e. multiple events over 2–3 years) will provide improved conditions for native vegetation recruitment. Multiple events in close proximity will also improve the condition of native veg communities.

Table 39 EWRs for Macintyre River floodplain upstream of Boomi planning unit (Macintyre at Terrewah 416047)[92]

Flow category and EWR code		Flow threshold	Timing	Duration[93]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Cease-to-flow	CFa	<1 ML/d	Any time	16 days maximum	No more than 5 years in 10 (50% of years)	N/A	
	CFb	<1 ML/d	Any time	57 days maximum	No more than 5 years in a 100 (5% of years)	N/A	
	CFc	<1 ML/d	Any time	Any duration	No more than 35% of years	N/A	
Very low flow	VFa	>40 ML/d	Any time	362 days per year minimum	5 years in 10 (50%) minimum	In accordance with cease-to-flow requirements	
	VFb	>40 ML/d	Any time	212 days per year minimum	Every year (100%)	In accordance with cease-to-flow requirements	
Baseflow	BF1a	>50 ML/d	Any time	345 days per year minimum	5 years in 10 (50%) minimum	62 days	
	BF1b	>50 ML/d	Any time	191 days per year minimum	Every year (100%)	62 days	
	BF2a	>50 ML/d	September to March	210 days per year minimum	5 years in 10 (50%) minimum	165 days	
	BF2b	>50 ML/d	September to March	132 days per year minimum	Every year (100%)	165 days	

92 Refer to Table 8 in Part A for definitions of terms and explanatory text for EWRs

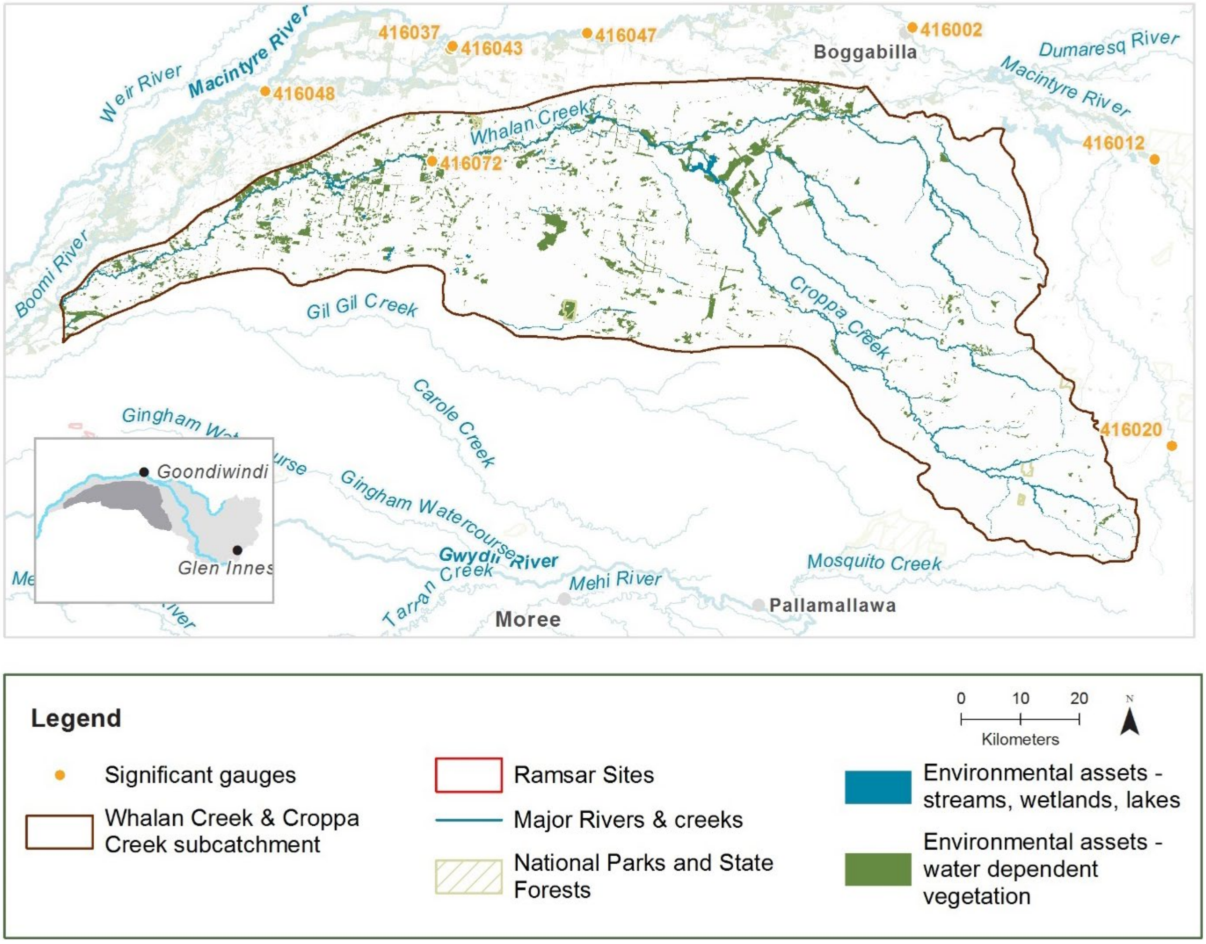
93 Durations can be non-consecutive days for very low flow and baseflows. All other durations are expressed as consecutive days.

Flow category and EWR code		Flow threshold	Timing	Duration[93]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Small fresh	SF1	>330 ML/d	Ideally October to April but can occur any time	13 days minimum	Every year (100%)	1 year	Ideal timing is based on preferred temperature range for fish spawning of >20°C for most native fish and >18°C for Murray cod SF1 ideally shortly after LF2 for increased likelihood of successful recruitment of fish, productivity and dispersal
	SF2	330–2,200 ML/d	September to April	21 days minimum	5–10 years in 10 (75%) minimum	2 years	
Large fresh	LF1	>2,200 ML/d	Ideally July to September but can occur any time	11 days minimum	5–10 years in 10 (75%) minimum	2 years	This flow in Jul to Sep will improve pre-spawning fish condition
	LF2	>2,200 ML/d	October to April	11 days minimum	3–5 years in 10 (42%) minimum	4 years	Temp. preferably >17°C to maximise spawning outcomes Ideally shortly before SF1
	LF3	5,000 ML/d	Any time	11 days minimum	5.5 years in 10 (55%) minimum	5 years	Designed to connect anabranches documented in Southwell (2008) and will benefit habitat and meet requirements for olive perchlet and purple-spotted gudgeon

Flow category and EWR code		Flow threshold	Timing	Duration[93]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Bankfull[94]	BK1	>7,900 ML/d	October to April	5 days minimum	4–5 years in 10 (45%) minimum	4 years	
	BK2	>7,900 ML/d	Ideally September to February but can occur any time	7 days minimum	2–3 years in 10 (42%) minimum	5 years	Spawning flow for floodplain specialists
Overbank[94]	OB1	>10,500 ML/d	Ideally October to April but can occur any time	5 days minimum	3–5 years in 10 years (40%) minimum	8 years (ideally 4 years)	

[94] Clustered bankfull and overbank events (i.e. multiple events over 2–3 years) will provide improved conditions for native vegetation recruitment. Multiple events in close proximity will also improve the condition of native vegetation communities.

9.14 Whalan and Croppa creeks (Whalan at Euraba 416072)



Priority environmental assets

Rivers, creeks, wetlands and their associated floodplains and water-dependant native vegetation, including (but not limited to):

- Whalan Creek
- Croppa Creek
- Mobbindry Creek
- Tackinbri Creek
- Mungle Creek
- Back Creek
- Forest Creek
- Yallaroi Creek
- Significant anabranches with billabongs and wetlands provide drought refugia and productivity pulses between floods that maintains ecosystem functions
- Billabongs and wetlands are known to provide habitat variability for a range of water-dependent species, including protected waterbirds such as brolga and black-necked stork
- Large areas of river red gum, coolibah, floodplain vegetation, lignum and water-dependent listed PCTs

Native fish[95]

- golden perch [X+Y]
- silver perch (CE) [Y]
- spangled perch [X+Y]
- Murray cod (V) [Y]
- bony herring [X+Y]
- freshwater catfish (E) [Y]
- southern purple-spotted gudgeon (E) [Y]
- olive perchlet (E) [Y]
- Australian smelt [Y]
- carp gudgeon [Y]
- flat-headed gudgeon [Y]
- Murray–Darling rainbowfish [X+Y]
- unspecked hardyhead [Y]

95 Native fish species marked with an X recorded in the planning unit via catch records and/or Australian Museum records where they exist. Species marked with a Y are expected to occur in the planning unit based on Maxent modelling with a minimum 33% probability of occurrence (Richies et al. 2016). CE = critically endangered, E = endangered, V = vulnerable.

Priority environmental assets		
Waterbirds	19 water-dependent bird species recorded, including the listed[96] waterbird species: freckled duck (V), black-necked stork (E), Latham's snipe (J,K) and marsh sandpiper (C,J,K)	
Native vegetation	17 water-dependent PCTs, including the BC Act listed Weeping Myall open woodland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion, Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions and Native Millet - Cup Grass grassland of the Darling Riverine Plains Bioregion	
	• 2,371 ha of river red gum woodland • 21,713 ha of floodplain vegetation • 26,020 ha of coolibah	• 220 ha of non-woody wetland • 2,672 ha of lignum
Cultural assets	• 2 culturally significant wetlands • waterhole	• Aboriginal ceremony and dreaming, burials • modified trees

[96] Listed as Commonwealth or NSW threatened (vulnerable [V], endangered [E] or critically endangered [CE]) or under international migratory bird agreements (JAMBA [J], CAMBA [C], ROKAMBA [K])

Table 40 EWRs for Whalan and Croppa creeks planning unit (Whalan at Euraba 416072)[97]

See Goondiwindi gauge table for additional EWRs that support ecological objectives of the upper end of Whalan Creek floodplain and whole of system flows down Whalan Creek to the gauge at Euraba. The EWRs within this table are a guide and have been informed by limited observed data from 2013, except for OB1 for which frequency was based on frequency of flows at Goondiwindi (416201A) that provide overbank flows to the Whalan Creek floodplain.

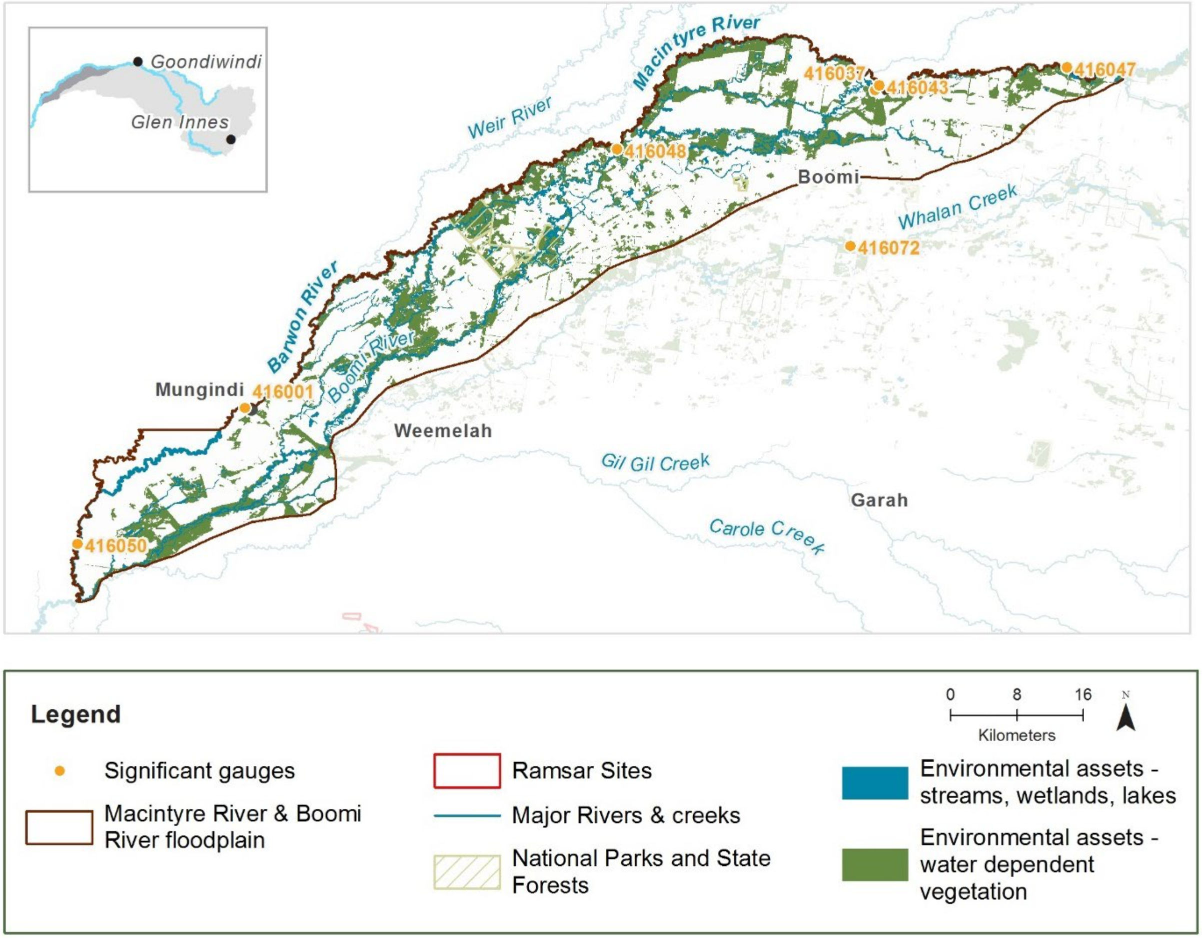
Flow category and EWR code		Flow threshold	Timing	Duration[98]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Cease-to-flow	CF	>4 ML/d	There is insufficient data to assign timing, duration and frequency to the cease-to-flow EWR at this gauge.				
Small fresh	SF1a	>240 ML/d	Ideally October to April but can occur any time	2 days minimum	6 in 10 years (60%) minimum	N/A	This small fresh is expected to be achieved through localised events that run tributaries to Whalan Creek, such as Croppa Creek
	SF1b	>240 ML/d	Ideally October to April but can occur any time	10 days minimum	3 in 10 years (30%) minimum	N/A	This small fresh is expected to be achieved through larger system events that include flows from the Macintyre
Bankfull	BK1	>850 ML/d	Any time	8 days minimum	3 in 10 years (30%) minimum	N/A[99]	
Overbank	OB1	>2,000 ML/d	Any time	5 days minimum	3 in 10 years (30%) minimum	N/A[99]	

[97] Refer to Table 8 in Part A for definitions of terms and explanatory text for EWRs

[98] Durations can be non-consecutive days for very low flow and baseflows. All other durations are expressed as consecutive days.

[99] Insufficient data to determine at this stage

9.15 Macintyre River and Boomi River floodplain (Macintyre at Kanowna 416048; Boomi River at Boomi Weir Offtake 416037; Barwon River at Mungindi 416001)



Priority environmental assets

Rivers, creeks, wetlands and their associated floodplains and water-dependant native vegetation, including (but not limited to):

- Boomi River
- Barwon River
- Tarpaulin Creek
- Gnoura Gnoura Creek
- Commillamori Creek
- Goodlayamma Creek
- Boomangera Creek
- Gravelly Creek
- Doondoona Creek
- Bonanga Billabong
- Breenie Creek
- Crooked Creek
- Geary Creek
- Carwal Creek
- Significant anabranches with billabongs and wetlands provide habitat variability, drought refugia and productivity pulses between floods that maintains ecosystem functions
- Large areas of river red gum, coolibah, floodplain vegetation, lignum and water-dependent listed PCTs
- Boomi River flows provide an important hydrological connection and contribution to downstream flows
- Macintyre River and floodplain lagoons are a key movement corridor with high biodiversity, hydrodynamic diversity, occurrence of threatened species and dry period/drought refuge

Native fish[100]	• golden perch X+Y • silver perch (CE) Y • spangled perch X+Y • Murray cod (V) X+Y	• freshwater catfish (E) Y • southern purple-spotted gudgeon (E) Y • olive perchlet (E) X+Y • Australian smelt X+Y	• carp gudgeon X+Y • Murray–Darling rainbowfish X+Y • bony herring X+Y
Waterbirds	32 water-dependent bird species recorded, including the listed[101] waterbird species: black-necked stork (E) and brolga (V)		
Native vegetation	12 water-dependent PCTs, including the BC Act listed Weeping Myall open woodland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion and Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions • 7,268 ha of river red gum woodland • 37,023 ha of coolibah • 424 ha of black box	• 3,354 ha of floodplain vegetation • 313 ha of non-woody wetland • 221 ha of lignum	
Threatened other species	• Sloane's froglet		
Cultural assets	• 6 culturally significant wetlands • artefact, shells	• ceremonial ring • modified trees	

100 Native fish species marked with an X recorded in the planning unit via catch records and/or Australian Museum records where they exist. Species marked with a Y are expected to occur in the planning unit based on Maxent modelling with a minimum 33% probability of occurrence (Richies et al. 2016). CE = critically endangered, E = endangered, V = vulnerable.

101 Listed as Commonwealth or NSW threatened (vulnerable [V], endangered [E] or critically endangered [CE]) or under international migratory bird agreements (JAMBA [J], CAMBA [C], ROKAMBA [K])

Table 41 EWRs for Macintyre River and Boomi River floodplain planning unit (Barwon River at Mungindi 416001)[102]

Flow category and EWR code		Flow threshold	Timing	Duration[103]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Cease-to-flow	CFa	<1 ML/d	Any time	20 days maximum	No more than 5 years in 10 (50% of years)	N/A	When managing water to restart flows, avoid harmful water quality impacts, such as de-oxygenation of refuge pools
	CFb	<1 ML/d	Any time	95 days maximum	No more than 5 years in a 100 (5% of years)	N/A	
	CFc	<1 ML/d	Any time	Any duration	No more than 5 years in 10 (50% of years)	N/A	
Very low flow	VFa	>45 ML/d	Any time	310 days per year minimum	5 years in 10 (50%) minimum	In accordance with maximum duration of cease-to-flow events	Flows that provide replenishment volumes to refuge pools Waterhole persistence can also be supported by groundwater
	VFb	>45 ML/d	Any time	220 days per year minimum	Every year (100%)	In accordance with maximum duration of cease-to-flow events	
Baseflow	BF1a	>160 ML/d	Any time	220 days per year minimum	5 years in 10 (50%) minimum	130 days	Aiming to provide a depth of 0.3 m to allow fish passage Also to manage water quality, prevent destratification and reduce risk of blue-green algal blooms
	BF1b	>160 ML/d	Any time	110 days per year minimum	Every year (100%)	130 days	

[102] Refer to Table 8 in Part A for definitions of terms and explanatory text for EWRs.

[103] Durations can be non-consecutive days for very low flow and baseflows. All other durations are expressed as consecutive days.

Flow category and EWR code		Flow threshold	Timing	Duration[103]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Baseflow, cont.	BF2a	>160 ML/d	September to March	145 days per year minimum	3 years in 10 (30%) minimum	205 days	Aiming to provide a depth of 0.3 m to allow fish passage
	BF2b	>160 ML/d		In very dry years, at least 80 days per year (within timing window)	Every year (100%)	205 days	
Small fresh	SF1	>540 ML/d	Any time, but ideally October to April	10 days minimum	Every year (100%)	1 year	Ideal timing is based on preferred temperature range for fish spawning of >20°C for most native fish and >18°C for Murray cod Aiming to provide a depth of greater than 0.5 m to allow movement of large fish Flow velocity ideally up to 0.3–0.4 m/s (depending on channel form) Ideally shortly after LF2 for increased likelihood of successful recruitment of fish, productivity and dispersal
	SF2	540–3,000 ML/d	September to April	14 days minimum	5–10 years in 10 (75%) minimum	2 years	Timing is based on preferred temperature range for fish spawning of >20°C for most native fish and >18°C for Murray cod Aiming to provide a depth of greater than 0.5 m to allow movement of large fish Flow velocity ideally up to 0.3–0.4 m/s (depending on channel form)

Flow category and EWR code		Flow threshold	Timing	Duration[103]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Large fresh	LF1	>3,000 ML/d	Any time, but ideally July to September	15 days minimum	5–10 years in 10 (75%) minimum	2 years	This flow in Jul to Sep will improve pre-spawning fish condition Aiming to provide a depth of 2 m to cover instream features and trigger response from fish Flow velocity ideally 0.3–0.4 m/s (depending on channel form)
	LF2	>3,000 ML/d	October to April	15 days minimum	3–5 years in 10 (42%) minimum	2 years	Flow velocity ideally 0.3–0.4 m/s (depending on channel form) Temp. preferably >17°C to maximise spawning outcomes Ideally shortly before SF1
Bankfull	BK1	>7,900 ML/d	Any time	5 days minimum	5 years in 10 (50%) minimum	4 years	
Overbank	OB1	>10,000 ML/d	Any time	5 days minimum	2–4 years in 10 years (30%) minimum	5 years	Clustered events (i.e. multiple events over 2–3 years) will provide improved conditions for native vegetation recruitment. Multiple events in close proximity will also improve the condition of native veg. communities
	OB2	>13,000	Any time	5 days minimum	1–3 years in 10 (20%) minimum	10 years	
	OB3	>19,000 ML/d	Any time	5 days minimum	0.5–1 years in 10 years (10%) minimum	15 years	

Table 42 EWRs for Macintyre River and Boomi River floodplain planning unit (Boomi River at Boomi Weir Offtake 416037)[104] [105]

Flow category and EWR code		Flow threshold	Timing	Duration[106]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Cease-to-flow	CFa	<1 ML/d	Any time	5 days maximum	No more than 5 years in 10 (50% of years)	N/A	
	CFb	<1 ML/d	Any time	56 days maximum	No more than 5 years in a 100 (5% of years)	N/A	
	CFc	<1 ML/d	Any time	Any duration	No more than 6 years in 10 (60% of years)	N/A	
Very low flow	VFa	<3 ML/d	Any time	315 days per year minimum	5 years in 10 (50%) minimum	In accordance with cease-to-flow requirements	
	VFb	<3 ML/d	Any time	168 days per year minimum	Every year (100%)	In accordance with cease-to-flow requirements	
Baseflow	BF1a	>25 ML/d	Any time	156 days per year minimum	5 years in 10 (50%) minimum	133 days	
	BF1b	>25 ML/d	Any time	73 days per year minimum	Every year (100%)	133 days	
	BF2a	>25 ML/d	September to March	92 days per year minimum	5 years in 10 (50%) minimum	237 days	
	BF2b	>25 ML/d	September to March	36 days per year minimum	Every year (100%)	237 days	

[104] A fishway is planned along the Macintyre River that may incur changes to EWRs in the future.

[105] Refer to Table 8 in Part A for definitions of terms and explanatory text for EWRs.

[106] Durations can be non-consecutive days for very low flow and baseflows. All other durations are expressed as consecutive days.

Flow category and EWR code		Flow threshold	Timing	Duration[106]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Small fresh	SF1	>75 ML/d	Ideally October to April but can occur any time	10 days minimum	Every year (100%)	1 year	Ideal timing is based on preferred temperature range for fish spawning of >20°C for most native fish and >18°C for Murray cod SF1 ideally shortly after LF2 for increased likelihood of successful recruitment of fish, productivity and dispersal
	SF2	75–750 ML/d	September to April	14 days minimum	5–10 years in 10 (75%) minimum	2 years	
Large fresh	LF1	>365 ML/d	Ideally July to September but can occur any time	5 days minimum	5–10 years in 10 (75%) minimum	2 years	This flow in Jul to Sep will improve pre-spawning fish condition
	LF2	>365 ML/d	October to April	10 days minimum	3–5 years in 10 (42%) minimum	4 years	Temp preferably >17°C to maximise spawning outcomes. Ideally shortly before SF1.
Bankfull	BK1	>1,000 ML/d	Any time	4 days minimum	5 years in 10 (50%) minimum	4 years	
	BK2	>1,000 ML/d	October to April	8 days minimum	2–3 years in 10 (25%) minimum	6 years (ideally 4 years)	
Overbank	OB1	>2,000 ML/d	October to April	Flows of this magnitude are recorded at this gauge and are visible on satellite imagery but do not appear to be accurately recorded at the gauge as they are often pushed out from the Macintyre River around the regulator. They provide useful ecological benefits but it is difficult to identify evidence-based durations and frequencies for this EWR at this stage. It is recommended that a gauge be added further down Boomi River to record and monitor larger flows.			

Table 43 EWRs for Macintyre River and Boomi River floodplain planning unit (Macintyre at Kanowna 416048)[107]

Flow category and EWR code		Flow threshold	Timing	Duration[108]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Cease-to-flow	CFa	<1 ML/d	Any time	8 days maximum	No more than 5 years in 10 (50% of years)	N/A	
	CFb	<1 ML/d	Any time	70 days maximum	No more than 5 years in a 100 (5% of years)	N/A	
	CFc	<1 ML/d	Any time	Any duration	No more than 46% of years	N/A	
Very low flow	VFa	73 ML/d	Any time	270 days per year minimum	5 years in 10 (50%) minimum	In accordance with cease-to-flow requirements	
	VFb	73 ML/d	Any time	120 days per year minimum	Every year (100%)	In accordance with cease-to-flow requirements	
Baseflow	BF1a	>210 ML/d	Any time	181 days per year minimum	5 years in 10 (50%) minimum	136 days	
	BF1b	>210 ML/d	Any time	65 days per year minimum	Every year (100%)	136 days	
	BF2a	>210 ML/d	September to March	126 days per year minimum	5 years in 10 (50%) minimum	192 days	
	BF2b	>210 ML/d	September to March	52 days per year minimum	Every year (100%)	192 days	

107 Refer to Table 8 in Part A for definitions of terms and explanatory text for EWRs.

108 Durations can be non-consecutive days for very low flow and baseflows. All other durations are expressed as consecutive days.

Flow category and EWR code		Flow threshold	Timing	Duration[108]	Frequency (LTA frequency)	Maximum inter-event period	Additional requirements
Small fresh	SF1	>400 ML/d	Ideally October to April but can occur any time	12 days minimum	Every year (100%)	1 year	Timing is based on preferred temperature range for fish spawning of >20°C for most native fish and >18°C for Murray cod SF1 ideally shortly after LF2 for increased likelihood of successful recruitment of fish, productivity and dispersal
	SF2	400–900 ML/d	September to April	14 days minimum	5 years in 10 (50%) minimum (ideally 5–10 years in 10 (75%))	4 years (ideally 2 years)	
Large fresh	LF1	>900 ML/d	Ideally July to September but can occur any time	10 days minimum	5–10 years in 10 (80%) minimum	2 years	This flow in Jul to Sep will improve pre-spawning fish condition
	LF2	>900 ML/d	October to April	10 days minimum	5 years in 10 (50%) minimum	4 years	Temp. preferably >17°C to maximise spawning outcomes Ideally shortly before SF1
	LF3	>2,500 ML/d	Any time	11 days minimum	50% minimum	4 years	
Bankfull / Anabranch connections	BK1	>3,300 ML/d	Any time	6 days minimum	5–10 years in 10 (75%) minimum	5 years (ideally 4 years)	For fish dispersal, productivity and condition
	BK2	>3,300 ML/d	October to April	7 days minimum	4–5 years in 10 (45%) minimum	5 years (ideally 4 years)	Spawning flow for floodplain specialists within anabranches and instream wetlands
Overbank	OB1	>4,900 ML/d	Any time	3 days minimum	2–3 years in 10 (25%) minimum	7 years (ideally 5 years)	
	OB2	>4,900 ML/d	October to April	10 days minimum	1 in 10 years (10%) minimum	13 years (ideally 4 years)	Spawning flow for floodplain specialists across the floodplain

Shortened forms

Basin Plan	Murray–Darling Basin Plan
BC Act	*Biodiversity Conservation Act 2016* (NSW)
BCT	Biodiversity Conservation Trust
BRC	Border Rivers Commission
BWS	Basin-wide environmental watering strategy
CAMBA	China–Australia Migratory Bird Agreement
CEWO	Commonwealth Environmental Water Office
DO	dissolved oxygen
DOC	dissolved organic carbon
DPE	Department of Planning and Environment (NSW) (from January 2022)
DPE–BC	Department of Planning and Environment – Biodiversity and Conservation Division (NSW)
DPE–Water	Department of Planning and Environment – Water (NSW)
DPIE	former Department of Planning, Industry and Environment (NSW)
DPIF	Department of Primary Industries Fisheries (NSW)
EEC	endangered ecological community
EPBC	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
EWAG	environmental water advisory group
EWR	environmental water requirement
FM Act	*Fisheries Management Act 1994* (NSW)
GL	gigalitre
ha	hectare
HEW	held environmental water
IQQM	Integrated Quantity and Quality Model
JAMBA	Japan–Australia Migratory Bird Agreement
LLS	Local Land Services (NSW)
LTA frequency	long-term average target frequency
LTWP	Long Term Water Plan
MDBA	Murray–Darling Basin Authority
MDBC	Murray–Darling Basin Commission
MER	Monitoring, evaluation and reporting
mg/L	milligrams per litre
ML	megalitre
ML/day, ML/d	megalitres per day
m/s	metres per second
NRAR	Natural Resources Access Regulator (NSW)
NSW	New South Wales
OEH	former Office of Environment and Heritage (NSW)

PEW	planned environmental water
RAS	resource availability scenario
RoKAMBA	Republic of Korea–Australia Migratory Bird Agreement
SDL	sustainable diversion limit
TEC	threatened ecological community
WRP	water resource plan
WRPA	water resource plan area
WSP	water sharing plan

Glossary

Actively managed floodplain	The area of floodplains and wetlands that can be inundated by managed environmental water deliveries alone or in combination with other flows from regulated river systems (see 'Regulated river').
Adaptive management	A procedure for implementing management while learning about which management actions are most effective at achieving specified objectives.
Allocation	The volume of water made available to water access licence or environmental water accounts in a given year by DPE–Water, which is determined within the context of demand, inflows, rainfall forecasts and stored water.
Alluvial	Comprised of material deposited by water.
Bankfull flow	River flows at maximum channel capacity with little overflow to adjacent floodplains. These flows engage the riparian zone, anabranches, flood runners and wetlands located within the meander train. They inundate all in-channel habitats including benches, snags and backwaters.
Baseflow	In perennial rivers, this is a reliable background flow level within a river channel that is generally maintained by seepage from groundwater storage, but also by surface inflows. Typically inundates geomorphic units such as pools and riffle areas.
Basin Plan	The Murray–Darling Basin Plan as developed by the Murray–Darling Basin Authority under the *Water Act 2007*.
Biota	The organisms that occupy a geographic region.
Blackwater	Occurs when water moves across the floodplain and releases organic carbon from the soil and leaf litter. The water takes on a tea colour as tannins and other carbon compounds are released from the decaying leaf litter. Blackwater plays an important role in transferring essential nutrients, such as carbon, from wetlands into rivers and vice versa. Carbon is a basic building block of the aquatic food web and an essential part of a healthy river system.
Cease-to-flow	The absence of flowing water in a river channel. Partial or total drying of the river channel. Streams contract to a series of isolated pools.
Cease-to-pump (access rule in WSP)	Pumping is not permitted: • from in-channel pools when the water level is lower than its full capacity • from natural off-river pools when the water level is lower than its full capacity or at an agreed pool drawdown level • from pump sites when there is no visible flow. These rules apply unless there is a commence-to-pump access rule that specifies a higher flow rate that licence holders can begin pumping.
Cold water pollution	The artificial lowering of water temperature that can extend hundreds of kilometres downstream of dams, due to releases of cold water from the dam. In older and deeper dams, water is typically released from the bottom of the dam where water temperatures can be significantly lower than surface readings. The effects of cold water pollution are harmful as it removes seasonal fish spawning cues, reduces availability of food, increases fish mortality and reduces the frequency and success of breeding events.
Constraints	The physical or operational constraints that effect the delivery of water from storages to extraction or diversion points. Constraints may include structures such as bridges that can be affected by higher flows, or the volume of water that can be carried through the river channel, or scheduling of downstream water deliveries from storage, or land uses in and around wetlands and floodplains.

Consumptive water	Water that is removed from available supplies without return to a water resource system (such as water removed from a river for agriculture). Consumptive water deliveries may contribute or support EWRs prior to the point of extraction.
Discharge	The amount of water moving through a river system, most commonly expressed in megalitres per day (ML/day).
Dissolved organic carbon (DOC)	A measure of the amount of carbon from organic matter that is soluble in water. DOC is transported by water from floodplains to river systems and is a basic building block available to bacteria and algae that microscopic animals feed on, that are in turn consumed by fish larvae, small-bodied fish species, yabbies and shrimp. DOC is essential for building the primary food webs in rivers, wetlands and floodplains, ultimately generating a food source for large-bodied fish like Murray cod and golden perch and predators such as waterbirds.
Ecological asset	The physical features that make up an ecosystem and meet one or more of the assessment indicators for any of the 5 criteria specified in Schedule 8 of the Basin Plan.
Ecological function	The resources and services that sustain human, plant and animal communities and are provided by the processes and interactions occurring within and between ecosystems. Identified ecosystem functions must also meet one or more of the assessment indicators for any of the 4 criteria specified in Schedule 9 of the Basin Plan.
Ecological objectives	Objectives for the protection and/or restoration of an environmental asset or ecosystem function. Objectives are set for all priority environmental assets and priority ecosystem functions, and have regard to the outcomes described in the BWS.
Ecological target	Level of measured performance that must be met to achieve the defined objective. The targets in this LTWP are SMART (specific, measurable, achievable, realistic, time-bound) and are able to demonstrate progress towards the objectives and the outcomes described in the BWS.
Ecological value	An object, plant or animal that has value based on its ecological significance.
Ecosystem	A biological community of interacting organisms and their physical environment. It includes all the living things in that community, interacting with their non-living environment (weather, earth, sun, soil, climate and atmosphere) and with each other.
Environmental water	Water for the environment. It serves a multitude of benefits to not only the environment, but to communities, industry and society. It includes water held in reservoirs (held environmental water) or protected from extraction from waterways (planned environmental water) for meeting the water requirements of water-dependent ecosystems.
Environmental water requirement (EWR)	An environmental water requirement describes the characteristics of a flow event (e.g. magnitude, duration, timing, frequency and maximum dry period) within a particular flow category (e.g. small fresh), that are required for that event to achieve a specified ecological objective or set of objectives (e.g. to support fish spawning and in-channel vegetation). There may be multiple EWRs defined within a flow category, and numerous EWRs across multiple flow categories within a planning unit. Achievement of each of the EWRs will be required to achieve the full set of ecological objectives for a planning unit.
Floodplain harvesting	The collection, extraction or impoundment of water flowing across floodplains. NSW is currently bringing floodplain harvesting extraction under a regulation and licensing framework and it is to be included under WSPs.

Flow category	The type of flow in a river defined by its magnitude (e.g. bankfull); see Table 7 and Table 8 for more details.
Flow regime	The pattern of flows in a waterway over time that will influence the response and persistence of plants, animals and their ecosystems.
Freshes	Temporary in-channel increased flow in response to rainfall or release from water storages.
Groundwater	Water located below the Earth's surface in soil pore spaces and in the fractures of rock formations. Groundwater is recharged from, and eventually flows to, the surface naturally.
Held environmental water (HEW)	Water available under a water access licence or right, a water delivery right, or an irrigation right for the purposes of achieving environmental outcomes (including water specified in a water access right to be for environmental use).
Hydrograph	A graph showing the rate of flow and/or water level over time at a specific point in a river. The rate of flow is typically expressed in megalitres per day (ML/day).
Hydrological connectivity	The linking of natural aquatic environments.
Hydrology	The occurrence, distribution and movement of water.
Hypoxic blackwater	Occurs when DO levels, as measured in milligrams per litre (mg/L), fall below the level needed to sustain native fish and other water-dependent species. Native fish begin to stress when DO levels fall below 4 mg/L and fish mortality occurs when DO levels are less than 2 mg/L. When bacteria that feed on DOC multiply rapidly, their rate of oxygen consumption can exceed the rate at which oxygen can be dissolved in the water, oxygen levels fall and a hypoxic (low oxygen) condition occurs.
Large fresh (LF)	A high-magnitude flow pulse that remains in-channel, connects most in-channel habitats, provides partial longitudinal connectivity by drowning out of some low-level weirs and other in-channel barriers and may engage flood runners and inundate low-lying wetlands.
Lateral connectivity	The flow linking river channels and the floodplain.
Long Term Water Plan (LTWP)	A requirement of the Basin Plan that gives effect to the BWS for each river system and will guide the management of water over the longer term. DPE is responsible for the development of 9 plans for river catchments across NSW, with objectives for 5, 10 and 20-year timeframes.
Longitudinal connectivity	The consistent downstream flow along the length of a river.
LTA frequency	Minimum long-term average target frequency.
NSW (Mitchell) landscapes	A classification of ecosystems established through multivariate mapping information, including rainfall, temperature, topography, geology, soil and vegetation (see Mitchell 2002).
Overbank flow (OB)	Flows that spill over the riverbank or extend to floodplain surface flows.
Pindari stimulus flow	PEW made under the WSP 2021 that is triggered by inflows into Pindari Dam of above 1,200 ML/day between 1 April and 31 August. If triggered, 4,000 ML is set aside in Pindari Dam at the start of each water year, with a carry-over capped to a maximum account balance of 8,000 ML, for a 'stimulus flow' released between 1 August and 1 December.
Planned environmental water (PEW)	Water that is committed by the Basin Plan, a WRP, a WSP, or a plan made under state water management law to achieve environmental outcomes.

Planning unit	A spatial division of a WRPA based on water requirements or a sub-catchment boundary.
Population structure	The range of age and size classes within a species' population. A population with a range of ages and sizes, with a good number of sexually mature individuals, demonstrates regular recruitment and is healthy.
Priority environmental asset	A place of particular ecological significance that is water-dependent, meets one or more of the assessment indicators for any of the 5 criteria specified in Schedule 8 in the Basin Plan, and can be managed with environmental water. This includes planned and held environmental water.
Priority ecological function	Ecological functions that can be managed with environmental water.
Recruitment	Successful development and growth of offspring so they can contribute to the next generation.
Registered cultural asset	A water-dependent cultural asset that is registered in the Aboriginal Heritage Information Management System (AHIMS).
Regulated river	A river that is gazetted under the *NSW Water Management Act 2000.* Flow is largely controlled by major dams, water storages and weirs. River regulation increases reliability of water supplies in most years but alters the natural flow regime required by water-dependent environmental assets and values.
Riffle	A rocky or shallow part of a river where river flow is rapid and broken.
Riparian	The part of the landscape adjoining rivers and streams that has a direct influence on the water and aquatic ecosystems within them.
Small fresh (SF)	Low-magnitude in-channel flow pulse that can inundate low-lying benches, connect sections of a channel or river and trigger animal movement.
Supplementary access	A category of water entitlement where water is made available to licence holder accounts during periods of high river flows that cannot be controlled by river operations (i.e. supplementary event).
Supplementary event	An uncontrolled flow (such as a tributary flow below a regulating structure) that is accessible for extraction under supplementary water access licences, as announced by the Minister for a set time period.
Surface water	Water that exists above the ground in rivers, streams, creeks, lakes and reservoirs. Although separate from groundwater, they are interrelated and over-extraction of either will impact on the other.
Sustainable diversion limit (SDL)	The grossed-up amount of water that can be extracted from Murray–Darling Basin rivers for human uses while leaving enough water in the system to achieve environmental outcomes.
Stimulus Flow rule	A PEW rule in the WSP 2021 that aims to provide a flow pulse in the Severn River downstream of Pindari Dam; see Section 4.5.1 for more details.
Unregulated river	A waterway where flow is mostly uncontrolled by dams, weirs or other structures.
Very low flow (VF)	Small flow that joins river pools, thus providing partial or complete connectivity in a reach. Can improve DO saturation and reduce stratification in pools.
Water-dependent	An ecosystem or species that depends on periodic or sustained inundation, waterlogging or significant inputs of water for natural functioning and survival.
Water-dependent cultural asset	A place that has social, spiritual and cultural value based on its cultural significance to Aboriginal people and is related to the water resource.
Water-dependent cultural value	An object, plant, animal, spiritual connection or use that is dependent on water and has value based on its cultural significance to Aboriginal people.

Water quality management plan	A document prepared by state authorities, as part of the WRP, that is accredited by the Commonwealth under the Basin Plan. It aims to provide a framework to protect, enhance and restore water quality.
Water resource plan (WRP)	A policy package prepared by state authorities and accredited by the Commonwealth under the Basin Plan. It describes how water will be managed and shared between users in an area and meet Basin Plan outcomes.
Water resource plan area (WRPA)	Catchment-based divisions of the Murray–Darling Basin defined by a WRP.
Water sharing plan (WSP)	A plan made under the NSW *Water Management Act 2000* that sets out specific rules for sharing and trading water between the various water users and the environment in a specified water management area. A WSP will be a component of a WRP.

More information

- NARCliM climate change projections
  http://climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/About-NARCliM

- NARCliM climate change projections map for New England And North West 2020–2039
  https://www.climatechange.environment.nsw.gov.au/projections-map?region=new-england-and-north-west&climateprojection=tasmean&range=0

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Appendix A. Ecological objectives relevant to each planning unit

Table 44 Ecological objectives for each planning unit in the NSW Border Rivers catchment

Code	Ecological objective	1. Tenterfield Creek	2. Mole River	3. Reedy Creek	4. Beardy River	5. Glen Innes	6. Bonshaw	7. Kings Plains	8.Inverell	9. Campbells Creek & Camp Creek	10. Yetman	11. Ottleys Creek	12. Confluence of Macintyre & Dumaresq	13. Macintyre floodplain upstream of Boomi	14. Whalan Creek & Croppa Creek	15. Macintyre River & Boomi River floodplain
Native fish																
NF1	No loss of native fish species	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NF2	Increase the distribution and abundance of short to moderate-lived generalist native fish species	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NF3	Increase the distribution and abundance of short to moderate-lived floodplain specialist native fish species											X	X	X	X	X
NF4	Improve native fish population structure for moderate to long-lived flow pulse specialist native fish species	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NF5	Improve native fish population structure for moderate to long-lived riverine specialist native fish species	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NF6	A 25% increase in abundance of mature (harvestable sized) golden perch and Murray cod	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Code	Ecological objective	1. Tenterfield Creek	2. Mole River	3. Reedy Creek	4. Beardy River	5. Glen Innes	6. Bonshaw	7. Kings Plains	8.Inverell	9. Campbells Creek & Camp Creek	10. Yetman	11. Ottleys Creek	12. Confluence of Macintyre & Dumaresq	13. Macintyre floodplain upstream of Boomi	14. Whalan Creek & Croppa Creek	15. Macintyre River & Boomi River floodplain
NF7	Increase the prevalence and/or expand the population of key short to moderate-lived floodplain specialist native fish species into new areas (within historical range)	X	X	X	X	X				X	X	X	X	X	X	X
NF8	Increase the prevalence and/or expand the population of key moderate to long-lived riverine specialist native fish species into new areas (within historical range)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Native vegetation																
NV1	Maintain the extent and viability of non-woody vegetation communities occurring within channels	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NV2	Maintain or increase the extent and maintain the viability of non-woody vegetation communities occurring in wetlands and on floodplains											X	X	X	X	X
NV3	Maintain the extent and improve the condition of river red gum communities closely fringing river channels	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Code	Ecological objective	1. Tenterfield Creek	2. Mole River	3. Reedy Creek	4. Beardy River	5. Glen Innes	6. Bonshaw	7. Kings Plains	8.Inverell	9. Campbells Creek & Camp Creek	10. Yetman	11. Ottleys Creek	12. Confluence of Macintyre & Dumaresq	13. Macintyre floodplain upstream of Boomi	14. Whalan Creek & Croppa Creek	15. Macintyre River & Boomi River floodplain
NV4a NV4b	Maintain or increase the extent and maintain or improve the condition of native woodland and shrubland communities on floodplains – river red gum woodland and forests										X	X	X	X	X	X
NV4c	Maintain or increase the extent and maintain or improve the condition of native woodland and shrubland communities on floodplains – black box woodland															X
NV4d	Maintain or increase the extent and maintain or improve the condition of native woodland and shrubland communities on floodplains – coolibah woodland												X	X	X	X
NV4e	Maintain or increase the extent and maintain or improve the condition of native woodland and shrubland communities on floodplains – lignum shrublands												X	X	X	X
Waterbirds																
WB1	Maintain the number and type of waterbird species	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Code	Ecological objective	1. Tenterfield Creek	2. Mole River	3. Reedy Creek	4. Beardy River	5. Glen Innes	6. Bonshaw	7. Kings Plains	8.Inverell	9. Campbells Creek & Camp Creek	10. Yetman	11. Ottleys Creek	12. Confluence of Macintyre & Dumaresq	13. Macintyre floodplain upstream of Boomi	14. Whalan Creek & Croppa Creek	15. Macintyre River & Boomi River floodplain
WB2	Increase total waterbird abundance across all functional groups	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WB3	Increase opportunities for non-colonial waterbird breeding											X	X	X	X	X
WB5	Maintain the extent and improve condition of waterbird habitats											X	X	X	X	X
Ecological function																
EF1	Provide and protect a diversity of refugia across the landscape	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
EF2	Create quality instream, floodplain and wetland habitat	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
EF3a	Provide movement and dispersal opportunities for water-dependent biota to complete lifecycles and disperse into new habitats – within catchments						X			X			X	X		
EF3b	Provide movement and dispersal opportunities for water-dependent biota to complete lifecycles and disperse into new habitats – between catchments													X		X
EF4	Support instream and floodplain productivity	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Code	Ecological objective	1. Tenterfield Creek	2. Mole River	3. Reedy Creek	4. Beardy River	5. Glen Innes	6. Bonshaw	7. Kings Plains	8.Inverell	9. Campbells Creek & Camp Creek	10. Yetman	11. Ottleys Creek	12. Confluence of Macintyre & Dumaresq	13. Macintyre floodplain upstream of Boomi	14. Whalan Creek & Croppa Creek	15. Macintyre River & Boomi River floodplain
EF5	Support nutrient, carbon and sediment transport along channels, and exchange between channels and floodplains/wetlands											X	X	X	X	X
EF6	Support groundwater conditions to sustain groundwater-dependent biota			X	X	X				X		X	X	X		
EF7	Increase the contribution of flows into the Murray and Barwon–Darling from tributaries	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Appendix B. Resource availability scenario

Guidelines for the method to determine priorities for applying environmental water[109]

The assessment of the RAS occurs throughout the water year. The critical information required for this assessment is the water availability and the condition of the environment (antecedent conditions). These can be determined with reference to existing data sourced from the Bureau of Meteorology and state water agencies. As set out in section 8.61 of the Basin Plan, a RAS will be one of: very dry, dry, moderate, wet, or very wet.

To determine the RAS, the following steps are followed:

a. determine the antecedent conditions for a given WRPA by (the 'X' axis of the matrix in Table 45):
   - i selecting a representative number of water accounting periods preceding the current water year (e.g. 3–5 years)
   - ii assessing the water received by the environment for those years
   - iii comparing the amount in (ii) to all the historical data
   - iv categorising the antecedent conditions as a percentile relative to all historical water years

b. determine the surface water availability by (the 'Y' axis of the matrix in Table 45):
   - i assessing all sources of water available for the environment for a given period
   - ii comparing these to all the historical data
   - iii categorising the surface water availability as a percentile relative to all historical water years

c. for the relevant water accounting period, determine the surface water availability relative to the antecedent conditions for the WRPA using all the historical climate condition data that are available (in Table 45); this is the surface water availability percentile)

d. using the matrix below, determine the applicable water RAS.

Table 45 Default matrix for determining the RAS

Surface water availability	Antecedent conditions				
	Very dry (0–15%)	Dry (16–45%)	Medium (46–60%)	Wet[110] (61–85%)	Very wet[110] (86–100%)
Very low (0–15%)	Very dry	Very dry	Dry	Dry	N/A
Low (16–45%)	Very dry	Dry	Dry	Moderate	Wet
Medium (46–60%)	Dry	Dry	Moderate	Wet	Wet
High (61–85%)	Dry	Moderate	Wet	Wet	Very wet
Very high (86–100%)	N/A	Moderate	Wet	Very wet	Very wet

[109] As outlined by the Murray–Darling Basin Authority in its Guidelines for the method to determine priorities for applying environmental water.

[110] Wet and very wet RAS are combined in this LTWP because the management strategies are the same.

Appendix C. Environmental assets across the catchment

The following series of tables provide summaries of the environmental assets found in each NSW Border Rivers planning unit.

Table 46 Hectares (ha) of native vegetation in each planning unit (compiled by DPIE in 2016 based on NSW OEH 2015)

Vegetation	1. Tenterfield Creek	2. Mole River	3. Reedy Creek	4. Beardy River	5. Glen Innes	6. Bonshaw	7. Kings Plains	8.Inverell	9. Campbells Creek & Camp Creek	10. Yetman	11. Ottleys Creek	12. Confluence of Macintyre & Dumaresq	13. Macintyre floodplain upstream of Boomi	14. Whalan Creek & Croppa Creek	15. Macintyre River & Boomi River floodplain
River red gum	951	2,740	847	1,227	1,430	533	1,492	2,948	1,238	1,485	839	3,419	1,359	2,371	7,268
Black box															424
Coolibah												416	4,724	18,248	36,923
Floodplain						243			617	324	1,710	1,596	2,536	29,496	3,455
Lignum		1								1		740	428	2,672	221
Non-woody wetland	634	2,310	226	102	1,242	212	18	642	60	105	254	240	107	220	313

Table 47 Native fish species catch records (C) and expected distribution (E) in each planning unit

Native fish species by functional group	Threatened species status[111]	1. Tenterfield Creek	2. Mole River	3. Reedy Creek	4. Beardy River	5. Glen Innes	6. Bonshaw	7. Kings Plains	8.Inverell	9. Campbells Creek & Camp Creek	10. Yetman	11. Ottleys Creek	12. Confluence of Macintyre & Dumaresq	13. Macintyre floodplain upstream of Boomi	14. Whalan Creek & Croppa Creek	15. Macintyre River & Boomi River floodplain
Flow pulse specialists																
Golden perch		CE	CE	CE	E	CE	CE	C	CE	CE	CE	E	CE	CE	CE	CE
Silver perch	V, CE					E		CE	CE		CE		E	E	E	CE
Spangled perch		C	C	E	CE		CE	C	E	CE	CE	CE	CE	CE	CE	CE
River specialists																
Murray cod	V	CE	CE	CE		CE	CE	CE	CE	CE	CE	E	CE	CE	E	CE
River blackfish						E			E							
Freshwater catfish	e	CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	E	CE	E	E	CE
Southern purple-spotted gudgeon*	e	CE	CE	CE	CE	E	CE	CE	E	E	E	E	E	E	E	E
Olive perchlet*	e	CE	CE	E	E		CE		C	CE	CE		CE	CE	E	CE
Darling River hardyhead		C	C		C	C			C	C						

[111] ce = listed as critically endangered in FM Act, e = listed as endangered in FM Act, v = listed as vulnerable in FM Act, CE = listed as critically endangered in EPBC Act, V = listed as vulnerable in EPBC Act

Native fish species by functional group	Threatened species status[111]	1. Tenterfield Creek	2. Mole River	3. Reedy Creek	4. Beardy River	5. Glen Innes	6. Bonshaw	7. Kings Plains	8.Inverell	9. Campbells Creek & Camp Creek	10. Yetman	11. Ottleys Creek	12. Confluence of Macintyre & Dumaresq	13. Macintyre floodplain upstream of Boomi	14. Whalan Creek & Croppa Creek	15. Macintyre River & Boomi River floodplain
Floodplain specialists																
Olive perchlet*	e	CE	CE	E	E		CE		C	CE	CE		CE	CE	E	CE
Southern purple-spotted gudgeon*	e	CE	CE	CE	CE	E	CE	CE	E	E	E	E	E	E	E	E
Rendahl's tandan																
Flat-headed galaxias	ce, CE															
Generalists																
Australian smelt		CE	CE	CE	CE	E	CE	CE	CE	CE	CE	E	CE	CE	E	CE
Carp gudgeon		CE	CE	CE	CE	CE	CE	CE	CE	CE	CE	E	CE	CE	E	CE
Mountain galaxias		CE	CE	E	E	CE		E	CE							
Dwarf flat-headed gudgeon							E		E	E	E	E			E	
Murray–Darling rainbowfish		CE	CE	CE	CE	E	CE	CE	CE	CE	CE	E	CE	CE	CE	CE
Bony herring		C	E	CE	E		CE		E	CE	CE	E	CE	CE	CE	CE
Unspecked hardyhead		CE	CE	CE	E	E	CE	E	CE	CE	CE	E	CE	CE	E	E

Table 48 Waterbird sightings recorded in each planning unit

Waterbird species by functional group	Threatened species status[112]	1. Tenterfield Creek	2. Mole River	3. Reedy Creek	4. Beardy River	5. Glen Innes	6. Bonshaw	7. Kings Plains	8.Inverell	9. Campbells Creek & Camp Creek	10. Yetman	11. Ottleys Creek	12. Confluence of Macintyre & Dumaresq	13. Macintyre floodplain upstream of Boomi	14. Whalan Creek & Croppa Creek	15. Macintyre River & Boomi River floodplain
Ducks																
Australasian grebe		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Australasian shoveler		X				X			X				X	X		
Blue-billed duck	V					X			X							
Buff-banded rail		X							X							
Chestnut teal		X				X							X			
Freckled duck	V												X		X	
Great crested grebe						X			X					X		
Grey teal		X	X	X	X	X		X	X	X	X	X	X	X	X	X
Hardhead		X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Hoary-headed grebe		X				X		X	X	X		X		X		
Musk duck		X				X			X				X			
Pacific black duck		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pink-eared duck		X				X			X				X	X	X	

[112] V = NSW vulnerable, E = Commonwealth endangered, C = CAMBA, J = JAMBA, K = ROKAMBA

Waterbird species by functional group	Threatened species status[112]	1. Tenterfield Creek	2. Mole River	3. Reedy Creek	4. Beardy River	5. Glen Innes	6. Bonshaw	7. Kings Plains	8.Inverell	9. Campbells Creek & Camp Creek	10. Yetman	11. Ottleys Creek	12. Confluence of Macintyre & Dumaresq	13. Macintyre floodplain upstream of Boomi	14. Whalan Creek & Croppa Creek	15. Macintyre River & Boomi River floodplain
Herbivores																
Australian wood duck		X	X	X	X		X	X	X	X	X	X	X	X	X	X
Black-tailed native-hen						X					X		X	X	X	X
Black swan		X			X	X	X	X	X	X	X		X	X	X	X
Dusky moorhen		X	X	X	X	X	X	X	X	X	X		X	X		X
Eurasian coot		X		X	X	X		X	X	X			X	X	X	
Magpie goose	V	X	X													
Plumed whistling-duck													X	X	X	X
Purple swamphen		X	X	X	X	X		X	X	X			X	X		
Large waders																
Australian white ibis		X	X	X	X		X		X	X	X	X	X	X	X	X
Black-necked stork	E									X	X			X	X	X
Brolga	V							X						X		X
Cattle egret	J												X	X	X	
Eastern great egret	J	X	X			X		X	X	X	X	X	X	X	X	X
Glossy ibis						X			X				X	X		X
Intermediate egret		X			X	X	X			X		X	X	X	X	X
Little egret		X				X			X				X	X		X

Waterbird species by functional group	Threatened species status[112]	1. Tenterfield Creek	2. Mole River	3. Reedy Creek	4. Beardy River	5. Glen Innes	6. Bonshaw	7. Kings Plains	8.Inverell	9. Campbells Creek & Camp Creek	10. Yetman	11. Ottleys Creek	12. Confluence of Macintyre & Dumaresq	13. Macintyre floodplain upstream of Boomi	14. Whalan Creek & Croppa Creek	15. Macintyre River & Boomi River floodplain
Nankeen night heron		X	X	X	X	X		X	X	X		X	X	X	X	X
Royal spoonbill						X	X	X	X		X	X	X	X	X	X
Straw-necked ibis		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
White-faced heron		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
White-necked heron		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Yellow-billed spoonbill		X	X			X	X	X	X	X	X	X	X	X	X	X
Piscivores																
Australasian darter		X			X		X	X	X	X	X	X	X		X	X
Australian gull-billed tern														X		
Australian pelican		X			X		X	X	X	X	X	X	X		X	X
Great cormorant		X	X		X	X	X	X	X	X		X	X	X	X	X
Little black cormorant		X	X	X	X	X	X	X	X	X	X		X	X	X	X
Little pied cormorant		X	X	X	X	X		X	X	X	X	X	X	X	X	X
Pied cormorant		X	X	X	X	X		X	X	X			X	X	X	X
Silver gull									X							
Whiskered tern								X	X				X	X	X	
White-winged black tern	CJK	X														

Waterbird species by functional group	Threatened species status[112]	1. Tenterfield Creek	2. Mole River	3. Reedy Creek	4. Beardy River	5. Glen Innes	6. Bonshaw	7. Kings Plains	8.Inverell	9. Campbells Creek & Camp Creek	10. Yetman	11. Ottleys Creek	12. Confluence of Macintyre & Dumaresq	13. Macintyre floodplain upstream of Boomi	14. Whalan Creek & Croppa Creek	15. Macintyre River & Boomi River floodplain
Shorebirds																
Banded lapwing			X				X	X	X	X		X	X		X	X
Bar-tailed godwit	CJK CE	X														
Black-fronted dotterel		X	X	X	X	X		X	X		X	X	X	X	X	X
Black-winged stilt		X		X		X			X				X	X	X	X
Common greenshank	CJK							X								
Latham's snipe	JK	X	X			X			X				X	X	X	
Marsh sandpiper	CJK					X								X	X	
Masked lapwing		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pectoral sandpiper	JK					X										
Red-capped plover											X					
Red-kneed dotterel		X				X			X		X		X	X		X
Red-necked avocet						X								X		
Sharp-tailed sandpiper	CJK													X		