Seasonal Watering Proposal 2022/2023

Goulburn River

Goulburn River at Kotupna (Dan, Lovell)

GOULBURN BROKEN CATCHMENT MANAGEMENT AUTHORITY

Published by:

Goulburn Broken Catchment Management Authority,

PO Box 1752, Shepparton 3632

Please cite this document as: GBCMA (2022). Goulburn River Seasonal Watering Proposal 2022/2023. Goulburn Broken Catchment Management Authority, Shepparton.

It should be noted that specific reference to funding levels in this document are for indicative purposes only. The level of Government investment in this plan is contingent on budgets and government priorities.

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Executive Summary

This proposal is for the use of water in the Goulburn River to maximise environmental outcomes in 2022/23. The Goulburn River, its floodplain and wetland habitats support intact river red gum forests, and numerous threatened species such as Murray cod, Trout cod, Macquarie perch and Eastern great egret. The region also contains many important cultural heritage sites, provides water for agriculture and urban centres, and supports a variety of recreational activities such as fishing, boating and camping.

The millennium drought led to terrestrial vegetation encroachment on the low and mid banks of the lower Goulburn River, and a reduction of appropriate flood tolerant plants. Since the end of the drought (2010), environmental condition has improved with the commencement of environmental water deliveries in 2011. This water has improved the cover and abundance of flood tolerant species with very positive responses between 2011 and 2016. Monitoring since 2014 has shown a reduction in mean grass cover, and an increase in mean total cover of water dependent species (Webb et al, 2017).

Environmental water delivery has also led to improved understanding of Golden perch spawning cues, increased fish spawning in the Goulburn River, and an increased understanding of large scale fish movement in the Murray River and tributaries. Improved abundance of Murray River rainbowfish in the lower Goulburn River in 2016/17 is thought to be in response to improved littoral bank vegetation which this species uses for spawning (Webb et al, 2017). Other river health improvements believed to have resulted from delivery of environmental water since 2011 include a positive effect on food resources used by fish and other aquatic biota (Webb et al, 2017).

Since 2017 consumptive water delivery (Inter valley transfers (IVT)) has resulted in unseasonal high summer flows, two to three times higher than environmental flow recommendations. These high flows have eroded some of the improvements in river health noted above.

Volumes of IVT delivery have increased over the years peaking at around 380 GL in 2018/19. A formal monitoring program has been undertaken in the lower Goulburn River since 2018/19 to monitor bank vegetation and condition changes (i.e. erosion) resulting from IVT deliveries. Monitoring has shown increased erosion rates, loss of vegetation on the lower bank below the IVT delivery level and reductions in recruitment of Murray cod.

Since September 2019 the Victorian Minister for Water has introduced interim operating rules directing how GMW and MDBA deliver IVT. This has resulted in lower flows over the summer and autumn period. IVT was delivered as a series of pulses interspersed with average flows around 1,300 ML/day for the 2019/2020 summer and in 2020/2021 summer IVT flows averaged 1,300 ML/day. Monitoring of the flow regime in these periods showed reduced erosion compared to years with constant high flows but impacts of notching was still higher than average due to higher flows and lack of vegetation. Some patchy vegetation recovery occurred on benches and bars in these years.

La Nina climate conditions across the Southern hemisphere led to higher than average rainfall across the Murray Darling Basin in 2021/2022. Although there was no flooding in the Upper Murray or Goulburn Rivers, large inflows led to full Murray River storages and numerous spills with unregulated flow conditions continuing into February 2022. Large monsoonal rainfall events led to flooding in the Northern Basin, the Menindee Lakes filling and high inflows from the Murrumbidgee and Darling rivers.

The combined high Murray River flows and high inflows from the northern tributaries (Darling and Murrumbidgee Rivers) led to minimal IVT delivery over summer and autumn. This has given the Goulburn River a chance to enjoy a more natural flow regime with lower flows at the recommended environmental flow levels (below 1,000 ML/day). The reduced IVT demand has meant that baseflows were primarily delivered within the environmental flow recommendations and met using environmental water. The lower flows have led to some good recovery of vegetation on the lower banks with patches of littoral vegetation in areas not seen since December 2016. Positive feedback was also provided from the community and recreational users on the lower flows both through the advisory groups and through media coverage.

Although lower flows in the last two years have seen some good growth of bank vegetation, greater recovery of the vegetation and lower bank condition is still required following the damage caused by three consecutive years of unseasonal (summer/IVT) inundation. Thus, the CMA are again proposing to continue the focus of environmental water use in 2022/2023 to maximise vegetation recovery of the lowest metre of the bank (equating to flow rates of 700 – 2,000 ML/day). Without the presence of vegetation to stabilise the bank, continued mass failure will occur.

High flows inundating wetlands in the Darling, Murrumbidgee and Murray Rivers has led to a good breeding and recruitment with a large cohort of Golden and Silver perch migrating up the Murray River. An autumn fresh delivered in March/April 2022 was designed to attract these fish into the Goulburn River. As the Goulburn River is reliant on migration of these species to maintain populations, attracting these fish will be a priority for 2022/2023.

Although environmental watering has been shown to improve the ecological condition of the lower Goulburn River, further improvements in ecological condition are limited by the ability to only provide in channel watering events that do not engage the floodplain and wetlands. Operational constraints mean environmental water can only influence half of the riverbank and a handful of low-lying wetlands.

In addition to addressing negative impacts of unseasonal flow, progression of the constraints management strategy for the Goulburn River (as per the Basin Plan) is imperative to maximise the potential benefits of environmental water use in the river.

This proposal considers annual environmental water management under a range of possible climate and corresponding water resource availability scenarios for 2022/2023 ranging from extremely dry to wet. Long term environmental objectives exist for the Goulburn River. Given antecedent conditions and watering actions achieved in 2021/2022, prioritisation of the environmental watering actions for 2022/2023 have been based around the following principles;

1. Maintain or re-establish lower bank vegetation.
2. Protect the bank and aquatic biota by minimising erosion and mass failure of the lower bank, managing water quality and re-introduce sediments/seed.
3. Achieve fish outcomes – improve Murray and Trout cod populations, cue Golden and Silver perch spawning and attraction into the river.
4. Maximise platypus breeding success by providing nesting cues
5. Maximise ecological outcomes by using tributary flows as much as possible to meet environmental watering objectives, and especially during the spring period.

The priority watering actions that could be met under each climate/water resource scenario are outlined in the table below.

Summary of potential environmental watering actions provided under each water resource scenario

Priority	Potential environmental watering actions	Scenario 1 – Extreme dry (99% PoE)	Scenario 2 – Dry (90% PoE)	Scenario 4 – Average (50% PoE)	Scenario 5 – Wet (10% PoE)
1	Provide a year round low flow 500 - 1000 ML/day in reach four and five for habitat diversity and sustaining the system	Y	Y	Y	Y
2	Provide 2022 winter fresh >7,300 ML/day or as high as possible in May - August for channel forming, and platypus nesting cues. Aim to use a natural fresh and provide most of the event from rainfall runoff with minimal releases from Lake Eildon. In the case of low Eildon releases provide a small winter fresh of 5,000 ML/day for 2 days in Reach 1 to provide nesting cues for platypus	Y	Y	Y	Y
3	Provide an early spring fresh (>7,300 ML for 7 days) up to 10,500 ML/day in September and October to prime the system for lower bank vegetation establishment and maintenance. Aim to use a natural fresh and provide most of the event from rainfall runoff with minimal releases from Lake Eildon.	Y	Y	Y	Y
4	Provide an autumn fresh (>5,700 ML for 2-5 days) between March and May for lower bank vegetation reinvigoration and maintenance and/or fish migration outcomes. *NOTE: this fresh will only be delivered depending on flow and vegetation condition over the summer period*	Y	Y	Y	Y
5	Provide higher winter/spring baseflows and freshes of up to 6,000 ML/day in the Mid Goulburn River to trial connection to wetlands and reflect natural flow levels between June and October	Y	Y	Y	Y
6	Provide a variable baseflow of 400-2,000 ML/day in the mid Goulburn River when required.	Y	Y	Y	Y
7	Provide a standing order for freshes up to 6,000 ML/day to maintain water quality and protecting the banks (up to 3,000 ML/day in Summer /Autumn and 6,000 ML/day in Winter/Spring)	Y	Y	Y	Y
8	Provide a standing order for higher baseflows or freshes up to 6,000 ML/day between May and October to mimic natural variability through the length of the Goulburn River.	Y	Y	Y	Y
9	Provide (carryover) for baseflow of 500-540 ML/day in July to September (22/23) for fish and macroinvertebrate habitat	Y	Y	Not needed	Not needed
10	Provide 2023 winter fresh >7,300 ML/day or as high as possible in May - August for channel forming, and platypus nesting cues. Aim to use a natural fresh and provide most of the event from rainfall runoff with minimal releases from Lake Eildon. In the case of low Eildon releases provide a small winter fresh of 5,000 ML/day for 2 days in Reach 1 to provide nesting cues for platypus		Partial	Y	Y
11^	Provide a late spring fresh (>6,600 ML for 1 day) between October and December for native fish spawning *NOTE: this fresh will only be delivered if flows will not damage littoral vegetation*			Y	Y

+ the autumn fresh will only be delivered if IVT pulses under the operating plan haven't met water requirements or flows have exceeded 2000ML/day for more than 20 days

^ to limit littoral vegetation damage this fresh will only be delivered if following the spring fresh there is 6-8 weeks of baseflows of around 1000 ML/day or flow have not been less than 2000ML/day for more than a week.

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Glossary and acronyms

Bankfull - carrying capacity of the stream before spilling out onto adjacent land

Baseflow - low flows sufficient to maintain fish passage, water quality, and pool and riffle habitats

Goulburn Broken Catchment Management Authority (GBCMA) -statutory authority established to manage regional and catchment planning, waterways, floodplains, salinity and water quality

Channel - that part of a river where water flows and includes the bed and banks, taken to mean the whole of the depression in which the water flows before it rises sufficiently to spill over onto adjacent lands as flood water

Commonwealth Environmental Water Office (CEWO) - (part of the Department of the Environment) holds and manages the water entitlements purchased through the Restoring the Balance water recovery program

Department of Environment, Land, Water and Planning (DELWP) – Victorian government department responsible for protecting the environment, responding to climate change and supporting sustainable population growth

DO - dissolved oxygen

Environmental flow regime - the timing, frequency, duration and magnitude of flows for the environment

Environmental flow study - a scientific study of the flow requirements of a particular basin's river and wetlands systems used to inform decisions on the management and allocation of water resources

Environmental water entitlement - an entitlement to water to achieve environmental objectives in waterways (could be an environmental entitlement, environmental bulk entitlement, water share, Section 51 license or supply agreement)

Flow component - components of a river system's flow regime that can be described by timing, seasonality, frequency and duration (for example, cease to flow and overbank flows)

Flow regime - pattern of seasonal flow variations in any one year, usually consisting of periods of low flow during summer-autumn then high flows during winter-spring

Freshes - flows that produce a substantial rise in river height for a short period, but do not overtop the riverbank.

Geomorphology (fluvial) - the physical interaction of flowing water and the natural channels of rivers including erosion and sedimentation

Gigalitre (GL) - one billion (1,000,000,000) litres

GMW – Goulburn-Murray Rural Water Corporation, trading as Goulburn-Murray Water

High flows - high flow within channel capacity.

High reliability entitlement - legally recognised, secure entitlement to a defined share of water, as governed by the reserve policy

Instream - refers to that area of a waterway below the surface of the water

Inter Valley Transfers (IVT) - means bulk transfers of water from the Goulburn water supply system to supply water users in the Murray water supply system

Low reliability entitlement - legally recognised, secure entitlement to a defined share of water, as governed by the reserve policy (full allocations are expected only in some years)

Macroinvertebrates - aquatic invertebrates whose body length usually exceeds 1 mm (included insects, crustacean, aquatic worms and aquatic snails)

Macrophytes - an aquatic plant that grows in or near water and is emergent, submergent, or floating

Megalitre (ML) - one million (1,000,000) litres

MDBA – Murray Darling Basin Authority

Overbank flow - flows that overtop the banks and spill onto the floodplain

Passing flow - water released out of storages to operate river and distribution systems (to deliver water to end users), provide for riparian rights and maintain environmental values and other community benefits

Planktonic algae - floating microscopic plants that are an important food source for aquatic fauna

Pool - a significantly deeper area in the river bed

Reach - a length of stream that is reasonably uniform with respect to geomorphology, flow and ecology

RWS – Regional Waterway Strategy

Riffle - a section of the river with fast and turbulent flow over a pebble bed with protruding rocks

Riparian vegetation - vegetation growing on the water line, up the bank or along the very top of the bank. It is the vegetation which has the most direct effect on instream biota.

Seasonal allocation - the volume of water allocated to a water share in a given season, expressed as a percentage of total entitlement volume

Slackwater habitat – an area in the river channel where water depth is less than 0.5 m and velocity is less than 0.05 m/s

The Living Murray (TLM) - an intergovernmental program, which holds an average of 500,000 ML of environmental water per year, for use at six icon sites along the River Murray

Unregulated entitlement - an entitlement to water declared during periods of unregulated flow in a river system, that is, flows that are unable to be captured in storages

Victorian Environmental Flow Monitoring and Assessment Program (VEFMAP) – assesses the effectiveness of environmental flows in delivering ecological outcomes

Victorian Environmental Water Holder (VEWH) - an independent statutory body responsible for holding and managing Victorian environmental water entitlements and allocations (Victorian Water Holdings)

Water entitlement - the right to a volume of water that can (usually) be stored in reservoirs and taken and used under specific conditions

Water Holdings - environmental water entitlements held by the Victorian Environmental Water Holder

Waterway manager - agency responsible for the environmental management of waterways (includes catchment management authorities and Melbourne Water)

Waterways - can include rivers, wetlands, creeks, floodplains and estuaries

Introduction

This seasonal watering proposal outlines the Goulburn Broken Catchment Management Authority's priorities for the use of water in the Goulburn River in 2022/23, as required under section 192A of the *Water Act 1989*.

The purpose of this Goulburn River Seasonal Watering Proposal is to:

- identify the environmental water requirements of the Goulburn River in 2022/23 under a range of climate and consumptive water delivery scenarios; and
- inform the development of environmental water priorities in the VEWH's seasonal watering plan.

The proposal is informed by current ecological conditions, and scientific studies and reports that identify the flow regimes required to meet the ecological objectives of the Goulburn River.

Priority reaches and measuring points

There have been a number of environmental flow studies of the Goulburn River. Each study divides the river into representative reaches for the development of flow recommendations and compliance points and monitoring. The reaches are as follows:

1. Lake Eildon to Yea River (85 km);
2. Yea River to Sunday Creek (Seymour) (45 km);
3. Sunday Creek (Seymour) to Goulburn Weir (65 km);
4. Goulburn Weir to Loch Gary (110 km); and
5. Loch Gary to the Murray River (125 km)

These reaches are detailed in Cottingham et al (2007) and (2014a) and are shown in Figure 1.

In spring, summer and autumn there are limited opportunities to manage water for environmental purposes in reaches one, two and three due to high flows required to meet downstream irrigation and consumptive water demands. During the non irrigation season (mid May to mid August) environmental water can be delivered in reach one to three, and flow delivered to reaches four and five throughout the year can also benefit reaches one, two and three.

The key measurement points for environmental flows are at Eildon/Alexandra for reach one, Trawool for reach two, Seymour for reach three, Murchison and Shepparton for reach four and McCoys Bridge for reach five.

Water sources

Water available to meet environmental needs in the Goulburn River are listed in Table 1 and include:

- minimum passing flows and a water quality allowance established in the Bulk Entitlement (Eildon – Goulburn Weir) Conversion Order 1995 and subsequent amendments;
- environmental entitlements held by the VEWH, the CEWH and the MDBA; and
- unregulated flows (not listed).

Water holders are able to trade or transfer water from one catchment to another. Consequently, the volumes listed below are entitlement volumes held by the water holders, but total volume available in the Goulburn River could be greater or less depending on priorities in the state and throughout the southern connected Murray Darling basin. This is negotiated with water holders throughout the year. Inter-Valley Transfers usually provide flows in summer and autumn that can be used to meet minimum flows and reduces the need to deploy water from environmental entitlements.

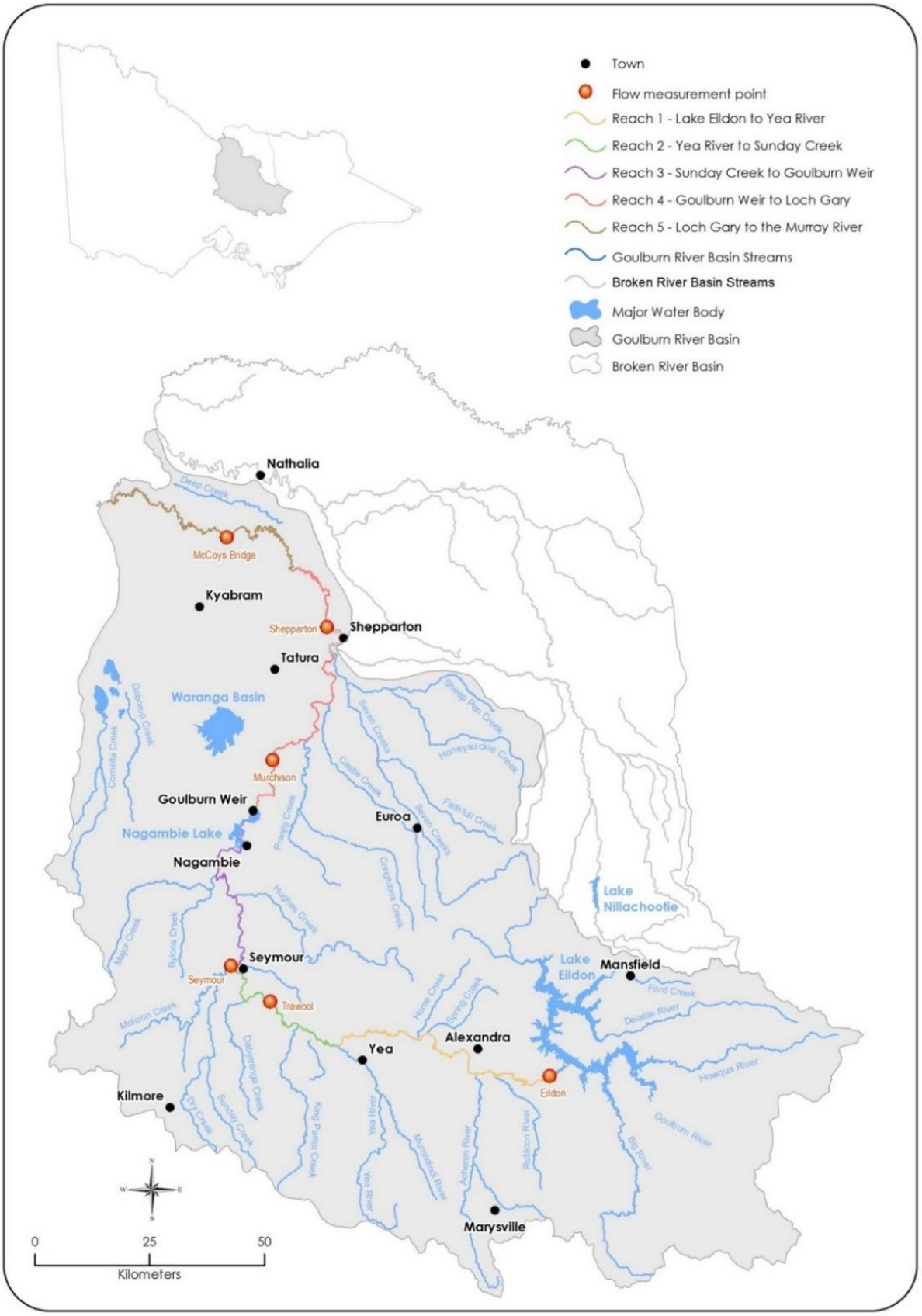


Figure 1: Goulburn River catchment

Table 1: Bulk entitlements and environmental water available for use in the Goulburn River

Environmental Water	Responsible Agency	Description	Conditions
Bulk Entitlement (Eildon – Goulburn Weir) Conversion Order 1995			
Minimum flow	GMW	Minimum flow of 120 ML/day at Eildon Pondage Weir	
Minimum flow	GMW	Minimum average weekly flow of 250 ML/day at Goulburn Weir	Daily rate to be no less than 200 ML/day[1]
Minimum flow	GMW	Minimum average monthly flow of 350 ML/day from November to June (inclusive) at McCoys Bridge	Daily rate to be no less than 300 ML/day[1]
Minimum flow	GMW	Minimum average monthly flow of 400 ML/day from July to October (inclusive) at McCoys Bridge	Daily rate to be no less than 350 ML/day[1]
Goulburn Water Quality Allowance	GMW and VEWH*	30 GL per year	Maintenance of water quality
Additional passing flow below Eildon Pondage Weir	GMW	Minimum passing flows at Eildon Pondage Weir increased to 250 ML/day	Inflows to Lake Eildon for previous 24 months must reach a specified volume[1]
Additional Passing Flow below Eildon Pondage Weir	VEWH	Up to 80 GL in November to provide up to 16,000 ML/day peak flow for one day	Inflows to Lake Eildon from previous 12 and 24 months must reach specified volumes and VEWH confirms the need for a release[1]
Environmental Water Entitlements			
Goulburn System NVIRP Stage 1	VEWH	35,781.3 ML HRWS One third of water savings created in the Goulburn system resulting from modernisation works completed as Stage 1 of the Northern Victorian Irrigation Renewal Project (NVIRP)	Volume based on works implemented and water losses saved in previous year's climate
Goulburn River Environmental Entitlement	VEWH	7,417 ML HRWS 1A 3,140 ML LRWS 1A 1,434 ML HRWS 1B (used in Loddon) This water is generally used in Goulburn catchment wetlands, however, is also available to the river	
Environmental Entitlement (Goulburn-System – The Living Murray) 2007	MDBA	39,625 ML high reliability entitlement 156,980 ML low reliability entitlement 5,559 Water Shares	Water allocated to this entitlement must be used for the Living Murray 'icon sites'. However, this water can provide environmental benefits in the Goulburn River on route to the Murray River
Commonwealth Environmental Water Holdings+	CEWH	317,557 ML Goulburn high reliability water share 42,467 ML Goulburn low reliability water share (as at 28 February 2021)	Water use is subject to agreement with the CEWH

1 Minimum flows in the Goulburn Bulk Entitlement can be reduced under drought conditions and banked for later use.

* The VEWH has delegated their role in the management of the Goulburn Water Quality Allowance to the GBCMA

+ CEWH may have the opportunity to trade additional environmental water allocations from the Murray to meet Goulburn demands

Engagement

There are two main audiences for engagement in the development of this proposal. The primary audience are the agencies involved in delivering the proposed flows. This includes Goulburn-Murray Water, the Victorian and Commonwealth Environmental Water Holders and the Murray-Darling Basin Authority (river operators and the Living Murray program).

The VEWH will use this proposal as the basis in developing their Seasonal Watering Plan. Water allocated is to be delivered in accordance with the plan and the plan is used to seek agreement from other water holders for the use of their water. Routine communication (videoconference, phone, email) will report on deployment of water under the plan.

The CEWO may allocate water to the Seasonal Watering Plan which is based on this proposal. Environmental water releases from the Goulburn River also assist in achieving further benefits at downstream environmental sites. Routine communication will be via the VEWH.

GMW is the key water delivery agency for this plan. When the final proposal for 2022/2023 is agreed, communications with GMW will continue to manage environmental water orders and releases and informing GMW and their customers of the intended purpose.

MDBA (river operators) is responsible for calling out Inter-Valley Transfers. IVT orders are placed with GMW. However, regular communications (phone, email) throughout the year with the CMA will be aimed at delivering IVT in a manner that does not do ecological damage to the Goulburn River environment. The Victorian Minister for Water and DELWP are also currently providing requests to MDBA relating to IVT delivery volumes due to the interim operating plan. The trade rule review and associated changes to the operating plan, operating rules or trade rules may impact on the delivery of IVT into 2022/2023.

A Goulburn and Broken Operational Advisory Group was formally established by the VEWH in 2016 and is comprised of representatives from the VEWH, Goulburn-Murray Water, CEWO, MDBA and GBCMA. This group aims to provide a regular and coordinated forum to discuss the environmental water resource management planning and delivery in the Goulburn River and discuss how this impacts system scale coordination of consumptive and other environmental water.

The secondary audience of this proposal are those potentially affected by, or interested in, environmental flows but not directly involved in planning and delivery. This includes Parks Victoria, water users along the river, local government, environment groups and the general public. The communication objective for these groups is to provide information about the decision to provide environmental flows and what it is trying to achieve. These communications are generally through media articles, emails, and potentially through presentations to special interest groups and direct engagement.

To assist with engaging the community, the GBCMA established a Goulburn Environmental Water Advisory Group in 2012. The aim of the group is for community members and interest groups to provide feedback to the CMA on river health trends observed by landholders and river users and provide advice on planning environmental water use. The group comprises community members and representatives from key agency partners. Indigenous groups have a seat in the group and are starting to attend the meetings on a regular basis. At times, limited resources have restricted their involvement and when this happens they have been consulted through separate meetings.

Table 2 outlines the consultation process the CMA has undertaken during the development of this seasonal water proposal.

Table 2: Engagement undertaken in development of the Seasonal Watering Proposal 2021/22

Who	Engaged on 2020/21 SWP	Engagement method	IAP2 level of engagement	Engagement purpose
Community groups and Environment groups	Goulburn Valley Environment Group	GEWAG meeting on the 24/2/2022	Involve	Seek feedback on environmental water priorities for 2022/23 Incorporate feedback and observations on river condition into the SWP
Program Partners (Government Agencies)	Goulburn Murray Water VEWH CEWO Parks Victoria MDBA/TLM	GEWAG meeting on the 24/2/2022 Direct engagement	Collaborate	Seek input to development of proposal and ensure partners understand any issues in environmental water planning and provide feedback on any constraints to delivery
Recreational users and Local businesses	Trellys fishing and hunting Local ecotourism operator	GEWAG meeting on the 24/2/2022 Direct engagement	Involve Involve	Seek feedback on environmental water priorities for 2022/23 and observations of the river Seek feedback on social and recreational use of the river
Landholders	Goulburn Environmental Water Advisory Group (GEWAG)	GEWAG meeting on the 24/2/2022	Involve	Seek feedback on e-flow priorities for 2022/23 Incorporate feedback and observations on river condition into the SWP
Traditional owners	Yorta Yorta	GEWAG meeting on the 24/2/2022 Direct engagement for contribution to the SWP - Met in March 2022	Involve	Seek feedback on e-flow priorities for 2022/23 Incorporate feedback and observations on river condition and objectives into the SWP
	Taungurung	Discussion with Baan Ganalina on the 9th and 10th March 2022 Direct engagement for contribution to the SWP- Met in March 2022	Involve	Seek feedback on e-flow priorities for 2022/23 Incorporate feedback and observations on river condition and objectives into the SWP
Technical experts	Scientific leads from the CEWO Monitoring, Evaluation and Research Program – Goulburn River G-M trade rule review Scientific Advisory panel	Direct engagement through various sources – FLOW MER annual workshop 7/2/2022.	Collaborate	Seeking advice from scientists on their observations from monitoring and adapting plans/objectives to these results Fish, Vegetation, Macroinvertebrates, Bank Condition

Aboriginal cultural values and uses of waterways

Taungurung Land and Waters Council and Yorta Yorta Nation Aboriginal Corporation kindly provided their values for inclusion in the table below. Based on discussions at the meetings below, the GB CMA has interpreted how the watering actions align with these values and will seek endorsement of the Seasonal Watering Proposal and this section.

A Yorta Yorta representative was present at the Goulburn River Environmental Water Advisory group meeting held on the 24 February 2022 and contributed to the development of the potential watering actions in this proposal.

The proposed watering actions and overall environmental watering objectives and management plans were discussed with the Taungurung water knowledge group, Baan Ganalina (Guardians of Water) on the 9th and 10th.

Table 3 outlines the shared benefits achieved from the delivery of environmental water.

Table 3: Traditional owner values provided in 2021 and alignment with potential watering actions

Values				
River/Wetland	**Traditional owner Group**	**Cultural NRM strategy (emerging) alignment**	**Outcomes**	**Alignment with potential watering action**
Waring **(Mid Goulburn River)**	Taungurung	Healing Country	Supporting the health of cultural values and landscapes - protecting intangible cultural heritage and valued species, traditional food and medicine plants	Reach 1 baseflows and the Winter and Spring freshes will have positive outcomes for protecting the landscape and health of the land. and connection of wetlands at appropriate times. The Reach 1 higher baseflows/freshes trial will help Baan Ganalina improve knowledge to protect valued species and medicine plants in connected wetlands.
			Actively fulfilling Caring for Country responsibilities - investigating on more natural water regimes to degraded significant sites, rehabilitation of native habitat conditions	The Winter and Spring freshes will have positive outcomes by instigating a more natural regime and connection of wetlands at appropriate times.

River/Wetland	Traditional owner Group	Values	Alignment with potential watering action
Kaiela **(Lower Goulburn River)**	Yorta Yorta	Environmental flows on the Lower Goulburn River are critical for culturally important species both flora and fauna. Flows encouraging spawning activity, recession flows to alleviate slumping of culturally important sites such as middens & scar trees and flows with a focus on reviving riparian vegetation are important in sustaining culturally valued food, fibre, and medicine.	All watering actions proposed for Reaches 4 and 5 align with the values of the Yorta Yorta peoples as they are designed to improve the ecological health of the Kaiela. The standing order for recession flows will help to prevent mass failure and the freshes will bring in sediment and seeds to rebuild the banks to protect culturally important sites. Watering actions have been developed using results from monitoring which has shown lower bank vegetation and health/abundance of aquatic animals has improved by delivery of environmental water in previous years that has been delivered in consistently with the actions in this proposal.

Social, recreational and economic values and uses of waterways

The Goulburn River has significant social values associated with passive recreation, fishing and boating, and economics. These revolve around enjoying the natural environment and are enhanced by improvements in river health achieved with targeted environmental flow objectives. The use of environmental water also improves water quality in the river which has a direct benefit for human consumption, stock and domestic and irrigation uses.

Table 4 outlines the shared benefits achieved from the delivery of environmental water.

Table 4: social, recreational and economic shared benefits of environmental water in 2022/23

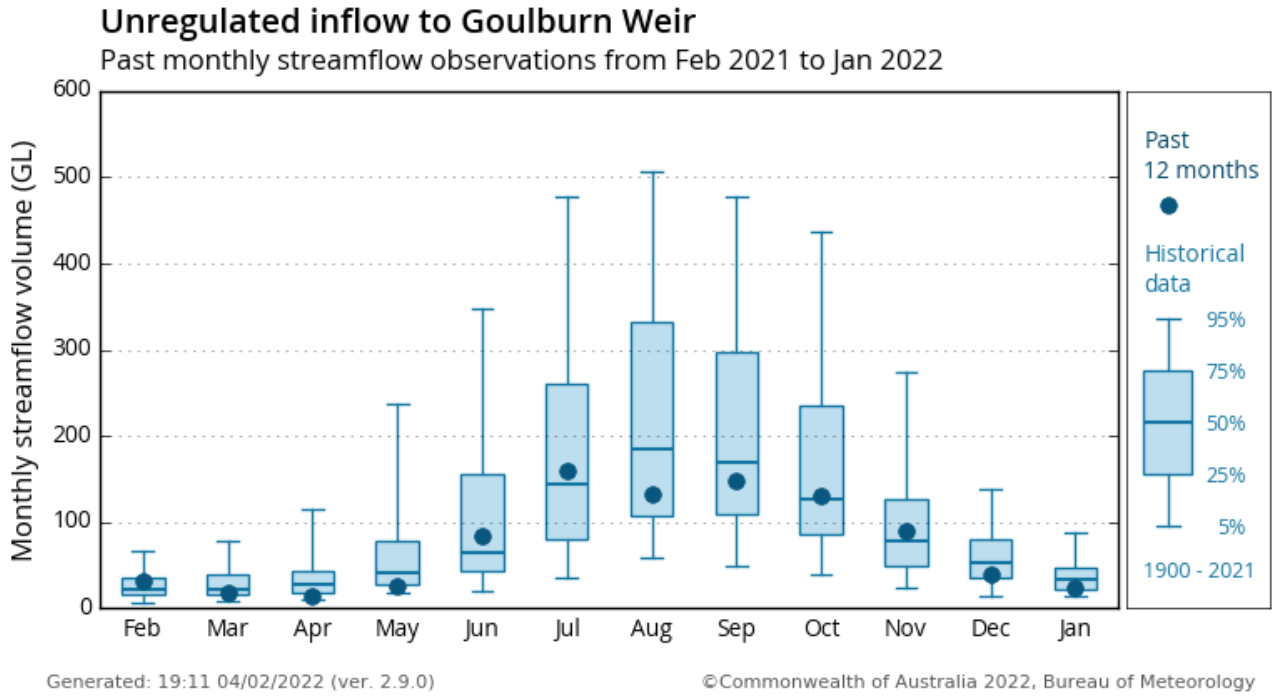
Goulburn River Reach	Shared benefit	Beneficiary	Description
All	Economic	Consumptive water users – GMW irrigators and diverters, Goulburn Valley Water (GVW) customers.	Environmental flows improve water quality, reduces blackwater risk and dilution of blackwater which reduces the treatment costs for GVW and reduces operational risk. Higher flows/water levels that reduces pumping costs and reduces water quality risks for water users.
All	Recreational Amenity	Broader community Local residents, visitors, anglers, game hunters, kayakers and canoers.	Environmental water improves vegetation and water quality and consequently provides an attractive area for campers, hikers, walkers to enjoy. Environmental water improves the local environment, increases species richness in the riparian area and retains natural assets that can be enjoyed by everyone and encourages community conservation and outdoor activities.
All	Recreational Economic	Broader community Anglers	Using environmental water to provide fish passage and habitat, and delivering freshes to encourage fish migration and spawning, enhances native fish populations for recreational benefit. The benefits are extended to other waterways in the entire southern connected Murray Darling basin. The delivery of spring freshes are timed to minimise impact to regional communities and businesses during the annual Cod Opening weekend (first weekend in December).

Seasonal Review

Flow history

In 2010/11 the first flood occurred in more than 15 years. Since then, the climate has got progressively drier with 2011/12 and 2012/13 drier than average, 2013/14 and 2014/15 very dry, and 2015/16 one of the driest on record in the Goulburn catchment. However, 2016/17 was a very wet year with above average rainfall for most months between May and October (MDBA weekly report, 7 December 2016). Inflows in the Goulburn catchment were very high and tracked in the above average to wet scenarios, with at least three distinct overbank flows during winter and spring. Since 2016, the climate has again started to dry and inflows have slowly receded.

Monthly flows generated from rainfall runoff into the Goulburn River storages of Lake Eildon and Goulburn Weir are shown in Figure 2 in comparison to the long term historical data. The charts show that rainfall runoff in 2021/22 led to river responses with several high flow and one bankfull events over winter and spring. Streamflow's were overall higher than average in winter and spring, and then continued to be near average over summer, particularly in the upper catchment as shown by inflows into Lake Eildon. Overall, inflows to Goulburn River storages in 2021/22 were considered to be average i.e. in 50 out of 100 years inflows into storages are greater than the inflow from this year (i.e. 50% PoE). Unregulated flows into Goulburn Weir were slightly below average for the season with several months having above average inflows.



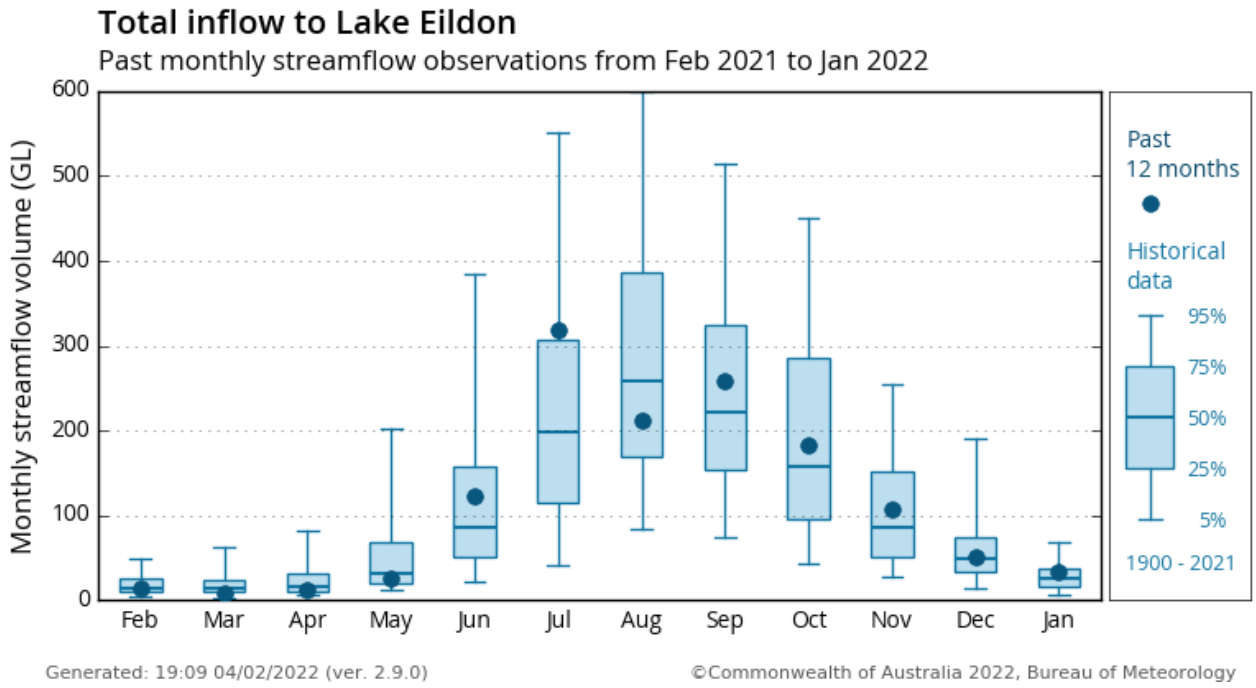


Figure 2: Comparison of 2021/22 inflows from rainfall runoff into Lake Eildon and Goulburn Weir ([Seasonal Streamflow Forecasts: Water Information: Bureau of Meteorology (bom.gov.au)](bom.gov.au))

Figure 3 shows mean daily flow at McCoys Bridge since 2012.

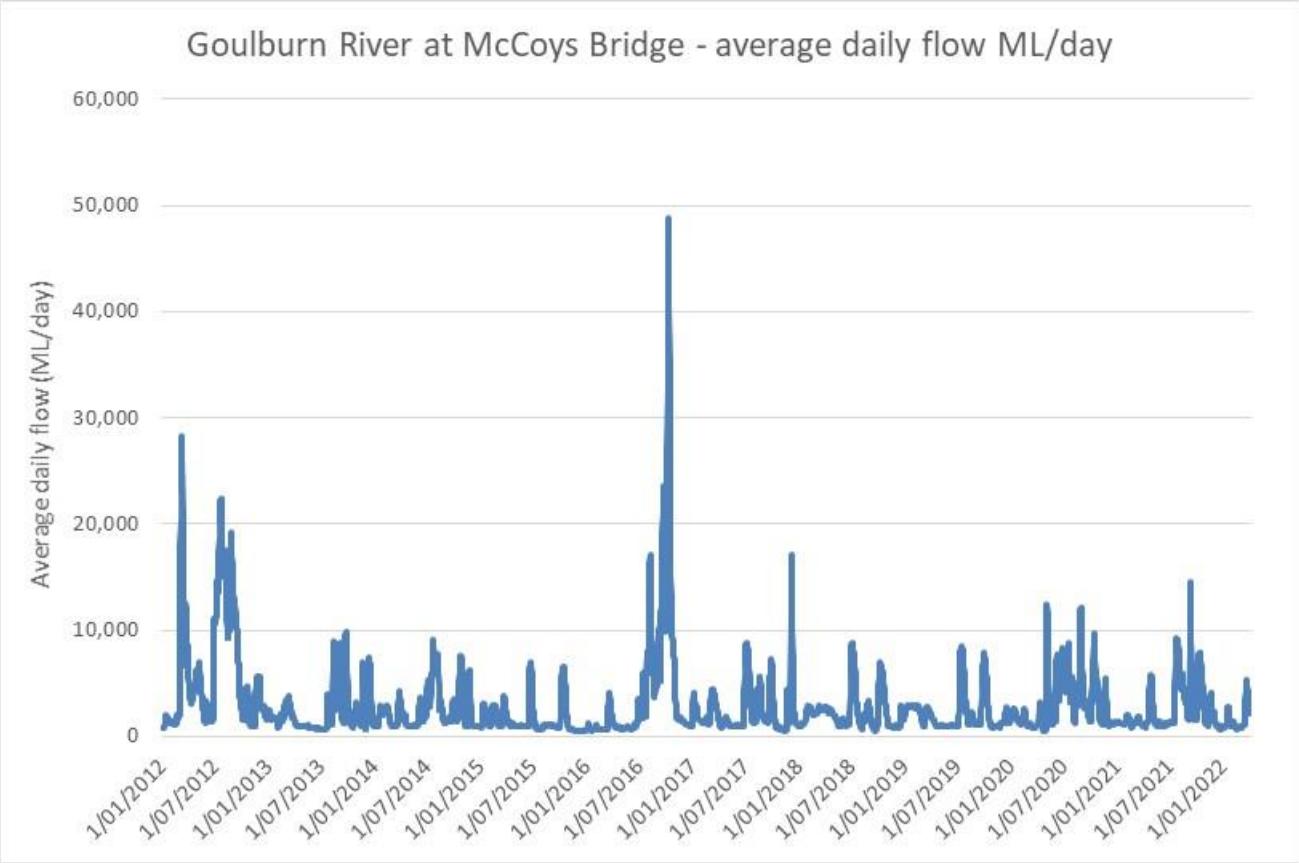


Figure 3: Ten years of flow at McCoys Bridge

2021/22 review

Mid Goulburn

Environmental water was delivered in the mid Goulburn River for the fourth consecutive year in 2021 and is planned for May and June in 2022 depending on GMW Eildon operations. A baseflow of 400 ML/day was targeted in reach one downstream of Lake Eildon. The baseflow has historically been ordered for the non irrigation season i.e. April to September 2019. However, this season due to wetter conditions and high flows downstream of Eildon from rainfall CMA's request of 400 ML/day was delivered for around 9 months between mid-March and November. In the section between Lake Eildon and the confluence with the Acheron and Rubicon River, flows only exceeded the 400ML/day order in March and November for delivery of environmental water (recession flow and spring fresh) and briefly in July for AGL releases.

High tributary inflows from the mid Goulburn tributaries, in particular the Rubicon and Acheron River meant that flows for the majority of reach one exceeded the winter fresh triggers for platypus. In the part of reach 1 immediately downstream of lake Eildon, the winter fresh for platypus cues was provided by AGL releases which went to 4,000 ML/day for 4-5 days. At 4,000ML/day the level was only 15cm off the 5,000 ML/day proposed release. This was considered suitable to provide nesting cues.

Lower Goulburn

In 2021/22 the lower Goulburn had slightly below average flows. Due to Waranga Basin filling in late spring, unregulated flow has provided a large proportion of the lower Goulburn flow in spring. Environmental water used to deliver the winter fresh using rainfall runoff from the Mid Goulburn and passing it through Goulburn Weir instead of being diverted to the Waranga basin. Following the Winter fresh, Waranga basin filled which led to unregulated conditions in the Lower Goulburn and several natural freshes, including a bankfull event at Shepparton. The Seven Creeks and Broken River provided a large proportion of these flows. A spring fresh was delivered following the natural fresh after a short period of low flows to allow for monitoring. Due to unregulated flow in the Murray River and large flows from the northern basin rivers, IVT has not been required and flows over spring and summer have been from environmental water delivery. shows a hydrograph showing watering events for the season.

Environmental water was used to slow the recession of a natural event in August to meet the recommendations of bank inundation time for the winter fresh. Most of the water came from tributary flows in the Mid Goulburn which delivered sediment and seeds as well as delaying germination of vegetation on the lower banks so that it would not be affected by delivery of the early or later spring freshes.

Although there was a short natural bankfull fresh in September it was not long enough to meet the recommended duration of the environmental flow recommendation. As such an early spring fresh was delivered in October using environmental water aimed at the establishment and growth of lower and mid bank vegetation and providing a soil moisture store for vegetation. The fresh also provided increased habitat for fish and macroinvertebrates and improved stream metabolism. Due to forecast rainfall on a wet catchment, GMW reduced releases from lake Eildon due to a risk of exceeding operational flow limits at Molesworth. With the rain that fell a natural flow event occurred during delivery of this fresh but the magnitude of the event was lower than planned with a peak of approximately 8,500 ML/day at Shepparton which attenuated to 7,960 ML/day at McCoys Bridge.

In September, the Minister for Water announced interim operating and trade rules setting limits and defining monthly default IVT delivery volumes over the year. The default volumes define volumes of IVT that MDBA agree to call out each month in line with the Operating Rules. There are certain conditions that may mean that these volumes are not delivered and actual flow monthly may exceed these volumes if environmental or unregulated flows occur. These set 3 pulses of 3000 ML/day to meet the default volumes over summer and autumn. The default monthly volumes of IVT delivery under the operating plan are shown in the table below

Month	Operating Plan IVT volume (ML)	Goulburn IVT volume (ML)
July	0	0
August	0	0
September	14,000	14,000
October	25,000	25,000
November	28,000	19,000
December	47,000	38,000
January	38,000	29,000
February	39,000	30,000
March	47,000	38,000
April	25,000	16,000
May	5,000	5,000
June	5,000	5,000
TOTALS	**273000**	**219000**

Table 5: Default monthly volumes of IVT to be delivered under the operating plan and rules

With high flows over the spring period providing good ancedent conditions a Spawning fresh was considered. However, it was not delivered due to the IVT planned pulse for late December and MDBA unable to give certainty around the timing of the pulse. As a result the potential impacts of 2 freshes/pulses following the spring fresh on Vegetation and the recommended 6-8 weeks of low flow, the spawning pulse did not go ahead. Natural freshes peaking at around 4,000ML/day at Shepparton occurred but no spawning was detected on first fresh (likely due to low water temperatures below 18 degrees Celsius), a small amount or spawning was detected at McCoys Bridge on the second smaller peak at around 3000ML/day.

La Nina climate conditions across the Southern hemisphere led to higher than average rainfall across the Murray Darling Basin. Although there was no flooding in the Upper Murray or Goulburn Rivers, large inflows led to full Murray River storages and numerous spills with unregulated flow conditions continuing into February 2022. Large monsoonal rainfall events led to flooding in the Northern Basin, the Menindee lakes filling and high inflows from the Murrumbidgee and Darling rivers.

The combined high Murray River flows and high inflows from the Northern Basin (Darling and Murrumbidgee Rivers) led to minimal IVT delivery over summer and Autumn. This has given the Goulburn River a chance to enjoy a more natural flow regime with lower flows at the recommended environmental flow levels (below 1.000ML/day). The reduced IVT demand has meant that baseflows were primarily delivered within the environmental flow recommendations and met using environmental water. The lower flows have led to some good recovery of vegetation on the lower banks with patches of littoral vegetation in areas not seen since December 2017.

Although lower flows in the last two years have seen some good growth of bank vegetation, it is still patchy with large areas of the lower bank still bare of vegetation. Greater recovery of this vegetation and lower bank condition is still required following the damage caused by three consecutive years of unseasonal (summer) inundation. Thus, the CMA are again proposing to continue the focus of environmental water use in 2022/23 to maximise vegetation recovery of the lowest metre of the bank (equating to flow rates of 700 – 2,000 ML/day). Without the presence of vegetation to stabilise the bank, continued mass failure will occur.

High flows inundating wetlands in the Darling, Murrumbidgee and Murray Rivers has led to good breeding and recruitment with a large cohort of Golden and Silver perch migrating up the Murray river. An Autumn fresh delivered in March/April 2022 was designed to attract these fish into the Goulburn River.

Last minute changes to the Autumn fresh occurred in response to potential third party impacts. This created a lot of work for GMW and the GBCMA above the normal processes and highlighted issues with delivery of water above the operational constraint of 3,000ML/day in summer and autumn. Two modifications occurred to mitigate potential third party impacts and still meet ecological objectives. The first change occurred to accommodate the pumping requirements of an irrigator and shifted the fish attractant extension to after the peak. The second modification was made at the request of the VFA. The VFA were concerned the rising water level over the Labour Day long weekend posed a risk to campers and recreational users along the river. This request delayed the fresh by two days and while it had no implications for the ecological outcomes it did raise some issues that need clarifying. These include acceptable rates of rise in water level to accommodate campers and recreational users, and where and how should they be applied.

Monitoring of Vegetation condition and response to the autumn fresh will occur in late April with GB CMA staff and ARI staff. Results of the fish movement monitoring will also be available later in the year to assess the impacts on fish movement from the fresh.

As the Goulburn River is reliant on migration of these species to maintain populations, attracting these fish will again be a priority for 2022/23.

Enviro water delivered at the baseflow level has given the river a break from higher flows seen from IVT delivery over summer and Autumn in previous years. Vegetation responses and positive feedback from the community has confirmed that the ewater recommendations are the preferred ecological and social flow levels over summer.

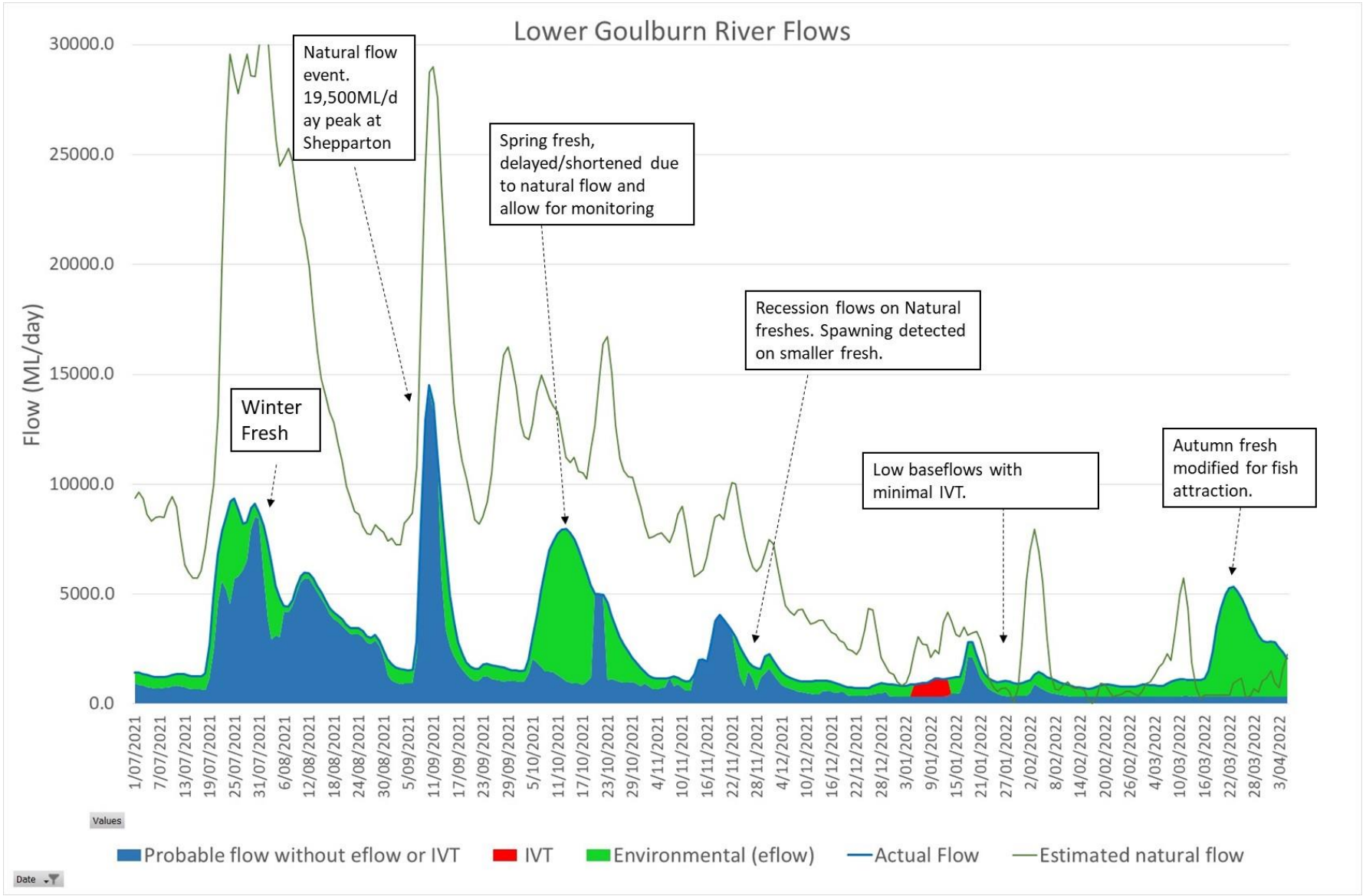


Figure 4: Flow and source of water at Goulburn River, McCoys Bridge

Current ecological conditions

Mid Goulburn River

Photo point monitoring commenced in June 2017 at eight sites in reach one monitoring the extent of baseflow coverage. This has been extended to include consideration of wetland connection and revision of the baseflow recommendation to consider higher flows and connection of wetlands.

Hundreds of off-channel habitats such as lagoons, backwaters and anabranches span the mid Goulburn River between Lake Eildon and Lake Nagambie. These sites are not only important ecologically but are culturally significant to Taungurung people.

A joint project in 2021 between the Taungurung Land and Waters Council (TLWC) and Goulburn Broken Catchment Management Authority (CMA), provided an exciting opportunity for Taungurung to work with government staff and ecologists to develop a plan to improve the health of these sites.

Figure 5: Off-stream wetland Reach 1 (Pam Beatie 2021)

During summer fish surveys ARI found a critically endangered Flat Headed Galaxias in one of the connected wetlands of the Mid Goulburn River (Figure 6). The Flat Headed Galaxias are an EPBC listed species and show the importance of the unique habitat provided by and importance of the off-stream locations supporting different species to the main river channel.

Figure 6: Flat Headed Galaxias found (ARI) and assessments of wetlands Reach 1 (Pam Beatie 2021)

A joint assessment between GB CMA, The Platypus Conservancy and Taungurung community members in 2022 confirmed the presence and use of the Mid-Goulburn off channel habitats by platypus for feeding and refuge. Several important sites were also identified that would be suitable for platypus breeding.

Platypus monitoring using citizen science started in August 2019 in the mid Goulburn. This project is being led by The Platypus Conservancy and involves residents logging platypus sightings on a phone application or website. Results are showing that good platypus numbers have been observed by the community in the mid Goulburn. For example, a very experienced and reliable local platypus observer recorded at least 33 different individuals in a 30-minute census of a 2-kilometre segment of the Goulburn above Alexandra (Australian Platypus Conservancy 2021). Results from this monitoring can be found on the Australian Platypus Monitoring Network (APMN) website (https://platypusnetwork.org.au/findings).

A number of sub-adult Rakali were observed by Goulburn EWAG member Ian Gibb (who also observed the 33 Platypus as noted by the APC) in February of 2021.

Lower Goulburn

The Commonwealth Environmental Water Office (CEWO) finished a five year monitoring program in the lower Goulburn River in 2018/2019. A new three year monitoring program has started in 2019/20 using very similar techniques and sites. Details of the program and all reports can be found on Flow - Monitoring, Evaluation and Research program (flow-mer.org.au).

The draft annual report containing results from monitoring in 2020/21 (CEWO 2021b) has been released and is available on the website (2020–21 Goulburn MER Annual Report - DAWE). Excerpts of the key results from 2020/21 report as well as any insights or preliminary results provided by the scientists on monitoring in 2021/22 are presented under each of the following sections.

Hydraulic habitat and bank condition:

The analysis of the entire 2020–21 period, along with observations from previous years, highlights that the sequencing of both natural events and planned environmental water actions, and particularly the antecedent conditions, is important with respect to the likely effects of future flows on bank condition (erosion and deposition) and sediment/seed deposition dynamics. The results suggest that:

- Natural, CEW delivered events and IVT deliveries all result in varying amounts of erosion. Erosion tends to occur across the inundated surface of the bank and deposition occurs on the lower bank. The greater the height of bank inundated the more distributed the erosion and the lower the overall magnitude of erosion. This means that erosion associated with natural and CEW events is spread across a wider bank zone. In contrast, erosion associated with IVT flows tends to result in more

severe erosion within a narrow band lower on the bank. The introduction of a cap on IVT deliveries and a more variable IVT delivery regime in 2020-21 has been successful at reducing the widespread severe erosion and mass failure seen in recent years, but there are still localised areas of notching occurring.

- The higher the tributary contribution to flow events, the greater the sediment deposition and the greater the abundance and diversity of seed deposition.
- The interval between events appears to be a factor in erosion and deposition characteristics. If freshly deposited sediment from one event has not had time to consolidate on the banks before the next inundation event, the more likely it is to erode, especially if the level of the subsequent event falls within the level of deposition of the previous event. This appears to be the case for the November 2020 fresh which may have eroded freshly deposited material from the earlier spring event. Furthermore, erosion associated with an event may be exacerbated by a subsequent event – this appears to be the case for the autumn 2021 event where a large number of days of flow were at a similar level to the flow band experienced during IVT.

The outcomes from these results suggest that:

- It is important to consider the flow volume and duration of previous events so as to not inundate the same areas of bank for long periods of time. This will reduce the likelihood of additional erosion within those flow bands.
- Deliver flows that gradually rise (to the upper bank zone related to flows >5,000 ML/day as a minimum but ideally >7,000 ML/day) and gradually fall (to the lower bank zone related to flows <900 ML/day) as this will (a) spread the influence of the event across a wider range of bank reducing defined erosion, and (b) allow for deposition in areas of past IVT-related notching near the toe of the bank.
- Attempt to increase sediment and seed content within flows by passing natural flow events where possible and piggybacking CEW on tributary inflows.

Stream Metabolism:

With seven years of data now available analysis on the amount of organic carbon that environmental water contributes to the Goulburn River for a range of flow events at McCoy's Bridge (the site with the most comprehensive metabolism dataset) has been done. The outcomes of this analysis indicate:

The importance of environmental water contributions to organic carbon creation, especially in winter and spring,

1. In winter, the same average daily organic carbon load is created at very low flows as it is for higher flows. Hence from this organic carbon perspective, there is no additional benefit from increasing flows above the very low category. However, there is still benefit of small increases in flow within the low flow bands.
2. Summertime environmental water additions only provide a small increase in daily organic carbon loads, hence if water availability is low or there is the prospect of needing CEW to ameliorate the low DO events sometimes witnessed after large summer storm events, then retaining that water in storage is a good management option.
3. The best outcomes for environmental water -assisted creation of organic carbon are found in the 'Medium Fresh' (peaking around 3,500 ML/day) flow category in spring and autumn where an average additional 800-1,100 kg organic carbon is created. The benefit of flow in this flow category is highest in autumn, where CEW contributions in the lower flow categories are much more modest (an additional 100-200 kg of organic carbon). In spring, substantial increases occur in all flow categories above low flow.

Macroinvertebrates:

Habitat monitoring showed that shrimps are more likely to be detected in habitats where there is some physical habitat, usually plants rather than snags. Prawns do not show a consistent preference for any particular habitat type.

Vegetation:

Monitoring outcomes in 2020/21, in conjunction with observations from previous years reinforces the management steps necessary to promote the recovery of vegetation along the river fringe are as follows:

- Synchronise freshes with tributary flows where possible to enhance propagule supply.
- Provide low flows for 6-8 weeks following the recession of the early spring Fresh to promote recruitment of vegetation before delivering higher flow pulses for environmental (e.g. late spring Fresh for native fish) or consumptive (i.e. IVT) purposes. Further windows of low flows should be provided over the growth season (Dec-Mar) to promote plant growth, flowering, seed set and vegetative expansion.
- The total number of days plants are inundated by >25 cm over recommended baseflow levels over summer should not exceed 40 days and individual inundation events should be less than two weeks.
- Provide adequate periods of low flows between inundation events to allow plants to recover.
- All effort should be made to avoid submergence of plants (do not exceed recommended baseflows) during flowering or seed set. This period varies among species but is most commonly the summer months.
- In some years provide low flows for ~13 weeks following the recession of the spring fresh to allow plants to set seed and replenish the local soil seed bank.
- Provide successive years of low summer flows (do not exceed recommended baseflows) to increase the spatial extent and propagule supply of water dependant species in the fringing zone.

Delivery of baseflows at recommended environmental flow levels over the 2021-22 summer have provided favourable conditions for the recovery of littoral vegetation with a large increase in the cover and height of vegetation observed along the littoral zone between December 2021 and March 2022 during surveys (Figure 7). This has re-inforced the suitability of the environmental baseflow recommendations and need for extended periods of low flow over summer.

Despite the good recovery in places, vegetation was still absent from the majority of the lower bank (below the level of IVT impact of 2,500ML/day) after it was killed from prolonged inundation and erosion of seed and sediments. It is probable that multiple successive years of favourable flow conditions over the growing season are likely to be needed to allow re-established plants to expand their distribution and enhance local propagule pools.

The key consideration is that cumulative inundation of vegetation by more than a total of 40 days over the growing season will kill native vegetation. Current planned operating rules with three pulses of 3,000ML/day will inundate littoral vegetation below 1000ML/day for around 27-30 days and is likely to negatively impact on the health of the vegetation. This means that any environmental water delivery such as for a spawning or Autumn fresh in this period would push inundation of vegetation over the tipping point and kill it. This will be a key issue to resolve going forward.

Figure 7: Darcy's Track Transect 11: overview of site in December 2021 (a) and in March 2022 (b). Transect 11, 38 m from start peg in December 2021 (c) and in March 2022 (d). Cyperus exaltatus (Tall flat- sedge) and Persicaria lapathifolia (Pale Knotweed) are the dominant species, both were flowering in March 2022. Photo Credits: Daniel Lovell (a), Chris Jones (b), Kay Morris (c, d)

Fish:

In the 2020-21 annual fish population surveys, nine native and three exotic species were collected from the ten survey sites. The nationally threatened trout cod (Figure 8) has now been collected in annual fish surveys in two consecutive years and four out of the past seven years. Spawning of trout cod was also detected for the fourth year in a row (2017-2020). Other species of conservation significance collected were Murray cod, silver perch and Murray River rainbowfish. A single unspecked hardyhead was collected in 2021. This species had not been collected in the previous six years but is occasionally encountered in the Goulburn River. A single young-of-year golden perch was also recorded. Similar to previous years, the small-bodied Australian smelt was the most abundant species collected, and the exotic carp was the most abundant large-bodied species collected. The abundance of Murray River rainbow fish was substantially higher than previous years.

The results from 2020 further strengthen previous conclusions that the probability of spawning of golden perch is related to discharge, with greatly increased spawning probability at flows between about 3500–4000 ML/day when water temperatures exceed ~18.6°C. Furthermore, flow conditions prior to spawning freshes are also important, with positive relationship between the probability of spawning and the average flows over the 5 weeks prior to spawning; put simply, the higher the prior flows, the higher the probability of spawning.

Figure 8: Trout Electrofishing and netting surveys in the Goulburn River. Photo: Wayne Koster

IVT monitoring 2021/22

As part of the review of the Goulburn-Murray Trade rule, the Victorian government has funded a monitoring program to specifically investigate issues arising from prolonged, unseasonal IVT deliveries and investigate ecological responses to the new operating rules and plans. A Scientific Advisory Panel (SAP) has been convened to oversee development of the monitoring program to address key research questions.

Due to the high River Murray flows there has been minimal IVT delivered throughout the summer and Autumn of 2021/22. As such there has been limited potential to monitor the ecological responses to the proposed flow regime of IVT delivery under the new rules.

The SAP have undertaken a risk assessment regarding the proposed operating rules with baseflows of 1,100ML/day and three pulses of up to 3,000ML/day along with the potential 6,000ML/day pulses. The risk assessment will be available in May 2022 but preliminary advice has indicated that the ecological risk of the proposed rules to the Lower Goulburn still represent a moderate to significant risk. Although there will not be the level of damage that occurred between 2017 and 2019 it is likely that there will be continued ecological degradation under the rules. In particular the higher baseflows are still a significant risk to geomorphology and will continue to cause a negative trajectory of notching and erosion just at a slower rate. In addition, the three pulses have been assessed as posing a significant risk to bank vegetation, macroinvertebrates and fish.

Based on the preliminary scientific advice, unless there are changes to the proposed rules, ongoing delivery of IVT is likely to continue to impact on ecological outcomes achieved by environmental water delivery in the Goulburn River.

Shared benefits 2022/23

A review of the shared benefits associated with delivery of water for the environment in the Goulburn River over 2022-23 is provided below.

Table 6: Shared Benefits from environmental water delivery along the Goulburn River in 2022/2023

Shared benefit	Beneficiary	Shared benefits
Cultural	Yorta Yorta Traditional Owners	During consultation with Yorta Yorta, specific cultural shared benefits were not identified from environmental water deliveries Goulburn River However, environmental water deliveries align with their values of caring for country.
Cultural	Taungurung Traditional Owners	Higher baseflow trial – co-ordination with Taungurung to allow them to investigate connection of culturally significant wetlands
Amenity	General community, adjacent landholders, visitors	Minimum low flows retained (aesthetically pleasing) flowing habitat for most of the year. Recession flows
Recreation	Local residents, visitors, anglers, game hunters, kayakers and canoers.	Enviro water delivered at lower baseflow have improved recreational activities with more sandbars etc. Feedback from the community – Boss's dog blog has been positive.
Economic	Consumptive water users – GMW irrigators and diverters, Goulburn Valley Water (GVW) customers.	Environmental water deliveries have continued to promote good water quality for local irrigators and D&S use.
Health/Amenity	Goulburn Valley Water (GVW) customers in Shepparton, Mooroopna	Ewater was deliberately delivered at highest baseflow (1000ML/day) to dilute and flush blackwater from the Broken and Seven Cks to improve water quality and reduce taste/odour issues.

Photo point monitoring

Photo point monitoring has been undertaken along the lower Goulburn River since 2012. This monitoring has been more formalised since 2013/14, with ten sites between Goulburn Weir and Yambuna. The following is a snapshot of a number of sites over the years, concentrating mostly on changes to the riparian vegetation and any evident erosion.

February 2015

February 2016

February 2017

February 2018

March 2019

February 2020

February 2021

February 2022

Figure 9: Goulburn River at Medland Road, Bunbartha

February 2015

February 2016

February 2017

February 2018 (note: higher water level)

March 2019

February 2020

February 2021

February 2022

Figure 10: Goulburn River at Carters Road, Arcadia

December 2018

March 2019

December 2019

February 2020

February 2021

February 2022

Figure 11: Goulburn River at Medland Road, Bunbartha. Close up of inside bend showing vegetation changes.

December 2018

March 2019

December 2019

February 2020

February 2021

February 2022

Figure 12: Goulburn River at Carters Road, Arcadia

Flow components delivered

With high water availability at the end of 2020/21 and near average conditions this year, environmental watering actions have been prioritised under the average climate/water resource scenario in 2021/22.

A combination of environmental water and unregulated flows were used to deliver watering actions over winter and spring. High flows in the Murray River and associated low volumes of IVT delivery led to environmental water being used to meet watering actions over summer and autumn. Importantly baseflows have been primarily within environmental flow recommendations for the first time since 2015/16.

Table 7 details each watering action that was delivered and the source of water used.

Although low volumes of IVT were delivered, potential delivery of IVT under the interim operating plan and rules along with uncertainty from the MDBA on IVT delivery plans impacted the ability to meet watering actions. In particular, delivery of the late spring fresh for native fish spawning was not undertaken due to the potential negative impacts to vegetation if pulses of IVT specified under the operating plan were delivered as well as the spawning fresh.

Key observations and learnings

- A year with very limited IVT delivery allowed baseflows at environmental flow recommendations for the majority of summer with environmental water used to target variable flow between 700 and 1,000 ML/day. A positive response to the lower flows saw bands of littoral vegetation re-establish in the zone severely impacted by unseasonal high flows. Positive community responses to the lower flows (compared to previous years) were also received and combined to reinforce that environmental flow recommendations are correct and the need for lower flow over summer and Autumn.
- Constraints in the Goulburn River and in the downstream River Murray again caused impacts and issues for delivery of watering actions. Following a combination of on-ground investigation and communication, the operating flow constraint of 18,000 ML/day downstream of Torrumbarry weir was lifted to 23,000ML/day to allow delivery of the spring fresh. This lifted limit is likely to become the new operating limit.
- The watering action modification for extended duration of Reach One baseflows was again needed. Further investigation into modification of the flows in reach one is required to potentially deliver wetlands and cultural/ecological outcomes.
- The standing order for recession flows when GMW has an unregulated release of water from Goulburn Weir to reduce the risk of bank slumping and stranding aquatic biota was again successfully used twice in the season. Several natural flow events in December and January from the lower Goulburn tributaries had the potential for blackwater or water quality issues. Modifying the standing order to allow for environmental water releases to mitigate water quality risk is recommended.
- Although rare, in years with cooler temperatures and higher rainfall, low water temperatures in November could potentially result in poor results when delivering the late spring fresh for native fish spawning. Following a rainfall event, a spill from Goulburn Weir combined with lower Goulburn tributary flows led to a natural fresh of around 4,500 ML/day. Although expected, no spawning was detected on this event likely due to the water temperatures below 18^{o}C. Some limited spawning was detected at one site on a second fresh of around 3,500 ML/day in early December.

Table 7: Flow components delivered in 2021/22

Priority Watering Action	Comment
Provide a year-round baseflow of 500 – 1,000 ML/day in reaches 4 and 5 for habit diversity and sustaining the system	Met all year. Low IVT demand in Spring and summer led to a variable baseflow between 700 and 1,000 ML/day being delivered.
Provide an early spring fresh (>7,300 ML for 7 days) up to 10,500 ML/day in September and October to prime the system for lower bank vegetation establishment and maintenance.	Natural flows provided a near bankfull event in September. A shorter duration spring fresh peaking at 7,960 ML/day at McCoys (around 8,500 ML/day at Shepparton) was provided by CEWH and TLM and natural flow in October. The magnitude of the fresh was less than planned due to risk of exceeding constraints at Torrumbarry Weir.
Provide 2021 winter fresh >10,500 ML/day or as high as possible in May - August for channel forming and platypus nesting cues. Aim to use a natural fresh and provide the majority of the event from rainfall runoff and minimal releases from Lake Eildon. In the case of low Eildon releases provide a small winter fresh of 5,000 ML/day for 2 days in Reach 1 to provide nesting cues for Platypus	A winter fresh was delivered (provided by CEWH and TLM and natural flows) in July/August and peaked at 9,350 ML/day
Provide variability of Winter-Spring baseflow and small freshes up to 5,000 ML/day to mimic natural variability by passing freshes and larger events from tributaries	Provided by unregulated flows.
Provide a standing order for slower recession to unregulated flows/releases from Goulburn Weir to prevent damage to the lower bank for 3,000ML/day and below in Summer /Autumn and 6,000 ML/day and below in Winter/Spring	Water provided by TLM and CEWH was used to slow the recession of natural events in September, October and December
Provide a variable baseflow of 400-1,000 ML/day in the mid Goulburn River when required	Provided by CEWH and VEWH water
Provide (carryover) for baseflow of 500-540 ML/day in July to September (21/22) for fish and macroinvertebrate habitat	Not needed
Flows should not exceed 1,000 ML/day for 6-8 weeks after a spring fresh for littoral vegetation establishment	Natural flows meant that this target was exceeded.
Provide an autumn fresh (>5,700 ML for 2 days) between March and May for lower bank vegetation establishment and maintenance NOTE: this fresh will only be delivered if various triggers are met over the summer period	An Autumn fresh, modified to target fish outcomes was delivered using TLM and CEWH water in March- April 2022
Provide a late spring fresh (>6,600 ML for 1 days) between October and December for native fish spawning	Did not occur due to negative impacts to vegetation of both the spawning fresh and the planned delivery of IVT as a pulse of 3,000 ML/day in December as designated in the interim operation plan.

Environmental objectives and scope of environmental watering

The Goulburn River Environmental Water Management Plan was completed in 2015 by the Goulburn Broken CMA (2015) and provides an overview of the long term environmental water management objectives. The following table lists these environmental objectives for the Goulburn River (GBCMA 2015).

Table 8: Environmental objectives for the Goulburn River

Ecological value	Long term ecological objective
Native fish	Increase the abundance, spatial distribution and size class diversity of key native fish species (i.e. Macquarie perch, Murray cod, Trout cod, Golden and Silver perch)
Native vegetation	Increase the abundance and richness of aquatic and flood dependant native species (i.e. instream and lower bank)
Macroinvertebrates	Increase macroinvertebrate biomass and diversity
Geomorphology	Protect and promote natural channel form and dynamics (e.g. sediment diversity, rates of sediment transport and bank erosion rates) Increase instream physical habitat diversity (e.g. shallow and deep water habitats)
Stream metabolism	Provide sufficient rates of instream primary production and respiration to support native fish and macroinvertebrate communities
Water Quality	Minimise risk of hypoxic blackwater after natural events.
Platypus*	Maximise self sustaining populations of Platypus
Turtles*	Maximise self sustaining populations of Turtles

*New objectives identified through community consultation in the 2020 flows study

A number of environmental flows studies have been undertaken for the Goulburn River. These are all listed in the references and include:

- "Environmental Flow Recommendations for the Goulburn River below Lake Eildon" (Cottingham et al 2003)
- "Evaluation of Summer Inter-Valley Water Transfers from the Goulburn River" (Cottingham et al 2007)
- "Objectives for flow freshes in the lower Goulburn River 2010/11" (Cottingham et al 2010)
- "Mid Goulburn River FLOWS study" (Cottingham et al 2014a)
- "Kaiela (Lower Goulburn River) Environmental flows study (University of Melbourne, 2020)

The 2007 and 2014 studies both recommend a maximum rate of rise and fall in river flows/levels to minimise bank slumping and flushing or stranding of biota. These guide the shaping of freshes and water management intervention actions, and where possible the rate of fall may be reduced further than recommended levels to minimise any potential erosion, bank slumping or stranding of biota. These recommended rates of fall are now regularly used when water releases are made from Goulburn Weir.

In 2018, some environmental flows objectives were reviewed as part of an investigation into IVT potential in the lower Goulburn River (Cottingham et al, 2018). This resulted in some new flow objectives and flow recommendations. Although not a new flow recommendation, the report advises that flow rates of 500 ML/day or less result in fine sediments settling out and smothering the bed. The report also suggests maintaining bench habitat by inundating three in five years to a depth of half a metre for two to four days. It is considered most beneficial to do this when there can be contributions from unregulated flows, or a combination of Goulburn environmental water released from Eildon and tributary inflows either above or below Goulburn Weir (Cottingham et al, 2018).

Cottingham et al (2018) also refined vegetation objectives to focus on maintaining fringing and aquatic vegetation and encouraging bench and bar vegetation diversity. Fish objectives remained largely the same as previous flows studies but were refined to focus on maintaining a diversity of hydraulic habitats and providing flow cues for spawning and migration with specific flow recommendations.

The Kaiela (lower Goulburn) River flows study (University of Melbourne, 2020) developed flow recommendations using a slightly different method to the standard Victorian government method. The adopted method used a 'designer' flow approach and recognises that the Goulburn River is highly regulated and is no longer compatible with the 'natural flow paradigm' approach. The designer approach uses input from scientists and the community to develop ecological objectives and then links ecological response models to flow components to determine flow recommendations required to achieve the agreed objectives. Further detail regarding this new method can be found in the Kaiela (lower Goulburn) flows study (University of Melbourne, 2020). The process has changed some of the high priority objectives in the lower Goulburn River, and now includes flow recommendations for floodplain inundation. After prioritising year round baseflows, the delivery of an overbank or high flow event was the second highest priority for the Goulburn River community and scientists. Flow recommendations for this include the delivery of flows ranging from 10,500 ML/day to 30,000 ML/day. However, the feasibility of delivering the overbank flow recommendations whilst avoiding damage to public and private assets is an issue requiring further investigation and negotiation. Accordingly, environmental water will not be used to provide overbank flow recommendations in 2022/23. Delivering overbank flows is critical to improve the health of the entire Goulburn River and its floodplain and until government policy permits using environmental water to deliver overbank flows, the full potential of water recovery will not be realised and ecological outcomes required for the Goulburn River and the Basin Plan may not be met.

While extensive floodplain inundation is presently unviable, there is potential in the Goulburn River to deliver flows that link very low lying wetlands and anabranches of the floodplain in reaches four and five. Vietz (2017) undertook an investigation into inundation of floodplain wetlands and anabranches using existing hydraulic models and made assumptions regarding model extrapolation, discharge-elevation relationships and lidar data quality and comparison to Australian Height Datum. Despite these, and other assumptions, some follow up field work has validated some of the results from the investigations. The results show with an increase in flows up to 13,000 ML/day, approximately 10 additional wetland areas can be inundated, and connected to the river channel, at the most downstream section of the river i.e. Wyuna to the confluence with the Murray River. The average wetland size is around three hectares. If the current freshes being delivered in the Goulburn River have a slightly larger peak flow rate, additional ecological benefits would be achieved. However, there are currently constraints of delivering flows above 9,500 ML/day.

Most flow objectives are derived from the various studies described above, however consultation also occurs with ecologists and geomorphologists from the CEWO Monitoring, Evaluation and Research Program (MER) program to incorporate the most recent learnings into operational water delivery. This adaptive management has resulted in some new flow objectives such as the previously delivered "attractant flow" (2017) that aims to move juvenile fish upstream in the Murray River and into tributaries such as the Goulburn River. This type of adaptive management will continue.

There are limited opportunities to manage water in reaches one to three for environmental purposes due to their location immediately downstream of Eildon Dam and irrigation releases in spring, summer and autumn. Therefore, the priority reaches for environmental water management are reaches four and five. However, this does not preclude the delivery of environmental water in the upper reaches if the opportunity is available. Flows objectives for reach one to three are included in appendix one.

An option to deliver environmental flows using tributary unregulated flow is an approach the CMA is aiming to achieve in 2022/23. Using unregulated flows to achieve ecological objectives provides greater benefit than dam releases by using natural ecosystem cues such as water pressure and chemistry which may encourage greater population response and delivering higher levels of sediment to assist with seed germination on the riverbanks (although further research into this is required). The CMA will work closely with GMW to deliver water in a manner that uses as much tributary flow as possible. GMW will advise all customers that there is the potential for flows up to 9,500 ML/day and notice may be short and only up to 2 days prior via text or email. This will provide the opportunity to pass flow events through the Goulburn Weir and the potential to deliver freshes using tributary flow rather than Eildon releases.

When describing flow priorities, the zonation of the riverbank vegetation displayed in Figure 13 is used when defining the objectives in terms of vegetation outcomes.

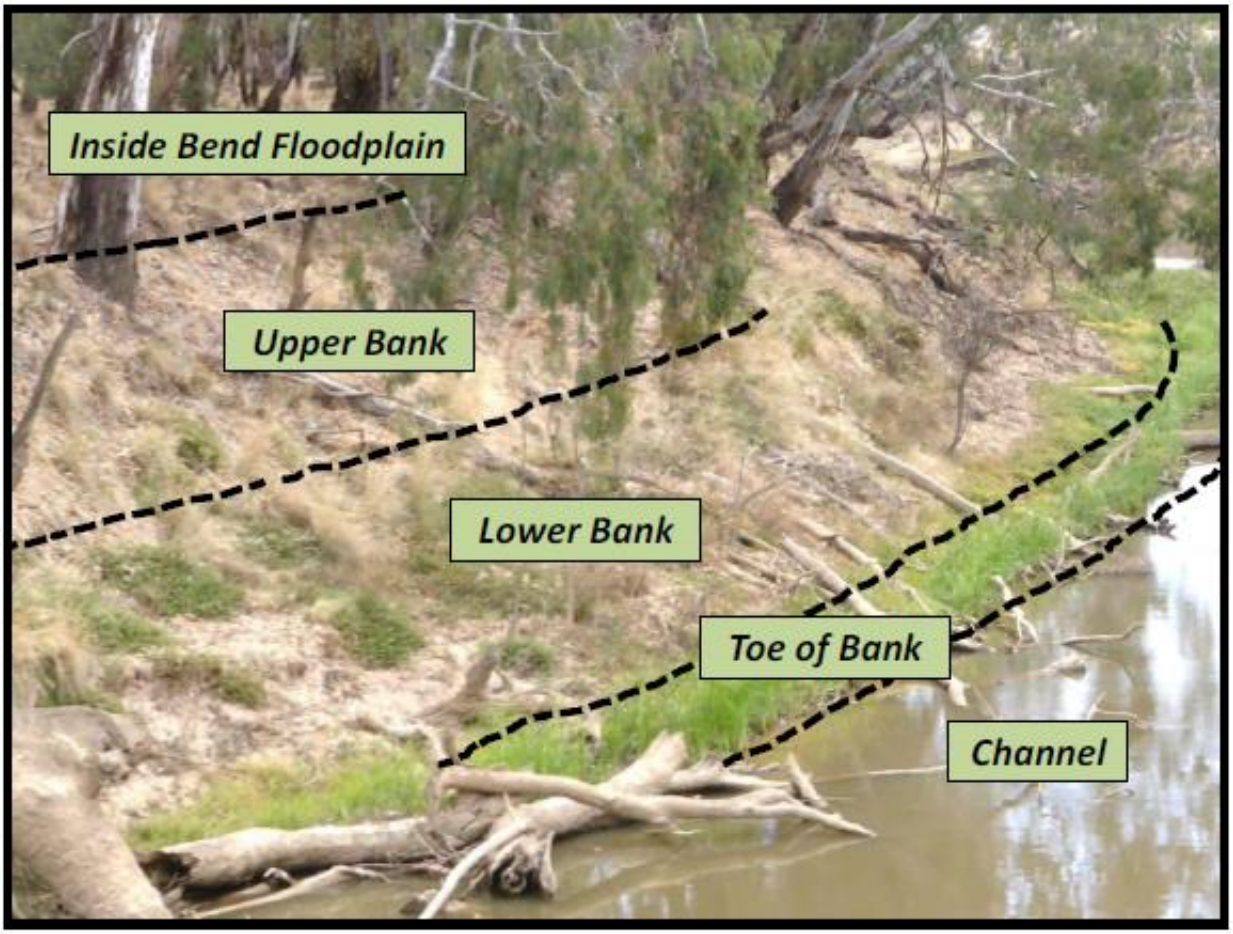


Figure 13: Illustration of bank differentiation for vegetation objectives. Toe of bank relates to flows between 750-1,100 ML/day and lower bank for flows up to 7,500 ML/day (Roberts 2018)

Table 9: Environmental objectives and flow components for reaches 4 and 5

Flow Component	Magnitude	Duration	Timing	Frequency	Environmental flow constraints or trade offs	Relevant objectives and key considerations	Discussion
Year round Baseflow (Providing habit diversity and sustaining the system)	During summer and autumn, preferred flows are between 500 – 1,000 ML/d (or unregulated) During summer and autumn, ensure variability in flow regime (CV > 0.2) (e.g. mean of 750 and standard deviation of 150 ML/d) During winter and spring, ensure flow greater than 500 ML/d	N/A	All year	Every Year	Cod season at start of December and importance of lower base flows for the two weeks prior to provide dry banks for anglers Baseflows > 1,000 ML/d at a constant rate for a duration of longer than 7 days may lead to notching and mass failure (slumping) • Flows with low variability (CV < 0.2) between 1,000 ML/d – 2500 ML/d cause the largest notching impacts - critical zone • Flows above 2500 ML/d also have potential for notching Higher rate of fall may pose a risk to bank stability through slumping (keep rate of fall <0.15m per day and rise <0.38m per day) Flows > 1,000ML/day for greater than 10 days will lead to damage/loss of littoral vegetation Flows > 1,750 ML/d may cause damage littoral vegetation Flows from Sep - Jan that are higher than the flows delivered in late winter challenge platypus by flooding nesting burrows	**All Fish** – Baseflow for fish passage, at least 40cm and habitat diversity (provided at 500ML/day). **Instream Productivity (to support Macroinvertebrates)** - Water depth < 2-3 m for best irradiation of benthic surfaces across substantial part of cross-section. Max of 2,000 ML/day above which slack areas are lost (this will decrease viable areas for biofilm growth) **Macroinvertebrates (to support fish, turtles and platypus)** – Flows engage with littoral vegetation to provide edge habitat. Ensure higher flows do not destroy instream vegetation **Littoral Vegetation –** Regular but small fluctuations will increase the width of the zone of littoral vegetation, improving habitat outcomes for fish and macroinvertebrates. **Mid bank Vegetation**- Occasional higher summer baseflows provide wetting mid bank elevations and maintaining vegetation, however sustained heightened baseflows causing severe inundation would negatively impact vegetation **Bank Stability –** Lower, but variable, baseflows are protective against bank notching. **Turtles –** No direct effects; affected through benefits of baseflows for macroinvertebrates as a food source **Social –** flows greater than 1,000 ML/d inundate high-level sand bars and limit access for camping and fishing (particularly important during holidays and through to Jan 25, with consideration during the Easter holidays)	Lower limit in place to ensure depth for fish and platypus passage (500 ML/d provides a depth of 30 – 40 cm). Upper limit to protect bank stability (slumping and notching), bank vegetation and social needs While habitat diversity is primarily determined by channel complexity, variable flows will improve habitat diversity by engaging different parts of the channel at different discharges, including slack water and slow velocity and deep pools. (Refer to hydraulic cross sections showing 500 and 1,000 ML/d) High summer flows identified as an issue for platypus burrows may become more likely under climate change scenarios, with decreased probabilities of high winter flow events being delivered. Note that the 'or natural' clause here is to allow flows to exceed 1,000 ML/d if there is a natural event outside the control of operations.

Flow Component	Magnitude	Duration	Timing	Frequency	Environmental flow constraints or trade offs	Relevant objectives and key considerations	Discussion
Winter-Spring variable baseflow (Ensure habitat diversity)	>500 ML/d - natural Variability required – mimic natural variability by passing freshes and larger events from tributaries		Winter and spring	Every year	Water availability and seasonal conditions may play a role here. Carryover of sufficient water to ensure that water is available to capitalise on rainfall runoff events in early season for flow variability. Water for spring fresh is higher priority.	**All Fish** – Baseflow for fish passage, at least 40cm and habitat diversity **Macroinvertebrates** – Flows engage with littoral vegetation to provide edge habitat. **Littoral Vegetation –** Regular fluctuations will increase the width of the zone of littoral vegetation, improving habitat outcomes for fish and macroinvertebrates. However, littoral vegetation is dormant in winter. **Mid bank Vegetation-** Higher winter baseflows appropriate to season support wetting of mid bank soils and vegetation maintenance **Instream Habitat Complexity –** Movement of sediment through the system and maintenance of deep pools by passing natural flow events and through the incorporation of tributary inflows	Using a bottom-up method to determine flow requirements the minimum recommendation has therefore been set at 500 ML/d for habitat provision. However, we know from the natural regime, that winter flows would be significantly higher than summer baseflows. The role these flows play may well be a knowledge gap, especially given monitoring tends to focus on other seasons. The passing of tributary flows ensures that winter flows do have some variability and larger magnitudes. This recommendation will need further data and investigation to support. It is anticipated that the 2a overbank/high bank full event and passing of tributary flows will provide the required variability in average and wet years. In dry years with little rainfall runoff variability will be much less.
Baseflow	No greater than 1,000 ML/day	5 – 6 weeks	Late spring/ summer			**Littoral vegetation -** maintain for more than one season a littoral fringe of emergent or amphibious plants **Macroinvertebrates and fish –** provide habitat for macroinvertebrates and small bodied fish. **Provides bank stability**	This flow recommendation has arisen from high irrigation demand immediately following a spring fresh. By keeping flows at a low flow rate, plant germination can proceed. From Roberts (2018)
Baseflow/freshes	1,000 – 5,000 ML/day		Spring / summer/ autumn			Maintain a zone with viable (patchy but persistent) perennial herbs or graminoids on mid to lower riverbank	Maximum continuous duration for P. prostrata is 50 days; maximum continuous duration for A. denticulata is 70 days Shorter duration of inundation is acceptable, but a longer duration is risky From Cottingham (2018)

Flow Component	Magnitude	Duration	Timing	Frequency	Environmental flow constraints or trade offs	Relevant objectives and key considerations	Discussion
Early Spring fresh (Priming the system)	(Provide if 2a not achievable or if 2a occurred early in winter allowing a second pulse) Range 5,000 ML/d to 10,500 ML/d >5,000 ML/d provide some benefit for bank vegetation >7,300 ML/d to mobilize bed sediments and scour fine sediment	7 days at peak	At least one annually in early spring	Yearly	Higher rate of fall may pose a risk to bank stability through slumping (keep rate of fall less than 20% change in flow from the previous day with lower variations expected to have decreased impact on banks)) Depending on the season the overbank or high flows will be provided in addition to or may replace the early spring fresh. No repeat event (as described in #5 below) within 8 weeks between events, as flows in this time period will negatively impact vegetation germination and establishment Monitoring of vegetation establishment may be advisable	**All Fish** – Provides cues for movement through the system allowing dispersal **Macroinvertebrates** – High flows scour fine sediments from interstitial spaces, improving habitat **Littoral/Bank Vegetation –** High flows increase moisture in bank soils and provide a source of propagules, driving germination/establishment of new plants and growth of existing ones **Instream Habitat Complexity –** Freshes transport fine sediments, helping to maintain within-channel habitat features	At least one should be provided per year preferably using tributary flows from rainfall runoff Current operational constraints require the shaping of flows and it will only be possible to achieve ~9,000 – 9,500 ML/d
Winter High Flows	5,000 – 7,000 ML/day	Up to 14 days	Winter/spring	Yearly		Provide cues for spawning and migration for flood specialist native fish Maintain macroinvertebrate habitat (e.g. snags) by mobilising fine sediments and biofilms, replenishing slackwater habitats	Cottingham (2018)
Late Spring fresh (to cue fish spawning)	>7,500 ML/d for high chance of spawning >5,600 ML/d for any benefit	2 days at peak	Ideally Nov or at latest Dec Water temperature > 19°C	Yearly	If this event occurs within 8 weeks of the early spring fresh there is likely to be a negative impact on vegetation, particularly where vegetation is not well established. Delivery of this event should be judged based on the relative antecedent condition of bank vegetation and periodic fish, and weighed against the alternative of recruiting periodic fish from the Murray (see Autumn fresh) Rates of rise and fall important for equilibrium fish (keep less than 10% per day) with higher rates disturbing nesting Sep to Dec, especially Nov and Dec Cod season at start of December and importance of lower base flows for the two weeks prior to provide dry banks for anglers. Noted previously in winter baseflows but a late Spring fresh could also impact opening	**Periodic Fish** – Provides cues for adult golden perch in the Goulburn to move downstream and spawn. Water temperatures must be over 19 °C **Macroinvertebrates** – High flows scour old biofilms from hard substrates, resetting them and improving food resources **Instream Habitat Complexity –** Freshes transport fine sediments, helping to maintain within-channel habitat features	The relative priority of this event may be greater if it has not been delivered for several years

Flow Component	Magnitude	Duration	Timing	Frequency	Environmental flow constraints or trade offs	Relevant objectives and key considerations	Discussion
Freshes			Summer / autumn		Flows should not exceed 1,000 ML/day for more than 10 consecutive days, with a minimum of 6 weeks between pulses	Maintain, for more than one season, a littoral fringe of emergent or amphibious plants. Recommended Provision of habitat for macroinvertebrates and small bodied fish. Provide bank stability	Roberts (2018) adapted to the recent flows study recommendations relating to vegetation.
Autumn fresh (flow variability and ecosystem maintenance)	>5,700 ML/d to reset surfaces	1 – 2 days at peak for vegetation and scouring 7 days at peak for migration of fish (noting that trade off with vegetation for longer event)	During the growing season	Yearly	Higher rate of fall may pose a risk to bank stability through slumping (keep rate of fall <20% change per day)	**All Fish** – Provides cues for movement through the system allowing dispersal. Autumn flows delivered while Murray River flows are relatively low can promote the migration of juvenile golden and silver perch into the Kaiela. **Macroinvertebrates** – High flows scour old biofilms from hard substrates, resetting them and improving food resources **Mid-Bank Vegetation –** If summer flows have been consistently low, high flows in autumn can reinvigorate drying vegetation on the bank, providing some growth before the weather cools and vegetation strops growing **Instream Habitat Complexity –** Freshes transport fine sediments, helping to maintain complexity.	
Overbank or high flows (channel forming event)	Opportunistic event – aim to provide as high as possible an event by utilising or re-creating natural events. Where overbank not possible, still provide as large an event as possible for channel maintenance and forming. >30,000 ML/d allow significant area of floodplain vegetation to be inundated	Areas on the lower floodplain will fill instantaneously. 5 days at peak to fill larger wetlands (base this on opportunity to piggyback).	Ideally late winter to spring or as naturally induced Not during summer to minimize black water events.	As often as possible given natural flow events. Aim for an event >10,500 or as high as possible each year (rainfall runoff or release) >20,000 7 in 10 years or as per natural rainfall runoff	Higher rate of fall may pose a risk to bank stability through slumping (keep rate of fall <20% change per day) Flows greater than 40,000 ML/d begin to inundate private properties with adverse social outcomes Late spring and summer high flows exceeding the high winter flows can have an adverse impact on platypus juveniles, increasing risks of flooding burrows. Important to monitor spring flows in relation to winter flows Late spring flows greater than 22,000 ML/D will have an impact on turtle nesting and juveniles	**Opportunistic Fish** – Provides connectivity to off-channel habitats with greater food resources **Periodic/Equilibrium Fish** – Provides cues for movement through the system allowing dispersal **Instream Productivity** – Return flows bring organic matter from the floodplain and off-channel habitats into the river channel, driving production and respiration **Macroinvertebrates** – Benefit from higher instream productivity as a food source **Littoral/Bank Vegetation –** Return flows bring large amounts of sediments and propagules into the river channel system rebuilding vegetation habitat **Floodplain Vegetation –** Semi-regular inundation of floodplain vegetation is necessary for plant condition and as part of reproductive cycle	There are currently operational constraints that limit the ability to deliver overbank flows and the achievement of this recommendation. There is also a delivery constraint of 9,500 ML/d release from Lake Eildon. Delivering this event is therefore opportunistic based on high tributary flows and is only likely to be possible in wetter years (requiring GMW not to divert tributary inflows to Waranga Basin). These tributary inflows also play an important role in transporting sediment/propagules. Note that climate change will alter the frequency of these natural events. This is an area that requires further investigation to consider how to sustain the objectives that require these overbank / high flow events

Flow Component	Magnitude	Duration	Timing	Frequency	Environmental flow constraints or trade offs	Relevant objectives and key considerations	Discussion
	>20,000 ML/d inundates floodplain near Loch Garry >10,500 ML/d starts to inundate low lying floodrunners and anabranches			>30,000 Natural frequency.		**Instream Habitat Complexity –** These are 'channel forming' events that create in-channel complexity by scouring bed sediments to recreate pools and deposit those sediments onto higher levels to create bars and benches that provide variable level niches, providing dynamic habitat complexity **Turtles –** Inundation of off-channel habitats creates superior nesting habitat for adults **Platypus** – Inundation of off-channel habitats creates superior feeding habitat (especially beneficial in late autumn-winter to support reproductive success)	and look at possible alternatives for managing the floodplain. As noted, these are opportunistic flow events. These flows would be generated naturally in the upper and mid Goulburn River and flow past the Waranga Basin offtake and through the Goulburn Weir. Contributions from tributaries may help increase these flow events. Cultural burns conducted in coordination with Yorta Yorta representatives floodplain inundation can help maximize benefits to native plants such as cumbungi (*typha ss.*), common reed (*Phragmites australis*),old man weed (*Centripeda cunninghamii*) and basket weaving grasses.

Priority watering actions 2022/23

This proposal considers environmental water management under a range of possible climate scenarios from extremely dry to wet. Long term environmental objectives exist for the Goulburn River as outlined in Table 9. Given antecedent conditions and watering actions achieved over last season, the environmental watering actions in the following for 2022/23 have been based around the following principles;

1. Maintain or re-establish lower bank vegetation.
2. Protect the bank and aquatic biota by minimising erosion and mass failure of the lower bank, managing water quality and re-introduce sediments/seed.
3. Achieve fish outcomes – improve Murray and Trout cod populations, cue Golden and Silver perch spawning and attraction into the River.
4. Maximise platypus breeding success by providing nesting cues
5. Maximise ecological outcomes by using tributary flows as much as possible to meet environmental watering objectives, and especially during the spring period.

Table 10: Potential Priority watering actions for reaches 1 to 3

Target reach: Reach 1	**Reach 1 is a priority to receive environmental water in 2022/23 as it provides different (flowing) habitat compared to downstream reaches, therefore increasing habitat diversity across the system. Reach 1 supports beds of *Vallisneria* and a range of aquatic species including platypus. Compliance point: Gauge 405204 Goulburn River downstream of Lake Eildon**		
Potential watering action	**Year round low flows (400 -2,000ML/day)**	**Winter/Spring Fresh**	**Higher winter/spring baseflows and freshes (up to 6,000ML/day)**
Climate/operational scenario variations	The volume of water used will vary based on climatic and operational scenarios and whether Goulburn Weir spills. The assumptions for planning are: Wet, Average and Below Average-30GL Dry and Extreme Dry – 0 ML	Average and Wet scenarios – 0 to 34,000 ML • depending on the interaction with the higher winter/spring trial and its timing, this may not be needed) Other scenarios -0 ML • This will be covered as part of the winter fresh	The volume of water used will vary operational scenarios and whether Goulburn Weir spills. The assumptions are: Wet, Average and Below Average-90GL • A stand alone event is required for reach 1 as its likely that higher flows from the tributaries will provide the majority of flow Dry and Extreme Dry – 50 ML • Partially provided as part of the winter fresh
Triggers	Will occur when GMW is not releasing from Lake Eildon for downstream demands. The lower flow of 400ML/day will be targeted for the majority of the time but short periods of higher flows will occur depending on scenarios	If the winter fresh is not delivered from Lake Eildon due to wet conditions then release more than 5,000 ML/day for two days in reach one between July to September	When GMW is not releasing from Lake Eildon for downstream demands and there is no rain, Provide higher winter/spring baseflows and freshes of up to 6,000ML/day in the Mid Goulburn river to trial connection to wetlands and reflect natural flow levels between June and October
Expected watering effects	Minimum baseflows of 400ML/day: • Maintain habitat for small bodied native fish • Reduce predation risk for platypus and turtles • Maintain existing beds of in-channel vegetation. • Wet and maintain riffles for biofilms and waterbug habitat Additional benefits of higher flows of 800ML/: • Improve connection with wetlands • Scour fine sediment from the gravel bed and riffle substrate • Increase habitat and food (including wetland connection) for Platypus and Turtles	Provide cues for Platypus nesting higher in the bank.	• Maintain habitat for small bodied native fish • Scour fine sediment from the gravel bed and riffle substrate • Maintain existing beds of in-channel vegetation. • Wet and maintain riffles to provide habitat for biofilms and waterbugs • Connect wetlands and anabranches and prevent them from drying out
Environmental objectives	Fish Geomorphology Platypus Reptiles Vegetation Waterbugs	Platypus	Fish vegetation Platypus
Rationale for delivery in 2022-23	It's a win-win for ewater use and ecological outcomes - in drier scenarios when there is less environmental water its less likely for the Goulburn Weir to spill and there will be no use of ewater.	The winter fresh provides cues for Platypus to build nests higher in the bank to avoid inundation and drowning of nests by subsequent high flows in the nesting period – September to November to deliver the spring freshes it is critical that adequate cues are provided to platypus for nesting in all reaches.	Wetlands and anabranches connected within operational flow limits are critical habitat. This action will trial flows at 1,000 ML/day increments for 3 days at a time up to 6,000 ML/day and monitor connection to wetlands to inform ongoing watering actions for the connected wetlands. Taungaraung will also be monitoring cultural wetlands

Table 11: Potential priority watering actions for reaches 4 and 5 in 2022/23

Target reach: Reach 4 and 5	**Reaches 4 and 5 are a priority for environmental watering Compliance point: Gauge 405200 Goulburn River at Murchison and Gauge 405232 Mc Coys Bridge**		
Potential watering action	**Year round baseflow**	**Early spring fresh in September/October**	**Provide a winter fresh**
Expected watering effects	• Provide slow, shallow habitat required for the recruitment of larvae/ juvenile fish and habitat for adult small-bodied fish • Provide deep-water habitat for large-bodied fish • Provide habitat and food for turtles • Submerge snags and littoral vegetation to provide habitat for fish and waterbugs and a substrate for biofilms to grow • Maintain habitat for aquatic vegetation and water the root zone of low- bank vegetation • Vary flow within a specified range to encourage planktonic production (for food), disrupt biofilms and maintain water quality • Low variable flows enable vegetation to establish to protect against notching and bank erosion	• Provide connectivity to off channel habitats and through the river for fish dispersal and greater food resources Improve macroinvertebrate habitat by scouring fine sediments. • Provide cues for fish movement and dispersal • Provide organic matter and carbon (e.g. leaf litter) to the channel • Increase moisture in bank soils and provide a source of propagules driving establishment of new plants and growth of existing ones. • Remove terrestrial vegetation, scour and transport fine sediments to maintain pools and bring in sediments to maintain instream complexity	• Provide connectivity to off channel habitats and through the river for fish dispersal and greater food resources • Trigger lamprey migration in South Australia if delivered to the Lower Lakes during July and/or August. • Channel forming events scour bed sediments to maintain and maintain pools and change in-channel complexity • Provide cues for platypus to nest higher up the bank so they are not impacted by the spring fresh. • Provide organic matter and carbon (e.g. leaf litter) to the channel • Tributary and high flows are a source of sediment and propagules driving establishment of new plants. • Remove terrestrial vegetation and trigger the recruitment of semi-aquatic vegetation • Improve macroinvertebrate habitat by scouring fine sediments, improving habitat area and food availability
Environmental objectives	All Fish Turtles Instream Productivity Littoral and Mid Bank Vegetation Macroinvertebrates Geomorphology and Bank Stability	All Fish Instream productivity Littoral/Bank Vegetation Macroinvertebrates Geomorphology - Instream Habitat Complexity	Opportunistic and Periodic/Equilibrium Fish Geomorphology Instream Habitat Complexity Platypus Instream Productivity Littoral/Bank Vegetation Macroinvertebrates
Application of potential watering action	Provide a variable baseflow of 600 - 800 ML/day in reach four and 600 - 1000 ML/day in reach five all year under all climate scenarios. The baseflow delivery rate in a given season is dependent on seasonal conditions and environmental water availability.	Deliver the fresh up to a Peak flow of 10,500 ML/day (>7,300 ML for 7 days) in September and October. The magnitude of the fresh will be dependent on the proportion of natural flow and only exceed 9,500 ML/day if it is from natural flows. The spring fresh is the highest priority of freshes and will be delivered under all climate scenarios.	In the Dry -Average climate conditions Provide winter fresh >10,500 ML/day or as high as possible in May - August. Aim to use a natural fresh and provide most of the event from rainfall runoff and minimal releases from Lake Eildon For the Extreme dry scenario or in the case of low Eildon releases in the wet conditions provide a small winter fresh of 5,000 ML/day for 2 days in Reach 1 to provide nesting cues for Platypus
Rationale for 2022-23	Baseflows are the highest priority and critical environmental watering action and required year round. With the higher volumes of water available baseflows will target 800 ML/day at Murchison and around 1000 ML/day at McCoys Bridge. Higher flows will provide more habitat and boost primary productivity.	Monitoring has shown the spring fresh provides the greatest overall ecological benefits of all the freshes. GMW has changed notification timing for irrigators and there is now potential to pass natural flow events from the mid Goulburn through Goulburn Weir. As a result, the aim will be to deliver the spring fresh using contributions from tributary flow as much as possible rather than release from Eildon.	The winter fresh is important to provide cues for platypus so they nest further up the bank and their nests will not be impacted by the spring fresh. With water availability high under all but the extreme dry scenario it is planned to do a full magnitude fresh but of a shorter duration than historic to contribute more water to the spring fresh.

Target reach: Reach 4 and 5	**Reaches 4 and 5 are a priority for environmental watering** **Compliance point: Gauge 405200 Goulburn River at Murchison and Gauge 405232 Mc Coys Bridge**	
Potential watering action	**Maintain water quality and protect the banks from erosion**	**Mimic natural variability through the length of the Goulburn River**
Expected watering effects	• Minimise the risk of bank erosion associated with mass failure from rapid drops in river levels • Minimise the risk of hypoxic blackwater after natural events • Reduce the risk of poor water quality harming aquatic biota	• Transport and deposit seed, plant propagules and sediment on the riverbank • Provide organic matter and carbon (e.g. leaf litter) to the channel
Environmental objectives	Geomorphology Vegetation Water Quality	Instream Productivity Vegetation
Application of potential watering action	Although these are two separate watering actions with different objectives they will have the same application. A standing order will be placed with GMW to deliver a fresh up to 6,000 ML/day to: 1) slow the recession of any unregulated flow/releases from Goulburn Weir. 2) maintain water quality 3) pass mid Goulburn tributary flow through to the lower Goulburn in late autumn to Spring. The magnitude and duration of these events will vary depending on seasonal condition, in line with operational constraints, rates of rise and fall and ecological implications the following maximum peak of freshes and starting points for recession flows will be use. In summer and autumn 3,000 ML/day and below and in winter/spring 6,000 ML/day and below When required environmental water will be used to slow the recession of a spill or release from Goulburn Weir to protect the lower banks. In the event of a water quality issue, most likely hypoxic blackwater, a fresh will be delivered to protect the instream aquatic biota. Between the winter and early spring freshes aim to pass tributary flow in the mid Goulburn through to the lower Goulburn. When tributary induced flows in reach 3 are above 4,000 ML/d pass flows on top of baseflows into in reaches four and five between May and October	
Rationale for 2022-23	These watering actions require rapid responses to natural flows arising from rain events (often of a high intensity), e.g hypoxic black water, spills from Goulburn Weir, or rapid short duration freshes from mid Goulburn tributaries. For these events there is often not enough time to arrange all approvals for use of environmental water to reduce the rate of fall and prevent slumping, respond to water quality events or pass natural mid Goulburn freshes to the lower Goulburn. There are no rates of rise and fall set for releases in GMW's operations or rules and unregulated spills can drop from 5,000 to 1,000 ML/day in 24 hours. Therefore, environmental water is used to slow the recession of unregulated flows downstream of Goulburn Weir to reduce bank slumping and stranding of biota. a standing order will exist for the whole season to slow the recession from either 6,000ML/day (winter/spring) or 3,000ML/day (summer/autumn) and below to protect the damaged lower band from slumping. This watering event is heavily dependent on climatic conditions and in this highly modified system will be delivered as a managed variable baseflow and designed fresh that passes a proportion of the tributary flows that occur in the mid Goulburn. The following assumptions for the application of the watering action (in terms of water needed) for each climate scenario are as follows: • Extreme Dry and Dry – not needed • Below Average – one event for winter/spring • Average – one event for summer/autumn and one event for winter/spring • Wet - two events for summer/autumn and two events for winter/spring	

Target reach: Reach 4 and 5	**Reaches 4 and 5 are a priority** **Compliance point: Gauge 405200 Goulburn River at Murchison and Gauge 405232 Mc Coys Bridge**	
Potential watering action	**Provide an autumn fresh**	**Provide a late spring fresh for fish spawning**
Expected watering effects	• Cue fish to move through the system allowing dispersal. Attract Golden and Silver perch to migrate into the Goulburn • Reinvigorate drying vegetation on the banks and provide some growth before the weather cools • Flush fine sediment and scour old biofilm from hard substrates to allow new biofilm growth and to improve food and habitat for macroinvertebrates • Scour and remove fine sediments to maintain instream habitat complexity	• Stimulate spawning of Golden and Silver perch • Scour bed sediments to maintain pools and change in-channel complexity for improved habitat • Improve waterbug habitat and food availability by scouring fine sediments and biofilms from hard substrates
Environmental objectives	Fish Macroinvertebrates Littoral/Bank Vegetation Instream Habitat Complexity	Periodic Fish Geomorphology Waterbugs
Application of potential watering action	Provide an autumn fresh (>5,700 ML for days) between March and May. When aiming to attract fish the duration of the fresh will be extended. Planned for all climate scenarios but delivery of the fresh will be dependent on low flow over the summer period and the number and magnitude of IVT pulses which may provide the fresh.	In November or December provide a short duration fresh >6,000ML/day for 2 days and >1500ML/day for around 14 days. A fresh in November will target Golden Perch whereas a fresh in December will target Silver Perch but will likely trigger some Golden Perch spawning as well. To limit littoral vegetation damage this fresh will only be delivered if following the spring fresh there is 6-8 weeks of baseflows of around 1000 ML/day or flow have not been less than 2000ML/day for more than a week
Rationale for 2022-23	An autumn fresh is now recommended annually in the latest flow recommendations. With sufficient environmental water likely it is planned to deliver this fresh if flow over summer is appropriate. An autumn fresh would target existing vegetation maintenance and encourage germination of new seed on the lower banks and benches. The fresh will also assist to improve water quality, and to achieve some macroinvertebrate objectives including resuspension of fine sediment from macroinvertebrate habitats and consequent increase in biofilm availability. To reduce the potential for damage from the fresh due to the banks being primed for failure from IVT delivery. The fresh should not be in the same area of bank targeted by IVT delivery over spring/summer and be of a higher magnitude. Depending on IVT delivery over the year a higher magnitude autumn fresh may help to repair/reset some of the erosional damage caused.	This is a low priority for 2021 due to the successful spawning event in November 2022 and the focus for reestablishment of vegetation in the littoral zone and lower bank. However, if conditions are average or wet with high natural flows over winter and spring (with likely bank full or overbank events) then as in 2019/2020 an event will be delivered. The duration and magnitude of the event will be dependant on seasonal conditions and consideration of implications for vegetation and erosion will be required. .

Target reach: Reach 4 and 5	**Reaches 4 and 5 are a priority** **Compliance point: Gauge 405200 Goulburn River at Murchison and Gauge 405232 Mc Coys Bridge**	
Potential watering action	**Provide an autumn fresh**	**Provide a late spring fresh for fish spawning**
Expected watering effects	• Cue fish to move through the system allowing dispersal. Attract Golden and Silver perch to migrate into the Goulburn • Reinvigorate drying vegetation on the banks and provide some growth before the weather cools • Flush fine sediment and scour old biofilm from hard substrates to allow new biofilm growth and to improve food and habitat for macroinvertebrates • Scour and remove fine sediments to maintain instream habitat complexity	• Stimulate spawning of Golden and Silver perch
Environmental objectives	Fish Macroinvertebrates Littoral/Bank Vegetation Instream Habitat Complexity	Periodic Fish
Application of potential watering action	Provide an autumn fresh (>5,700 ML for days) between March and May. When aiming to attract fish the duration of the fresh will be extended. Planned for all climate scenarios but delivery of the fresh will be dependent on low flow over the summer period and the number and magnitude of IVT pulses which may provide the fresh.	In November or December provide a short duration fresh >6,000ML/day for 2 days and >1,500 ML/day for around 14 days. A fresh in November will target Golden Perch whereas a fresh in December will target Silver Perch but will likely trigger some Golden Perch spawning as well. To limit littoral vegetation damage this fresh will only be delivered if following the spring fresh there is 6-8 weeks of baseflows of around 1000 ML/day or flow have not been less than 2,000 ML/day for more than a week
Rationale for 2022-223	An autumn fresh is now recommended annually in the latest flow recommendations. With sufficient environmental water likely it is planned to deliver this fresh if flow over summer is appropriate. An autumn fresh would target existing vegetation maintenance and encourage germination of new seed on the lower banks and benches. The fresh will also assist to improve water quality, and to achieve some macroinvertebrate objectives including resuspension of fine sediment from macroinvertebrate habitats and consequent increase in biofilm availability. To reduce the potential for damage from the fresh due to the banks being primed for failure from IVT delivery. The fresh should not be in the same area of bank targeted by IVT delivery over spring/summer and be of a higher magnitude. Depending on IVT delivery over the year a higher magnitude autumn fresh may help to repair/reset some of the erosional damage caused.	This is a low priority for 2021 due to the successful spawning event in November 2022 and the focus for reestablishment of vegetation in the littoral zone and lower bank. However, if conditions are average or wet with high natural flows over winter and spring (with likely bank full or overbank events) then as in 2019/2020 an event will be delivered. The duration and magnitude of the event will be dependant on seasonal conditions and consideration of implications for vegetation and erosion will be required. .

Scenario Planning and Prioritisation

Climatic outlook for 2022/23

The long term climate outlook for environmental water planning is difficult to determine. Consequently, the CMA uses allocation outlook scenarios provided by Goulburn-Murray Water to assist in scenario planning. Table 12 shows the outlook (based on historic river flows and inflows) into storages provided and used as a basis for this Seasonal Watering Proposal.

With good inflows in 2021/22 and allocations reaching 100% early in the season there are reserves in the Goulburn system that will provide for an opening allocation under all inflow conditions. There is also a large volume of environmental water carryover that will aid in delivering early season watering priorities.

Table 12: Goulburn system outlook for 2022/23 seasonal determination of high reliability shares

Inflow Conditions	1 July 2022	16 August 2022	15 October 2022	15 February 2023
Wet	100%	100%	100%	100%
Above Average	77%	100%	100%	100%
Average	65%	100%	100%	100%
Below Average	57%	85%	100%	100%
Dry	51%	67%	92%	100%
Very Dry	50%	61%	79%	92%
Extreme Dry	49%	52%	59%	67%

Source: GMW, 15 February 2022

The scenario planning for 2022/23 under the different inflow scenarios is outlined in Table 13 . It builds on details included in the previous section on seasonal watering priorities. For next seasons scenario planning given the high carryover volume from 2021/22 and good early season allocations all watering priorities are the same for every inflow scenario except the extreme dry inflow scenario.

Table 13: Scenario planning summary

Reaches 4 and 5	Scenario 1 Extreme dry 99% POE	Scenario 2 Dry 90% POE	Scenario 3 Below average 70% POE	Scenario 4 Average 50% POE	Scenario 4 Wet 10% POE
Expected river conditions	No unregulated flow Blackwater could be an issue over the warmer months	One or two small, short duration freshes in winter/spring (perhaps up to 5,000 ML/day) and reasonable baseflows for half a month Blackwater could be an issue over the warmer months	One or two freshes (3,000 to 20,000 ML/day) and reasonable baseflows for a few months.	One to three freshes (up to 20,000 ML /day) Good baseflows for most of the year (would be reduced during irrigation season), perhaps two to three months baseflow provided by unregulated Blackwater could be an issue over the warmer months	Three to five freshes (including overbank flows) Unregulated flow to provide the majority of flow over winter and spring
	Bulk entitlement minimums will be delivered 400 ML/day at McCoys from July – October 350 ML/day at McCoys from November – June				
Expected water allocations	67% HRWS allocation	100% HRWS allocation	100% HRWS allocation	100% HRWS Small chance of Eildon spilling	100% HRWS Chance of Eildon dam spilling
Expected water availability from water holders *	CEWH – 212 GL TLM – 30 GL VEWH – 16 GL	CEWH –317 GL TLM – 45 GL VEWH – 25 GL	CEWH –317 GL TLM – 45 GL VEWH – 25 GL	CEWH –317 GL TLM – 45 GL VEWH – 25 GL	CEWH –317 GL TLM – 45 GL VEWH – 25 GL
Forecast carryover from 19/20	CEWH, TLM and VEWH combined 180 GL	CEWH, TLM and VEWH combined 180 GL	CEWH, TLM and VEWH combined 180 GL	CEWH, TLM and VEWH combined 180 GL	CEWH, TLM and VEWH combined 180 GL
Total water available from water holders	390 GL	518 GL	518 GL	518 GL	518 GL

Demands	50 GL will be supplied to the Broken Creek and Lower Goulburn Wetlands from CEWH/VEWH Goulburn entitlement in every scenario				
Assumed IVT available	400 GL+	400 GL+	400 GL+	400 GL+	400 GL+
Assumed IVT water deliveries to support Goulburn River environmental outcomes	It assumed that the default monthly volumes of IVT outlined in Table 5 are delivered for the year. These volumes are assumed to meet all of the baseflow volume requirements for the year	It assumed that the default monthly volumes of IVT outlined in Table 5 are delivered for the year. These volumes are assumed to meet all of the baseflow volume requirements for the year	It assumed that the default monthly volumes of IVT outlined in Table 5 are delivered for the year. These volumes are assumed to meet all of the baseflow volume requirements for the year	It assumed that the default monthly volumes of IVT outlined in Table 5 are delivered for the year. These volumes are assumed to meet all of the baseflow volume requirements for the year. However its likely that in this scenario not all IVT will be delivered but unregulated flows would cover baseflow needs.	It assumed that the default monthly volumes of IVT outlined in Table 5 are delivered for the year. These volumes are assumed to meet all of the baseflow volume requirements for the year. However its likely that in this scenario not all IVT will be delivered but unregulated flows would cover baseflow needs.
Environmental objectives	In addition to the environmental objectives 1. Maintain or re-establish lower bank vegetation. 2. Protect the bank and aquatic biota by minimising erosion and mass failure of the lower bank, managing water quality and re-introduce sediments/seed. 3. Achieve fish outcomes – improve Murray and Trout cod populations, cue Golden and Silver perch spawning and attraction into the River. 4. Maximise platypus breeding success by providing nesting cues 5. Maximise ecological outcomes by using tributary flows as much as possible to meet environmental watering objectives, and especially during the spring period.				
Priority watering actions	Lower Broken Creek environmental water requirements. (50GL)				
1	Provide a year round baseflow of in reach four and 500 - 1000 ML/day in reach four and five for habitat diversity and sustaining the system (41GL) – primarily provided by IVT	Provide a year round baseflow of in reach four and 500 - 1000 ML/day in reach four and five for habitat diversity and sustaining the system (37GL) – primarily provided by IVT	Provide a year round baseflow of in reach four and 500 - 1000 ML/day in reach four and five for habitat diversity and sustaining the system (48GL) – primarily provided by IVT	Provide a year round baseflow of in reach four and 500 - 1000 ML/day in reach four and five for habitat diversity and sustaining the system (48GL) – primarily provided by IVT or unregulated flow	Provide a year round baseflow of in reach four and 500 - 1000 ML/day in reach four and five for habitat diversity and sustaining the system (48GL) – primarily provided by IVT or unregulated flow

2	Provide 2022 winter fresh >7,300 ML/day or as high as possible in May - August for channel forming, and platypus nesting cues. Aim to use a natural fresh and provide most of the event from rainfall runoff with minimal releases from Lake Eildon. In the case of low Eildon releases provide a small winter fresh of 5,000 ML/day for 2 days in Reach 1 to provide nesting cues for platypus (95GL)	Provide 2022 winter fresh >7,300 ML/day or as high as possible in May - August for channel forming, and platypus nesting cues. Aim to use a natural fresh and provide most of the event from rainfall runoff with minimal releases from Lake Eildon. In the case of low Eildon releases provide a small winter fresh of 5,000 ML/day for 2 days in Reach 1 to provide nesting cues for platypus (95GL)	Provide 2022 winter fresh >7,300 ML/day or as high as possible in May - August for channel forming, and platypus nesting cues. Aim to use a natural fresh and provide most of the event from rainfall runoff with minimal releases from Lake Eildon. In the case of low Eildon releases provide a small winter fresh of 5,000 ML/day for 2 days in Reach 1 to provide nesting cues for platypus (50GL)	Provide 2022 winter fresh >7,300 ML/day or as high as possible in May - August for channel forming, and platypus nesting cues. Aim to use a natural fresh and provide most of the event from rainfall runoff with minimal releases from Lake Eildon. Some unregulated flow will contribute to the event In the case of low Eildon releases provide a small winter fresh of 5,000 ML/day for 2 days in Reach 1 to provide nesting cues for platypus (50GL)	Its assumed that natural flows will provide the winter fresh and due to low Eildon releases provide a small winter fresh of 5,000 ML/day for 2 days in Reach 1 to provide nesting cues for Platypus. (34GL)
3	Provide an early spring fresh (>7,300 ML for 7 days) up to 10,500 ML/day in September and October to prime the system for lower bank vegetation establishment and maintenance. (145GL)	Provide an early spring fresh (>7,300 ML for 7 days) up to 10,500 ML/day in September and October to prime the system for lower bank vegetation establishment and maintenance. (145GL)	Provide an early spring fresh (>7,300 ML for 7 days) up to 10,500 ML/day in September and October to prime the system for lower bank vegetation establishment and maintenance. Aim to use a natural fresh and provide the majority of the event from rainfall runoff and minimal releases from Lake Eildon. Assume one quarter from natural flow. (102GL)	Provide an early spring fresh (>7,300 ML for 7 days) up to 10,500 ML/day in September and October to prime the system for lower bank vegetation establishment and maintenance. Aim to use a natural fresh and provide the majority of the event from rainfall runoff and minimal releases from Lake Eildon. Assume one quarter from natural flow. (102GL)	Provide an early spring fresh (>7,300 ML for 7 days) up to 10,500 ML/day in September and October to prime the system for lower bank vegetation establishment and maintenance. It is assumed that the spring fresh will be met using environmental water to extend a natural fresh will to and natural flows will provide half of the flow. (73GL)
4	Provide an autumn fresh (>5,700 ML for 2-5 days) between March and May for lower bank vegetation establishment and maintenance *NOTE: this fresh will only be delivered depending on flow and vegetation condition over the summer period* (60GL)	Provide an autumn fresh (>5,700 ML for 2-5 days) between March and May for lower bank vegetation establishment and maintenance *NOTE: this fresh will only be delivered depending on flow and vegetation condition over the summer period* (60GL)	Provide an autumn fresh (>5,700 ML for 2-5 days) between March and May for lower bank vegetation establishment and maintenance *NOTE: this fresh will only be delivered depending on flow and vegetation condition over the summer period* (60GL)	Provide an autumn fresh (>5,700 ML for 2-5 days) between March and May for lower bank vegetation establishment and maintenance *NOTE: this fresh will only be delivered depending on flow and vegetation condition over the summer period* (60GL)	Provide an autumn fresh (>5,700 ML for 2-5 days) between March and May for lower bank vegetation establishment and maintenance *NOTE: this fresh will only be delivered depending on flow and vegetation condition over the summer period* (60GL)

5	Provide higher winter/spring baseflows and freshes of up to 6,000ML/day in the Mid Goulburn river to trial connection to wetlands and reflect natural flow levels between June and October. Likely to be in conjunction with winter fresh (30GL)	Provide higher winter/spring baseflows and freshes of up to 6,000ML/day in the Mid Goulburn river to trial connection to wetlands and reflect natural flow levels between June and October Likely to be in conjunction with winter fresh (50GL)	Provide higher winter/spring baseflows and freshes of up to 6,000ML/day in the Mid Goulburn river to trial connection to wetlands and reflect natural flow levels between June and October Likely to be in conjunction with winter fresh (50GL)	Provide higher winter/spring baseflows and freshes of up to 6,000ML/day in the Mid Goulburn river to trial connection to wetlands and reflect natural flow levels between June and October. Will need to be a separate event in May/ June to avoid high tributary flows (60GL)	Provide higher winter/spring baseflows and freshes of up to 6,000ML/day in the Mid Goulburn river to trial connection to wetlands and reflect natural flow levels between June and October . Will need to be a separate event in May/ June to avoid high tributary flows (60GL)
6	Provide a variable baseflow of 400-2,000 ML/day in the mid Goulburn River when required (5 GL)	Provide a variable baseflow of 400-2,000 ML/day in the mid Goulburn River when required (25 GL)	Provide a variable baseflow of 400-2,000 ML/day in the mid Goulburn River when required (25 GL)	Provide a variable baseflow of 400-2,000 ML/day in the mid Goulburn River when required (35 GL)	Provide a variable baseflow of 400-2,000 ML/day in the mid Goulburn River when required (35 GL)
7	Provide a standing order for freshes up to 6000ML/day for maintaining water quality and protecting the banks (up to 3,000ML/day in Summer /Autumn and 6,000 ML/day in Winter/Spring) (0 GL) No events expected	Provide a standing order for freshes up to 6000ML/day for maintaining water quality and protecting the banks (up to 3,000ML/day in Summer /Autumn and 6,000 ML/day in Winter/Spring) (0 GL) No events expected	Provide a standing order for freshes up to 6000ML/day for maintaining water quality and protecting the banks (up to 3,000ML/day in Summer /Autumn and 6,000 ML/day in Winter/Spring) (25 GL) Recession flow and/or water quality flow expected	Provide a standing order for freshes up to 6000ML/day for maintaining water quality and protecting the banks (up to 3,000ML/day in Summer /Autumn and 6,000 ML/day in Winter/Spring) (25 GL) Recession flow and/or water quality flow expected	Provide a standing order for freshes up to 6000ML/day for maintaining water quality and protecting the banks (up to 3,000ML/day in Summer /Autumn and 6,000 ML/day in Winter/Spring) (30 GL) Recession flow and/or water quality flow expected
	Provide a standing order for higher baseflows or freshes up to 6,000ML/day between May and October to mimic natural variability through the length of the Goulburn River. (0 GL) No events expected	Provide a standing order for higher baseflows or freshes up to 6,000ML/day between May and October to mimic natural variability through the length of the Goulburn River. (0 GL) No events expected	Provide a standing order for higher baseflows or freshes up to 6,000ML/day between May and October to mimic natural variability through the length of the Goulburn River. (50 GL)	Provide a standing order for higher baseflows or freshes up to 6,000ML/day between May and October to mimic natural variability through the length of the Goulburn River. (50 GL)	Provide a standing order for higher baseflows or freshes up to 6,000ML/day between May and October to mimic natural variability through the length of the Goulburn River. (15 GL)
8	Provide (carryover) for baseflow of 500-540 ML/day in July to September (23/24) for fish and macroinvertebrate habitat (23GL)	Provide (carryover) for baseflow of 500-540 ML/day in July to September (23/24) for fish and macroinvertebrate habitat (23GL)			

9		Provide 2023 winter fresh >7,300 ML/day or as high as possible in May - August for channel forming, and platypus nesting cues. Aim to use a natural fresh and provide most of the event from rainfall runoff with minimal releases from Lake Eildon. In the case of low Eildon releases provide a small winter fresh of 5,000 ML/day for 2 days in Reach 1 to provide nesting cues for platypus (85GL)	Provide 2023 winter fresh >7,300 ML/day or as high as possible in May - August for channel forming, and platypus nesting cues. Aim to use a natural fresh and provide most of the event from rainfall runoff with minimal releases from Lake Eildon. In the case of low Eildon releases provide a small winter fresh of 5,000 ML/day for 2 days in Reach 1 to provide nesting cues for platypus (95GL)	Provide 2023 winter fresh >7,300 ML/day or as high as possible in May - August for channel forming, and platypus nesting cues. Aim to use a natural fresh and provide most of the event from rainfall runoff with minimal releases from Lake Eildon. In the case of low Eildon releases provide a small winter fresh of 5,000 ML/day for 2 days in Reach 1 to provide nesting cues for platypus (95GL)	Provide 2023 winter fresh >7,300 ML/day or as high as possible in May - August for channel forming, and platypus nesting cues. Aim to use a natural fresh and provide most of the event from rainfall runoff with minimal releases from Lake Eildon. In the case of low Eildon releases provide a small winter fresh of 5,000 ML/day for 2 days in Reach 1 to provide nesting cues for platypus (95GL)
Volume required	390	520	505	525	443
Tier 2 actions					
10	Provide 2023 winter fresh >7,300 ML/day or as high as possible in May - August for channel forming, and platypus nesting cues. Aim to use a natural fresh and provide most of the event from rainfall runoff with minimal releases from Lake Eildon. In the case of low Eildon releases provide a small winter fresh of 5,000 ML/day for 2 days in Reach 1 to provide nesting cues for platypus (60GL) – partial event	Provide a late spring fresh (>6,600 ML for 1 days) between October and December for native fish spawning NOTE: this fresh will only be delivered if there is 8 weeks of baseflows of around 1000 ML/day or Lower bank vegetation has not been inundated for less than a week (50GL)	Provide a late spring fresh (>6,600 ML for 1 days) between October and December for native fish spawning NOTE: this fresh will only be delivered if there is 8 weeks of baseflows of around 1000 ML/day or Lower bank vegetation has not been inundated for less than a week (50GL)	Provide a late spring fresh (>6,600 ML for 1 days) between October and December for native fish spawning NOTE: this fresh will only be delivered if there is 8 weeks of baseflows of around 1000 ML/day or Lower bank vegetation has not been inundated for less than a week (50GL)	Provide a late spring fresh (>6,600 ML for 1 days) between October and December for native fish spawning NOTE: this fresh will only be delivered if there is 8 weeks of baseflows of around 1000 ML/day or Lower bank vegetation has not been inundated for less than a week (50GL)
	Provide a late spring fresh (>6,600 ML for 1 days) between October and December for native fish spawning NOTE: this fresh will only be delivered if there is 8 weeks of baseflows of around 1000 ML/day or Lower bank vegetation has not				

	been inundated for less than a week				

+ Based on conversations with GMW

* CEWH may have the opportunity to trade additional environmental water allocations from the Murray to meet Goulburn demands

Delivery Constraints

Changing water demands, such as the need and availability of water for South Australia, and expansion of horticulture and almond growing in the mid Murray, is increasing demand for water to be delivered from the Goulburn system. When demand is high in the mid and lower Murray and releases from Hume Dam are constrained by the Barmah Choke, the Goulburn River is called on to supply demand from Lake Eildon. This water is referred to as IVT and is predominately delivered between December and March/April. The demand for IVT can vary from year to year and is highly dependent on climate conditions and if supply to South Australia can come from Menindee Lakes, the Murrumbidgee River or is reliant on Murray River water. The balance of trade in the Murrumbidgee, trading of environmental water, environmental water deliveries and MDBA requirements to meet passing flow requirements can also increase the requirement to deliver water from the Goulburn.

IVT deliveries have a benefit of meeting environmental watering priorities in the Goulburn River if the demand coincides with environmental demands. However, it can also lead to elevated flows that conflict with lower Goulburn River environmental watering priorities and objectives. The average annual volume of IVT delivered through the lower Goulburn River over the past eight years (2014/15 to 2020/21) is approximately 210 GL, with a low of 70 GL in 2015/16 and a high of 430 GL in 2018/19. In 2017/18 and 2018/19 IVT demand over summer increased dramatically with 80-90 GL of water delivered in some months at a constant rate of around 2700ML/day. The aim of environmental water to deliver baseflows up to approximately 1,000 ML/day throughout summer may be constrained, and not achievable due to high demand for IVT water in 2022/2023. This presents a delivery constraint to being able to achieve two objectives:

1. Use of environmental water in the Goulburn River, as IVT water takes precedence
2. Achieving ecological outcomes from environmental water delivery, and increasing the risk to bank stability and vegetation resilience and native fish populations

The current Goulburn-Murray Trade rule review and new operating rules for the Goulburn River aimed at protecting the ecology of the lower Goulburn River further increase this constraint as e-water use is constrained for 6 months of the year. Further, high volumes of IVT likely to be carried over from 2021/22 may limit the ability to deliver environmental water over winter and spring if IVT carryover reduction is given precedence. This is unclear in the current rules and plans.

Implementation arrangements

Metering and flow monitoring arrangements for the Goulburn River are documented in the *Northern Victorian Environmental Metering Program* (VEWH 2018).

Draft operating arrangements exist for the Goulburn River. Operational arrangements at regulating structures and delivery of consumptive water within the catchment and downstream can constrain the ability to meet flow recommendations (GBCMA, 2015). Capacity constraints at Goulburn Weir are also possible, and GMW consult with GBCMA when such circumstances occur.

Environmental water delivery is primarily constrained by the risk of flooding adjacent land and assets. The Bureau of Meteorology minor flood levels at each flow measurement point along the Goulburn River are as follows:

- 3 metres (14,500 ML/day) at Eildon (reach 1)
- 4 metres (21,700 ML/day) at Trawool (reach 2)
- 4 metres (24,800 ML/day) at Seymour (reach 3)
- 9 metres (33,100 ML/day) at Murchison (reach 4)

- 9 metres (28,300 ML/day) at McCoys Bridge (reach 5)

However, constraints to delivery of environmental flows are known at lower flows than these. The following limitations and reasoning have been identified:

- during the irrigation season flows greater than 3,000 ML/day impact on some diverter's access to pumps and landholder notification of any flows above this flow is required approximately three weeks prior to delivery. This 3,000 ML/day limit also extends to the delivery of IVT water.
- releases from Lake Eildon are typically limited to 9,500ML/day to avoid inundation of private land
- managed releases from Goulburn Weir are limited to 10,000 ML/day by GMW due to the unknown impact of inundating land downstream.

Costs

Relevant headworks costs for environmental entitlements are met by the environmental water entitlement holders. There are no water delivery costs.

Notice and time required

A minimum notice period of one to two days, and preferably four days, is required for environmental water orders from Goulburn system storages. Releases from Lake Eildon take approximately two and a half days to reach Goulburn Weir. Releases from Goulburn Weir take three to four days to reach Shepparton, and approximately six to seven days to reach McCoys Bridge from Goulburn Weir. However, this can be influenced by existing conditions in the river channel and seasonal conditions. If flows are being harvested at Goulburn Weir into Waranga Basin, releases can be made from Goulburn Weir to the lower Goulburn River by reducing harvesting, hence saving travel time from Lake Eildon.

When flows above 3,000 ML/day are being targeted, notification to landholders adjoining the Goulburn River is required up to three weeks in advance during irrigation periods. GMW have improved their knowledge of impacted diverters and moved from letters to email and text notifications for events.

For the winter and early spring (up until the proposed spring fresh in September/October) GMW will advise all customers that there is the potential for flows up to 9,500 ML/day and notice may be short and only up to 2 days prior. This will provide the opportunity to pass flow events through the Goulburn Weir and the potential to deliver freshes using tributary flow rather than Eildon releases.

Confounding factors

The main confounding factor is the inability to inundate the floodplain to meet ecological and community outcomes. This is being addressed under the Victorian Constraints Measures Program.

Increasing Knowledge

Monitoring

River flows and water quality are currently monitored through the North East Monitoring Partnership and often assist in environmental flow management. Sites of flow monitoring on the Goulburn River are Lake Eildon, Killingworth, Trawool, Seymour, Goulburn Weir, Murchison, Shepparton, Loch Garry (level only) and McCoys Bridge.

Water quality monitoring includes continuous (i.e. 15 minute intervals) and non-continuous monitoring. Continuous data collection has been occurring since 2009 (primarily in response to drought) and non-continuous monitoring (monthly) has been occurring for more than ten years. Table 14 lists the sites, frequency and parameters that are used for environmental flow monitoring. This monitoring is used frequently (sometimes daily) in short term environmental flow management to assist decision making, especially for minimising the risk of dissolved oxygen sags and potential fish deaths or other water quality issues.

Table 14: Monitoring sites used in environmental flow management

Site	Parameter
Continuous monitoring	
Goulburn River @ McCoys Bridge	Dissolved oxygen, electrical conductivity, temperature, level
Goulburn River @ Shepparton Golf Club	Dissolved oxygen, temperature
Goulburn River @ Trawool	Turbidity, electrical conductivity, temperature, level
Seven Creeks @ Galls Gap Road	Dissolved oxygen, temperature
Non-continuous monitoring	
Goulburn River @ McCoys Bridge	TP, TN, dissolved organic carbon
Goulburn River @ Shepparton	Suspended solids, turbidity, TP, TN
Goulburn River @ Murchison	Dissolved oxygen, temperature, turbidity, electrical conductivity, suspended solids, TP, TN
Goulburn River @ Trawool	Dissolved oxygen, temperature, turbidity, electrical conductivity, suspended solids, TP, TN
Goulburn River @ Eildon	Dissolved oxygen, temperature, turbidity, electrical conductivity, suspended solids, TP, TN

Knowledge gaps and limitations

As delivery and monitoring of environmental water continues we are increasing our knowledge and understanding of ecosystem responses. However, with the increased knowledge comes new knowledge gaps. Below are some key knowledge gaps of ecosystem response to flow management in the Goulburn River:

- What is the recommended frequency of baseflow delivery in reach one (400 ML/day at Eildon) with regard to native fish objectives?
- How many years can Murray River Rainbow fish tolerate unseasonal, prolonged summer/autumn flows before local extinction?

- What happens to Golden perch eggs and larvae from the Goulburn River once they enter the Murray River?
- What habitat requirements do large bodied native fish require in the juvenile stage?
- What are the ecological processes and productive value of instream benches following inundation? This might include mapping of benches and hydraulic modelling to see what gets inundated when, vegetation survey to see what organic matter is on bench pre and post inundation.
- What are the specific ecohydraulic habitat requirements for different life stages of fish and for macroinvertebrates?
- Understanding of native fish, particularly Silver and Golden perch movement and life history requirements through the entire southern connected basin requires more research.
- How often should golden/silver perch spawning flows be targeted as a high priority in the Goulburn River, without having impact on the population structure of these fish within the Goulburn and broader southern connected basin?
- What are the areas and types of habitats (wetlands, bars, benches, anabranches) connected by current environmental flows and what are the benefits of connecting the different habitat types?

Knowledge gaps also exist with regard to the integration of traditional ecological knowledge to improve the alignment of environmental watering with Traditional Owner biocultural values. It will be necessary to continue to work closely with Traditional Owners, and facilitate Traditional Owner led assessments of biocultural values to identify cultural priorities for watering such as support for food and medicinal plant species, or protection of culturally significant aquatic fauna. Investigation is also necessary to determine how best to facilitate ongoing involvement of Traditional Owners in order to identify and adequately consider indicators of these tangible biocultural values in e-water planning, as well as better respond to intangible values such as the maintenance of connection to Country and the expression of cultural obligations to heal Country.

Risk Management

The risks associated with the proposed water delivery in the Goulburn system are listed in Table 15 . Risks were primarily identified at the VEWH risk workshop held via an online meeting in February 2022. Associated risks and risk ratings are the same for each season, with the exception of winter. Mitigation strategies that will be employed to address the identified risks are detailed in **Error! R eference source not found.** along with lead agencies.

The key management activities with immediate outcomes include:

- management of flood risk associated with delivering freshes by considering potential runoff in deciding when to commence releases or whether to cease releases prematurely;
- to keep key stakeholders advised of release plans and outcomes of releases

The risk of flooding arises from catchment runoff adding flow on top of environmental releases. The key issue is the unpredictability of the amount of rainfall and runoff. At Shepparton, flooding occurs at approximately 18,000 ML/day, although inundation of some assets (such as irrigation pumps) occurs at much lower flows (anecdotally as low as 3,000 ML/day). Managing the risk of flooding is a balance in determining spare capacity in the river to carry runoff and the potential reduction/suspension of environmental releases required when rainfall is forecast. The highest flow (due to capacity constraints) that can be provided from Lake Eildon is 9,000 to 10,000 ML/day under dry conditions, and assumes no irrigation water supply demand. This leaves 8,000 to 9,000 ML/day of spare river capacity in the lower Goulburn to carry runoff on a dry catchment. Under wet conditions, lower flow releases would be needed to manage the likely higher runoff. However, following a rainfall runoff event short duration releases of 9,000 ML/day could be added to the recession to achieve higher flow rates or extended duration when little or no rainfall is forecast in the seven day outlook. The higher the flow rate (due to runoff), the more likely the flow release would be reduced or ceased, making provision of the environmental or water supply flow erratic and potentially unreliable.

Natural high rainfall and floods have resulted in hypoxic blackwater in parts of the Goulburn River and Murray River in recent years. In December 2017, GMW and the GBCMA used the water quality reserve to make additional releases from Goulburn Weir to manage potential hypoxic blackwater in the lower Goulburn River. The water quality reserve can be used at GMW's discretion at short notice, but there are specific conditions attached to its use, and it cannot be replenished within a season.

Another key risk in the lower Goulburn River is the management of water from Lake Eildon to consumptive and environmental users downstream. This can provide ecological benefits to the river and reduce the volume of environmental water required, however if large volumes of consumptive water are required at times contradictory to the environmental flow recommendations for the Goulburn River, this can pose a significant risk to achieving the ecological outcomes intended with the Goulburn environmental water.

The implications of (and direct damage caused) by delivery of consumptive water over summer and Autumn has been recognised by the Victorian Government and at the time of writing proposed new trading and operational rules for delivery of traded water through Inter Valley transfers have been released Goulburn to Murray trade rule review | Engage Victoria. The actual rules arising from the review are currently not finalised but the operating rules proposed under the preferred option in the Regulatory Impact Statement (RIS) has the potential prevent several watering actions proposed in this plan from being delivered. In particular there are large risks that the late spring fresh and Autumn fresh cannot be delivered. This is identified as a extreme risk and still has a high residual risk following mitigation actions.

Table 15: VEWH risk assessment for 2022/23 watering proposals – risks medium or higher –

Risk ID	Risk category	Risk description	Likelihood	Consequence	Risk Rating	Mitigation actions	Lead organisn. for action	Remains medium/high after mitigation	Risk type Static or Dynamic
NOGB2020-01	Environment	Specified flow rates are insufficient to achieve the intended extent of wetland inundation or magnitude and duration of river flows, resulting in a failure to achieve planned environmental outcomes.	Possible	Major	Medium	• Include contingency allowance in estimated watering requirements, based on previous event data, and consider a contingency in the duration of the event to achieve desired wetland inundation. • Monitor event (especially for deliveries to new sites or for previously untested events) and adjust flows as necessary, or terminate event if it becomes clear that insufficient water is available. • Identify and address constraints that may limit the flow rates for environmental deliveries.	CMA CMA CMA/GMW		Static
NOGB2020-02	Reputational	Specified flow rates are insufficient to achieve the intended extent of wetland inundation or magnitude and duration of river flows, resulting in a failure to achieve planned environmental outcomes and loss of community support.	Possible	Major	Medium	• Communications on the environmental benefits of watering actions. • Monitor event (especially for deliveries to new sites or for previously untested events) and adjust flows as necessary, or terminate event if it becomes clear that insufficient water is available. • Communicate the need for complimentary measures to optimise the benefits of environmental watering actions.	CMA		Static
NOGB2020-08	Environment	Failure of poorly maintained environmental delivery infrastructure results in planned/specified flows not being achieved, reducing the ability to achieve planned environmental outcomes.	Likely	Moderate	Medium	• Asset ownership is clarified, and the asset owners perform regular maintenance, and pre-event asset inspections, on delivery infrastructure. **Note that insufficient resources are likely to limit the asset owner's ability to regularly inspect and maintain infrastructure. Increased resources for these activities may further reduce the likelihood and risk ratings.* • Report vandalism to police. • Review asset design to minimise opportunities for interference or damage. • For privately owned assets, arrange approvals to use/operate assets and undertake pre-delivery inspections • Communicate failures to the CMA • Initiate documentation of asset ownership and management arrangements in national parks.	Asset Owner Asset Owner Asset Owner CMA Asset Owner PV		Static
NOGB2020-09	Environment	Poor condition of delivery infrastructure results in the asset owner being unable to operate the structure due to OH&S risks, leading to failure to deliver environmental flows and to achieve environmental objectives. Note: This issue may affect multiple sites *GMW to confirm OH&S status and likelihood rating*	Likely	Moderate	Medium	• Asset owner to undertake regular maintenance and pre-event asset inspections on delivery infrastructure. **Note that insufficient resources are likely to limit the asset owner's ability to regularly inspect and maintain infrastructure. Increased resources for these activities may further reduce the likelihood and risk ratings.* • Communicate failures to the CMA • Develop design for new regulating structure and seek funding to implement necessary upgrades in conjunction with asset owner. *Note: PV proposing to issue operating licences for BMF regulators*	Asset Owner Asset Owner CMA (MDBA in Barmah Forest)		Dynamic
NOGB2020-11	Environment	High downstream demands may lead to flows that exceed local environmental requirements and targets (including rates of river rise and fall), leading to negative environmental outcomes, including negating previous environmental improvements. Recent monitoring and assessment is confirming consequences in Goulb and Lwr Bkn - high water avail. in 22-23 increases likelihood	Almost certain	Major	Extreme	- Seek to negotiate and formalise acceptable seasonal flow limits for river systems, with annual negotiation and management of release plans and reviews during the season as required. - Monitor impacts of new trade limits and revised operating rules and review as necessary (Note: This risk may still be rated as *extreme* after mitigation actions.)	VEWH and DELWP DELWP/GBCMA	High	Dynamic
NOGB2020-12	Legal	Environmental releases, either on their own or potentially in combination with unexpected tributary inflows, cause unauthorised inundation of private land, resulting in impacts on landowner activities and assets.	Possible	Major	Medium	• Ensure currency of any landholder agreements for inundation of private land. • Release plans designed to avoid exceeding operational thresholds or unauthorised flooding. • Monitor events and adjust releases to avoid overbank flows. This may include limiting deliveries to daylight hours only, where feasible and consistent with watering requirements. • Monitor forecast rainfall and tributary inflows and adjust releases to avoid overbank flows. • Monitor deliveries to new locations to build an understanding of flow patterns and inundation thresholds and adjust releases accordingly.	CMA CMA GMW/MDBA GMW/MDBA CMA		Static
NOGB2020-13	Reputational	Public land and/or access routes into public land areas may be inundated by delivery of environmental water, leading to potential impacts on recreational opportunities for park users (e.g. access to boat ramps, fishing spots, firewood collection etc.).	Almost certain	Moderate	High	• Watering proposals to identify potential impacts. communication of planned events, access closures, alternative recreational opportunities and alternative access routes	CMA Land Manager		Static

NOGB2020-14	Reputational	Environmental water delivery results in inundation of roads and recreation areas (e.g. Barmah Forest campsites) during their use, potentially stranding recreational users.	Possible	Moderate	Medium	• Watering proposals to identify potential impacts (e.g. flooding footprint overlaid with key land roads and recreational assets). • Land Managers implement the required management activities prior to and during environmental watering events. This includes: • identification of impacted assets • preparation of resources required (e.g. signage, maintenance of alternative recreational sites) to implement road and campsite closures and to direct users to alternative sites • communication of planned events, access closures and alternative recreational opportunities. • Land managers to seek powers to temporarily close roads without the need for a gazettal process. • Land managers given powers to remove people from affected areas and establish day visitor areas. • Consider rationalisation of road networks to remove unwanted access tracks and improve the standard of retained tracks. **Note that insufficient resources may limit the land manager's ability to implement management activities and hence ability to effectively mitigate the described risk.*	CMA Land Manager		Static
NOGB2020-15	Business Costs	Public land visitor vehicles cause damage to tracks, or to other assets in the surrounding landscape, due to off-road activity (by users going off track to avoid floodwaters) during and after environmental watering	Likely	Moderate	Medium	Land Managers: • implement management activities to prevent access to flooded roadways (e.g. close roads, communicate planned events, install signage) • repair damage during and after environmental watering events • maintain key higher ground tracks to enable alternative access routes during environmental watering. **Note that insufficient resources may limit the land manager's ability to implement management activities and hence ability to effectively mitigate the described risk.*	Land Manager		Static
NOGB2020-16	Legal	Access routes into public land areas may be inundated by delivery of environmental water, leading to potential economic impacts on commercial operators who are unable to undertake activities (includes timber and firewood harvesting, apiarist, tourism operators).	Likely	Moderate	Medium	Communication and advice to commercial operators to alert them of environmental watering, via Land Manager as licensing authority.	Land Manager		Static
NOGB2020-17	Service Delivery	Access routes into public land areas may be inundated by delivery of environmental water, leading to potential impacts on land management and maintenance activities (e.g. fire mgmt. works)	Almost certain	Moderate	High	Early planning and communications of proposed actions with land manager to minimise likelihood of impacts, and scheduling of maintenance works outside of planned delivery periods.	CMA		Static
NOGB2020-20	Environment	Environmental water deliveries may generate or mobilise BGA blooms, with adverse water quality and/or health impacts (including to people, livestock and pets), resulting in cessation of releases and environmental impacts	Possible	Major	Medium	• Consider likelihood of initiating BGA blooms in event planning and amend as required to manage risk. • Land managers or water corporation implement a risk-based monitoring program during environmental watering events, and where issues are identified, activate BGA response processes. **Notes: Parks Victoria are currently writing a BGA risk management plan for Northern Victoria Region that considers the potential risk of environmental water events. This plan will outline proactive and reactive monitoring and management responsibilities that Parks Victoria commits to as a Local Waterway Manager for BGA. Adequate BGA resourcing is being considering as part of this plan.* • Regional monitoring and advice on BGA status.	CMA / GMW Land Manager GMW GMW		Static
NOGB2020-21	Reputational	Environmental water management activities may conflict with or not complement water based recreational objectives, leading to loss of community support for activities.	Almost certain	Moderate	High	• Communicate benefits of environmental water management to the broader community and engage with recreational user peak bodies. • Engage with local recreational user groups to inform them of environmental water management activities and the underlying rationale. • Adjust events or actions to reduce/avoid impact where practical without reducing environmental outcomes. • Communicate alternate recreational opportunities. • Enhance community understanding of water system operations and entitlement frameworks (water literacy).	VEWH CMA CMA Land Manager VEWH		Static
NOGB2020-22	Business Costs	Insufficient resources available (including staff, funding for maintenance of roads, regulators etc.) across partner organisations to deliver all planned environmental watering actions, leading to cancellation or interruptions of deliveries.	Possible	Major	Medium	• Partners notify the CMA and VEWH of resource constraints in advance of deliveries and VEWH convene OAG meetings to consider implications and potential solutions. • Continue to actively prioritise actions to match available resources and ensure key actions are delivered. • Reallocate tasks and available funds to ensure highest priority watering actions are delivered.	VEWH CMA CMA		Static
NOGB2020-24	Legal	Failure to recognise cultural heritage issues at a site targeted for watering may result in necessary permits and approvals not being obtained, leading to prosecution and fines.	Possible	Moderate	Medium	• Undertake desktop reviews and site assessments with archaeologists, traditional owners and land managers, to identify approval needs and contingency measures. • Obtain any necessary formal approvals/permits and implement required actions.	CMA		Dynamic
NOGB2020-26	Reputational	Inability to demonstrate outcomes achieved through environmental watering activities may lead to a loss of public/political support for activities	Possible	Major	Medium	• Rationalise and refocus current monitoring programs (e.g. Wetmap) to better identifying outcomes. • Seek additional funds to address gaps in monitoring programs and knowledge. • Communicate the benefits of environmental watering and monitoring results (Note: It may not be possible/affordable to address all monitoring gaps, so this risk may still be rated as medium after mitigation actions.)	DELWP VEWH CMA	Medium	Static

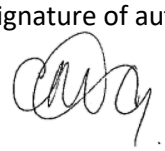
NOGB2020-27	Environment	Environmental deliveries improve conditions for non-native species (e.g. carp, invasive species, feral horses) and over-abundant native species (e.g. kangaroos, Red Gum encroachment) leading to adverse environmental impacts.	Likely	Moderate	Medium	• Study/understand life history of species and develop high level management strategies. • Develop and implement site specific management strategies aimed at eradication/control of existing populations (e.g. carp management strategy, willow removal program, water-lily spraying program, feral animal programs). - Implement pest reduction efforts prior to delivery of water, to ensure increases in populations remain within "tolerable" levels *(Note: This risk is still rated as **medium** after mitigation actions.)*	DELWP CMA/Land Manager	Medium	Static
NOGB2020-28	Environment	Environmental watering actions trigger non-targeted environmental responses (e.g. bird breeding) causing unintended consequences (or lost opportunities) for other environmental values.	Likely	Moderate	Medium	• Undertake monitoring and communicate these issues as they arise and apply adaptive management and review of delivery plans. • Consider including contingency allowance in delivery plan water volumes to complete breeding events.	CMA		Dynamic
NOGB2020-32	Reputational	Sections of the community perceives (incorrectly) that high river flows are due to environmental releases in dry conditions, leading to a loss of support for watering activities.	Possible	Moderate	Medium	• Communications to inform the community on the drivers/reasons for high flows in river systems, especially under dry scenarios	System operator & CMA		Dynamic
NOGB2020-34	Reputational	Under dry conditions, community expectations of the extent of environmental watering that can be achieved are not met, leading to a loss of support for environmental watering actions. Note - e-water deliveries may be constrained in 22-23 due to high consumptive avail.	Possible	Moderate	Medium	• Communications to inform the community on the limits of environmental water holdings and the extent of actions possible under dry conditions. *Note that public concern in this regard may be heightened as a result of the Menindee 2019 fish death events.*	CMA		Dynamic
NOGB2021-41	Safety	Negative community sentiment in relation to government decisions/actions creates a safety risk for staff involved in environmental watering actions **This is state wide risk, but may not apply in all systems - the risk rating will reflect local risk levels*	Possible	Moderate	Medium	- ensure staff are alerted to warnings about violent members of public - Strategic Communication of benefits of e-water and concern over safety to wider public (with co-ordination between partners) - ensure safe operational procedures for staff are followed	All		Static
NOGO2022-42	Reputational	Watering wetlands in wetter conditions leads to community concern over incr. flood risk resulting in loss of support for environmental watering program. Note: especially for Loch Garry flood protection district	Possible	Moderate	Medium	- communicate results of modelling to d/s landholders demonstrating low impacts - notification of planned delivery events to landholders - staged trial flows with increasing flows over several years to enable monitoring and assessment of outcomes	CMA		Dynamic
NOGO2022-44	Environment	High operational and consumptive water demands lead to reduced access for environmental deliveries, with the result that target flows/volumes cannot be achieved, impacting on environmental outcomes Note: Consumptive water en route may achieve some outcomes in Goulb, but limiting e-water from the Goulburn has d/s implications for environmental outcomes at downstream Victorian sites in the Murray system, as well as the Murray River and Lower Lakes	Likely	Moderate	Medium	• Event planning will seek to avoid peak demand periods, and events will be monitored and adjusted as necessary. - Ensure SCBEWC multi-site planning includes operational demands in its planning for downstream sites • System operators to provide longer term forecasts for future consumptive demands as an input to planning watering proposals • Develop longer term agreements on river capacity access for environmental deliveries.	CMA and GMW VEWH GMW/MDBA VEWH		Dynamic

Approval

I, Chris Cumming, the authorised representative of the agency shown below, approve the Seasonal Watering Proposal for the Goulburn River 2022-23.

SIGNED FOR AND ON BEHALF OF Goulburn Broken Catchment Management Authority

Signature of authorised representative



Name of authorised representative

Chris Cumming (CEO)

Date: 13 April 2022

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Appendix 1:Historic and current ecological objectives for the Goulburn River for reaches one to five

Flow Component	Ecological Value	Ecological Objectives	Functional Watering Objectives	Season	Flow (ML/day)					Report
					Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	
Baseflow	Macroinvertebrates Vegetation Native fish	Wet and maintain riffles for macroinvertebrates and small bodied fish, maintain wetted perimeter and aquatic vegetation	• scour fine sediment from gravel bed and riffle substrate • maintain existing beds of in channel vegetation	All	Minimum of 400 or natural	Minimum of 500 or natural	Minimum of 800 or natural	N/A	N/A	2014
Baseflow	Native fish	Provide suitable in channel habitat for all life stages.	Provide slow shallow habitat required for larvae/juvenile recruitment and adult habitat for small bodied fish	All	N/A	N/A	N/A	400	540	2007
			Provide deep water habitat for large bodied fish (depth of 2m)	All	N/A	N/A	N/A	800	800	2018 (Cottingham et al)
Baseflow	Macroinvertebrates	Provide food and habitat for macroinvertebrates including suitable water quality	Entrainment of litter packs available as food/habitat source for macroinvertebrates	All	N/A	N/A	N/A	540	770	2007
Baseflow	Macroinvertebrates	Provide habitat and food source for macroinvertebrates by submerging snag habitat within the euphotic zone	• provide conditions suitable for aquatic vegetation • provide slackwater habitat favourable for planktonic production (food source) for macroinvertebrates	All	N/A	N/A	N/A	830	940	2007

Flow Component	Ecological Value	Ecological Objectives	Functional Watering Objectives	Season	Flow (ML/day)					Report
					Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	
			• entrain litter packs as food source for macroinvertebrates • maintain water quality suitable for macroinvertebrates							
			• provision of conditions suitable for establishment of aquatic vegetation (for macroinvertebrate habitat) • provide slackwater habitat favourable for planktonic production (food source) for macroinvertebrates	Summer (30 – 40 days)	N/A	N/A	N/A	1,500	NA	2007
Baseflow	Littoral vegetation	Maintain, for more than one season, a littoral fringe of emergent or amphibious plants	Provision of habitat for macroinvertebrates and small bodied fish. Provide bank stability	Late spring/summer	N/A	N/A	N/A	Flows should not exceed 1,000 ML/day for 5-6 weeks	Flows should not exceed 1,000 ML/day for 5-6 weeks	2018 (Roberts)
Baseflow/ fresh	Geomorphology	Maintain pool depth especially from unseasonal events that fill pools but do not flush them	Maintenance of water quality suitable for macroinvertebrates	Summer < 90 days	N/A	N/A	N/A	856 – 6,590 (variable flow rates based on length of delivery time)	1096 – 6,060 (variable flow rates based on length of delivery time)	2007
Baseflow/fresh	Lower to mid vegetation	Maintain a zone with viable (patchy but persistent) perennial herbs or		Spring/summer/ autumn				Maximum continuous duration for P. prostrata is 50 days; maximum continuous duration for A. denticulata is 70 days		2018 (Cottingham et al)

Flow Component	Ecological Value	Ecological Objectives	Functional Watering Objectives	Season	Flow (ML/day)					Report
					Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	
		graminoids on mid to lower river bank						Shorter duration of inundation is acceptable, but a longer duration is risky		
Freshes	Littoral vegetation	Maintain, for more than one season, a littoral fringe of emergent or amphibious plants. Recommended frequency is every 1 in 2-4 years	Provision of habitat for macroinvertebrates and small bodied fish. Provide bank stability	Summer autumn	N/A	N/A	N/A	Flows should not exceed 1,000 ML/day for more than 20 consecutive days, with a minimum of 7 days between pulses	Flows should not exceed 1,000 ML/day for more than 20 consecutive days, with a minimum of 7 days between pulses	2018 (Roberts)
Fresh	In channel habitat Macroinvertebrate	Scour fine sediments from riffle surfaces to maintain invertebrate habitat Maintain habitat for macrophytes	• macroinvertebrates provide food source for fish • mobilise sediments	Winter Spring	900 1 day					2014
Fresh	Macroinvertebrates Native fish	Sloughing filamentous algae and refreshing biofilms Maintain areas of riffle habitat	Increase flow variability to more closely mimic natural hydrological regime	Summer Autumn Winter Spring	2,500 5-7 days 2 per year	2,500-3,500 5-7 days 2 per year	2,500-3,500 5-7 days 2 per year			2014
Fresh	Native fish	Provide flows to promote large bodied endangered species colonisation	Promote Macquarie perch spawning	Spring			0.5m increase in stage height over one week			2014

Flow Component	Ecological Value	Ecological Objectives	Functional Watering Objectives	Season	Flow (ML/day)					Report
					Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	
Fresh	Native fish	Provide cues for spawning and migration for flood specialist native fish	Maintain macroinvertebrate habitat (e.g. snags) by mobilising fine sediments and biofilms, replenishing slackwater habitat	Winter Spring				5,000 – 7,000 Up to 14 days (winter/ spring)	5,000 – 7,000 Up to 14 days (winter/ spring)	2018 (Cottingham et al)
Fresh	Native fish	Initiate spawning, pre-spawning migrations and recruitment of native fish	Maintain aquatic macrophytes, macroinvertebrate and fish habitat (e.g. snags) by mobilising fine sediments, replenishing slackwater habitat	Summer	NA	NA	NA	2-4 days (summer/ autumn)	2-4 days (summer/ autumn)	2010
Fresh	Riparian vegetation	Remove terrestrial vegetation and re-establish amphibious vegetation	Provide carbon (e.g. leaf litter) to the channel, inundate bench habitats to encourage germination	Winter Spring Summer/ Autumn				6,600 ML/day 14 days (winter/ spring) 2-4 days summer/ autumn 1 – 4 events	6,600 ML/day 14 days (winter/ spring) 2-4 days summer/ autumn 1 – 4 events	2010
Bankfull	Geomorphology	Maintain channel form and key habitats (including in channel benches)		Winter Spring	7,000-9,000 2 days					2014
Bankfull	Geomorphology / habitat diversity Native Fish Riparian vegetation Macroinvertebrates	Maintain bed diversity Provide flows to increase native fish recruitment and colonisation Provide periodic regeneration	• overturn bed substrate • maintain channel form and key habitats • maintain riffle habitat for macroinvertebrates	Winter Spring	11,000 1-4 days	11,000 1-4 days	12,000 – 13,000 2 days			2014

Flow Component	Ecological Value	Ecological Objectives	Functional Watering Objectives	Season	Flow (ML/day)					Report
					Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	
		opportunities for native riparian species Retain natural seasonality for macroinvertebrate life stages	• maintain or increase connection to warmer water • maintain channel connectivity to tributaries							
Bankfull	Geomorphology Native fish Native vegetation	Maintain bed diversity Provide periodic opportunities for regeneration of riparian and floodplain species and improve in channel carbon availability Retain natural seasonality to ensure synchronicity of life cycle of macroinvertebrates	• overturn of bed substrate • scour sediments from base of pools to maintain quantity and quality of habitat • maintain channel and inlet for connectivity to main channel with floodplain and wetlands • promote colonisation by large bodied endangered species provision of lateral connectivity for habitat and production	Spring and Autumn			14,000 1-4 days			2014
Overbank	Geomorphology Native fish Riparian vegetation Macroinvertebrates	Maintain channel form Maintain connectivity to floodplain and wetlands Provide floodplain connection for	• maintain diversity among low lying wetlands • promote colonisation by large bodied endangered species	Winter Spring	15,000 - 20,000 1-4 days	15,000 – 20,000 1-4 days	15,000 - 20,000 1-4 days			2014

Flow Component	Ecological Value	Ecological Objectives	Functional Watering Objectives	Season	Flow (ML/day)					Report
					Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	
		exchange of organic matter Provide periodic regeneration opportunities for native floodplain wetland plants	• overturn of bed material and maintain benches • improve in channel carbon availability • provide lateral connectivity as habitat and recruitment areas for native fish							
Overbank	Floodplain and wetland vegetation	Increase the extent and diversity of flood dependent vegetation communities	• provide habitat for wetland specialist fish • exchange of food and organic material between the floodplain and channel • increase breeding and feeding opportunities for native fish, waterbirds and amphibians	Winter Spring				25,000 5+ days 2-3 events in a year 7-10 event years in10	NA	2011
Overbank	Floodplain and wetland vegetation higher in the landscape	Increase the extent and diversity of flood dependent vegetation communities	• provide habitat for wetland specialist fish • exchange of food and organic material between the floodplain and channel • increase breeding and feeding opportunities for native fish,	Winter Spring				40,000 4+ day 1-2 events in a year 4-6 event years in 10	NA	2011

Flow Component	Ecological Value	Ecological Objectives	Functional Watering Objectives	Season	Flow (ML/day)					Report
					Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	
			waterbirds and amphibians							
Rate of flow rise	Native fish and macroinvertebrates	Reduce displacement of macroinvertebrates and small/juvenile fish		All year	Max rate 2.0 (i.e. 2 times previous days flow) for flows from 1,000-5,000 ML/d 2.7 times previous days flow for flows above 5,000 ML/d	NA	NA	Max rate of 0.38/0.38/ 1.20/0.80 metres river height in summer/ autumn/ winter/ spring	NA	2014 2007
Rate of flow fall	Geomorphology, native fish and macroinvertebrates	Reduce bank slumping/erosion and stranding of macroinvertebrates and small/juvenile fish		All year	Max rate 0.8 of previous days flow	NA	NA	Max rate of 0.15/0.15/ 0.78/0.72 metres river height in summer/ autumn/ winter/ spring	NA	2014 2007
Cease to flow	Wetland vegetation	Maintain appropriate vegetation in low lying connected wetlands		Summer Autumn Winter				150 days with flows below cease to flow levels on an annual or biennial frequency	150 days with flows below cease to flow levels on an annual or biennial frequency	2018