Seasonal Watering Proposal for the Wimmera River System 2021-22

Report prepared for: **Victorian Environmental Water Holder**
Report prepared by: Wimmera CMA
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Wimmera River at Horseshoe Bend, 2020

GLOSSARY

Baseflows: low flows, volumes that constitute a baseflow according to environmental flow recommendations vary depending on the season and achieve objectives around water quality and fish.

Freshes: larger flow events mimicking storm events, volumes that constitute a fresh according to environmental flow recommendations vary depending on the season and achieve objectives around water quality, vegetation diversity and fish.

Bankfull/Overbank: Much higher flows that fill or overtop the river channel in places that typically occur during natural very wet spells that are important for functions like watering riparian vegetation and preventing channel constriction.

Passing flows: portion of inflows that must be released at harvesting infrastructure (Huddleston's Weir, Lake Lonsdale, Fyans Creek, Rocklands Reservoir).

Carryover: unused allocations from the previous water year minus a deduction for evaporation

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Executive summary

Dry conditions again prevailed across the Wimmera for much of 2020-21, with another year of well below average streamflows although brief spells of wet weather in October 2020 and January 2021 did generate streamflows of note. The well below average inflows continue to limit the purpose and magnitude of possible watering actions and ecological outcomes within the region. However the management of environmental water to provide drought refuges and mitigate the risk of blackwater conditions has been vital for the protection of a number of water dependent species across the region.

These achievements include:

- the maintenance of a high value fish and crayfish populations in the MacKenzie River and Burnt Creek after another year of watering targeted at priority refuge pools;
- avoidance of major flow/water quality related incidents after flows in January and February 2021 that created blackwater conditions;
- although many events were cancelled or severely limited due to COVID-19 protocols, there were still several Wimmera River-based events that were able to take place in 2020-21.

This proposal is for the use of available water in the Wimmera Catchment to maximise environmental water related outcomes in 2021-22 to continue to prevent critical losses if the catchment remains dry or enhance conditions if wetter conditions prevail. The proposal focuses on the regulated waterways of the lower Wimmera River, Burnt Creek, MacKenzie River, Bungalally Creek and Mt William Creek. The delivery of environmental water to these waterways is intended to support the environmental assets within these waterways such as riparian vegetation, iconic Freshwater Catfish and Platypus populations, locally vulnerable Southern Pygmy Perch and River Blackfish populations and threatened species such as Glenelg Spiny Crayfish and Western Swamp Crayfish. These waterways also contain many shared benefits including important cultural heritage sites, provide water for agriculture and public open spaces and sustains a variety of recreational activities such as fishing, swimming, boating and camping.

Brief spells of wet weather in October and January helped partially offset yet another very dry year in 2020-21, on a par with 2019-20 and marginally better than the record dry conditions in 2018-19. Natural flows from the upper Wimmera catchment in October/November enabled a postponement of environmental water deliveries until early 2021 for the Wimmera River. High flows for the Wimmera River in January/February created other challenges about using environmental water to help mitigate risks of blackwater conditions. The dry conditions led to allocations for the Victorian Environmental Water Holder entitlement only reaching 57% in March 2021 and so water carried over from earlier years was again vital for achieving outcomes in 2020-21.

This proposal outlines the range of environmental watering actions for the Wimmera River system for the 2021-22 water year. Assuming the dry conditions experienced since 2017 persist, the focus for 2021-22 is again to prevent loss of high value refuge habitat and mitigating water quality declines (especially salinity) and a key to this will be the effective management of drought refuge pools throughout the system. This in turn reduces the likelihood of fish deaths, algal blooms and die back of fringing vegetation. Should conditions be wetter, than the objective is to pursue vegetation and fish recruitment objectives by implementing baseflows and freshes. Fish recruitment objectives are achieved by providing baseflows throughout the year as well as spring/summer freshes to stimulate native fish breeding. They will provide opportunities for movement and increase available habitat, given water for the environment has only been delivered to short sections of these waterways in recent years. Vegetation recruitment objectives are provided by implementing baseflows to maintain edge habitats and freshes to maintain existing plants, promote the establishment of new seed/plants in the growing season and maintain and encourage germination of aquatic plants. For the Wimmera River it is very important to provide regular baseflows and freshes to ensure adequate water quality through keeping salinity and dissolved oxygen concentrations at acceptable levels, particularly in the absence of large flows in recent years that would have mobilised and dispersed large quantities of organic material and salt.

Environmental water will be adaptively managed as environmental conditions unfold throughout the year. Five management scenarios have been developed to cover the range of possible conditions. These scenarios and associated watering actions are outlined in Table 26. A wide variety of shared benefits will be provided by environmental watering actions, including watering for cultural outcomes at The Ranch in Dimboola as well as the recreational activities the Wimmera River provides that lead to enormous positive economic and health outcomes for the region.

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Purple Swamp Hen on the Wimmera River at Horsham, February 2021

1. Introduction

1.1 Background

Environmental entitlements are available to be released from storages when needed and delivered to waterways to protect or enhance their environmental values and condition. They also lead to a number of broader social, cultural and economic benefits as well. In the Wimmera, environmental entitlements are held by the Victorian Environmental Water Holder (VEWH) and the Commonwealth Environmental Water Holder (CEWH). The Wimmera Catchment Management Authority (Wimmera CMA) is responsible for ensuring environmental water is delivered to rivers, streams and wetlands in its region through developing and submitting seasonal watering proposals to the VEWH for consideration and managing the delivery of environmental water in accordance with the VEWH's seasonal watering statements and agreements with the CEWH.

The VEWH prepares a statewide seasonal watering plan each water (financial) year. The plan describes the desired environmental water use for rivers and wetlands across Victoria in the coming year, based on seasonal watering proposals submitted by CMAs and Melbourne Water. The VEWH then prepares seasonal watering statements that authorise CMAs and Melbourne Water to undertake the agreed watering activities. As water availability and seasonal conditions change, the VEWH may prepare additional seasonal watering statements.

Should there be any allocation to the CEWH in 2021-22, a new agreement will need to be developed between Wimmera CMA, CEWH and VEWH around water delivery given the expiry of the original one.

1.2 Purpose

The purpose of the Seasonal Watering Proposal for the Wimmera System is to:

- identify the environmental water requirements of the lower Wimmera River, MacKenzie River, Burnt Creek, Mt William Creek, Bungalally Creek and Dock Lake in the coming year under a range of climatic scenarios to protect or improve their environmental values and health;
- inform the development of environmental water priorities in the VEWH's seasonal watering plan; and
- Inform the development of CEWH plans for its portfolio management in 2021-22.

The proposal is informed by scientific studies and reports that identify the flow regimes required to meet the ecological objectives of the priority waterways. This proposal was prepared in consultation with key stakeholders and partners and has been approved by the Wimmera CMA. It is required under section 192A of the *Water Act 1989*.

1.3 System Overview

Located in western Victoria, the Wimmera River has a total catchment area of 24,011 km^2. Regulated waterways within the Wimmera River catchment include the lower Wimmera River, MacKenzie River, Burnt Creek, Mt William Creek and Bungalally Creek. A proportion of flow in the Wimmera River also flows up the Yarriambiack Creek – a distributary creek. Refer to Figure 1 for the location of these waterways. Stretches of the Wimmera River and MacKenzie Rivers have been reserved as National Park, State Park and Natural Features Reserves. Sections of the lower Wimmera River are listed under the *Heritage Rivers Act* 1992.

These waterways support a diverse and abundant native fish community including Freshwater Catfish, River Blackfish, Southern Pygmy Perch, Australian Smelt, Flat-headed Gudgeon, Common Galaxias, Carp Gudgeon, Obscure Galaxias, Golden Perch and Silver Perch. Occasional captures of Murray Cod and Short-finned Eels have been noted too. The associated floodplain habitats support largely Red Gum-dominated grassy woodland communities, and numerous threatened species of state and national conservation significance. The waterways and associated floodplain habitats also contain many important cultural heritage sites, provide water for agriculture and public open spaces, and support a variety of recreational activities such as fishing and bushwalking. More detail around the Wimmera River system is available in the *Wimmera River System Environmental Water Management Plan* (Wimmera CMA, 2015). This document will be updated through 2021 to incorporate subsequent work on wetlands in the system (Dock Lake and the Terminal Lake system) and improvement linkages with other environmental water planning documents.

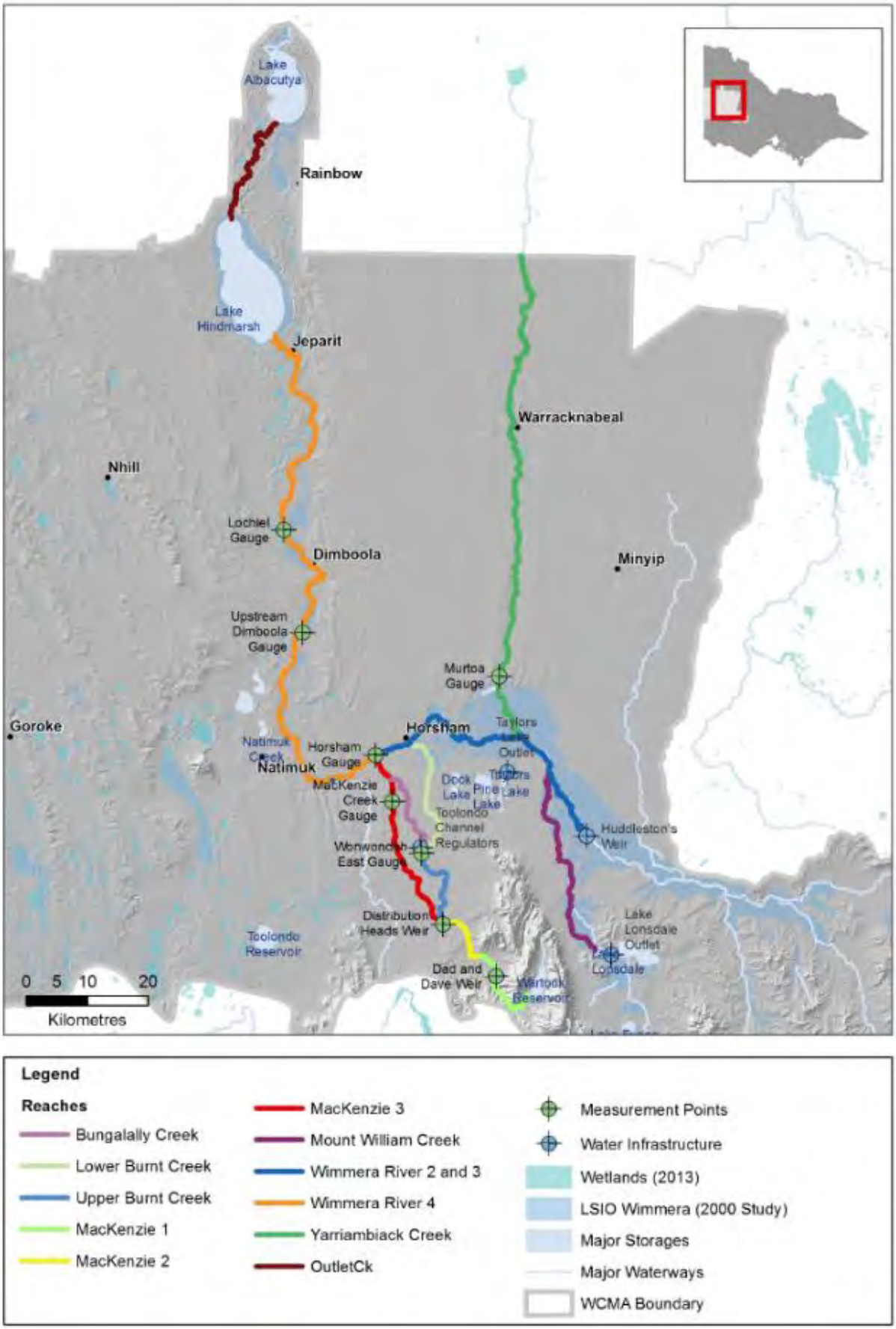


Figure 1. Wimmera system reaches, measurement points and target locations.

1.4 Flow Regime

The Wimmera River, MacKenzie River, Burnt Creek, lower Mt William Creek and Bungalally Creek have been regulated for decades, significantly altering their flow regimes. Under natural conditions these waterways would have received much greater flows, particularly during winter/spring. They have been further modified due to processes like channel incision, infilling of deep pools with sediment and dryland salinity which means that releasing environmental water is vital for retaining their values. More detail around the flow regime and characteristics for these waterways is available in the *Wimmera River System Environmental Water Management Plan* (Wimmera CMA, 2015).

1.5 Priority reaches and measuring points

Environmental flow recommendations for waterways in the Wimmera Catchment were initially developed in 2003. They were revised in 2013 to provide more relevant environmental objectives that were endorsed by a community advisory group and considered new knowledge obtained after drought and floods and the completion of the Wimmera Mallee Pipeline Project (Table 1). These recommendations also included adaptable components based on different climatic conditions (drought, dry, average and wet). Flow recommendations for upper Mt William Creek are based on work completed in 2005 (SKM 2005). To facilitate the flow volume determination, process the waterways were divided into reaches with similar channel morphology, flow regimes and ecological values (Figure 1). Refer to the table below for the priority waterway reaches, compliance monitoring points, flow recommendations and report references.

Table 1. Summary of waterway reaches, compliance points and flow study reference.

Waterway reach	Compliance point	Key ecological values identified	FLOWS Study
Lower Wimmera River Reach 2	Horsham 415200	Contains a self-sustaining population of Freshwater Catfish. Golden Perch and Silver Perch are also present (stocked). High quality macroinvertebrate population within well-vegetated sections. Supports abundant native fish, waterbirds, turtle, frog and rakali populations.	Alluvium 2013
Lower Wimmera River Reach 3			Alluvium 2013
Lower Wimmera River Reach 4	Lochiel Railway Bridge 415246		Alluvium 2013
Lower Burnt Creek	No current compliance point	Contains sections of valuable riparian vegetation which provides important habitat connectivity for terrestrial and aquatic species. Recent fish monitoring indicates that high value fish species are present which warrants a review of management objectives and flow recommendations.	Alluvium 2013
Upper Burnt Creek	East Wonwondah 415223	Very high variety and proportion of native fish including River Blackfish, Southern Pygmy Perch, Obscure Galaxias. Key location for Southern Pygmy Perch and Obscure Galaxias breeding. Contain a regionally vulnerable Western Swamp Crayfish population. High quality macroinvertebrate population within well vegetation sections.	Alluvium 2013
Upper Mt William Creek	None applicable	Very high proportion of native fish including River Blackfish, Southern Pygmy Perch, Obscure Galaxias. Key location for breeding Southern Pygmy Perch, River Blackfish and Obscure Galaxias. Contain a regionally vulnerable Western Swamp Crayfish population (Ecology Australia, 2017b). Good quality vegetation within National park boundaries with remnant vegetation along the rest of the waterway.	SKM 2005
Lower Mt William Creek	Lake Lonsdale tail gauge 415203		Alluvium 2013
Bungalally Creek	No current compliance point	Contains sections of valuable riparian vegetation which provides important habitat connectivity for terrestrial and aquatic species.	Alluvium 2013
MacKenzie River Reach 1	No current compliance points	Regionally valuable Platypus population which has shown evidence of breeding. Very high proportion of native fish including River Blackfish, Southern Pygmy Perch and Obscure Galaxias. Contain a regionally vulnerable Glenelg Spiny Crayfish population (Ecology Australia, 2017b). Good quality vegetation within national park boundaries with remnant vegetation along the rest of the waterway. Excellent quality macroinvertebrate population.	Alluvium 2013
MacKenzie River Reach 2			
MacKenzie River Reach 3	McKenzie Creek Reserve 415251	Contains sections of valuable riparian vegetation which provides important habitat connectivity for terrestrial and aquatic species. Also contains good populations of Obscure Galaxias and Southern Pygmy Perch when it contains water.	Alluvium 2013

1.7 Water sources

Water available for use in the lower Wimmera River, MacKenzie River, Burnt Creek, Mt William Creek and Bungalally Creek include:

- regulated environmental entitlements held by the VEWH and the CEWH
- unregulated flows; and
- passing flow requirements as detailed in Table 1 in Schedule 1 of the *Wimmera and Glenelg Rivers Environmental Entitlement.*

Forecasts for regulated water availability in comparison to priority watering actions are included in Table 2. In addition to these sources there are periodic transfers between headworks storages which provide environmental benefits.

Table 2. Environmental water volumes required for priority watering actions and forecast allocations for 2021/22 water year under a range of climatic scenarios.

WIMMERA REGULATED WATERWAYS Inflow Probability of Exceedance (likelihood of inflows being more than % indicated)	EXTREME DROUGHT 95%	VERY DRY 90%	DRY 75%	AVERAGE 50%	WET 20%
Environmental water indicated as available to deliver Tier 1a priority watering actions (ML) for the Wimmera System	6,700	7,727	11,718	16,113	18,980
Forecast carryover (ML) to share between the Wimmera and Glenelg Systems	21,400				
Current forecast environmental allocation (ML) for the Wimmera and Glenelg Systems in October 2021 (not including Glenelg compensation flow)	0	4,056	17,035	30,826	40,560

2. Engagement

In developing this proposal, consultation with key stakeholders is summarised in Table 3. In addition to consultation listed in Table 3 the Wimmera CMA have had regular discussions with stakeholders and community members including recreational users during the implementation of water releases.

Day-to-day environmental release operations are communicated to the public via a registered SMS service. Quarterly media updates have been published in local newspapers, on the Wimmera CMA website and on social media to update the community regarding environmental releases planned and delivered, fish and vegetation survey results and water quality results. Examples of media updates developed are included in Appendix 1.

COVID-19 has altered the way Wimmera CMA engaged with community members and stakeholders in 2020-21 and limited opportunities for more 'traditional' engagement whether via meetings or printed and social media. The results were mixed, with the opportunity to reach stakeholders more at the periphery of the environmental watering program a pleasing outcome but the inability to continue the dialogue with key stakeholders and community members in a face to face format was less than ideal. Examples include:

- Instead of the annual Environmental Water Management Forum (usually held in August/September in Dimboola or Horsham) Wimmera CMA sent letters to invitees outlining plans for 2020-21 and seeking feedback to inform future watering events (i.e. 2021-22);
- Meetings with environmental watering partners like Barengi Gadjin Land Council, GWMWater and Parks Victoria transitioned to online formats such as Microsoft Teams; and
- A short animated film clip was produced in August that featured Mallee the Mighty Mussel that highlighted the amazing lifecycles of Freshwater Mussels. It emphasised the link between flows in the Wimmera River and the health of the local mussel population which in turn provide a valuable ecological and water quality function. The concept and animation was developed by Wimmera CMA staff member Tracey Rigney and Dimboola-based animator Desiree Cross and is planned to be part of a series of informative and engaging clips involving Mallee.

Table 3. Consultation undertaken regarding environmental water management for the Wimmera River System.

Who		IAP2 Engagement	Purpose of consultation	Form and timing of consultation	Issues identified/comments
Wimmera CMA	Wimmera CMA Board	NA	Informing the Board regarding actions and communication approaches.	Monthly updates of EWR actions in Board reports. Review and approve draft Seasonal Watering Proposal	Nil
Program Partners	VEWH	Collaborate	Involve VEWH in development of proposal to assist with aligning document with VEWH requirements	Direct engagement and via formal advisory groups (meetings between Glenelg Hopkins CMA, GWMWater, Wimmera CMA & VEWH, throughout the year such as during Storage Manager Reference Group and Western Rivers Advisory Group).	Discussion of the likely seasonal forecast for environmental water allocation, priority watering actions for a range of environmental allocations and risk management issues.
	Glenelg Hopkins CMA		Justification for water use in Wimmera River system		
	GWMWater		Consult with storage manager to identify operational issues with proposed releases and likely resource availability under different scenarios	Direct engagement and via formal advisory groups. The WCMA are constantly consulting with GWMWater regarding the seasonal outlook, improvements to monitoring and delivery of priority watering actions through the Storage Manager Reference Group, and directly.	It is important to receive feedback on water delivery constraints, planned maintenance and upgrades etc. to inform the proposal.
	DELWP		Communicate environmental monitoring outcomes, research project outcomes and project delivery for a number of projects.	Direct engagement (periodic phone conversations and e-mail updates).	DELWP fund a number of projects associated with environmental water delivery and engagement in the region.
	CEWH		Discuss proposed watering actions that can include CEWH water in the unlikely event that it is available in 2021-22 given dry conditions.		Need to understand local priorities to inform portfolio management and determine outcomes of watering activities.
	MDBA	Consult	Highlight risks and outcomes associated with environmental watering		Understanding local conditions helpd with reporting/information at a MDB scale (e.g. water quality alerts)
Councils and Agencies	Yarriambiack Shire Council	Consult	Discuss likely flow regimes for the Wimmera River and the impact this has on the Yarriambiack Creek	Direct engagement and via formal advisory groups. Attend Yarriambiack Creek Advisory Committee meetings.	See Yarriambiack Creek Advisory Committee
	Northern Grampians Shire Council		Outline planned flow regimes for the Mt William Creek	Periodic contact throughout the year and via annual environmental watering forum e.g. e-mails/phone calls around Mt William Creek flows.	The impact of environmental flows on levels in Lake Lonsdale is an ongoing concern to the council.
	Hindmarsh Shire Council	Involve	Work with council to manage weir heights to facilitate events whilst enabling flows to pass downstream and mitigating erosion in the weir pool. Also to communicate proposed environmental watering actions and seasonal outlook in relation to likely environmental water allocation for 2021-22.	Periodic contact throughout the year regarding weir management such as via onsite meetings, e-mails and via annual environmental watering forum. Participation in Wimmera River Stakeholders Advisory Group run by Hindmarsh Shire.	Councils are very interested in environmental water allocations available and its impact on the region's economy, tourism and the environment. Also weir management for events, maintenance works, erosion issues etc. is an ongoing requirement.
	Horsham Rural City Council (HRCC)				
	Victorian Fisheries Authority	Consult	Victorian Fisheries Authority are interested in environmental watering activities to inform fish stocking and population dynamics.	Periodic contact throughout the year and via annual environmental watering forum.	Useful to share information on fish population responses
	Parks Victoria		Parks Victoria are interested in monitoring outcomes and flows relating to land they manage in the Grampians and the Wimmera Heritage River sections.	Periodic contact throughout the year and via annual environmental watering forum.	Further consultation with local PV staff will help identify opportunities around complementary onground works and enhance their understand of the environmental watering process.
Environmental Groups	Yarriambiack Creek Advisory Committee	Consult	Discuss likely flow regimes for the Wimmera River and the impact this has on the Yarriambiack Creek	Direct engagement and via formal advisory groups. Attend Yarriambiack Creek Advisory Committee meetings.	The committee are interested in the role of structures (e.g. bridges, culverts) on flows along the creek.
	Friends of Bungalally and Burnt Creek Group		Consult with members of the group in relation to flows for Bungalally Creek and Burnt Creek.	Direct engagement. Periodic discussions with group members and attend meetings throughout the year when requested.	Keen to see more flows along the Bungalally and Burnt Creek. Timing of lower Burnt Creek flows to fill pools is important given low water availability in Lake Wartook.
Recreational users	Lake Lonsdale Action Group	Consult	Discuss impact of releases on storage levels with respect to recreation, water quality etc.	Direct engagement and via environmental watering forum. Regular discussions with members and attend meetings throughout the year when requested.	The Lake Lonsdale Action Group want to ensure that environmental water is supplied by a series of storages to share the impacts on water levels. Should conditions remain dry very little to no water will be able to be sourced from Lake Lonsdale.
	Field and Game		Communicate proposed environmental watering actions and seasonal outlook in relation to likely environmental water allocation for 2021/22 next watering year.	Contacted Natimuk Field and Game via e-mail with offer to review draft seasonal watering proposal	NA
	VRFish			Invite to attend annual environmental watering forum.	Interested in fish outcomes from ongoing environmental watering
	Natimuk Lake Water Ski Club			Periodic contact throughout the year and via annual environmental watering forum.	In past years Wimmera CMA has worked with HRCC to maximised weir pool levels in Horsham for ski events that were followed by releasing additional water from the weir pool.
	Dimboola Water Ski Club			Periodic contact throughout the year and via annual environmental watering forum.	Ski club has been undertaking revegetation works to reduce erosion impacts of water skiing. Management of the weir pool level as been important in allowing vegetation to establish. Also the water levels in Dimboola Weir Pool are important for the Peter Taylor Memorial Compeititon.
	Dimboola Fishing Classic			Periodic contact throughout the year and via annual environmental watering forum.	Flows will help the event's appeal should it go ahead in 2021.
	Horsham Triathlon Committee			Periodic contact throughout the year and via annual environmental watering forum.	Future of this event is uncertain due to a lack of volunteer capacity to organise it.
	Wimmera Anglers' Association			Periodic contact throughout the year and via annual environmental watering forum.	Infrequent discussions occur to share information in particular around instream woody habitat and water levels
	Dimboola Rowing Club			Periodic contact throughout the year and via annual environmental watering forum.	Infrequent discussions occur to share information around planned flows for November regatta.
	Jeparit Anglers' Club			Periodic contact throughout the year, including phone calls, e-mails and via annual environmental watering forum.	Feedback has been that conditions are fine for the Easter competition to go ahead in 2021.

Who		IAP2 Engagement	Purpose of consultation	Form and timing of consultation	Issues identified/comments
	Hindmarsh Ski Club			Invitation to annual environmental watering forum.	Club appears to be in recess given low water levels in Wimmera River and Lake Hindmarsh is dry.
	Horsham Fishing Competition Committee		Water level remain stable in the lead up to the event to remove misconception that environmental flows affect the number of fish caught at the competition	Periodic contact throughout the year, including phone calls, e-mails and via annual environmental watering forum.	Kept committee informed regarding the impact of natural and environmental flows in February on water quality in weir pool.
	Canoeing Victoria		Highlight the value of the Wimmera River for potential canoeing events given the positive impact of environmental watering on water levels.	Periodic contact via e-mail	There have been annual kayak/canoe guide training/accreditation sessions held in the Wimmera River at Horsham
Traditional Owners	Barengi Gadjin Land Council	Collaborate	Consult with the council regarding environmental water delivery and communicate likely deliveries for next season and next watering year. Obtain information around cultural values where available.	Online meetings with BGLC staff to discuss plans and contact throughout the year as part of the Ranch Billabong Project Committee and via annual environmental watering forum. Fortnightly meetings about BGLC and CMA shared interests.	Supportive of the continuation of actions seen in 2020-21 continuting in 2021-22. Timing of Ranch Billabong watering to consider need for onground works at the site (weed control and track construction).
Landholders/ farmers	Wimmera community members, especially landholders and stock and domestic water users	Inform	Consult with community on environmental water delivery, particularly of those from storages with high recreational value, and communicate likely deliveries for next season and next watering year. Raise community awareness regarding environmental water releases.	Media releases and advertisements have been published in local newspapers and on our web site.	Important to give the community knowledge of what environmental flows are being delivered, environmental benefits recorded and provide an opportunity for discussion and feedback.
			Inform community (especially landholders) around flows and changes to flow rates.	Direct engagement on flow changes via SMS or indirect via CMA webpage	Some landholders appreciate being notified of flows being released to inform stock movement. Anglers appreciate updates around freshes given they have noted fish are more active when freshes occur. Stock and domestic water users are affected by low water levels with pump priming issues.

The Wimmera CMA supports the Horsham Fishing Comp in a number of ways, through managing environmental water to enhance fishing opportunities at the event, sponsoring the carp prizes and enabling vehicles to be used for event stewarding. It also supports other events like the Jeparit Fishing Competition.

There is also ongoing engagement with stakeholders (e.g. local government and fishing competition committees) about environmental flows where relevant. It should also be noted that Wimmera CMA participates in a number of groups and committees that provide an opportunity to exchange information around environmental watering actions and outcomes. They include the Yarriambiack Creek Advisory Committee (Yarriambiack Shire), Ranch Billabong Project Committee (Barengi Gadjin Land Council), Irrigation Diverters' Committee (GWMWater) and Wimmera River Stakeholders Advisory Group (Hindmarsh Shire).

Mallee the Mighty Mussel talks about how mussels are important for filtering the water and how they need environmental flows to survive (https://www.youtube.com/watch?v=ixr6Loqocxc)

3. Shared Benefits

3.1 Aboriginal Cultural Values and Uses of Waterways

July 2020, saw the completion of the *Maximising cultural benefits and Aboriginal community outcomes from managing water in the environment in the lower Wimmera River* (RMCG, 2020) which reviewed environmental water actions like the watering of Ranch Billabong as well as other initiatives such as the *River Yarns* Aboriginal Waterway Assessments of the lower Wimmera River. It documented the positive outcomes associated with these actions as well as providing recommendations to enhance them further, such as including clearer links to objectives related to cultural benefits and Aboriginal community outcomes as well as improved monitoring, evaluation and reporting to show if and how these objectives are being achieved. Wimmera CMA is keen to work with Barengi Gadjin Land Council (BGLC) to implement these recommendations.

The Ranch Billabong near Dimboola continues to be an example of being able to enhance aboriginal cultural and environmental values (Table 4). The site is managed by BGLC on behalf of the Wotjobaluk people and listed as a significant place in their Country Plan, *Growing What is Good* (BGLC, 2017) which represents the views of a wide cross-section of the Wotjobaluk Traditional Owner community. The billabong is currently connected to the Wimmera River channel by a road culvert constructed by Hindmarsh Shire Council (Walker 2017). The culvert is very high up on the riverbank would only be able to receive flows when the Wimmera River is in flood. The Country Plan lists as priority goals restoring a natural flooding regime to the billabong system and restoring indigenous plant and animal habitats, with particularly attention to controlling priority weeds (BGLC, 2017).

Watering events have taken place at the Ranch Billabong in December 2018, March and October 2019 and June 2020. The enhancements to the site's condition (improved water quality and vegetation condition) links with the aspirations of Traditional Owners to increase the site's amenity and accessibility via the construction

of walking tracks and boardwalks. This will enable it to be more suitable for gatherings and events such as earth oven and bark canoe re-creations (Ben Muir, Wimmera CMA, *pers. comm.*). It is anticipated that these works will take place from March-June 2021 so watering of the billabong is on hold until these and other works (such as weed control) are completed, given the lower water levels improve accessibility (Daniel Clarke, BGLC, *pers. comm.*) and Wimmera CMA will liaise closely with BGLC around the delivery of water to the billabong.

It should also be emphasised that the whole waterway system in the Wimmera is important to the Wotjobaluk people, being valued in its entirety with heritage values existing through the environment. Furthermore, Native Title is held along much of the lower Wimmera River, the first successful claim in Victoria, reinforcing the significance of these values.

Table 4. Traditional Owner Values and Uses

River/Wetland	Values/uses/objectives/opportunities	How will this opportunity be considered in environmental watering in 2021-22?
Ranch Billabong	This site is managed by BGLC and the enhanced condition of the billabong will support the site's use for gatherings and other events as well as tie in with other onground works to improve the billabong's accessibility and condition. It will support contemporary cultural events, such as the Wotjobaluk Cultural Festival by improving water quality and amenity at this site during this event Water will supporting the health of a culturally significant site and some valued species, such as Old Man Weed/Sneezeweed.	There is an explicit priority watering action to supply water to the Ranch Billabong.
Other waterways	All waterways are important to the Wotjobaluk people with heritage values existing with the environment.	Environmental watering is intended to maintain and improve the condition of the environmental values of these waterways.

3.2 Social, Recreational and Economic Values and Uses of Waterways

The COVID-19 pandemic decimated the busy calendar of events centred around the Wimmera River in 2020. The Horsham Fishing Competition, held on the March Labour Day Weekend took place successfully just before conditions came into force prohibiting public events to contain the spread of COVID-19. However the Jeparit Easter Fishing Competition was unfortunately forced to cancel their event and instead conducted the world's first and perhaps only virtual fishing competition where participants (who were required to isolate) submitted short video clips of them 'fishing' in their homes or backyards.

The Peter Taylor Memorial Barefoot Water Ski Tournament was also cancelled that was scheduled for Dimboola Weir Pool in late March and forecasted to attract 1800 spectators and generate $280,000 for Dimboola (Lawson, 2019). It was intended that it would serve as the lead in event to the IWWF World Barefoot Waterski Championships in Sydney in April. Border restrictions between South Australia and Victoria that prevented the entry of many competitors and spectators left organisers with no choice but to cancel it. The Dimboola Fishing Classic and Rowing Regatta as well as Horsham Triathlon were cancelled and the modified Kannamaroo Festival was not able to incorporate river-based activities.

With the decreasing prevalence of COVID-19 within the community in early 2021, river-based events started to return to the Wimmera calendar. The 2021 Horsham Fishing Competition took place on the 7th March with a cap on numbers of 1000 entrants and new protocols around event logistics. The Jeparit Easter Fishing Competition is also planned to take place in April. After a hiatus of 10 months, the Wimmera River Parkrun in Horsham restarted in January, with typically 90-120 participants of all ages and abilities enjoying exercise along the Wimmera River on Saturday mornings.

Whilst the community events calendar was heavily impacted, Wimmera waterways provided other benefits during the COVID-19 lockdown. With people confined to their houses except for essential reasons and for exercise, the Wimmera River became a hub of activity with people taking advantage of the great access via the tracks along the Wimmera River at Horsham, Dimboola and Jeparit. In Horsham, during November 2020 new tracks and water regulators at Langlands Anabranch were officially opened which enabled people to access the southern bank of the Wimmera River between Horsham Weir and ANZAC Bridge and created additional wetland habitat.

The Wimmera River continues to be a focus of enhancements to the Wimmera Southern Mallee's visitor economy, a key priority of the Wimmera Southern Mallee Regional Partnership, co-ordinated by Regional Development Victoria. Horsham Rural City Council has commenced activating the Wimmera River frontage as it passes through the town through planning and contruction work as part of the City to River project including improved tracks and a water activity playspace. Whilst in Hindmarsh Shire, planning work for the Wimmera River Discovery Trail continues. The trail will start in Dimboola and continue through to Lake Hindmarsh, taking advantage of the large tract of public land that exists along the Wimmera River. At Jeparit, Hindmarsh Shire Council is planning to redevelop the section of the Wimmera River that passes the town's caravan park and recreation reserve which is known as the 'swimming hole' and is currently a steep concete embankment which is in poor condition.

Street Ryan has continued their work capturing the socio-economic benefits of water in the region's waterways in 2019-20 (Street Ryan, 2020) enabling a comparison over the four years since the surveys commenced in 2016-17. However the COVID-19 pandemic affected the approach used and results generated, although this was only a major factor from March to June 2020. Highlights include:

- Out of 282,148 participants using the 27 recreational/environmental water sites across the Wimmera Southern Mallee (-14% on 2018-19), 84,103 were at the Wimmera River at Horsham (-0.5% on 2018-19) and 22,463 were at the Wimmera River at Dimboola (-6% on 2018-19). These sites continue to have the highest and third highest number of participants in the region;
- Estimated expenditure for locations on the Wimmera River was $1.34 million, a decrease of 16% on 2018-19;
- Overnight visitors to the Wimmera River at Horsham, Dimboola and Jeparit contributed an average of $41, $39 and $24 per night respectively. For day visitors these figures were $22, $15 and $13. These figures are showing steady improvements year on year, emphasising the economic benefits the enhanced appeal and activation of these sites are having.
- Physical and mental health benefits are estimated to total of just over $4 million across the 27 sites, of which the three sites on the Wimmera River at Jeparit, Horsham and Dimboola contributed a large proportion.
- The Wimmera Southern Mallee faces a number of challenges around entrenched socio-economic disadvantage and these sites are located within the bottom third of disadvantaged 'suburbs' in Victoria. Therefore economic outcomes generated in this part of Victoria will be proportionally more beneficial than for other, more affluent areas.

Regulator and walking track at Langlands Anabranch – November 2020

The Wimmera CMA will continue to actively support community events including the ones listed previously by consulting with local community groups around environmental water releases and where possible supporting them with environmental water releases where this aligns with environmental objectives and environmental outcomes are not compromised (Table 3). The benefits for the community along the Wimmera River system since the return of regular flows in 2010 have been enormous through increased recreation opportunities and tourism as well as the sense of wellbeing that comes through seeing water in a waterway and the life it brings. There is also strong alignment with the Our Catchments, Our Communities program with community values from environmental water being enhanced by improved facilities at Horsham and Dimboola Weir pools (new shelters/rowing pontoons/fish habitat/erosion control/canoe launches). Other waterways (MacKenzie River, Burnt Creek, Mt William Creek) are valued for angling opportunities albeit not to the same degree as the Wimmera River. Dadswell's Bridge has a walking track featuring the Mt William Creek. Dock Lake is also a renowned bird watching site when it contains water.

Table 5. Social, Recreational and Economic Shared Benefits Associated with Environmental Water in the Wimmera

River/ Wetland	Beneficiary	Values/uses/ objectives/ opportunities	How will this opportunity be considered in environmental watering in 2021-22?
Wimmera River only	Rowers/ Canoers	The Horsham and Dimboola Weir Pools are the locations of rowing clubs and an annual regatta is held at Dimboola. Training events and school trips using canoes are an annual occurrence at these weir pools.	Provision of environmental water to maintain pool levels and water quality for multiple reasons will also assist the maintenance of weir pool water levels. (Winter/spring baseflows/freshes)
	Walkers/ Runners/ Cyclists	Tracks along the Wimmera River at Horsham, Dimboola and Jeparit are very popular and support events like the Wimmera River Parkrun.	Provision of environmental water to maintain pool levels and water quality for multiple reasons will also assist the aesthetics and appeal of these tracks.
	Waterskiiers	The Dimboola Weir Pool has a waterski club that regularly uses the river for recreation and organises annual competitions. Horsham Weir Pool is also used for waterski demonstrations at the Kannamaroo Fesitival.	Provision of environmental water to maintain pool levels and water quality for multiple reasons will also assist the maintenance of weir pool water levels (including tailoring flows around events that align with environmental outcomes). (Winter/spring baseflows/freshes)
	Visitor Economy	The appeal of the Wimmera River in terms of being a destination for visitors for holidays or events such as fishing competitions is enormous, see Street Ryan (2020).	Provision of environmental water to maintain pool levels and water quality for multiple reasons will support these events (including tailoring flows around events that align with environmental outcomes). (Summer/autumn baseflows and freshes)
All waterways (except Ranch Billabong and Dock Lake)	Landholders with Stock and Domestic and/or Irrigation licenses	There are a number of landholders as well as councils along these waterways who extract water for various purposes such as watering gardens/ovals (subject to licence conditions).	Environmental water deliveries help maintain water quality and levels.
	Anglers	The Wimmera River is a highly valued destination for anglers looking to catch native (and exotic) fish species. Other waterways are not as highly valued but still provide opportunities.	Provision of environmental water to maintain fish communities will enhance angling opportunities. (Summer/autumn baseflows and freshes and winter/spring baseflows/freshes)
Dock Lake	Birdwatchers	The lake is renowned for the waterbird response when it contains water.	There is a priority watering action for Dock Lake for waterbird outcomes.

4. Flow objectives and recommendations

Environmental Objectives

Long-term environmental objectives that form the basis of this proposal are from the *Wimmera River Environmental Flows Study* (Alluvium, 2013). These objectives where identified by the Wimmera CMA at the time in consultation with the Wimmera CMA's Rivers and Streams Advisory Group. The study outlines the flow components that are required to affect the functions and processes that contribute to the over-arching objectives for nominated environmental assets. The *Wimmera River Environmental Flows Study* supersedes the previous information contained within the *Wimmera Bulk Entitlement Conversion – Environmental Flows Study* (SKM, 2003) that had previously been the guiding document for environmental watering in the region.

This study included revised and more relevant environmental objectives that was endorsed by community advisory group members. It considered new knowledge obtained after drought and floods as well as improved understanding of waterway ecology and post-Wimmera Mallee Pipeline system operations to provide a more rigorous and adaptable set of flow recommendations for different climatic conditions (drought, dry, average and wet).

The environmental objectives and flow components for each asset are summarised in Table 6 and outlined in detail in Appendix 2. They are consistent with the *Wimmera River Environmental Flows Study* (Alluvium 2013). The exception is the upper Mt William Creek, which was not part of the scope of that study and have been drawn from a previous report, *Environmental Recommendations for the Mt William Creek* (SKM 2005). The *Wimmera River System Environmental Water Management Plan* (Wimmera CMA, 2015) outlines in more detail the objectives, recommendations and other matters pertaining to environmental water management (e.g. system operation) in the Wimmera. It is currently being reviewed to include improved objectives to link with broader environmental watering documents required under the *Basin Plan*.

Studies providing environmental watering recommendations have also been undertaken for the Wimmera River's terminal lakes system (Jacobs, 2019) and Dock Lake (Jacobs, 2015). These lakes are not normally targeted for regulated environmental water releases but chiefly rely on passing and/or unregulated flows to provide suitable inundation to achieve ecological outcomes although regulated releases are of some value for enhancing terminal lake levels and environmental outcomes (Jacobs, 2014). Although currently there is no capacity to deliver regulated flows to Yarriambiack Creek, a small percentage of flows in the Wimmera River pass into the Yarriambiack Creek. The flow requirements of Yarriambiack Creek can only be met by unregulated and passing flows.

Hydrological data illustrates that environmental water availability is often less than the water needed to deliver recommended flows. It should also be noted that most of the larger flow components (e.g. bankfull and overbank) cannot be delivered through regulated releases in almost all cases (see Section 8 Constraints). Other factors (e.g. prohibitive channel losses and risks around inundation private land) also make these releases unfeasible. Overbank flow recommendations will only be provided by natural events.

Australian Wood Ducks, Wimmera River at Horsham, February 2021

Table 6. Environmental objectives and flow recommendations for Wimmera Catchment rivers/creeks (not terminal lakes).

Waterway	Flow Compon-ent	Ecological Value	Environmental Objective	Ecological Objectives	Flow (ML/day)			
					Reach 1	Reach 2	Reach 3	Reach 4
Wimmera River	Baseflow	Macro-invertebrates	Achieve SEPP compliant macroinvertebrate communities	Provide variable flow during low flow season for macroinvertebrates (over woody debris to increase biofilm abundance as a food source). Flush surface sediments from hard substrates for macroinvertebrates. Maintain edge habitats in deep pools and runs, and shallow water habitat availability for macroinvertebrates.	NA	10-100 ML/d		15-30 ML/d
Wimmera River	Baseflow/ fresh	Native fish	Maintain endemic and recreational fish communities and self-sustaining freshwater catfish population	Maintain self-sustaining Freshwater Catfish population in the Wimmera River. Maintain endemic fish communities (provide freshes Oct-Dec to assist spawning/nesting). Restore endemic fish community diversity and abundance by providing flow variability to maintain water quality and a diversity of habitats. Provide adequate water quality/habitat for fish refuge locations in dry periods. Provide native fish passage. Provide increased flow and variability to support fish movement and diversity of habitat.	NA	10-100 ML/d baseflow 35 – 400 ML/d ML fresh		15-30 ML/d baseflow 70 – 200 ML/d fresh
Wimmera River	Baseflow/ fresh	Vegetation	Maintain healthy and diverse mosaics of water-dependent vegetation	Maintain submerged and emergent aquatic vegetation quality, diversity and extent for fish habitat. Maintain near permanent inundated stream channel for riparian vegetation and to prevent excessive in stream terrestrial growth. Prevent terrestrialisation of the lower banks from invasive *phragmites*.	NA	10-100 ML/d baseflow 35 – 400 ML/d ML fresh		15-30 ML/d baseflow 70 – 200 ML/d fresh
MacKenzie River	Baseflow/ freshes	Platypus	Maintain platypus populations	Sustain a platypus population and facilitate its dispersal into the Wimmera River. Provide flow variability to maintain diversity of habitat.	2-27 ML/d baseflow 5-130 ML/d fresh		10 ML/d (baseflow) 35-190 ML/d (fresh)	NA
MacKenzie River	Baseflow/ freshes	Vegetation	Maintain healthy and diverse mosaics of water-dependent vegetation	Protect and restore riparian and floodplain EVCs. Maintain edge habitats in deeper pools and runs, and shallow water habitat availability. Maintain submerged and emergent aquatic vegetation quality, diversity and extent for fish habitat. Inundate riparian vegetation to maintain condition and facilitate recruitment.. Maintain permanent inundation of stream channel to prevent excessive in stream terrestrial species growth.	2-27 ML/d baseflow 5-130 ML/d fresh		10 ML/d (baseflow) 35-190 ML/d (fresh)	NA
MacKenzie River	Baseflow/ freshes/ bankfull/ overbank	Macro-invertebrates	Achieve SEPP compliant macroinvertebrate communities	Maintain edge habitats in deeper pools and shallow water habitat availability for macroinvertebrates. Provide variable flow (freshes) during low flow season for macroinvertebrates (over wood debris to increase biofilm abundance as a food source). Flush surface sediments from hard substrates to support macroinvertebrates. Entrain organic debris in the channel to support macroinvertebrates.	2-27 ML/d baseflow 5-130 ML/d fresh, 500-900 ML/d bankfull and overbank		10 ML/d baseflow 35-190 ML/d freshes 500-1,000 ML/d bankfull and overbank flows	NA
MacKenzie River	Bankfull/ overbank	Geomorph-ology	Maintain structural integrity of stream bed and channel and prevent loss of channel capacity	Maintain the structural integrity of the channel. Maintains floodplain geomorphic features.	500-900 ML/d bankfull and overbank flows		500-1,000 ML/d bankfull and overbank flows	NA
MacKenzie River	Baseflow/ freshes	Native fish	Maintain endemic fish communities	Increase the baseflow water depth to provide stimulus for fish movement. Provide flow variability to maintain water quality and diversity of fish habitats.	2-27 ML/d baseflow 5-130 ML/d fresh		10 ML/d baseflow 35-190 ML/d fresh	NA
Burnt Creek	Baseflow /freshes/ bankfull/ overbank	Vegetation	Maintain healthy and diverse mosaics of water-dependent vegetation	Inundate riparian vegetation to maintain condition and facilitate recruitment. Maintain edge habitats and shallow water habitats and inundated stream channel for riparian vegetation and prevents excessive instream terrestrial growth.	Upper: 1 ML baseflow, 30-160 ML/d fresh 400 bankfull 1,000ML/d overbank		Lower: 45 ML/d bankfull 90 ML/d overbank	
Burnt Creek	Baseflow /freshes/ bankfull/ overbank	Macroinverteb rates	Achieve SEPP compliant macroinvertebrate communities	Entrain organic debris in the channel to support macroinvertebrates. Maintain edge habitats and shallow water habitats and shallow water habitat availability for fish and macroinvertebrates. Also flushes surface sediments from hard substrates for macroinvertebrates. Disturb the algae/bacteria/organic biofilm present on rock or wood debris to support macroinvertebrate communities.	1 ML baseflow, 30-160 ML/d fresh 400 bankfull 1,000ML/d overbank		45 ML/d bankfull 90 ML/d overbank	
Burnt Creek	Baseflow/ freshes	Native fish and water quality	Maintain endemic fish communities	Maintain edge habitats and shallow water habitats and shallow water habitat availability for fish. Provide variable flow for fish movement and diversity of habitat.	1 ML baseflow, 30-160 ML/d fresh		NA	
Burnt Creek	Bankfull/ overbank	Geomorphic	Maintain structural integrity of stream bed and channel and prevent loss of channel capacity	Maintain structural integrity of channel. Maintains floodplain geomorphic features.	400 bankfull 1,000ML/d overbank		45 ML/d bankfull, 90 ML/d overbank	
Mt William Creek	Baseflow/ freshes/ bankfull/ overbank	Geomorphic	Maintain structural integrity of stream bed and channel and prevent loss of channel capacity	Maintain structural integrity of channel. Maintains floodplain geomorphic features.	Upper: >500 ML/d bankfull/overbank		Lower: 750/d ML/d bankfull 1,500 ML/d overbank	
Mt William Creek	Baseflow/ freshes/ bankfull/ overbank	Vegetation	Maintain healthy and diverse mosaics of water-dependent vegetation	Maintain edge habitats and shallow water habitat availability for near-permanent inundated stream channel for riparian vegetation and prevents excessive instream terrestrial species growth. Inundate riparian and floodplain vegetation to maintain condition and facilitate recruitment.	>500 ML/d bankfull/overbank		5 ML/d baseflow 20-500 ML/d freshes 750 ML/d bankfull 1,500 ML/d overbank	
Mt William Creek	Baseflow/ freshes/ bankfull/ overbank	Native fish and water quality	Maintain endemic fish communities	Provide variable flow during low flow season for fish movement and to maintain water quality and diversity of habitat. Prevent water quality decline by flushing pools during low flows. Wet low and highest benches, entraining organic debris and promoting diversity of habitat.	>24 ML/d baseflow, >1 ML/d - > 52 ML/d fresh		5 ML/d baseflow 20-500 ML/d freshes 750 ML/d bankfull 1,500 ML/d overbank	
Mt William Creek	Baseflow/ freshes/ bankfull/ overbank	Macroinverteb rates	Achieve SEPP compliant macroinvertebrate communities	Maintain edge habitats and shallow water habitat availability for macroinvertebrates. Provide variable flow during low flow season for macroinvertebrates (over wood debris to increase biofilm abundance as a food source). Flush surface sediments from hard substrates to support macroinvertebrates.	>24 ML/d baseflow, >1 ML/d - > 52 ML/d fresh		5 ML/d baseflow 20-500 ML/d freshes 750 ML/d bankfull 1,500 ML/d overbank	
Bungalally Creek	Bankfull/ overbank	Vegetation	Maintain healthy and diverse mosaics of water-dependent vegetation	Protect and restore riparian and floodplain EVCs. Inundate riparian vegetation to maintain condition and facilitate recruitment.	60 ML/d bankfull 150 ML/d overbank			
Bungalally Creek	Bankfull/ overbank	Geomorphic	Maintain structural integrity of stream bed and channel and prevent loss of channel capacity	Maintains the floodplain geomorphic features and the structural integrity of the channel	60 ML/d bankfull 150 ML/d overbank			

5. Seasonal review

5.1 Climatic conditions this year and seasonal outlook

Conditions in 2020-21 continued the series of very dry years experienced since 2016. Conditions started off in promising fashion with very good rainfall in April and May although these gains were lost on the back of dry conditions in June and July. However, reasonable rainfall totals from August to mid-October were sufficient to generate some streamflows in a number of waterways in the upper catchment. Therefore it wasn't until mid-late October that the Wimmera River started flowing naturally. This was in contrast to 2019 and 2020 where flows took place earlier in winter before ceasing later in spring. Figure 2 illustrates the cumulative rainfall deficits of four very dry winter/springs and the importance of undertaking restrained watering actions given the volumes carried over from the wet conditions in 2016. Conditions in 2021 have started off with two heavy rainfall events in January-February generating comparatively high flows for the Wimmera River although the isolated nature of these events within the upper Wimmera catchment has meant that the benefits on water availability elsewhere (e.g. the MacKenzie River system) has been negligible.

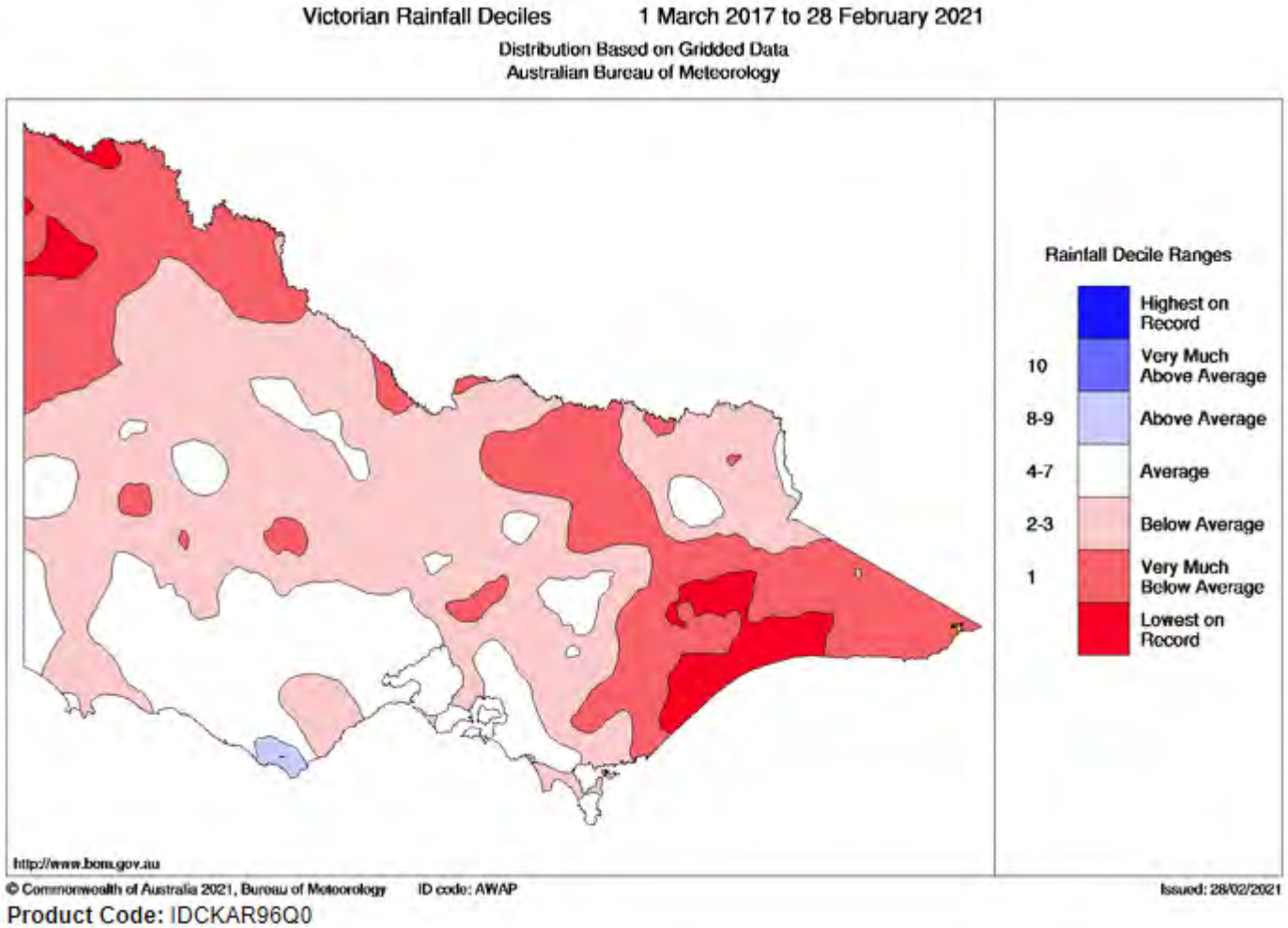


Figure 2. Bureau of Meteorology rainfall deficiencies from 1 March 2017 to 28 February 2021 (http://www.bom.gov.au/jsp/awap/rain/archive.jsp?colour=colour&map=decile&year=2021&month=2&period=48month&area=vc).

Like 2019-20, conditions over summer in 2020-21 were mild which lessened evaporation losses and reduced temperature-induced stresses on aquatic biota. Inflows to all storages were again very low across the storages with

gains outweighed by losses/usage (

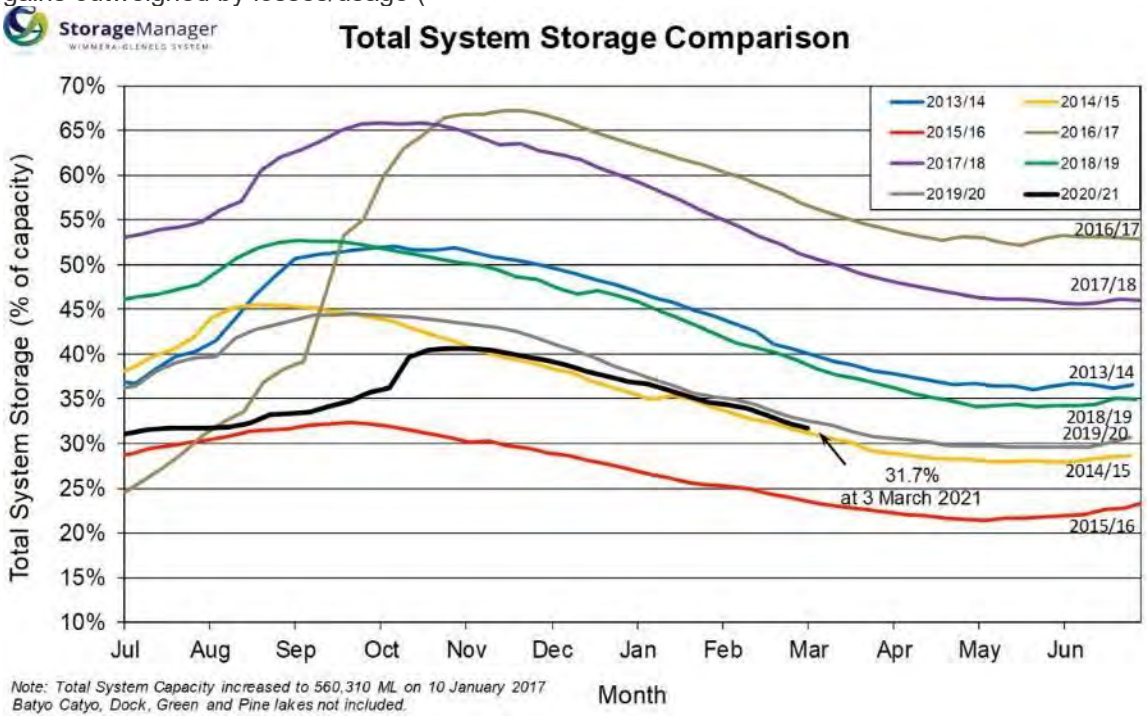


Figure 3). Inflows to storages to the end of February 2021 totalled 63,880 ML, tracking along 84% probability of exceedance. This comes on the back of 2017-18 with 70,320 ML, 2018-19 with 46,490 ML and 2019-20 with 56,610 ML in comparison to 2016-17's 244,600 ML. Therefore, as of March 2021, allocations for high reliability entitlements (VEWH product for Wimmera/Glenelg Rivers) were at 57% whilst CEWH allocations remained at 0% with no prospect of any allocations in the coming months.

In contrast to previous years, there was not a major spatial discrepancy in rainfall across the catchment beyond the usual gradient from wetter conditions in the south-west compared to the north-east of the catchment. Comparisons with 2016 (a wet year with about 30% probability of exceedance) and 2017-2020 (very dry years with 85-90% probability of exceedance) are shown in Table 7. Although MacKenzie River at Wartook is mostly regulated by Lake Wartook upstream, there have been flows due to upstream pickup and releases to meet target levels at Lake Wartook. Since 2017 most flows along the MacKenzie River have been due to releases for environmental watering and Horsham's water supply.

Table 7. Annual streamflows from 2016-2020 at gauges in unregulated reaches (Mt William Creek and Wimmera River) and regulated reach (MacKenzie River)

Location	Yearly Flow (ML)				
	2016	2017	2018	2019	2020
Mt William Creek at Mokepilly	35,022	3,614	264	11,472	2,416
Wimmera River at Glenorchy	116,737	3,824	0	11,708	4,347
MacKenzie River at Wartook	19,572	13,003	8,956	5,752	5,987

Passing flows in 2020/21 have again been very limited due to the dry conditions, however, flows from Huddleston's Weir were very important for providing spring baseflows and freshes that connected the length of the Wimmera River. Small passing flow volumes held in Lake Lonsdale were released to refill refuge pools in December although unfortunately there was also the death of a number of fish, yabbies and turtles that were trapped on the outlet infrastructure following the release. The limited passing flows led again to a high reliance on regulated releases in 2020/21 to provide a number of priority watering actions. Dry conditions again severely impacted the MacKenzie River/Burnt Creek system with Lake Wartook being at very low levels through winter and into early spring. Large shortfalls in meeting consumptive and environmental demands from the storage were forecasted to occur until wet conditions in October led to a temporary reprieve. Drought contingency planning is likely to continue for Lake Wartook into 2021/22 in consultation with VEWH, DELWP and GWMWater, given the ramifications low storage levels has on critical consumptive and environmental water needs.

Table 8. Passing flows for 2016/17-2020/21 for Mt William Creek at Lake Lonsdale and Wimmera River at

Huddleston's Weir (*2020/21 figure to March)

Location	Passing Flow 2016/17 (ML)	Passing Flow 2017/18 (ML)	Passing Flow 2018/19 (ML)	Passing Flow 2019/20 (ML)	Passing Flow 2020/21* (ML)
Mt William Creek at Lake Lonsdale	3,321	2,078	335	690	440
Wimmera River at Huddleston's Weir	51,064	1,750	0	262	2196

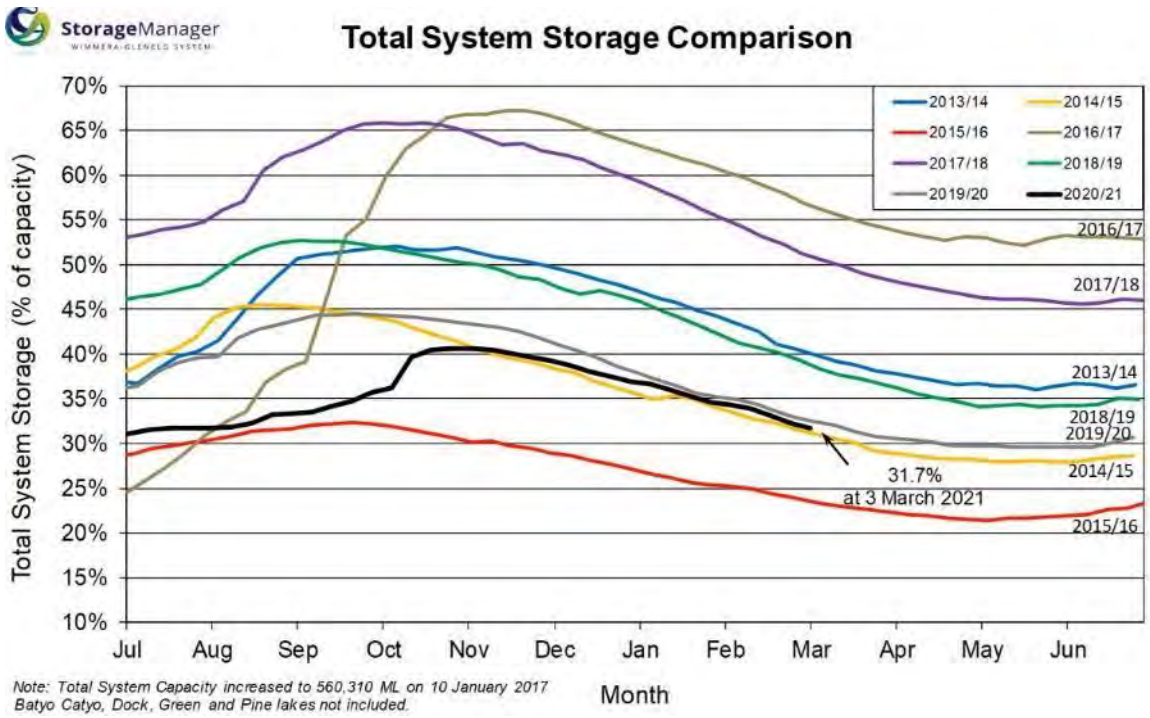


Figure 3. GWMWater storage volume comparison to start of March 2021 (GWMWater 2021).

Summer 2020/21, was noted for its mild weather and a couple of very heavy rain events that led to flows in the Wimmera River. The mild weather led to reduced evaporative losses and temperature-stresses on biota in waterways. The impact of these events on the Wimmera Rivers is outlined in Section 5.2 but given the isolated nature of these rainfall events, they did not lead to notable inflows into storages. It is anticipated that they will lead to reduced demands for regulated water deliveries to the Wimmera River with some objectives around reduced salinity and habitat provision being achieved by these flows. Similar to recent years, significant rainfall in autumn and winter 2021 will be required to fill pools/dams and generate streamflows given warm, dry weather since January has again dried out catchments across the region. With a shortfall in system operating water currently forecast, allocations are likely to be 0% at the start of 2021-22 and this will also affect passing flows (should they take place) through restrictions as prescribed in the Environmental Entitlement.

5.2 Review of 2020-21 watering with respect to shared benefits outcomes

Section 3 discusses the various outcomes with respect to shared benefits and how they were affected by the COVID-19 pandemic. They are summarised in Table 9.

Table 9. Shared benefits outcomes associated with environmental watering in 2020-21

Beneficiary	Noted benefits/outcomes from 2020-21 watering
Traditional Owners	Enhancements to the water quality, birdlife and vegetation associated with watering at Ranch Billabong which is very important site for traditional owners.
Rowers/Canoers	Regular opportunities to train on the Horsham and Dimboola Weir Pools for regattas were provided by a combination of environmental water and unregulated flows that maintained water levels (although Dimboola Regatta was cancelled due to COVID-19). Training sessions to obtain accreditation as a canoe guide were held in Horsham Weir Pool by Canoeing Victoria.
Waterskiiers	Regular opportunities to waterski on the Dimboola Weir Pool was provided by a combination of environmental water and unregulated flows that maintained water levels (although the Peter Taylor Barefoot Classic event was cancelled due to COVID-19).
Anglers	There was very good fishing noted along the Wimmera River apart from when there were blackwater impacts in February-March. Fish populations were protected from the impacts of poor water quality (blackwater and salinity) by environmental water releases and unregulated flows.
Visitor Economy	Amidst COVID-19 impacts to regional tourism and local visitation, some events like the Horsham Fishing Competition were still able to go ahead. Caravan parks adjacent to the Wimmera River at Horsham, Dimboola and Jeparit received strong visitor numbers when conditions permitted.

Water extractors	Environmental water provided opportunities for stock and domestic and garden/oval watering through enhanced water quality and water levels (helping priming of pumps).

5.3 Review of 2020-21 watering, ecological observations and monitoring

The Wimmera system's regulated environmental water usage in 2020-21 is planned to be up to 10,000 ML from 16 September to 30 June based on the volume authorised by VEWH (Seasonal Watering Statement #2). No water was available from the CEWH entitlement. This water was authorised to provide a proportion of baseflows and freshes for several waterways. Some unregulated flows meant that regulated releases were not required for some watering actions and there remains a concerted focus on conserving water for watering in 2021-22 given the current resource situation. Results are summarised for various waterways in Table 10. Planning through to the end of June (as of March 2021) indicates that approximately 5,830 ML of regulated water will be used – about 1,500 ML less than the same time last year.

Table 10. Summary of the environmental water delivered compared to what was authorised and required to achieve compliance of priority watering actions (PWA).

Waterway	Estimated water required to achieve Tier 1a PWA compliance under scenario (ML)		Planned to be Delivered by 31st March (ML)
	Extreme Drought	Average	
Wimmera River	7,500	10,370	4,020
MacKenzie River	1,400	3,600	1,810
Burnt Creek	1,150	1,485	
Mt William Creek	200	2,245	0
Bungalally Creek		300	0
Total	**10,250**	**18,000**	**5,830**

5.3.1 Wimmera River summary

With very low water environmental water availability coming into 2020-21 and with suitable conditions created by environmental watering in May-June 2020 as well as modest unregulated flows in late spring, no releases for the Wimmera River took place until January. Above average rainfall in August and September created a wetted catchment that generated streamflows from wet conditions in early-mid October. So unregulated flows reached the lower Wimmera River in early October, with flows peaking at Horsham with 636 ML/d on 15 October and they had essentially ceased a month later. This meant that there was no need to undertake the planned environmental water release for late spring intended to refill refuge pools and enhance water quality prior to the extremes of summer. Therefore releases were planned to commence in January to achieve this purpose given the time elapsed since the spring flows and duration of time it takes for flows to reach the end of the Wimmera River after a period of no flow given the need to refill and connect refuge pools. However these flows were required to help manage conditions created by two heavy rainfall events that month. These rainfall events, concentrated in the upper catchment, created a mixture of benefits and issues given the circumstances.

Firstly, an intense rainfall event took place on 2 January in a narrow band from Dadswells Bridge and Glenorchy to Deep Lead (north-west of Stawell). Anecdotal sources indicated more than 100mm of rain fell in a couple of hours combined with very strong winds causing damage to buildings and many trees losing limbs. The intense rain created a short, sharp pulse of flow, peaking at 750 ML/d at Glenorchy before rapidly dropping within hours, continuing to decline to less than 50 ML/d within a couple of days (Figure 4). The runoff contained large amounts of organic matter (leaves, twigs and bark) that were swept off areas like Deep Lead Nature Conservation Reserve and into small waterways that discharged into the Wimmera River at Glenorchy. This flow continued downstream although its peak volume rapidly attenuated as it flowed down a mostly dry river channel (the peak flow at Horsham was only 120 ML/d). Environmental water released from Taylors Lake at the same time was able to provide a degree of mixing and dilution to this flow although observations of potential blackwater in Horsham Weir Pool prompted an increase in the delivery rate of environmental water to provide a source of better quality water to increase this mixing/dilution effect as well as providing an opportunity for fish and other biota to escape anoxic conditions.

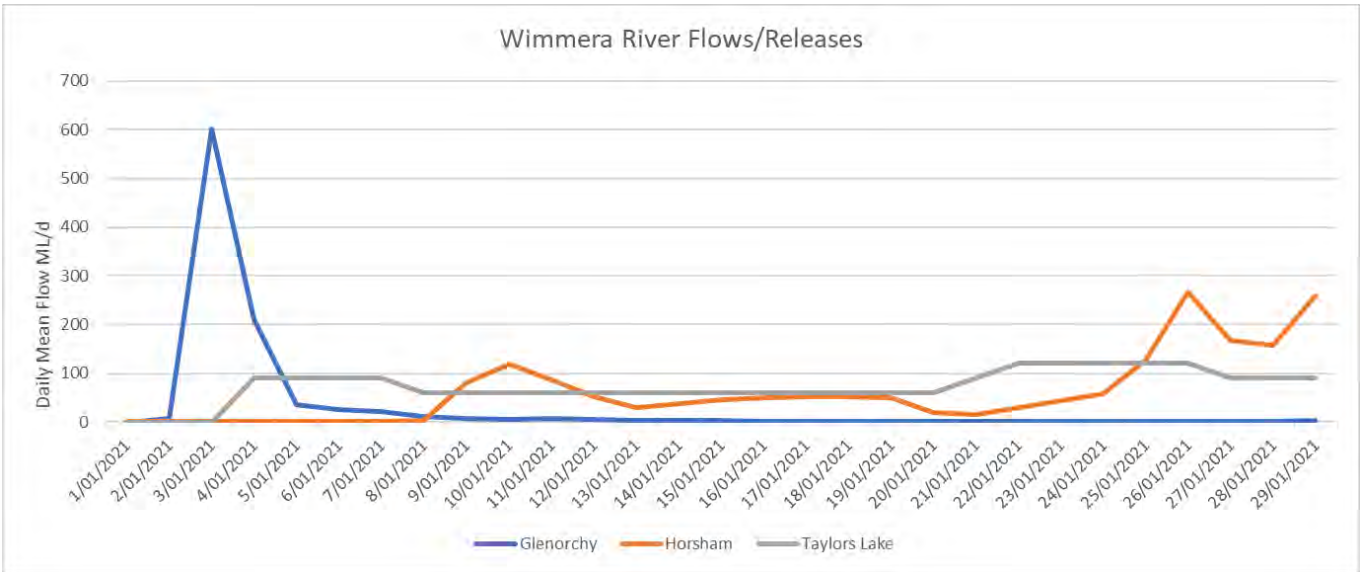


Figure 4 Flows/environmental water releases for the Wimmera River at Glenorchy (415201), Horsham (415200) and Taylors Lake associated with heavy rainfall event on 2 January (as well as stormwater flows from Horsham on 28 January).

Whilst this was occurring, on 28/29 January another very heavy rainfall event took place in a broader section of the upper Wimmera catchment again from Dadswells Bridge and Glenorchy but also extending past Stawell to Navarre with totals from around 70 to 100 mm over 24 hours. This generated major streamflows which were the highest for the Wimmera River since the 2016 floods (Table 11), reaching close to bankfull levels at Glenorchy before dissipating steadily as they continued downstream. In some catchments such as Wattle (Heifer Station) Creek in Navarre, flows have been negligible for several years which led to a major build up of organic matter which was mobilsed by these high flows (Figure 5) and washed into waterways, ultimately making it into the Wimmera River.

Table 11. Mean peak daily flows for the Wimmera River at Glenorchy (415201)

Year	Month	Peak Mean Daily Flow (ML/d)
2016	September	22,978
2017	August	410
2018	N/A	0
2019	August	904
2020	October	634
2021	January	3447

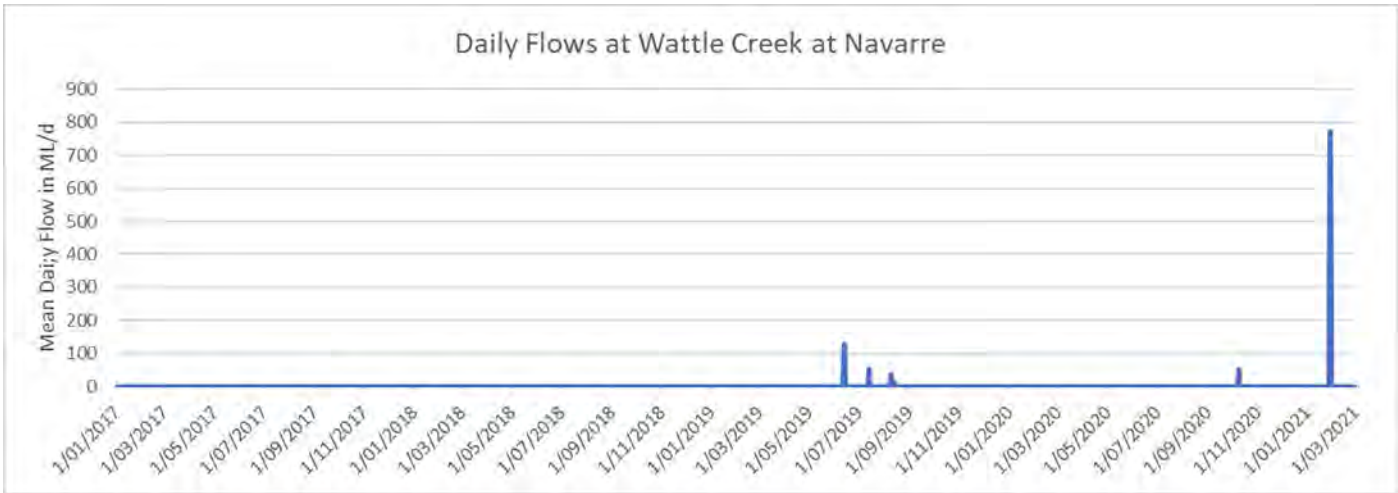


Figure 5 Daily Average Streamflows at Wattle Creek at Navarre (415238)

This created issues with very large quantities of organic material being washed into the Wimmera River as well as mobilising pools that had low dissolved oxygen due to the breakdown of organic material from the early January event. The peak flow rates were such that they engaged instream features like bars and benches, so the organic material was sourced from both the catchment and within waterways themselves. The high levels of organic material combined with warm temperatures and lack of subsequent natural flows created anoxic conditions in parts of the

Wimmera River, particularly in and around Horsham. Water quality measurements showed continuous stretches that had very low (<1 mg/L) to no dissolved oxygen and there were observations of blackwater and fish under stress through being sluggish or being very close to the surface. Large quantities of water ribbons (*Cycnogeton sp*) and eelgrass (*Vallisenaria sp.*) were ripped out by the flows and deposited in the Horsham Weir Pool. In the Horsham Weir pool the river channel is wider (due to historic flood mitigation works) and also possesses features like backwaters, jetties, bridges and the weir itself that trapped the floating plants and leaves in extensive rafts.

Environmental water releases at 120 ML/d commenced from Taylors Lake on 9 February, as soon as flow rates from the upper Wimmera dropped to low levels (<100 ML/d) to provide a source of oxygenated water as well as ensuring reasonable connectivity between pools to enable fish and other biota to escape anoxic conditions. When it was noted that conditions continued to decline, releases from Taylors Lake increased to the maximum of 200 ML/d to try and arrest this trajectory through diluting the poorer water quality, providing localised mixing and replenishing the photosynthetic algae population that had been lost following the blackwater event. It was noted that the flows were able to achieve this by mid-February (Figure 6, Figure 7, Figure 8) although other factors were also important. These included mild weather conditions, the use of pumps to reoxygenate the water, physical removal of rafts of aquatic vegetation and the quick recovery of aquatic vegetation enabling them to reach the water surface and access sunlight despite the increased turbidity in the river. Their cumulative effects meant that fish death events were avoided despite conditions being highly conducive for one to take place.

Pumps deployed to aerate water in the Horsham Weir Pool, February 2021

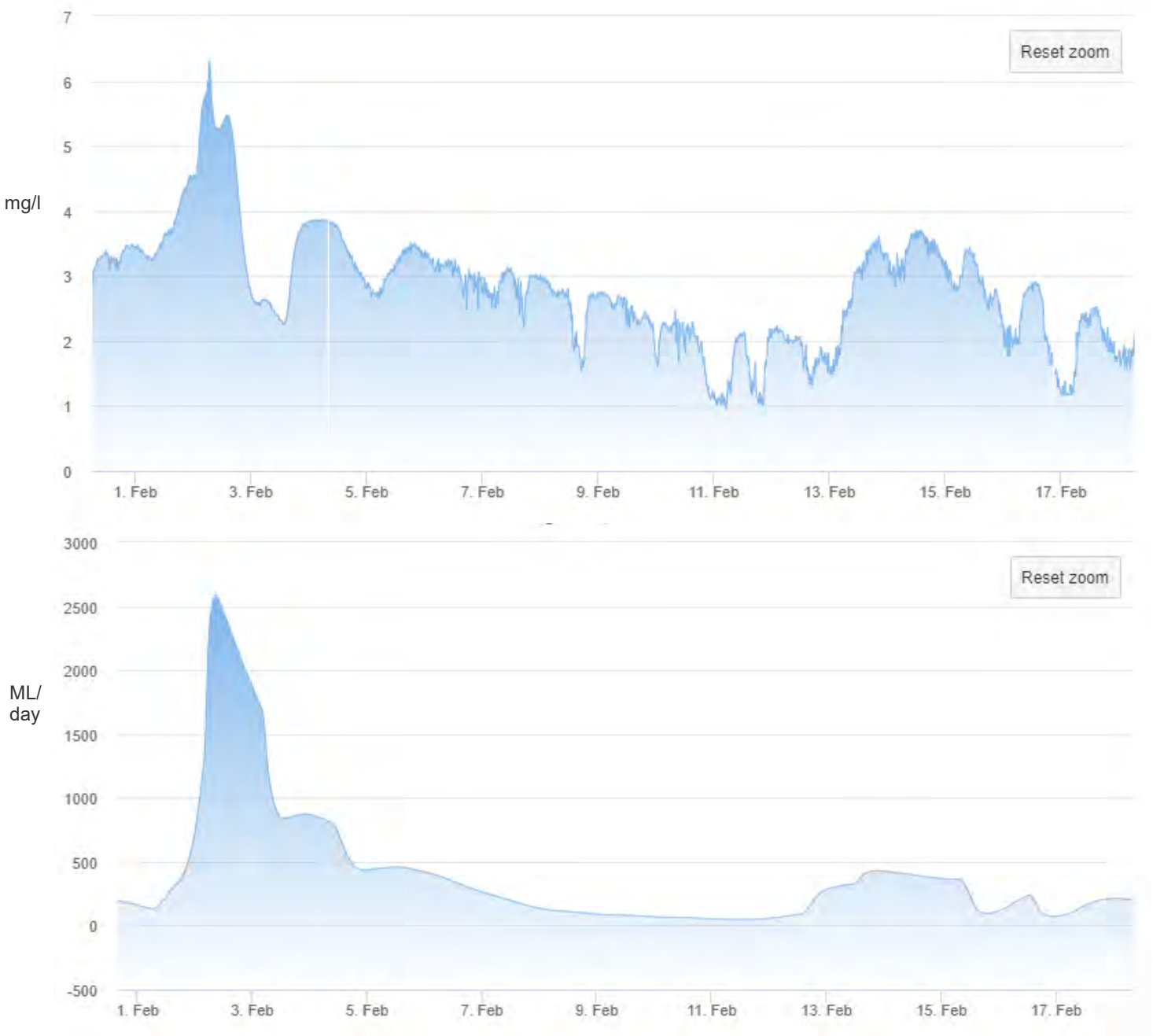


Figure 6 Dissolved oxygen (top) and flow (bottom) for the Wimmera River at Horsham (415200), February 2021

Releases from Taylors Lake were steadily reduced until being ceased on 22 February, by which time dissolved oxyen levels in and near Horsham Weir Pool had been noted as improving and other signs like water colour and stressed fish were no longer evident. However, dissolved oxygen levels remain comparatively low and organic carbon levels are elevated for a long stretch of the river through to Polkemmet, so additional environmental water releases may be required should conditions deteriorate.

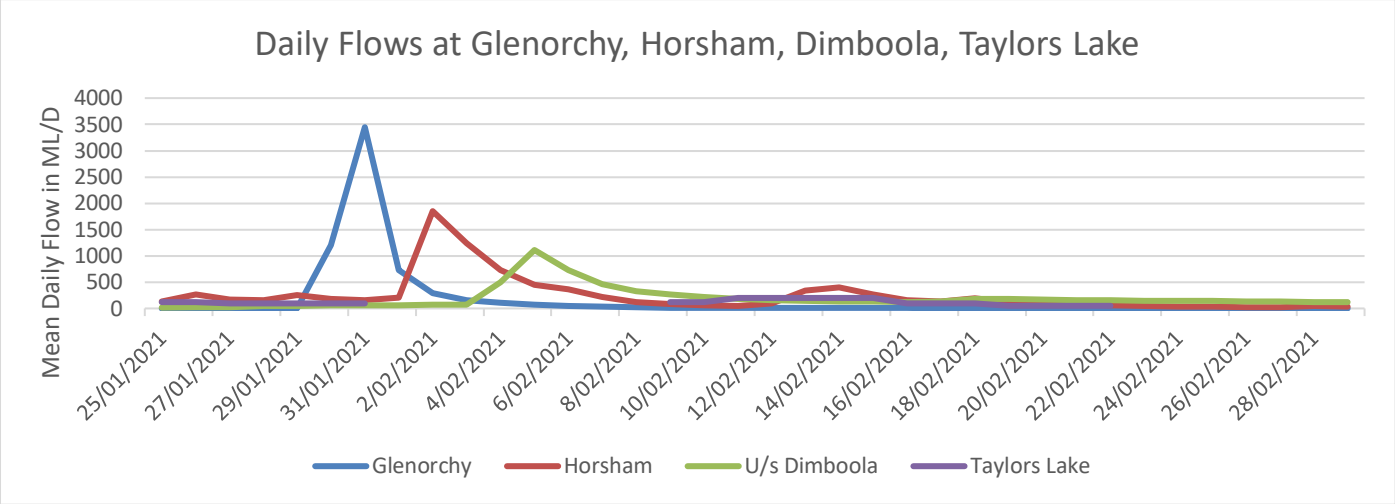


Figure 7. Flows/environmental water releases for the Wimmera River at Glenorchy (415201), Horsham (415200), u/s Dimboola (415256) and Taylors Lake associated with heavy rainfall event on 28/29 January.

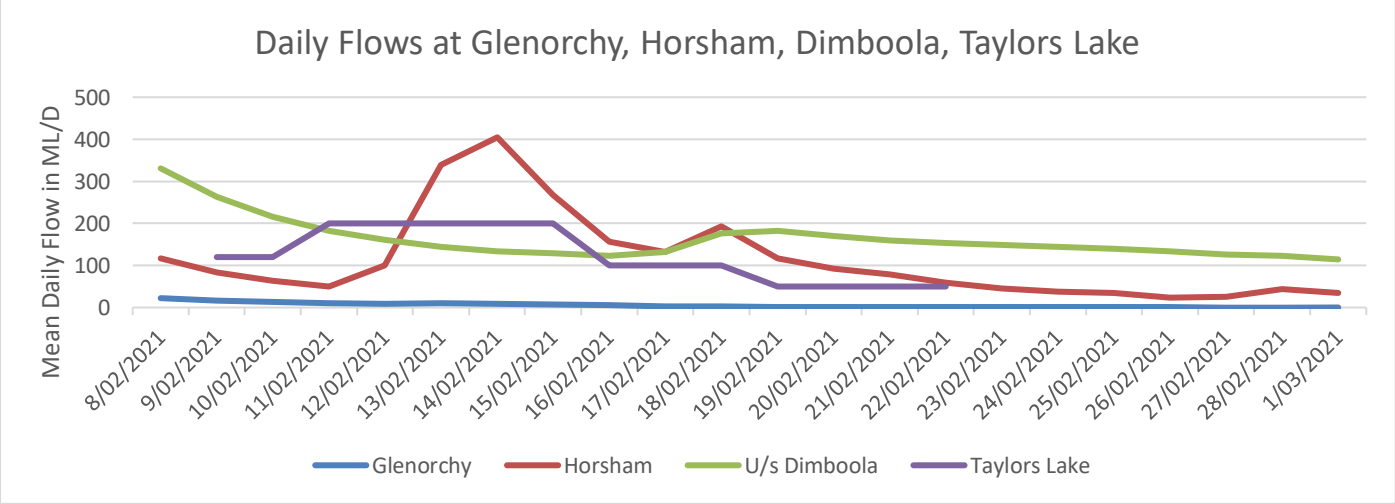


Figure 8. Flows/environmental water releases for the Wimmera River at Glenorchy (415201), Horsham (415200), u/s Dimboola (415256) and Taylors Lake showing the role of environmental water releases in lifting flows at Horsham.

Raft of Vallisenaria (sp) and Cycnogeton (sp) at Horsham Weir, February 2021.

Conversely, the addition of large amounts of organic carbon to the Wimmera River will be an important driver for ecological productivity in coming months and years and has been only available in limited amounts since 2016. Furthermore the higher flows have been very beneficial in diluting salinity levels in the parts of the Wimmera River prone to saline groundwater intusions (especially Tarranyurk where levels had reached about half that of seawater, Figure 9). Flows have also reached parts of the channel that cannot be watered by regulated environmental water releases (e.g. instream benches) which will benefit fringing vegetation species such as Totem Poles (*Melaleuca decussata*). It even led to a noticeable volume of water reaching Lake Hindmarsh (see Figure 10).

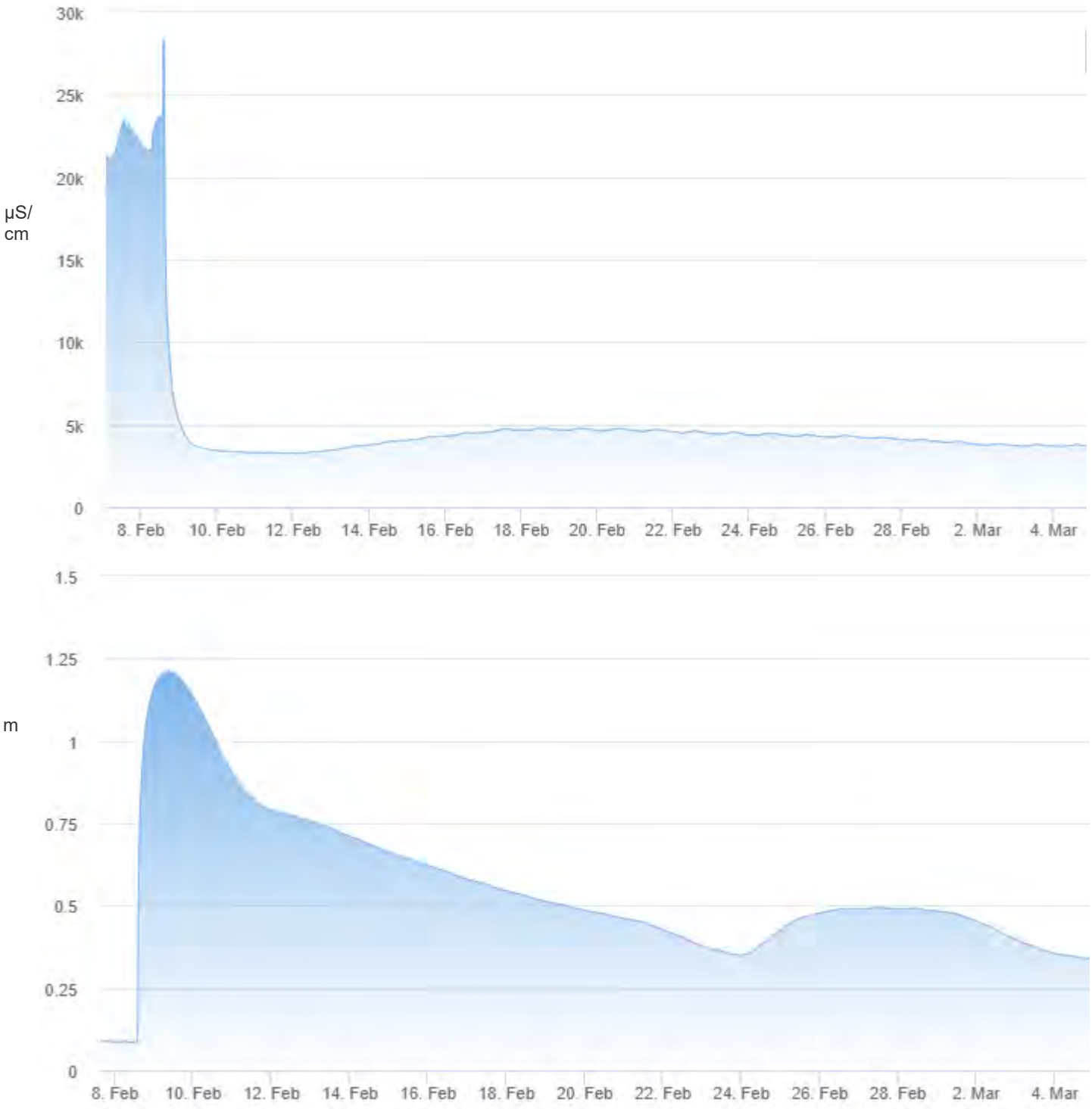


Figure 9. Salinity (top) and water level (bottom) for the Wimmera River at Tarranyurk (415247), February- March 2021

Other factors to note include the low levels in Lake Wartook and Lake Lonsdale which mean that contributions from releases to the Mt William Creek, Burnt Creek and MacKenzie River were not noted in the Wimmera River, with only a very small volume of passing flows from the Mt William Creek reaching the Wimmera River (< 50 ML). The dry conditions also meant that the trigger for irrigation diversions from the Wimmera River was not met (three out of the last four years have been below this trigger which has a historic reliability of about 90%, indicating the run of very dry years). Water use for stock and domestic and watering of recreational areas is still a factor though, especially during summer/autumn.

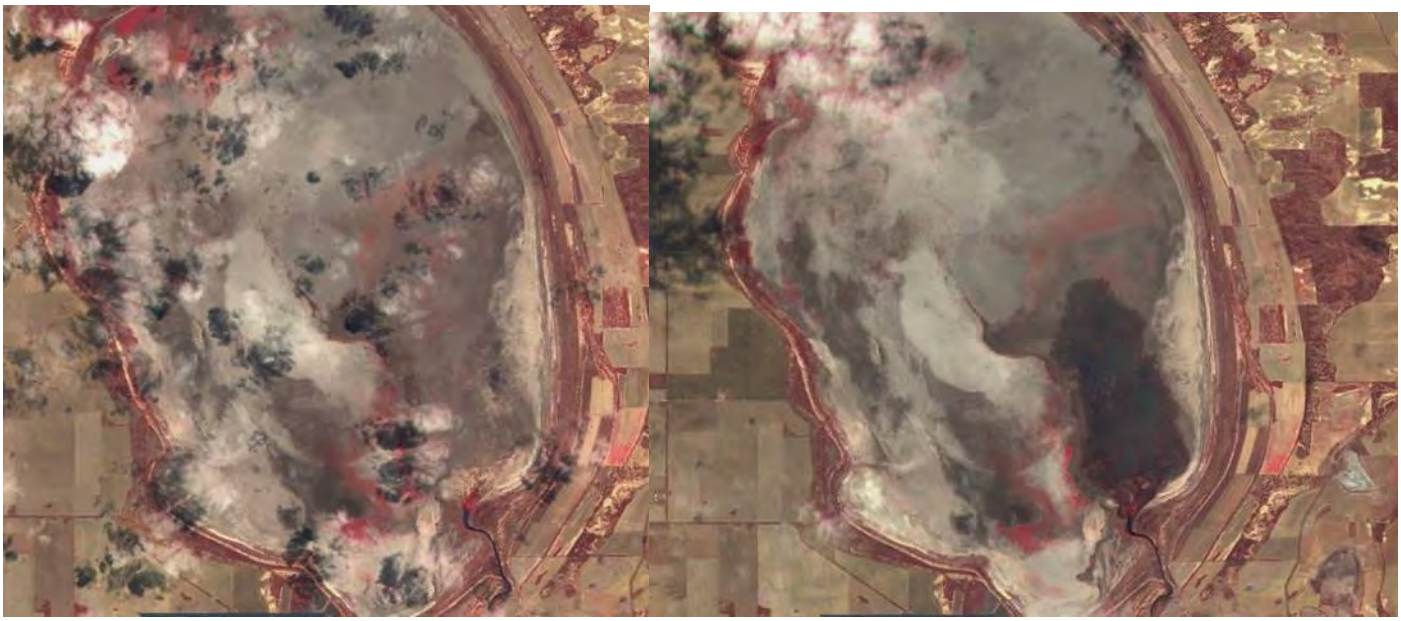
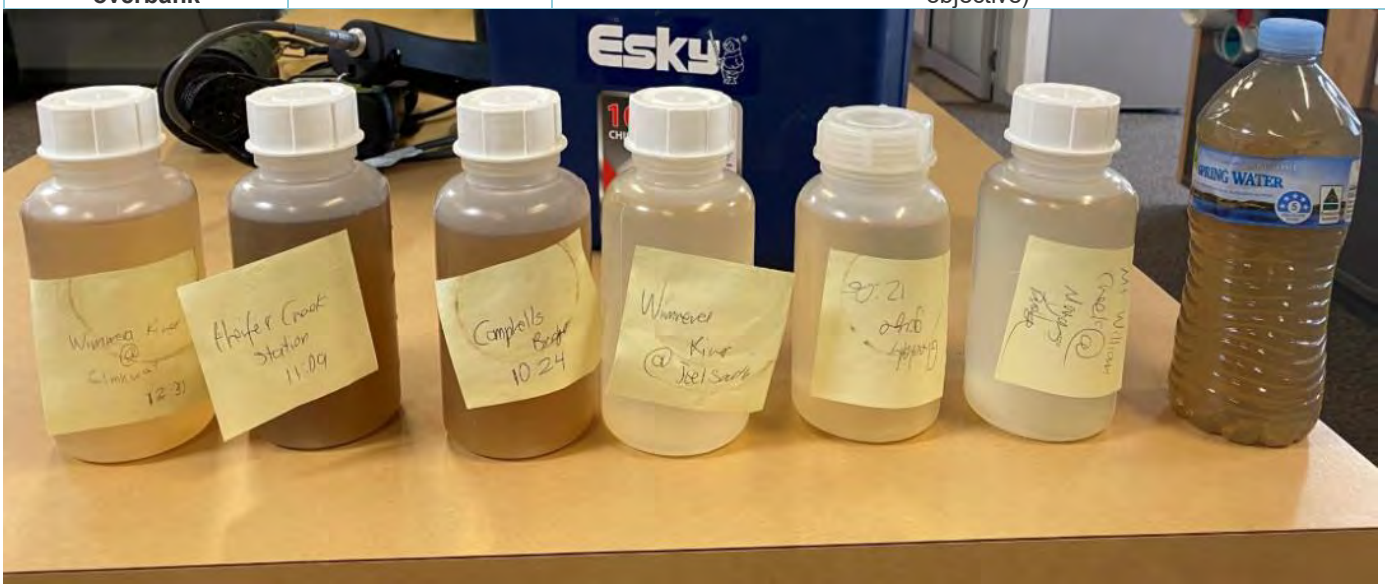


Figure 10. Satellite photos from 7 and 17 February 2021 showing the extent of inundation of Lake Hindmarsh from January/February flows in south-east corner (Source: https://apps.sentinel-hub.com/sentinel-playground/)

Table 12. Summary of Priority Watering Actions (PWA) delivered for Reach 4 of the Wimmera River 2020/21 (Wimmera River at Lochiel, 415246).

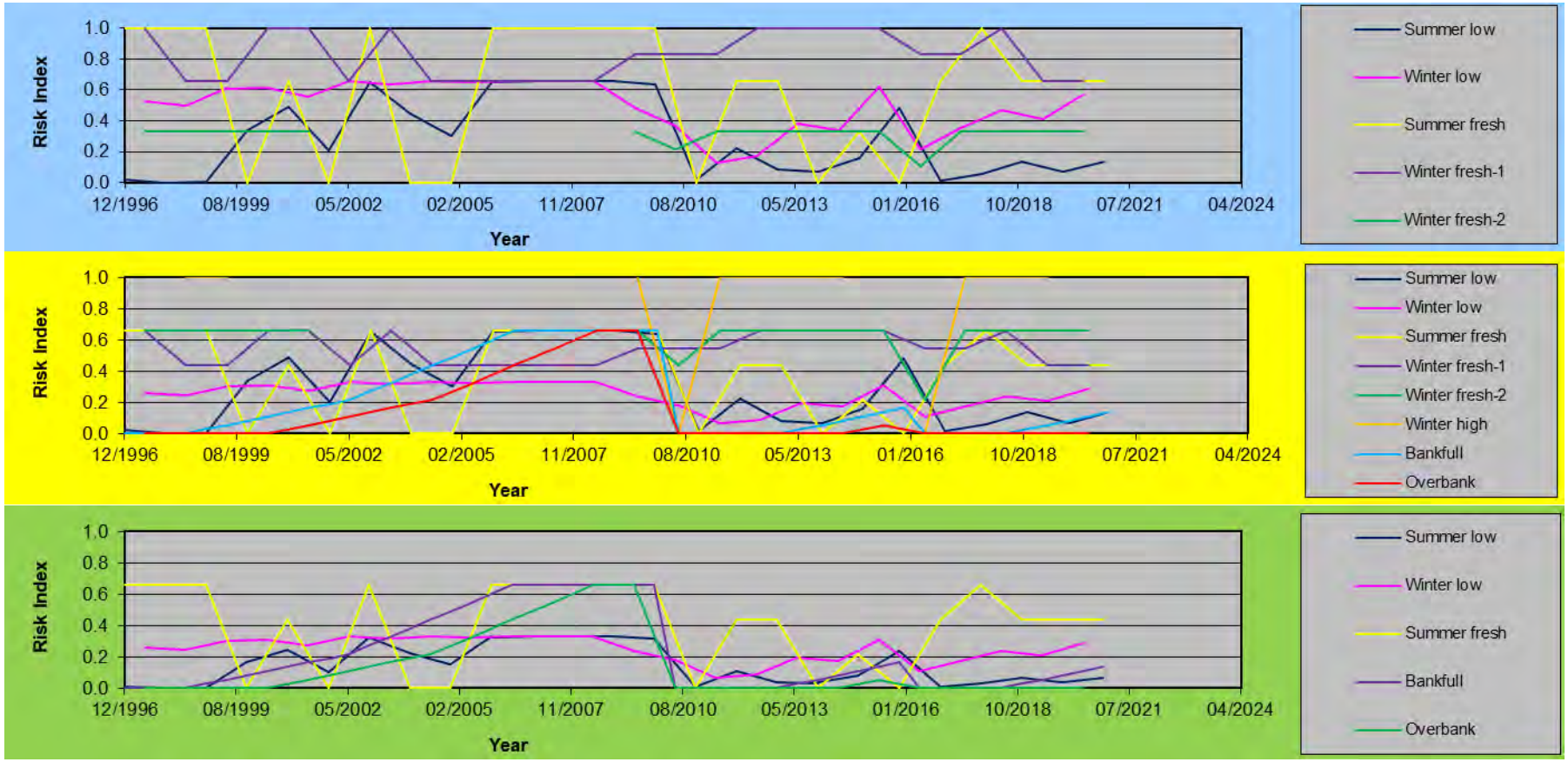
PWA delivered for reach 4 Wimmera River	Flow magnitude/ duration/ frequency	Comment
Winter/Spring baseflow	30 ML/d	Partially delivered due to a combination of unregulated and regulated flows. Dry conditions meant that it was not able to be met for most of the time.
Summer/Autumn baseflow	15 ML/d	Partial achievement of this mostly due to unregulated flows.
Summer/Autumn freshes	70 ML/d 2-7 days x 3	Two achieved with one more planned.
Winter/Spring freshes	70 ML/d 5 days x 4	Only two delivered (June, October/November). Dry conditions in winter/spring meant that more were not achieved. Potential for one in June 2021.
Winter/Spring freshes	200 ML/d 3 days x 3	Only one achieved (October) through unregulated flows
Winter/Spring freshes	1,300 ML/d 3 days x 2	Unregulated flows insufficient to provide component. (Not regulated water objective unless unregulated component is large given capacity constraints)
Anytime bankfull	2,000 ML/d 2 days x 1	Unregulated flows insufficient to provide component. (Not regulated water objective). February flows peaked at about 1,000 ML/d for 2 days.
Winter/Spring overbank	6,000 ML/d 1 day x 1	Unregulated flows insufficient to provide component. (Not regulated water objective)



Water samples showing the material in the water column from Heifer Station Creek, Navarre (second from left), Wimmera River near Glenorchy (third from left), Wimmera River at Horsham Weir Pool (right – Springwater bottle disposed of afterwards for safety) and sites in the upper catchment not substantially affected by heavy January rainfall (others).

Risks to ecological and physical objectives for the Wimmera River Reaches 3 and 4 are included in Table 13 and Table 14 below. The results highlight for Reach 3 there has been a reduction in risks to all objectives brought about due to the wet conditions in winter/spring 2016, followed by environmental water releases since then, especially in relation to baseflows. This has been important for building resilience to cope with reduced flows compared to previous years should dry conditions continue. Unfortunately the low water availability and high losses due to hit weather and extraction in summer/autumn have led to increases in the risk profiles for Reach 4. This illustrates the contrasting circumstances affecting the two reaches with the section through to Dimboola being in comparatively good condition when contrasted with the section downstream.

Table 13. Risk indices for Fish (blue), Macroinvertebrates (yellow), Vegetation (green), Geomorphology (grey) and Water Quality (pink) for Reach 3 of the Wimmera River.



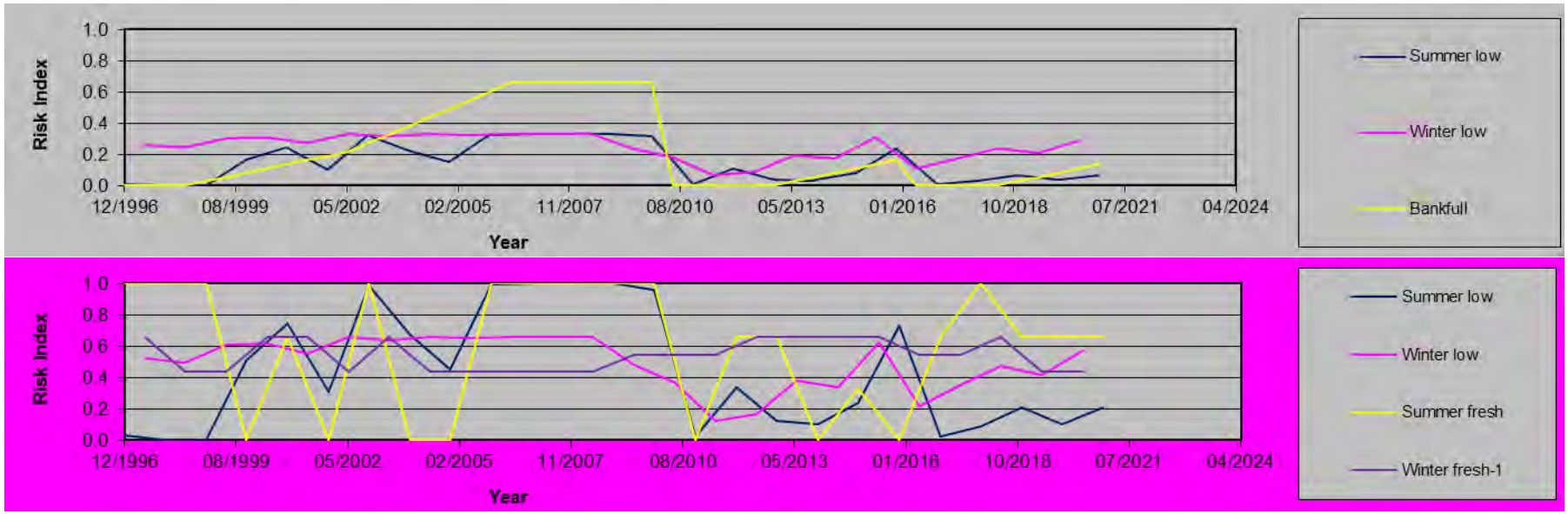
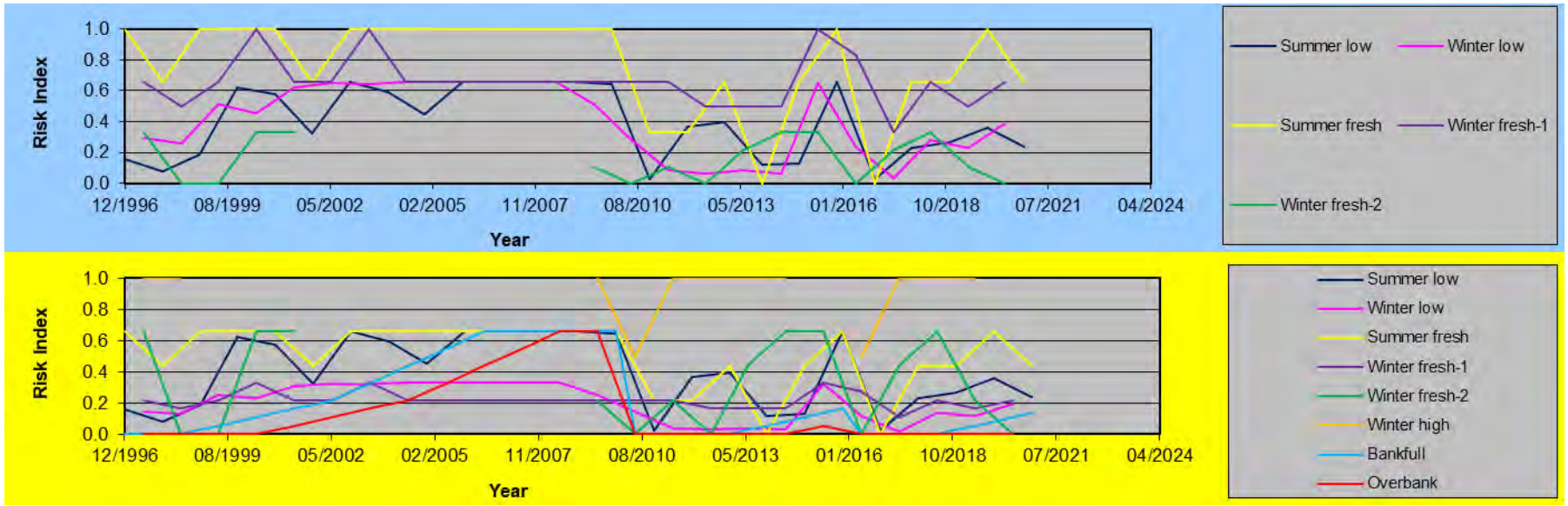
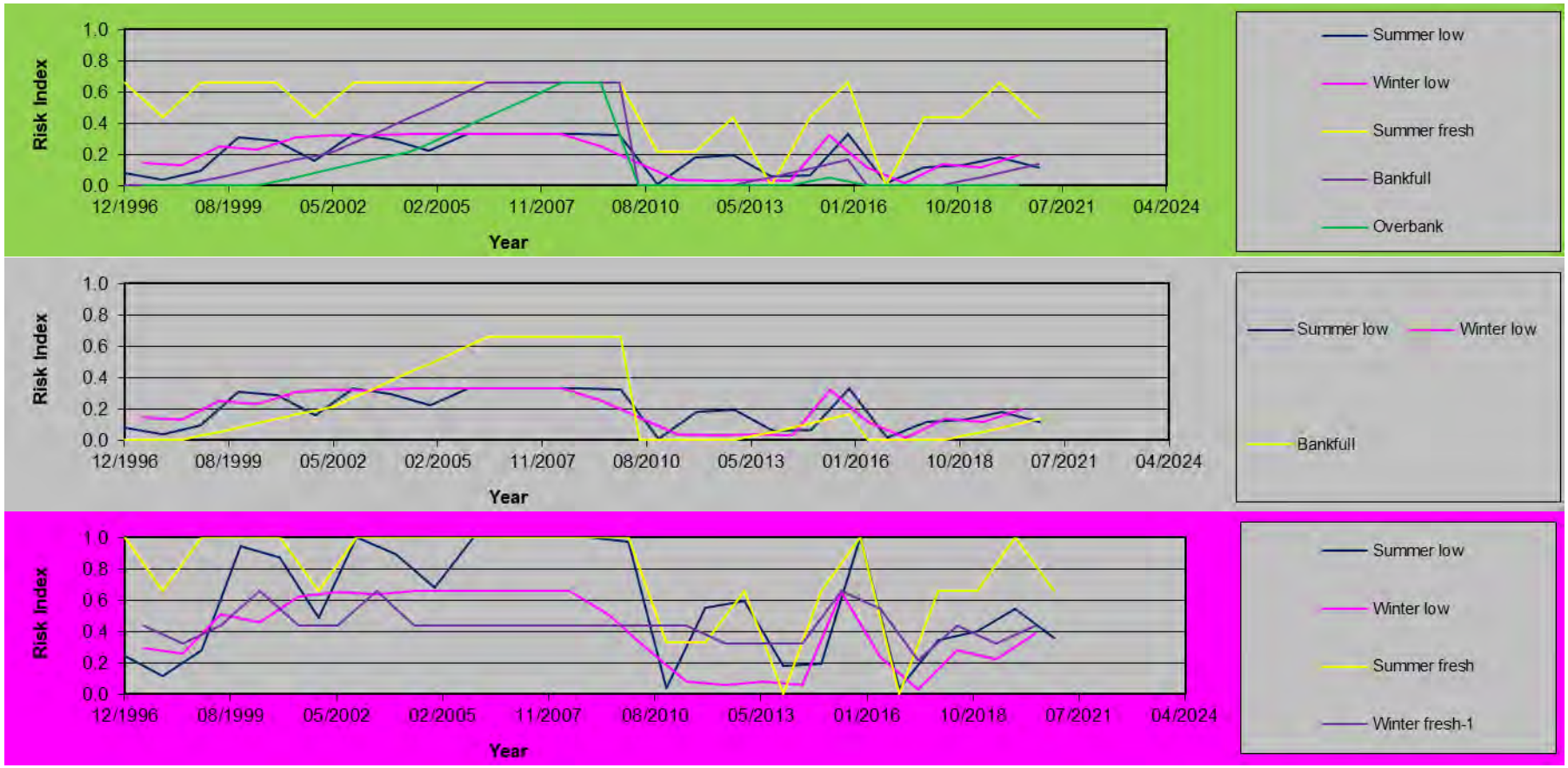


Table 14. Risk indices for Fish (blue), Macroinvertebrates (yellow), Vegetation (green), Geomorphology (grey) and Water Quality (pink) for Reach 4 of the Wimmera River.




Risk Index
1.0
0.8
0.6
0.4
0.2
0.0
12/1996
08/1999
05/2002
02/2005
11/2007
08/2010
05/2013
01/2016
10/2018
07/2021
04/2024
Year
Summer low
Winter low
Summer fresh
Bankfull
Overbank
Risk Index
1.0
0.8
0.6
0.4
0.2
0.0
12/1996
08/1999
05/2002
02/2005
11/2007
08/2010
05/2013
01/2016
10/2018
07/2021
04/2024
Year
Summer low
Winter low
Bankfull
Risk Index
1.0
0.8
0.6
0.4
0.2
0.0
12/1996
08/1999
05/2002
02/2005
11/2007
08/2010
05/2013
01/2016
10/2018
07/2021
04/2024
Year
Summer low
Winter low
Summer fresh
Winter fresh-1

Wimmera River Angler Report Card Fish Surveys

The fourth round of fish surveys for the angler report card were undertaken in May 2020 by staff Austral Research and Consulting at eight sites along the Wimmera River from upstream of Horsham (Longerenong) to Jeparit using a combination of fyke nets and electrofishing. Whilst the focus was on angling species of interest (Golden Perch and Freshwater Catfish), there were observations of Flathead Gudgeon, Common Galaxias and Australian Smelt as well as Carp, Goldfish, Eastern Gambusia and Redfin. Only one Freshwater Catfish was caught at Horseshoe Bend near Dimboola, however numbers have been consistently low with only four caught in 2019 and two in 2017 and 2018. Golden Perch numbers were also down with only 21 caught compared with 38 caught in 2019, 41 in 2018 although it is higher than the 11 caught in 2017. Unfortunately no Silver Perch were caught compared to 10 collected in 2019 and two and three trapped in 2018 and 2017 respectively. It is planned to undertake another round of surveys in autumn 2021.

Wimmera Carp Monitoring Program

Austral Research and Consulting used the results of the Wimmera carp monitoring program that existed from 2016-2019 as well as other advances in carp management to develop the *Wimmera Carp Management Plan 2020* (Austral, 2020) which considers how management tools like monitoring, removal, suppression of recrtuiment and release of pathogens/piscicides might be applied. So whilst no dedicated carp removal work took place in 2020, a number if sites were surveyed as part of the angler report card surveys. The results again showed that there had not been a large carp breeding event and numbers remain relatively static (
Table **15** and Figure 11), with no strong cohorts of young fish coming through judging by the relatively linear fork lengths measured.

Table 15. Carp numbers caught as part of the Wimmera Carp Monitoring Program 2016-19 and Angler Report Card monitoring. Sites labelled [c] are control sites. Sites in black are riverine sites and in red are weir pool sites (Austral, 2018). Sites are listed in most upstream to most downstream by group.

	Oct 16	Dec 16	Jan 17	April 17	June 17	June 18	Feb 19	May 19	May 20
Lwr Norton [c]					2		34	7	
Quantong	15	15	22	24	9	23			
Polkemmet	15	17	47	7	23				
Lochiel	2	16	26	42	10				
Spears Crossing	0	3	17	12	0		19	19	25
Antwerp	0	31	21	61	1	23	99	12	
d/s Jeparit Weir	45	49	70	31	28		18	23	4
Bigwater	11	12	26	19	-				
Horsham[c]			46			10	17	10	13
Dimboola	7	4	19	10	17	27	24	19	
Jeparit	6	2	13	13	9				17

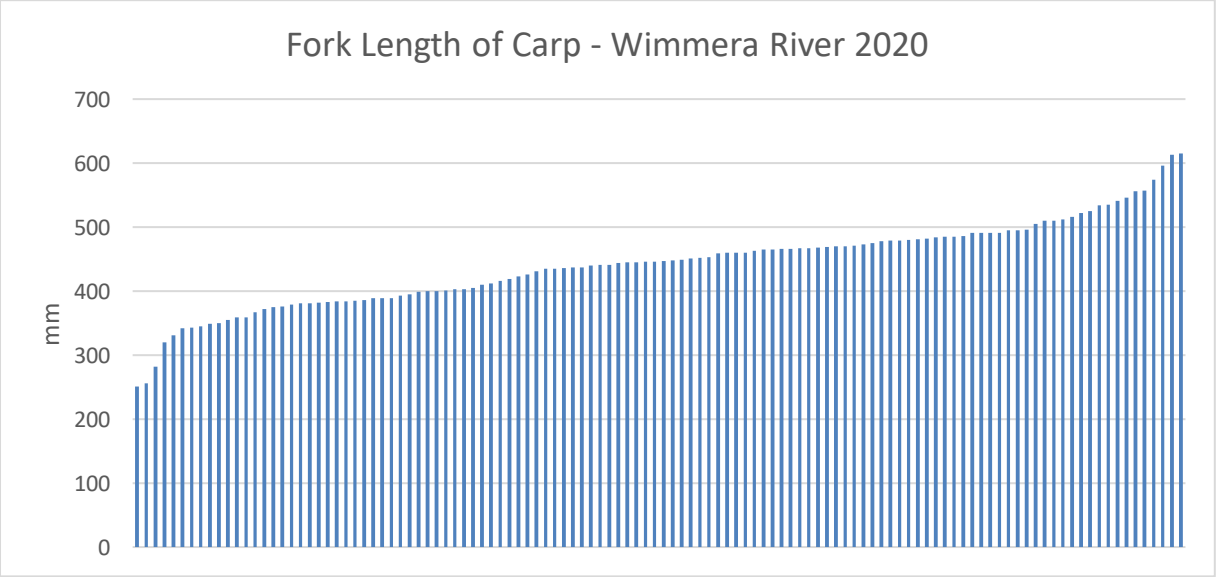


Figure 11. Carp Fork Length from Angler Report Card Survey Work (Austral, 2020).

Fishing Competition Results

Unfortunately with the Jeparit and Dimboola Fishing Competitions cancelled to due COVID-19, there were no results to contrast with previous years to indicate trends in fish communities. However, the Horsham Fishing Competition was able to go ahead in 2021, albeit in a different format (capped numbers at 1000 entrants and measuring the length not weight of fish to determine the winner). The trends around carp numbers are corroborated by the results of the 2021 competition where carp numbers caught have plummeted since 2016 (Figure 12) and there being a distinct lack of small fish indicating limited recruitment.

Native fish captures almost reached the highest number since 2017 and the numbers of entrants would have been about 50% less in 2021 compared to 2017, indicating a greater catch per unity effort. With the competition transitioning to being judged by length and not weight, statistics around weights were not able to be obtained but the feedback from many participants was that the fish were in good condition and not impacted by the recent water quality issues brought about by the heavy rainfall events in January. A notable statistic was the number of Freshwater Catfish caught (45) which is more than double the next highest number caught since 2014 (21 in 2020).

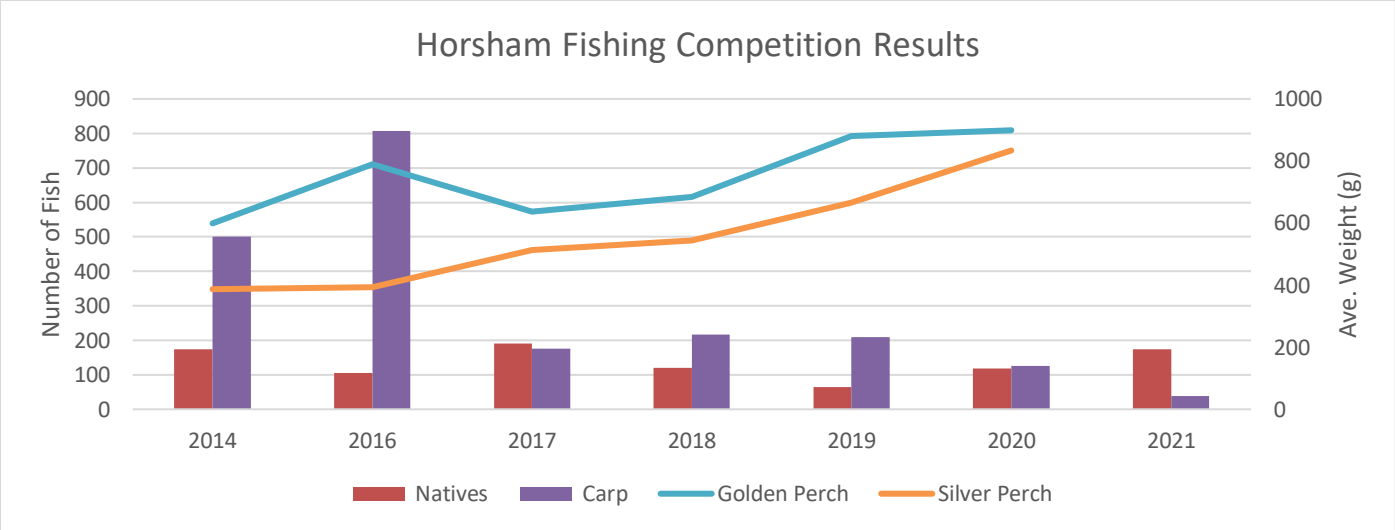


Figure 12. Native fish and carp capture numbers and average weight of stocked native fish species at the Horsham Fishing Competition

5.3.2 Ranch Billabong summary

The supply of 6 ML to Ranch Billabong in June 2020 through pumping water from the Wimmera River led continuing reductions salinity levels and a noted increase in bird activity. Salinity levels at the site were extremely high prior to the first watering in December 2018 (21,900 µS/cm) and have steadily decreased after successive watering events to 3,450 µS/cm in places in October 2019, which was slightly higher than the adjacent river (≈2000 µS/cm). The watering in June 2020 again helped to supress salinity levels again. Although they have risen steadily to 7620 µS/cm by March 2021. There is continuing improvements canopy condition of River Red Gums and the appearance of water in the billabong that have been noted (Figure 13). The timing of the delivery (for winter) has been noted with enhancing mudflat plant species outcomes (e.g. Old Man Weed/Sneezeweed) which are valued at this sight given its cultural significance.

Figure 13. Ranch Billabong December 2018 (left) and October 2020 (right) (Photo: B Muir).

5.3.3 MacKenzie River summary

Conditions for the MacKenzie River similar to those seen since 2018-19 but slightly drier again with insufficient runoff to provide unregulated flows into Reach 3 (apart from approximately 70 ML in October), with all flows provided by regulated releases (Figure 14). Given the precarious state of Lake Wartook with respect to water availability over coming years if conditions remain dry, it was necessary to maintain the drought refuge management approach developed in early 2019. After spilling in 2017, three very dry years means that it is still at the lowest levels since the Millennium Drought (Figure 16), with levels in 2020 mirroring what was observed in 2019. A short spell of wet weather from mid August to mid October was sufficient to avoid the need for greater restrictions to be applied for consumptive and environmental water use from Lake Wartook. It is critical that there is sufficient water available for flows to protect the extremely fragile and important platypus and native fish populations. It is also the main water supply for Horsham, Natimuk and Supply System 6 of the Wimmera Mallee Pipeline.

The refuge pools in the lower MacKenzie River remained at suitable levels through winter and early spring due to the low evaporative losses and rain on the pools. As conditions became warmer and drier after the rain in mid-October, releases commenced periodically from Distribution Heads to top up the pools. Unregulated flows from local runoff and transfers to deliver water from Distribution Heads were sufficient to maintain conditions in the mid-MacKenzie River through to late November when releases took place to target refuge pools in the lower MacKenzie River and Burnt Creek.

There are three priority refuge pools in the lower MacKenzie River, the two upstream pools are comparatively close to Distribution Heads and have been targeted for more regular environmental watering (Figure 15) . The most downstream one (at the McKenzie Creek Reserve Gauge) (Table 16) requires a lot more water to reach so only receives occasional top ups every few months with a flow in October 2020, intended to maintain aquatic and fringing vegetation being the last occasion. However, it is the largest, deepest and holds water much better due to the base being rock instead of clay/sand. From an operational perspective, flows for the MacKenzie River from Dad and Dave were again combined with periodic transfers for the Brimpaen Storages to share losses given the high instream losses noted in this reach now, presumably due to a sand slug washing in to the river at Wartook from Chinaman's Creek following the 2014 bushfires and 2016 floods.

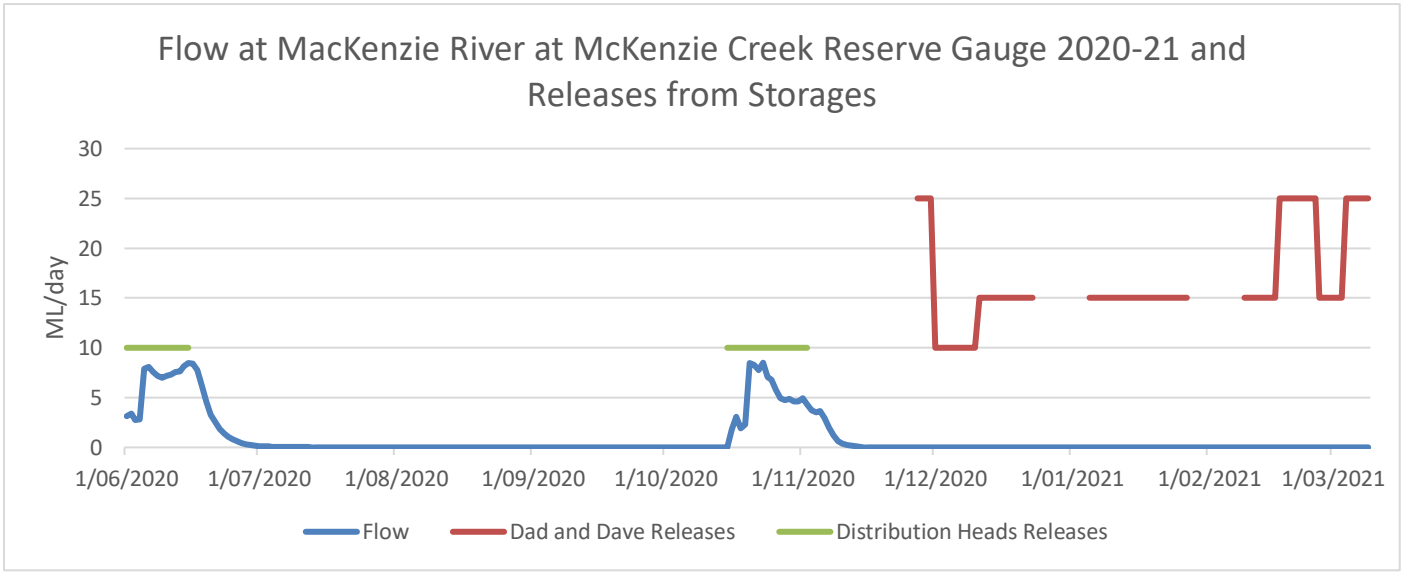


Figure 14. Flow summary for Reach 3 of MacKenzie River at McKenzie Creek Reserve stream gauge (415451).

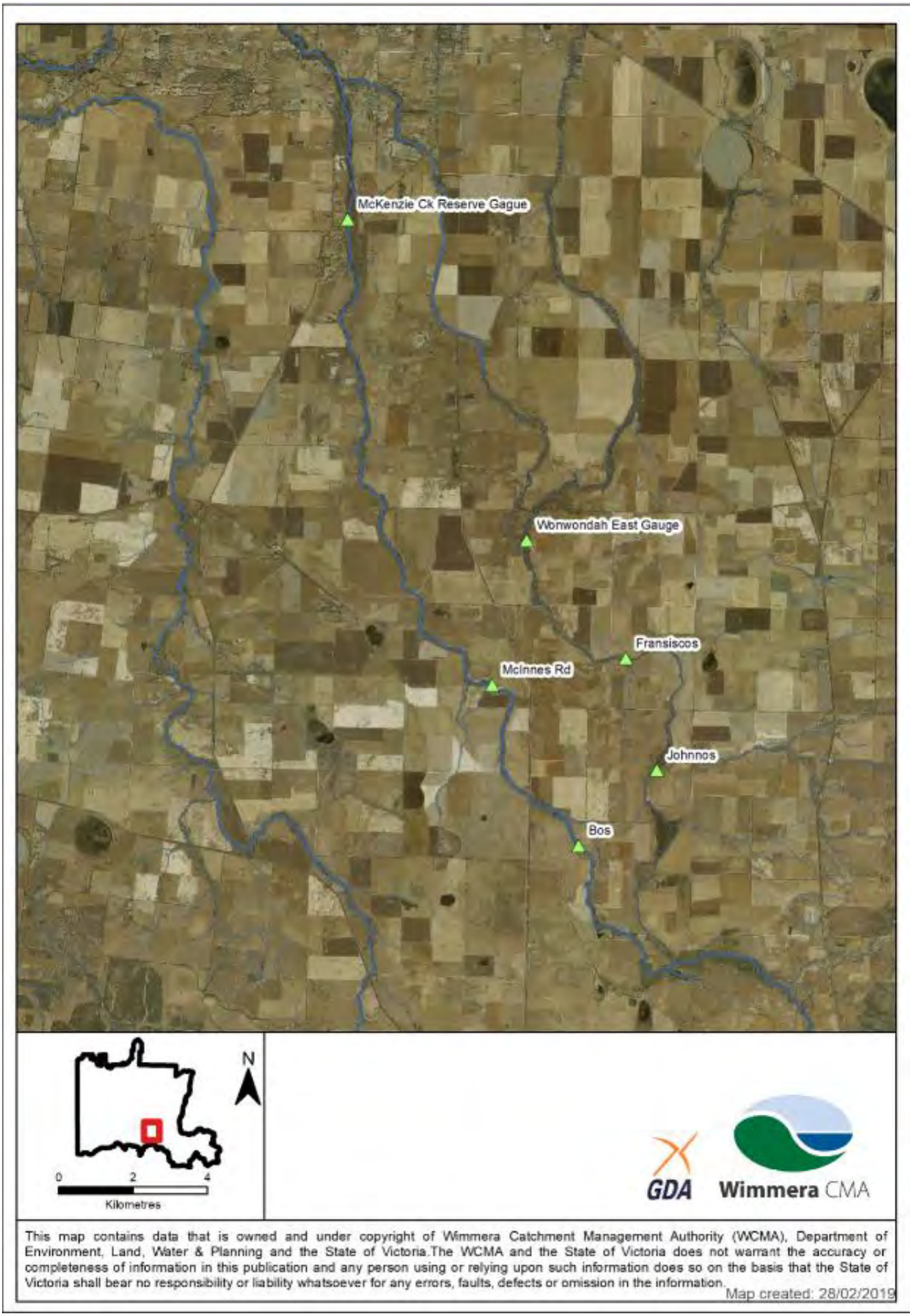


Figure 15. Refuge Pool locations on the lower MacKenzie River and Burnt Creek.

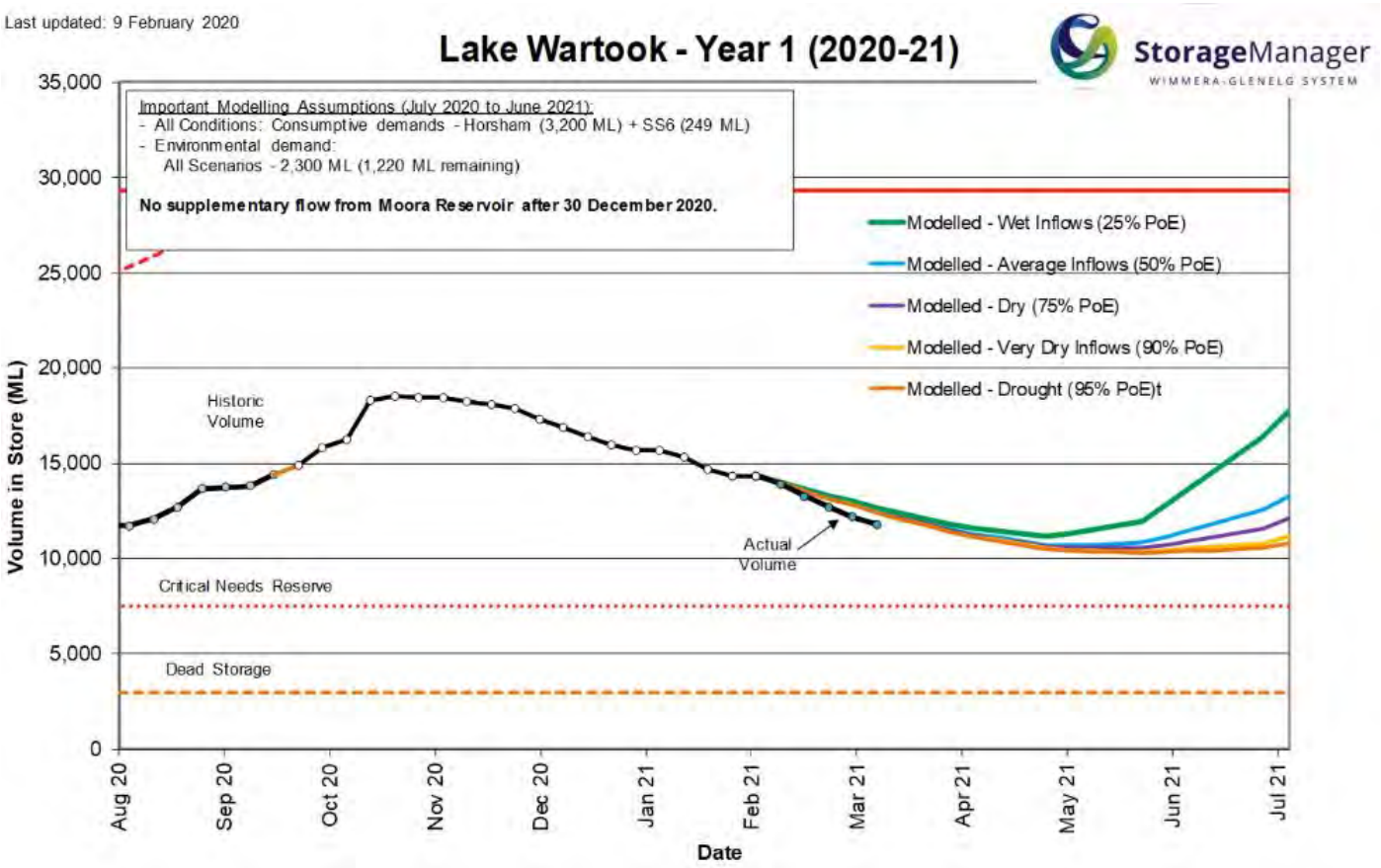


Figure 16. Storage levels for Lake Wartook 2020-21, including forecast levels from March 2021 based on a range of inflow scenarios (Source: Storage Manager, Wimmera-Glenelg System)

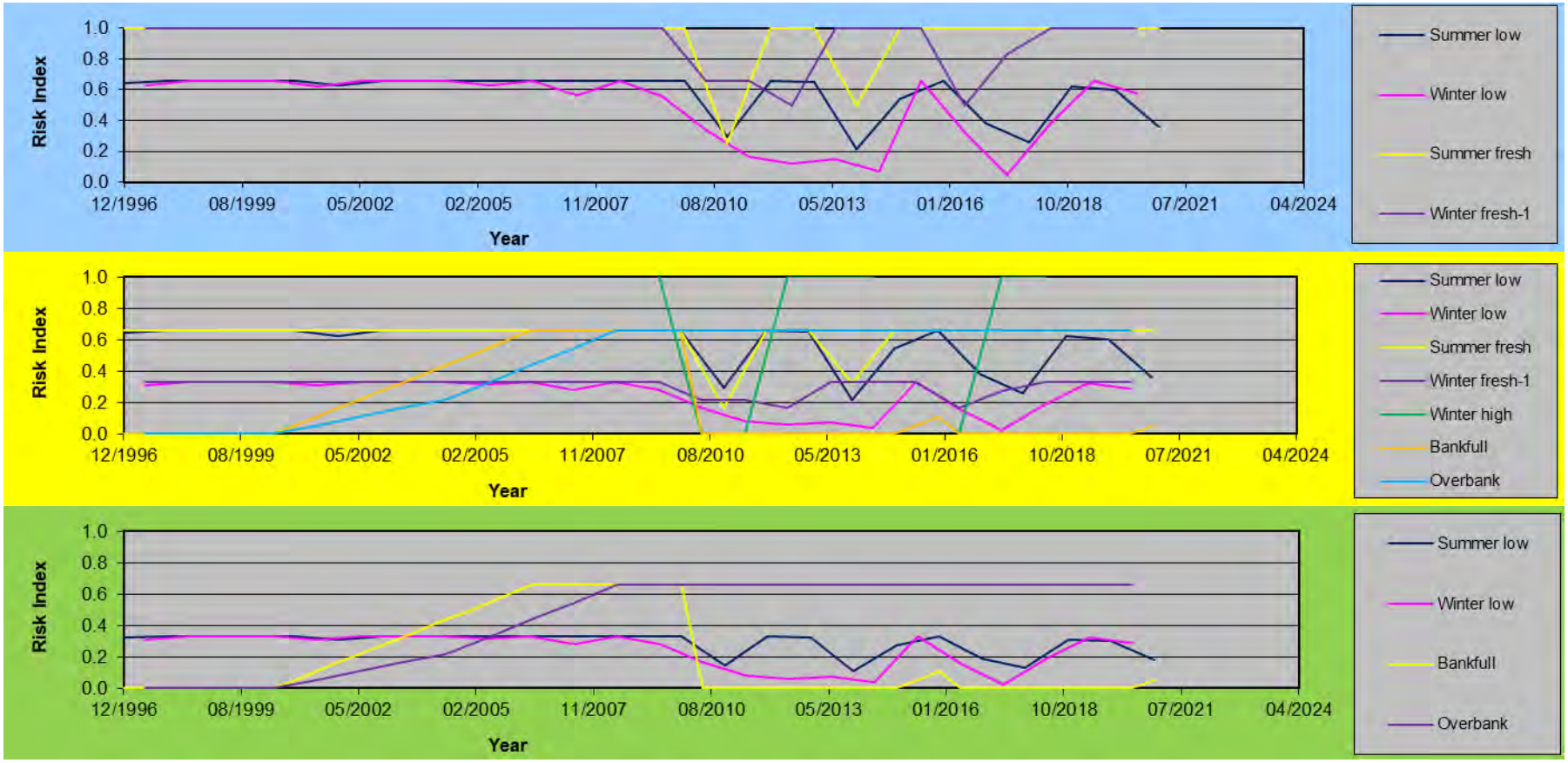
Table 16. Summary of Priority Watering Actions (PWA) delivered for Reach 3 of the MacKenzie River.

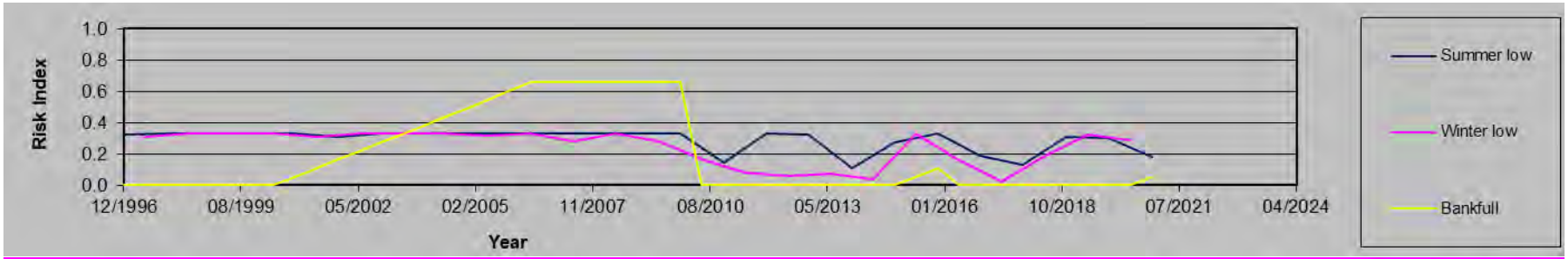
PWA delivered for Reach 3 MacKenzie River	Flow magnitude/ duration/ frequency	Comment
Baseflows	10 ML/d or natural	Dry conditions have prevented this with almost no unregulated flows and limited volumes in Lake Wartook/Moora Reservoir.
Summer/Autumn freshes	35 ML/d 2-7 days x 3 - 4	Not an objective given the low levels in Lake Wartook and preference is to conserve volumes for flows in future years.
Winter/Spring freshes	35 ML/d 2-7 days x 5	Not an objective given the low levels in Lake Wartook and preference is to conserve volumes for flows in future years.
Winter/Spring freshes	190 ML/d 1-2 days x 1	Unregulated flows insufficient to provide component. (Not regulated water objective unless unregulated component is large given capacity constraints)
Winter/Spring freshes	500 ML/d 1 day x 1	Unregulated flows insufficient to provide component. (Not regulated water objective). Average to wet years only.
Anytime bankfull	1,000 ML/d 1 day x 1	Unregulated flows insufficient to provide component. (Not regulated water objective). Wet years only

Southern Pygmy Perch – MacKenzie River at McInnes Road, Wonwondah, November 2020

Risks to ecological and physical objectives for the MacKenzie River Reach 3 is included in Table 17 below. The high risks that exist for most values are in response to the lack of flows that are due to the current low water availability in Lake Wartook and need to focus on retaining volumes for refuge pool watering should 2021 be dry.

Table 17. Risk indices for Fish (blue), Macroinvertebrates (yellow), Vegetation (green), Geomorphology (grey) and Water Quality (pink) for MacKenzie River Reach 3.





Ecology Australia staff Chris Bloink and Bryce Halliday surveying the refuge pool on the MacKenzie River at McInnes Road, November 2020

Platypus Surveys
Platypus monitoring for the MacKenzie River was planned to take place in spring 2020 in the hope of capturing juvenile platypuses born in late 2019, however due to COVID-19 restrictions this did not occur and no community observations were noted in the MacKenzie River on the platypusSPOT app in 202/21. However monitoring work is planned for autumn 2021 to build on the comprehensive data set that exists. The successful role of environmental watering in the expansion of the MacKenzie River platypus population has received widespread attention (see links below) and Wimmera CMA staff are working in with DELWP to develop actions for their recovery given their new status as a threatened species in Victoria.

https://www.smh.com.au/environment/conservation/victorians-urged-to-help-scientists-count-vulnerable-platypuses-20210113-p56tt5.html
https://www.facebook.com/9NewsWesternVictoria/videos/1210006619413529

Ecology Australia Dry Conditions Planning Surveys
Ecology Australia undertook rapid fish surveys, revisiting three identified refuge pool sites surveyed in 2019 in November 2020 (Figure 15). Modest numbers of native species were found at the two most upstream sites (near the Bos and McInnes Rd sites) that were the target of releases over the previous two years (Table 18). However, this was not the case at the McKenzie Creek Reserve Gauge refuge pool (near the downstream McKenzie Creek Reserve Road) which was not able to be watered regularly with only tadpoles found. Western Swamp Crayfish were again found at the most upstream refuge pool on the MacKenzie River (Ecology Australia, 2021). Unfortunately there is a declining trend in Catch Per Unit Effort (CPUE) which is indicative of suboptimal conditions given they have only received periodic top ups since 2018 with large fluctuations of water levels and likely high predation by Redfin and herons due to the confined nature of these pools with only limited habitat from snags and aquatic vegetation.

Table 18. Survey results for rapid fish surveys at refuge pools on the MacKenzie River (Ecology Australia, 2019)

Site		Obscure Galaxias		Southern Pygmy Perch		Western Swamp Crayfish	
		Numbers	**CPUE**	**Numbers**	**CPUE**	**Numbers**	**CPUE**
Lower	**1/19**	**5**	**0.50**	**3**	**0.3**	**0**	
	6/19	**1**	**0.76**	**2**	**0.14**	**0**	
	11/20	**0**		**0**		**0**	
Mid	**1/19**	**7**	**0.70**	**47**	**4.70**	**0**	
	6/19	**0**		**39**	**3.90**	**0**	
	11/20	**0**		**16**	**0.8**	**0**	
Upper	**1/19**	**24**	**2.40**	**42**	**4.20**	**1**	**0.10**
	6/19	**6**	**0.60**	**24**	**2.40**	**3**	**0.30**
	11/20	**5**	**0.33**	**21**	**1.4**	**1**	**0.067**

5.3.4 Burnt Creek summary

Regulated releases were not required during most of winter due to wet conditions meaning that runoff from the MacKenzie River downstream of Lake Wartook was being transferred via Burnt Creek to Taylors Lake. This continued through the rest of winter and into mid spring however (like 2018 and 2019) volumes were again very low (Table 19). One flow briefly in mid-October provided the winter/spring fresh (55 ML/d), this is aligned with the recommended frequency and duration under a drought scenario (Figure 17 and Table 20). The relatively dry conditions in spring meant that regulated releases commenced in November from Distribution Heads to maintain refuge habitat in thethree refuge pools in the upper Burnt Creek.

Table 19. Flows during winter/spring for the Burnt Creek at Wonwondah East (415223)

Year	2016	2017	2018	2019	2020
Winter/Spring Flow (ML)	20833	4767	2110	2819	1860

No attempts were made to use environmental water to provide recommended flows beyond the provision of drought refuges for high value fish and crayfish species based on the recommendations of Ecology Australia (2019). It should be noted that some flows were at such low rates that they seeped through the flow measurement control weir and so would not have been recorded. Releases during February and March were sufficient to enable flows to reach the lower Burnt Creek. This helped reduce the decline of fringing and riparian vegetation in the lower Burnt Creek.

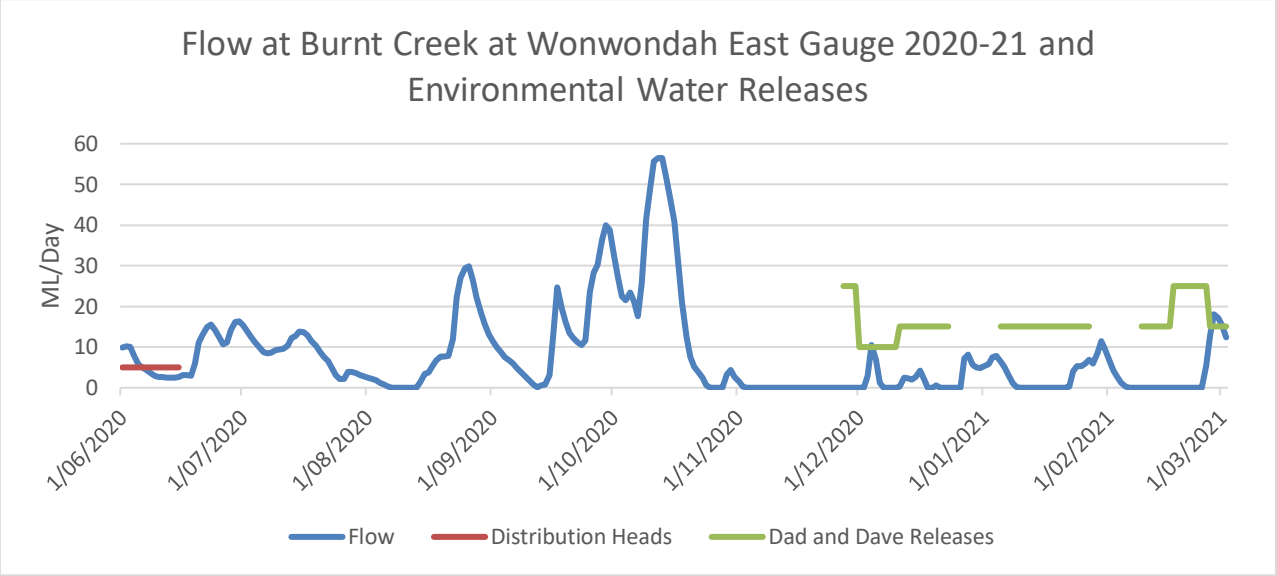


Figure 17. Burnt Creek streamflow at Wonwondah East gauge (415223) and environmental water releases at Distribution Heads and Dad and Dave Weir.

Table 20. Summary of Priority Watering Actions (PWA) delivered for upper Burnt Creek recorded at the Wonwondah East gauge (415223).

PWA delivered for upper Burnt Creek	Flow magnitude/ duration/ frequency	Comment
Baseflow all year	1 ML/d	Delivered mostly by unregulated flows from June until regulated releases started in November. Cease to flow duration has been greater than recommended due to focus on drought refuge management.
Summer/autumn freshes	30 ML/d 3-7 days x 3	Not an objective this year due to low water availability in Lake Wartook
Winter/spring freshes	55 ML/d 3-7 days x 1-5	Unregulated flows achieved the one fresh recommended under a drought scenario.
Winter/spring freshes	160 ML/d 1-3 days x 1-3	Unregulated flows insufficient to provide component. (Not regulated water objective). Dry-Wet years only.
Any time bankfull	400 ML/d 2 days x 1	Unregulated flows insufficient to provide component. (Not regulated water objective). Ave-Wet years only.
Overbank	1,000 ML/d 1 day x 1	Unregulated flows insufficient to provide component. (Not regulated water objective). Wet years only.

Ecology Australia Dry Conditions Planning Surveys

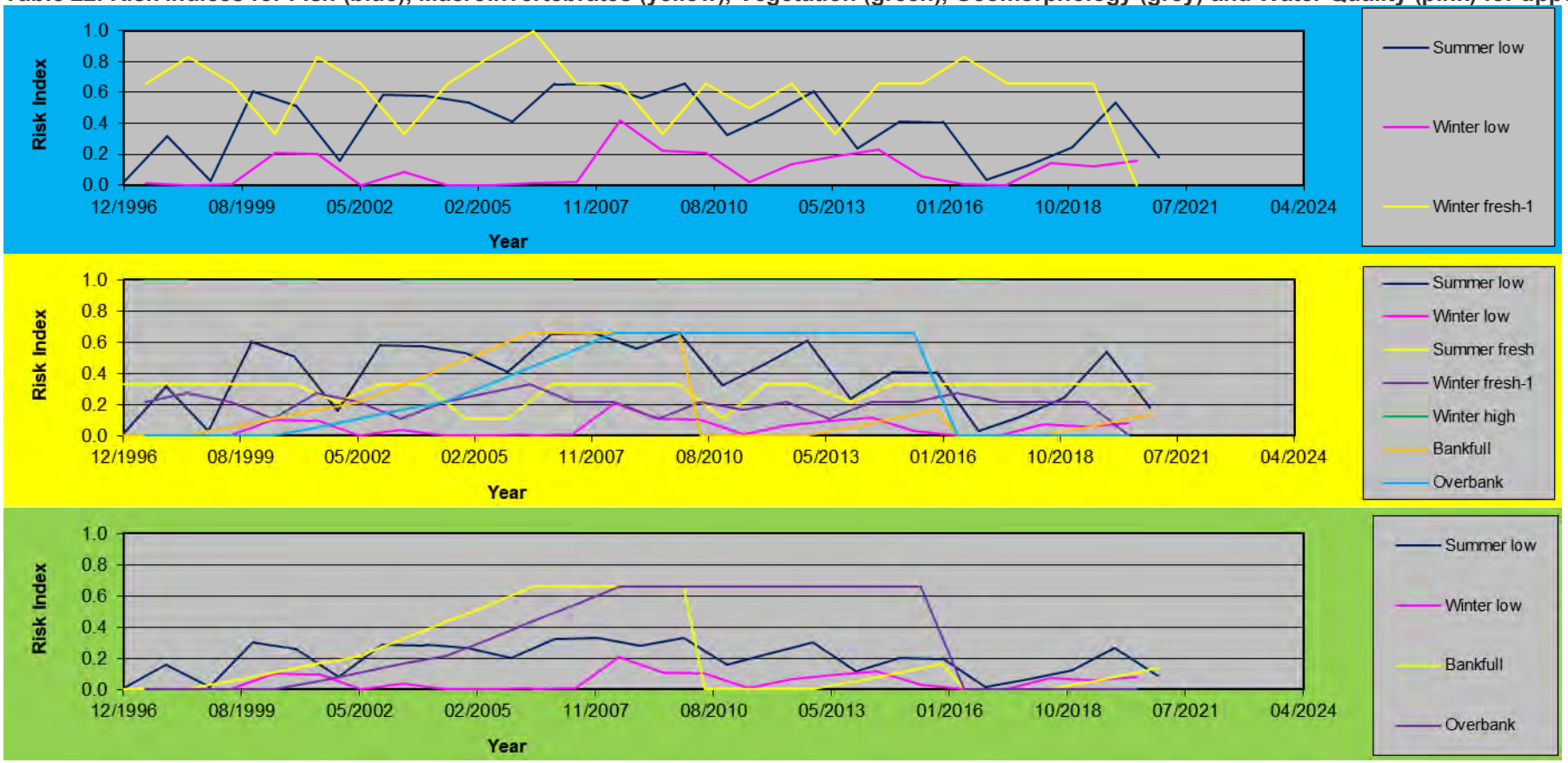
As discussed in Section 5.3.2, Ecology Australia undertook rapid fish surveys in November 2020 in the upper Burnt Creek to ascertain the location and value of refuge pools. In contrast to the MacKenzie River refuge pool results, it appears that the priority species populations are remaining fairly steady (Table 21) and they were captured at each site. This is presumably due to the more continuous flows that took place along this reach which maintained water levels and higher proportion of aquatic vegetation to provide better habitat. The high numbers of Southern Pygmy Perch as well as evidence of recruitment of Western Swamp Crayfish were particularly pleasing outcomes given the circumstances.

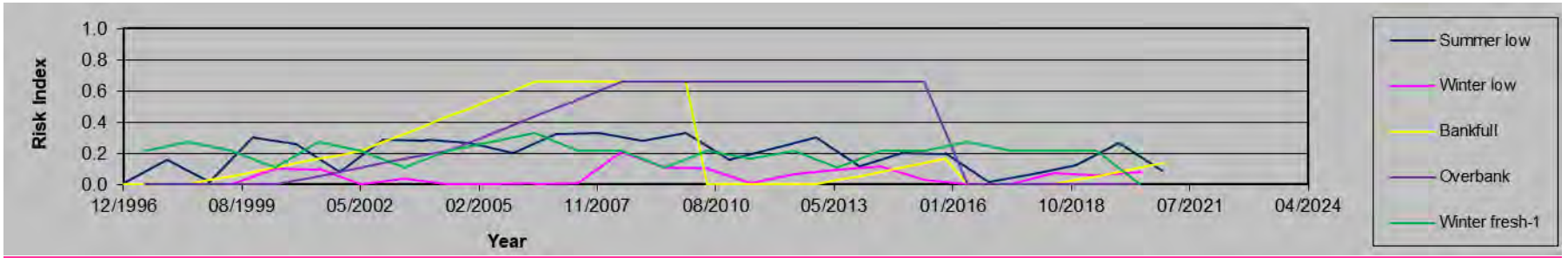
Table 21. Survey results for rapid fish surveys at refuge pools on the Burnt Creek (Ecology Austalia, 2021)

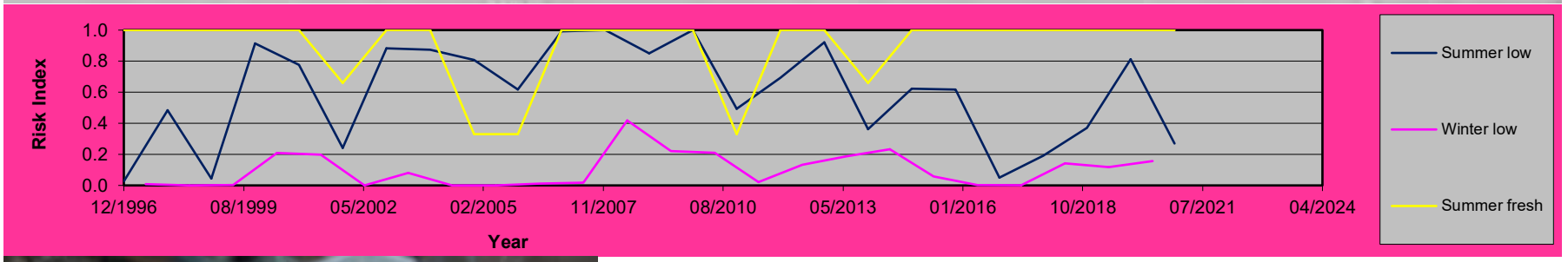
Site		Obscure Galaxias		Southern Pygmy Perch		Western Swamp Crayfish	
		Numbers	**CPUE**	**Numbers**	**CPUE**	**Numbers**	**CPUE**
Lower	**1/19**	**1**	**0.40**	**24**	**9.60**	**5**	**2.00**
	6/19	**10**	**1.00**	**29**	**2.90**	**1**	**0.10**
	11/20	**2**	**0.20**	**25**	**2.50**	**2**	**0.20**
Mid	**1/19**	**3**	**0.30**	**453**	**45.30**	**3**	**0.30**
	6/19	**0**		**105**	**5.25**	**0**	
	11/20	**13**	**1.04**	**226**	**18.08**	**10**	**0.80**
Upper	**1/19**	**2**	**0.20**	**255**	**25.50**	**3**	**0.30**
	6/19	**1**	**0.77**	**95**	**7.38**	**1**	**0.77**
	11/20	**21**	**2.10**	**380**	**38.00**	**1**	**0.10**

Risks to ecological and physical objectives for the Upper Burnt Creek is included in Table 22 below. The results highlight either a maintenance or slight increase of risks to ecological objectives despite the prevailing dry conditions.

Table 22. Risk indices for Fish (blue), Macroinvertebrates (yellow), Vegetation (green), Geomorphology (grey) and Water Quality (pink) for upper Burnt Creek.







Western Swamp Crayfish in berry and juvenile Western Swamp Crayfish, Burnt Creek, Wonwondah, November 2021 (Photo: B. Halliday)

5.3.5 Bungalally Creek summary

No regulated environmental flows were delivered to Bungalally Creek in 2020-21, which means its last flow was in June 2018 when Burnt Creek flows reaching the Toolondo Channel were routed to the Bungalally Creek The creek typically has a very small, shallow channel which does not retain water well, preventing the establishment of fish populations. Unfortunately, it is unlikely that there will be sufficient volumes to provide flows prior to June 2021 due to the low volumes in Lake Wartook and need to conserve volumes for higher priority flows should 2021 be dry. There is no stream flow monitoring available on Bungalally Creek.

5.3.6 Mt William Creek summary

Regulated releases were not initially required for Mt William Creek given the unregulated flows coming from the creeks flowing from the north-eastern edge of the Grampians (e.g. Briggs Creek, Mud Hut Creek). The rocky catchment of the northern Grampians means that it is relatively responsive to rainfall events as opposed to the upper Mt William Creek which has a catchment of agricultural land and the eastern edge of the Grampians. Although anectdotally runoff volumes appear to be affected by bushfire regrowth and waterway scouring following floods. The streamflow gauge is located at the very upstream end of this reach, immediately below the reservoir and so flows measured there do not factor in these contributions. However a Portable Automated Logger System (PALS) Unit located downstream at Roses Gap provides water level and salinity data after most tributaries have entered the Mt William Creek (Figure 18). Figure 19 shows the flows at Lake Lonsdale Tailgauge in response to passing flows as well as flows at Mokepilly which is unregulated given it is immediately upstream of Lake Lonsdale (see also Table 24). It highlights the very dry conditions that have affected this part of the catchment which have resulted in Lake Lonsdale reaching very low levels which in turn results in very poor water quality (high levels of salinity and nutrients).

As in past years, salinity levels were very low when unregulated flows were happening but rose very steeply when passing flows and regulated releases commenced for the Wimmera River via the Mt William Creek as unfortunately water quality in Lake Lonsdale is much poorer than that coming from streams flowing from the Grampians. A volume of passing flows (440ML) accrued over winter/spring was mostly released into the creek in December to refill refuge pools after natural flows ceased in October. Whilst it was able to achieve this and lifted water levels by a meter at Roses Gap, it was noted to increase salinity levels approximately tenfold (about 200 µS/cm to 2000 µS/cm).

Environmental water delivery in the Mt William Creek continues to be problematic. Following the cessation of the passing flow in late December, a number of dead fish (Australian Smelt, Obscure Galaxias, Redfin), yabbies and turtles were noted on the concrete apron and adjacent rockwork immediately below the lake outlet. It is presumed that the fish and yabbies were stranded after moving upstream from the deep pool immediately downstream, unable to move into the lake due to water velocities. The turtles may have also been trapped in the outlet pipes by a grate installed to prevent human entry. Given there were no other deaths of fish/yabbies/turtles noted anywhere along the creek it is assumed that this is attributable to the configuration of infastucture (acting as a partial fish ladder but not enabling passage into the lake). This recent incident follows a small fish death event in the Mt William Creek in autumn 2019 (a handful of dead carp) and blue green algal blooms in early and late 2020 that are indicative of systemic poor water quality in the system.

Releases are planned to take place in March for the upper Mt William Creek given the dry conditions in the upper Mt William Creek with fish monitoring works to determine the effectiveness of watering. This is via the outlet from Fyans Outlet Channel. Mild weather and heavy rain in summer 2020-21 meant that it was able to receive a small natural flow at the end of January which topped up the refuge pool and so the large beds of water ribbons (*Cycnogeton sp*) have remained inundated, providing good habitat for small-bodied native fish. Monitoring at the pool in March 2020 highlighted the continued decline of priority fish populations with no Southern Pygmy Perch noted there again (like May 2019) and comparatively high numbers of Redfin and Goldfish (it appears that spring 2019 was a successful breeding event for Goldfish) (Table 23). Redfin predation and limited habitat availability during the breeding season (September – January) due to uncontrolled grazing and fluctuating water levels appear to be affecting Southern Pygmy Perch numbers. Although spring surveys have been recommended to provide a better opportunity for understanding total fish abundance and other responses (e.g. recruitment) (Austral, 2020).

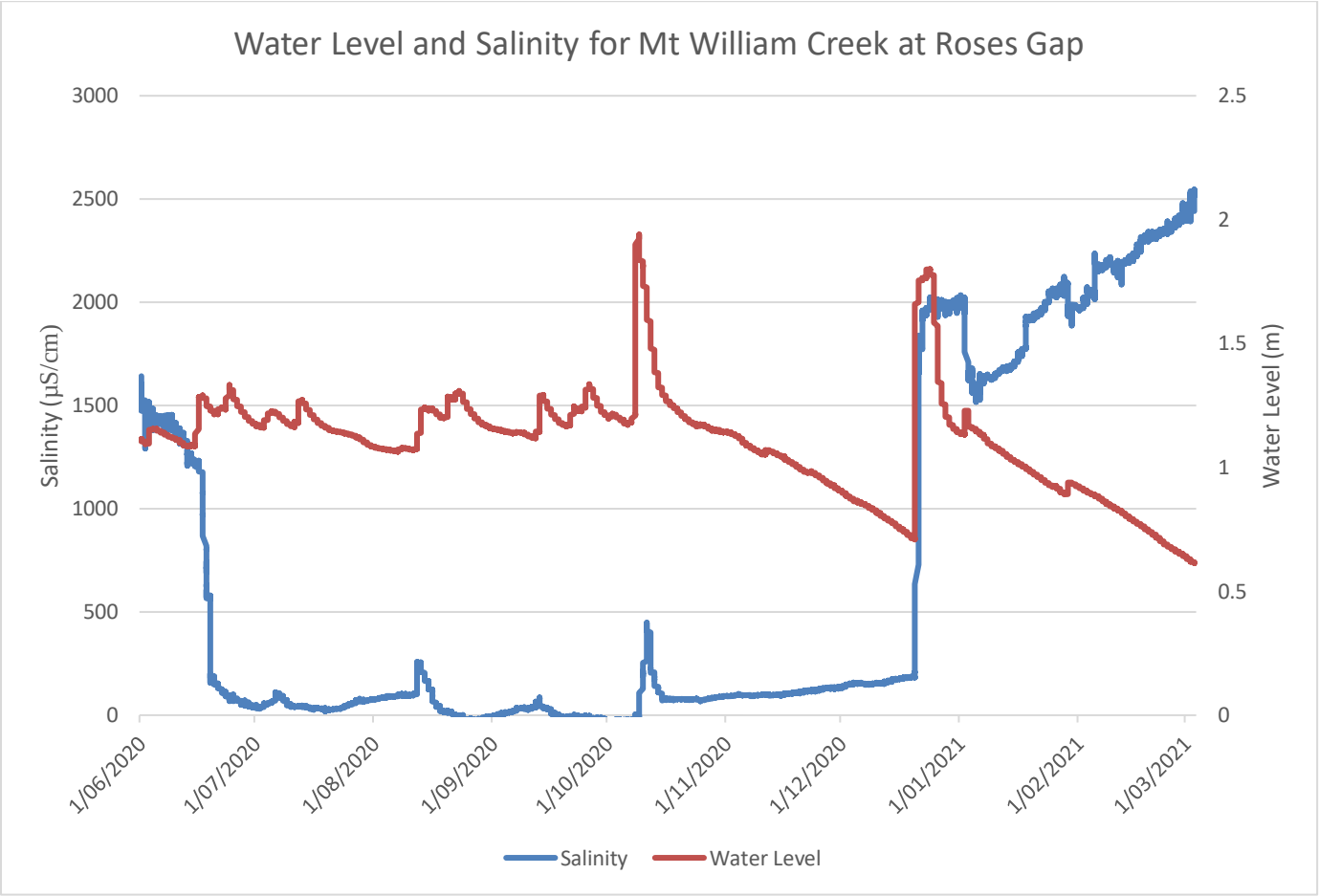


Figure 18. Mt William Creek water levels and salinity at Roses Gap

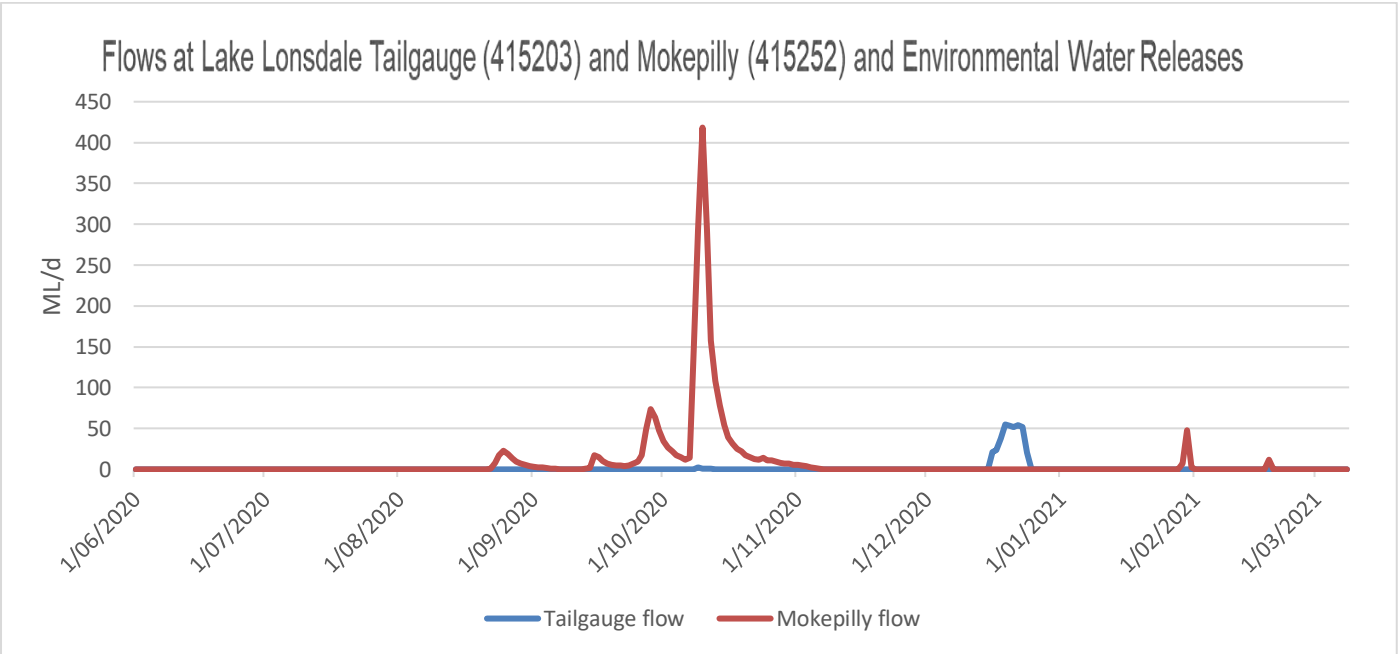


Figure 19. Mt William Creek streamflows (Mokepilly - 415252) and passing flows delivered (Lake Lonsdale Tailgauge – 415203)

Table 23. Results for fish surveys at Mt William Creek Refuge Pool (Austral, 2020)

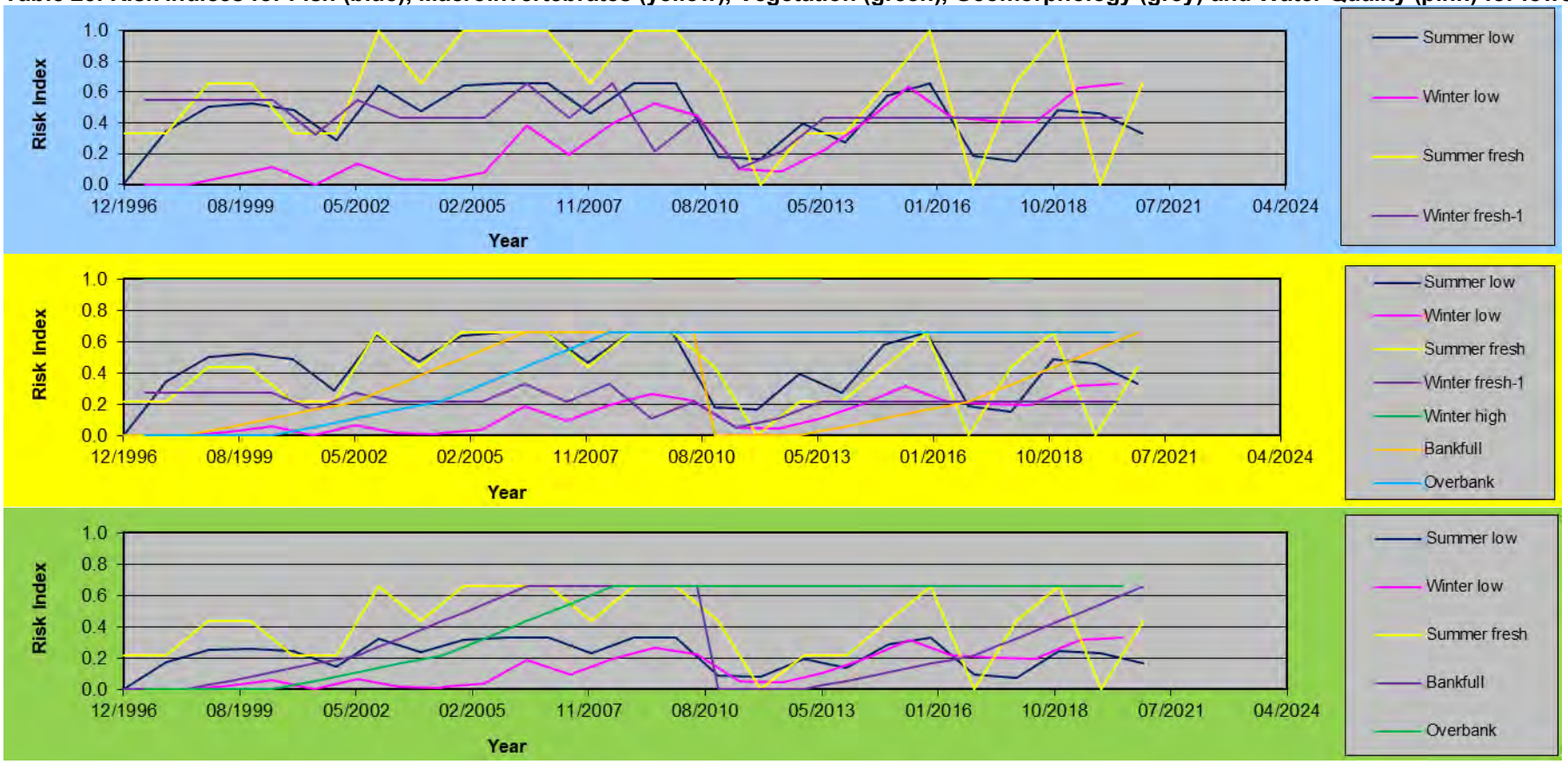
Common Name	Species Name	Previous Surveys				Current	Total
		4/2015	10/2015	2/2019	5/2019	3/2020	
Native Species							
Common galaxias	*Galaxias maculatus*	3		2		7	12
Flatheaded gudgeon	*Philypnodon grandiceps*	79	57	6	3	41	186
Carp gudgeon	*Hypseleotris klunzingeri*	8	19				27
Southern pygmy perch	*Nannoperca australis*	72	46	1			119
Australian smelt	*Retropinna semoni*	2	25			1	28
Introduced							
Gambusia	*Gambusia holbrooki*	100	4	5			109
Goldfish	*Carassius auratus*	19	1	27	4	287	338
Common carp	*Cyprinus carpio*			1			1
Redfin perch	*Perca fluviatilis*	40	2	19	13	26	100
Total		**323**	**154**	**61**	**20**	**362**	**920**
Aquatic invertebrates							
Common yabby	*Cherax destructor*	1	7	2		1	12

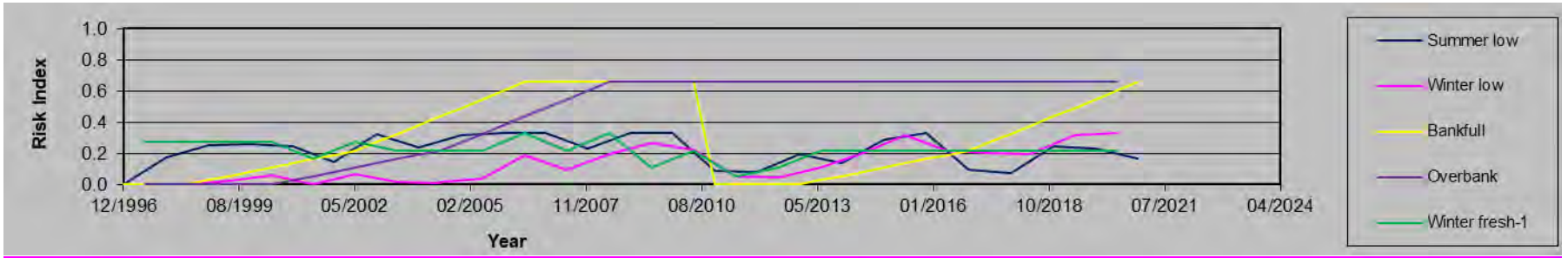
Table 24. Summary of Priority Watering Actions (PWA) delivered for lower Mt William Creek recorded at the Lake Lonsdale Tail gauge (415203) and upper Mt William Creek

PWA delivered for lower Mt Wiliam Creek	Flow magnitude/ duration/ frequency	Comment
Baseflow all year	5 ML/d or natural	Unable to be provided due to low water availability in Lake Lonsdale and concerns over water quality. Some unregulated flows took place downstream of the gauge.
Summer/autumn freshes	20-30 ML/d 2-7 days x 3	One achieved via passing flows (December) the rest are unable to be provided due to low water availability in Lake Lonsdale and concerns over water quality.
Winter/spring freshes	100 ML/d 3-7 days x 1-5	Unable to be provided due to low water availability in Lake Lonsdale and concerns over water quality.
Winter/spring freshes	500 ML/d 1-3 days x 1-3	Unregulated flows insufficient to provide component. (Not regulated water objective). Dry-Wet years only.
Any time bankfull	750 ML/d 2-4 days x 1 or natural	Unregulated flows insufficient to provide component. (Not regulated water objective). Ave-Wet years only.
Overbank	1,500 ML/d 1 day x 1	Unregulated flows insufficient to provide component. (Not regulated water objective). Wet years only.
PWA delivered for upper Mt Wiliam Creek	**Flow magnitude/ duration/ frequency**	**Comment**
Refuge pool filling	N/A (150 ML total)	To take place later in March due to natural event in January refilling refuge pool.

Risks to ecological and physical objectives for the lower Mt William Creek is included in Table 25 below. The results highlight that risks are increasing due to the dry conditions although a focus on providing summer/autumn freshes will lower this risk. The risk posed by shortfalls in winter/spring low flows are not representative of the risk to the entire reach (given the gauge is immediately below Lake Lonsdale) which receives unregulated flows from tributaries like Briggs and Mud Hut Creeks.

Table 25. Risk indices for Fish (blue), Macroinvertebrates (yellow), Vegetation (green), Geomorphology (grey) and Water Quality (pink) for lower Mt William Creek.





Ibis at Mt William Creek Refuge Pool at Mokepilly, December 2020

6. 2021-22 Priority watering actions

With inflows in 2020-21 again being very low, there have been modest allocations, reaching 57% in March 2021 for the VEWH regulated entitlement. No allocation for the CEWH product can be foreseen in 2020-21 under any scenario and it would be very unlikely to receive one in 2021-22. Ongoing dry conditions since 2017 has seen a continued conservative approach to watering, congnisant of the need to set aside reasonable volumes of carryover for future years should conditions remain dry. Although there is great uncertainty about whether or not the targeted carryover volume will be achieved going into 2022-23 given the continued drawdown on available water each year since 2017. The targeted carryover volume means that drought refuge protection actions can take place intended to prevent critical losses, but they fall well below the minimum recommended watering requirements under a drought scenario. Actions like water trade or use of the Wimmera Mallee Pipeline to fill refuge pools as per the *Wimmera River Drought Refuge Management Strategy* (Alluvium, 2018) should continue to be given the utmost consideration by VEWH given the circumstances. There is ongoing work to develop management plans for these refuge pools to improve the collective understanding of the approach to and benefits from watering them.

Given at least 59,345 ML is needed to deliver all Priority Watering Actions (PWAs) for the Wimmera River system in wet conditions (not including the terminal lakes) from a combination of regulated, unregulated and passing flows, wet conditions are required to provide unregulated and passing flows as well as boost allocations to avoid shortfalls. Wet conditions also provide high flow rates (e.g. bankfull flows) that cannot be provided by regulated watering actions. Priority Watering Actions are outlined initially in Table 26 and in further detail in Appendix 4.

6.1 Wimmera River Reach 4 Priority Watering Actions

Reach 4 of the Wimmera River is a priority reach based on managing risks to environmental values and the critical role of flow in maintaining water quality for aquatic and riparian ecosystems. Delivering PWAs to this reach will also facilitate social outcomes such as fishing competitions and rowing regattas through improved water quality in town weir pools. In 2021-22 flows will be important in sustaining habitat and water quality to levels that reduce the risks of extreme events like fish deaths and major algal blooms. These events have a very high risk of occurring if priority watering actions do not take place given the relatively limited flows that have occurred since 2017. It will also help to prevent what was experienced during drought conditions in 2014 and 2015 which meant that the river did not flow beyond Dimboola for 18 months, leading to extremely high salinities and lack of habitat with all but the deepest pools drying out. The ability to provide regulated water will be critical for trying to manage potential blackwater events (such as that experienced in February 2021) and/or hypersaline conditions. The limited flows from the upper catchment since 2016 have meant that large quantities of organic material continue to build up in some areas and could create blackwater conditions again should there be a small flow from the upper catchment that can mobilise the organic matter but not provide sufficient subsequent flows to maintain dissolved oxygen levels. Likewise, with increasing salinity levels, there is a need to provide the necessary flows for adequate dilution to avoid mobilising and transporting a slug of hypersaline water downstream.

Improvements in aquatic vegetation in response to improved water quality and concerted carp removal work in recent years have been vital for maintaining dissolved oxygen levels, providing habitat and supporting species like glass shrimp which in turn have been a ready food source for small-bodied and juvenile large-bodied native fish. The relatively stable water levels and better water quality provided by environmental watering activities have also supported phytoplankton and zooplankton populations that are vital for productive food web. There is a strong expectation by communities that live near the Wimmera River for environmental watering to maintain water levels and quality which in turn provides recreational and aesthetic benefits. Flows in this reach will also assist with the planned watering of Ranch Billabong to boost riparian and wetland plant condition, in conjunction with cultural outcomes.

6.2 MacKenzie River Reach 3 Priority Watering Actions

Very high environmental values mean that the MacKenzie River lifts its priority for environmental watering. Important populations of indigenous fish species, platypuses and riparian vegetation rely on flow in the MacKenzie River to persist and disperse, especially given the fact that pools do not persist for long periods. Southern Pygmy Perch and Obscure Galaxias are clinging on in refuge pools targeted for top up flows in 2020-21.

Surveys in Reach 3 show the ongoing presence of *Flora and Fauna Guarantee Act*-listed Western Swamp Crayfish (Ecology Australia, 2019) therefore making it a priority for ongoing environmental water delivery. This crayfish species does not create its own burrows to live in when waterways dry out and so will die unless it can find a burrow created by other species (i.e. Common Yabby). Should conditions remain dry then the focus will continue to be on maintaining the refuge pools in the upper-mid section of Reach 3 through intermittent baseflows given the low volumes that may be available from Lake Wartook and Moora Moora Reservoir (Figure 16, pg. 35). Unfortunately, there are unlikely to

be sufficient volumes available to maintain shallower pools in the reach and the large refuge pool at the McKenzie Creek Reserve Gauge which is the most downstream significant refuge pool. However this pool is located in an outcropping section of sandstone and so retains water comparatively well compared to upstream pools that are underlain by sand and/or clay although surveys in 2020 indicate that the fish population has disappeared given the inability to regularly water it in 2019-20.

Should conditions improve with wet-average conditions over winter/spring 2021 then priority watering actions will revert to fulfilling environmental flow recommendations with a focus on:

- Regular freshes/baseflows over summer/autumn combined with periodic cease to flows that may be beneficial in limiting the growth of the Eastern Gambusia population in this reach (Ecology Australia, 2014). Gambusia are a small-bodied, aggressive pest fish species that compete with native fish and frog species for habitat and resources. Indications are that cease to flows are also important for the growth and recruitment of aquatic vegetation in this reach given the shallow water/mudflat habitat they provide (Chris Jones, ARI, *pers.comm.*) The cease to flows are not to be too long such that water levels decline too much particularly during September-January which are important times for Southern Pygmy Perch breeding and survival outcomes;
- A fresh in late autumn will assist in the dispersal of juvenile platypuses into this reach (Melody Serena, Australian Platypus Conservancy. *pers. comm.*) This is becoming increasingly important as platypuses appear to have fully repopulated the upstream reach;
- A six to seven day fresh has been recommended for this reach in August/September for vegetation outcomes and low flows in autumn will assist in the germination of Water Ribbons (*Cycnogeton sp.*) (Chris Jones, ARI, *pers.comm.*); and
- Winter flows are also recommended for this reach to facilitate Obscure Galaxias spawning and larval survival (Ecology Australia, 2017a).

Water quality in the MacKenzie River is typically excellent so flows in this reach are important in boosting water quality in the Wimmera River and there is typically high levels of organic matter that can be delivered to the Wimmera River as a source of carbon during the cooler months. Prior to spring 2016, due to drought conditions, Reach 3 was completely dry for almost 18 months so native fish and other water-dependent fauna populations have since recolonised parts of this reach although they are under severe pressure. Not providing water to at least protect the refuge pools in Reach 3 will eliminate these gains. The high environmental values of the MacKenzie River provide several flow-on social benefits through the numbers of people who enjoy fishing and birdwatching when environmental water releases are taking place. There was also some community outcry to the lack of flows along the lower MacKenzie River in 2019-20 with an online petition being established.

6.3 MacKenzie River Reach 2 Priority Watering Actions

The MacKenzie River Reach 2 supports the source population of indigenous fish that populate MacKenzie River Reach 3 and Burnt Creek during wet conditions. Platypuses appear to have fully recolonised this reach after disappearing in 2007 when the reach dried out. Expanding the size and spread of the threatened platypus population in the MacKenzie River is vitally important as the upper Wimmera River population is now functionally extinct (Josh Griffiths, cesar, *pers. comm.*). Also having the River Blackfish population expand along the length of Reach 2 (and ideally into Burnt Creek and Reach 3) is a long-term goal of environmental water management in this reach. Wimmera CMA is undertaking planning works to upgrade the fishway at Dad and Dave Weir to improve the ability for fish to disperse upstream and downstream from Reach 1 to Reach 2. River Blackfish remain confined to the top of Reach 2 in small numbers and so having suitable habitat for them to repopulate is important as they can rapidly recolonise areas should conditions be suitable (Zeb Tonkin, ARI, *pers. comm.*) and the good numbers in Reach 1 can make their way downstream.

Priority Watering Actions for Reach 3 typically remove the need for Priority Watering Actions for Reach 2. However if conditions are exceptionally dry and preclude delivering water to Reach 3 then small volumes will be required to support the environmental values in Reach 2.

6.4 Upper Burnt Creek Priority Watering Actions

As with MacKenzie River Reach 3, priority watering actions may be confined to drought refuge management if conditions remain dry. Refuge pools have been identified at the upper, mid and lower section of this part of Burnt Creek (Figure 15, pg. 34). With only limited volumes potentially available from Lake Wartook and Moora Moora Reservoir if conditions remain dry then the priority will be to maintain these pools through intermittent flows from late spring through to late autumn. Unregulated flows should maintain them during winter and early spring.

Should conditions improve, year-round baseflows will assist the restoration and maintenance of fish communities in the upper reaches of Burnt Creek, especially when in combination with the strong aquatic vegetation growth and recruitment observed in recent years. Populations of the *FFG Act*-listed Western Swamp Crayfish have been

identified in this reach of Burnt Creek (Biosis, 2013, Ecology Australia, 2017) and surveys in November 2020 have again found them throughout this reach. Like the MacKenzie River, this section of Burnt Creek is valued by the local community which like to see regular flows and the environmental benefits they provide.

Burnt Creek is supplied from the MacKenzie River or Moora Moora Reservoir and so is therefore highly regulated, without environmental watering the only flows taking place along this reach are typically transfers of inflows into the mid-MacKenzie River to Taylor's Lake in winter/spring. Therefore, environmental water releases will be critical to supplement these flows, especially in the drier months. During winter/spring baseflows and freshes may be provided by catchment pickup or transfers from Moora Moora Reservoir or Lake Wartook to Taylor's Lake or releases to lower Burnt Creek, particularly if conditions are average or wet. This will offset the need to make a specific release to target outcomes in the upper Burnt Creek. A two to three day fresh has been recommended for this reach in August/September for vegetation outcomes (Chris Jones, ARI, *pers. comm.*) which also aligns with the flow recommendations although this should be able to be provided by unregulated flows unless conditions are exceptionally dry. Also, as with the MacKenzie River, low flows in autumn will assist in the germination of Water Ribbons (*Cycnogeton sp.*).

6.5 Lower Burnt Creek Priority Watering Actions

Lower Burnt Creek has valuable riparian vegetation in some sections which provides important habitat for terrestrial and aquatic species. Releases in previous years have been noted to lead to enhancement in the presence of frogs and waterbirds, including one of the first discoveries of a Peron's Tree Frog in the region. Environmental water releases provide a lifeline for maintenance of its values given the complete absence of flow from this reach apart from in periods of flood due to its extremely high levels of regulation. Despite the limited flows, a reasonable diversity of native fish species was captured in this section of the creek in November 2017 which have moved downstream from the Upper Burnt Creek, indicating the potential environmental outcomes that can be achieved. Unfortunately, the absence of flows over summer meant that these fish disappeared. It is anticipated that if water availability substantially improves then these fish outcomes could then be pursued again. There is a contrast in the morphology of the lower compared to upper Burnt Creek in that it still retains a larger number of deep pools which can contain water for long periods (>1 month). However it has been noted that areas of phragmites are expanding due to the infrequent watering, meaning that water levels are not high enough for long durations to confine their growth to pool margins.

Previous fish monitoring results were fairly disappointing which is somewhat attributable to the effect of barriers to fish movement from upstream (Biosis, 2013). However, the use of an undershot weir gate to pass flows through to this reach in conjunction with a pipe outlet (instead of just the pipe outlet) seems to be improving this situation. A passing flow for the creek has been recommended as part of the review of the storage management rules which may be able to meet some PWAs when it is eventually implemented. There is a strong desire amongst adjacent landholders to see increased flows for this reach and there has been good uptake of riparian enhancement projects to increase its environmental values.

Approximately 150 – 200 ML is required to fill pools in the creek before the PWA of a bankfull flow can take place which is now able to be achieved (if water is available) due to the upgrading of an undersized culvert across the creek by Horsham Rural City Council (funded by Wimmera CMA) in 2019.

6.6 Bungalally Creek Priority Watering Actions

Bungalally Creek has riparian vegetation in some sections which provides habitat for terrestrial and aquatic species and due to high levels of regulation, it only receives flows in times of flood or environmental water releases (like lower Burnt Creek). The on-going collaboration between the Storage Manager and Wimmera CMA will be important for maximising the opportunities and outcomes from system water that can be directed to the creek if there are very wet conditions, as what happened in 2016 and 2017. A passing flow for the creek has been recommended as part of the review of the storage management rules which may be able to meet some PWAs when it is implemented. Local landholders have a strong interest in the maintenance and enhancement of its riparian ecological values. In April 2019 Horsham Rural City Council upgraded a stream crossing that may be impacted by the PWA (Earth Tech, 2006) with funding provided by Wimmera CMA. Like the lower Burnt Creek, this will reduce risks and maximise outcomes should the PWA take place.

Due to the high level of regulation of this system and the fact that it would only receive flows during high flow events, the creek bed will most probably be completely dry when watering commences. Previous experience shows that about 100 ML is required to enable this reach to be filled and connected before the PWA (bankfull flows) can be delivered.

6.7 Upper Mt William Creek Priority Watering Actions

The upper Mt William Creek supports good populations of endemic fish species and there are no European carp present in this reach due to the downstream barrier of Lake Lonsdale (Biosis, 2012). Following wet conditions in 2010-2011, several dry years caused Lake Lonsdale to dry out in 2015. Good inflows in 2016 led to it reaching its maximum operating level but water levels have been steadily declining since then with the lake only being 8% of the maximum operating level in March 2021 and so is likely to dry out completely in coming months. The small section of the creek upstream of Lake Lonsdale at Mokepilly can provide crucial drought refuge for endemic fish species although its values are diminishing on the back of a series of dry years impacting on habitat and recruitment. Protection of fish habitat in this reach with summer-autumn flows is considered important for maintenance of the fish community in this reach (SKM, 2005). The fish community in this reach in turn replenishes Lake Lonsdale during wet years, which like many lakes in the district provides a significant drawcard for anglers. With a dry or almost dry Lake Lonsdale, this PWA may be required if again winter/spring proves to be dry.

A regulator has been constructed to deliver water to this location in early 2017, prior to this pumping or temporary structures were required to provide water to the refuge pools in this reach although wet conditions in February 2021 removed the need for this PWA. The PWA has not related to a flow rate but rather topping up refuge pools to ensure that they provide meaningful habitat. This has been successfully undertaken in the past, triggering Southern Pygmy Perch breeding events (Austral, 2016).

6.8 Lower Mt William Creek Priority Watering Actions

Maintenance of intact native fish populations in the lower Mt William Creek in order to facilitate dispersal to the Wimmera River is considered important, as is the need to provide flushing flows to prevent major declines in water quality (salinity) and habitat availability. The creek has had a fish population that is almost unique in the Wimmera with a mix of species that are found in more headwater streams (Southern Pygmy Perch, Obscure Galaxias, River Blackfish) with lowland species (Golden Perch, Flathead Gudgeons, Australian Smelt). Monitoring results are highly variable from year to year which are potentially indictive of the importance of the emigration of species from upstream and downstream and challenges with sustaining meaningful fish populations in this reach over a series of years given the vast fluctuations with water quality and water availability. Unless 2021 is a very wet year, there is a prospect that Lake Lonsdale will dry out or be at such low levels that PWAs from this source are not feasible in 2021-22, as they were in 2020-21.

The ongoing challenge is to balance the provision of habitat with the fact that environmental water supplied is typically much poorer quality than the receiving waters, especially with Lake Lonsdale at low levels. Unregulated flows from the northern Grampians during winter/spring have typically excellent water quality with salinity levels about 10% that of those in Lake Lonsdale. There are concerns about the impact of poor water quality on fish populations in this reach given impacts in the last few years like blue green algal blooms and fish death events. Also compounding this is the periodic use of flows from Lake Lonsdale to provide demands for the Wimmera River and also during a series of dry years the lake dries out (such as is likely in 2021) which prevents flows for this reach. Infrastructure configurations (high rates of leakage) prevent releases from Lake Bellfield from being an adequate backup option. This means the delivery of environmental water for the Upper Mt William Creek becomes even more critical.

This reach also contains very high value macroinvertebrate and vegetation communities given it flows through or near large tracts of public land, particularly the Grampians National Park. The presence of Lake Lonsdale at the top of this reach and historical diversions for consumptive supply means that this reach has been one of the most flow-stressed in all of Victoria (SKM, 2005a). A week-long fresh has been recommended for this reach in August/September to achieve vegetation outcomes (Chris Jones, ARI, *pers. comm.*) which also aligns with the flow recommendations. Also low flows in autumn will assist in the germination of Water Ribbons (*Cycnogeton sp.*). This reach also flows through the locality of Dadswell's Bridge which has made a concerted effort to improve the community benefits of the creek through construction of a heritage walking trail focussing on the creek.

Typically there have been opportunities to achieve these PWAs through passing flows or regulated releases from Lake Lonsdale to meet objectives in the lower Mt William Creek and Wimmera River. However this has not always been the case, especially under ongoing dry conditions and shifting operational arrangements. Therefore there is a need to specify specific PWAs for this reach given demands for the Wimmera River are more likely to be provided from Taylor's Lake given the low levels and poor water quality in Lake Lonsdale.

6.9 Ranch Billabong Priority Watering Actions

Four watering events in December 2018, March and October 2019 and June 2020 were successful in terms of raising water levels and significantly dropping salinity. It also led to a rapid responses from frogs and waterbirds. The salinity levels rise in the months after water was supplied and so additional watering events are recommended to further dilute salinity levels and provide suitable habitat for frogs and ducks. The watering will also lead to continued improved health of River Red Gums currently experiencing stress from the dry conditions and saline water remaining in the billabong. It will also lead to improved conditions for culturally significant vegetation species like Old Man Weed/

Sneezeweed (*Centipeda cunninghamii*) and improve the appeal of the site which is a focus for onground works (weed removal and creation of walking trails and board walks) by Barengi Gadjin Land Council in 2021.

6.10 Dock Lake Priority Watering Actions

Successful outcomes such as Whiskered Tern and other waterbirds breeding following the water provided to the lake by unregulated flows/spills in spring 2016 indicates the value of Dock Lake becoming a PWA in line with the environmental flow study for the lake (Jacobs, 2015). Given the episodic nature of wetland watering in the Wimmera, and the low water availability leading into 2021-22 the PWA only applies during wet conditions. Environmental water delivery would need to ensure that Green Lake (through which water must be routed to reach Dock Lake) would not increase in volume as a result with water being outfalled at the same water level when inflows commence. This currently requires Green Lake to be nearly full, given the outfall at lower lake levels has silted up as it has not been used as a water supply storage for decades. Green Lake is likely to have high water levels in wet conditions from inflows from its own catchment and Storage Manager operations to protect water quality in Taylor's Lake. However, as of March 2021 Green Lake is at very low levels, having not received any meaningful inflows since 2019.

Lower Burnt Creek at Bungalally (Dingley Dell) (February 2021)

7. Scenario Planning

Table 26. Summary of the Wimmera System environmental conditions, ecological objectives and environmental water requirements under a range of climatic (inflow) scenarios. Probability of Exceedance (POE) indicates likelihood of inflows being less than the % indicated based on historic inflows (e.g. a 95% Probability of Exceedance year means 95% of years will have greater inflows).

Wimmera River System	EXTREME DROUGHT 95% POE	VERY DRY 90% POE	DRY 75% POE	AVERAGE 50% POE	WET 25% POE
Allocation against environmental entitlements (VEWH shared with Glenelg and not including Glenelg compensation flow)	November VEWH Allocation 0 ML (0%)*	November VEWH Allocation 4,056 ML (10%)	October VEWH Allocation 17,035 ML (42%)	November VEWH Allocation 30,826 ML (76%)	November VEWH Allocation 40,560 ML (100%)
	October CEWH Allocation 0 ML	CEWH Allocation 0 ML	CEWH Allocation 0 ML	CEWH Allocation 0 ML	CEWH Allocation 0 ML
	VEWH Carryover 21,400 ML, CEWH Carryover 0 ML				
	Spill loss 0 ML	Spill loss 0 ML	Spill loss 0 ML	Spill loss 0 ML	Spill loss 0 ML
	Total Available 21,400 ML	Total Available 28,046 ML	Total Available 38,435 ML	Total Available 52,226 ML	Total Available 61,960 ML
Assumed available to the Wimmera allowing for carryover in 2022-23	6,700 ML	7,728 ML	11,718 ML	16,113 ML	18,980 ML
Expected climatic conditions and water available	Effectively no unregulated or passing flows (< 1000 ML total flows at Glenorchy)	Very little unregulated flow (~ 2000 ML for the Wimmera River at Glenorchy)	Some unregulated flows (~ 10,000 ML for the Wimmera River at Glenorchy)	Good unregulated flows (~ 50,000 ML for the Wimmera River at Glenorchy)	Significant unregulated flows (>100,000 ML for the Wimmera River at Glenorchy)
Expected river conditions (inc. unregulated and, consumptive water)	Periodic unregulated flows for Reach 2 MacKenzie River, Upper Burnt Creek, lower Mt William Creek. Regulated releases provide flows at other times and locations	Periodic unregulated flows for Reach 2 MacKenzie River, Upper Burnt Creek, lower Mt William Creek. Regulated releases provide flows at other times and locations.	Periodic unregulated flows for Reach 2 MacKenzie River, Upper Burnt Creek, lower Mt William Creek. Regulated releases provide flows at other times and locations apart from modest passing flows.	Regular unregulated flows for Reach 2 MacKenzie River, Upper Burnt Creek, lower Mt William Creek. Reasonable passing flows and unregulated releases for the Wimmera River and lower Mt William Creek. Regulated releases provide flows at other times and locations.	Regular unregulated flows for Reach 2 MacKenzie River, Upper Burnt Creek, lower Mt William Creek. Frequent passing flows and unregulated releases for the Wimmera River and lower Mt William Creek. Regulated releases provide flows at other times and locations
Estimated Passing Flows	0 ML	2000 ML	5000 ML	15,000 ML	50,000 ML
VEWH Carryover Requirements	8,000 ML	10,000 ML	15,000 ML	20,000 ML	24,000 ML

Table 27. Priority Watering Actions for 2021-22 – Wimmera River System

Waterway	Reach and Compliance Point	Action	Timing	Watering Effects	Environmental Objectives	Scenario	Tier 1a volume (ML)	Tier 1b volume (ML)	Rationale	Details about and differences between scenarios
Wimmera River	Reach 4 – Wimmera River at Lochiel (415246) although Extreme Drought and Drought scenario PWAs will be insufficient to reach the compliance point. (Note PWAs will benefit Reach 3 – Wimmera River at Horsham (415200)	Baseflows and freshes	Summer-autumn	Baseflows will dilute and flush saline water that intrudes from groundwater systems. It will refill and maintain water levels in refuge pools and connect pools such that they provide habitat during a time of year where they are affected by high temperatures (i.e. pools do not dry out or become too shallow and hot). Freshes provide additional mixing/dilution benefits for salinity outcomes and may also assist with creating localised reoxygenation effects in case of blackwater events. Inundation of bed/banks also provides soil moisture for fringing and riparian vegetation to access to maintain condition.	Maintain suitable conditions to reduce risks of fish deaths and blue green algal blooms as well as provide suitable habitat to maintain current native fish, macroinvertebrate and aquatic/riparian vegetation communities.	Extreme Drought	3750*	7,695*	Critical for refilling pools and managing hypersaline conditions over warmer months to prevent catastrophic losses of fish population etc. **Note: Some flows are likely to need to be provided by Wimmera Mallee Pipeline outlets connected to refuge pools.**	Period of winter-spring baseflow may extend across into this time to try and avoid critical loss due to water quality impacts. Tier 1a has period of baseflows but no freshes, 1b has 1 fresh and extends baseflow duration.
						Drought	3500	7945		Tier 1a baseflows will be unlikely to reach compliance point but extend the length of river channel that will be refilled to Dimboola. Tier 1a has no freshes, 1b has 1 fresh and extends baseflow duration.
						Dry	5000	6970		Will extend the duration of baseflows and length of river channel that will be refilled to the end of the river. 2 freshes provided.
						Average	7000	4970	Enhancing conditions over summer-autumn will lead to improved outcomes for recruitment events for fish, macroinvertebrates and vegetation. It will avoid the extremely high salinity levels noted at places like Tarranyurk and Wail after extensive periods of no flow.	As above but longer baseflows based on increased volumes will be important for reducing duration of cease to flows and resultant deterioration of water quality (salinity) and habitat (declining water levels). 2 freshes provided.
						Wet	7000	5495		As above but Tier 1b provides additional fresh duration to further improve connectivity and water quality. 3 freshes provided.
		Baseflows and freshes	Winter-spring	Baseflows will dilute and flush saline water, refill or maintain water levels in refuge pools and connect pools at a time of year when water-dependent species are typically within the recruitment phase of life cycles and so benefit from the maximising of wetted habitat for access/food resources. The higher flow rate of baseflows increases water depth between pools beyond summer/ autumn baseflows.	Maintain pool levels and connectivity to create suitable conditions for some macroinvertebrate and small-bodied fish species to breed (e.g. Flathead Gudgeons) and move (e.g. Australian Smelt). Also provides a productivity function with carbon nutrient cycling and disturbing sediments in the substrate and biofilm on snags and rocks. Inundation of bed/banks also provides soil moisture for fringing and riparian vegetation to access to maintain	Extreme Drought	3750*	7290*	Flow during winter-spring will take advantage of reduced losses from cooler weather and refill pools prior to the onset of summer. It will also transport organic carbon that has gathered in dry sections of channel, reducing blackwater risks.	Insufficient volume for a period of baseflow to reach end of river but protects refuges pools upstream of Dimboola. Tier 1a has no small freshes, Tier 1b has 1 small fresh and extends baseflow duration.
						Drought	1200	9840		
						Dry	3000	8470		Volume assumes that passing/unregulated flows will provide some flows but there will be cease to flow periods. Beyond a period of baseflows, Tier 1a has one small fresh, 1b has 3 small freshes, 1 medium fresh and extends baseflow duration.
						Average	6000	6400	Enduring and higher flows during winter-spring will provide enhanced nutrient cycling outcomes and has notable effect	Volume assumes that passing/unregulated flows will provide some flows but there will be cease to flow periods. Beyond period of baseflows Tier 1a has 3 small

Waterway	Reach and Compliance Point	Action	Timing	Watering Effects	Environmental Objectives	Scenario	Tier 1a volume (ML)	Tier 1b volume (ML)	Rationale	Details about and differences between scenarios
				Freshes increase water depth into shallow benches and help transport organic matter.	condition and enable successful recruitment.				on suppressing saline groundwater intrusion effects on surface water quality at Tarranyurk and Wail.	freshes, 1b has 5 small freshes and 2 medium freshes and extends baseflow duration
						Wet	6450	6900		Volume assumes that passing/unregulated flows will provide the bulk of the flows and there will be little/no cease to flows. As well as aperiod of baseflows, 3 small and 2 medium freshes to be provided under Tier 1a and Tier 1b to provide 2 additional small and 1 medium fresh.
Ranch Billabong	N/A – wetland is watered via pumping from Wimmera River at Dimboola Weir pool.	Refill (top ups after draw down)	1 winter and 1 autumn (if needed)	Will lift water levels, enhance water quality by diluting salinity and extend wetted perimeter to engage with wetland/ riparian vegetation. Water levels will decline between watering events.	Enhance the conditong of River Red Gums whilst enabling fringing and mudflat plant species to grow/recruit through the cycle of wetting/drying, creating a mosaic of water-dependent plant species.	All	20		Small volume involved for shared benefits and will continue gains noted at the site.	N/A
MacKenzie River	Reach 3 – MacKenzie River at McKenzie Creek Reserve (415251) although only Average and Wet Scenarios will have sufficient water in PWAs to reach the compliance point. (Note PWAs will benefit Reach 2 – No compliance point available.)	Baseflows and Freshes	Summer-autumn	Baseflows maintain water levels in refuge pools, provides regular connectivity between pools and engages fringing vegetation. Freshes increase depth between pools and water levels on banks as well as creating additional biofilms on instream woody debris. Also flows are important to enhance dissolved oxygen levels given high organic loads.	Baseflows are needed to enable fish and platypuses to access habitat and avoid predation. Engaging fringing vegetation will also help with aquatic vegetation outcomes (pondweeds, water ribbons) that are also vital for fish outcomes (especially Southern Pygmy Perch recruitment and survival). Retention of water is needed to retain Western Swamp Crayfish population. Freshes are important for creating a mosaic of fringing vegetation (e.g. *potamageton sp.*).	Extreme Drought	1200	4400	Vital for refilling priority refuge pools for fish/crayfish preservation and providing connectivity for platypuses	Tier 1a will only water Reach 2 and upper Reach 3 refuges pools with baseflows and 4 freshes for Reach 2. Tier 1b enables watering of all Reach 3 with 3 freshes and a period of baseflows.
						Drought	1200	4400		
						Dry	1200	4400		
						Average	1700	4250	Period of low water levels in refuge pools can be reduced given their impact on small-bodied native fish due to increased Redfin predation	Tier 1a enables more frequent replenishment of refuge pools via longer baseflows. Tier 1b enables watering of all Reach 3 with baseflows and 4 freshes.
						Wet	2070	3880	Provides opportunity to protect fish/crayfish/ platypus populations that may have established at lower part of the reach and provide opportunities for emigration into Wimmera River.	Tier 1a enables 1 fresh, more frequent replenishment of refuge pools and periodic connectivity with Wimmera River via longer baseflows. Tier 1b enables watering of all Reach 3 with 4 freshes and Tier 2 demands include increased fresh duration.
		Baseflows and freshes	Winter-spring	Higher baseflow rates compared to summer/ autumn baseflows provide greater depths and connectivity (length of watering) which is important for transporting organic matter. Freshes increase depths further to facilitate movement of species as well as creating access to backwater areas given the anastomosing channel form.	Baseflows are needed to enable fish and platypuses to access habitat and avoid predation. Engaging fringing vegetation will also help with aquatic vegetation outcomes (pondweeds, water ribbons) that are also vital for fish outcomes (especially Southern Pygmy Perch recruitment and survival). The higher flow rates are important for movement and habitat access given the shallow morphology of much of the river and paucity of large refuge pools. It will help disperse high value species downstream along Reach 3 (and potentially into Wimmera River) and enable Obscure Galaxias to undertake migration. Retention of water is needed to retain Western Swamp Crayfish population.	Extreme Drought	200	3810	Flow will provide a top up for refuge pools and increased connectivity assuming unregulated flows have ceased in early spring	Tier 1a is just focused on refuge pool top up via a short period of baseflow. Tier 1b enables longer duration baseflows and 5 freshes with differences between scenarios relating to duration of freshes.
						Drought	200	3810		
						Dry	200	3960		
						Average	1530	3005	Provides opportunity to protect fish/crayfish/ platypus populations that may have established at lower part of the reach and provide opportunities for emigration into/from the Wimmera River.	Tier 1a enables more frequent replenishment of refuge pools and periodic connectivity with Wimmera River via longer baseflows and 1-2 freshes. Tier 1b enables longer duration baseflows and 5 freshes with differences between scenarios relating to duration of freshes.
						Wet	1530	3355		
Burnt Creek	Upper - Burnt Creek at Wonwondah East (415223) Lower - No compliance point available. (Estimated based on releases delivered at Burnt Creek Escape (Toolondo Channel))	Baseflows and Freshes	Summer-autumn	Baseflows maintain water levels in refuge pools and provide regular connectivity between pools and engages fringing vegetation. Freshes increase depth between pools and water levels on banks as well as creating additional biofilms on instream woody debris. Also flows are important to enhance dissolved oxygen levels given high organic loads.	Baseflows are needed to enable fish to access habitat and avoid predation when pools contract. Engaging fringing vegetation will also help with aquatic vegetation outcomes (water ribbons, milfoils) that are also vital for fish outcomes (especially Southern Pygmy Perch recruitment and survival). Retention of water is needed to retain Western Swamp Crayfish population. Freshes are important for creating a mosaic of fringing vegetation (e.g. sedges) and inundate very low benches.	Extreme Drought	700	1155	Vital for refilling priority refuge pools for fish/crayfish/mussel preservation and continuing gains in aquatic vegetation extent/abundance. Some flow also makes its way into lower Burnt Creek for fish, vegetation and frog outcomes.	Tier 1a is just focused on refuge pool top ups via baseflows with Tier 1b providing 3 freshes.
						Drought	700	1155		
						Dry	700	1155		Tiers 1a and 1b assumes some contribution from unregulated flows for baseflows with Tier 1b providing 3 freshes.
						Average	650	1205		
						Wet	685	1175		
		Baseflows and freshes	Winter-spring	Baseflows are important for maintaining water levels to engage woody habitat and fringing vegetation. Higher flow rates provide greater depths and connectivity (length of watered channel) and will flush sediments from substrates, creating additional intersitial habitat for macroinvertebrates. Freshes will also engage low benches that are	Baseflows are needed to enable fish to access habitat and avoid predation. Engaging fringing vegetation will also help with aquatic vegetation outcomes (milfoils, water ribbons) that are also vital for fish outcomes (especially Southern Pygmy Perch recruitment and survival). The higher flow rates will help create additional habita for fish and macrinvertebrates and disperse high value species downstream into lower Burnt Creek (and potentially into Wimmera	Extreme Drought	100	995	Flow will provide a top up for refuge pools for fish/crayfish/mussel preservation assuming unregulated flows have ceased in early spring due to dry conditions.	Tier 1a is just focused on refuge pool top up via a short baseflow. Tier 1b relates to providing small freshes (1 for Drought and 3 for Dry scenario) Average and Wet scenarios are not included for this reach as it is assumed that they will be met by unregulated flows and transfers in these scenarios.
						Drought	100	995		
						Dry	100	1355		

Waterway	Reach and Compliance Point	Action	Timing	Watering Effects	Environmental Objectives	Scenario	Tier 1a volume (ML)	Tier 1b volume (ML)	Rationale	Details about and differences between scenarios
				reappearing now the creek is being used less frequently for water transfers.	River) and enable Obscure Galaxias to undertake migration. Retention of water is needed to retain Western Swamp Crayfish and Freshwater Mussel population.					
		Bankfull (Lower Burnt Creek only)	Winter-spring	Baseflow will be needed to fills pools prior to bankfull that provides a sufficient flow rate to reach upper margins of creek channel. Bankfull flow will mobilse organic matter and inundate the bank soil profile as well as fringing/aquatic vegetation.	Required to maintain condition of riparian vegetation (River Red Gum) given the creek only receives infrequent flows and important to reduce terrestrialisation of vegetation through improving conditions for riparian species. Will also help maintain fish, frog and macroinvertebrate populations that may have established in this reach under baseflow/fresh regime.	Average	300		Waters soil profile for riparian vegetation and reaches fringing sedges. Frog population in this reach is pronounced given limited fish population and predation of eggs/tadpoles.	N/A – short baseflow to fill (presumably) dry creek channel prior to 1 fresh.
						Wet	300			
Mt William Creek	Upper – Mt William Creek at Mokepilly (415252) Lower – Mt William Creek at Lake Lonsdale Tailgauge (415203)	Baseflows and Freshes	Summer-autumn	Baseflows maintain water levels in refuge pools, provides regular connectivity between pools and engages fringing vegetation. Baseflows and freshes mix and push saline water (from Lake Lonsdale) downstream and help reduce impacts of high organic loads on dissolved oxygen. Higher freshes also increase biofilm abundance on woody debris and increase water depth for increased dispersal opportunities.	Having refuge pools refilled and connected will help populations of Obscure Galaxias, River Blackfish and Southern Pygmy Perch to recruit and persist. Poor water quality and predation from Redin at low water levels have been major factors in the decline in the fish population in recent years. Water supplied from Lake Lonsdale is typically poor quality to flows are important to dilute and mix flows. Similarly, saline groundwater intrusions in the upper Mt William Creek lead to salinity impacts.	Extreme Drought	150	1315	Important to maintain water levels so that they do not recede to below level of band of water ribbons that exists at the refuge pool at Mokepilly that provides habitat for Southern Pygmy Perch and Flathead Gudgeon. Tier 1b relates to maintaining suitable refuge pool levels and water quality in lower Mt William Creek for native fish and macroinvertebrates.	Tier 1a involves filling Mokepilly refuge pool by baseflows only and assumes Lake Lonsdale is dry. Tier 1b assumes Lake Lonsdale contains usable water and can be used to provide baseflows and 3 freshes.
						Drought	150	1365		
						Dry	900	375	Maintains refuge pool levels and minimises water quality declines in lower Mt William Creek for native fish and macroinvertebrates. Provides minor opportunities for emigration to Wimmera River.	Tiers 1a and 1b involve filling Mokepilly refuge pool by baseflows only and assumes Lake Lonsdale contains useable water. Tier 1a extends the duration of baseflows and provides 3 freshes.
						Average	900	585		As above but with higher fresh flow rate.
						Wet	955	620		
		Baseflows and freshes	Winter-spring	Higher flow rates of freshes provide greater depths and connectivity (length of watering) for dispersal as well as entraining organic matter, engaging low benches and creating interstitial habitat by flushing sediments. Baseflows maintain pool levels.	Flows are needed to enable fish to access habitat and avoid predation. Engaging fringing vegetation will also help with aquatic vegetation outcomes (water ribbons) that are also vital for fish outcomes (especially Southern Pygmy Perch recruitment and survival). The higher flow rates will help disperse high value species downstream into Wimmera River.	Wet	1290	2950	Provides opportunities for high value species to emigrate downstream given they have been largely confined to upland areas in last few years.	Having this PWA in Wet scenario assumes reasonable passing flows available and water quality in Lake Lonsdale is suitable. Tier 1a volume provides baseflows and 1 fresh while Tier 1b volumes provides 5 freshes.
Bungalally Creek	No compliance point available (Estimated based on releases delivered at Bungalally Channel Outfall (Toolondo Channel))	Baseflow (to fill dry channel) and bankfull	Winter-spring	Baseflow will be needed to fills pools prior to bankfull flow that provides a sufficient flow rate to reach upper margins of creek channel to inundate soil profile to benefit riparian vegetation.	Required to maintain condition of riparian vegetation (River Red Gum) given the creek only receives infrequent flows and important to reduce encroachment of terrestrial vegetation species.	Wet	300		It has been five year since this reach received reasonable flows and River Red Gum condition is declining.	N/A
Dock Lake	N/A – water delivered estimated based on water outfalled into Green Lake via Green Lake Channel.	Partial fill	Winter-spring	Creates low level inundation (typically <0.8m) across approx. 80% of the lakebed, drowning terrestrial grasses over several weeks.	Provides habitat for numerous waterbirds (e.g. Whiskered Tern, Grey Teal, Black-winged Stilts, Australian Shelducks, Purple Swamphens, Eurasian Coots) as well as several frog species. Also enables growth/ recruitment of wetland plants (e.g. nardoos).	Wet	400	600	Substantial wetland bird outcome for the volume involved based on observations and it has been five years since the wetland's last inundation which may impact on seedbed viability.	Tier 1a and 1b volume differences fall within the band of recommended low level inundation and allows for more seepage losses. Tier 2 is volume between recommended low level inundation and lake full supply level.

Scenario Planning Context

It is important to note that the Tier 1a volumes under all scenarios are well below those recommended to achieve compliance for PWAs based on the *Wimmera River Environmental Flows Study* (Alluvium, 2013) and are solely focussed on protecting priority drought refuges and avoiding critical losses based on best available information. It also recognises that due to the series of very dry years since 2017 there is very limited water availability and needs to be an emphasis on retaining some volume of carryover into 2022-23. Tier 1b reflects additional volumes required to obtain compliance with recommendations whilst Tier 2 volumes still sit within that objective and largely relate to extending the duration of freshes to the maximum recommended length. Should additional volumes be available between scenarios then they will be allocated to in part deliver PWAs and bolster carryover reserves via the Western Rivers Advisory Group (WRAG) process through 2021-22. The WRAG process includes considerations around the Glenelg River given the shared VEWH entitlement and enables factors to be considered like the contribution of unregulated/passing flows and where regulated water may be accessed given some storages like Lake Wartook cannot be supplemented by transfers from other parts of the system. Volumes with an asterisk (*) both pertain to the same volume given the timing of the flows is likely to bracket spring/summer with the intent of refilling refuge pools. Appendix 3 contains more detail regarding PWAs in relation to ecological objectives and expected watering effects.

8. Delivery Constraints

The *Wimmera River System Environmental Water Management Plan* (Wimmera CMA, 2016) outlines delivery constraints in detail. Given the Wimmera-Mallee Headworks system was designed to harvest water to be released into the former stock and domestic and irrigation channel systems at comparatively modest rates, releases are only typically able to provide baseflows and freshes. Where bankfull and overbank flows are able to be provided (lower Mt William Creek, MacKenzie River and Burnt Creek) instream losses in swampy areas and risks to inundating freehold land make these releases unfeasible. Other features like the configuration of the Burnt Creek where it bisects the Toolondo Channel create issues with extra losses given the need to raise water levels in the channel before flows enter the lower Burnt Creek, although measures like sandbagging the channel lead to minor benefits. Upgrades to infrastructure in recent years at locations like Dad and Dave Weir, Distribution Heads and Lake Lonsdale Outlet to include automation and telemetry will assist with providing improved rates of rise and fall in flows with more regular flow rate changes possible.

The key delivery constraint in 2021-22 is likely to be the continuation of low levels in Lake Wartook and Lake Lonsdale which means that unless there are significant inflows into these storages, many priority watering actions for the MacKenzie River, Burnt Creek, Bungalally Creek and Mt William Creek will be unachievable.

9. Confounding Factors

Environmental water can only achieve so much when it comes to maintaining and enhancing waterway condition and needs to be contextualised within the frameworks of integrated catchment management that Victoria has championed for decades. Factors that affect environmental outcomes in association with environmental watering are outlined in Section 7 of the *Environmental Water Management Plan - Wimmera River System* (Wimmera CMA, 2015). Key factors include the presence of hypersaline groundwater intrusions in the lower Wimmera River and upper Mt William Creek, high numbers exotic fish species (Redfin, Carp, Eastern Gambusia) and instream barriers such as weirs.

10. Increasing Knowledge

Monitoring of waterways is critical in order to better understand the effectiveness of environmental watering activities across a range of climatic conditions. This enhances community confidence in future environmental watering activities and enables adaptive management of future environmental flows.

Although this Seasonal Watering Proposal has been developed using the best available information there are still key knowledge gaps and recommendations that remain that can enhance environmental water management in the Wimmera for the benefit of the entire region. The key focus is the development of management plans for the five refuge pools identified in *Wimmera River Drought Refuge Management Strategy* (Alluvium, 2018). This work is being undertaken in 2021 by experts from Streamology and La Trobe University and overseen by a project steering group involving representatives from BGLC, DELWP, GWMWater, Parks Victoria, Hindmarsh Shire and Wimmera CMA. It will consider the scientific basis and practical management implications for providing water to these pools from the Wimmera Mallee Pipeline.

Environmental water deliveries are underpinned by an adaptive management approach. Compliance points for priority reaches are often some distance downstream, a higher release rate is required to cover instream losses through seepage, evaporation and diversion experienced between the delivery point and the compliance point. Therefore ongoing monitoring of flow rates at stream gauges enables environmental flows to be increased or decreased to efficiently meet recommendations. In time the current dataset will be increasingly refined to enable effective and efficient environmental water delivery through better understanding in-stream losses and timing of flows along various waterways.

Compliance monitoring is needed to show flows have been delivered in accordance with recommendations and at the times specified to target areas as precisely and as efficiently as possible. Locations where stream monitoring is needed include: Bungalally Creek, lower Mt William Creek at Dadswell's Bridge or Roses Gap, Reach 2 of the MacKenzie River near Distribution Heads Weir and lower Burnt Creek at the Western Highway crossing. If funded, the installation of these gauges will significantly improve environmental water managers' decision making through ensuring regulated releases are providing the recommended volumes at compliance points as well as quantifying the effect of various flow components on water quality. The installation of Portable Automated Logger System (PALS) unit at Roses Gap, funded by VEWH has been a valuable tool to inform decision making around environmental water releases.

Given the substantial expenditure of public funds that has been undertaken to recover water for environmental flows there is a need to demonstrate the outcomes this will achieve. Recommended condition monitoring, required to

document trends and provide context for intervention monitoring though answering key questions around flow-ecology relationships are listed below;

- Fish monitoring provides a valuable annual snapshot into the ecological response of environmental flows. Annually sites on the Wimmera River will be monitored as part of the Angler Report Card program instigated by DELWP although the focus is on angling species rather than small bodied species. Occasionally other fish monitoring programs (e.g. targeted intervention monitoring on the MacKenzie River and Burnt Creek) will complement this data;

- Should good water levels be present in regulated wetlands (Lake Hindmarsh, Dock Lake) bird monitoring will take place; and

- Continue annual platypus surveys using trapping and e-DNA sampling in the MacKenzie River with the option to include Burnt Creek if deemed worthwhile.

Wimmera CMA is also working with GWMWater, Project Platypus and other stakeholders to build evidence for funding and implementing environmental watering from the pipeline supplied from Mt Cole Reservoir to protect high value sections of the Mt Cole Creek at Warrak. If it is successfully funded and constructed, it is anticipated that it will be included in future seasonal watering proposals.

Other broader research projects underway will also have long-term benefits for enhancing the knowledge base with respect to environmental watering in the Wimmera River System. The first of these is a project being undertaken by Water Technology which has involved mapping the extent and locations of phragmites and typha along the Wimmera River from Horsham through to Lake Hindmarsh and comparing the results with that mapped in 2006. It also involves analysing the nutrients and biomass associated with the stands of phragmites to understand how water availability and quality are affecting their dynamics. Secondly a project involving renowned ecologists Professor Peter Gell (Federation University) and Lance Lloyd (Lloyd Environmental) has commenced which will seek to understand more about the history of the flora and fauna of the Wimmera River system through analysing sediment cores from the Wimmera and MacKenzie River (for pollen, and DNA), historical records and local expertise. This will also establish further research priorities to enhance the understanding of what the Wimmera River system has been able to historically sustain.

Professor Peter Gell with sediment core sample from Wimmera River at Jeparit, February 2021 (Photo: L. Lloyd)

11. Risk Management

Risk assessment and management is an important aspect of environmental water planning. A teleconference was undertaken with VEWH, CMAs and GWMWater on 15 February 2021 to discuss risk management and environmental watering in detail. Table 28 illustrates the various risks covered in this workshop (likelihood and consequence) associated with planned environmental flow components.

Table 28. Risks associated with environmental water release components planned for 2021-22.

Legend for Table
1. Risk category abbreviations are: Env. – environment/sustainability; BC – business cost; Safety – People/safety/wellbeing; Rep – Political/reputation; Legal – legal consequence; Service – service delivery
2. L refers to the Likelihood of a risk occurring. Abbreviations for consequence ratings are: AC – almost certain; L – likely; P – possible; U – unlikely; R - rare
3. C refers to the Consequence if the risk occurs. Abbreviations for consequence ratings are: N – negligible; Min – minor; Mod – moderate; Maj – major; Ext - extreme

No.	Risk category[1]	Risk description	L[2]	C[3]	Risk rating	Mitigation actions	Lead organisn. for action	Risk type (Static/ Dynamic)
1	Env	Insufficient water available for proposed watering actions to meet environmental objectives. *Note: there is a need to be alert to cumulative impacts of multiple dry years*	L	Maj	High	Adaptively prioritise and revise watering actions to optimise outcomes from water available considering seasonal conditions, including consideration the need to reserve contingency volumes for the following season. Identify any reservoir release constraints due to low water levels and adapt plans accordingly Maximise use of consumptive water en-route for environmental benefit. Communicate with community and stakeholders around planned watering actions and any revisions required. Undertake extra monitoring to guide complementary actions (e.g. carp removal, fencing). Undertake studies to identify key refuge areas for protection in the Glenelg and Wimmera systems. Where feasible, deliver water via pipelines to key drought pools on the Wimmera River •Look for water savings to build up a "water bank" for reducing stress in subsequent years	CMA/WRAG CMA/WRAG GWMWater CMA CMA CMA CMA VEWH/WRAG	Dynamic
2	Env	Environmental water deliveries may generate or mobilise poor quality water (e.g.	L	Min	Medium	Ongoing monitoring to inform water deliveries specifically from Lake Lonsdale .	WCMA	Static

No.	Risk category[1]	Risk description	L[2]	C[3]	Risk rating	Mitigation actions	Lead organisn. for action	Risk type (Static/ Dynamic)
		blackwater, BGA, salinity), with adverse water quality and environmental outcomes; or Areas not targeted for environmental watering actions experience poor quality water (e.g. blackwater, BGA), with adverse water quality and environmental outcomes				Adapt flow management based on antecedent conditions and local knowledge. Maximise use of consumptive water en route for environmental benefit. Establish environmental reserve to manage management needs. Communicate around current conditions and revised objectives. Undertake complementary actions, including provision of information to the community	CMA GWMWater VEWH CMA CMA	
3	Env	Environmental deliveries create improved conditions for non-native species (e.g. carp, invasive weeds, rabbits, foxes) leading to adverse environmental impacts. (*Note: This risk addresses the incremental impact of environmental water deliveries on pest plant and animal populations, noting that even in the absence of environmental delivery actions these pests are likely to spread in waterways with adverse environmental impacts).*	P	Min	Low	Adaptively manage flow to incorporate new knowledge from monitoring and research. Monitor invasive species extent and control existing populations (e.g. opportunistic removal of carp in dry conditions). Install physical barrier to prevent translocation (e.g. carp barriers). Develop management agreements with landholders that include pest plant and animal control measures. Communicate data from fish surveys etc. to inform the community on pest species and outcomes of control measures. Seek additional funding for carp control activities.	CMA CMA CMA CMA CMA CMA	Dynamic
4	Rep	Inability to demonstrate that environmental water objectives have been achieved, which may lead to a loss of public/political support for activities.	P	Mod		Seek additional funding for and undertake targeted local monitoring (leveraging existing data sets where possible). Invest in monitoring and research to address knowledge gaps and influence existing monitoring programs.	CMA VEWH/ DELWP	Static

No.	Risk category[1]	Risk description	L[2]	C[3]	Risk rating	Mitigation actions	Lead organisn. for action	Risk type (Static/ Dynamic)
						Share new knowledge to promote adaptive management. Communicate monitoring results to local communities.	VEWH CMA	
5	Legal	Environmental releases cause unauthorised inundation of private land, resulting in impacts on landowner activities and assets.	U	Mod	Low	Ensure the currency of any landholder agreements for environmental watering actions. Ongoing communication with GWMWater and land managers in planning and delivery phases. Consider weather forecasts when conducting environmental releases and reschedule deliveries if forecasts indicate potential for flooding. Test and monitor delivery rate and respond to potential incidents. Maintain and inspect infrastructure, including upgrading infrastructure where required before delivery occurs. Identify likely areas of impact by understanding historical impacts and previous experience, and modify flow planning, or undertake works to reduce risk of inundation.	CMA CMA GWMWater GWMWater GWMWater CMA	Static
6	BC	Insufficient staff resources available to deliver all planned environmental watering actions, leading to cancellation or interruption of deliveries.	L	Mod	Low	Continue to actively prioritise actions to match available resources and ensure priority actions are delivered. Ongoing communication with GWMWater to understand constraints and develop a schedule of delivery to manage staff resources. Implement remote monitoring to minimise staff time in the field, within available funding. Provide delivery plans with required lead time prior to target delivery date (usually 2 weeks). Ensure timely approval of seasonal watering statements.	CMA CMA GWMWater CMA VEWH	Static

No.	Risk category[1]	Risk description	L[2]	C[3]	Risk rating	Mitigation actions	Lead organisn. for action	Risk type (Static/ Dynamic)
						Upgrade infrastructure to reduce the need for manual operations. Adjust delivery timing to avoid holidays, weekends and high-risk periods for resourcing.	CMA CMA	
7	BC	Volume delivered or released exceeds volume approved and/or ordered for use in the event or year.	U	Mod	Low	Communicate seasonal watering statements to all partners. Monitor delivery rate, provide delivery data to CMA/VEWH and respond to potential incidents. Monitor water use against volume approved for use in seasonal watering statement and adapt water orders if required. Monitor water use against volume approved and undertake regular communications with CMA and GWMWater as part of portfolio management activities. Review and update established ordering processes with GWMWater, (as documented in Operating Arrangements document) at regular intervals.	VEWH GWMWater CMA VEWH VEWH	Static
8	Safety	Where delivery structures are unsafe and have limitations on their operation, planned environmental deliveries may not be feasible leading to a failure to achieve environmental outcomes.	U	Ext	Medium	Upgrade or modify infrastructure to improve safety. Modify method of operation to avoid unsafe work practices and update safety procedures to reflect this (Note: safe work procedures will need to be communicated to community/volunteer resources as well as agency staff where they undertake structure operations).	Asset owner Asset owner	Static
9	Env	Flow rate at environmental flow compliance point not able to be demonstrated, which may lead to failure to achieve target flows and environmental benefits not being achieved.	P	Mod	Medium	Install/upgrade stream gauge monitoring to improve ability to demonstrate target flow rate achievement.	CMA	Static

No.	Risk category[1]	Risk description	L[2]	C[3]	Risk rating	Mitigation actions	Lead organisn. for action	Risk type (Static/ Dynamic)
						Consider data collection and modelling studies to improve understanding of flow behaviour of systems.	CMA	
10	Env	Target flow rate at environmental flow compliance point not achieved due to environmental conditions, (for example high losses at very dry sites, hot weather causing excessive evaporation, antecedent conditions and inflow rates) and environmental benefits not being achieved.	L	Min	Low	Monitor flow rate and adjust delivery volume within approved volume. Use flow forecasting tools/modelling to better understand and allow for losses Arrange releases from weir pools to complement environmental deliveries. Consider adjusting delivery timing to avoid holidays, weekends and high-risk periods for system operations resourcing.	CMA GHCMA WCMA CMA	Dynamic
11	Env	Target flow rate at environmental flow release or measurement point not delivered as ordered, leading to sub-optimal environmental outcomes.	U	Mod	Low	Monitor flow rate and adjust delivery to meet ordered flow rates. Ongoing communication with the CMA to manage infrastructure or maintenance constraints.	GWMWater GWMWater	Static
12	Safety	Environmental releases create rapid or unexpected changes in flow conditions, resulting in injury to river user[1]	U	Mod	Low	Communicate flow deliveries to communities and key stakeholders and avoid large flows or rapid changes in flow rate during periods of high river use. (e.g. using community SMS stock management updates services). Erect signage where appropriate. Consider safety management around relevant automated structures.	GWMWater/CMA GWMWater/CMA GWMWater	Dynamic
13	Rep	Changing seasonal conditions results in changes to previously announced watering plans, which leads to a loss of community confidence in environmental water management. (Note: These proposed mitigations are also relevant to Risks 12 and 14)	L	Mod	Medium	Ensure community is informed about intended watering objectives and the scenario planning process used. Provide regular local, place-based updates on planned delivery actions and the current/changing situation in river systems leading to changed actions.	CMAs CMAs VEWH	Dynamic

No.	Risk category[1]	Risk description	L[2]	C[3]	Risk rating	Mitigation actions	Lead organisn. for action	Risk type (Static/ Dynamic)
						Undertake broader awareness programs focussing on the importance of e-watering, its complexity and the need for adaptive management.		
14	Rep	Community groups not supportive of environmental watering delivery.	L	Mod	Medium	Engage with the local community through a variety of avenues (e.g. workshops, forums, individually to communicate benefits of environmental watering. Develop state-wide communication products and engage with peak bodies Each organisation to share their intended environmental water related communications plans with all partners. Provide the community with information on the risks and management changes implemented in response to drier conditions.	CMA VEWH CMA/VEWH CMA	Dynamic

12. Approval and endorsement

I, the authorised representative of the agency shown below, approve the Seasonal Watering Proposal for the Wimmera system 2021-22.

SIGNED FOR AND ON BEHALF OF Wimmera Catchment Management Authority

Signature of authorised representative

Name of authorised representative:
David Brennan, Chief Executive Officer

Date: 23 April 2021

Horsham Weir Pool, February 2021

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Pelicans at the Wimmera River at Jeparit – March 2021

Appendix 1: Media Information Regarding Environmental Water Releases

Floating wetlands on the Wimmera River at Dimboola, the first project of its type in the region, are greatly reducing the wave energy that causes bank erosion. We installed the wetlands last December to help protect the banks and have since added an extra 800 native plants.

Water for the Environment
Spring 2020

WATERWAYS FOR LIFE

The Wimmera River is one of our region's most popular places to enjoy the physical and mental benefits of a walk, run, ride or picnic along its edges. It's also usually a hub of activity for community events, fishing competitions, park runs, rowing regattas and large family gatherings.

Working for Victoria environmental and ag crews have completed waterway fencing and revegetation

This year, the river has become a more solitary refuge.

During the changes we've adapted to in 2020, our focus has remained on taking care of Wimmera waterways – using a combination of environmental water releases and waterway works to keep them healthy and prepare for the hot summer ahead. We are feeling optimistic as we count down to the end of 2020 with hopes for a wetter year and the return of our all-important river-based events in 2021.

Wimmera River improvements

In partnership with council staff and community volunteers the new Langlands Track in Horsham has created an extra nature loop between Horsham Weir and Anzac Bridge

Late winter & spring rain

Winter started as one of the driest on record before above-average rainfall in August. Higher totals in early October delivered a brief but welcome pulse of water into many waterways. Although inflows into our storages are again well below historical averages, every little bit counts when it comes to environmental water releases, especially as we come into our hot and generally dry summers.

SPRING FLOWS

Due to natural flows in October, our planned spring environmental flows to top up refuge pools and provide a water quality boost weren't needed. We have been able to pause this delivery of environmental flows which will help us achieve additional periods of flow when the weather warms up. This means refuge pools will get a top up when needed and won't dry out over coming months.

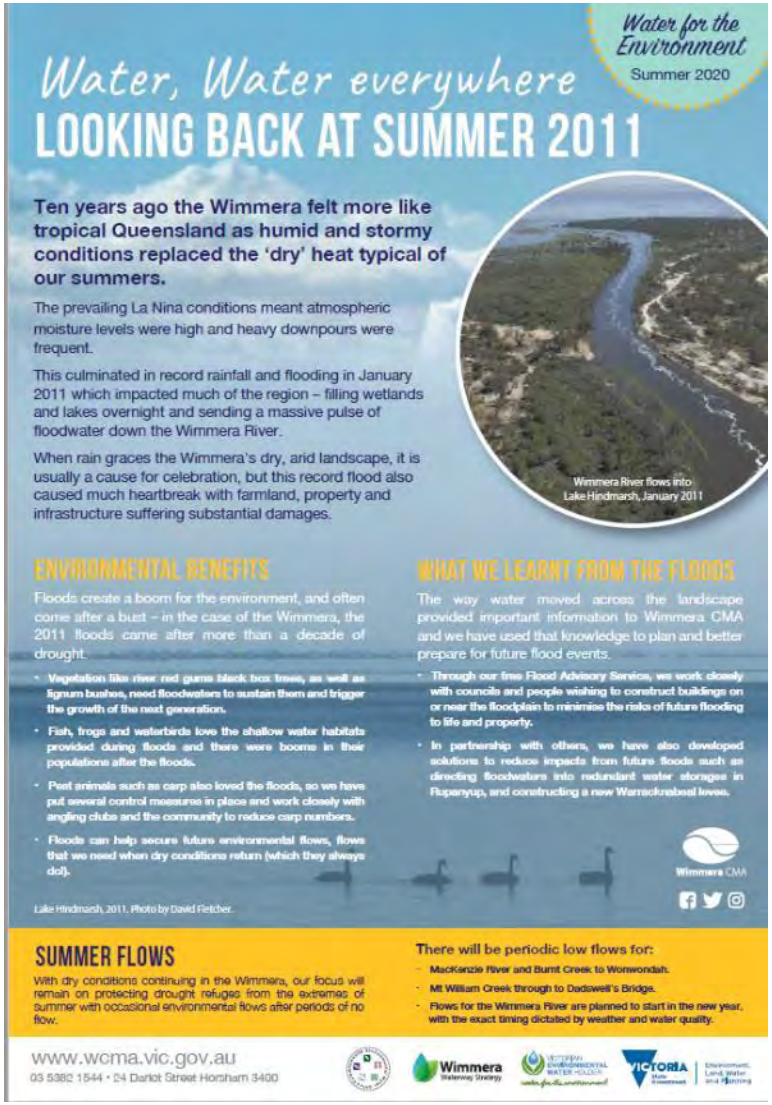
Wimmera River
No spring environmental flows

MacKenzie River, Laharum to Haven
Low flows

If conditions dry out low flows will start in:
- MacKenzie River between Wartook and Laharum
- Burnt Creek to Wonwondah
- Mt William Creek to Dadswells Bridge

Wimmera CMA

www.wcma.vic.gov.au
03 5382 1544 • 24 Darlot Street Horsham 3400



Water for the Environment
Summer 2020

Water, Water everywhere
LOOKING BACK AT SUMMER 2011

Ten years ago the Wimmera felt more like tropical Queensland as humid and stormy conditions replaced the 'dry' heat typical of our summers.

The prevailing La Nina conditions meant atmospheric moisture levels were high and heavy downpours were frequent.

This culminated in record rainfall and flooding in January 2011 which impacted much of the region – filling wetlands and lakes overnight and sending a massive pulse of floodwater down the Wimmera River.

When rain graces the Wimmera's dry, arid landscape, it is usually a cause for celebration, but this record flood also caused much heartbreak with farmland, property and infrastructure suffering substantial damages.

Wimmera River flows into Lake Hindmarsh, January 2011

ENVIRONMENTAL BENEFITS

Floods create a boom for the environment, and often come after a bust – in the case of the Wimmera, the 2011 floods came after more than a decade of drought.

- Vegetation like river red gums black box trees, as well as lignum bushes, need floodwaters to sustain them and trigger the growth of the next generation.
- Fish, frogs and waterbirds love the shallow water habitats provided during floods and there were booms in their populations after the floods.
- Pest animals such as carp also loved the floods, so we have put several control measures in place and work closely with angling clubs and the community to reduce carp numbers.
- Floods can help secure future environmental flows, flows that we need when dry conditions return (which they always do!).

WHAT WE LEARNT FROM THE FLOODS

The way water moved across the landscape provided important information to Wimmera CMA and we have used that knowledge to plan and better prepare for future flood events.

- Through our free Flood Advisory Service, we work closely with councils and people wishing to construct buildings on or near the floodplain to minimise the risks of future flooding to life and property.
- In partnership with others, we have also developed solutions to reduce impacts from future floods such as directing floodwaters into redundant water storages in Rupanyup, and constructing a new Warracknabeal levee.

Lake Hindmarsh, 2011. Photo by David Fletcher.

Wimmera CMA

SUMMER FLOWS

With dry conditions continuing in the Wimmera, our focus will remain on protecting drought refuges from the extremes of summer with occasional environmental flows after periods of no flow.

There will be periodic low flows for:
- MacKenzie River and Burnt Creek to Wonwondah.
- Mt William Creek through to Dadswell's Bridge.
- Flows for the Wimmera River are planned to start in the new year, with the exact timing dictated by weather and water quality.

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Appendix 2: Environmental Flow Recommendations

Table A1. Environmental objectives and flow components for the Wimmera River Reaches 2 and 3. Compliance Point – Wimmera River @ Horsham (415200) from Alluvium (2013).

Flow component	Timing	Magnitude	Climatic scenario	Frequency	Duration	Associated environmental objective	Expected watering effects
Cease to Flow	Dec-May	0 ML/d	DROUGHT	As infrequently as possible	Less than 21 days in total	Ensure stress on environmental values is not exacerbated beyond natural. Cease to flow periods should be completed with fresh lasting at least 7 days duration.	Diminishing water levels and water quality (hence upper limit on duration)
			DRY				
			AVERAGE		Less than 7 days in total		
Baseflow	Dec - May	10 ML/d or natural	ALL	Continuous	Continuous	Maintain habitat availability for macroinvertebrates and endemic fish. Maintains riparian vegetation and prevents excessive in stream terrestrial growth.	Maintain edge habitats in deeper pools and runs, and shallow water habitat availability Maintains near permanent inundated stream channel
	June-Nov	100 ML/d	ALL	Continuous	Continuous	Prevent terrestrialisaton of the lower banks from invasive phragmites and provides fish movement and diversity of habitat.	Increased pool depth, flow and variability, including wetting lowest benches.
Freshes	Dec - May	35-40 ML/d	DROUGHT	2 per period	3 - 7 days	Periodically improving water quality for fish and macroinvetebrates	Flushes and mixes small pools during low flows.
			DRY				
	Dec - May	100 ML/d	AVERAGE	2 per period	2 - 7 days	Provide habitat and food for macroinvertebrates, enables fish movement and maintains water quality and diversity of habitat.	Variable flow during low flow season over wood debris increases biofilm abundance as a food source for macronvertebrates), higher flows enables fish movement (increases baseflow depth by approx. 200mm) and flushes and mixes small pools.
			WET	3 per period			
	June - Nov	400 ML/d	DROUGHT	1 per period	1 day	Provides fish movement and to maintain water quality and diversity of habitat for fish and macroinvertebrates.	Increases baseflow depth by approx. 200mm to enable fish passage and and higher shear stresses flushes surface sediments from hard substrates.
			DRY	3 per period	2 days		
			AVERAGE	5 per period	3 days		
			WET	5 per period	4 days		
	June - Nov	1,300 ML/d	DRY	1 per period	1 day	Promotes diversity of habitat for fish, macroinvertebrates and in-channel vegetation.	Wets in-stream benches and entrains organic debris.
			AVERAGE	2 per period	2 days		
			WET	3 per period	3 days		
	June - Nov	2,600 ML/d	AVERAGE	1 per period	2 days	Provides a food source and additional habitat provides additional habitat and wetting of benches for vegetation/ primary production benefits.	Disturbs algae/bacteria/organic biofilm present on rock or wood debris and entrains organic debris.
			WET	2 per period	3 days		

Bankfull	Any	4,000 ML/d	AVERAGE	1 per period or natural	2 days	Riparian vegetation condition and recruitment. Food sources for macroinvertebrates and primary production. Geomorphic outcomes in terms of maintaining channel size.	Reaches base of riparian vegetation, watering subsoil. Also entrains organic debris and mobilises some sediment/aquatic vegetation.
			WET	1 per period			
Overbank	Aug-Nov	8,000 ML/d	WET	1 per period	1 day	Floodplain vegetation outcomes - maintaining condition of adults and facilitate recruitment. Provides food source for macroinvertebrates and primary production. Maintains floodplain geomorphic features.	Waters floodplain which provides moisture for floodplain vegetation. Entrains organic matter and mobilises sediment and scours instream vegetation.

Table A2. Environmental objectives and flow components for the Wimmera River Reach 4. Compliance Point- Wimmera River @ Lochiel Railway Bridge (415246) from Alluvium (2013)

Flow component	Timing	Magnitude	Climatic scenario	Frequency	Duration	Associated environmental objective	Expected watering effects
Cease to flow	Dec-May	0 ML/d	DROUGHT	As infrequently as possible	Less than 21 days in total	Limits cease to flow to ensure stress on environmental values is not exacerbated beyond the point of return.	Diminishing water levels and water quality (hence upper limit on duration)
			DRY				
			AVERAGE		Less than 7 days in total		
Baseflow	Dec-May	15 ML/d or natural	ALL	Continuous	Continuous	Maintain habitat availability for macroinvertebrates and endemic fish. Maintains riparian vegetation and prevents excessive in stream terrestrial growth.	Maintain edge habitats in deeper pools and runs, and shallow water habitat availability Maintains near permanent inundated stream channel (>1.5m deep pools)
	Jun-Nov	30 ML/d	ALL	Continuous	Continuous	Provide additional habitats for fish and macroinvertebrates	Increases depth by 8-18 cm over summer baseflows
Freshes	Dec - May	70 ML/d	DROUGHT	1 per period	2-7days	Provide habitat and food for macroinvertebrates, enables fish movement and maintains water quality and diversity of habitat.	Variable flow during low flow season over wood debris increases biofilm abundance as a food source for macronvertebrates), higher flows enables fish movement (increases baseflow depth by approx. 11-25cm) and flushes and mixes small pools.
			DRY	2 per period			
			AVERAGE				
			WET	3 per period			
	June - Nov	70 ML/d	DROUGHT	1 per period	1 day	Provide habitat and food for macroinvertebrates, enables fish movement and maintains water quality and diversity of habitat.	Variable flow during low flow season over wood debris increases biofilm abundance as a food source for macronvertebrates), higher flows enables fish movement (increases baseflow depth by approx. 16-22 cm) and flushes and mixes small pools.
			DRY	3 per period	2 days		
			AVERAGE	5 per period	3 days		
			WET	5 per period	4 days		
	June - Nov	200 ML/d	DRY	1 per period	1 day	Provides fish movement and to maintain water quality and diversity of habitat for fish and macroinvertebrates.	Inundates low benches and increases edge coverage.
			AVERAGE	2 per period	2 days		
			WET	3 per period	3 days		
	June - Nov	1300 ML/d	AVERAGE	1 per period	2 days		Disturbs algae/bacteria/organic biofilm present on rock or wood debris and entrains organic

Flow component	Timing	Magnitude	Climatic scenario	Frequency	Duration	Associated environmental objective	Expected watering effects
			WET	2 per period	3 days	Provides a food source and additional habitat provides additional habitat and wetting of benches for vegetation/ primary production benefits.	debris. Flushes surface substrates and inundates benches.
Bankfull	Any	2,000 ML/d	AVERAGE	1 per period, or natural	2 days	Riparian vegetation condition and recruitment. Food sources for macroinvertebrates and primary production. Geomorphic outcomes in terms of maintaining channel size.	Reaches base of riparian vegetation, watering subsoil. Also entrains organic debris and mobilises some sediment/aquatic vegetation.
			WET	1 per period			
Overbank	Aug-Nov	6,000 ML/d	WET	1 per period or natural	1day	Floodplain vegetation outcomes - maintaining condition of adults and facilitate recruitment. Provides food source for macroinvertebrates and primary production. Maintains floodplain geomorphic features.	Waters floodplain which provides moisture for floodplain vegetation. Entrains organic matter and mobilises sediment and scours instream vegetation.

Table A3. Environmental objectives and flow components for MacKenzie River Reach 1 and 2. Compliance Point: Not present, from Alluvium (2013)

Flow component	Timing	Magnitude	Climatic scenario	Frequency	Duration	Associated environmental objective	Expected watering effects
Cease to Flow	Dec - May	0 ML/d	DROUGHT	As infrequently as possible	Less than 80 days in total	Limits cease to flow to ensure stress on environmental values is not exacerbated beyond the point of return.	Diminishing water levels and water quality (hence upper limit on duration). Disconnects pools.
			DRY		Less than 30 days in total		
			AVERAGE				
Baseflow	Dec - May	2 ML/d or natural	ALL	Continuous	Continuous	Maintain habitat availability for macroinvertebrates and endemic fish. Maintains riparian vegetation and prevents excessive in stream terrestrial growth.	Maintain edge habitats in deeper pools (0.5 – 2m) and runs, and shallow water habitat availability. Maintains near permanent inundated stream channel.
	June - Nov	27 ML/d	ALL	Continuous	Continuous	Facilitates dispersal of juvenile platypuses along the river and into the Wimmera River	Intended to create a depth >50cm over riffles
Freshes	Dec - May	5 ML/d	DROUGHT	3 per period	4-7 days	Prevent water quality decline that impacts on macroinvertebrates and fish	Flushes pools
			DRY	4 per period	4-7 days		
	Dec - May	50 ML/d	AVERAGE	2 per period	2-7 days	Enhances food and habitat sources for macroinvertebrates, creates additional habitat, enhances water quality and enables fish movement.	Provides flows over wood debris to increase biofilm abundance as a food source, higher flow also facilitates fish movement with deeper flows over riffles, flushes pools for water quality outcomes and engages higher on pool/riffle margins, creating additional habitat.
			WET	3 per period	2-7 days		
	June-Nov	55 ML/d	DROUGHT	5 per period	2 days	Provides habitat outcomes for macroinvertebrates	Flush surface sediments from hard substrates through increased shear stress.
			DRY	5 per period	4 days		
			AVERAGE	5 per period	5 days		

Flow component	Timing	Magnitude	Climatic scenario	Frequency	Duration	Associated environmental objective	Expected watering effects
			WET	5 per period	7 days		
	June-Nov	130 ML/d	DROUGHT	1 per period	1 days	Stumluate fish movement and provide flow variability to maintain water quality and diversity of fish habitats.	Increase the baseflow water depth.
			DRY	3 per period	2 days		
			AVERAGE	5 per period	3 days		
			WET	5 per period	4 days		
Bankfull	Any	500 ML/d	AVERAGE	1 per period	2 days	Riparian vegetation condition and recruitment. Food sources for macroinvertebrates and primary production. Geomorphic outcomes in terms of maintaining channel size.	Reaches base of riparian vegetation, watering subsoil. Also entrains organic debris and mobilises some sediment/aquatic vegetation.
			WET	1 per period	2 days		
Overbank	Aug-Nov	900 ML/d	WET	1 per period	1 day	Floodplain vegetation outcomes - maintaining condition of adults and facilitate recruitment. Provides food source for macroinvertebrates and primary production. Maintains floodplain geomorphic features.	Waters floodplain which provides moisture for floodplain vegetation. Entrains organic matter and mobilises sediment and scours instream vegetation.

Table A4. Environmental objectives and flow components for MacKenzie River Reach 3. Compliance Point: MacKenzie River @ McKenzie Creek Reserve (415251) from Alluvium 2013.

Flow component	Timing	Magnitude	Climatic scenario	Frequency	Duration	Associated environmental objective	Expected watering effects
Cease to Flow	Dec-May	0 ML/d	DROUGHT	As infrequently as possible	Less than 80 days in total	Limits cease to flow to ensure stress on environmental values is not exacerbated beyond the point of return.	Diminishing water levels and water quality (hence upper limit on duration). Disconnects pools.
			DRY		Less than 30 days in total		
			AVERAGE				
Baseflow	Any	10ML/d or natural	ALL	Continuous	Continuous	Maintain habitat availability for macroinvertebrates and endemic fish. Maintains riparian vegetation and prevents excessive in stream terrestrial growth.	Riffles have >10cm inundation, also widens bed coverage and inundates edges at pools.
Freshes	Dec - May	35 ML/d	DROUGHT	3 per period	2-7 days	Enhances food and habitat sources for macroinvertebrates, creates additional habitat, enhances water quality and enables fish movement.	Provides flows over wood debris to increase biofilm abundance as a food source, higher flow (approx. 200mm) also facilitates fish movement with deeper flows over riffles, flushes pools for water quality outcomes and engages higher on pool/riffle margins, creating additional habitat.
			DRY	3 per period	3-7 days		
			AVERAGE	4 per period	3-7 days		
			WET	4 per period	3-7 days		
	Jun-Nov	35ML/d	DROUGHT	5 per period	2 days	Enhances fish communities by stimulating movementand maintains water quality and diversity of habitat.	Increases depth by approx.. 200mm which will enable fish to more easily move between pools.
			DRY		4 days		
			AVERAGE		5 days		
			WET		7 days		

Flow component	Timing	Magnitude	Climatic scenario	Frequency	Duration	Associated environmental objective	Expected watering effects
	Jun-Nov	190 ML/d	AVERAGE	1 per period	1 day	Provides habitat outcomes for macroinvertebrates	Flush surface sediments from hard substrates through increased shear stress.
			WET		2 days		
Bankfull	Any	500 ML/d	WET	1 per period, or natural	1-day	Riparian vegetation condition and recruitment (including Callistemon Wimmensis). Food sources for macroinvertebrates and primary production. Geomorphic outcomes in terms of maintaining channel size.	Reaches base of riparian vegetation, watering subsoil. Also entrains organic debris and mobilises some sediment/aquatic vegetation.
Overbank	Aug-Nov	1000 ML/d	WET	1 per period, or natural	1 day	Floodplain vegetation outcomes - maintaining condition of adults and facilitate recruitment (including Callistemon Wimmerensis). Provides food source for macroinvertebrates and primary production. Maintains floodplain geomorphic features.	Waters floodplain which provides moisture for floodplain vegetation. Entrains organic matter and mobilises sediment and scours instream vegetation.

Table A5. Environmental objectives and flow components for Lower Mt William Creek (below Lake Lonsdale). Compliance Point: Mt William Creek at Lake Lonsdale Tail gauge (415203) from Alluvium 2013.

Flow component	Timing	Magnitude	Climatic scenario	Frequency	Duration	Associated environmental objective	Expected watering effects
Cease to Flow	Dec - May	0 ML/d	DROUGHT	As infrequently as possible	Less than 90 days in total	Limits cease to flow to ensure stress on environmental values is not exacerbated beyond the point of return.	Diminishing water levels and water quality (hence upper limit on duration). Disconnects pools.
			DRY		Less than 30 days in total		
			AVERAGE				
Baseflow	Any	5 ML/d or natural	All	Continuous	Continuous	Maintain habitat availability for macroinvertebrates and endemic fish. Maintains riparian vegetation and prevents excessive in stream terrestrial growth.	Creates near-permanent inundated stream channel and shallow water habitat as well as inundating edges at pools.
Freshes	Dec-May	20 ML/d	DROUGHT	3 per period	2-7 days	Maintain water quality for fish and macroinvertebrates	Flushes small pools
			DRY	3 per period	4-7 days		
	Dec - May	30 ML/d	AVERAGE	3 per period	2-7 days	Enhances food and habitat sources for macroinvertebrates, creates additional habitat, enhances water quality and enables fish movement.	Increases flow depths from baseflow by 16-19 cm and inundates benches
			WET	3 per period	3-7 days		
	June-Nov	100 ML/d	DROUGHT	1 per period	3 days	Enhances food and habitat sources for macroinvertebrates.	Inundates benches (number of benches wetted depends on this size of the fresh) and entrains
			DRY	3 per period	3 days		

Flow component	Timing	Magnitude	Climatic scenario	Frequency	Duration	Associated environmental objective	Expected watering effects
			AVERAGE	3 per period	5 days		organic material as well as flushing surface sediments from hard substrates.
			WET	5 per period	7 days		
	Jun-Nov	500 ML/d	DRY	1 per period	1 days		
			AVERAGE	2 per period	2 days		
			WET	3 per period	2 days		
Bankfull	Any	750 ML/d	AVERAGE	1 per year or natural	2 days	Riparian vegetation condition and recruitment. Food sources for macroinvertebrates and primary production. Geomorphic outcomes in terms of maintaining channel size.	Reaches base of riparian vegetation, watering subsoil. Also entrains organic debris and mobilises some sediment/aquatic vegetation.
			WET	1 per year	4 days		
Overbank	Aug - Nov	1,500 ML/d	WET	1 per year	1 day	Floodplain vegetation outcomes - maintaining condition of adults and facilitate recruitment. Provides food source for macroinvertebrates and primary production. Maintains floodplain geomorphic features.	Waters floodplain which provides moisture for floodplain vegetation. Entrains organic matter and mobilises sediment and scours instream vegetation.

Table A6. Environmental objectives and flow components for Upper Mt William Creek (above Lake Lonsdale). Compliance Point: Mt William Creek @ Mokepilly (415252) from SKM (2005)

Flow component	Timing	Magnitude	Climatic scenario	Duration	Associated environmental objective	Expected watering effects
Cease to Flow	Dec-May	0 ML/d	1 per period	90 days maximum	increase in macroinvertebrate species diversity.	Provides a physical disturbance to the exposed river channel.
Baseflow	June-Nov	Minimum 24 ML/d	Continuous	Continuous	Conditions suitable to sustain native fish and macroinvertebrates.	Increases water quality and habitat in pools.
Freshes	Dec – May	> 1 ML/d	2 per year	5 days	Assists in maintaining and access to suitable habitat for macroinvertebrate and fish species. Triggers spawning in many Western Carp Gudgeon as well as a number of other key native fish species.	Prevents sediment accumulation that can smother habitat. Assists in maintenance of wetted channel during summer low flow period and improves water quality in pools.
	June-November	>52 ML/d	4 per year	7 days	Provides disturbance to macroinvertebrate communities which increases abundance and diversity in native fish species and triggers spawning in Western Carp Gudgeon. Improves water quality in pools.	Flushes small pools to improve water quality and opens up benthic habitat.
	Winter-Spring	>500 ML/d	2 per year	2 days	Maintains instream/riparian//terrestrial vegetation dynamics and geomorphic character as well as habitat for macroinvertebrates.	Transports sediment downstream to prevent the smothering of key habitats. Flushes fine sediment and organic material from pools. Disturbs terrestrial vegetation on bank.

Table A7. Environmental objectives and flow components for Bungalally Creek. Compliance Point: Not Present, from Alluvium (2013).

Flow component	Timing	Magnitude	Climatic scenario	Frequency	Duration	Associated environmental objective	Expected watering effects
Bankfull	Any	60 ML/d	AVERAGE WET	1 per period or natural	2 days	Maintain condition and facilitate recruitment or riparian vegetation. Maintain structural integrity of channel.	Flows will reach high on the bank, providing moisture to subsoil and drowning terrestrial species.
Overbank	Aug-Nov	150 ML./d	WET	1 per period or natural	1 days	Maintain condition and facilitate recruitment of floodplain vegetation. Maintains floodplain geomorphic features.	Flows will reach high on the bank, providing moisture to subsoil and drowning terrestrial species. It will also mobilise fine sediments.

Table A8. Environmental objectives and flow components for Burnt Creek Reach 1 (upper Burnt Creek). Compliance Point: Burnt Creek at Wonwondah East (415223), from Alluvium (2013)

Flow component	Timing	Magnitude	Climatic scenario	Frequency	Duration	Associated environmental objective	Expected watering effects
Cease to Flow	Dec-May	0 ML/d	DROUGHT DRY AVERAGE	As infrequently as possible	Less than 80 days in total Less than 30 days in total	Limits cease to flow to ensure stress on environmental values is not exacerbated beyond the point of return.	Diminishing water levels and water quality (hence upper limit on duration). Disconnects pools.
Baseflow	All year	1 ML/d or natural	ALL	Continuous	Continuous	Maintain habitat availability for macroinvertebrates and endemic fish. Maintains riparian vegetation and prevents excessive in stream terrestrial growth.	Provides bed coverage and inundates edges at pools.
Freshes	Dec - May	30 ML/d	DROUGHT	3 per period	2-7 days	Prevent water quality decline for macroinvertebrate and fish populations	Flushes pools during low flows.
			DRY	3 per period	4-7 days		
			AVERAGE	3 per period	2-7 days		
			WET	3 per period	3-7 days		
	Jun-Nov	55 ML/d	DROUGHT	1 per period	3 days	Provides improved habitat for fish and macroinvertebrates.	Flushes surface sediments from hard substrates for macroinvertebrates via increased shear stress. Also increases depths by approx.. 200mm.
			DRY	3 per period	3 days		
			AVERAGE	5 per period	5 days		
			WET	5 per period	7 days		
	May - Jun	160 ML/d	DRY	1 per period	1 day	Support macroinvertebrate communities through increased food/habitat availability.	Velocities are sufficient to disturb the algae/bacteria/organic biofilm present on rock or wood debris.
			AVERAGE	2 per period	2 days		
			WET	3 per period	3 days		
Bankfull	Any	400 ML/d	AVERAGE	1 per period, or natural	2 days	Riparian vegetation condition and recruitment. Food sources for macroinvertebrates and primary	Reaches base of riparian vegetation, watering subsoil. Also entrains organic

Flow component	Timing	Magnitude	Climatic scenario	Frequency	Duration	Associated environmental objective	Expected watering effects
			WET			production. Geomorphic outcomes in terms of maintaining channel size.	debris and mobilises some sediment/aquatic vegetation.
Overbank	Aug-Nov	1,000 ML/d	WET	1 per year	1 day	Floodplain vegetation outcomes - maintaining condition of adults and facilitate recruitment. Provides food source for macroinvertebrates and primary production. Maintains floodplain geomorphic features.	Waters floodplain which provides moisture for floodplain vegetation. Entrains organic matter and mobilises sediment and scours instream vegetation.

Table A9. Environmental objectives and flow components for Burnt Creek Reach 2 (lower Burnt Creek). Compliance Point: Not Present, from Alluvium (2013).

Flow component	Timing	Magnitude	Climatic scenario	Frequency	Duration	Associated environmental objective	Expected watering effects.
Bankfull	Any	45 ML/d or natural	AVERAGE WET	1 per period, or natural	2 days	Riparian vegetation condition and recruitment. Food sources for macroinvertebrates and primary production. Geomorphic outcomes in terms of maintaining channel size.	Reaches base of riparian vegetation, watering subsoil. Also entrains organic debris and mobilises some sediment/aquatic vegetation.
Overbank	Aug - Nov	90 ML/d	WET	1 per period	1 day	Floodplain vegetation outcomes - maintaining condition of adults and facilitate recruitment. Provides food source for macroinvertebrates and primary production. Maintains floodplain geomorphic features.	Waters floodplain which provides moisture for floodplain vegetation. Entrains organic matter and mobilises sediment and scours instream vegetation.

Table A10. Environmental objectives and flow components for Dock Lake Compliance Point: Not Present, from Jacobs (2015)

Flow component	Timing	Magnitude	Climatic scenario	Frequency	Duration	Associated environmental objective	Expected watering effects
Inundation (partial fill)	Any	Between 271 ML and 973 ML	DRY/AVERAGE/WET	1 in 2 years (WET) 1 in 3-4 years (AVE) 1 in 5 years (DRY)	3 to 14 months	Wetland vegetation and bird life cycles with ancillary benefits for frogs, macroinvertebrates and turtles	Provide shallow water inundation to enable nesting habitat and food sources for waterbirds and other fauna species. Drowns terrestrial annual grasses and supports growth of wetland herbs.

Appendix 3: Flow components that have been delivered from 2005 to 2021.

Reach	Flow Component	Hydrological achievement of flow components over time													
		06-07	07-08	08-09	09-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21
4 Wimmera River	Summer-autumn baseflows 15 ML/d	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E	E	E	E	E	E

Reach	Flow Component	Hydrological achievement of flow components over time														
		06-07	07-08	08-09	09-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21
4 Wimmera River	Winter-spring baseflows 30 ML/d	U	U	U	U	E/U	E/U	E/U	E/U	E/U	U	U	E/U	E	U	
4 Wimmera River	Summer-autumn freshes 70 ML/d x 1-3 x 2-7 d	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E	E	E	E		U
4 Wimmera River	Winter-spring freshes 70 ML/d x 1-5 x 1-4 d	U	U	U	U	E/U	E/U	E/U	E/U	E/U	U	U	U/E	E	U	U
2 MacKenzie River	Summer autumn, baseflows 2 ML/d	E/U/O	E/U/O	E/U/O	E/U/O	E/U/O	E/U/O	E/U/O	E/U/O	E/U/O	E/O	E	E	E	E	E
2 MacKenzie River	Winter spring baseflows 27 ML/d	U	U	U	U	E/U/O	E/U/O	E/U/O	E/U/O	E/U/O	U/O	U	U/E	E	U	U
2 MacKenzie River	Summer-autumn freshes 5 to 50 ML/d x 2-4 x 2-7 d	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E	E	E	E	E	E
2 MacKenzie River	Winter-spring freshes 55 ML/d x 5 x 2-7d	U	U	U	U	E/U	E/U	E/U	E/U	E/U	U	U	U/E	E	U	
2 MacKenzie River	Winter-spring freshes 130 ML x 1-5 x 1-4 d	U	U	U	U	E/U	E/U	E/U	E/U	E/U	U	U	U			
3 MacKenzie River	Summer, autumn, Winter, spring baseflows 10 ML/d	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E/U		U/E	E/U	E		
3 MacKenzie River	Summer-autumn freshes 35 ML/d x 3-4 x 2-7 d	U	U	U	U	E/U	E/U	E/U	E/U	E/U		E	E	E		
3 MacKenzie River	Winter-spring freshes 35 ML/d x 5 x 2-7 d	U	U	U	U	E/U	E/U	E/U	E/U	E/U		U	U	U/E		
Lower Mt William	Summer, autumn, Winter, spring baseflows 5 ML/d	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E/U	U	E/U	E	E	E	
Lower Mt William	Summer-autumn freshes 20-30 ML x 3 x 2-7 d	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E/U		E	E	E	E	E
Lower Mt William	Winter-spring freshes 100-500 ML/d x 1-5 x 1-7d	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E/U		U	U		E	
Upper Mt William Creek	Summer-autumn baseflows 500 ML/total	U	U	U	U	U/E	U/E	U/E	U/E	E/U	E/U	U	U	E	E	
Upper Burnt Creek	Summer autumn Winter-spring baseflows 1 ML/d	E/U/O	E/U/O	E/U/O	E/U/O	E/U/O	E/U/O	E/U/O	E/U/O	E/U/O	E/O/U	E/U	E/U	E	E	E

Reach	Flow Component	Hydrological achievement of flow components over time														
		06-07	07-08	08-09	09-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21
Upper Burnt Creek	Summer-autumn freshes 30 ML/d x 3 x 2-7d	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E	E	E	E		
Upper Burnt Creek	Winter-spring freshes 55 ML/d x 1-5 x 3-7d	U	U	U	U	U	U/E	E/U	E/U	E/U	O/U	U	U	U	U	U
Upper Burnt Creek	Autumn-winter freshes 160 ML/d x 1-3 x 1-3d	U	U	U	U	U	U/E	U	U	U	O/U	U	U			
Lower Burnt Creek	Winter-spring freshes 45ML/d x1 x 2d	U	U	U	U	U	U	E/U	E/U	E/U		U	U			
Bungalally Creek	Winter-spring freshes 60 ML/d x 1 x 2d	U	U	U	U	U	U	E/U	E/U	E		U	U			

Key for Table.

	No significant part of the flow component achieved
	Flow component partially achieved
	Flow component has been completely achieved, i.e. complete duration, frequency and magnitude was achieved

E	Managed environmental water release
O	Consumptive water en route/other managed flow
U	Unregulated flows
X	Unknown

Appendix 4: Priority Watering Actions

Table A11. Priority Watering Actions Wimmera Reach 4.

PWA Target	Flow function	Priority	Rationale	Volume (ML)
Baseflow Dec-May 15 ML/day	Maintain edge habitats in deeper pools and runs, and shallow water habitat availability for macroinvertebrates and endemic fish. Maintains near-permanent inundated stream channel for riparian vegetation and to prevent excessive in stream terrestrial species growth.	Very High	Salinity levels in the lower Wimmera River reach 50,000 µS/cm during cease to flow conditions. This flow component plays a critical role in maintaining water quality for aquatic and riparian ecosystems. This flow mitigates severe salinity impacts so reduces likelihood of fish kills, algae blooms and die back of fringing vegetation and macroinvertebrates which were common events during the 2002 to 2010 when there were long cease to flow periods. This baseflow also supports vegetation in low benches.	9,100 ML

PWA Target	Flow function	Priority	Rationale	Volume (ML)
Baseflow June-Nov 30 ML/day	Provides flow variability to maintain diversity of habitats.	Very High	It is of high importance to maintain constant baseflows in the lower Wimmera River during winter and spring when there are periods of low rainfall. Salinity levels in the lower Wimmera River reach 50,000 uS/cm during cease to flow conditions. This flow component plays a critical role in maintaining water quality for aquatic and riparian ecosystems. This flows diminish the high risk of die back of vegetation and fish fills which were common events during the 2002 to 2010 when there were long cease to flow periods.	10,980 ML
Freshes Dec-May, 1-3 events of 70 ML/day 2-7 days	Prevent water quality decline by flushing pools during low flows. Provide variable flow during low flow season for macroinvertebrates (over wood debris to increase biofilm abundance as a food source), fish movement and to maintain water quality and diversity of habitat.	Very High	Salinity levels in the lower Wimmera River reach 50,000 uS/cm during cease to flow conditions. This flow component plays a critical role in freshening the water quality during very hot period of the year where evaporation and seepage levels are high and baseflows are not able to prevent water quality decline in refuge pools. These freshes maintain water quality for aquatic and riparian ecosystems. These freshes diminish the high risk of algal blooms, die back of vegetation and fish fills which were common events during the 2002 to 2010 when there were long cease to flow periods.	150 – 1575 ML
Freshes - smaller June-Nov 1-5 events of 70 ML/day 1-4 days	Increase the baseflow water depth by to provide stimulus for fish movement (not required in drought years, frequently required in wet years). Provide flow variability to maintain water quality and diversity of fish habitats. Wets lower benches, entraining organic debris and promoting diversity of habitat.	Very High	This flow component plays a critical role in freshening the water quality during winter and spring periods when there is low rainfall. These freshes are useful when baseflows are not able to prevent water quality decline. These freshes provide flow variability to stimulate fish movement and maintain a healthy water quality for aquatic and riparian ecosystems.	60 – 1200 ML
Freshes - medium June-Nov 1-3 events of 200 ML/day 1-3 days	Provide variable flow during high flow season for fish movement and to maintain water quality and diversity of habitat. Also flushes surface sediments from hard substrates for macroinvertebrates	Medium	Wet lower benches, entraining organic debris and promoting diversity of habitat	130 – 1170 ML
Inundation of Ranch Billabong	Provide water to disconnected anabranch of Wimmera River at Dimboola via pumping	High	Provides cultural outcomes given the significance of the site and also some riparian and aquatic vegetation outcomes (e.g. Common Sneezeweed).	20 ML

Table 12. Priority Watering Actions MacKenzie River Reach 3.

PWA Target	Flow function	Priority	Rationale	Volume (ML)
Baseflow all year 10 ML/day	Maintain edge habitats and shallow water habitat availability for macroinvertebrates and endemic fish and near-permanent inundated stream channel for riparian vegetation and prevents excessive instream terrestrial species growth. Facilitate annual dispersal of juvenile platypus into the Wimmera River.	High (Very High June-November)	Prevents reach 2 and reach 3 from drying out completely and loss of high value fish and platypus communities. Lack of flows would see it dry out in a few weeks thereby losing a high value fish community and opportunities for fish movement/dispersal.	8210 ML
Freshes December-May 3-4 events of 35 ML/day 2-7 days	Provide variable flow during low flow season for macroinvertebrates (over wood debris to increase biofilm abundance as a food source), fish movement and to maintain water quality and diversity of habitat.	High	This watering action benefits native fish movement and macroinvertebrate heath and maintenance of water quality and dispersal of the very high value platypus population.	300 – 1400 ML
Freshes June-November 5 events of 35 ML/day 2-7 days	Stimulate fish movement and maintain water quality and diversity of habitat.	Very High	This watering action benefits native fish movement and macroinvertebrate heath and maintenance of water quality and diversity of habitat.	350 – 1225 ML

Table 13. Priority Watering Actions MacKenzie River Reach 2.

PWA Target	Flow function	Priority	Rationale	Volume (ML)
Baseflow Dec-May 2 ML/day	Maintain edge habitats in deeper pools and runs, and shallow water habitat availability for macroinvertebrates and endemic fish. Maintains near-permanent inundated stream channel to prevent excessive in stream terrestrial species growth.	Very High	This reach of Mackenzie River supports the source population of indigenous fish (River Blackfish, Mountain Galaxias, Flathead Gudgeon, Southern Pygmy Perch) and a population of platypus that are regionally important. This watering action prevents this reach from drying out completely and loss of high value fish and platypus communities.	950 ML
Baseflow June-Nov 27 ML/day	Facilitate annual dispersal of juvenile platypus into the Wimmera River. Provides flow variability to maintain diversity of habitat.	High	Whilst these flows are typically generated through pickup, if it is a dry winter spring there's still a risk that it could dry out in parts.	5,490 ML

PWA Target	Flow function	Priority	Rationale	Volume (ML)
Freshes Dec-May 2-4 events of 5-50 ML/day 2-7 days	Prevent water quality decline by flushing pools during low flows. Provide variable flow during low flow season for macroinvertebrates (over wood debris to increase biofilm abundance as a food source), fish movement and to maintain water quality and diversity of habitat.	Very High	Smallish volume has typically meant it has been delivered with baseflows to get the full suite of flow for the reach. This watering action prevents water quality decline and supports fish movement. This watering action is important to reduce salinity levels and vegetation diversity on banks.	120 – 1260 ML
Freshes June-Nov 5 events of 55 ML/day 2-7 days	Provide variable flow during low flow season for macroinvertebrates (over wood debris to increase biofilm abundance as a food source), fish movement and to maintain water quality and diversity of habitat. Flush surface sediments from hard substrates to support macroinvertebrates.	High	Provides some variation of flow to encourage fish movement, healthy macroinvertebrate communities, maintains water quality and mobilisation of sediment.	250 - 875 ML

Table 29. Priority Watering Actions Upper Burnt Creek.

PWA Target	Flow function	Priority	Rational	Volume (ML)
Baseflow all year 1 ML/day	Maintain edge habitats and shallow water habitat availability for fish and macroinvertebrates and inundated stream channel for riparian vegetation and prevents excessive instream terrestrial growth.	Very High	This watering action is critical for supporting a good native fish community as well as Western Swamp Crayfish.	1,825 ML
Fresh Dec-May 3 events of 30 ML/day 2-7 days	Prevent water quality decline by flushing pools during low flows	Very High	This watering action provides good vegetation, macroinvertebrates and native fish outcomes.	270 - 945 ML
Fresh Jun-Nov 1-5 events of 55 ML/day 3-7 days	Provide variable flow for fish movement and diversity of habitat. Also flushes surface sediments from hard substrates for macroinvertebrates. Disturb the algae/bacteria/organic biofilm present on rock or wood debris to support macroinvertebrate communities.	Very High	This watering action provides good vegetation, macroinvertebrates and native fish outcomes.	180 – 2100 ML
Fresh May-Jun 1-3 events of 160 ML/day 1-3 days	Disturb the algae/bacteria/organic biofilm present on rock or wood debris to support macroinvertebrate communities.	Medium	This watering action provides good vegetation, macroinvertebrates and native fish outcomes.	160 - 1440 ML

Table 15. Priority Watering Actions Lower Burnt Creek.

PWA Target	Flow function	Priority	Rational	Volume (ML)
Bankfull Any month 1 event of 45 ML/d for 2 days	Inundate riparian vegetation to maintain condition and facilitate recruitment. Entrain organic debris in the channel to support macroinvertebrates. Maintain structural integrity of channel.	High	This watering action is critical for supporting a good fish community as well as Western Swamp Crayfish.	300 ML
Overbank Aug-Nov 1 event of 90 ML/d for 1 day	Inundate floodplain vegetation to maintain condition and facilitate recruitment. Entrain organic debris from the floodplain to support macroinvertebrates. Maintains floodplain geomorphic features.	Medium	This watering action provides good vegetation, macroinvertebrates and native fish outcomes.	180 ML

Table 16. Priority Watering Actions Bungalally Creek.

PWA Target	Flow function	Priority	Rationale	Volume (ML)
Bankfull Any time of year 1 event of 60 ML/day for 2 days	Inundate riparian zone to maintain condition of adults and facilitate recruitment for riparian EVCs Maintain structural integrity of channel and prevents loss of channel diversity through lack of flow variability.	Medium	Bungalally Creek has valuable riparian vegetation in some sections which provides important habitat for terrestrial and aquatic species and much like Reach 2 of the Burnt Creek. Due to the high level regulation of this system and the fact that it would only receive flows during high flow events, the creek bed will most probably be completely dry when watering commences.	300 ML

Table 17. Priority Watering Actions Upper Mt William Creek.

PWA Target	Flow function	Priority	Rationale	Volume (ML)
Fill refuge pools during dry conditions (summer/ autumn)	Prevents sediment accumulation that can smother habitat. Assists in maintaining and access to suitable habitat for macroinvertebrate and fish species. Assists in maintenance of wetted channel during summer low flow period and improves water quality in pools. Triggers spawning in many Western Carp Gudgeon as well as a number of other key native fish species.	Very High	Lake Lonsdale levels are reducing following dry conditions in 2017. It is very important to continue to monitor these refuge pools that provide crucial drought refuge to high value native fish populations, Obscure Galaxias, Australian Smelt, Flathead Gudgeon, short finned eel (rarely) and the 'vulnerable' Southern Pygmy Perch, (Biosis 2012), (SKM 2005).	300 ML

Table 18. Priority Watering Actions Lower Mt William Creek.

PWA Target	Flow function	Priority	Rationale	Volume
Baseflow year round 5 ML/day	Maintain edge habitats and shallow water habitat availability for macroinvertebrates and endemic fish and near-permanent inundated stream channel for riparian vegetation and prevents excessive instream terrestrial species growth.	High	The lower Mt William Creek contains high value native fish populations, River Blackfish, Mountain Galaxias, Australian Smelt, Flat-headed Gudgeon, short finned eel and the 'vulnerable' Southern Pygmy Perch, (Austral 2015). The absence of flow would place these very high environmental values at risk. River Blackfish have been increasingly rare in the sections of the Wimmera catchment outside the Grampians (EnviroDNA 2017a, 2017b).	1,825 ML
Fresh Dec-May 3 events of 20 to 30 ML/day 2-7 days	Prevent water quality decline by flushing pools during low flows. Provide variable flow during low flow season for macroinvertebrates (over wood debris to increase biofilm abundance as a food source), fish movement and to maintain water quality and diversity of habitat.	Very High	This watering action provides a much needed improvement to water quality with a pulse of water reaching the end of the creek which baseflows tend not to be able to do.	90 - 525 ML
Fresh June-Nov 1-5 events of 100 ML/day 1-7 days	Wets benches, entraining organic debris and promoting diversity of habitat. Flush surface sediments from hard substrates to support macroinvertebrates. Wets low benches, entraining organic debris and promoting diversity of habitat.	Medium	If flow for the Wimmera River is provided from Taylors Lake then these freshes are important to water the Wimmera River above Taylors. This watering action also provides a dispersal mechanism for high value native fish communities as well as vegetation and macroinvertebrate outcomes.	285 - 3325 ML

Table 19. Priority Watering Actions Dock Lake

PWA Target	Flow function	Priority	Rationale	Volume (ML)
Provide low-level inundation for high quality wetland habitat	Provides abundant vegetation response and subsequent bird-breeding events for a number of wetland bird species.	High	Aligns with objectives and recommendations in *Dock Lake FLOWS Study* (Jacobs, 2015). Water provided from unregulated flows/spills in 2016 led to a significant bird-breeding event and an abundance of wetland birds.	300 - 1000ML