RMCG

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Environmental Water Management Plan - MacKenzie River and Burnt and Bungalally Creeks

Final Report

Wimmera Catchment Management Authority

Certified B Corporation

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Executive Summary

This Environmental Water Management Plan sets out long-term objectives for environmental values of the MacKenzie River and Burnt and Bungalally Creeks.

This Environmental Water Management Plan (EWMP) includes the MacKenzie River, and Burnt and Bungalally Creeks. The EWMP is an important part of the Victorian Environmental Water Planning Framework. It provides guidance for environmental watering actions for the next decade, based on scientific information and stakeholder consultation. It is used by government departments and agencies, including Catchment Management Authorities (CMAs), Victorian Environmental Water Holder (VEWH), and Department of Energy, Environment and Climate Action (DEECA) for both short and long-term water planning.

This EWMP complements existing strategic plans (Wimmera Regional Catchment Strategy 2021-2027 and Wimmera Waterway Strategy 2014-2022). It focuses on management of water for the environment, supporting the waterways of the Wimmera CMA region to continue to provide their environmental, social, cultural and economic values for the community.

A second separate EWMP covers the other parts of the catchment that receive environmental water (Wimmera River, Yarriambiack Creek and their terminal lakes including Lake Hindmarsh and Lake Albacutya and the Ross Lakes).

The main sections of the EWMP are briefly summarised here.

Major updates to the EWMP and reasons for change/s

This EWMP updates the previous Environmental Water Management Plan – Wimmera River System completed in 2015. It has been updated to align with the Environmental Water Management Plan Guidelines for Rivers and Wetlands (Version 6) (DELWP, 2022a).

The Wimmera CMA has also separated the previous single EWMP for the Wimmera River system into two components:

- Wimmera River, Yarriambiack Creek and their terminal lakes including Lake Hindmarsh and Lake Albacutya and the Ross Lakes
- MacKenzie River, and Burnt and Bungalally Creeks.

Asset overview and characteristics

The Wimmera River System, of which the MacKenzie River, and Burnt and Bungalally Creeks are tributaries, is a large and geographically diverse system which experiences great variability in climate, in particular rainfall, which in turn influences water regimes for creeks, rivers and wetlands. Much of the land where the Wimmera River System is located, including the MacKenzie River, and Burnt and Bungalally Creeks, is classified as Crown land as stream frontage or set aside as a reserve for nature conservation or water supply.

Variability in rainfall leads to substantial fluctuations in streamflows in the Wimmera region, although in general the seasonal rainfall patterns mean streamflows are much lower (or non-existent) during summer and autumn, increasing during early winter and then reducing in late spring. The series of storages, weirs and channels that comprise the Wimmera Mallee Headworks System are very effective at harvesting and transferring streamflows. Historically, this had impacted downstream waterways by dramatically reducing flows through diversions into the former stock and domestic channel system. However, the water recovery works delivered

through the completion of the Wimmera Mallee pipeline has led to an increased environmental entitlement for the rivers and 13 wetlands in the catchment. The system now also provides a range of opportunities to direct water for the environmental back into different waterways in the Wimmera River system.

MacKenzie River, originates above Lake Wartook, and runs through Gariwerd (Grampians National Park), joining the Wimmera River south-west of Horsham. The upper and mid MacKenzie River are separated by Dad and Dave Weir, whereas the lower and mid MacKenzie River are separated by Distribution Heads Weir.

Burnt Creek is an anabranch or distributary of the MacKenzie River, which originates from the Distribution Heads Weir, near Laharum, and terminates at the Wimmera River confluence. Upper and lower Burnt Creek are separated by the Toolondo Channel.

Bungalally Creek is a high-flow channel that flows north-west from the Burnt Creek at Wonwondah to the MacKenzie River at Haven, south-west of Horsham (EA, 2019).

Partnerships and consultation undertaken for EWMP preparation and implementation

A variety of mechanisms have been used to gather information from stakeholders and the community on ecological and social values and observations from previous environmental watering events. This in turn has been incorporated into the EWMP. The Wimmera CMA's annual Environmental Water Reserve forum comprised of community members and agency representatives plays an important role in advising the Wimmera CMA on environmental watering planning and delivery in the Wimmera River system. There are also processes in place for public consultation around ongoing environmental watering activities.

Water dependent environmental values present

The MacKenzie River, and Burnt and Bungalally Creeks support threatened flora species such as Spiny Lignum (*Duma horrida*) as well as substantial tracts of riparian and wetland vegetation including iconic species like River Red Gum (*Eucalyptus camaldulensis*) and Black Box (*Eucalyptus largiflorens*). Notable water-dependent fauna include fish species such as the Flat-headed Gudgeon (*Philypnodon grandiceps*), Southern Pygmy Perch (*Nannoperca australis*), and River Blackfish (*Gadopsis marmorata*), as well as freshwater mussels and the threatened Western Swamp Crayfish (*Gramastacus insolitus*) (EA, 2019). Sections of these waterways (e.g. mid Burnt Creek) also provide important refuge sites during periods of drought or low flows.

The MacKenzie River and Burnt Creek are also the home of and represent future translocation opportunities for the Wimmera's only confirmed population of the iconic Platypus (*Ornithorhynchus anatinus)*.

MacKenzie River, and Burnt and Bungalally Creeks also provide an important regional biolink (or biodiversity corridor) connecting Gariwerd (Grampians National Park) with the Wimmera River.

Water-related threats to the environmental values

The condition of the Wimmera River system including MacKenzie River, and Burnt and Bungalally Creeks has been impacted by a range of threats that have led to its deterioration. Systemic issues around over-extraction of water have been compounded by poor water quality, particularly salinity and impacts from exotic species including carp. In response Wimmera CMA and its partners have undertaken a range of integrated waterway improvement works aimed at improved condition, such as management of water for the environment, erosion control and riparian fencing.

Management goal

The long-term management goal for the MacKenzie River, and Burnt and Bungalally Creeks is aligned to the recently updated Wimmera Regional Catchment Strategy (RCS) 2021-2027[1], which is detailed below. Management of water for the environment is aligned to these RCS outcomes based on the ecological requirement for each target reach, requirements for specific flora and fauna species, and the social and economic values of the water in the region balancing water availability with potential future inflow forecasts.

RCS outcomes relevant to management of water for the environment include:

- **20-year outcomes**
- The knowledge and experience of First Nations people is informing water planning, management and delivery in the Wimmera.
- The Wimmera Heritage River's values are maintained or improved.
  - The connectivity and condition of native vegetation along riparian corridors are improved.
- Water quality is improved at important areas for water supply, environmental and recreational values.
- Rivers and streams with high environmental, social, cultural and economic values are improving their value despite climate change.
- **Six-year outcomes**
  - Ongoing collaboration and two-way learning in river and stream planning and management by supporting and strengthening partnerships with First Nations people.
- Recreational participation numbers on the Barringgi Gadyin (Wimmera River) are increasing.
  - More river and stream reaches have improved management of and access for recreation.
  - Healthier rivers and streams enable more on Country activities for First Nations people.
- Blue green algal blooms and fish deaths are prevented where possible in the Barringgi Gadyin (Wimmera River).
- No new pest plants and animals are established beyond small, localised populations.
- More rivers and stream reaches have less stock access.
  - More reaches have improved riparian width and connectivity.
  - More river reaches are permanently protected through management agreements.
- Drought refuges are protected and retain water during drought.
  - Net rates of streamflow interception are stabilising.
  - Native fish and platypus are increasing their abundance and distribution.
  - Native fish numbers are greater than carp numbers in most fish surveys and fishing competitions.

The ecological and hydrological objectives that sit under the long-term management goal have been informed by environmental flow studies and technical reports that prescribe the environmental watering regime for the MacKenzie River, and Burnt and Bungalally Creeks contained within this EWMP. This includes:

- Wimmera River Environmental Flows Study (Alluvium, 2013)
- Lower MacKenzie River and Burnt Creek flow optimisation project (EA, 2019).

These flows studies are used as a guide for environmental flows planning, conducted each year for a range of model climate scenarios, and are used to inform annual seasonal watering proposals finalised each April for the following water year (July-June). Accordingly, these studies need to be updated periodically to ensure the latest information on climate variability, climate change scenarios and operational constraints are included.

[1] Wimmera CMA (2021)

The accumulated knowledge of 10 years of environmental watering also highlights a need to ensure future watering actions are adaptable and outcome driven, and guided by conditions in the river at the time.

For example, the Lower MacKenzie River and Burnt Creek flow optimisation project was commissioned by the Wimmera CMA in 2019 to address reduced water allocations available for environmental watering in summer/autumn 2019 compared with previous years; and well below the flows recommended in the 2013 Alluvium flows study (2013). The focus of this work was on targeted use of available water to refuge pools to protect fish, crayfish and platypus populations rather than achieve desired objectives around recruitment and dispersal. This was off the back of environmental watering undertaken in 2016-17 and 2017-18, which was observed to have maintained refuge pools over two successive years for the first time since the Millenium Drought (EA, 2019).

Risks and delivery constraints associated with environmental water delivery

There are several challenges that need to be addressed to achieve desired ecological outcomes using water for the environment. These challenges include threats such as exotic species, barriers to fish passage and system constraints. The risks associated with these threats are outlined and mitigation actions are prescribed.

Availability of water for the environment is often less than the water needed to deliver the recommended flows. For example, most of the larger flow components (such as bankfull or overbank) cannot be delivered through regulated releases in most cases due to the physical restrictions of upstream dams and weirs. Other factors (such as prohibitive channel losses and risks around inundation of private land) mean most of these releases are also not feasible. As a consequence, overbank flow recommendations can only be met by natural events.

As detailed above, the recent 2019 Lower MacKenzie River and Burnt Creek flow optimisation project was commissioned to target watering for the protection of refuge habitat that protects fish, crayfish and platypus populations.

The Wimmera CMA is exploring the potential of current pipelines that source supply from lakes Wartook and Moora Moora to water high-value ecological sites in the MacKenzie River and tributaries when dry. The aim is to pursue water savings and better manage water in this tributary system, especially in the face of climate change. This will also assist in restoring the historic riparian connectivity between Gariwerd (Grampians National Park) and the broader region.

Climate impacts

Climate change and a drying climate also influence the use of water for the environment. For example, the recent climatic water cycle has a seen a large rain event every six or so years that fills the headworks storages and causes minor to moderate flooding (i.e. flash-flooding storm events potentially replacing the gradual wetting of the catchment of past years). While this meets the larger flow components of the flow studies, careful management of the environmental water reserve is needed between these high-flow periods to ensure flows still meet the river's ecological requirements.

If MacKenzie River, and Burnt and Bungalally Creeks are meeting optimal ecological requirements, planned flows for the period may be reduced to preserve water for use in subsequent seasons.

A key focus for the management of watering in the MacKenzie River and Burnt Creek is the maintenance of endemic fish communities and the provision of adequate water quality and habitat for fish refuge locations in dry periods, which is often limited by low storage levels (EA, 2019).

Objectives of monitoring and assessment activities

To enable adaptive management and highlight the outcomes of environmental watering to stakeholders and the community, a comprehensive monitoring program needs to be implemented, with a focus on maintaining

the refuge pools. This EWMP recommends a suite of intervention and long-term condition monitoring activities that will meet these requirements.

Knowledge gaps to address

While there has been a long history of environmental watering in the Wimmera, and a lot of information gathered in this time, there remains several important knowledge gaps. These include:

- the effect of instream water loss rates in MacKenzie River and Burnt Creek
- the cultural values of these waterways and Bungalally Creek and how these could be enhanced with environmental watering actions
- the time lag required for watering to reach key refuge pools in these waterways.

This also involves:

- Better understanding the travel times of flows between gauging points through the collection of monitoring data on flow rates (this includes observing requested flow rates with actual flow rates delivered through the regulator and noting any operational anomalies that may have influenced or interrupted watering events).
- Evaluating the cost and long-term benefits of installing real time depth loggers at the mid or upper refuge pools on each waterway (lower refuge pools are located at gauges), prioritised as follows:
  - 1st – Burnt Creek (upper refuge pool)
  - 2nd – Burnt Creek (mid refuge pool) and MacKenzie River (upper refuge pool)
  - 3rd – MacKenzie River (mid refuge pool).
- Observing the effects of variations in the split in water delivered to each waterway (MacKenzie River and Burnt Creek), and the results of alternating the releases between the two waterways.

Figure ES-1: Chain of ponds geomorphology at lower Burnt Creek (Source: WCMA)

ACKNOWLEDGEMENT OF COUNTRY

We acknowledge the Wotjobaluk, Jaadwa, Jadawadjali, Wergaia and Jupagalk Peoples as the Traditional Owners of the Country on which this project has been conducted. We recognise their continuing connection to land, waters and culture and pay our respects to their Elders past and present. Moreover, we express gratitude for the knowledge and insight that Traditional Owners and other Aboriginal and Torres Strait Islander people contribute to our shared work in Australia.

Abbreviations, acronyms and glossary

ABBREVIATIONS AND ACRONYMS

AHD	Australian Height Datum
BGLC	Barnegi Gadjin Land Council
CEWO	Commonwealth Environmental Water Office
CMA	Catchment Management Authority
COAG	Council of Australian Governments
DCCEEW	Australian Government Department of Climate Change, Energy, and Environment and Water
DEECA	Victorian Department of Energy, Environment and Climate Action
EHNV	Epizootic Haemotopoietic Necrosis Virus
EPBC	Environment Protection and Biodiversity Conservation Act
EOS	Environmental Operating Strategy
ERS	Environmental Reference Standard
EWMP	Environmental Water Management Plan
EWR	Environmental Water Reserve
FFG	Flora and Fauna Guarantee Act
ICAG	Inter Catchment Advisory Group
ISC	Index of Stream Condition
IWC	Index of Wetland Condition
LiDAR	Light Detection and Ranging
GWMWater	Grampians Wimmera Mallee Water Corporation
MBI	Macroinvertebrate Biotic Index
MDBA	Murray Darling Basin Authority
MWS	Mallee Waterway Strategy
NES	National Matters of Environmental Significance
NTU	Nephelometric Turbidity Units
NWI	National Water Initiative
PAL	Portable Automated Logger
RBA	Rapid Biological Assessment
RCS	Regional Catchment Strategy
SCADA	Supervisory Control and Data Acquisition
SRA	Sustainable Rivers Audit
SWS	Sustainable Water Strategy
TRG	Technical Reference Group
VEFMAP	Victorian Environmental Flows Monitoring and Assessment Program
VEWH	Victorian Environmental Water Holder
VWMS	Victorian Waterway Management Strategy
WetMAP	Wetland Monitoring and Assessment Program
WRAG	Western Rivers Advisory Group
WWS	Wimmera Waterway Strategy

GLOSSARY

Aeolian	Relating to the action of the wind
Anastomosing	Channels that separate and reconnect
Bankfull	Very high flow that fills but is contained within the river channel
Cease to flow	Period with no flow
Channelised	Removal of hydraulic diversity (runs, riffles, ponds) due to excavation/erosion
Chain-of-ponds	Type of streamform with deep pools that are separated by raised areas
Deflation basin	Shallow depression created by wind blowing sediment
Endemic	Native to the local area
Episodic	Takes place after significant episodes (i.e. floods)
Exotic	Not native to Australia
Ferruginised	Sandstone containing high levels of iron which is more resistant to erosion
Fresh	Higher flow than baseflow that would naturally take place following a modest rainfall event. Important for improving water quality, inundating habitat and providing biological cues
Fresh water	Salinity level below approximately 1,000 µS/cm
High value waterway	Waterway (river/creek/lake/wetland) with a value (environmental/social/cultural/economic) that is deemed to be above a certain threshold defined within a regional waterway strategy
Hydraulic	Related to the movement of water over a surface
Hydrologic	Related to the distribution of water in space and time
Hypersaline water	Salinity levels over approximately 40,000 µS/cm
Intermittent	Takes place temporarily typically less frequently than annually
Lunette	Crescent shaped high point created by wind movement of sediment
Overbank	Very large flow that exceeds the capacity of the river channel (flood)
Passing flow	Flows that must be passed at regulating infrastructure (Lake Lonsdale, Huddleston's Weir, Stawell Diversion Weir) under conditions specified within the Environmental Entitlement
Priority waterway	Subset of high value waterways that have a range of feasible management activities that can be undertaken to maintain or improve their values
Refuge	Location (e.g. deep pool) that possesses many attributes that means that aquatic communities (fish, platypus) can resist stresses of drought, bushfire etc
Regulated	Water controlled by headworks infrastructure (weirs, channels, dams). Regulated environmental water is that allocated within the entitlement framework and can be called on to be released from headworks infrastructure subject to approval by the storage manager
Reach	Sub-section of a river or creek based on distance or common attribute (geomorphology/hydrology). Generally, at least several kilometres in length
Seasonal	Takes place during particular seasons
Translocated	Species moved from one location to establish another one elsewhere.

1 Introduction

Environmental water management practices within the Murray-Darling Basin have advanced significantly since the mid-2000s. The completion of various water recovery and purchase programs combining with enhanced policy and greater scientific knowledge has resulted in on-ground change. The most dramatic change in the Wimmera River System was the completion of the Northern Mallee and Wimmera Mallee pipelines and purchase of the Wimmera Irrigators' Association entitlement in 2012.

Completion of these environmental water recovery initiatives has resulted in:

- 40.5 GL high reliability regulated entitlement shared between the Wimmera and Glenelg River systems (VEWH managed entitlement)
- 28 GL low reliability former irrigation entitlement for the Wimmera River (CEWH held entitlement)
- An average of 36.8 GL/y of passing flows and additional unregulated flows for the Wimmera River System.

Policy documents developed in consultation with the community such as Securing Our Water Future Together (DSE, 2004), Western Region Sustainable Water Strategy (DSE, 2011), Basin Plan (Commonwealth of Australia, 2012) and Victorian Waterway Management Strategy (DEPI, 2013) progressed the development of water sharing arrangements to ensure water is used effectively and efficiently. Local scientific information on responses of fish, platypuses, macroinvertebrates and water quality to environmental water releases has also been collected through monitoring for many years to enable adaptive management.

The development of this Environmental Water Management Plan (EWMP) for the MacKenzie River, and Burnt and Bungalally Creeks provides an opportunity to consolidate these advancements and develop a solid foundation document for environmental water management for these waterways for the next decade.

1.1 PURPOSE AND SCOPE

This EWMP for the MacKenzie River, and Burnt and Bungalally Creeks is a 10-year management plan that:

- Describes the ecological values present
- Establishes long-term ecological objectives and water requirements of the MacKenzie River, and Burnt and Bungalally Creeks
- Identifies and addresses risks associated with environmental watering and mitigating actions for those risks.

The purpose of this EWMP is to:

- Synthesise technical information relating to environmental values, condition, hydrology, threats and water resource infrastructure
- Identify the long-term ecological objectives and their water requirements for the MacKenzie River, and Burnt and Bungalally Creeks
- Provide a vehicle for community consultation, including setting of long-term objectives and water requirements of these waterways
- Operationalise flow studies, including providing guidance on the environmental watering targets appropriate under different seasonal conditions to inform the development of Seasonal Watering Proposals and Plans
- Inform the Long-term Watering Plan for the Wimmera-Mallee Water Resource Plan area, as required under the Basin Plan (Chapter 8).

1.2 ASSET CHARACTERISTICS

This EWMP includes the MacKenzie River, and Burnt and Bungalally Creeks. The Wimmera River and Yarriambiack Creek, and their terminal lakes; Mount William Creek and Dock Lake are not included in this EWMP. The EWMP is limited to issues related to the management of environmental water and flow-dependent values and does not constitute a holistic management plan for the Mackenzie River, Burnt and Bungalally Creek system. Please refer to the Wimmera EWMP for an overview of the broader Wimmera River system.

A map showing the main features of the Wimmera River catchment is shown in Figure 1-1. The reaches covered in this EWMP are MacKenzie River Reaches 1, 2 and 3, Upper Burnt Creek, Lower Burnt Creek and Bungalally Creek.

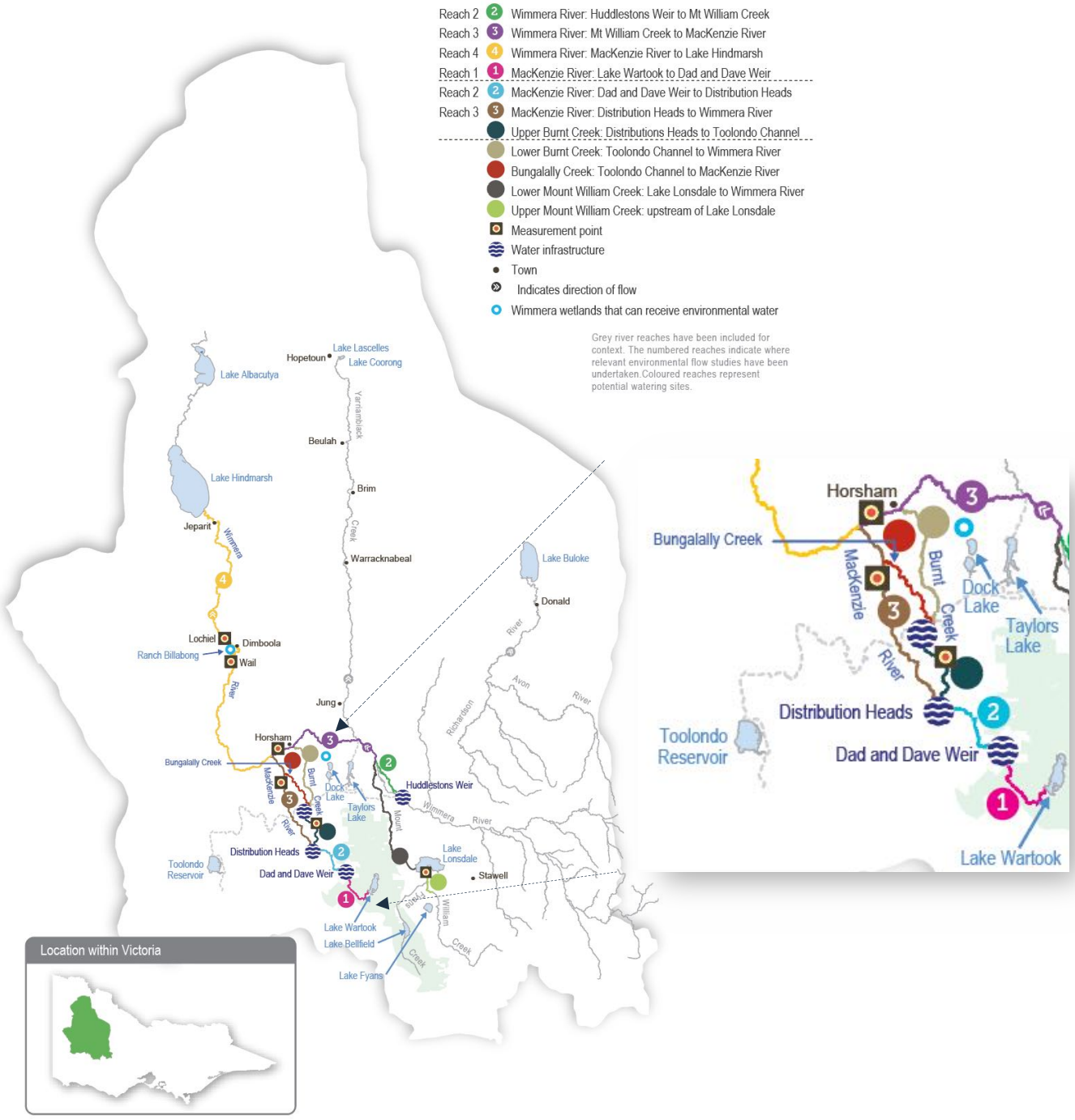

Figure 1-1: Map showing the Wimmera River system. Reaches covered in this EWMP are MacKenzie River Reaches 1, 2 and 3, Upper Burnt Creek, Lower Burnt Creek and Bungalally Creek (VEWH, 2024)

1.3 PROCESS USED TO UPDATE THE EWMP.

The Wimmera CMA has been funded through the Department of Energy, Environment and Climate Change (DEECA) to update this EWMP for the MacKenzie River, and Burnt and Bungalally Creeks. Initial development of this EWMP was a management activity specified in the Wimmera Waterway Strategy (Wimmera CMA, 2014).

The EWMP has been developed in consultation with the community as well as including input from technical specialists in waterway ecology and water resource management to provide a robust and thorough planning document for the next decade. It will form the basis for future Seasonal Watering Proposals for the MacKenzie River, and Burnt and Bungalally Creeks.

1.4 POLICY CONTEXT

Environmental water in Victoria is managed as an integral part of the Victorian Waterway Management Program, with the state-level Victorian Waterway Management Strategy (VWMS) providing the overarching framework for environmental water management (Figure 1-2). Regional Waterway Strategies (RWS) drive the implementation of the VWMS at the regional level. Information from the region's RWS is a key input to environmental water planning arrangements, including the selection of eligible assets to receive environmental water. Environmental water management plans are site-specific plans developed for those assets deemed a priority to receive environmental water through the RWS development process.

Environmental water management in Victoria is now firmly established with water recovery enabling the return of significant volumes of water to the environment. The increased environmental water availability has provided opportunities to protect, restore and reinstate high-value ecosystems throughout Victoria.

Environmental watering in Victoria has historically been supported by management plans such as this one, that document key information including the watering requirements of an asset, predicted ecological responses and water delivery arrangements. These plans support annual decisions about which sites should receive water and assist managers to evaluate how well those assets respond to the water they receive or what could be done better.

In the Murray-Darling Basin, environmental water management is further underpinned by the Murray-Darling Basin Plan 2012 (Commonwealth) and the associated Basin-wide environmental watering strategy. In accordance with Basin Plan requirements, Victoria has also developed relevant Water Resource Plans and Long-Term Watering Plans.

Victoria's Catchment Management Authorities (CMAs), Melbourne Water, DEECA, the Victorian Environmental Water Holder (VEWH) and Traditional Owner groups have worked together to develop Environmental Water Management Plans for watered assets throughout Victoria. These plans are continually updated through an adaptive management process. A primary purpose of the plans is to provide a consistent set of documents that support seasonal watering proposals to be submitted by asset managers to the VEWH annually. The supporting information includes:

- Lead management agencies and their management responsibilities
- The water-dependent environmental, social and economic values of the asset
- The asset's environmental condition and threats
- Environmental objectives and intended watering regime
- Contributions from Traditional Owner groups (included in an EWMP with free, prior and informed consent) that may include information about cultural values, management goals, environmental objectives and intended watering regime

- Opportunities for improved water delivery, efficiency or capacity through structural works or other measures
- Scientific knowledge gaps and recommendations for future work.

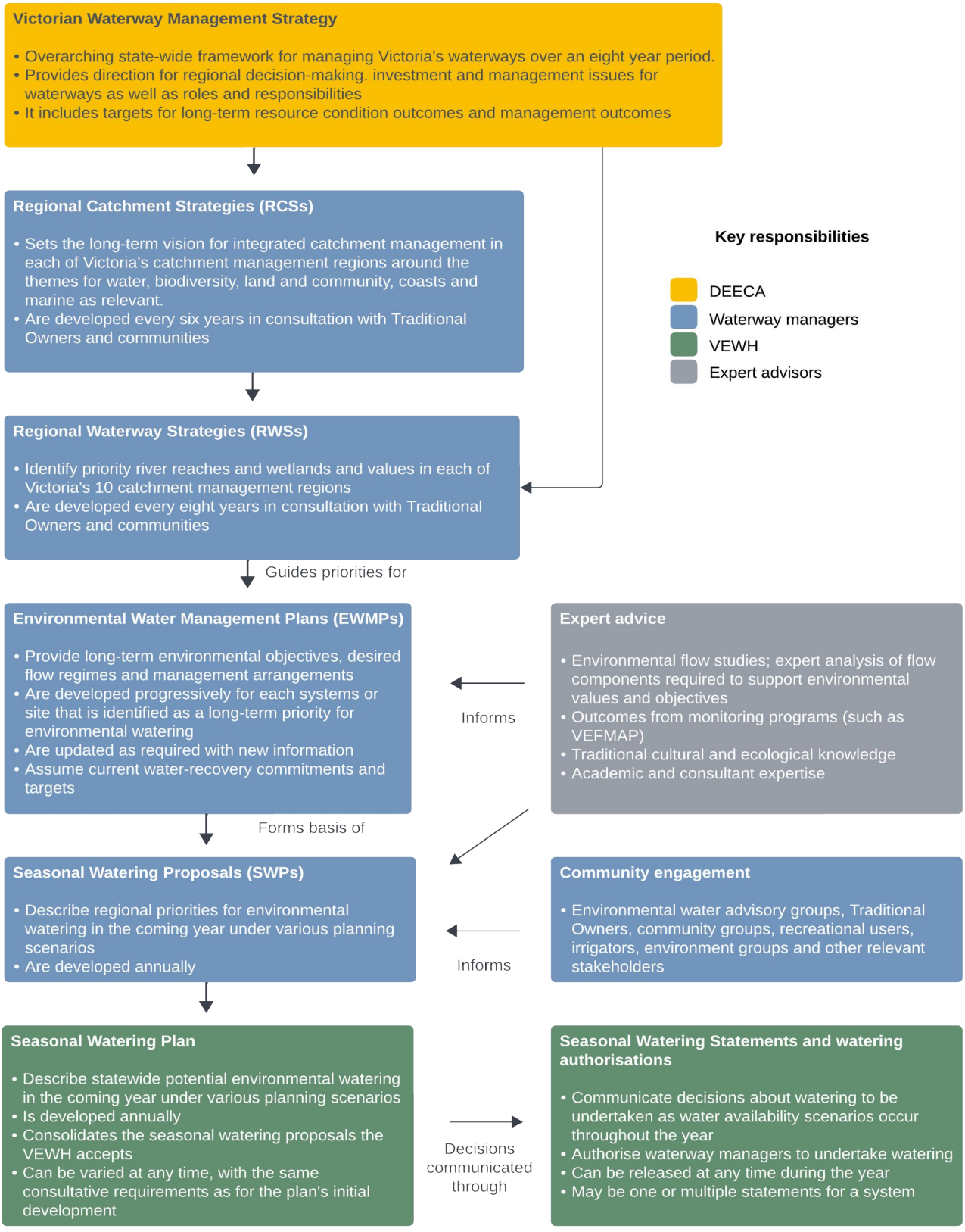

Figure 1-2: Victoria's environmental watering program planning framework (adapted from (VEWH, 2020)).

Table 1-1: Roles and responsibilities with respect to environmental watering in the MacKenzie River, and Burnt and Bungalally Creeks

PARTNERS	ROLES AND RESPONSIBILITIES/LINKS WITH WATERWAYS
Wimmera CMA	Catchment Management Authorities (CMAs) are responsible for the integrated planning and coordination of land, water and biodiversity management in their respective catchment and land protection regions. Under the *Water Act 1989*, the CMAs also have specific functions in relation to waterway management, floodplain management and regional drainage as the regional waterway manager. This includes identifying regional priorities for environmental watering and facilitating environmental water delivery. In line with these functions, the Wimmera CMA is responsible for the development of environmental water management plans and annual seasonal watering proposals, and for coordinating the implementation of the Victorian Seasonal Watering Plan as it applies to the Wimmera CMA region.
Department of Energy, Environment and Climate Action (DEECA)	DEECA is the lead agency for waterway management. It is responsible for the development of waterway policy, co-ordination of regional delivery and prioritisation of Government investment in waterways. DEECA is also responsible for other aspects of natural resource management that are of relevance to environmental water management, including: ▪ sustainable management of Victoria's water resources through managing the water allocation and entitlements framework ▪ developing state policy for water resource and waterway management. DEECA also has a number of other responsibilities that relate to broader waterway management such as oversight of Crown land and integrated catchment management.
Victorian Environmental Water Holder (VEWH)	The VEWH is appointed under the *Water Act 1989* to manage Victoria's environmental water entitlements. The VEWH works with waterway managers, Commonwealth Environmental Water Holder, Murray–Darling Basin Authority, storage operators and land managers to ensure environmental water entitlements are used to achieve the best environmental outcomes in line with the Environmental Water Management Plan.
Grampians Wimmera Mallee Water (GWMWater)	Water corporations in Victoria are established under the *Water Act 1989* and provide a range of water services to customers within their service areas. GWMWater provides a combination of irrigation services, domestic and stock services, bulk water supply services and urban water and wastewater services in most of the Wimmera CMA region. Their link with environmental water management is in their role as resource and storage manager – responsible for determining and delivering allocations to holders of environmental water entitlements. They also conduct water transfers using waterways as conduits, which present both risks and opportunities in achieving ecological objectives for these waterways. Regionally they are also responsible for coordinating the management of major outbreaks of blue-green algae, and also for take and use surface water and groundwater licensing. They also manage land on which their infrastructure is located (e.g. weirs and storages).
Barengi Gadjin Land Council Aboriginal Council (BGLC)	BGLC can provide advice on how management of water for the environment can improve or maintain cultural values, and care for and heal Country.

PARTNERS	ROLES AND RESPONSIBILITIES/LINKS WITH WATERWAYS
Murray–Darling Basin Authority (MDBA)	The MDBA was established under the federal *Water Act 2007* as an independent, expertise based statutory agency. The primary roles of the Authority as outlined in the Water Act 2007 include: ▪ Preparing and reviewing the Basin Plan ▪ Measuring, monitoring and recording the quality and quantity of the Basin's Water resources ▪ Supporting, encouraging and conducting research and investigations about the Basin's Water Resources ▪ Developing equitable and sustainable use of Basin water resources ▪ Disseminating information about the Basin's water resources ▪ Engaging and educating the Australian community about the Basin's water resources.
Community members/ representatives	Community members who have a detailed understanding of these waterways can provide advice and feedback on the effect of management of water for the environment on local waterways. Often, they are responsible for managing riparian land either as freehold landowner or licensee of Crown land.
Parks Victoria	Parks Victoria is the responsible public land manager for much of the upper sections of the MacKenzie River (Reach 1), which is largely located in the Grampians (Gariwerd) National Park.

Figure 1-3: MacKenzie River at Distribution Heads (Source: Wimmera CMA, 2009)

2 Partnership and engagement

Engagement for the development of this EWMP builds on a wide array of consultation which has been undertaken for previous strategies and plans pertaining to the management of water for the environment in the Wimmera CMA region. This includes the following key documents:

- Wimmera Regional Catchment Strategy (Wimmera CMA, 2021 – 2027)
- Wimmera River Environmental Flows Study (Alluvium, 2013).

Wimmera RCS

As detailed above, management of water for the environment has been aligned to six-year and 20-year outcomes in the Wimmera RCS 2021 – 2027. Engagement that was undertaken to develop the Wimmera RCS 2021 – 2027 involved:

- Meetings with community stakeholders to discuss feedback on the previous strategy, and focus on looking forward, identifying regional and Local Area priorities, challenges and issues.
- Preparation of working drafts, collating a range of information and discussing content with stakeholders
- Preparation of a Stakeholder Consultation Draft for review by a range of partner and stakeholder organisations and groups
- Public exhibition of a full draft was released for public consultation from 31 March until 3 May 2021

Wimmera River Environmental Flows Study

The Wimmera River Environmental Flows Study (Alluvium, 2013), which formed a key component of this EWMP, involved the development of the environmental objectives by Wimmera CMA staff and technical specialists in flow ecology, fish biology, vegetation, macroinvertebrates and geomorphology. The draft environmental objectives were presented for feedback to the Wimmera CMA's Rivers and Streams Advisory Committee for review, comment and endorsement. This advisory committee was comprised of both community and agency representatives (Table 2-1).

Table 2-1: **Advisory Committee Members involved in the development of the Wimmera River Environmental Flows Study (Alluvium, 2013)**

ADVISORY COMMITTEE MEMBER	AFFILIATION
Gary Aitken	Wimmera River Improvement Committee Member
Graham Campbell	Senior Property Officer, DEECA
Andrea Cooper	Landholder near the Wimmera River (Glenorchy)
Ken Flack	Wimmera Anglers' Association Secretary
Michael Greene	Project Platypus Landcare Network Board Member
Peter Hallam	Landholder near the Yarriambiack Creek (Hopetoun)
James McFarlane	Landholder near the Yarriambiack Creek (Brim)
Jim McGuire	Former Superintendent of Fisheries and Wildlife Division for the Wimmera and Mallee – Department of Natural Resources and Environment
Brad Mitchell	Federation University - Head of School of Ecology and Environment
Michael Stewart	Barengi Gadjin Land Council - CEO

Information Sources

Information used in the development of this plan was compiled from various sources including the studies listed above, as well as:

- Environmental Water Management Plan – Wimmera River System (WCMA, 2015)
- Maximising cultural benefits and Aboriginal community outcomes from managing water for the environment in the lower Wimmera River (RMCG, 2020)
- Wimmera Waterway Strategy 2014-2022 (WCMA, 2014)
- Wimmera River Seasonal Watering Proposals (WCMA, various years)
- Lower MacKenzie River and Burnt Creek flow optimisation project (EA, 2019)
- Assessment of connecting current and potential drought refuge sites on the MacKenzie River and tributaries to the Wimmera Mallee Pipeline (Wimmera CMA, 2024) – in draft.

As with the engagement processes for the studies and Wimmera RCS listed above, this information was supplemented through engagement with key partners with an intimate knowledge of the river, its environmental values and the management and operation of the system (refer Appendix A-4).

2.1 TRADITIONAL OWNERS

Barengi Gadjin Land Council (BGLC) represents Traditional Owners from the Wotjobaluk, Jaadwa, Jadawadjali, Wergaia and Jupagulk peoples, who were recognised in a 2005 Native Title Consent Determination, the first in south-eastern Australia. The organisation is also the only body in the region with the legislative authority to make legal decisions about cultural heritage. BGLC is also the Prescribed Body Corporate for the Wotjobaluk claim area, as outlined in the Native Title Act, giving them the legal authority and obligation to work on behalf of the region's Traditional Owners.

BGLC is also a Registered Aboriginal Party, as appointed by the Victorian Aboriginal Heritage Council, under the Aboriginal Heritage Act 2006. As a Registered Aboriginal Party, BGLC is the primary source of advice and knowledge for the Victorian Government on matters relating to Aboriginal places located in or Aboriginal objects originating from the area for which the party is registered. BGLC participates in the preparation of Cultural Heritage Management plans and evaluates plans written by other cultural heritage advisors. They also consider and advise the State and Local Governments on applications for Cultural Heritage Permits, negotiate and enter into Cultural Heritage Agreements and advise on and negotiate the repatriation of Aboriginal cultural heritage.

Many Aboriginal cultural sites in the western region of Victoria are on or near waterways, and streams and water bodies are still important sources of food and medicine. Waterways are important meeting places for families and communities to come together for cultural, social and recreational activities, and to teach culture to young people. Access to healthy waterways is vitally important for these activities. This relationship, between people and water is demonstrated by the Creation Stories about the formation of the Wimmera River and other waterways in the region.

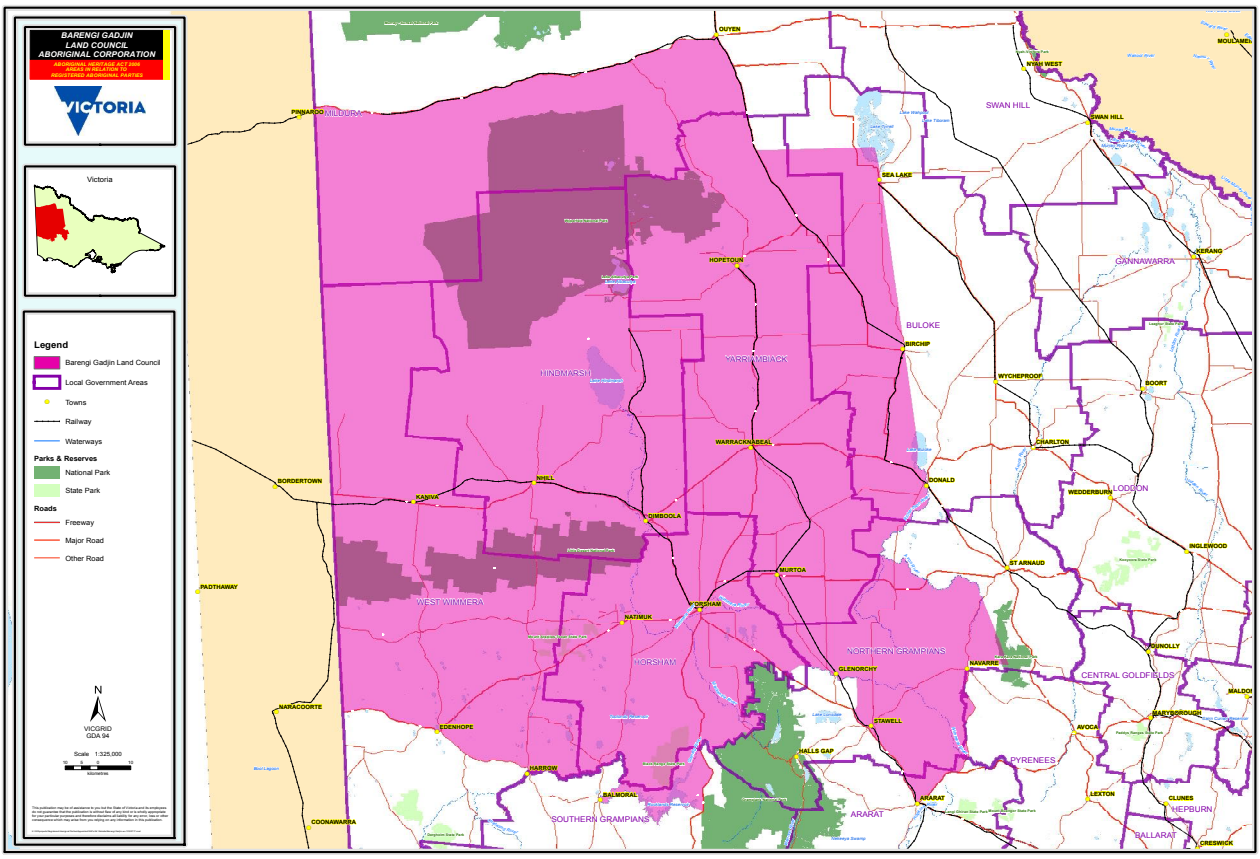

Figure 2-1: Boundary of the BGLC Registered Aboriginal Party (RAP)[2]

Through the delivery of its key activities, the Wimmera CMA has built strong foundations and significant momentum in supporting BGLC and the Wotjobaluk Traditional Owners to:

- engage in the planning and management of waterway management outcomes
- achieve cultural benefits and Aboriginal community outcomes from managing water for the environment in the Wimmera River system (including the MacKenzie River and Burnt and Bungalally Creeks).

These activities have highlighted the Wotjobaluk Peoples' close and continual connections with the Wimmera River (Barringgi Gadyin) and its associated tributaries (MacKenzie River and Burnt and Bungalally Creeks). It has also highlighted the relationship that often exists between the health of cultural heritage places and broader waterway health.

These activities have also assisted the Wotjobaluk Traditional Owners to identify and articulate their values, aspirations and interests to its water sector delivery partners, the Wimmera CMA, VEWH and GWMWater. These partnerships and increased knowledge sharing will be crucial to realising further cultural benefits and Aboriginal outcomes from managing water for the environment.

As detailed earlier, the MacKenzie River and Burnt Creek are home to a unique matrix of freshwater aquatic species important to the Wotjobaluk Traditional Owners. This includes an isolated species of River Blackfish *Gadopsis marmorata*, known to them as Wirrap.

BGLC and the Wotjobaluk Traditional Owners are partners in the development of this EMWP, and will be engaged in its implementation through the annual Seasonal Watering Proposal/ Planning process.

[2] Source: BGLC website (https://www.bglc.com.au/native-title)

3 Asset overview

3.1 CATCHMENT SETTING

The Wimmera CMA region covers approximately 23,500 km2, or 13%, of Victoria and is largely cleared for agriculture, though sizeable tracts of public land remain including the Grampians (Gariwerd) and Little Desert National Parks, the Black Range and Mount Arapiles-Tooan State Parks, as well as the Pyrenees and Mount Cole State Forests. About 50,000 people live in the region, with most of the region's income derived from agriculture (dryland cropping and sheep grazing) (Wimmera CMA, 2013).

Hydrophysical Characteristics

The Wimmera River commences in the Pyrenees northeast of Ararat, flowing northwest out of state forest through undulating grazing and cropping country where tributaries such as Concongella, Heifer Station and Mount Cole Creeks provide significant streamflows during wet conditions. The MacKenzie River, a major tributary of the Wimmera River, rises in the northern Grampians in the localities of Wartook and Laharum and flows into the Wimmera River at Lower Norton, southwest of Horsham. Burnt Creek is also a tributary of the Wimmera River, entering the River at Horsham. Its upper reach has been modified to act as a transfer channel commencing at Distribution Heads in Laharum where a regulator supplies flows from the upper MacKenzie River and Moora Channel. Bungalally Creek is a high-flow channel that flows northwest from Burnt Creek at Wonwondah to the MacKenzie River at Haven, southwest of Horsham.

3.2 LAND STATUS AND MANAGEMENT

Waterway land ownership and management across Victoria is inherently complex, with combinations of freehold and Crown land, often depending on the timing of settlement and purchase by pastoralists in the 1800's as well as government surveying. Therefore, throughout the Wimmera River System there is a mosaic of land management (Table 3-1) and (Figure 3-1).

Statistics around the land tenure of the MacKenzie River, and Burnt and Bungalally Creeks are outlined in Table 3-1. The MacKenzie River is almost entirely within Crown land. This includes some small portions leased to adjacent landholders, as well as large parts managed as public reserves, or for water transfers through vested management with GWMWater. The upper reach of MacKenzie River is largely within the Grampians (Gariwerd) National Park.

The upper sections of Burnt Creek are within Crown land where it has a role as a water transfer channel, through vested management with GWMWater. Further downstream, the creek is within Crown land licenced to adjacent landholders for grazing. As the creek nears Horsham it is largely within freehold land.

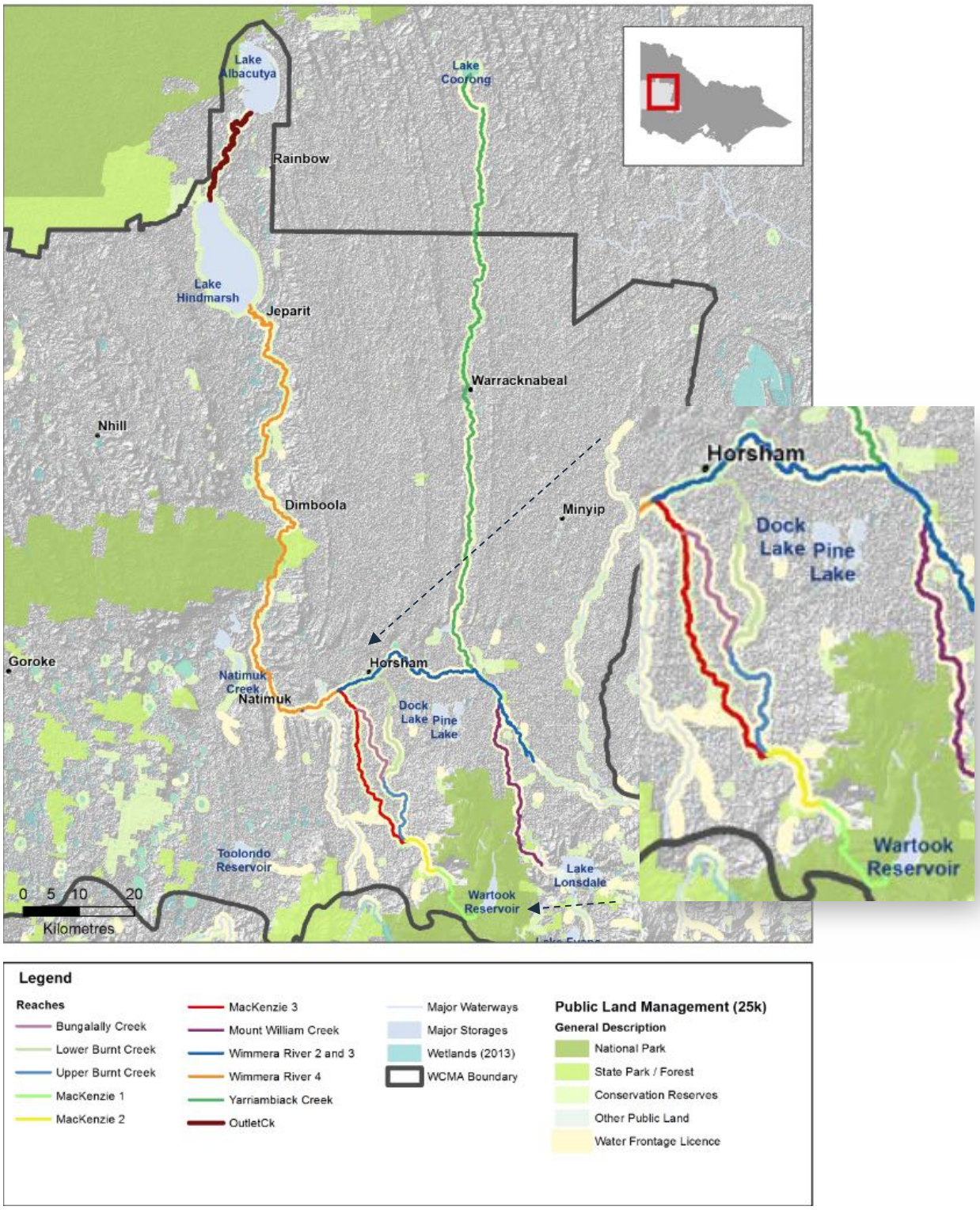

Figure 3-1: Land management arrangements for Wimmera waterways (Source: WCMA).

Table 3-1: Summary of statistics with respect to land tenure for the reaches of the MacKenzie River, and Burnt and Bungalally Creeks

WATERWAY	DISTANCE (KM)	DISTANCE CROWN LAND (KM)	% CROWN LAND
MacKenzie River	68.5	66.5	97
Burnt Creek	47	33.9	72
Bungalally Creek	19.2	15.5	81

3.3 ENVIRONMENTAL WATER SOURCES

Water in the Wimmera system is stored in three onstream reservoirs — Lake Wartook on the MacKenzie River, Lake Lonsdale on Mount William Creek and Lake Bellfield on Fyans Creek, and in several off-stream storages, Taylors Lake, Lake Fyans and Toolondo Reservoir. A channel system enables water to be moved between several storages. Water can also be transferred from Rocklands Reservoir in the Glenelg system to the Wimmera system via the Rocklands–Toolondo Channel and from Moora Moora Reservoir via the Moora Channel. The connected storages and channels are collectively called the Wimmera—Mallee System Headworks, and harvested water is used for towns and stock and domestic supply throughout the Wimmera catchment and parts of the Avoca, Hopkins, Loddon, Glenelg and Mallee catchments. Passing flows are provided to the Wimmera River and to lower Mount William Creek.

The Environmental Water Reserve (EWR) is the legally recognised amount of water set aside to meet environmental needs. The EWR can include minimum river flows (passing flows), unregulated flows and regulated environmental allocations specified within entitlements. Regulated environmental allocations are released from storage according to pre-determined environmental needs when needed and delivered to wetlands or streams to maintain their environmental values and condition.

The VEWH is responsible for holding and managing Victoria's regulated environmental water entitlements and making decisions on their use. The VEWH works closely with the Wimmera CMA which, as the regional waterway manager, coordinates the planning and delivery of the entitlement through its seasonal water planning and delivery processes.

Environmental water for the MacKenzie River, and Burnt and Bungalally Creeks and Wimmera River downstream may be sourced from the water entitlement listed in Table 3-2.

Table 3-2: Summary of managed environmental water sources for the MacKenzie River, and Burnt and Bungalally Creeks

WATER ENTITLEMENT	VOLUME (ML)	RESPONSIBLE AGENCY
Wimmera and Glenelg Rivers Environmental Entitlement	40,560 ML high reliability[3]	Victorian Environmental Water Holder

The Wimmera and Glenelg Rivers Environmental Entitlement also states that it includes all surface water resources beyond those permitted to be extracted under the *Water Act 1989* under licences and consumptive Bulk Entitlements. This would include flows provided by operational spills (when storages exceed the maximum operating levels) and physical spills (flows entering storages and channels exceeded outlet capacities).

Although not environmental water per se, transfers between storages (from Lakes Bellfield, Lonsdale and Wartook to Taylor's Lake) use various regulated waterways (Fyans Creek, Mount William Creek, MacKenzie

[3] Note this entitlement is shared with the Glenelg River system.

River and Burnt Creek) which can contribute to meeting ecological objectives in these reaches, depending on how flows are managed.

The waterways defined within this EWMP; MacKenzie River, and Burnt and Bungalally Creeks are shown in Figure 3-2. These are outlined as follows:

- MacKenzie River
  - Reach 1 – Lake Wartook to Dad and Dave Weir
  - Reach 2 – Dad and Dave Weir to Distribution Heads
  - Reach 3 – Distribution Heads to Wimmera River
- Burnt Creek:
  - Upper Burnt Creek – downstream of Distribution Heads to Toolondo Channel
  - Lower Burnt Creek – downstream of Toolondo Channel to the Wimmera River
- Bungalally Creek.

The Wimmera River is outside the scope of this EWMP.

3.3.1 MACKENZIE RIVER

The MacKenzie River flows northwest from the northern Grampians through the localities of Wartook, Laharum and McKenzie Creek into the Wimmera River at Lower Norton, southwest of Horsham (Figure 3-2). Lake Wartook, Dad and Dave Weir and Distribution Heads regulate flows in the river for consumptive and environmental demands. Small tributaries enter the river as it flows through the Grampians. At Distribution Heads flows can be directed to the Burnt Creek. Bungalally Creek enters the MacKenzie River at Haven, several kilometres upstream of its confluence with the Wimmera River.

Reaches 1 and 2 of the MacKenzie River have rocky stretches, transitioning to pools and runs downstream. Reach 3 is characterised by an intact discontinuous anastomosing channel form (sandy area) noted as unique in Victoria, with the only other examples noted as occurring in the Mt Lofty Ranges in South Australia (Earth Tech, 2004).

3.3.2 BURNT CREEK

Burnt Creek is a tributary of the Wimmera River, its upper reach has been modified to act as a transfer channel commencing at Distribution Heads in Laharum where a regulator supplies flows from the upper MacKenzie River and Moora Channel (Figure 3-2). At Wonwondah, the Toolondo Channel intercepts flows from the upper Burnt Creek for supply to Taylor's Lake. A regulator with a capacity of 10 ML/day can release water into the lower Burnt Creek from the Toolondo Channel which flows north, entering the Wimmera River at Horsham.

The geomorphic character of upper Burnt Creek has been modified by frequent water transfers between headworks storages leading to incision and loss of the chain of ponds, although there are still some sizable pools at its most downstream section (Figure 3-3). The lower Burnt Creek has a section about 15 km long that contains an intact chain-of-ponds morphology, however between the Western Highway and Wimmera River it has largely been channelised to improve drainage (Earth Tech, 2005).

3.3.3 BUNGALALLY CREEK

Bungalally Creek is a high-flow channel that flows northwest from the Burnt Creek (Figure 3-4Figure 3-2) at Wonwondah to the MacKenzie River at Haven, southwest of Horsham.

While high flows from Burnt Creek can still enter Bungalally Creek (above regulated release volumes), a regulator in the Toolondo Channel with a capacity of 10 M L/day provides a mechanism to deliver regulated

flows. This is in place because the southern half of the creek was previously a stock and domestic distribution channel. In general, Bungalally Creek has a small channel which can be ill-defined in places, reflective of its historically episodic hydrology.

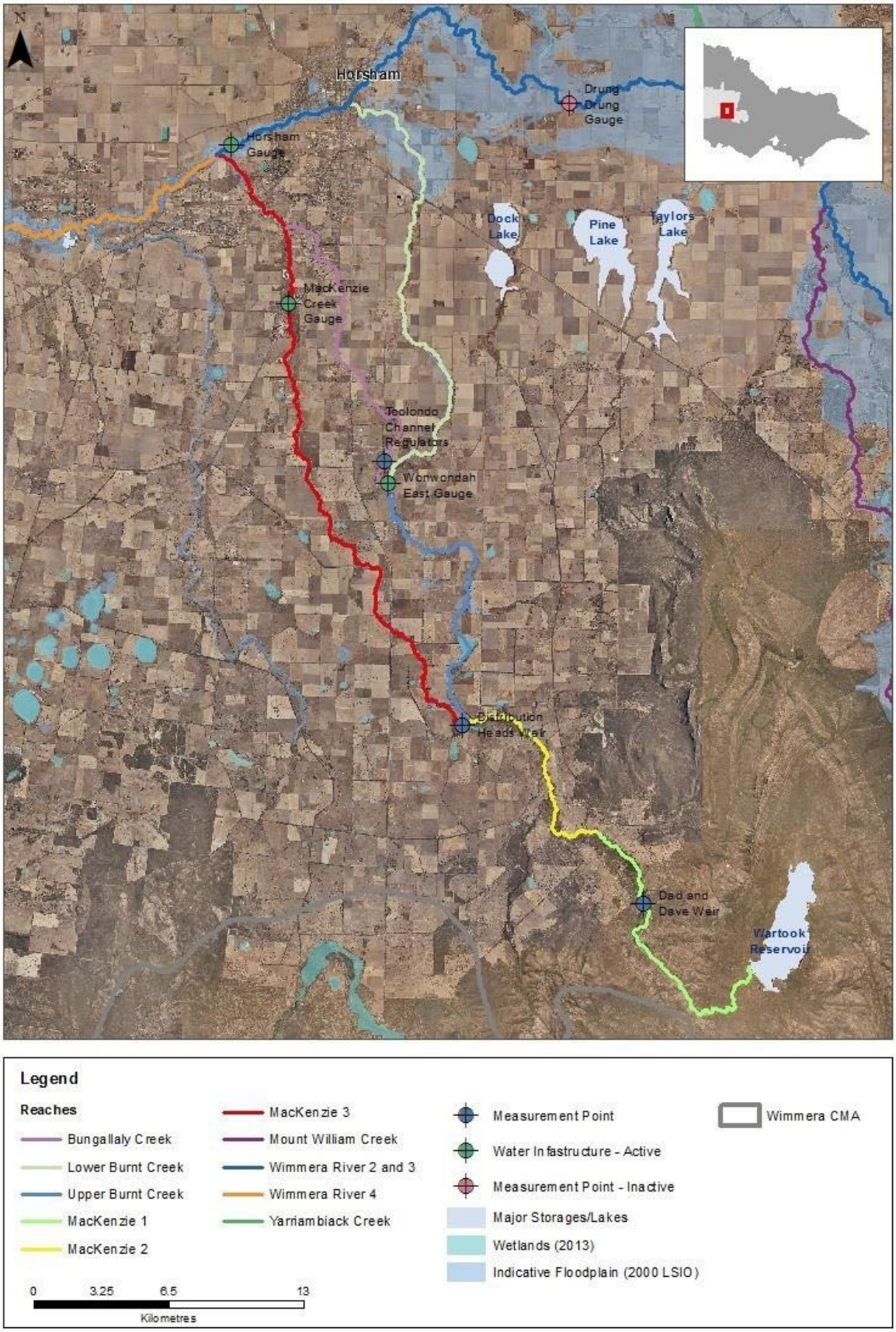

Figure 3-2: MacKenzie and Wimmera Rivers, Burnt Creek and Bungalally Creek

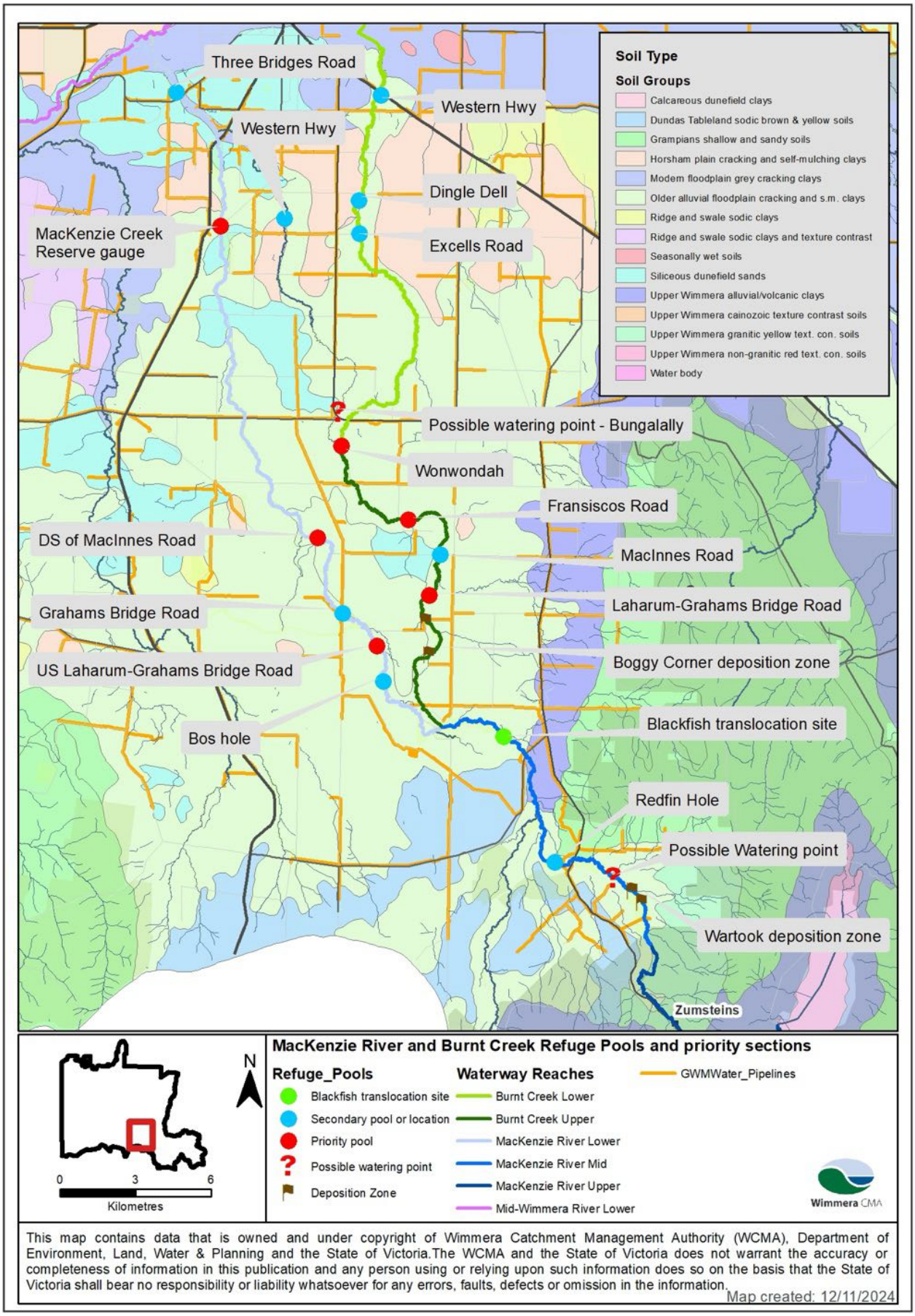

Figure 3-3: MacKenzie Rivers and Burnt Creek Refuge Pools

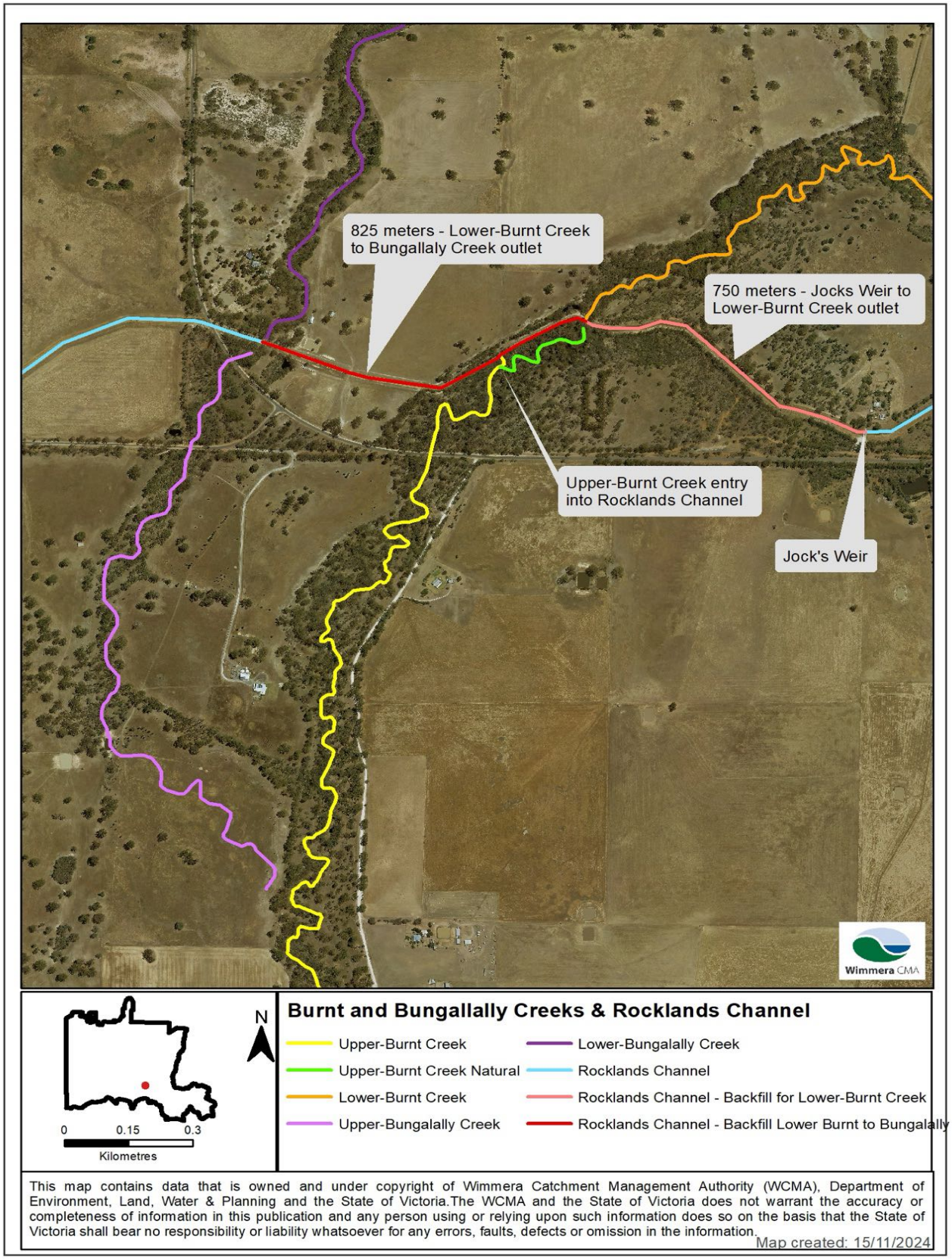

Figure 3-4: Burnt and Bungalally Creeks and Rocklands Channel

4 Current/historical hydrological regime and system operations

4.1 RIVER HYDROLOGY

Surface water flows in the Wimmera River are controlled by weirs, irrigation diversion points, tributary inflows and distributary outflows. A schematic diagram showing the location of these regulating structures is shown in Figure 4-1.

Further information on the hydrology of the Wimmera River system is detailed in the Wimmera EWMP (RMCG, 2024).

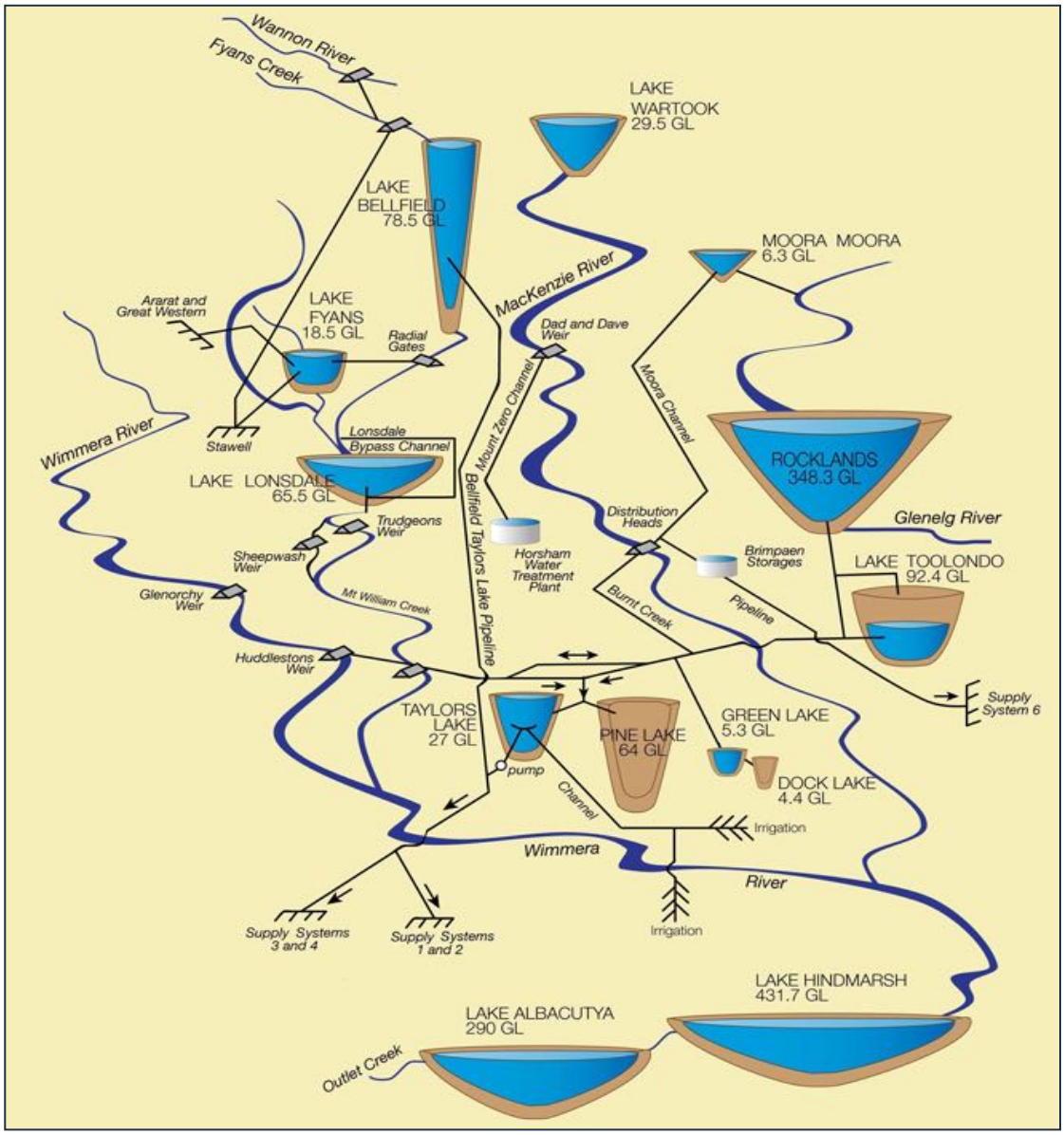

Figure 4-1: Storage and delivery system (Source: GWMWater)*

** Note irrigation demands are no longer present and Lakes Albacutya and Hindmarsh are not storages and Pine Lake and Dock Lake are shown as empty in this figure denoting their status as being off-line.)*

Discharge in the MacKenzie River and Burnt Creeks is measured at two established gauging stations (Table 4-1). Water levels are also measured in weirs and storages.

Table 4-1: Victorian Water Measurement Information System flow gauging sites along the MacKenzie River, and Burnt and Bungalally Creeks

SITE IDENTIFICATION (ID) NUMBER	LOCATION AND YEAR ESTABLISHED	NOTES
415251	MacKenzie River at McKenzie Creek (1988)	Measures flow from upper catchment (both MacKenzie and also contributions from Moora). Compliance point for Reach 3 of MacKenzie River. Also, a site of monthly dissolved oxygen, conductivity and temperature monitoring.
415223	Burnt Creek at Wonwondah East (1965)	An important site for water supply operations, flood warning and also to meter environmental flows to the lower Burnt and Bungalally Creeks. It is also the compliance point for upper Burnt Creek.

The gauging network provides useful information on unregulated and passing flows, which informs regulated environmental water delivery. The streamflow gauges at the downstream ends of reaches are also important compliance points to determine the extent to which volumes requested from delivery points are of sufficient volume and duration to attain ecological objectives. In the last decade improved telemetry has greatly increased the timeliness of information from the gauging network. Flood warning gauges provide continuous height data to the Bureau of Meteorology website and continuous information around flow and water quality is available for other gauges via an online data hosting service and the Victorian Government Water Measurement Information System[4].

Gauging site upgrades

The stream gauge network is an important tool for effective management of water for the environment and there are opportunities for it to be reviewed. For example, Bungalally Creek, Reach 2 of the MacKenzie River and lower Burnt Creek do not have streamflow gauges with which to determine compliance.

4.2 WATER MANAGEMENT AND DELIVERY

At its peak, the Wimmera headworks and channel system supplied about 20,000 dams via 16,000 km of open earthen channel (Wimmera Mallee Pipeline Project Planning Group, 2003) which caused significant issues for waterways and consumptive water users due to inefficiencies and system losses (see Section 4-1 and Figure 4-6). The completion of two major infrastructure projects – the Northern Mallee Pipeline and Wimmera Mallee Pipeline – has resulted in improved reliability of supply for consumptive users with most water savings achieved through the infrastructure upgrades returned to the Wimmera and Glenelg Rivers as environmental flows. The full volume of entitlements within the system is 52,690 ML, with Coliban Water and Wannon Water having relatively small entitlements (300 ML and 2,120 ML respectively) and the remainder held by GWMWater. Within GWMWater's entitlement, 2,590 ML is dedicated to maintaining water supply within lakes used for recreational purposes, 2,960 ML is used to compensate for distribution losses in the pipeline systems and a further 3,300 ML makes up the Glenelg Compensation Flow. The Glenelg Compensation Flow is an entitlement for flows that are provided to the lower Glenelg River from Rocklands Reservoir to meet stock and domestic needs but also provides benefits for the environment. Beyond the environmental entitlements described in Table 3-2, there is a 1,000 ML environmental entitlement for off-stream wetlands supplied by the Wimmera Mallee Pipeline. This entitlement is held by the VEWH and is addressed in separate EWMPs.

[4] https://data.water.vic.gov.au

Table 4-2: Annual allocations as per the VEWH's environmental entitlement for the Wimmera River (e-mail correspondence VEWH, 2024)

	RIVERS	
Year	**Allocation Received (ML)**	**Allocation Received (%)**
2010-11	40,560	100%
2011-12	40,560	100%
2012-13	33,268	82%
2013-14	32,970	81%
2014-15	19,509	48%
2015-16	6,490	16%
2016-17	40,560	100%
2017-18	32,854	81%
2018-19	22,308	55%
2019-20	17,035	42%
2020-21	23,119	57%
2021-22	25,553	63%
2022-23	40,560	100%
2023-24	35,287	87%
Average	**29,331**	**72%**

MACKENZIE RIVER

The MacKenzie River's headwaters flow into Lake Wartook, the highest storage in the Grampians headworks system (Figure 4-1). From Lake Wartook, the MacKenzie River flows perennially through Gariwerd (Grampians National Park) to Dad and Dave Weir (Figure 4-2). This structure is used to divert water into the Mt Zero Channel for Horsham's water supply. Downstream of Dad and Dave Weir, the MacKenzie River flows to Distribution Heads due to environmental water releases during drier months (typically summer/autumn) and during wetter months with inflows from tributaries downstream of Lake Wartook. Occasional transfers (e.g. to maintain airspace for flood mitigation) are diverted down the MacKenzie River through Distribution Heads to the Burnt Creek and Toolondo Channel to Taylor's Lake.

Flow can also be directed over a weir at Distribution Heads to the lower MacKenzie River (Figure 4-2). Only environmental water releases or spills are released into the lower MacKenzie River. Section 3.1 contains details around the severe impact that regulation has historically had on streamflows in the lower MacKenzie River.

Figure 4-2: Dad and Dave Regulator on the MacKenzie River (left) and Distribution Heads (right).

BURNT CREEK

Burnt Creek is a distributary of the MacKenzie River, commencing at Distribution Heads in Laharum which was a swampy area that was modified with walls and regulators to direct flows to downstream channels and waterways. Distribution Heads and in turn Burnt Creek also receive intervalley transfers as inflows from the Moora Channel which begins at Moora Moora Reservoir in the upper Glenelg River Catchment. Water is also extracted locally at Distribution Heads from a pump into a balancing storage for Supply System 6 of the Wimmera Mallee Pipeline.

Prior to regulation and development, Burnt Creek would have received flows from overbank flows in the MacKenzie River at Distribution Heads, as well as from its own catchment which is near the northwestern edge of the Grampians. It has been heavily modified to act as a headworks distribution channel, with water regularly transferred through winter/spring from the MacKenzie River from Distribution Heads via Burnt Creek to the Toolondo Channel which supplies Taylors Lake (Figure 4-3). The reach that flows north from the Toolondo Channel previously supplied water for stock and domestic purposes during February/March before 2003 (Earth Tech, 2005) but now flows only in response to environmental water releases or during floods.

Where Burnt Creek is used as a headworks channel it has lost some of its diversity in channel shape and form due to earthworks connecting the most upstream section with Distribution Heads, and other parts have enlarged in response to increases in the duration and volume of flows (Earth Tech, 2005). Whereas downstream, between the Grampians Road and Western Highway, the creek has a more intact form with deep pools. Downstream of the Western Highway the creek has been channelised to improve drainage for adjacent rural and residential land (Earth Tech, 2005).

Figure 4-3: Burnt Creek Regulator at Distribution Heads (left) and Toolondo Channel (right)

BUNGALALLY CREEK

Bungalally Creek is a distributary of the Burnt Creek that commences in East Wonwondah, and flows into the MacKenzie River, about five kilometres upstream of its confluence with the Wimmera River (Figure 4-4). Before regulation and development, it would have naturally flowed episodically in response to bankfull and overbank flows in Burnt Creek (likely to be between 100 ML/d and 300 ML/d).

Historically, its most upstream reach was used as a distribution channel for the previous stock and domestic and irrigation channel system. It was supplied by a regulator on the Toolondo Channel. This function ceased with the completion of the Wimmera Mallee Pipeline. Currently, it only flows in response to environmental water releases for the Bungalally Creek through the regulator and during high flows and floods. There are several low-level road crossings which make it difficult to implement the recommended flow rates without impacting adjacent landholders and attenuating peak flow rates. Similar issues exist for the Burnt Creek.

Figure 4-4: Bungalally Creek Regulator at Toolondo Channel (left) and low level crossing on the Bungalally Creek (right)

Figure 4-5 is a schematic diagram showing key features associated with the MacKenzie River, and Burnt and Bungalally Creeks.

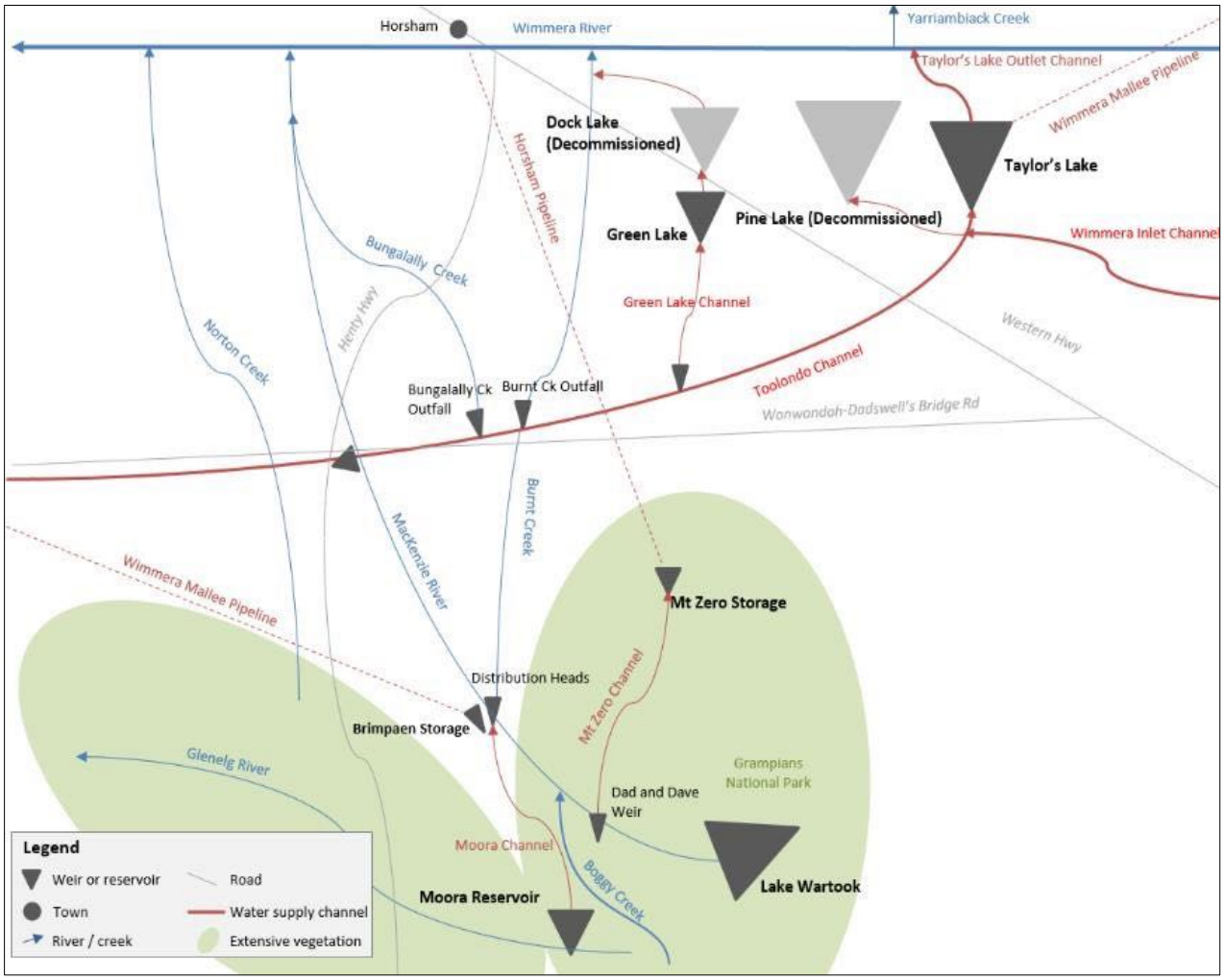

Figure 4-5: Schematic diagram of key features relating to the MacKenzie River, Burnt Creek, Bungalally Creek and part of the Wimmera River

4.3 DELIVERY OF WATER FOR THE ENVIRONMENT

The Wimmera River has one of the longest records of environmental watering in Victoria. In early 1988 water was released down the Wimmera River with the intent of improving the water quality in pools that had become hypersaline (Anderson & Morison, 1989). Since the 1990s infrastructure projects, initially the Northern Mallee Pipeline and later the Wimmera Mallee Pipeline, have resulted in water savings that now enable the delivery of environmental water to enhance water quality and provide habitat for fish, platypus and other aquatic life. Despite these improvements, water scarcity still remains a problem for the Wimmera River. The Millennium Drought from 1997 to 2009 severely restricted the allocations available for environmental watering (Figure 4-6Figure 4-6). The system breakdown for this delivery, including the MacKenzie River system, is reflected in Figure 4-7.

During this time Wimmera CMA has played a pivotal role in managing flows in the Wimmera River, with its involvement dating back to the establishment of CMAs in the late 1990s.

Further information on broader environmental water deliver in the Wimmera River system is provided in the Wimmera EWMP (RMCG, 2024).

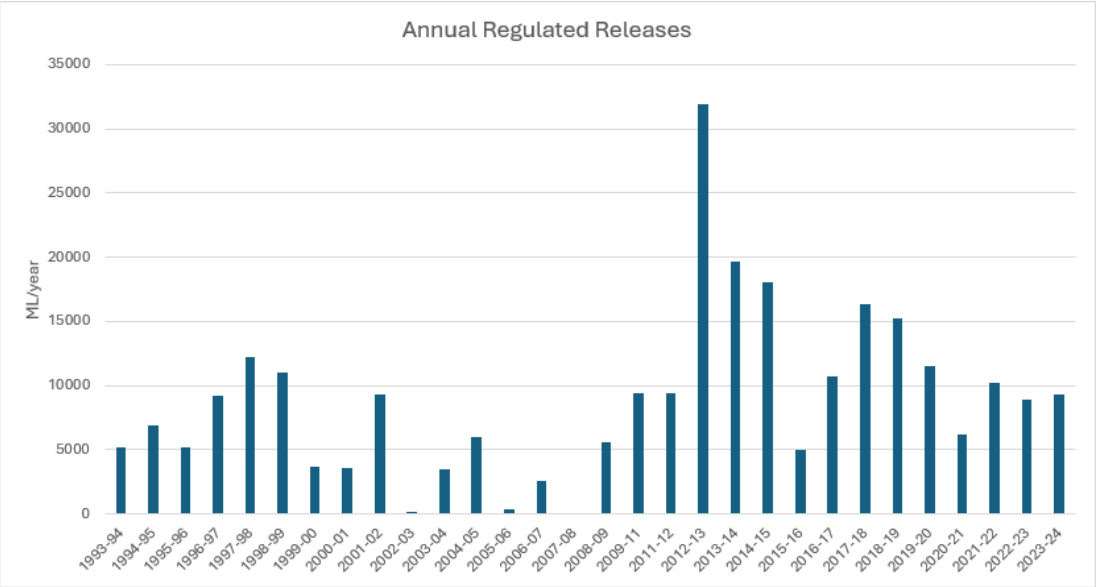

Figure 4-6: Record of environmental water releases for the Wimmera River system from 1993-94 to 2023-24

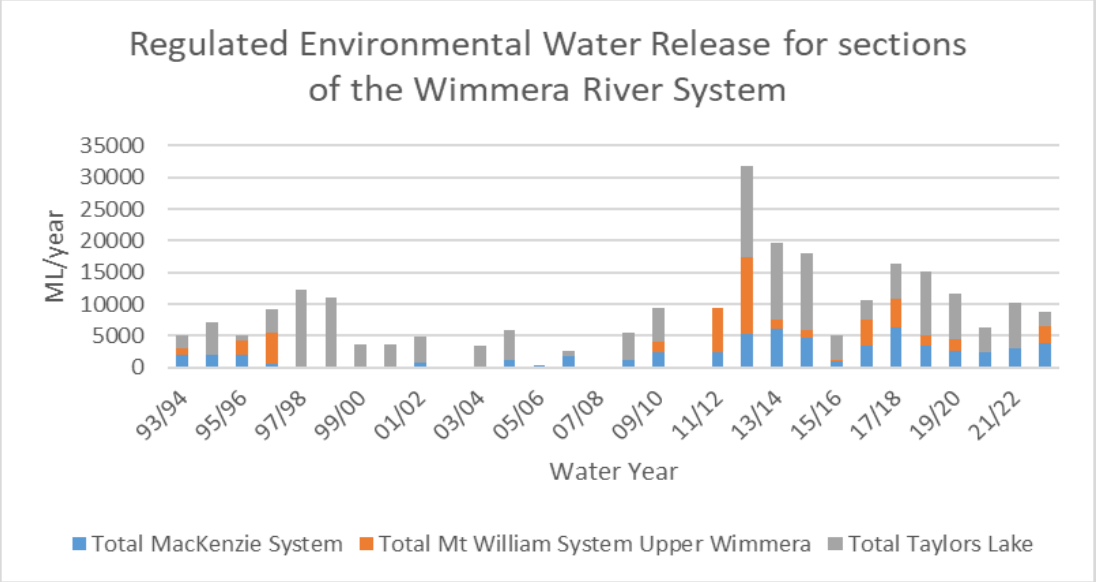

Figure 4-7: Record of environmental water releases for sections of the Wimmera River system from 1993-94 to 2022-23

5 Water-dependent values

The MacKenzie River and Burnt Creek were noted as high-value waterways in the 2014 WWS, meaning they had at least one high environmental, social or economic value.

The MacKenzie River had such an abundance of high values for social and environmental attributes that it was deemed to be priority waterway for management activities in the WWS. At the time, priority waterways were deemed a subset of high-value waterways where feasible and effective management activities (such as weed control or environmental water management) could be undertaken to improve or maintain their condition.

With the pending release of the new draft VWMS, and the release of the new guidelines for regional waterway strategies (DEECA, 2024), new regional management priorities will be developed for waterways in the region. MacKenzie River, and Burnt and Bungalally Creeks will be considered as part of that process.

5.1 ENVIRONMENTAL VALUES

Some species within the MacKenzie River, and Burnt and Bungalally Creeks have been listed under legislation and other formal instruments (Table 5-1).

Table 5-1: Threatened Species Lists developed under legislation, agreements or conventions that apply to the MacKenzie River, and Burnt and Bungalally Creeks

THREATENED SPECIES LIST	JURISDICTION	RIVERS/ CREEKS	LAKES
Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act)	National		
Flora and Fauna Guarantee Act 1988 (FFG Act)	State		
DEECA Advisory Lists (revoked in 2021)	State		

The MacKenzie River, and Burnt and Bungalally Creeks support some flora and fauna species listed as threatened at either the National or State level (Table 5-2, Table 5-3, Table 5-4 and Table 5-5).

SIGNIFICANT FAUNA

The following section outlines the various flow-dependent fauna species that have been observed in and around the MacKenzie River, and Burnt and Bungalally Creeks, in particular current listed threatened species under the EPBC Act (DCCEEW, 2023) and FFG Act (DEECA, 2023). A complete list of fauna species is in Appendix A-1, while waterway-dependent threatened species are listed in the following sections.

The Wimmera River System can be broken into two separate fish communities, upland and lowland with transition zones between them in the lower Mt William Creek and Reach 3 of the MacKenzie River. The upland fish community comprises endemic species such as River Blackfish, Southern Pygmy Perch (*Nannoperca australis*) and Obscure Galaxias (*Galaxias oliros*) as well as non-endemic Common Galaxias (*Galaxias maculatus*) and is within parts of the system in and near Gariwerd (Reaches 1 and 2 of the MacKenzie River). Golden Perch (*Macquaria ambigua*) are occasionally found in Reach 3 of the MacKenzie River).

Golden Perch was previously listed as ‘near threatened’ on the Advisory List of Threatened Vertebrate Fauna of Victoria (DSE, 2013). However, this only applies to natural populations and Golden Perch is not endemic to the Wimmera River System and not considered self-sustaining. Golden Perch were also not included as threatened in the latest Flora and Fauna Guarantee Act 1988 Threatened List (DEECA, 2023).

River Blackfish (*Gadopsis marmorata*) found in MacKenzie River are believed to be part of a genetically distinct subspecies confined to the Wimmera and Glenelg systems (Hammer et al., 2014) but has no formal status with regards to being threatened.

Macroinvertebrate communities in the Wimmera River system are highly variable. In the MacKenzie River system there is a wide range of species reflective of upland waterways, whereas in the lower Wimmera River, there are fewer species, and they are more tolerant of poor water quality (WEC, 2012). When conditions are wet and there are good streamflows, the macroinvertebrate community demonstrates a 'very good' level of resilience as can be seen from Macroinvertebrate Biotic Index (MBI) scores across the Wimmera River System (Figure 5-1). However, during dry conditions, such as those experienced during the Millennium Drought, poor water quality and a lack of habitat leads to much lower MBI scores (WEC, 2009).

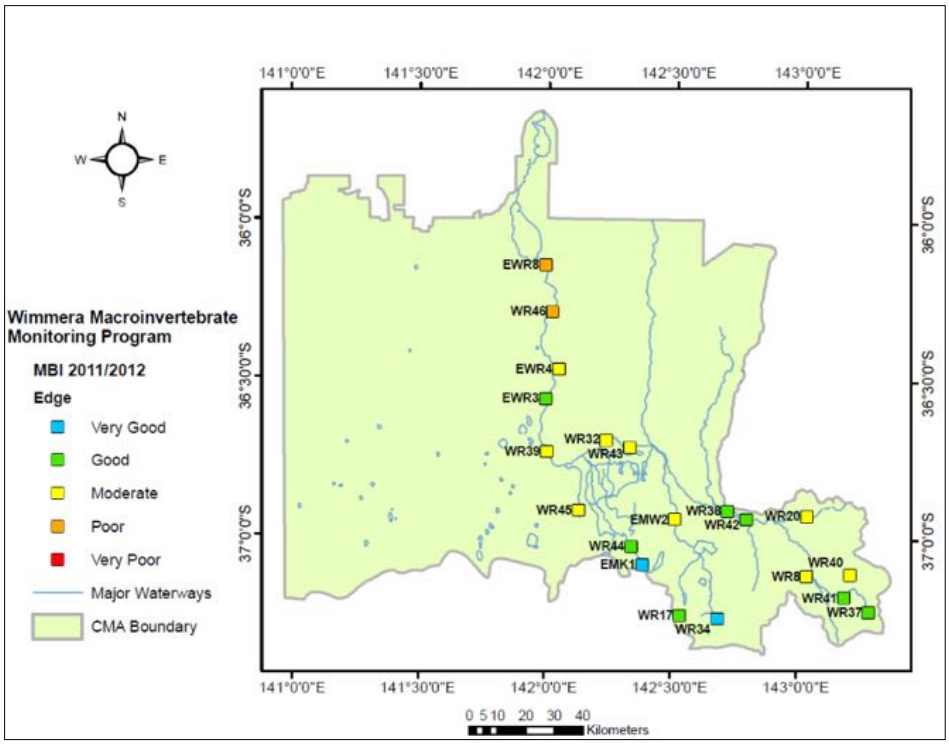

Figure 5-1: MBI classifications for the Wimmera River System (and other waterways) 2011/12 (Source: WEC, 2012)

There has been no systematic monitoring of crustaceans in the Wimmera River System with incidental captures during fish surveys providing all current data. Threatened invertebrate (crustacean) species within the Wimmera River System include Western Swamp Crayfish (*Gramastacus insolitus*) in the upper Burnt Creek (Biosis, 2013) and Glenelg Spiny Crayfish (*Euastacus bispinosis*) in the upper MacKenzie River (M. Burns, DEDJTR, pers. comm.) (Table 5-2).

Table 5-2: Threatened Invertebrate Species in the MacKenzie River and Burnt Creeks and associated status

SPECIES NAME	COMMON NAME	EPBC ACT[5] STATUS	FFG ACT[6] STATUS	REACHES APPLICABLE
Gramastacus insolitus	**Western Swamp Crayfish**		Endangered	Upper Burnt Creek
Euastacus bispinosis	**Glenelg Spiny Crayfish**	Endangered	Endangered	MacKenzie Reach 1

[5] EPBC: *Environment and Biodiversity Conservation Act*
[6] FFG: *Flora and Fauna Guarantee Act*

Other water-dependent species of conservation significance occurring in the MacKenzie River includes the Platypus (Table 5-3), which is highly vulnerable in the Wimmera with the only confirmed population being in the MacKenzie River. Isolated sightings indicate that a population of platypus may be present in the Wimmera River, although it is considered to be in extremely low numbers as the latest surveys have failed to locate or capture any (EA, 2023).

Figure 5-2: Platypus is known to occur in the MacKenzie River

Table 5-3: Mammals in the MacKenzie River of conservation significance

SPECIES NAME	COMMON NAME	EPBC ACT STATUS	FFG ACT[7] STATUS	REACHES APPLICABLE
Ornithorhynchus anatinus	**Platypus**		Vulnerable	MacKenzie River

The Peron's Tee Frog (*Litoria peronii*) has also been located in the MacKenzie River, and would benefit from environmental watering actions.

Figure 5-3: Peron's Tree Frog (Source: Angus Schmidt, 2019 supplied to WCMA).

FLORA

The Wimmera Bulk Entitlement Conversion Environmental Flows Study (SKM, 2003) noted that 135 threatened flora species occur in the Wimmera River catchment, and of these 24 species were considered reliant on waterways for their survival. Dyer and Roberts (2006) reviewed these species and concluded only four were possibly flow-dependent, the others not being found in the Wimmera River system, rather associated with nearby salt lakes. A comprehensive list of flora species within or adjacent to waterways considered in this EWMP is presented in Appendix A-3. They have been recorded in riparian and wetland areas through the Victorian Biodiversity Atlas, as well as vegetation monitoring undertaken for the Victorian Environmental Flows Monitoring and Assessment Program (VEFMAP).

[7] FFG: *Flora and Fauna Guarantee Act*

VEGETATION COMMUNITIES

Because the Wimmera River System flows from the edge of the Grampians to the southern Mallee, it supports a wide variety of vegetation communities. Due to widespread clearing for agriculture, many of these vegetation communities are now spatially restricted compared with their pre-European settlement distribution and extent. Much of the Wimmera River System, including the MacKenzie River, and Burnt and Bungalally Creeks are dominated by an overstorey of River Red Gums (*Eucalyptus camaldulensis*).

Submerged vegetation (e.g. *Triglochin, Vallisneria, Potamogeton*) and emergent vegetation (e.g. *Typha, Phragmites, Eleocharis*) are also a notable feature of the Wimmera River System. They provide a nursery for small-bodied native fish like Southern Pygmy Perch (B. McInnes, Wimmera CMA pers. comm) and habitat for birds like Australian Reed-Warblers (*Acrocephalus australis*) (Wimmera CMA, 2012). They are also a valuable sink for nutrients (namely nitrogen and phosphorus) which in turn reduces their availability for blue-green algae blooms (Roberts, Grace, Sherwood, Lind, & Nash, 2006).

Table 5-4: Ecological Vegetation Classes associated with the MacKenzie River, and Burnt and Bungalally Creeks and their floodplains.

EVC NO.	ECOLOGICAL VEGETATION CLASS NAME	BIOREGION(S)	BIOREGIONAL CONSERVATION STATUS
103	**Riverine Chenopod Woodland**	Wimmera	Endangered
		Murray Mallee	Depleted
641	**Riparian Woodland**	Wimmera	Vulnerable
		Lowan Mallee	
		Murray Mallee	
823	**Lignum Swampy Woodland**	Wimmera	Vulnerable
		Murray Mallee	
200	**Shallow Freshwater Marsh**	Dundas Tablelands	Vulnerable
292	**Red Gum Swamp**	Wimmera	Vulnerable
3	**Damp Sands Herb-rich Woodland**	Dundas Tablelands	Vulnerable
414	**Shrubby Woodland/Damp Sands Herb-rich Woodland Complex**	Dundas Tablelands	Least Concern
659	**Plains Riparian Shrubby Woodland**	Wimmera	Vulnerable
757	**Damp Sands Herb-rich Woodland/ Shrubby Woodland Mosaic**	Wimmera	Vulnerable

Threatened species found in and adjacent to the MacKenzie River, and Burnt and Bungalally Creeks that rely on flows or inundation to maintain condition and/or recruitment are included in Table 5-5.

Table 5-5: Threatened flow-dependent flora species in the MacKenzie River, and Burnt and Bungalally Creeks and associated status

SPECIES NAME	COMMON NAME	EPBC ACT[8] STATUS	FFG ACT[9] STATUS	REACHES APPLICABLE
Callistemon wimmerensis	***Wimmera Bottlebrush***	Critically Endangered	Endangered	MacKenzie Reach 3
Gratiola pumilo	***Dwarf Brooklime***		Endangered	MacKenzie Reach 3

[8] EPBC: *Environment and Biodiversity Conservation Act*
[9] FFG: *Flora and Fauna Guarantee Act*

ECOSYSTEM FUNCTION

'Ecosystem function' is the term used to define the biological, geochemical and physical processes and components that take place or occur within an ecosystem. Ecosystem functions relate to the structural components of an ecosystem (e.g. vegetation, water, soil, atmosphere and biota) and how they interact with each other, within ecosystems and across ecosystems (Maynard, James, & Davidson, 2012). Ecosystem functions critical to support primary water-dependent environmental values of the Wimmera River system include, but are not limited to:

- Food Web Support - a critical function is the conversion of matter to energy by primary producers for uptake by biota. Structural components include substrate surfaces (e.g. large woody habitat and rocks) for biofilms, and plant matter. Interactions between primary producers and consumers such as zooplankton and macroinvertebrates break down the carbon and nutrients required for higher order consumers.
- Reproduction – recruitment of new individuals is important for all of the river system's biota and the maintenance of local and regional populations. Flows and inundation can act as cues for fish to spawn through changing water temperatures and habitat availability (e.g. inundating fringing vegetation) (Lintermans, 2007). It also prompts the reproduction of vegetation, for example Wimmera Bottlebrush has shown a strong recruitment response to flows (Marriott, 2006).
- Movement/Dispersal – movement of individuals throughout various waterway habitats to take advantage of different resources is linked to the food web support. By providing flows of differing volumes, different areas of the river are accessible for foraging by fish, waterbirds, other aquatic fauna and propagules. Variability in lake levels is also an important mechanism to disperse species and provide a range of habitats. Flow and connectivity also facilitate the dispersal of different species up and down the Wimmera River which is especially important following dry spells to allow recolonisation.
- Landscape Contribution – the Wimmera River and terminal lakes are crucial to the overall biodiversity of the broader Murray Darling Basin and south-east Australia as a whole. The terminal lakes are crucial breeding sites for a variety of waterbirds as well as species such as the Wimmera Bottlebrush that have a limited distribution.

A summary of how this EWMP will address various ecosystem functions is given in Table 5-6. This table also shows which ecosystem functions are being specifically addressed in this EWMP by using the ecosystem functions structure suggested in the Basin Plan (Australian Government, 2012).

Table 5-6: Ecosystem functions provided within the broader Wimmera River system including MacKenzie River, and Burnt and Bungalally Creeks

CRITERIA		MEETS CRITERION	EXPLANATION
1.	**The ecosystem function supports the creation and maintenance of vital habitats and populations**		
	Assessment indicator: An ecosystem function requires environmental watering to sustain it if it provides vital habitat including:		
	(a) A refugium for native water-dependent biota during dry periods and drought; or	✓	The Wimmera River has deep pools (including weir pools) which provide refuge for aquatic fauna (notably Freshwater Catfish, Golden and Silver Perch) during seasonal dry phases and extended droughts. Providing low flows during seasonally dry and very dry conditions will maintain this refuge habitat and ensure its water quality (salinity) remains within the tolerance range of the dependent fauna.
	(b) Pathways for the dispersal, migration and movement of native water dependent biota; or	✓	Flows enable some species (e.g. platypus) to disperse and genetic mixing of some species (e.g. Mountain Galaxias and Southern Pygmy Perch).
	(c) A diversity of important feeding, breeding and nursery sites for native water-dependent biota; or	✓	The Wimmera River System contains one of four self-sustaining Freshwater Catfish population in Victoria (DSE, 2005) with suitable habitat for nesting sites. Stretches of the Burnt and Mt William Creeks as well as the MacKenzie River are key locations for the breeding of Southern Pygmy Perch and Mountain Galaxias. There has been evidence of platypus breeding in the MacKenzie River (cesar, 2014).
	(d) A diversity of aquatic environments including pools, riffle and run environments; or	✓	The Wimmera River is characterised by deep pools, particularly near Dimboola. These pools have runs in between to provide a diversity of habitat. This morphology is similar for the lower Burnt and Mt William Creeks as well as parts of the MacKenzie River. The reaches of the MacKenzie River and Mt William Creek located near the Grampians contain more of a rocky substrate and so have riffles as well.
	(e) A vital habitat this is essential for preventing the decline of native water-dependent biota.	✓	Experience during the Millennium Drought has shown that without environmental water releases, native fish species are at a very high risk of being lost from the region, riparian vegetation rapidly declines, macroinvertebrate communities become depauperate and other species like platypus and rakali are vulnerable to becoming regionally extinct. Environmental watering has enabled these impacts to be minimised and facilitated recovery post drought conditions.

CRITERIA		MEETS CRITERION	EXPLANATION
2.	**The ecosystem function supports the transportation of nutrients, organic matter and sediment**		
	Assessment indicator: An ecosystem function requires environmental watering to sustain it if it provides for the transportation of nutrients, organic matter and sediment, including:		
	(a) Pathways for the dispersal and movement of organic and inorganic sediment, delivery to downstream reaches and the ocean, and to and from the floodplain	✓	The Wimmera River flows into a series of terminal lakes, some of which are of national and international importance. Inputs of organic and inorganic sediment are vital for the establishment and maintenance of food webs that support an abundance of birds, fish and other aquatic species when the lakes contain water.
3.	**The ecosystem function provides connections across floodplains, adjacent wetlands and billabongs (lateral connections)**		
	Assessment indicator: An ecosystem function required environmental watering to sustain it if it provides connections across floodplains, adjacent wetlands and billabongs, including:		
	(a) For dispersal and re-colonisation of native water-dependent communities; or	✓	Monitoring has shown the re-establishment of platypus in reaches of the MacKenzie River following the provision of environmental flows. One of the objectives within the Wimmera River environmental flows study is the provision of habitat and conditions to enable re-colonisation of platypus from the MacKenzie River to the Wimmera River.
	(b) For migration to fulfil requirements of life history stages; or	✗	No endemic species of fish require migration to complete life history stages.
	(c) For in-stream primary production	✓	Freshening flows along all regulated waterways are required in order to try and mobilise sediment and biofilms on woody habitat and interstitial spaces (Alluvium, 2013).
4.	**The ecosystem function provides connections across floodplains, adjacent wetlands and billabongs (longitudinal connections)**		
	Assessment indicator: An ecosystem function required environmental watering to sustain it if it provides connections across floodplains, adjacent wetlands and billabongs, including:		
	(a) Longitudinal connections for foraging, migration and re-colonisation of native water dependent species and communities; or	✓	The Wimmera River and MacKenzie Rivers as well as Mt William Creek have high-flow channels that are engaged by large fresh and bankfull flows to provide additional habitat. Furthermore, many of the biota that inhabit the Wimmera River enter the terminal lakes when they contain water in order to establish food webs.
	(b) Longitudinal connections for off-stream primary production	✓	Inputs from flows are critical for primary production in high-flow channels.

5.2 SHARED BENEFITS

TRADITIONAL OWNER CULTURAL

The significance of the Wimmera River System (including the MacKenzie River, and Burnt and Bungalally Creeks) to the local indigenous community is substantial.

Abundant scar trees, shell middens, burial sites and artefact scatters bear testimony to the profound connection between local Aboriginal people and the MacKenzie River, and Burnt and Bungalally Creeks. Aboriginal Water Assessments and cultural heritage surveys undertaken on the downstream Wimmera River and terminal lakes since 2017 continue to illustrate the profound connections of traditional owners to these waterways.

The region's Waterway Strategy (Wimmera CMA, 2014) contains priorities for action to maintain and enhance cultural values. A recent 2020 report on maximising the cultural benefits and Aboriginal community outcomes from managing water in the environment in the lower Wimmera River (RMCG, 2020) highlighted the importance of River Yarns Aboriginal Waterway Assessments as a way of promoting connection with Country and its waterways. Recommendations included 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.

Table 5-7: provides an example of the shared benefits for cultural outcomes from environmental watering at MacKenzie River, and Burnt and Bungalally Creeks.

Table 5-7: Traditional Owner Values and Uses (WCMA, 2023)

RIVER/ WETLAND	VALUES/ USES/ OBJECTIVES/ OPPORTUNITIES	ALIGNMENT WITH POTENTIAL WATERING ACTIONS
MacKenzie River, and Burnt and Bungalally Creeks	MacKenzie River, and Burnt and Bungalally Creeks are important to the Wotjobaluk people. These waterways are home to a unique matrix of freshwater aquatic species important to the Wotjobaluk Traditional Owners. This includes an isolated species of River Blackfish Gadopsis marmorata, known to them as Wirrap.	Maintaining continuous flows with the current Seasonal proposals is seen to align with BGLC requirements. Ongoing fish monitoring and any future proposed carp removal is seen to be a proactive management step.

RECREATION

Water in the Wimmera landscape provides social and recreational values, and many of these values (e.g. fishing, which occurs in the MacKenzie River and Burnt Creek) directly rely on environmental flow regimes. Water for Victoria - Victoria's water plan that sets long-term direction for managing Victoria's water resources (DELWP, 2016) and the 2019 Water Act amendments require that all water management agencies to consider achieving shared benefits and social values in environmental watering decisions.

ECONOMIC VALUES

There are several stock and domestic licences along the MacKenzie River, and Burnt and Bungalally Creeks as well as irrigation licences on the Burnt Creek (Table 5-8). Stock and domestic water is now largely provided by the Wimmera Mallee Pipeline and irrigation is limited due to issues around poor water quality (high salinity) and limited reliability of supply. There are community concerns around the impact of large numbers of stock and domestic diverters taking water during droughts.

Table 5-8: Licenced diversion details for the Burnt Creek

WATERWAY	NUMBER OF LICENCES (TYPE)	TOTAL VOLUME (ML)
Upper Burnt Creek	1 (Domestic and Stock)	2.2
	14 (Domestic)	30.8
Lower Burnt Creek	12 (Domestic and Stock)	26.4
	2 (Irrigation)	23.5

A wide variety of shared benefits (which includes recreational use) will be provided by environmental watering actions, and Table 5-9 outlines the expected social, recreational and economic shared benefits to be derived from environmental water delivery.

Table 5-9: Expected social, recreational and economic shared benefits to be derived from environmental water delivery (WCMA, 2023).

RIVER/ WETLAND	BENEFICIARY	CONNECTION TO THE RIVER	VALUES/ USES/ OBJECTIVES/ OPPORTUNITIES	ALIGNMENT WITH POTENTIAL WATERING ACTIONS
MacKenzie River, and Burnt and Bungalally Creeks	Landholders with Stock and Domestic and/or Irrigation licences	Landholders have a close connection to the river, and interest in maintaining its health. Water quality improvements associated with increased flow can be important to landholders who are reliant on the river to meet their stock and domestic needs.	There are several landholders along these waterways that access water for stock and domestic purposes.	Environmental water deliveries help maintain water quality and levels.
	Anglers	Recreation plays an important social and economic role in the catchment. Wellbeing associated with recreational use of waterways in the region complements the annual economic contribution to regional communities.	The MacKenzie River and Burnt Creek provide opportunities for anglers looking to catch native (and exotic) fish species.	Provision of environmental water to maintain fish communities will enhance angling opportunities. (Summer/autumn baseflows and freshes and winter/spring baseflows/freshes)

5.3 CURRENT ECOLOGICAL CONDITION

The broader Wimmera River system of which MacKenzie River, and Burnt and Bungalally Creeks are a part has been modified by various factors in the past 200 years which has affected its condition and led to ongoing threats that need addressing to prevent additional declines. Flows within the system are impacted by the presence of dams, weirs and channels. Water quality has declined due to increased nutrient and sediment inputs from eroding tributaries. Exotic flora and fauna have also invaded the system with annual grasses and pest fish species like Common Carp and Eastern Gambusia becoming the dominant species in many parts of the system during the Millennium Drought. The protection of riparian areas through their designation as Crown land within parks, reserves or frontage has led to riparian and wetland areas retaining many of their environmental values.

The condition of the MacKenzie River, and Burnt and Bungalally Creeks and the threats they face vary depending on climatic circumstances with flood, drought and fire all having major impacts. The following sections provides an outline of the environmental values these waterways provide and the threats that they face.

CURRENT CONDITION

Various programs have assessed the condition of waterways in the broader Wimmera River system over the last 15 years as part of Murray Darling Basin or statewide programs or as part or more local catchment condition monitoring. The following results for the MacKenzie River, and Burnt and Bungalally Creeks provide an overview of their current values and trends.

Index of Stream Condition (ISC)

The ISC is an assessment of stream condition across Victoria. Scores and classifications are provided for reaches of several kilometres up to about 50 km long for rivers and creeks based on five sub-indices (hydrology, physical form, water quality, streamside zone, aquatic life) (Figure 5-4). The ISC has been undertaken on three occasions (1999, 2004 and 2010) and the methods applied for collecting data have varied significantly each time so the results are not directly applicable and trends in condition cannot be inferred.

Reaches of the MacKenzie River, and Burnt and Bungalally Creeks covered in this EWMP have many of the attributes of a healthy waterway and problems associated with weeds and erosion are comparatively minor when compared to other waterways across the state.

The ISC results for MacKenzie River and Burnt Creek are detailed in Table 5-10. MacKenzie River has a virtually intact zone of riparian vegetation and water flowing from upstream is typically of excellent quality. The lack of flow has been the main threat for this reach (Section 3.1) although increased water savings leading to additional environmental flows may reduce this threat. For Burnt Creek the riparian vegetation is in good condition in the upper reach, however the lower reach's condition is comparatively poorer with limited understorey vegetation, which is reflected in ISC scores for Streamside Zone. Again, the impact of water resource management has led to very poor Hydrology scores.

Bungalally Creek was not assessed in the ISC. It is assumed that due to its location and characteristics (including flow regime) that ISC scores would be similar to the lower Burnt Creek.

Table 5-10: ISC results for the MacKenzie River and Burnt Creek reaches subject to this EWMP

ISC REACH	FLOWS REACH	PHYSICAL FORM			STREAM-SIDE ZONE			HYDROLOGY			WATER QUALITY			AQUATIC LIFE			TOTAL			CONDITION		
		Year																				
		99	04	10	99	04	10	99	04	10	99	04	10	99	04	10	99	04	10	99	04	10
McKenzie River																						
14	3	7	6	8	7	7	8	2	0	8	8	-	-	9	-	3	28	16	30	M	P	M
15	1, 2	6	5	8	6	3	9	2	0	8	-	-	7	-	5	5	21	12	35	P	VP	G
16	1, 2	8	9	8	8	9	9	2	0	8	-	-	6	-	9	7	29	27	36	M	M	G
Burnt Creek																						
18	Lower	-	4	8	-	4	7	-	1	0	-	7	-	-	-	7	-	13	21	-	P	M
19	Upper	-	4	8	-	6	7	-	1	0	-	8	-	-	-	7	-	15	22	-	P	M

*VP: Very Poor, P: Poor, M: Moderate, G: Good.

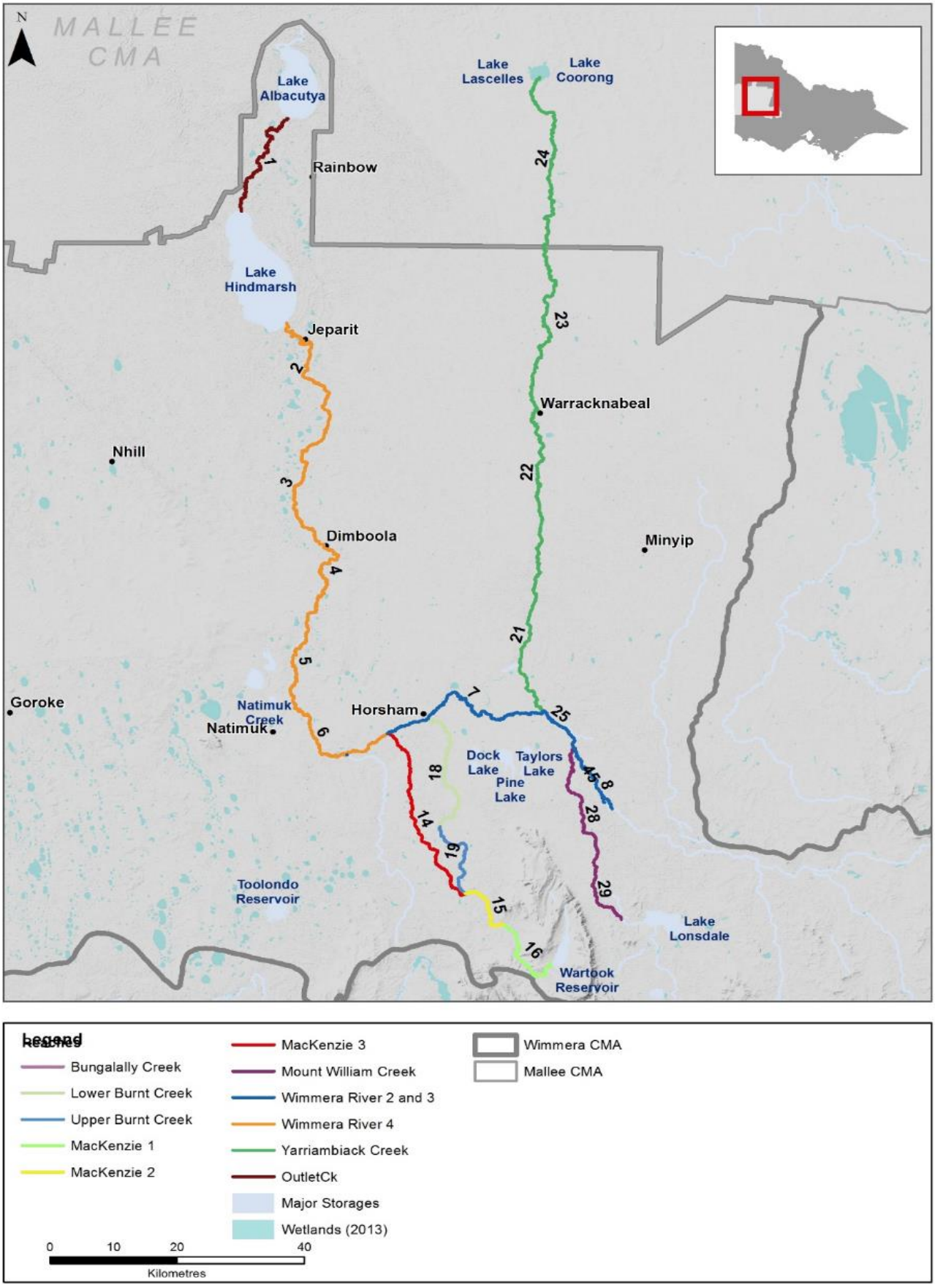

Figure 5-4: ISC reaches within the Wimmera River system (Source: WCMA)

Regional Fish Monitoring

Regional fish monitoring has been taking place since 2006 when SKM developed a methodology that involved determining the condition of parts of the Wimmera CMA region using a sampling method similar to that used in SRA assessments (SKM, 2006). The Wimmera River catchment was broken up into several 'Waterway Health Management Units' (WHMUs) for strategic planning purposes.

Figure 5-5 shows the locations of fish monitoring sites within the area covered by this EWMP for the MacKenzie River, and Burnt and Bungalally Creeks. Table 5-11 shows a summary of data following analysis of results from 2005-2010 (SKM, 2010). The condition of the fish population in each WHMU is classified based on the proportion of native species compared with exotic in terms of abundance, diversity and biomass. Using these monitoring sites, and to assist in recovery of aquatic biodiversity and to guide strategic management, environmental flow regimes, cost-effective investment and recovery of native fish in the Wimmera region, the CMA commissioned a Native Fish Management Plan to be developed for the Wimmera Region (ARI, 2022).

Table 5-11: Fish monitoring data (species numbers) for WHMUs included in this EWMP (SKM, 2010)

WHMU	MACKENZIE AND BURNT UPPER		MACKENZIE AND BURNT LOWER (INC. REACH 3 WIMMERA RIVER)		
Year	2006	2009	2008	2009	2010
#Native Species	4	4	4	5	4
#Exotic Species	3	4	4	4	4
Total Species	7	8	8	9	8
Condition	Excellent	Good	Poor	Poor	Poor

*HD: Highly Degraded

Limited regional fish monitoring has taken place in the MacKenzie River, Bungalally Creek and Burnt Creek since 2010. A survey in 2012 led to the overall classification of fish population being in 'good' condition when collectively assessed according to the qualitative assessment criteria in SKM (2010) (Biosis, 2013). However, sites closer to the Wimmera River had much poorer fish populations being dominated by exotic species Common Carp and Goldfish (*Carassius auratus*).

Regional Macroinvertebrate Monitoring

Macroinvertebrate monitoring was undertaken from 2005-2012 such as the regional fish monitoring project, to detect trends in catchment condition. Macroinvertebrate monitoring has provided useful insight into the decline in waterway condition during drought (e.g. EPA (2008)) as well as their recovery following wetter years in 2010 and 2011 (e.g. WEC (2012)). The condition of macroinvertebrate communities is highly variable across Wimmera River sites although there was improvement due to increased flows following drought conditions. MBI classifications for the latest regional macroinvertebrate sampling program for the MacKenzie River site are shown in Table 5-12.

Table 5-12: MBI scores and ratings 2011/12 and 2008/09 for the MacKenzie River (location shown in Figure 5-6) (Source: WEC (2012 & 2009))

REACH	SITE NAME	MBI SCORE AND RATING 2011/12		MBI SCORE AND RATING 2008/09	
Reach 2 MacKenzie River	Mount Victory Road	8	Moderate	5	Moderate

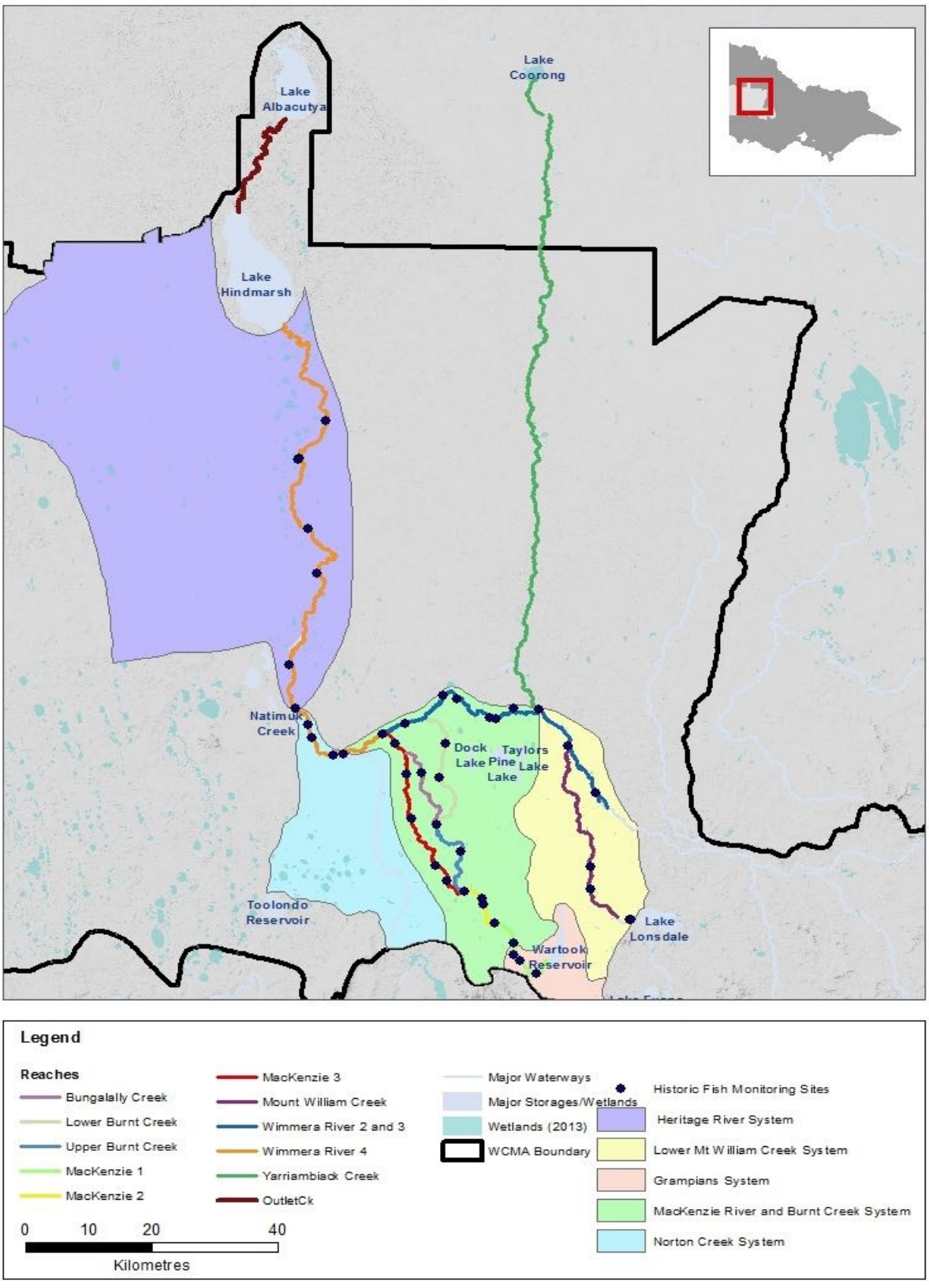

Figure 5-5: Regional fish monitoring sites within the Wimmera River system (SKM, 2010)* –

**Note this map from 2010 does not include data from Yarriambiack Creek.*

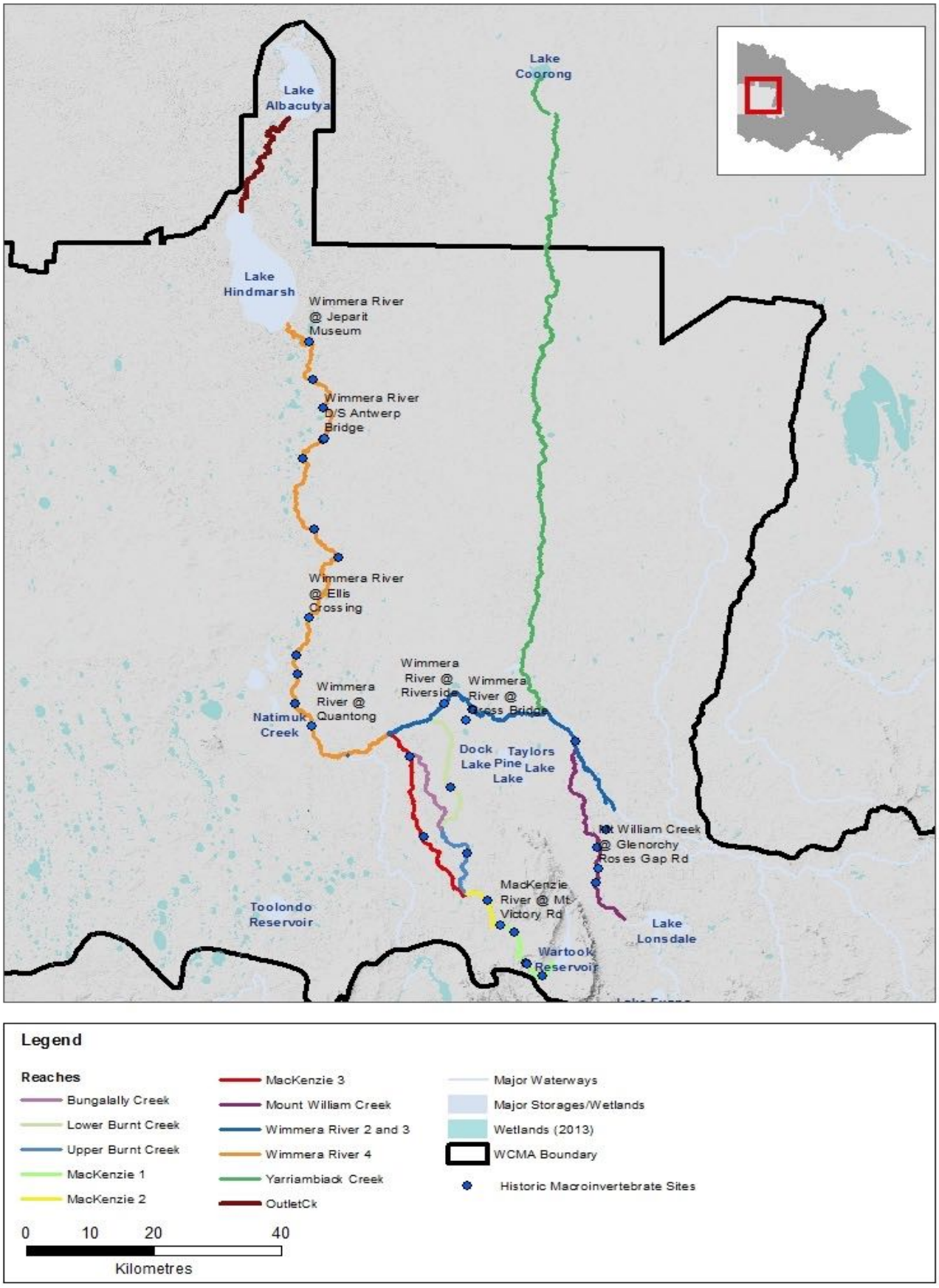

Figure 5-6: Macroinvertebrate monitoring sites within the area covered by this EWMP

Vegetation monitoring

Monitoring of aquatic and riverbank vegetation has been taking place on multiple survey sites along MacKenzie River and Burnt Creek under Stage 6 of the Victorian Environmental Flows Monitoring and Assessment Program (VEFMAP), examining vegetation responses to flows. The latest results from VEFMAP Stage 6 (ARI, 2020) can be found here.

Under the Victorian Environmental Flows Monitoring and Assessment Program (VEFMAP), vegetation is monitored for responses to environmental flows released from impoundments on eight major streams across Victoria. Wimmera CMA established vegetation monitoring at five sites, and monitoring at 10 sites for the health of river red gums (*Eucalyptus camaldulensis*). The five sites included one on the MacKenzie River and four on the Wimmera River (at Gross Bridge, Polkemmet, Big Bend and Wundersitz). River red gum-monitoring sites were all on the Wimmera River.

In 2023 Ecology Australia was commissioned to conduct the fifth round of vegetation and tree health monitoring. At each of the five vegetation sites quadrat data were collected at one-metre intervals on 15 transects spanning the streams. Further information on the results of this work can be found in the Wimmera EWMP (RMCG, 2024).

Large Woody Debris

Much of the Wimmera River system (including MacKenzie River, and Burnt and Bungalally Creeks) contains 'good' physical habitat values. Historically, de-snagging took place on the reach of the Wimmera River upstream of Horsham to Longerenong, but there is limited evidence of de-snagging in MacKenzie River, and Burnt and Bungalally Creeks).

While there has been some historic tree clearing in riparian areas, they remain largely intact and over time fringing river red gums will fall into the waterway to provide additional habitat. This was particularly noticeable in 2009-10 when water returned to much of the Wimmera River system (including MacKenzie River, and Burnt and Bungalally Creeks) and streambanks became sodden, which triggered the fall of many large trees into the river.

Synthesis

The information presented around the condition of the MacKenzie River, and Burnt and Bungalally Creeks, illustrates the increasing impact of threats like water extraction, poor water quality and exotic flora and fauna. Native fish and vegetation assemblages become increasingly dominated by exotic species moving from the MacKenzie River towards the Wimmera River.

WATER-DEPENDENT THREATS

Exotic species

Exotic species are a major threat to native flora and fauna in the MacKenzie River, and Burnt and Bungalally Creeks. Redfin are voracious predators of small-bodied native fish as well as frogs and tadpoles with monitoring showing that Southern Pygmy Perch were absent in remnant pools containing Redfin (SKM, 2007). They also carry the epizootic haematopoiestic necrosis virus (EHNV) which can be transferred to native species like Obscure Galaxias (SKM, 2007). Brown Trout (*Salmo trutta*) are found in the MacKenzie River and Rainbow Trout (*Onchrynchus mykiss*) have also been stocked in Lake Wartook. Galaxiids and River Blackfish are susceptible to predation and competition from these species (SKM, 2007). Eastern Gambusia (*Gambusia holbrooki*) are widespread throughout the Wimmera River System and have been noted to predate on macroinvertebrate and frog eggs as well as out-competing small-bodied native fish for habitat and resources.

Their aggressive behaviour such as fin-nipping and biting means other species such as Southern Pygmy Perch and Australian Smelt cannot co-exist with Gambusia.

Common Carp, along with Tench (*Tinca tinca*) and Goldfish are found throughout much of the Wimmera River system. However, carp are largely absent from Reaches 1 and 2 of the MacKenzie River and upper Burnt Creek with only small numbers of carp caught in the MacKenzie River. These species impact on these waterways through their feeding behaviour of ingesting sediment and filtering out food. This in turn prevents the growth of instream vegetation through disturbance and the increased turbidity reduces light penetration and nutrient mobilisation (SKM, 2007).

With respect to exotic or overabundant native aquatic and riparian vegetation, there are no species such as Willows (*Salix spp.*) or Azolla (*Azolla spp.*) within or along the MacKenzie River, and Burnt and Bungalally Creeks that would be advantaged by environmental flows, threatening environmental values. Although there can be large beds of Azolla in Burnt Creek in Horsham, the main risk to overabundant growth of Azolla is the scouring effects of floods favouring recolonization by annual species which take advantage of the disturbance (SMEC, 2011) rather than environmental flow releases. Stormwater-collection dams in new housing established around Horsham can be impacted by Azolla, which has also impacted the Lower Burnt Creek when releases occur from dams.

Recreation

The MacKenzie River and Burnt Creek have historically been used for angling. Fishing is managed by Victorian Fisheries Authority (VFA) which undertakes regulation and stocking in the Wimmera catchment to maintain and enhance fish populations. VFA also manages other activities specified in the Wimmera Fishery Management Plan (DPI, 2009) such as raising awareness of responsible conduct with respect to fishing. This is intended to reduce the threat around overfishing as well as damage to riparian areas by anglers. This is supported by the Wimmera Native Fish Management Plan (ARI, 2022).

WATER QUALITY

Water quality along MacKenzie River, Burnt Creek and Bungalally Creek is amongst the best in the region with streamflows from the Lake Wartook and downstream tributaries containing low levels of salinity, nutrients and turbidity (typically within SEPP (WoV) guidelines). Cold water pollution is not generally an issue as Lake Wartook is a shallow storage. Flows from the Moora Channel can be delivered to Reach 3 of the MacKenzie River, Burnt Creek and Bungalally Creek. Whilst water supplied from the Moora Channel is of low salinity, observations indicate it has higher turbidity than water supplied from Lake Wartook. Likewise, water can be delivered to the lower Burnt Creek and Bungalally Creek from the Toolondo Channel, which is of lesser quality as well (salinity of approximately 1000 µS/cm and turbity of 10 NTU (GWMWater, 2014)).

5.4 TRAJECTORY OF CHANGE

What was experienced during the past 20 years provides a valuable insight into what would happen should environmental water not be provided to the Wimmera River system into the future. The impacts would be further exacerbated under climate change scenarios which indicate that winter/spring rainfall (and subsequent runoff into waterways) will be much reduced.

Without environmental water most reaches would only flow in years when rainfall was well above average which would lead to drastic declines in the condition of many of the values including the likely loss of fish communities from many of these waterways. Lowland fish communities would be restricted to unregulated tributaries of the Wimmera River system as well as deep remnant pools that could retain sufficient water to endure a sequence of years with no flow.

Macroinvertebrate populations and riparian vegetation condition would decline, and channels would be colonised or even blocked by River Red Gum saplings and emergent macrophytes such as *Typha* and *Phragmites*.

Cultural values would be impacted by the death and/or decline of scar trees in riparian areas. Townships would suffer from the loss of amenity and recreation opportunities and fish deaths and algal blooms would be more prevalent.

Occasionally floods would still make their way along these waterways, providing a brief period of respite for fish and other water-dependent vertebrate species and triggering various ecological processes (Section 4.4). However, the lack of baseflows and freshes following these flood events would limit the success of recruitment events for fish and aquatic vegetation.

6 Managing water-related threats

A qualitative risk assessment has been undertaken to assign the level of long-term risk to achieving the ecological objectives for the MacKenzie River, and Burnt and Bungalally Creeks system as well as risks related to the delivery of environmental water through the implementation of this EWMP. The relationship between likelihood (probability of occurrence) and the severity (severity of impact) provides the basis for evaluating the level of risk (Table 6-1). This risk matrix (as well as the definitions as to consequences) are taken from Victorian Environmental Watering Partnership Risk Management Framework (RMCG, 2014).

Table 6-1: Risk matrix (derived from RMCG (2014))

		Consequences				
		Extreme	Major	Moderate	Minor	Negligible
Likelihood	Almost Certain	Extreme	Extreme	High	Moderate	Low
	Likely	Extreme	Extreme	High	Moderate	Low
	Possible	Extreme	High	Moderate	Moderate	Low
	Unlikely	Extreme	High	Moderate	Low	Low
	Rare	High	Moderate	Low	Low	Low

Management measures are recommended and the residual risk, assuming the measures have been successfully completed, is recalculated using the same matrix. It should be noted that risk management for the delivery of environmental water is undertaken on an annual basis through the development of the Wimmera River and terminal lakes Seasonal Watering Proposal developed by the Wimmera CMA in accordance with the guidelines provided by the Victorian Environmental Water Holder.

Table 6-2: Risk assessment and management measures for the MacKenzie River, and Burnt and Bungalally Creeks

THREAT	OUTCOME	RELEVANT OBJECTIVE	REACH(ES)	LIKELIHOOD	CONSEQUENCES	RISK	MANAGEMENT MEASURES	FEASIBILITY	RESIDUAL RISK
Threats to achieving ecological objectives									
1. Artificial instream structures (e.g. town weirs)	Impacts on ecological processes such as recolonisation, habitat utilisation and dispersal	Fish, platypus, aquatic and riparian vegetation	All	Almost certain	Moderate	High	Use fishways effectively, provide high flows that drown out structures	Medium	Moderate
3. Recreational fishing	Freshwater Catfish and River Blackfish population declines through unsustainable levels of take	Fish	MacKenzie Reach 2	Unlikely	Major	High	Continue to work with anglers to highlight the risks to fish population. Enforce angling regulations.	High High	Low
4. Grazing pressures	Unrestricted grazing leads to impacts such as the consumption of aquatic, floodplain and riparian vegetation in particular grasses, herbs and juvenile woody vegetation. This in turn leads to reductions in habitat and water quality (increased erosion) affecting fish and macroinvertebrate populations.	Water quality, fish, macroinvertebrates, aquatic, floodplain and riparian vegetation	All (in isolated sections)	Almost certain	Moderate	High	Implement management activities in Victorian Waterway Management Strategy and WWS around improving management of riparian areas through such actions as ensuring licence conditions are being complied with.	High	Moderate
5. Carp/Goldfish/ Tench	The 'mumbling' feeding behaviour of Carp impacts on vegetation through disturbance of seeds/seedlings as well increasing turbidity which limits light penetration for photosynthesis.	Water quality, fish, macro-invertebrates, aquatic vegetation	All although carp numbers are low in MacKenzie 2 and Upper Burnt	Almost certain	Extreme	Extreme	Implement management activities in WWS intended to prevent the dispersal of carp as well as increase understanding of their movement and behaviour in the Wimmera River system. Support initiatives such as the Koi Herpes Virus and Daughterless Carp gene technology.	Low	Extreme
6. Redfin/ Gambusia	Redfin impact on native fish communities through being voracious predators of small-bodied native fish as well as young large-bodied species. They also carry a disease that impacts on native species. Gambusia also impact on small-bodied native fish populations through aggressive behaviour (fin-nipping) and predating on fish and frog eggs.	Fish	All	Almost certain	Major	Extreme	Encourage a catch and take approach from anglers with respect to Redfin. Little can be done to mitigate the threat of these species.	Low	Extreme
7. Foxes	Foxes impact on Platypus, Rakali and Eastern Long-Necked Turtle populations through predation.	Platypus	MacKenzie Reach 2 and potentially MacKenzie Reach 3, Upper Burnt Creek	Likely	Minor	Moderate	Implementing fox control actions as part of the Wimmera Invasive Plant and Animal Management Strategy (Wimmera CMA, 2010) (WIPAMS).	Moderate	Moderate
8. Weeds	Riparian and floodplain vegetation outcomes are threatened by invasive plant species such as Bridal Creeper, Boneseed, Blackberry, Perennial Veldt Grass and Cape Tulip through outcompeting and smothering native species.	Riparian and floodplain vegetation	All	Almost certain	Extreme	Extreme	Implement invasive plant management activities outlined in the WWS.	Low	Extreme

THREAT	OUTCOME	RELEVANT OBJECTIVE	REACH(ES)	LIKELIHOOD	CONSEQUENCES	RISK	MANAGEMENT MEASURES	FEASIBILITY	RESIDUAL RISK
9. Rabbits	Rabbits impact on riparian and floodplain vegetation through consuming herbs, grasses and seedlings of woody species. They have been known to have prevented recruitment of species when at high densities including Cypress-Pine at Lake Albacutya.	Riparian and floodplain vegetation	All	Almost certain	Moderate	High	Implement invasive plant and animal management activities outlined in the WWS and WIPAMS.	High	Moderate
Threat related to the delivery of water for the environment									
11. Releasing poor quality water	In a couple of cases environmental water being released is poorer quality than tributary inflows or environmental water released from another location. This in turn impacts on water quality outcomes through increased salinity and turbidity which affects aquatic vegetation, fish and macroinvertebrate communities.	Water quality, fish, aquatic and riparian vegetation	MacKenzie River Reach 3	Possible	Minor	Moderate	Source water from Lake Wartook in preference to the Moora Channel for the lower MacKenzie River.	Moderate	Low
12. Aging and degrading infrastructure	Could cause interruptions to planned water releases.	All	All	Possible	Moderate	Moderate	Support water asset management and maintenance plans with water management partners		
Abundant water									
13. Drowning infant platypuses	If flows are too high during late spring through to mid-autumn there is a risk of maternal burrows filling with water and the drowning infant platypuses.	All	MacKenzie Reach 2	Unlikely	Minor	Low	Do not conduct high flows during late spring through to mid-autumn.	High	Low

7 Management goals, objectives and targets

7.1 MANAGEMENT GOALS

The Wimmera Waterway Strategy 2014-2022 lists a number of long-term (20+ year) goals for the region's waterways. They were developed with community, partner and stakeholder feedback to inform the preparation of the Wimmera Waterway Strategy and these provide context for this EWMP. They are:

- Maintaining and improving the values and condition of waterways that have formally recognised significance (*WWS-G1*)
- Improve connectivity and condition along priority wetland systems and riparian corridors (*WWS-G2*)
- Improve water quality in priority areas for; water supply, environmental condition and recreation (*WWS-G3*)
- Waterways with high social, cultural and economic values are maintained in a state that continues to support those values in line with climatic conditions (*WWS-G4*).

The recently developed Wimmera RCS 2021 – 2027 also outlines a series of outcomes relevant to management of water for the environment:

20-year water theme river and stream outcomes (20Y-RSO)

- The knowledge and experience of First Nations people is informing water planning, management and delivery in the Wimmera (*RCS-20Y-RSO1*).
- The connectivity and condition of native vegetation along riparian corridors are improved (*RCS-20Y-RSO3*)
- Water quality is improved at important areas for water supply, environmental and recreational values (*RCS-20Y-RSO4*)
- Rivers and streams with high environmental, social, cultural and economic values are improving their value despite climate change (*RCS-20Y-RSO5*).

Six-year water theme outcomes (6Y-WO)

- Ongoing collaboration and two-way learning in river and stream planning and management by supporting and strengthening partnerships with First Nations people (*RCS-6Y-RSO1*)
- Healthier rivers and streams enable more on Country activities for First Nations people (*RCS-6Y-RSO4*)
- Blue green algal blooms and fish deaths are prevented where possible in the Barringgi Gadyin (Wimmera River) and MacKenzie River, and Burnt and Bungalally Creeks (*RCS-6Y-RSO5*)
- No new pest plants and animals are established beyond small, localised populations (*RCS-6Y-RSO6*)
- More reaches have improved riparian width and connectivity (*RCS-6Y-RSO8*)
- Drought refuges are protected and retain water during drought (*RCS-6Y-RSO10*)
- Native fish and platypus are increasing their abundance and distribution (*RCS-6Y-RSO12*).
- Native fish numbers are greater than carp numbers in most fish surveys and fishing competitions (*RCS-6Y-RSO13*).

The management goal for this EWMP aligns with these outcomes.

> *"Environmental water will maintain and enhance the condition of the MacKenzie River, and Burnt and Bungalally Creeks to support its role in providing connectivity for flora, fauna, carbon and nutrients between the Wimmera River and Gariwerd (Grampians National Park), as well as maintaining its strong environmental and cultural values, particularly as a refuge in periods of drought or low flows. This includes its diverse, abundant and resilient native fish communities (including River Blackfish) and sustainable platypus population."*

Environmental watering of MacKenzie River, and Burnt and Bungalally Creeks will be a critical plank in achieving this goal as well as being an important part of the 50-year visions of the Wimmera RCS (2021-2027) and the 2013 Victorian Waterway Management Strategy that are listed as follows:

> *"A healthy Wimmera catchment where a resilient landscape supports a sustainable and profitable community. (Wimmera CMA, 2021)."*
>
> *"Victoria's rivers, estuaries and wetlands are healthy and well-managed; supporting environmental, social, cultural and economic values that are able to be enjoyed by all communities (DEPI, 2013)."*

Specific ecological objectives that underpin the achievement of these long-term goals and visions are outlined in Section 6.1.

- Environmental objectives and targets

MACKENZIE RIVER, BURNT AND BUNGALALLY CREEKS

In 2002, ecological objectives were developed by an expert panel in consultation with Wimmera CMA staff for the Wimmera River in the Stressed Rivers Project – Environmental Flow Study Wimmera River System (SKM, 2002). In 2003, this was expanded to other regulated reaches in the Wimmera Bulk Entitlement Conversion Environmental Flows Study (SKM, 2003). Since then, there have been advances in the methodology for determining environmental flow requirements and in understanding the ecological condition (e.g. through monitoring projects) of rivers in Victoria. These advances warranted a comprehensive review and updating of these objectives and the required flow regimes. This was undertaken in the Wimmera River Environmental Flows Study (Alluvium, 2013).

Instead of the ecological objectives being solely determined by scientists and waterway managers, FLOWS Edition 2 (DEPI, 2013) recommends the involvement of a Project Advisory Group involving community and agency representatives in terms of providing a level of endorsement of the ecological objectives. In this case, instead of a new group being established, the objectives developed by Alluvium and Wimmera CMA staff were endorsed by the Wimmera CMA's Rivers and Streams Advisory Committee which comprises community and agency representatives (Section 1.3).

The review investigated the available monitoring data (e.g. in terms of plant, fish and macroinvertebrate species and platypus distribution as well as geomorphology and water quality data) to determine where certain objectives are feasible. The objectives have been refined to ensure that they are feasible and measurable and are listed in Table 7-1.

Table 7-1: Ecological objectives for the MacKenzie River, and Burnt and Bungalally Creeks

Ecological Value	Ecological Objectives	Target ecological objective	RCS Outcomes WWS Goals	Rationale
MacKenzie River				
Native fish	1. Maintain extant indigenous fish communities.	Evidence of Obscure Galaxias, Southern Pygmy Perch and River Blackfish recruitment and survival through targeted repeat fish surveys.	WWS-G2 WWS-G3 WWS-G4 RCS-20Y-RSO4 RCS-20Y-RSO5 RCS-6Y-RSO5 RCS-6Y-RSO10 RCS-6Y-RSO12 RCS-6Y-RSO13	Indigenous fish communities containing species including Obscure Galaxias, Southern Pygmy Perch and River Blackfish are now severely limited in their abundance and distribution in the Wimmera Catchment, including the MacKenzie River.
	1. Maintain fish in refuges in dry conditions through the provision of adequate water quality/habitat.	Presence of Obscure Galaxias, and Southern Pygmy Perch in the (mid and upper refuge pools) and River Blackfish in the upper refuge pool through targeted repeat fish surveys.		Without flows, virtually all of the MacKenzie River dries out within several months with major negative consequences for the fish community.
	2. Facilitate dispersal and establishment of endemic fish species.	Evidence of dispersal of high value fish species (Southern Pygmy Perch and River Blackfish) along reach 3 (and potentially into the Wimmera River) and evidence of Obscure Galaxias undertaking migration.		Dispersing and establishing endemic fish species throughout the system during wet/average conditions will lead to increased resilience during drought/dry conditions.
Vegetation	3. Protect and restore riparian and floodplain EVCs, and improved connectivity between Gariwerd and the Wimmera River	Instream and riparian vegetation in MacKenzie River reaches 1, 2 and 3 maintained through periodic vegetation surveys of riparian and floodplain EVC condition.	WWS-G2 RCS-20Y-RSO3 RCS-20Y-RSO5 RCS-6Y-RSO4 RCS-6Y-RSO8	Healthy and diverse riparian and floodplain vegetation is critical for supporting fauna values and contributing to carbon and nutrient cycling. Important for preventing excessive erosion and also plays a role in flood mitigation.
	4. Maintain submerged and emergent aquatic vegetation quality, diversity and extent for fish habitat	Diversity, extent and quality of submerged and emergent aquatic vegetation quality, for Southern Pygmy Perch – maintained through periodic vegetation surveys.		Aquatic and emergent vegetation is vital habitat for small-bodied native fish such as Southern Pygmy Perch as well as performing an important role in nutrient cycling.
	5. Stimulate reproduction and recruitment of *Callistemon wimmerensis* and maintain condition of current mature specimens.	Reproduction and recruitment of *Callistemon wimmerensis* through periodic vegetation surveys.		*Callistemon wimmerensis* (Wimmera Bottlebrush) is a critically endangered species and has been shown to be reliant on flows for its recruitment and condition on the MacKenzie River.

Ecological Value	Ecological Objectives	Target ecological objective	RCS Outcomes WWS Goals	Rationale
Habitat	6. Maintain structural integrity of stream bed and channel and prevent loss of channel capacity	Channel capacity maintained as determined by observed flow rates at the MACKENZIE RIVER @ MCKENZIE CREEK flow gauge (#415251)	WWS-G2 WWS-G3 WWS-G4 RCS-20Y-RSO4 RCS-20Y-RSO5 RCS-6Y-RSO4 RCS-6Y-RSO5 RCS-6Y-RSO8 RCS-6Y-RSO10 RCS-6Y-RSO12 RCS-6Y-RSO13	Flows are important in maintaining channel capacity through scouring and preventing excessive sedimentation which in turns retains pool habitat and provides minor flood mitigation benefits.
	7. Maintain habitat values through prevention of stream-bed colonisation by terrestrial species	Channel capacity maintained as determined by observed flow rates at the MACKENZIE RIVER @ MCKENZIE CREEK flow gauge (#415251)		During periods of no or severely reduced flow species like River Red Gum colonise the base of waterways which in turn affects channel shape and capacity as well as diminishing some recreational values.
Macro-invertebrates	8. Maintain a 'good' diversity of macroinvertebrate species (based on MBI classifications)	A 'good' rating for diversity of macroinvertebrate species maintained at Reach 2 (based on MBI classifications)	WWS-G3 RCS-20Y-RSO4 RCS-6Y-RSO5 RCS-6Y-RSO10	Macroinvertebrates are a critical component of the food web, supporting a variety of aquatic fauna species.
Platypus	9. Sustain a platypus population and facilitate its dispersal	Ongoing presence of platypus and expansion of range (through eDNA surveys and /or trapping) at strategic locations including Zumsteins and downstream of Dad and Dave Weir (i.e. Tatlocks Bridge).	WWS-G3 WWS-G4 RCS-20Y-RSO1 RCS-6Y-RSO1 RCS-6Y-RSO10	Anecdotal and monitoring evidence highlights the severe decline of the Wimmera's platypus population which is at very high risk of local extinction.
Frog	10. Maintain species richness of frog communities	Ongoing presence of Peron's Tee Frog (*Litoria peronii*) through targeted surveys.	WWS-G3 WWS-G4 RCS-20Y-RSO1 RCS-6Y-RSO1 RCS-6Y-RSO10	The Peron's Tee Frog (*Litoria peronii*) has also been located in the MacKenzie River, and would benefit from environmental watering actions
Burnt Creek				
Native fish	11. Facilitate dispersal and establishment of endemic fish species.	Evidence of dispersal of high value fish species (Southern Pygmy Perch and Obscure Galaxias) along Lower, Mid and Upper Burnt Creek through targeted repeat fish surveys.	WWS-G2 WWS-G4 RCS-20Y-RSO4 RCS-20Y-RSO5 RCS-6Y-RSO5 RCS-6Y-RSO10 RCS-6Y-RSO12 RCS-6Y-RSO13	Dispersing and establishing endemic fish species throughout the system during wet/average conditions will lead to increased resilience during drought/dry conditions.
Vegetation	12. Protect and restore riparian and floodplain EVCs.	Instream and riparian vegetation Lower, Mid and Upper Burnt Creek maintained through periodic vegetation surveys of riparian and floodplain EVC condition.	WWS-G2 RCS-20Y-RSO3 RCS-20Y-RSO5 RCS-6Y-RSO4 RCS-6Y-RSO8	Healthy and diverse riparian and floodplain vegetation is critical for supporting fauna values and contributing to carbon and nutrient cycling. Important for preventing excessive erosion and also plays a role in flood mitigation.

Ecological Value	Ecological Objectives	Target ecological objective	RCS Outcomes WWS Goals	Rationale
Habitat	13. Maintain structural integrity of stream bed and channel and prevent loss of channel capacity	Channel capacity maintained as determined by observed flow rates at the BURNT CREEK AT WONWONDAH EAST flow gauge (#415223)	WWS-G2 WWS-G3 WWS-G4 RCS-20Y-RSO4 RCS-20Y-RSO5 RCS-6Y-RSO4 RCS-6Y-RSO5 RCS-6Y-RSO8 RCS-6Y-RSO10 RCS-6Y-RSO12 RCS-6Y-RSO13	Flows are important in maintaining channel capacity through scouring and preventing excessive sedimentation which in turns retains pool habitat and provides minor flood mitigation benefits.
	14. Maintain habitat values through prevention of stream-bed colonisation by terrestrial species	Channel capacity maintained as determined by observed flow rates at the BURNT CREEK AT WONWONDAH EAST flow gauge (#415223)		During periods of no or severely reduced flow species like River Red Gum colonise the base of waterways which in turn affects channel shape and capacity as well as diminishing habitat values.
	15. Improve channel diversity through increasing flow variability	Varied flow rates as observed at the BURNT CREEK AT WONWONDAH EAST flow gauge (#415223)		Constant flow rates (e.g. for water transfers) pose a risk of increasing issues created by incision leading to loss of pool/run geomorphology
Macro-invertebrates	16. Maintain a 'good' diversity of macroinvertebrate species (based on MBI classifications)	A 'good' rating for diversity of macroinvertebrate species maintained at Lower, Mid and Upper Burnt Creek (based on MBI classifications) and targeted sampling introduced to Burnt Creek	WWS-G3 RCS-20Y-RSO4 RCS-6Y-RSO5 RCS-6Y-RSO10	Macroinvertebrates are a critical component of the food web, supporting a variety of aquatic fauna species.

8 Environmental water requirements and intended water regime

8.1 WATERING REQUIREMENTS AND INTENDED WATERING REGIMES

FLOW RECOMMENDATIONS FOR THE MACKENZIE RIVER, AND BURNT AND BUNGALALLY CREEKS

The water regimes required for achieving ecological objectives described in Section were developed according to the FLOWS method for determining environmental water requirements in Victoria (DEPI, 2013) for the MacKenzie River, and Burnt and Bungalally Creeks. This approach makes allowance for seasonal conditions (drought to wet conditions) rather than recommending the same flow regime every year regardless of the prevailing climate. For example, during dry or drought conditions the recommended number and volume of freshes will be fewer than during average or wet conditions and cease to flow periods will be longer. Bankfull and overbank flows may only be recommended during average and/or wet periods. Ecological information (e.g. required frequency of recruitment events to maintain a species) still underpins the recommendations around the frequency of various flow components. Details of magnitude, timing, duration and frequency of each flow component for each reach are given in Tables 8-1 to 8-5, with the relevant ecological objectives documented. Recommended rates of rise and fall for flows greater than baseflows have also been developed to assist mitigating negative impacts such as riverbank slumping and fish stranding that could occur should flow rates vary too quickly.

These recommendations have been extracted as a subset of priorities to target in the next ten years. However, additional ecological objectives and flow recommendations may be targeted if the opportunity or need arises.

To meet the hydrological requirements of this EWMP, flow recommendations have been set considering the following factors:

- The preferred timing of watering events
- The recommended duration for watering events
- The tolerable intervals between events (condition tolerances)
- The volume required to provide these events – per event / per season.

These flows studies are used as a guidance for environmental flows under ideal climate scenarios, with annual seasonal proposals developed six months ahead of planned delivery. With the accumulated knowledge of 10 years of environmental watering there is need to ensure future objectives, targets and outcomes are adaptable and outcome driven to meet conditions in the river at the time, rather than as a compliance tool. This could include, for example, watering when certain quality is declining, or delivery of freshes to coincide with known spawning requirements for fish or to meet the water requirements for habitat that promotes movement of regionally specific fauna.

There are a number of challenges that need to be addressed in order to achieve the desired ecological outcomes using water for the environment. These challenges include threats such as exotic species, instream infrastructure and system constraints, and saline groundwater intrusions. The risks associated with these threats are outlined and mitigation actions are prescribed.

- Availability of water for the environment is often less than the water needed to deliver the recommended flows. For example, most of the larger flow components (such as bankfull or overbank) cannot be delivered through regulated releases in most cases. Other factors (such as prohibitive channel losses

and risks around inundation of private land) mean most of these releases are also not feasible. As a consequence, overbank flow recommendations will only be met by natural events.

- Infrastructure limits flows with suggested bank flows and overbank flows not achievable. Flows suggested in the studies would cause flooding and there are currently no agreements with landholders for this to occur. Any flows over 500 ML are not feasible under these conditions.
- Climate change and a drying climate also influences the use of the water for the environment. For example, the recent climatic water cycle has a seen a large rain event every six or so years that fills the headwork storages and causes minor to moderate flooding. Whilst this meets the larger flow components of the flow studies, management of the water is needed to occur between these high flow periods to ensure flows still meet the river's ecological requirements.
- If the river or tributaries are meeting optimal ecological requirements, planned flows for the period may be reduced for use in the upcoming season. The amount of water not used at the end of the financial year is carried over, for use in the upcoming season.

The Lower MacKenzie River and Burnt Creek and flow optimisation project was commissioned by the Wimmera CMA in 2019 to address short falls in water available for environmental watering in summer/autumn 2019 compared with previous years and well below the flows recommended in Alluvium (2013). The focus of this work was on targeted use of available water to refuge pools to protect current fish, crayfish and platypus populations rather than achieve desired objectives around recruitment and dispersal. This was off the back of environmental watering undertaken in 2016/17 and 2017/18, which was observed to have maintained refuge pools over two successive years for the first time since the Millenium Drought (EA, 2019).

Table 8-1: Flow recommendations for MacKenzie River Reach 1 and 2

FLOW COMPONENT	TIMING	MAGNITUDE	CLIMATIC SCENARIO	FREQUENCY	DURATION	OVERARCHING ENVIRONMENTAL OBJECTIVE	DETAILED ENVIRONMENTAL OBJECTIVE	SOURCE
Cease to flow	Dec-May	0 ML/d	Drought	As infrequently as possible	Less than 80 days in total	1,2,5,6,10	Ensure stress on environmental values is not exacerbated beyond the point of no return. Cease to flow periods should be concluded with fresh lasting at least 7 days duration.	Alluvium (2013)
			Dry					
			Average		Less than 30 days in total			
Baseflow	Dec-May	2 ML/d or natural	All	Continuous	Continuous	1,2,3,5,6,8,9,10	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.	
	Jun-Nov	27 ML/d						
Freshes	Dec-May	5 ML/d	Drought	3 per period	4-7 days	1,2,5,6,10	Prevent water quality decline by flushing pools during low flows.	
			Dry	4 per period				
	Dec-May	50 ML/d	Average	2 per period	2-7 days	1,2,5,6,10	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.	
			Wet	3 per period				
	Jun-Nov	55 ML/d	Drought	5 per period	2 days	1,3,8,10	Flush surface sediments from hard substrates to support macroinvertebrates.	
			Dry		4 days			
			Average		5 days			
			Wet		7 days			
	Jun-Nov	130 ML/d	Drought	1 per period	1 day	1,3,8,10	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.	
			Dry	3 per period	2 days			
			Average	5 per period	3 days			
			Wet		4 days			
Bankfull*	Any	500 ML/d	Average	1 per period	2 days	4,7	Inundate riparian vegetation to maintain condition and facilitate recruitment. Entrain organic debris in the channel to support macroinvertebrates. Maintain structural integrity of channel.	
			Wet					
Overbank*	Aug-Nov	900 ML/d	Wet	1 per period	1 day	4,7	Inundate floodplain vegetation to maintain condition and facilitate recruitment. Entrain organic debris from the floodplain to support macroinvertebrates. Maintains floodplain geomorphic features.	

***** *Please note that bankfull and overbank flows cannot be met with the release of water for the environment.*

Table 8-2: Environmental flow recommendations for the MacKenzie River Reach 3

FLOW COMPONENT	TIMING	MAGNITUDE	CLIMATIC SCENARIO	FREQUENCY	DURATION	OVERARCHING ENVIRONMENTAL OBJECTIVE	DETAILED ENVIRONMENTAL OBJECTIVE	SOURCE
Cease to flow	Dec-May	0 ML/d	Drought	As infrequently as possible	Less than 80 days in total	1,2,5,6,10	Ensure stress on environmental values is not exacerbated beyond the point of no return. Cease to flow periods should be completed with fresh lasting at least 7 days duration.	Alluvium (2013)
			Dry		Less than 30 days in total			
			Average					
Baseflow	Any	10 ML/d or natural	All	Continuous	Continuous	1,2,3,5,6,8,9,10	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.	
Freshes	Dec-May	35 ML/d	Drought	3 per period	2-7 days	1,2,5,6,10	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.	
			Dry		3-7 days			
			Average	4 per period				
			Wet					
	Jun-Nov	35 ML/d	Drought	5 per period	2 days	1,3,6,8	Stimulate fish movement and maintain water quality and diversity of habitat.	
			Dry		4 days			
			Average		5 days			
			Wet		7 days			
	Jun-Nov	190 ML/d	Average	1 per period	1 day	1,3,8,10	Achieve shear stress to flush surface sediments from hard substrates to support macroinvertebrates.	
			Wet		2 days			
Bankfull*	Any	500 ML/d	Wet	1 per period or natural	1 day	4,7	Inundate riparian vegetation to maintain condition and facilitate recruitment (including *Callistemon Wimmerensis*). Entrain organic debris in the channel to support macroinvertebrates. Maintain structural integrity of channel.	
Overbank*	Aug-Nov	1,000 ML/d	Wet	1 per period or natural	1 day	4,7	Inundate floodplain vegetation to maintain condition and facilitate recruitment (including *Callistemon Wimmerensis*). Entrain organic debris in the channel to support macroinvertebrates. Maintains floodplain geomorphic features.	

***** *Please note that bankfull and overbank flows cannot be met with the release of water for the environment.*

Table 8-3: Environmental flow recommendations for the Bangalally Creek

FLOW COMPONENT	TIMING	MAGNITUDE	CLIMATIC SCENARIO	FREQUENCY	DURATION	OVERARCHING ENVIRONMENTAL OBJECTIVE	DETAILED ENVIRONMENTAL OBJECTIVE	SOURCE
Bankfull	Any	60 ML/d	Average Wet	1 per period, or natural	2 days	4,7,12,13,15	Inundate riparian vegetation to maintain condition and facilitate recruitment. Maintain structural integrity of channel.	Alluvium (2013)
Overbank	Aug-Nov	150 ML/d	Wet	1 per period or natural	1 day	4,7, 12,13,15	Inundate floodplain vegetation to maintain condition and facilitate recruitment. Maintains floodplain geomorphic features.	

***** *Please note that bankfull and overbank flows cannot be met with the release of water for the environment.*

Table 8-4: Environmental flow recommendations for the Lower Burnt Creek Reach 2

FLOW COMPONENT	TIMING	MAGNITUDE	CLIMATIC SCENARIO	FREQUENCY	DURATION	OVERARCHING ENVIRONMENTAL OBJECTIVE	DETAILED ENVIRONMENTAL OBJECTIVE	SOURCE
Bankfull	Any	45 ML/d	Average Wet	1 per period, or natural	2 days	12,13,15	Inundate riparian vegetation to maintain condition and facilitate recruitment. Entrain organic debris in the channel to support macroinvertebrates. Maintain structural integrity of channel.	Alluvium (2013)
Overbank	Aug-Nov	90 ML/d	Wet	1 per period	1 day	12,13,15	Inundate floodplain vegetation to maintain condition and facilitate recruitment. Entrain organic debris from the floodplain to support macroinvertebrates. Maintains floodplain geomorphic features.	

***** *Please note that bankfull and overbank flows cannot be met with the release of water for the environment.*

Table 8-5: Environmental flow recommendations for the Upper Burnt Creek Reach 1

FLOW COMPONENT	TIMING	MAGNITUDE	CLIMATIC SCENARIO	FREQUENCY	DURATION	OVERARCHING ENVIRONMENTAL OBJECTIVE	DETAILED ENVIRONMENTAL OBJECTIVE	SOURCE
Cease to flow	Dec-May	0 ML/d	Drought	As infrequently as possible	Less than 80 days in total	11,14,15,16	Ensure stress on environmental values is not exacerbated beyond the point of no return. Cease to flow periods should be concluded with fresh lasting at least 7 days duration.	Alluvium (2013)
			Dry		Less than 30 days in total			
			Average					
Baseflow	All year	1 ML/d or natural	All	Continuous	Continuous	11,14,16	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.	
Freshes	Dec-May	30 ML/d	Drought	3 per period	2-7 days	16	Prevent water quality decline by flushing pools during low flows.	
			Dry		4-7 days			
			Average		2-7 days			
			Wet		3-7 days			
	Jun-Nov	55 ML/d	Drought	1 per period	3 days	11,14,15,16	Provide variable flow for fish movement and diversity of habitat. Also flushes surface sediments from hard substrates for macroinvertebrates.	
			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	11,14,15,16	Disturb the algae/bacteria/organic biofilm present on rock or wood debris to support macroinvertebrate communities increase biomass and species diversity.	
			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	12,13,15	Inundate riparian vegetation to maintain condition and facilitate recruitment. Entrain organic debris in the channel to support macroinvertebrates. Maintain structural integrity of channel.	
			Wet					
Overbank*	Aug-Nov	1,000 ML/d	Wet	1 per year	1 day	12,13,15	Inundate floodplain vegetation to maintain condition and facilitate recruitment. Entrain organic debris from the floodplain to support macroinvertebrates. Maintains floodplain geomorphic features.	

***** *Please note that bankfull and overbank flows cannot be met with the release of water for the environment.*

9 Environmental water delivery infrastructure

9.1 WATER DELIVERY INFRASTRUCTURE

The Wimmera-Mallee system headworks have a long history of development commencing with the construction of Lake Wartook in 1887 through to the completion of Lake Bellfield in 1966. Over this time, the system has been operating through a broad range of climatic conditions. It is necessary to operate the Wimmera-Mallee system headworks as a total integrated system.

A schematic of the Wimmera - Mallee system headworks (not to scale) provided in Figure 4-6 of the report shows the relative elevation, depth, surface areas and connectedness of reservoirs including a representation of the Wimmera Mallee Pipeline. The system is complex, interconnected, with many possible combinations for supply and movement of water.

The successful operation of the system as a whole underpins many important features of the entitlements within the Wimmera and Glenelg, including:

- The calculation of available water for seasonal allocations
- The calculation of carryover and system reserve and its distribution across the system
- The ability to trade water
- The successful delivery of water to some entitlement holders or customer groups dependent on parts of the system for their supply
- The delivery of passing flow volumes on behalf of the Environment, without impacting on the reliability of supply to other entitlement holders.[10]

9.1.1 COMPLEMENTARY WORKS AND ACTIVITIES

A waterway management strategy (Wimmera CMA 2014) has been developed for the waterways within the Wimmera River system by the Wimmera CMA. It has documented several complementary management activities to try and ensure that the outcomes derived from environmental watering can be maximised.

Program logic models were developed which prescribed a range of actions that would address waterway threats (such as modified flow regimes, degraded water quality and riparian vegetation) (GHD, 2012). Typically, this includes invasive plant and animal control (e.g. rabbit, bridal creeper, boneseed) as well the establishment of riparian management agreements to remove threats around livestock impacts on riparian areas.

Other complementary management activities planned to take place over the life of the EWMP include community engagement activities as well as trial interventions to mitigate the threats of carp and saline groundwater intrusions. Details around the types and quantities of complementary management activities are outlined in the Wimmera Waterway Strategy 2014-2022 (Wimmera CMA, 2014).

[10] https://www.storagemanager.com.au/about-the-storage-manager/storage-management-rules

9.2 CONSTRAINTS

The Wimmera – Mallee Headworks System was designed to harvest and deliver water to the stock and domestic and irrigation channel systems which typically involved outfalling modest volumes (35 ML/d - 400 ML/d) at constant rates for long periods (typically several months). Therefore, the headworks infrastructure was not originally intended to deliver water to waterways (apart from when they are a conduit for water transfers). Therefore, some sites have undergone upgrades to improve their effectiveness in delivering environmental water. However, there remain several sites where physical constraints on environmental water delivery remain.

MACKENZIE RIVER

Following recommendations from a report looking at capacity constraints of infrastructure (Earth Tech, 2005), regulating structures on the MacKenzie River were upgraded at Dad and Dave Weir and Distribution Heads. Previous drop board weirs were replaced by automated flume gates at both sites and a fishway was also installed at Dad and Dave Weir. The flume gates can provide volumes up to and including all freshes, however, instream losses (a swampy area with low channel capacity in Wartook) potentially makes delivering the highest fresh (190 ML/d) unfeasible (Earth Tech, 2006). There is a need to ensure that these flume gates are being operated to their full capacity in terms of automation to improve their effectiveness in delivering flows. This entails having the regulators at Dad and Dave and Distribution Heads as well as the Lake Wartook outlet remotely operated by Supervisory Control and Data Acquisition (SCADA), which has been problematic due to telecommunication issues and damage to the sites due to floods and vandalism.

Swampy sections of the river restrict the ability to deliver higher recommended flows to Reaches 2 and 3 (130 ML/d – 1000 ML/d) (Earth Tech, 2006). These flows also present unacceptable risks in terms of flooding freehold land and so will not be delivered or supplemented by regulated releases.

BURNT CREEK

The upgraded infrastructure at Distribution Heads included upgrading the regulator into Burnt Creek by replacing the drop boards with automated flume gates. Again, despite the ability for these gates to be automatically operated, a lack of telecommunications means that they are still manually operated. An upgrade also took place to the outlet from the Toolondo Channel into the lower Burnt Creek through the installation of a low flow pipe with magnetic flow meter. This can deliver up to 15 ML/d which is below the updated flow rates recommended for the reach although there are three large undershot gates that can deliver water to this reach however currently there is no way to meter flows through these gates. All infrastructure at this location has to be manually operated.

An assessment on physical influences on environmental water releases (Earth Tech, 2006) highlighted that a number of low level road crossings would be impacted by recommended flows . It also flagged the negative effect the concentrated pumping diversions (near its confluence with the Wimmera River) would have on environmental water releases .Similar to the MacKenzie River, the Burnt Creek regulator at Distribution Heads needs to be upgraded to be operated remotely by SCADA. There is scope for upgrades to the regulators at the Toolondo Channel in terms of automation and accuracy. There are also a number of opportunities to improve the passage of environmental flows through upgrading and improving maintenance at a number of low level road crossings. In recent years Wimmera CMA has undergone a series of trials where progressively larger volumes were released and the impacts on low level crossings was assessed.

Another action is reviewing and amending water licencing arrangements for the proliferation of extraction points for the lower Burnt Creek (Figure 9-1) to ensure flows reach the end of the waterway, especially since all diverters have ready access to reticulated water supplies.

Figure 9-1: Pump on the lower Burnt Creek

BUNGALALLY CREEK

The current undershot weir could be upgraded to include a magnetic flow meter to improve the accuracy of measurement as well as potential automation. Other required works would be to address the number of low level crossings and informal weir structures which hinder the effective passage of environmental flows.

Future actions

Infrastructure constraints will continue to prevent the delivery of larger recommended flow components (400 ML/d to 6000 ML/d) from regulated releases alone, therefore unregulated and/or passing flows will be required to achieve this.

Recommendations addressing delivery constraints are listed in detail in the following reports:

- Assessing the Physical Constraints on Environmental Flow Delivery in the Wimmera Catchment (Earth Tech, 2005)
- Wimmera and Glenelg Systems Environmental Metering Program (VEWH, 2014).
- Assessing Influences on Environmental Water Releases in the Wimmera, Phase 1, Stages 1 and 2 (Earth Tech, 2006)
- Assessing Influences on Environmental Water Releases in the Wimmera, Phase 2, Stages 1 and 2 (Earth Tech, 2007)
- Influences on Environmental Water Releases in the Wimmera River (SKM, 2008)

The CMA is currently exploring the potential of current pipelines that source supply from lakes Wartook and Moora Moora to water high-value ecological sites in the MacKenzie River and tributaries when dry. The aim is to pursue water savings and better manage water in this tributary system, especially in the face of climate change. This will also assist in restoring the historic riparian connectivity between Gariwerd (Grampians National Park) and the broader region.

This work is being explored through the following report “Assessment of connecting current and potential drought refuge sites on the MacKenzie River and tributaries to the Wimmera Mallee Pipeline (Wimmera CMA, 2024) – in draft”.

10 Demonstrating outcomes – monitoring and assessment

Monitoring is required to demonstrate that watering is achieving long term environmental outcomes. Monitoring is also a critical component of the adaptive management of the Wimmera River system, including the MacKenzie River, and Burnt and Bungalally Creeks. Two types of monitoring are used to assess the effectiveness of the environmental water regime on objectives and to facilitate adaptive management:

- Long-term condition monitoring
- Intervention monitoring.

Currently the principal monitoring program for the release of environmental water on the Wimmera River is the VEFMAP program.

Since 2009, VEFMAP fish monitoring has taken place at 12 sites along the Reach 3 and 4 of the Wimmera River capturing the fish condition during drought conditions, and also after more consistent environmental flow releases from 2010-11 onwards.

Also, as part of VEFMAP vegetation monitoring transects were established in 2008 at four sites on the Wimmera River and have been surveyed every two years. River Red Gum condition has been monitored in the riparian zone of the Wimmera River every two years.

The latest results from VEFMAP Stage 6 (ARI, 2020) can be found here.

The Victorian Government has recently reviewed the VEFMAP program, which will inform the next phase of environmental watering monitoring. It is understood that long term fish condition monitoring is not planned for the Wimmera River system in Stage 7 of VEFMAP.

Future monitoring priorities are detailed in and Table 10-2.

10.1 MONITORING PRIORITIES FOR THE MACKENZIE RIVER, AND BURNT AND BUNGALALLY CREEKS

Section 7 sets out the management objectives for environmental water use in the MacKenzie River, and Burnt and Bungalally Creeks, which have been aligned with objectives set out in the Long-Term Watering Plan for Wimmera-Mallee prepared for Basin Plan obligations (DELWP, 2015). Table 10-1 sets out target variables to evaluate progress towards the objectives at the asset scale.

Table 10-1: Objectives and target variables for the use of delivery of water for the environment.

THEME	OBJECTIVE	INDICATOR TO BE MEASURED
Platypus	Maintenance of platypus populations, particularly in drought refuges.	Species numbers and recruitment and extent of platypus population (via eDNA or trapping) (refer EA, 2019)
Fish	Improve recruitment, maintenance and dispersal of targeted fish communities (Southern Pygmy Perch and River Blackfish), particularly in drought refuges.	Catch Per Unit Effort electrofishing surveys for targeted fish species in MacKenzie River and Burnt Creek (refer EA, 2023b)
Frogs	Maintain species richness of frog communities	Frog species numbers (e.g. Peron's Tree Frog)
Vegetation	Improve condition of riparian EVCs	Condition of riparian EVCs
	Maintain condition of river red gum dominated EVCs	Condition of river red gum dominated EVCs
Connectivity	Improve longitudinal connectivity between Gariwerd and the Wimmera River	Baseflow and freshes
	Improve riparian connectivity between Gariwerd and the Wimmera River	Riparian vegetation condition

Table 10-2: Monitoring and evaluation priorities for EWMP objectives for the MacKenzie River, and Burnt and Bungalally Creeks

THEME	OBJECTIVE	TARGET WATERWAYS	MONITORING METHOD	VARIABLE TO BE ASSESSED
MacKenzie River, and Burnt and Bungalally Creeks				
Fish	Improve the abundance, movement and species richness of native fish species	All	Electrofishing, bait traps, fyke nets (as per the Wimmera Native Fish Management Plan (SKM, 2006))	**Abundance** – spatial distribution & age class distribution **Species richness** – number of different species present during monitoring **Movement** – spatial distribution
Vegetation	Maintain the species richness and extent of in-channel aquatic vegetation, improve the abundance of aquatic vegetation.	All	Quadrats and photopoints	**Species richness** – number of different species present during monitoring **Abundance** – spatial distribution
	Improve the condition of riparian EVCs	All	▪ River Red Gum and Black Box – tagged trees or remote sensing ▪ Seedling survey at pre-designated points ▪ Growth rate at seedlings above/below areas watered by large freshes ▪ % new growth and other reproduction stages on branches	The condition of River Red Gum EVCs in the asset is better at the end than at the start of a 10-year monitoring period as measured by the following sub-targets: ▪ Health of adult River Red Gum trees ▪ Recruitment and survival of juvenile trees ▪ Native species richness ▪ Native species cover/abundance ▪ Recruitment of understorey vegetation
Habitat	Maintain the quality of geomorphic habitat (maintain channel form, clean substrates, prevent stream bed colonisation)	All	▪ Environmental flow compliance ▪ Cross-sections ▪ Digital elevation models (from LiDAR	The baseflow and fresh flow requirements as specified in each asset are met in eight years of a ten-year period
	Improve longitudinal connectivity (between river reaches) to facilitate fish movement	All	▪ Environmental flow compliance	The baseflow and fresh flow requirements as specified in each asset are met in eight years of a ten-year period
	Maintain refuges for native fish species (prevent loss of channel capacity through sedimentation)	All	▪ Cross-sections	Refuge depth and extent

THEME	OBJECTIVE	TARGET WATERWAYS	MONITORING METHOD	VARIABLE TO BE ASSESSED
	Maintain adequate surface water salinity to enable growth and reproduction of aquatic vegetation	MacKenzie River and Burnt Creek	Ongoing use of water quality meter or Portable Automated Loggers	Surface water salinity
Macroinvertebrates	Maintain macroinvertebrate diversity	Macroinvertebrates in MacKenzie River and Burnt Creek	MBI classification Sites in WEC (2008) within regulated reaches with macroinvertebrate objectives	**Species richness** – number of different species present during monitoring
Platypus	Improve habitat for Platypus and Rakali	Platypus habitat in MacKenzie River	▪ Trapping ▪ Environmental DNA	**Abundance** – spatial distribution & age class distribution
Other	Maintain habitat for crayfish communities	Crayfish in MacKenzie River and Burnt Creek	▪ TBC	**Abundance** – spatial distribution & age class distribution

11 Knowledge gaps and recommendations

The EWMP has been developed using the best available information to hand. However, despite the ongoing improvements in environmental water management through experience in implementation, there are still a number of knowledge gaps and recommendations that remain that if addressed, can enhance environmental water management in the MacKenzie River, and Burnt and Bungalally Creeks. These knowledge gaps, and the recommendations to address them are listed in Table 11-1. These recommendations will be actioned by the Wimmera CMA in conjunction with its water management partners as opportunities and funding allow.

Table 11-1: Knowledge gaps and recommendations following the development of the EWMP

KNOWLEDGE GAP	RECOMMENDATION	WHO	PRIORITY
Instream loss rates	Continue to refine understanding of the effect of instream water loss rates in the MacKenzie River and Burnt Creek and the cultural values of these waterways and the Bungalally Creek and how these could be enhanced with environmental watering actions. This includes the time lag required for watering to reach key refuge pools in these waterways. This includes better understanding the travel times of flows between gauging points	Wimmera CMA	High
	Evaluating the cost and long-term benefits of installing real time depth loggers at the mid or upper refuge pools on each waterway (lower refuge pools are located at gauges), prioritised as follows: ▪ 1st – Burnt Creek (upper refuge pool) ▪ 2nd – Burnt Creek (mid refuge pool) and MacKenzie River (upper refuge pool) ▪ 3rd – MacKenzie River (mid refuge pool).		
Limited hydrologic models	Improve hydraulic models for reaches of the Burnt Creeks and upper MacKenzie River to enable refinement of flow recommendations. Observing the effects of variations in the split in water delivered to each waterway (MacKenzie and Burnt Creeks), and the results of alternating the releases between the two waterways.	Wimmera CMA, DEECA, GWMWater	Medium
Cultural values and watering	Investigate options to undertake watering actions to enhance cultural values.	Wimmera CMA, BGLC	High
Community information on the effects of releases	Maintain regular contact with stakeholders, use Wimmera CMA communications tools (e.g. Facebook, website) to garner information.	Wimmera CMA	High

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Appendices

A-1 FAUNA SPECIES

Table A1-1 provides a list of the fauna species of the MacKenzie River, and Burnt and Bungalally Creeks.

Table A1-1: Fauna species of the MacKenzie River, and Burnt and Bungalally Creeks.

COMMON NAME	SCIENTIFIC NAME	EPBC	FFG
Amphibians			
Southern Smooth Froglet	*Geocrinia laevis*		
Birds			
Australasian Bittern	*Botaurus poiciloptilus*	E	CE
Australasian Grebe	*Tachybaptus novaehollandiae*		
Australian Magpie	*Cracticus tibicen*		
Australian Pelican	*Pelecanus conspicillatus*		
Australian White Ibis	*Threskiornis molucca*		
Australian Wood Duck	*Chenonetta jubata*		
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*		
Black-faced Woodswallow	*Artamus cinereus*		
Black-fronted Dotterel	*Elseyornis melanops*		
Brown Falcon	*Falco berigora*		
Brown Treecreeper	*Climacteris picumnus*		
Bush Stone-curlew	*Burhinus grallarius*		CE
Common Bronzewing	*Phaps chalcoptera*		
Common Starling*	*Sturnus vulgaris**		
Crested Pigeon	*Ocyphaps lophotes*		
Diamond Dove	*Geopelia cuneata*		V
Eastern Cattle Egret	*Bubulcus coromandus*		
Eastern Great Egret	*Ardea alba modesta*		V
Eastern Rosella	*Platycercus eximius*		
Fairy Martin	*Petrochelidon ariel*		
Freckled Duck	*Stictonetta naevosa*		E
Galah	*Eolophus roseicapilla*		
Grey-crowned Babbler	*Pomatostomus temporalis*		V
House Sparrow*	*Passer domesticus**		
Little Button-quail	*Turnix velox*		
Little Eagle	*Hieraaetus morphnoides*		
Little Pied Cormorant	*Microcarbo melanoleucos*		

COMMON NAME	SCIENTIFIC NAME	EPBC	FFG
Long-billed Corella	*Cacatua tenuirostris*		
Masked Lapwing	*Vanellus miles*		
New Holland Honeyeater	*Phylidonyris novaehollandiae*		
Noisy Miner	*Manorina melanocephala*		
Pacific Black Duck	*Anas superciliosa*		
Red-rumped Parrot	*Psephotus haematonotus*		
Straw-necked Ibis	*Threskiornis spinicollis*		
Superb Fairy-wren	*Malurus cyaneus*		
Tawny Frogmouth	*Podargus strigoides*		
Welcome Swallow	*Petrochelidon neoxena*		
Whistling Kite	*Haliastur sphenurus*		
White-breasted Woodswallow	*Artamus leucorynchus*		
White-faced Heron	*Egretta novaehollandiae*		
White-necked Heron	*Ardea pacifica*^		
White-plumed Honeyeater	*Ptilotula penicillatus*		
Willie Wagtail	*Rhipidura leucophrys*		
Yellow-tailed Black Cockatoo	*Calyptohynchus funereus*		
Fish			
Australian Smelt	*Retropinna semoni*		
Brown Trout*	*Salmo trutta**		
Carp*	*Cyprinus carpio**		
Carp Gudgeon (Complex)	*Hypseleotris klunzingeri*		
Common Galaxias	*Galaxias maculatus*		
Eastern Gambusia*	*Gambusia holbrooki**		
Flat-headed Gudgeon	*Philypnodon grandiceps*		
Freshwater Catfish	*Tandanus tandanus*		E
Golden Perch	*Macquaria ambigua*		
Goldfish*	*Carassius auratus**		
Obscure Galaxias	*Galaxias olidus*		
Redfin Perch*	*Perca fluviatilis**		
River Blackfish	*Gadopsis marmoratus*		
Southern Pygmy Perch	*Nannoperca australis*		V
Tench*	*Tinca tinca**		
Invertebrates			
Glenelg Spiny Crayfish	*Euastacus bispinosus*	E	E
Upland Burrowing Crayfish	*Engaeus lyelli*		
Western Swamp Crayfish	*Gramastacus insolitus*		E

COMMON NAME	SCIENTIFIC NAME	EPBC	FFG
Yabby	*Cherax destructor*		
Mammals			
Black Wallaby	*Willabia bicolor*		
Platypus	*Ornithorhynchus anatinus*		V
Rakali	*Hydromys chrysogaster*		
Red-necked Wallaby	*Macropus rufogriseus*		
Reptiles			
Eastern long-necked turtle	*Chelodina longicollis*		
Lace Monitor	*Varanus varius*		E
Large Striped Skink	*Ctenotus robustus*		

*Introduced species, V (vulnerable), E (endangered), CE (critically endangered), T (Threatened).

A-2 ECOLOGICAL VEGETATION CLASSES (EVCS)

Table A2-1 provides a list and description of the Ecological Vegetation Classes (EVCs) associated with the MacKenzie River, and Burnt and Bungalally Creeks and their floodplains.

Table A2-1: Description of EVCs associated with the MacKenzie River, and Burnt and Bungalally Creeks and their floodplains.

EVC NO.	ECOLOGICAL VEGETATION CLASS NAME	BIOREGION(S)	DESCRIPTION
103	**Riverine Chenopod Woodland**	Wimmera Murray Mallee	Grassy and low chenopod-dominated eucalypt woodland to 15 m tall with large range of herbs including several annuals. Occurs on fertile, silty clay-loams associated with alluvial terraces of major rivers in areas receiving >500 mm annual rainfall. Sites are associated with recent Quaternary swamp deposits and may be occasionally inundated during flood events. Clay soils are generally waterlogged in winter and dry and cracking in summer.
641	**Riparian Woodland**	Wimmera Lowan Mallee Murray Mallee	Occurs beside permanent streams, typically on narrow alluvial deposits. Woodland to 15 m tall generally dominated by *Eucalyptus camaldulensis* over a tussock grass-dominated understorey. Tall shrubs may be present and amphibious herbs may occur in occasional ponds and beside creeks. While flooding may be common, sites are rarely inundated for lengthy periods.
823	**Lignum Swampy Woodland**	Wimmera Murray Mallee	Understorey dominated by Lignum, typically of robust character and relatively dense (at least in patches), in association with a low Eucalypt and/or Acacia woodland to 15 m tall. The ground layer includes a component of obligate wetland flora that is able to persist even if dormant over dry periods.
200	**Shallow Freshwater Marsh**	Dundas Tablelands	The landscape is typically dominated by sedges, rushes, and a variety of water-loving grasses that thrive in the wet conditions. Species such as Common Reed (*Phragmites australis*) and Bulrush (*Schoenoplectus spp.*) are commonly found, creating a dense, lush undergrowth. These plants not only stabilise the soil but also provide essential habitat for numerous bird species, amphibians, and aquatic insects.
292	**Red Gum Swamp**	Wimmera	This habitat is characterized by its permanent to semi-permanent shallow waterlogged conditions, often dominated by River Red Gums (*Eucalyptus camaldulensis*), which create a unique microhabitat. The understorey of the Red Gum Swamp is typically rich in a variety of wetland grasses, sedges, and herbs, including species such as Common Reed (*Phragmites australis*) and various rushes that thrive in the damp conditions.
3	**Damp Sands Herb-rich Woodland***	Dundas Tablelands	A low, grassy or bracken-dominated eucalypt forest or open woodland to 15 m tall with a large shrub layer and ground layer rich in herbs, grasses, and orchids. Occurs mainly on flat or undulating areas on moderately fertile, relatively well-drained, deep sandy or loamy topsoils over heavier subsoils (duplex soils).
414	**Shrubby Woodland/Damp Sands Herb-rich Woodland Complex**	Dundas Tablelands	This complex is a distinctive ecological community found in the Dundas Tablelands. This complex features a dynamic interplay between two unique habitat types: the dense, shrub-dominated woodland and the rich herbaceous layer characteristic of damp sands.
659	**Plains Riparian Shrubby Woodland**	Wimmera	Shrub-dominated eucalypt woodland to 15 m tall with large range of grasses, sedges and perennial herbs. Occurs on moderately fertile, relatively well-drained, sandy alluvial topsoils over heavier subsoils. Associated with Quaternary alluvial deposits along narrow, seasonal streams in plains areas receiving <600 mm annual rainfall.
757	**Damp Sands Herb-rich Woodland/ Shrubby Woodland-Mosaic**	Wimmera	This ecological community characterised by a blend of damp sandy soils and varying vegetation types that create a rich mosaic of habitats.

A-3 FLORA SPECIES

Table A3-1 provides a list of the flora species of the MacKenzie River, and Burnt and Bungalally Creeks.

Table A3-1: Flora Species of the Wimmera River, Mount William Creek, Dock Lake and Wimmera River terminal lakes.

COMMON NAME	SCIENTIFIC NAME	EPBC	FFG
Annual Cudweed	*Euchiton sphaericus*		
Annual Veldt-grass*	*Ehrarta longiflora*		
Australian Salt-grass	*Distichlis distichophylla*		
Awned Club-sedge*	*Isolepis hystrix*		
Black Box	*Eucalyptus largiflorens*		
Black Nightshade*	*Solanum nigrum*		
Black-anther Flax-lily	*Dianella revoluta*		
Blackberry*	*Rubus fruticosus spp. agg.*		
Black Bristle-sedge	*Chorisandra enodis*		
Bridal Creeper*	*Asparagus asparagoides*		
Broad-fruit Club-sedge	*Isolepis cernua var. platycarpa*		
Brown-back Wallaby-grass	*Austrodanthonia duttoniana*		
Buloke	*Allocasuarina luehmannii*		CE
Caltrop	*Tribulus terrestris*		
Cape weed*	*Arctotheca calendula*		
Cherry Ballart	*Exocarpos cupressiformis*		
Chocolate Lily	*Arthropodium strictum s.s.*		
Coarse Dodder-laurel	*Cassytha melantha*		
Common Blown-grass	*Lachnagrostis filiformis s.s.*		
Common Everlasting	*Chrysosephalum apiculatum*		
Common Love-grass	*Eragrostis brownii*		
Common Onion Orchid	*Microtis unifolia*		
Common Raspwort	*Gonocarpus tetragynus*		
Common Rice-flower	*Pimelea humilis*		
Common Sow-thistle*	*Sonchus oleraceus*		
Common Spike-salt sedge	*Eleocharis acuta*		
Common Swamp Wallaby Grass	*Amphibromus nervosus*		
Common Wallaby-grass	*Austrodanthonia caespitosa*		
Common Water-ribbons	*Triglochin procera s.s.*		
Common Wheat-grass	*Anthosachne scabra s.l.*		

COMMON NAME	SCIENTIFIC NAME	EPBC	FFG
Couch*	*Cynodon dactylon*		
Dark Wire-grass	*Aristida calycina var calycina*		
Dense Crassula	*Crassula colorata*		
Drain Flat-sedge*	*Cyperus eragrostis*		
Dwarf Mat-rush	*Lomandra nana*		
Dwarf Brooklime	*Gradtila pumilo*		E
Erect Guinea-flower	*Hibbertia riparia*		
Fairies' Aprons	*Utricularia dichotoma s.l.*		
Feathertop*	*Pennisetum villosum*		
Fen Sedge	*Carex gaudichaudiana*		
Flame Heath	*Astroloma conostephioides*		
Flannel Cudweed	*Actinobole ulginosum*		
Flatweed*	*Hypochaeris radicata*		
Flecked Flat-sedge	*Cyperus gunnii subsp. Gunnii*		
Floating Club-Sedge	*Isolepis fluitans*		
Floating Pondweed	*Potommogeton tricarinatus s.l.*		
Fox-tail Mulga-grass	*Neurachne alopecuroidea*		
Glandula Brooklime	*Gratiola pubescens*		
Grass Triggerplant	*Stylidium graminifolium s.l.*		
Grassland Wood-sorrel	*Oxalis perennans*		
Great Brome*	*Bromus diandrus*		
Grey Box	*Eucalyptus microcarpa*		
Hairy Centrolepis	*Centrolepis strigosea subsp. Strigosa*		
Hakea Wattle	*Acacia hakeoides*		
Hollow Rush	*Juncus amabilis*		
Hop Goodenia	*Goodenia ovata*		
Jersey Cudweed	*Pseudognaphalium luteoalbum*		
Joint-leaf Rush	*Juncus holoschoenus*		
Kangaroo Grass	*Themeda triandra*		
Kidney-weed	*Dichondra repens*		
Kneed Wallaby-grass	*Austrodanthonia geniculata*		
Knob Sedge	*Carex inversa*		
Knobby Club-sedge	*Ficinia nodosa*		
Large Quaking-grass*	*Briza maxima*		
Magenta's Stork-bill	*Pelargonium rodneyanum*		

COMMON NAME	SCIENTIFIC NAME	EPBC	FFG
Narrow Rock-fern	*Cheilanthes sieberi*		
Native Flax	*Linum marginale*		
Nodding Chocolate Lily	*Arthropodium fimbriatum*		
Onion Grass*	*Romulea rosea*		
Pale Sundew	*Drosera peltata*		
Perennial Veldt-grass*	*Ehrarta calycina*		
Pithy Sword-sedge	*Lepidosperma longitudinale*		
Pointed Centrolepis	*Centrolepis aristata*		
Poong'ort	*Carex tereticaulis*		
Red Brome*	*Bromus rubens*		
River Red-gum	*Eucalyptus camaldulensis*		
Rough Raspwort	*Haloragis aspera*		
Rough Sow-thistle*	*Sonchus asper s.l.*		
Rough Spear-grass	*Austrostipa scabra*		
Scarlet Bottlebrush	*Callistemon rugulosus*		
Scented Leek-orchid	*Prasophyllum odoratum s.l.*		
Silvery Hair-grass*	*Aira caryophyllea*		
Slender Cicendia*	*Cicendia filiformis*		
Slender Dock	*Rumex brownii*		
Slender Goodenia	*Goodenia gracilis*		
Small Loosestrife	*Lythrum hyssopifolia*		
Small Mat-rush	*Lomandra sororia*		
Small St John's Wort	*Hypericum gramineum*		
Small Triggerplant	*Stylidium despectum*		
Small-leaved Clematis	*Clematis microphyllia s.l.*		
Smooth Solenogyne	*Solenogyne dominie*		
Spear Thistle*	*Cirsium vulgare*		
Spider Grass	*Enteropogon acicularis*		
Squirrel-tail Fescue*	*Vulpia bromoides*		
Streaked Arrowgrass	*Triglochin striata*		
Supple Spear-grass	*Austrostipa mollis*		
Swamp Goodenia	*Goodenia humilis*		
Sweet Bursaria	*Bursaria spinosa subsp. spinosa*		
Tiny Flat-sedge*	*Isolepis levynsiana*		
Toowoomba Canary-grass*	*Phalaris aquatic*		

COMMON NAME	SCIENTIFIC NAME	EPBC	FFG
Vanilla Lily	*Arthropodium spp. (s.s.)*		
Variable Stinkweed	*Opercularia varia*		
Variable Willow-herb	*Epilobium billardierianum*		
Water Buttons*	*Cotula cornopifolia*		
Water-milfoil	*Myriophyllum spp.*		
Wattle Mat-rush	*Lomandra filiformis*		
Weeping Grass	*Microlaena stipoides var. stipoides*		
Wild Oat*	*Avena fatua*		
Wimmera Bottlebrush	*Callistemon wimmerensis*	CE	E
Wimmera Rye-grass*	*Lolium rigidum*		
Wirilda	*Acacia provincialis*		
Woodland Swamp-daisy	*Bracyscome basatlica var. gracilis*		
Yellow Box	*Eucalyptus melliodora*		
Yellow Rush-lily	*Tricoryne elatior*		

*Introduced species, V (vulnerable), E (endangered), CE (critically endangered), T (threatened).

A-4 PARTNERSHIP AND CONSULTATION

The following water management partners were involved in the update of the EWMP, mainly through review of the EWMP document once drafted:

- Grampians Wimmera Mallee Water (GWMWater)
- Victorian Environmental Water Holder (VEWH)
- Commonwealth Environmental Water Holder (CEWH)
- Department of Energy, Environment and Climate Action (DEECA).

A-5 PAST ENVIRONMENTAL WATERING HISTORY AT THE ASSET.

HISTORY OF WATER RESOURCE MANAGEMENT AND ENVIRONMENTAL WATER RECOVERY IN THE WIMMERA

The Wimmera Mallee headworks system is very old within the context of water resource management in Victoria with the location of Victoria's first water resource infrastructure works when in 1850's the Wilson brothers built a weir across the Wimmera River and lowered the bed level to increase flows into the Yarriambiack Creek for stock and domestic supply (Van Veldhuisen, 2001). Lake Wartook was the first storage, commissioned in 1887 to supply water to fledgling irrigation colonies and townships like Horsham and Natimuk. Various systems involving weirs, pumps, flumes and channels were designed to take water north to land that was being cleared and converted to cropping and grazing. From 1913 to 1966 the remaining headworks storages were constructed and channels supplied water from Clear Lake in the south to Ouyen and beyond in the north and Wedderburn in the east (Van Veldhuisen, 2001). This provided essential supplies to 35,000 people covering 10% of Victoria (Wimmera Mallee Pipeline Project Planning Group, 2003). Irrigation districts also were established around Quantong, Riverside/Drung and Murtoa. Despite the ever-increasing storage

capacity to supply the stock and domestic and irrigation systems, water restrictions were historically common due to the massive volumes used in running channels and filling dams. Following the completion of the Northern Mallee Pipeline, the unrestricted demands could be met 77% of the time for stock and domestic and 74% for irrigation supplies under historical inflows (Wimmera Mallee Pipeline Project Planning Group, 2003).

For decades there has been a widespread acknowledgement that the volume of water harvested to supply towns and farms using open earthen channels and farm dams were having a significant impact on the condition on the region's waterways (Van Veldhuisen, 2001). Apart from wet years when storages were full and/or streamflows were too large to harvest, many of these waterways did not flow at all and their environmental, cultural, social and economic values were frequently under severe threat.

Pioneering work in the late 1980's involved trial 'environmental flows' along the lower Wimmera River and monitoring their effectiveness to demonstrate the need for and value of additional environmental water (Anderson & Morison, 1989). There were also some other operational releases that took place outside of drought conditions that had environmental benefits (e.g. stock and domestic supplies for the lower Burnt Creek). However, the Wimmera system was heavily over-allocated (CSIRO, 2008) and so there simply was not the water available to regularly supply the region's regulated waterways.

It was not until the 1990's that action began to take place to redress this with the progressive construction of several stages of the Northern Mallee Pipeline, meaning that a proportion of water savings created by replacing channels and dams with pipes and tanks became available for environmental flows. In the early-2000's further sections of pipeline were completed, increasing the entitlements available for the environment although the record drought greatly restricted allocations. The severe water shortages brought about by the Millennium Drought provided the trigger for the escalation of pipeline works with the Wimmera Mallee Pipeline completed in 2010. This in turn led to further increases to environmental water availability through the creation of passing flow rules and improving the reliability of the environment's regulated entitlement.

The Wimmera Irrigators' Association also showed leadership with their offer to sell the entire channel-supplied irrigation entitlement for environmental flows and it was subsequently purchased for use in 2012 by the Commonwealth Environmental Water Holder. As of 2019, there is a 40,560 ML regulated environmental entitlement to be shared across the Wimmera and Glenelg systems brought about due to water savings from pipeline projects as well as an additional 28,000 ML of low security environmental entitlement solely for use in the Wimmera system from the irrigation entitlement purchase.

Within that same period there has been just as many changes to environmental water management institutions and policy. Wimmera Catchment Management Authority (CMA) took responsibility for planning for environmental water management in the Wimmera in the early 2000's on behalf of the Minister for Environment. Wimmera Mallee Water, the storage manager responsible for environmental water delivery merged with Grampians Water to create Grampians Wimmera Mallee Water (GWMWater) in 2004. In more recent years, the Victorian Environmental Water Holder and Commonwealth Environmental Water Office were created to manage the now substantial environmental water portfolios across multiple river and wetland systems in their jurisdictions.

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