Maintaining drought refuge pools in the lower Wimmera River

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Key Points

- During drought conditions, it can be difficult to deliver environmental flows through river systems to maintain drought refuge pools. We have explored an alternative option for environmental water delivery in the Wimmera River that uses a nearby stock and domestic water supply pipeline.
- Drought refuge pools are particularly important in the lower Wimmera River for protecting freshwater catfish (*Tandanus tandanus*) and lowland endemic small-bodied fish species including Australian smelt (*Retropinna semoni*) and flathead gudgeon (*Philypnodon grandiceps*).
- Environmental water supplied by the pipeline during drought periods can efficiently address the main threats to water quantity and quality in these refuge pools.
- A strategy for drought refuge management in the lower Wimmera River was developed by mapping all potential refuge pools, and establishing a framework to prioritize sites based on 1) the ability to manage non-flow related threats and 2) minimizing the mean distance between sites across the reach to assist with dispersal and recolonization after drought periods.
- This management option is only likely to be used during drought periods and when the condition of each site requires intervention. Given the small volumes required to water these sites, this could be implemented alongside other watering of high priority sites in the region.

Abstract

In semi-arid climates such as the Wimmera River, where there can be periods of months to years of no flow, it is critical to preserve water-dependent species. This will be increasingly important with climate change. The Wimmera Catchment Management Authority (WCMA) manages drought refuge pools as part of their environmental water management and broader catchment and waterway management responsibilities.

The paper explores environmental water management options for drought refuge pools in a stretch of the Wimmera River between Dimboola and Jeparit (approximately 55 km), where it is typically difficult to deliver environmental water during drought periods. This is due to available volumes of environmental water and the conditions of the river upstream during drought conditions, which can include large losses through the system and refilling of refuge pools. We describe the process of mapping refuge pools, selecting priority sites for management, and establishing reach-scale and site-specific management strategies.

Keywords

Drought refuge pools, environmental water management, Wimmera River

Introduction

Droughts and climate change pose a threat to water-dependent values. Deep pools that persist during drought periods are critical to the survival of aquatic communities (e.g. fish, platypus) during these events and their reestablishment afterwards (Bond 2008). These drought refuge pools are particularly important in semi-arid climates, where there can be periods of months to years of no flow.

Typically, refuge pools can be managed during periods of drought and little to no flow, through the provision of environmental flows or the management of unregulated stream licensing. However, available volumes of environmental water and the conditions of the river during drought conditions (losses through the system and filling of pools) can pose challenges to the delivery of environmental water to support drought refuge pools. In such areas, alternative strategies to environmental flows need to be considered to support water dependent values through drought periods.

The Dimboola to Jeparit reach of the Wimmera River in western Victoria experiences these challenges, with limited scope for environmental flow releases that extend to this reach during dry conditions. Fortunately, this reach also has a unique opportunity: the nearby Wimmera Mallee stock and domestic pipelines provides a potential water supply.

We undertook a strategic assessment of drought refuge pools in the lower Wimmera River, including mapping of refuge pools, field assessment and site prioritisation, a reach-scale strategy, and site-specific strategies for priority sites. The strategy adopted a holistic, reach-scale approach to ensure that water-dependent environmental values have a greater likelihood of long-term survival and presence in the Wimmera River system compared to undertaking no management actions or management of an isolated site only.

While providing water directly to refuge pools via pipes may not be a long-term sustainable water supply solution, it is an important management option to utilise in drought conditions, where there are no other water management options available. This approach to drought refuge management for locations such as the lower Wimmera River can be used in the medium-term while other water management approaches and adaption to drier conditions are explored.

Study area

The Wimmera River is located in north-western Victoria, receiving flows from tributaries heading out of the Pyrenees Ranges and the Grampians. The catchment lies in the semi-arid, north-western part of Victoria with high maximum temperatures in summer and extremely variable rainfall from year to year. As such, stream flows are naturally highly variable.

Despite the significant volume of water recovered for the Wimmera River through projects such as the Wimmera Mallee Pipeline, the ongoing challenges and threats to water-dependent values in the face of future droughts and climate change remain a concern. In the Wimmera River system, droughts are part of the natural landscape. It is predicted that climate change will lead to warmer and drier conditions, reduced stream flows, and more severe droughts (DELWP 2015).

The Millennium Drought (the most severe on record) presented many challenges for waterway managers and exceeded the boundaries in which the water supply systems and water sharing rules across Victoria were designed to operate (DELWP 2016). Within the Wimmera System, streamflow during the Millennium Drought was so limited that it was insufficient to connect and therefore supply deep pools in the lower reaches for several years (WCMA 2015).

Despite the provision of environmental water and efficiency improvements in the water supply network, historic flow data shows that frequent shortfalls in environmental water should be expected (Alluvium 2013). Experience from the Millennium Drought and the recent 2014-2015 drought demonstrated that planning for environmental water is difficult in the Wimmera system and is strongly influenced by the prevailing climatic conditions. In periods of drought, streamflow fails to meet even the minimum environmental flow requirements and the focus necessarily shifts to protecting the highest priority drought refuge sites (WCMA 2015).

Mapping and assessment framework

Mapping of potential drought refuge sites was completed using aerial photography and LiDAR to determine where water pools occurred under dry conditions and current water management arrangements.

A framework was used to guide the prioritisation of sites and selection of appropriate management actions at specific sites (Figure 1). The framework was adapted from The Protection of Drought Refuges for Native Fish in the Murray-Darling Basin (McNeil et al. 2013). It sets out a process to understand the values, characteristics, threats, and management actions at drought refuge sites.

Values

The Environmental Water Management Plan (EWMP) for the Wimmera River System (WCMA 2015) identifies fauna values supported by drought refuges including fish species, platypuses and macroinvertebrates. In addition, refuge waterholes can be important hotspots for sustaining terrestrial biodiversity, including invertebrates, bats, birds and other vertebrates (Sánchez-Montoya et al. 2017). In particular, for the lower Wimmera River this Strategy is focused on protecting freshwater catfish (*Tandanus tandanus*) and lowland endemic small-bodied fish species including Australian smelt (*Retropinna semoni*) and flathead gudgeon (*Philypnodon grandiceps*). Where possible, the strategy also considered management to support multiple benefits, including social, cultural and economic values.

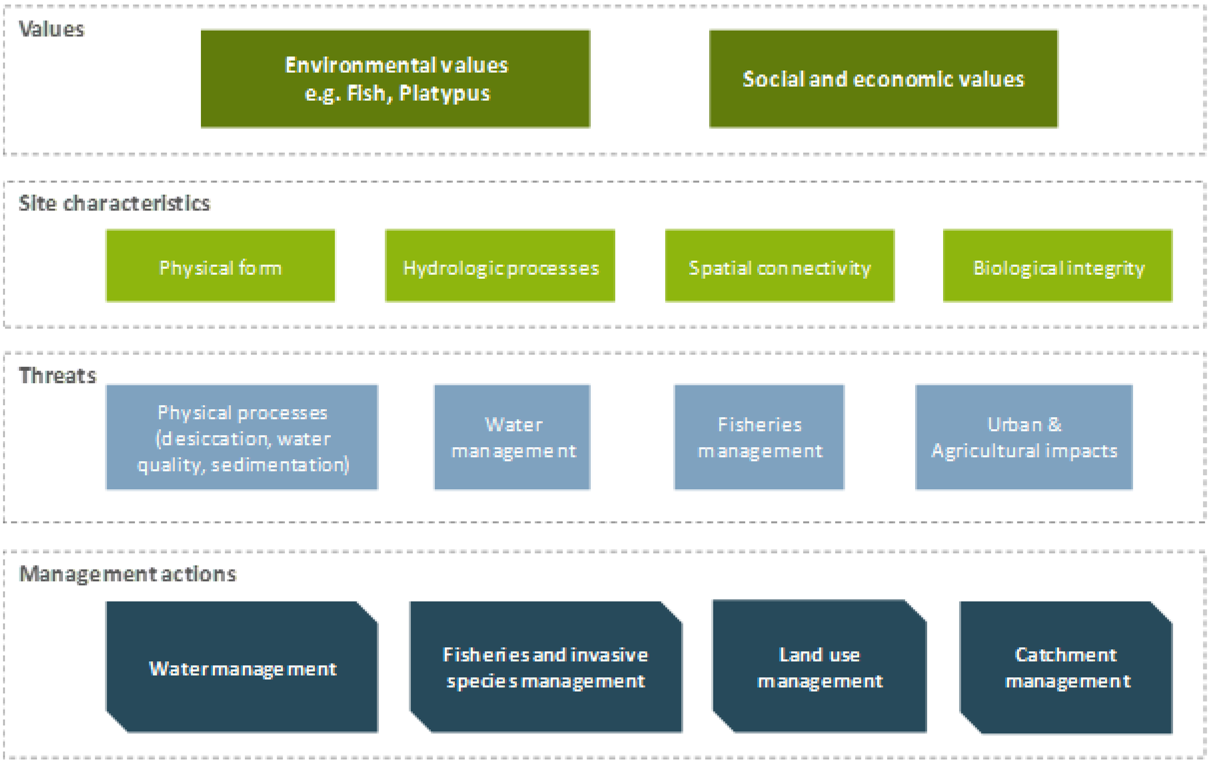

Figure 1. Framework for managing drought refuges in the Wimmera River

Site characteristics and threats

Physical habitat and refuge area

Much of the Wimmera River system contains good physical habitat values, with large woody debris present (WCMA 2015). The identified refuge pools in the study area vary in area from 2,800 m^2 to 420,000 m^2, with a median of 22,000m^2. The refuge pools are large enough to support, for an interim period, viable populations of fish that will be capable of recolonising the Wimmera River once flows resume. Therefore, this Strategy was focused on maintaining the size and improving the quality of the refuge habitat.

Vegetation

Where there is stock access at drought refuge sites, fencing of the riparian zone and the creation of alternative watering points may assist in improving vegetation condition as well as preventing unnecessary decline in water quality within refuge pools. This is not a significant issue at most sites as most of the study area is part of the Heritage River Park.

Hydrological processes

Low and zero flows in the system are common under natural conditions; however, under the regulated conditions downstream of Huddleston's Weir, these events are more frequent and of longer duration (SKM 2001).

Groundwater

Historically, in the Dimboola to Jeparit reach of the Wimmera River, there have been concerns regarding the inflow of saline groundwater during low flow periods. The lower Wimmera River is gaining; i.e. groundwater is able to flow into the base of the river. The only circumstance in which this would not be the case is during very high flow periods (floods), where the gradient is from the river into the underlying groundwater system.

The refuges identified within this study will have varying degrees of groundwater connection, with the potential flux of groundwater into them varying over time depending on the recent climatic conditions that control regional groundwater levels. The actual rate of groundwater inflow into each site is a function of the hydraulic conductance of the refuge pool sediments. The higher the clay content, the slower the rate of groundwater movement into the refuge.

Water quality

Water availability and water quality both impact on habitat availability and suitability in the lower Wimmera River (EPA 2008). Salinity is a particularly important issue due to saline groundwater intrusions. Salinity tends to increase towards the most downstream reaches. The interplay between surface runoff and groundwater intrusions mean that even small decreases in surface water availability can lead to significant increases in the salinity of pools within the channel. Salinity levels have been well in excess of sea water after years of no flow.

High levels of salinity can strongly influence the ability of fish, invertebrates and aquatic plants to survive in refuge pools (see Hart et al. 1991; James et al. 2003). Salinity can also interact with other stressors. For example, the toxicity of pesticides tends to increase at higher salinity levels, possibly because of the combined physiological stress imposed by multiple stressors acting at the same time (Schäfer et al. 2011).

A further water quality issue is stratification of deep pools, which is relatively common and leads to hypoxic conditions in deeper areas that otherwise would provide valuable habitat for fish. Dissolved oxygen levels can also be influenced by plant and algal biomass, light intensity and water temperature (because they influence photosynthesis) (Connell & Miller 1984). Strong diurnal fluctuations in dissolved oxygen conditions are typical, governed by rates of community respiration and daytime production of oxygen by plants. These fluctuations in dissolved oxygen have led to fish deaths in this area.

Figure 2. Drought refuge pool on the lower Wimmera River

Spatial connectivity

Both physical barriers and distance act as a barrier to dispersal and recolonization of re-inundated habitats following dry periods. Dimboola and Jeparit weirs present barriers to connectivity and may therefore limit recolonization from the weir pools to the rest of the system. Investigations have been completed into this issue, and the potential negative impacts of providing fishways at these weirs, such as carp movement, were deemed to outweigh the potential benefits (SKM 2006). There are also a number of low-level culvert road crossings that act as barriers in low flows.

Even where barriers are absent, it is well known that some species of smaller bodied fish, as well as many invertebrate taxa, can have relatively restricted swimming abilities, which may limit their ability to recolonise from isolated refuge habitats (e.g. Dexter et al., 2013; Tonkin et al., 2014). Further work is required to understand how connectivity among refuges influences population persistence in the Wimmera River at a whole of river scale, and while there are available approaches for undertaking such analyses (e.g. Bond et al., 2015), they are relatively data intensive and beyond the scope of the project.

Biological integrity

Macroinvertebrate populations within the lower Wimmera River are responsive to changes in flow and salinity. High salinity can lead to reduced diversity, while increased flows have brought an increased number of taxa at Jeparit (WCMA 2015). Previous studies (e.g. Westbury, Tiller and Metzeling 2007; EPA 2008) have also shown that macroinvertebrate community condition is strongly positively influenced by flows that reduce salinity.

Fisheries management

Exotic fish species and recreational fishing of catfish during drought periods (given lack of other suitable angling water bodies) are identified as threats to the environmental values of the Wimmera River (WCMA 2015), and it is common for refuge habitats to also support populations of species such as carp (*Cyprinus carpio*), gambusia (*Gambusia holbrooki*) and redfin (*Perca fluviatilis*).

Applying the framework

In the framework, a rating was assigned on how well the threats can be managed. The ratings used were: Low, Moderate, High, Very High, with Low indicating the threat cannot be adequately managed, and Very High indicating that the threat can be (relatively) easily managed. For the site selection, two main approaches were used, as follows.

Principle 1

The best sites in the study reaches should be selected; i.e. sites that have the highest likelihood of supporting environmental values during drought periods, and sites where any threats can be feasibly and easily managed. Conversely, any sites where threats cannot be feasibly managed (i.e. a 'Low' rating in the framework assessment) should not be considered as sites for drought refuge management as part of this Strategy, or into the future (unless significant site changes occur).

Principle 2

The selected sites should, where possible, be well spread throughout the study reach. Therefore, if there are two high priority sites near to each other, only one site should be selected for the strategy. This approach spreads the risk of failure across different parts of the study reaches. It ensures greater accessibility to the drought refuge sites and greater chances of recolonization across the whole reach once drought periods have ended.

System scale strategies

The primary management tool recommended in the strategy was the provision of water to high priority sites during drought periods. The difficulties of providing environmental flows to these sites via the river network, and the presence of delivery pipelines within close proximity to many sites, presents a unique opportunity.

We proposed the following actions for priority sites:

- Establish permanent connection points to the existing stock and domestic pipeline (and for the Jeparit site, connection from the stormwater system)
- Establish infrastructure (e.g. culverts) as required to ensure temporary pipes can reach refuge pools from the existing water supply pipeline
- Provide temporary pipes to tap into the water supply during drought periods
- Provide water to sites on an as-needed basis during drought periods, with water supplied to offset water loss through evaporation

Watering should be provided to offset evaporation and maintain salinity levels in the refuge pools, such that the salinity risk level does not increase once watering has commenced. Therefore, it is recommended that watering commences before salinity levels approach unacceptable levels. Monitoring of salinity and water levels at sites will help to inform the decision to commence watering.

In addition, vegetation management is recommended at some sites, along with invasive species and fish management. Small embankments are recommended at the Jeparit site between the refuge pools and the main waterway to allow the site to hold more water during drought periods. At stakeholder engagement, monitoring and a policy review will be required to address issues of water extraction from refuge pools and potential water theft.

Site specific strategies

Five drought refuge sites were selected that have the best potential to be managed for habitat quality and quantity. The sites are distributed throughout the reach to minimise the mean distance between sites to support dispersal and recolonization of re-inundated habitats following dry periods. By implementing simple connections and associated infrastructure, the water quantity and quality at these sites can be managed during drought periods. Some sites would also benefit from complementary riparian revegetation works to enhance habitat quality.

As the water is delivered directly to these sites, the annual average water volumes required are relatively small to provide critical habitat during drought periods. The average annual water requirements (volume in a given watering year) would be a total of 335 ML across the five sites; this is significantly lower (by an order of magnitude) than the volume of water that would be required to provide flows to this reach during drought periods.

The total infrastructure cost across all sites is estimated to be $155,000 plus $45,000 for revegetation ($235,000 in total). If all sites were watered based on the typical water requirements in a given watering year (~240 days), the water cost is likely to be around $1 million.

Environmental water to fulfil the recommendations in this strategy will be allocated based on decisions of competing objectives for environmental watering and waterway management in the local region, including consideration of carryover.

In the Wimmera system, the MacKenzie River, Mt William Creek and Burnt Creek systems, as well as refuge pools in the Wimmera River upstream of Dimboola, will generally be prioritised above the sites included in this strategy. However, given the small water volumes required for the sites in this strategy, they could be watered concurrently with the other higher priority sites during drought periods.

Conclusions

Droughts and climate change pose a threat to water-dependent values and exacerbate the challenges of environmental water delivery. Where there are opportunities to provide environmental water through nearby water supply pipelines, these options can be explored to help support aquatic fauna through drought periods.

In this paper, we have presented a simple approach for mapping, assessing and developing site specific management approaches for drought refuge pools in the lower Wimmera River. The strategy adopted a holistic, reach-scale approach to ensure that water-dependent environmental values have a greater likelihood of long-term survival and presence in the Wimmera River system, compared to undertaking no management actions or management of an isolated site only.

Five priority drought refuge sites have been identified for management in the study area. This includes initial works to enable watering of the sites and revegetation to improve habitat quality. During drought periods, it is recommended that direct watering of the priority sites occurs to maintain water levels and salinity conditions of the refuge pools to support native fish populations throughout the reach. Site-based operational plans will be developed, including monitoring, use of short- and long-term rainfall forecasts, and procedures for establishing watering at drought refuge sites.

Acknowledgments

Thank you to the Department of Environment, Land, Water and Planning (DELWP) for funding this project, and to DELWP and the Victorian Environmental Water Holder (VEWH) for their feedback and advice during the project. Thank you to the Wimmera CMA and Grampians Wimmera Mallee Water for supplying useful data for the initial site assessments.

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