



# Environmental watering in the Glenelg River

## Seasonal watering proposal 2017-18



*Photo: Tyson Lovett-Murray and Brett Harrison on the Glenelg River at Harrow*



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## Executive summary

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This Seasonal Watering Proposal outlines Glenelg Hopkins CMA priorities for environmental water use in the Glenelg River in 2017-18 to achieve environmental outcomes and maximise the shared community benefits associated with its use. The Proposal has been prepared to inform the Victorian Environmental Water Holder's (VEWH) state-wide Seasonal Watering Plan 2017-18.

Recent climate and rainfall patterns of the Glenelg catchment have been highly variable, with years of consecutive drought followed by flood events. Whilst variability is normal in nature, these events have been extreme and have placed significant stress on plant and animal communities by lessening the extent and quality of available habitat.

Drought conditions were experienced throughout 2015-16. Low rainfall and extremely low runoff yield across the catchment resulted in minimal unregulated river flows. The system received only 12% of the long-term average inflow, making it one of the lowest inflow years on record. Much of the river was reduced to a series of pools which provided limited but critical habitat for aquatic and plants and animals. Due to the dry conditions, environmental water availability was low, with only 3,000 ML made available to the Glenelg River through the critical summer period. Throughout this period, habitat and primary production was significantly reduced due to the cease to flow conditions. Fish movement and recruitment was heavily restricted.

Heavy winter rainfall in early 2016-17 provided much needed relief to the system. Consistent high rainfall continued throughout winter and spring 2016 leading to widespread flooding across the Glenelg catchment. These floods connected the river and floodplain, providing a significant influx of carbon into the system, scouring woody debris and boosting food resources for aquatic species. The high flows also reconnected the river longitudinally, enabling migratory species to disperse and recolonise throughout the system, with conditions also likely to have been suitable for some fish species to breed. However, the velocity of these high flows may have made migration and spawning difficult for some small bodied native fish species. Providing flows to support breeding in short-lived species such as Yarra Pygmy Perch, Variegated Pygmy Perch and Tupong becomes more important following multiple years of poor breeding conditions.

In many parts of the catchment, the high flows inundated the floodplain, providing riparian vegetation with a much-needed water. The high velocity of the flows scoured, and in some cases uprooted already stressed riparian and instream vegetation. Whilst plants and animals are capable of withstanding difficult conditions, they all have limits. Environmental water is an important tool that can ease some of these extremes in seasonal conditions and flow variability to ensure we can continue to protect and maintain healthy and resilient populations into the future.

In considering the recent conditions, environmental watering in 2017-18 will be targeted to:

- promote the spawning of small bodied native fish
- support the recruitment of juvenile native fish
- assist in the recovery and reestablishment of instream and bank vegetation following the recent high flows.

The delivery of environmental water to achieve these environmental outcomes is also expected to support important cultural outcomes by helping to maintain healthy country; improve water quality for stock and domestic water users; and support a wide range of recreational benefits including improved angling opportunities and increased amenity for campers, canoeists and other river users.

## 1. Introduction

This Seasonal Watering Proposal outlines Glenelg Hopkins CMA priorities for environmental water use in the Glenelg River in 2017-18. The Proposal has been prepared to inform the Victorian Environmental Water Holder's (VEWH) state-wide Seasonal Watering Plan 2017-18.

This seasonal watering proposal has been endorsed by the Glenelg Hopkins CMA Board of Directors and is submitted to the VEWH in accordance with section 192A of the *Water Act 1989*.

## 2. Environmental water engagement

Engagement on environmental watering in the Glenelg River occurs through various means – directly through regular ongoing conversations with landholders and community members, through engagement events (such as angler engagement days and local fishing competitions), and through more structured channels which included the Glenelg River environmental water workshop held in March 2017.

The 'Towards cultural flows' project continued throughout 2016-17 with the aim to understand and document Indigenous values and knowledge relating to Glenelg River. This project has been invaluable in increasing Indigenous participation in water management in the Glenelg River, supporting and fostering connection to country, further developing relationships between organisations and providing opportunities for traditional owners to help inform environmental watering.

A summary of engagement relating to the development of the Seasonal Watering Proposal is presented in Table 1 (page 5) and Case study 1 (page 4). Further details regarding the specific issues and opportunities identified through this engagement are outlined in section 5.

### CASE STUDY 1. COMMUNITY CONVERSATIONS – GLENELG RIVER ENVIRONMENTAL WATERING WORKSHOP

Glenelg Hopkins CMA convened a workshop with stakeholders and local community to discuss environmental water management in the Glenelg River in late-March 2017. The event brought together over 30 people, representing a diverse range of interests and backgrounds (outlined in Table 1 on page 5).



Participants at the environmental watering workshop (photo courtesy of GH CMA)

## CASE STUDY 1. COMMUNITY CONVERSATIONS – GLENELG RIVER ENVIRONMENTAL WATERING WORKSHOP

The workshop was designed to share new science and information on environmental watering on the Glenelg River and gain feedback from the community on the environmental watering program. The workshop also aimed to identify opportunities to maximise community benefits through the delivery of environmental water.

The session highlighted the significant passion the local community have for protecting the health of the river. Many individuals told of the improvements they have observed in the river in recent years, and the link these improvements had to environmental water management and river health works. This included an improvement in the diversity and number of angling species being caught throughout the extent of the river, better water quality, and improved amenity in local towns. There was significant concern from many of the attendees about the severe environmental stress the low flows experienced during 2015-16 placed on the system. Attendees were appealing to environmental water holders and managers to prevent this from happening again in future to ensure the health of the Glenelg River can be protected and maintained.

Stakeholders and the community were supportive of environmental watering, however the consultation highlighted several areas of improvement. This included better communicating what we do and why, and addressing some of the common questions people ask about environmental water in the region.

Telangatuk East sheep farmer and keen fisherman Charlie Officer attended the forum. He said it was good to get a sense that people in the CMA are listening. "When we just started it was just black and white, and now we've got a grey area where we are meeting in the middle. With the public getting more involved hopefully we can get the message back to the wider community and answer those questions on environmental water."

**TABLE 1 SEASONAL WATERING PROPOSAL CONSULTATION SUMMARY**

Who	Engaged on the 2017-18 Seasonal Watering Proposal	Engagement method
Program partners	GWMWater VEWH Wimmera CMA (WCMA) Department of Land, Environment, Water and Planning (DELWP) Parks Victoria	<ul style="list-style-type: none"> <li>Community consultation – environmental water workshop (March 2017)</li> <li>Formal partnership meetings (Western Rivers Advisory Group – VEWH &amp; WCMA)</li> <li>Review of draft proposal (GWMWater &amp; VEWH)</li> </ul>
Indigenous groups	Gunditj Mirring Traditional Owner Corporation (GMTOC) Barengi Gadjin Land Council (BGLC)	<ul style="list-style-type: none"> <li>Community consultation – environmental water workshop (March 2017)</li> <li>Direct engagement (one-on-one, email distribution list)</li> </ul>
Landholders	Individual landholders	<ul style="list-style-type: none"> <li>Community consultation – environmental water workshop (March 2017)</li> <li>Direct engagement (one-on-one, email distribution list)</li> </ul>
Recreational users	Balmoral Angling Club Casterton Angling Society Dartmoor Angling Club VRFish Fishcare Victoria South-west Fishing Reports Individual anglers	<ul style="list-style-type: none"> <li>Community consultation – environmental water workshop (March 2017)</li> <li>Direct engagement (email distribution list)</li> </ul>

Who	Engaged on the 2017-18 Seasonal Watering Proposal	Engagement method
Environment groups	Baghalla/Killara Landcare Group Balmoral Land Management & Tree Group Chetwynd Landcare Group Culla-Pigeon Ponds Landcare Group Dunrobin Landcare Group Red Cap Landcare Group Wando River Landcare Group	<ul style="list-style-type: none"> <li>Community consultation – environmental water workshop (March 2017)</li> <li>Direct engagement (email distribution list)</li> </ul>
	Glenelg River User Group Friends of the Glenelg River	
Local businesses	Vickery Brothers (sand extraction) Paestan Canoe Hire Nelson Boat and Canoe Hire Grampians Resort Glenelg River Boat Cruises Balmoral Post Office Balmoral Bush Nursing Centre	<ul style="list-style-type: none"> <li>Community consultation – environmental water workshop (March 2017)</li> <li>Direct engagement (email distribution list)</li> </ul>
Other Government agencies	Fisheries Victoria Southern Grampians Shire West Wimmera Shire	<ul style="list-style-type: none"> <li>Community consultation – environmental water workshop (March 2017)</li> <li>Direct engagement (email distribution list)</li> </ul>

### 3. Environmental objectives and flow recommendations

The Glenelg River supports a wide range of flow dependent environmental values including a range of rare and threatened flora and fauna. This diversity is driven by the range of landforms, river-styles, climate conditions, connection with the estuary, and the largely perennial nature of the river.




Long-term environmental objectives for the health of the Glenelg River have been described through the Glenelg Hopkins Regional Catchment Strategy (RCS) 2013, Glenelg Hopkins Waterway Strategy 2014-22 and the Glenelg River Environmental Water Management Plan 2016 (EWMP). This proposal draws on information from these documents to identify more targeted objectives appropriate for the upcoming water year.

Overarching ecological objectives for the Glenelg River are outlined in Table 2 (page 7). These targeted objectives reflect priorities across the Glenelg River with consideration of recent ecological outcomes and catchment conditions.

Highest priority objectives for 2017-18 are to provide optimum flows to:

- promote the spawning of small bodied native fish
- support the recruitment of juvenile native fish
- assist in the recovery and reestablishment of instream and bank vegetation following the recent floods.

TABLE 2. PRIORITY ECOLOGICAL OBJECTIVES 2017-18

	Ecological objective	Flow related requirements
	<p>Protect, maintain and where possible, enhance populations of endemic fish, including threatened and diadromous species.</p> <p>Threatened species include:</p> <ul style="list-style-type: none"> <li>• Yarra pygmy perch</li> <li>• Variegated pygmy perch</li> <li>• Little galaxias</li> </ul> <p>Diadromous species include:</p> <ul style="list-style-type: none"> <li>• Estuary perch</li> <li>• Black bream</li> <li>• Tupong</li> <li>• Eel</li> </ul>	<p><b>Connectivity</b> for migration. A severe lack of connecting flows (freshes) has increased the priority of flows that enable fish movement along the river.</p> <p><b>Habitat</b> including suitable water quality in diverse flow areas, submergent vegetation, inundation of large wood and scour around large wood. Increasing the available habitat with suitable conditions will help manage threats such as predation.</p> <p><b>Food</b> production through the promotion of instream primary production of vegetation and plankton which underpins reproductive condition, recruitment rates and survival of fish.</p> <p><b>Recruitment</b> depends on reproductive condition of adults, connectivity for genetic flow, migration to spawning areas, dispersal of juveniles, and low salinity to protect eggs and larvae.</p>
	<p>Maintain healthy and diverse mosaics of water-dependent vegetation.</p> <p>Important species and communities include:</p> <ul style="list-style-type: none"> <li>• Wimmera River bottlebrush</li> <li>• River redgum woodland</li> </ul>	<p><b>Recruitment</b> including triggers for flowering, seed dispersal and germination.</p> <p><b>Growth and survival</b> of riparian vegetation through soil moisture and changes in level.</p> <p><b>Primary production</b> to underpin the trophic structure and abundance of the river system.</p>
	<p>Maintain healthy macroinvertebrate, amphibian, platypus and water rat communities.</p> <p>Threatened species include:</p> <ul style="list-style-type: none"> <li>• Glenelg spiny cray</li> <li>• Glenelg freshwater mussel</li> <li>• Growling grass frog</li> </ul> <p>Other important species include:</p> <ul style="list-style-type: none"> <li>• Platypus</li> <li>• Water rat</li> </ul>	<p><b>Food</b> through biofilm, access to leaf packs, carbon entrainment and vegetation growth.</p> <p><b>Survival</b> through provision of suitable water quality and access to diverse habitats.</p>

Flow recommendations for the target reaches, Reach 1a, Reach 1b and Reach 2 (as outlined in Figure 1 – page 8) were developed in the 2013 Glenelg River environmental flows study (Alluvium 2013). The flow recommendations from the 2013 Glenelg River environmental flows study are used in this Seasonal Watering Proposal without modification, as outlined in Appendix 1 of this document.



FIGURE 1. GLENELG RIVER ENVIRONMENTAL FLOW REACHS

#### 4. Seasonal review




Recent climate and rainfall patterns of the Glenelg catchment have been highly variable, with years of consecutive drought followed by significant flood events. Whilst some variability is normal in nature, these extreme events reduce the resilience of plants and animals, making it difficult for populations and communities to establish, recover and successfully recruit.

Environmental water has become an important tool that can mitigate some of these extremes in seasonal conditions and flow variability to ensure we can continue to protect and maintain healthy and resilient populations into the future.

A summary of recent climatic conditions and the effect of environmental watering on ecological outcomes are outlined in Table 3 (page 9). Complementary community benefits supported by these ecological outcomes are summarised separately in Table 6 (page 17).



TABLE 3. ECOLOGICAL OUTCOMES 2016-17

	<p>Habitat for aquatic species was severely constrained during the dry conditions experienced in 2015-16. Populations persisted in isolated pools where they were more vulnerable to predators due to the reduced habitat and food resources. Populations potentially suffered significant stress from low dissolved oxygen and increased temperatures and salinity levels, which would likely have impacted on the resilience and diversity of populations.</p> <p>The floods that broke these dry conditions in winter 2016 provided an opportunity for some species to migrate, seeking new habitat and food resources to improve physical condition in preparation for breeding. The high flows extended into spring, providing conditions to support the migration and spawning of many native fish species. The juvenile fish that recruited through these breeding events require flows to provide diverse habitats, food and suitable water quality to support their growth and survival. Juvenile fish are particularly susceptible to elevated salinity as they have limited ability to osmoregulate themselves.</p> <p>The high velocity and extended duration of the high flows may however have reduced the ability of some small bodied native species to move and spawn. Given these species are also likely to have been under significant stress during the preceding low flow conditions, and many are short-lived, there is an imperative to provide conditions suitable to ensure these population recover and can redistribute throughout the system. These less extreme conditions will provide much needed relief from the boom-bust scenario that has been seen in recent years, this will go a long way to stabilise the unique native fish populations in the Glenelg river.</p>
	<p>The high flows provided much needed inundation of many floodplain and riparian vegetation communities, supporting their recovery from an extended dry period. The wet conditions that continued throughout spring will likely have supported flowering, seed set and dispersal for many species.</p> <p>Whilst the high flows provided benefits to floodplain vegetation, the impacts on already stressed instream and bank vegetation were more damaging and severe.</p> <p>Supporting the germination, establishment and growth of floodplain vegetation and the reestablishment of instream vegetation communities will be important to ensure sufficient habitat is available to support aquatic species inhabiting the river along with driving instream primary production (which can be a limitation for population).</p>
	<p>The recent extremes in climatic and river conditions are likely to have caused stress to macroinvertebrate, amphibian, platypus and water rat populations in the Glenelg River.</p> <p>Though little is known of their lifecycles, the threatened Glenelg Spiny Crayfish are thought to be particularly sensitive to poor water quality, especially when moulting. It is expected that populations will have been impacted by the dry conditions in 2015-16, however improved water quality following high flows in 2016-17 are likely to have increased available habitat and food resources for the populations. Continuing to provide suitable water quality is a priority for 2017-18 to support the maintenance and recovery of the spiny cray populations.</p> <p>The wet spring is expected to have been favourable for frog breeding, with landholders reporting significant frog activity, especially in the more braided, swampy sections of the river such as Reach 1a.</p>

## Hydrological outcomes

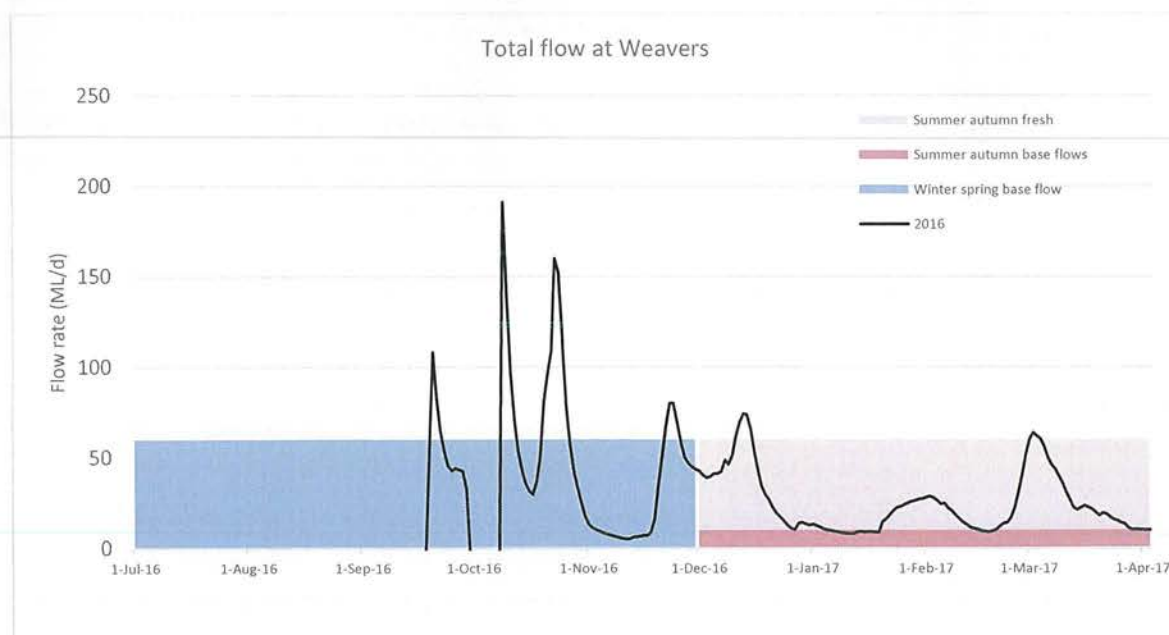
Due to the high natural flows experienced throughout the catchment in winter and spring, passing flow obligations were suspended in partnership with the Storage Manager to ensure they were not exacerbating flooding impacts. This decision resulted in the accumulation of significant volumes of passing flow.

No environmental releases were made from Rocklands Reservoir until late-November 2016, when the threat of destructive flooding subsided. From this time, accumulated passing flows supported the delivery of baseflows throughout the summer and early-autumn period. Two freshes were released, in early-December 2016 and late-February 2017, followed by baseflows which are intended to continue until the recommencement of passing flows in June 2017. Regulated environmental water releases were expected to commence in late-April 2017.

### Reach 1a

A temporary Portable Automated Logger System (PALS) gauge was in place throughout 2016-17 to monitor flows in Reach 1a, approximately two kilometres downstream of Frasers Swamp (Figure 2 – page 10). Despite data issues experienced early in the water year, the gauge provided an accurate representation of flows from the late-spring period onward.

This part of the system experienced high natural flows throughout winter and spring, which subsided in early November 2016. The delivery of passing flows recommenced in late-November, with accumulated passing flows used to provide a fresh to the reach in mid-December. Baseflows were then released throughout the summer period, with some variation added to increase flow variability in early-February to increase available habitat and food resources for fish and increase the area of inundation for bank vegetation. A second summer fresh was released in early-March 2017. Both these events achieved their recommended duration and magnitude.



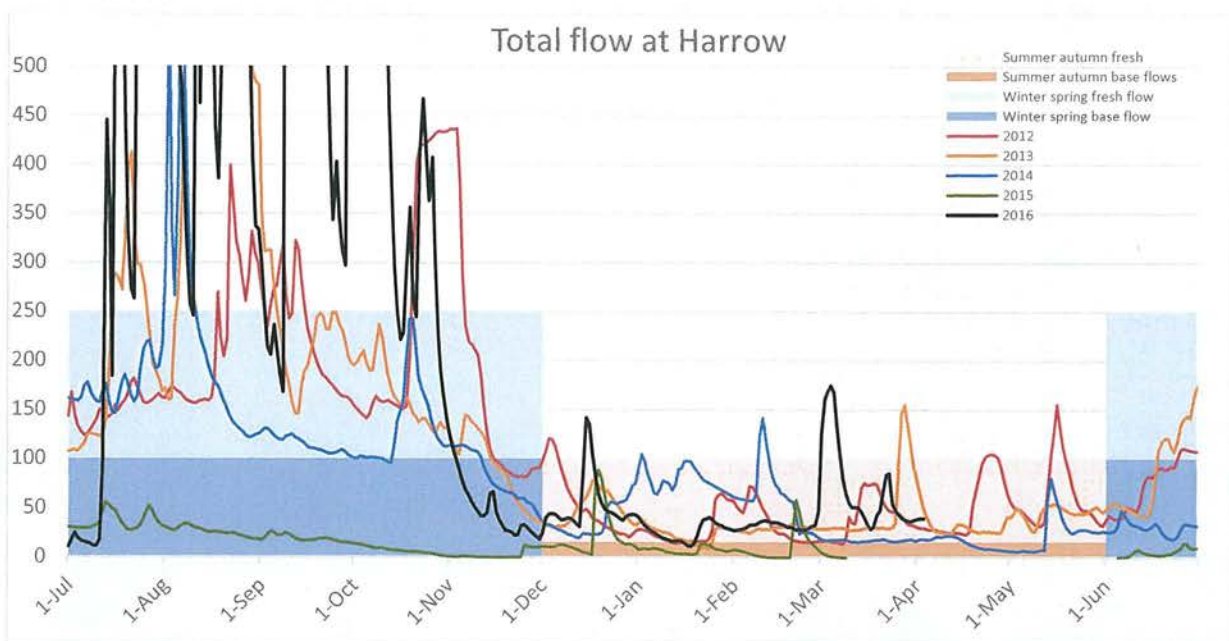
Note: Gauging was not calibrated until September 2016 due to flood conditions experienced at the site. Similarly, a data gap exists for the site in early-October 2016.

**FIGURE 2. REACH 1A HYDROGRAPH AND KEY FLOW COMPONENTS**

Metering on this reach was used to inform our adaptive management approach throughout the water year. Monitoring flows at this location was critical to ensure environmental water releases achieved the desired flow rates to meet our objectives in the most efficient way possible. Due to the changing nature of Frasers Swamp and the lack of flow records available for this section of the river, there is little information available to inform loss rates and travel times. This gauge has facilitated the refinement of these factors to ensure the target flow rate could be achieved.

### Reach 1b

Significant natural flows were experienced in Reach 1b throughout winter/spring 2016, achieving bankfull flows, though falling short of overbank flow recommendations (peaking at around 4,400 ML/day during mid-September 2016). Natural flows subsided by late-November, with the system then largely reliant on environmental water releases to maintain flow, except for some peaky flows caused by localised rainfall and catchment inflow during January and late-March.



**FIGURE 3. REACH 1B HYDROGRAPH AND KEY FLOW COMPONENTS (2012-13 TO 2016-17)**

Wetter catchment conditions and higher water availability enabled Reach 2 to be targeted for environmental watering in 2016-17. This priority resulted in higher than required flows being delivered through Reach 1b to ensure target flow rates were achieved in Reach 2. These higher flows do not pose ecological risks to this part of the system. The increased flow supported a more extensive mixing of deep pools, increased habitat and food resources for fish and other aquatic species, and increased wetting of river banks which provides benefits to fringing vegetation. Historical hydrological flow compliance in Reach 1b is illustrated in Table 4 (page 15).

## Reach 2

Similar to Reach 1b, significant natural flows were experienced throughout winter/spring 2016, achieving many of the flow targets during this period. Natural flows subsided by late-November, however some localised rainfall increased flows during January and late-March.

Under the wet catchment conditions, environmental watering targeted outcomes throughout the upper Glenelg River to the confluence with the Wannon River (the end of reach 2). Baseflow targets were achieved throughout summer, however delivery losses were more significant than expected due to dry catchment conditions, which resulted in freshes not reaching their intended magnitude at Dergholm. Flow delivery plans were adjusted following the December fresh to extend the volume and duration of the release from the 5-mile outlet to achieve the recommended flows. Despite these changes, the summer/autumn fresh recommendation at Dergholm was not achieved. The freshes, although not meeting target flows, added considerable flow variability to the system, helping to boost habitat and freshen water quality throughout the system. The historical hydrological flow compliance in Reach 2 is illustrated in Table 5 (page 16).

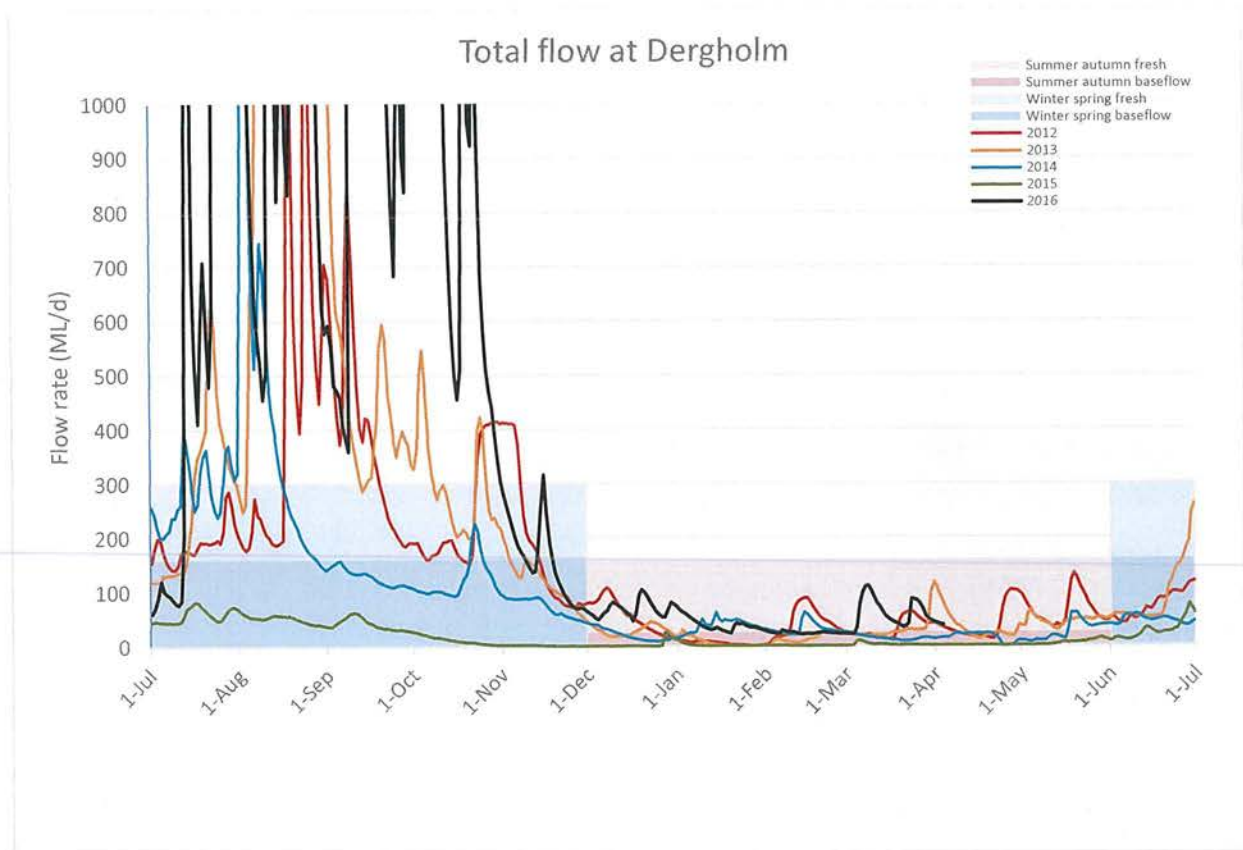


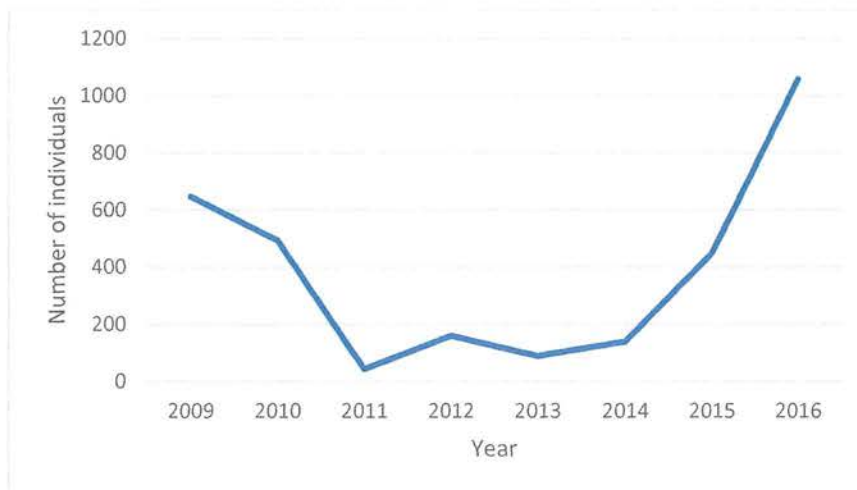
FIGURE 4. REACH 2 HYDROGRAPH AND KEY FLOW COMPONENTS (2012-13 TO 2016-17)

## CASE STUDY 2. EXPANDING DISTRIBUTIONS IN RESPONSE TO FLOW – VARIAGATED PYGMY PERCH

The variegated pygmy perch (*Nannoperca variegata*) is a small freshwater fish endemic to south-eastern Australia. The species occurs in a very restricted area within the Glenelg catchment and the Eight Mile Creek drainage area in South Australia (Saddler, Koehn et al. 2013) and is listed under a range of state and federal legislation. The species is considered vulnerable under the Federal Government's *Environment Protection and Biodiversity Conservation Act 1999* and threatened under the Victorian *Flora and Fauna Guarantee Act 1988*.

The historical distribution and abundance of variegated pygmy perch is largely unknown. It is likely that there has been a significant decline in abundance due to wetland drainage, groundwater extraction, river regulation, increased predation from introduced fish species and habitat destruction. This decline appears to be continuing, with at least one population across its range becoming extinct in recent decades.

The population of variegated pygmy perch in the Glenelg River has been monitored through the Victorian Environmental Flows Monitoring and Assessment Program (VEFMAP) (Figure 5 – below).



**FIGURE 5. TOTAL NUMBER OF VARIAGATED PYGMY PERCH CAUGHT IN GLENELG RIVER FISH SURVEYS**

The first fish surveys were undertaken in 2009, towards the end of the millennium drought. During this time the river was restricted to a chain of pools with very low or no connectivity between suitable habitats. High numbers of individuals were captured during this time, although there was no evidence of recruitment in the population. The high numbers recorded is likely to have reflected the relative ease of sampling due to the restricted distribution in refuge pools. There was however a clear downward trajectory in the population during this time.

Flooding in the system in 2010/11 created significant disturbance. Available habitat and food resources for the species dramatically increased, allowing them to move and recolonise parts of the river that were inaccessible during the low flow period. Low numbers of individuals were captured during this time, which likely reflects sampling difficulties encountered due to the abundance of water in the system.

Populations appear to have steadily increased since 2011. The highest recorded number of individuals were caught in 2016, with fish sampled at 12 of the 20 sites in the Glenelg River downstream of the Chetwynd River confluence. Variegated pygmy perch were the most commonly encountered native fish species in the survey, accounting for 28% of the fish caught. Diverse age classes were detected at most sites in 2015 and 2016, indicating conditions have been suitable for spawning and recruitment.

**CASE STUDY 2. EXPANDING DISTRIBUTIONS IN RESPONSE TO FLOW – VARIEGATED PYGMY PERCH**

Environmental flows have played an important role in increasing connectivity and maintaining habitat availability for variegated pygmy perch since 2011. These conditions have allowed populations to recover, increasing in their abundance and spatial distribution in the Glenelg River.

**TABLE 4. HISTORICAL HYDROLOGICAL FLOW COMPLIANCE REACH 1B**

Climate condition	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
Summer-autumn base flow 15 ML/d	Drought 100%	Drought 100%	Drought 6%	Drought 0%	Dry 100%	Wet 100%	Wet 100%	Dry 100%	Dry 100%	Dry/ drought 100%	Drought 42%	Wet 100% <sup>1</sup>
Summer-autumn fresh flow 100ML/d	0%	0%	0%	0%	100%	100%	100%	100%	50%	0%	0%	50% <sup>1</sup>
Winter-spring base flow 100 ML/d	93%	3%	0%	0%	57%	51%	78%	100%	100%	100%	0%	78%
Winter-spring fresh flow 250 ML/d (fish)	100%	0%	0%	0%	100%	100%	60%	100%	100%	50%	0%	80%
Winter-spring fresh flow 550 ML/d (geomorphology)	n/a	n/a	n/a	n/a	n/a	100%	50%	n/a	n/a	n/a	n/a	100%
Year-round bank full flow 1000 ML/d	n/a	n/a	n/a	n/a			100%		100%	0%	n/a	100%
Winter-spring overbank flow 6000 ML/d	n/a	n/a	n/a	n/a	n/a	n/a	100%	n/a	n/a	n/a	n/a	0%

<sup>1</sup> Flow compliance was only assessed for the December 2016 to February 2017 period, which only represents half of the season in which these flows can be delivered. This compliance statistic may therefore differ once the season is complete.

<sup>2</sup> The overbank flow recommendation is for "1 per period or natural" in wet seasons. This analysis does not incorporate the 'or natural' component of the recommendation (i.e. it does attempt to examine whether an overbank event would have occurred naturally during the wet year).

**TABLE 5 HISTORICAL HYDROLOGICAL FLOW COMPLIANCE REACH 2**

Climate condition	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16 <sup>1</sup>	2016-17
Summer-autumn base flow 25 ML/d <sup>2</sup>	Drought 0%	Drought 4%	Drought 0%	Drought 5%	Dry 1%	Wet 99%	Wet 58%	Dry 56%	Dry 100%	Drought /dry 100%	Drought 69%	Wet 90% <sup>3</sup>
Summer-autumn fresh flow 150ML/d	Drought 2%	Drought 50%	Drought 0%	Drought 0%	Drought 0%	Wet 100%	Wet 0%	Dry 0%	Dry 0%	Drought /dry 0%	Drought 0%	Wet 0%
Winter-spring base flow 160 ML/d <sup>2</sup>	Drought 0%	Drought 0%	Drought 6%	Drought 1%	Dry 48%	Wet 43%	Wet 86%	Dry 92%	Dry 89%	Drought /dry 52%	Drought 82%	Wet 86%
Winter-spring fresh flow 300 ML/d (fish)	Drought 0%	Drought 6%	Drought 100%	Drought 0%	Dry 100%	Wet 20%	Wet 40%	Dry 100%	Dry 100%	Drought /dry 100%	Drought 100%	Wet 20% <sup>5</sup>
Winter-spring fresh flow 1800 ML/d (geomorphology)	n/a	n/a	n/a	n/a	n/a	Wet 50%	Wet 50%	Dry n/a	Dry n/a	Drought /dry n/a	Drought n/a	Wet 100%
Year-round bank full flow 6000 ML/d	n/a	n/a	n/a	n/a	n/a	Drought 0%	Wet 100%	Dry n/a	Dry n/a	Drought /dry n/a	Drought n/a	Wet 100%
Winter-spring overbank flow 9000 ML/d	n/a	n/a	n/a	n/a	n/a	Drought 0%	Drought 0%	Dry n/a	Dry n/a	Drought /dry n/a	Drought n/a	Wet n/a

<sup>1</sup> Flow compliance in 2015-16 was assessed at Sandford, rather than Dergholm, due to inaccuracy of the Dergholm gauge during periods of low flow.

<sup>2</sup> The baseflow compliance includes the application of the 'or natural' provision, which results in quite high flow compliance despite flow in the system being limited and posing risks to the ecology of the system throughout these periods.

<sup>3</sup> Flow compliance was only assessed for the December 2016 to February 2017 period, which represents half of the season in which these flows can be delivered. This compliance statistic may therefore differ once the season is complete.

<sup>4</sup> No events achieved the recommended specifications. One event approached the magnitude but did not strictly achieve the requirement.

<sup>5</sup> Although the flow was above the threshold for much of this period, because of the independence criteria, there was only one fresh event that met the recommendation specifications.



## Shared community benefits

High natural winter/spring flows and delivery of environmental water in 2016-17 increased ecosystem resilience and also provided many benefits to local communities. Some examples of the benefits these shared benefits are outlined in Table 6 (page 17) and Case studies 3 (page 17) and 4 (page 18).

**TABLE 6. SHARED BENEFITS ASSOCIATED WITH ENVIRONMENTAL WATERING IN 2016-17**

User group	Description of shared benefit
Traditional owner groups	The timing of the second summer fresh (late-February 2017) was coordinated to support contemporary cultural outcomes on the Glenelg River at the annual Johnny Mullagh Cricket match between the Gunditj Mirring and Barengi Gadjin Traditional Owners. The fresh helped to improve water quality in swimming holes and improve amenity for the traditional owners attending the cricket event, an important cultural event held on the river.
Landholders	The baseflow and freshes made throughout summer and autumn assisted in preventing steep declines in water quality (particularly salinity), which helped to maintain a water quality within a suitable range for stock and domestic use.
Recreational users/environment groups/local businesses	The summer fresh released in December 2016 provided a freshening flow which improved water quality in popular swimming holes at camp grounds in the upper reaches of the Glenelg River (including Fulham Reserve near Balmoral and the Johnny Mullagh Reserve at Harrow). The release improved amenity and water quality for swimmers and campers over Christmas and New Year holiday period.
	Details of the summer fresh released during December was shared with the community and assisted to improve accessibility, water quality and amenity for canoeists planning trips on the Glenelg River over the Christmas break (refer to case study below).
	Environmental water releases were delivered to support the spawning and recruitment of native fish, including popular angling species like estuary perch and bream. Local anglers have reported an increase in fish activity associated with the delivery of freshes, improving fishing opportunities in the river.

### CASE STUDY 3. RIDING THE FLOW

Knowing the timing of environmental water releases along the Glenelg River, meant George Turner could plan an adventure of a lifetime with his family, on a rarely paddled stretch of the Glenelg.

George Turner knows the lower Glenelg well. Originally hailing from the Coleraine area, he estimates he's canoed from Dartmoor to Nelson a least a dozen times in his life.

Now Adelaide based and with a family in tow, the 44-year old surveyor's fondness for the Glenelg River remains. That's why when he was planning his Christmas holidays last year, his thoughts turn to canoeing the Glenelg with his family, his partner Sue and his two sons aged 10 and 12.

He thought, maybe given the wet year of 2016, they might be able to canoe beyond the typical Glenelg river canoeing route into the area north of Dartmoor.

But before he planned a trip, he wanted to be certain there'd be enough water to paddle on. "I wanted to know how canoeable different sections of the river would be," he said.

He figured, if they could time their adventure with an environmental flow, they'd be assured a clear passage. Wanting to find out more about river condition and planned environmental flows he contacted Glenelg Hopkins CMA. Talking with Water Manager Bryce Morden, he was able to plan a 40-km trip upstream of Dartmoor around the timing of the environmental flow.

Using river height data, they estimated when the fresh would reach the area of river his family was hoping to paddle. "It's always going to be better from a canoeing perspective, jumping in your boat when there is extra water around,"

### CASE STUDY 3. RIDING THE FLOW

George said. "Knowing what is happening on the water is very helpful. It's useful for knowing if the trip is viable and for managing any threats and risks to the trip," he said.

From December 27 to December 29 2016 George and his family enjoyed the benefits of the December fresh as they navigated a rarely canoed stretch of the Glenelg River north of Dartmoor



**George's sons preparing for the day of paddling ahead (courtesy of George Turner)**

George said he was impressed by the range of wildlife they saw along the river. "The wildlife was pretty amazing. We saw platypus, wedgetail eagles, koalas, emus, kangaroos and snakes." He said finding sandy spots along the Glenelg to pitch a tent was easy, and the kids loved every minute.

Bryce Morden said part of the reason for releasing water into the Glenelg from Rocklands in early December was so it can benefit holiday makers in the lower reaches later in the month. He said it was gratifying to be able to help people like George and his family enjoy some of what the Glenelg River has to offer. "Environmental water supports more than just plants and animals, it's for people too. It's good that message is getting out there about environmental flows and people like George are taking up the opportunity to speak with us about them to help them plan their recreational activities like canoeing."

### CASE STUDY 4. USING ENVIRONMENTAL WATER TO SUPPORT CULTURAL VALUES

In a first for Victoria, an environmental water release in early 2017 was delivered to support environmental outcomes as well as Aboriginal values on the Glenelg River.

By improving the health of the Glenelg River and its associated wetlands and floodplains, environmental water creates community benefits. The water released from Rocklands Reservoir between 21<sup>st</sup> February and 1<sup>st</sup> March aimed to improve river health and reduce salinity, at the same time as helping to sustain the health of Country for Traditional Owners who have a continuing connection to the river system.

Aboriginal water values for the Glenelg River are being identified as part of a two-year partnership project involving Gunditj Mirring Traditional Owners Aboriginal Corporation, Barengi Gadjin Land Council and Glenelg Hopkins CMA. Adjusting planned environmental water releases to better protect Aboriginal values at culturally significant locations, such as Harrow, is an important outcome of the project.

Some of the Aboriginal values at Harrow that can be supported by environmental water releases include cultural

#### CASE STUDY 4. USING ENVIRONMENTAL WATER TO SUPPORT CULTURAL VALUES

heritage sites, particularly scarred trees and native plants which are sources of traditional foods and medicines. These values would have benefited from the March environmental water release.



**Cricketers and supporters Shane Bell, Elder Laura Bell, Tyson Lovett-Murray (photo courtesy of GMTOC)**

The timing of the environmental flow was planned to coincide with the March long-weekend, freshening water quality for native plants and animals and improving useability and amenity for river users. This benefited people attending the Johnny Mullagh Cricket Competition, an annual event held in Harrow that recognises the first all-Aboriginal cricket team which toured internationally. Each year a team of Indigenous cricketers and a local cricket team vie for the Johnny Mullagh Memorial Cup.

#### 5. Scenario planning and prioritisation

In reviewing recent catchment and ecological conditions, the overarching ecological objectives and priority environmental watering in 2017-18 are described under various scenario's in Table 7 (page 20). The volumes of environmental water required to meet these needs is outlined in Table 8 (page 22).

Highest priority ecological objectives for the Glenelg River in 2017-18 are to:

- provide optimum flows to promote the spawning of small bodied native fish species
- support the recruitment of juvenile native fish
- assist in the recovery and reestablishment of instream and riparian vegetation following the recent high flows.

TABLE 7 PRIORITIES UNDER VARIOUS CLIMATIC SCENARIOS 2017-18

		2017-18											
		DROUGHT/DRY			AVERAGE			WET					
Ecological objectives		<ul style="list-style-type: none"> <li>Protect and maintain water quality to provide suitable habitat in drought refuges to support juvenile fish, macroinvertebrates and other water-dependant animals</li> <li>Ensure a range refuges are available throughout the system to support populations of water-dependant animals, such as platypus, water rats and water birds.</li> </ul>			<ul style="list-style-type: none"> <li>Promote the recruitment of juvenile native fish, providing opportunities to migrate and access a range of habitats and food resources</li> <li>Support the reestablishment of small-bodied native fish populations in the upper Glenelg River and associated wetlands (Fraser's Swamp)</li> <li>Support the upstream migration of diadromous species to complete their lifecycles</li> <li>Foster the establishment and growth of riparian vegetation and recovery of instream vegetation post-floods</li> </ul>			<ul style="list-style-type: none"> <li>Restore floodplain connectivity to maximise carbon inputs to the river which provide food resources for aquatic species (non-managed)</li> <li>Complement floodplain inundation and provide supplementary summer flows to promote vegetation health and recruitment</li> </ul>					
	Possible river flows	<ul style="list-style-type: none"> <li>Unregulated flows: Localised rainfall events possible that may provide some flow variability at discrete locations</li> <li>Passing flows: Some passing flows will contribute to baseflows over winter/spring</li> <li>Glenelg River compensation flow: Delivery of some compensation flow to supplement farm water storages and contribute to improved water quality in the river for stock and domestic use.</li> </ul>			<ul style="list-style-type: none"> <li>Unregulated flows: Significant unregulated winter/spring flows which may contribute to the achievement of baseflow and fresh requirements throughout the system</li> <li>Passing flows: Passing flows will supplement baseflow requirements over winter/spring</li> <li>Glenelg River compensation flow: Possible delivery of some compensation flow depending on catchment conditions and farm storage levels</li> </ul>			<ul style="list-style-type: none"> <li>Unregulated flows: Sustained unregulated winter/spring flows that will contribute to the achievement of baseflow and fresh requirements throughout the system, in addition to bank-full and overbank flows</li> <li>Passing flows: Passing flows meet baseflow requirements over winter/spring</li> <li>Glenelg River compensation flow: No delivery of the compensation flow is likely under a wet scenario as farm water storages are likely to be full and unregulated flows will contribute to freshening of water quality in the Glenelg River</li> </ul>					
Priorities for environmental water management		Reach 0	Reach 1a	Reach 1b	Reach 2	Reach 0	Reach 1a	Reach 1b	Reach 2	Reach 0	Reach 1a	Reach 1b	Reach 2
Summer/autumn Fresh		N/A	High	Very high	Very high	N/A	High	Very high	Very high	N/A	High	High	High
Summer/autumn baseflow			Medium	Very high	Very high		Very high	Very high	Very high		Very high	High	Very high
Winter/spring Fresh			N/A	High	High		N/A	Very high	Very high		N/A	High	Medium
Winter/spring baseflows			Medium	Medium	Low		Very high	Medium	Low		High	Medium	Low
Summer/autumn cease-to-flow				Low				Low				Low	
Trial release <sup>1</sup>		Medium		N/A		Very high		N/A		High		N/A	
Comments	<p>Providing summer/autumn flows to target both reaches 1b and 2 is a priority under a drought/dry scenario as these parts of the system are significantly impacted by sand inputs and salt water intrusion, which compound issues associated with reduced habitat availability and water quality during low flow conditions (refer to Case study 5 for further information). These issues increase survival risks to fish populations, particularly juvenile fish, which are a priority objective in 2017-18 post-floods.</p> <p>Supporting the recovery of instream and bank vegetation is also important in both reaches 1b and 2 to assist in stabilising sand and ensuring sufficient food and shelter is available in refuge pools for fish under a drought/dry scenario.</p> <p>Under an average scenario, reaches 1a, 1b and 2 are considered a priority for environmental water management, with the aim of assisting in system recovery following successive years of unfavourable and extreme conditions.</p> <p>The provision of winter/spring flows is important to ensure we can provide flows to facilitate the migration and spawning of native fish that may not have successfully recruited in recent years. Extending these events to target reach 2 will ensure maximum connectivity to facilitate the movement of native fish throughout the upper reaches and allow diadromous species to migrate from the estuarine reaches to spawn.</p> <p>Typically, under a wet scenario a significant portion of the priority winter/spring watering is achieved naturally, with environmental watering focusing on augmenting natural flows to assist in achieving environmental objectives, such as through the provision of additional freshes or extending the duration of flow events, where operationally possible.</p> <p>The provision of summer/autumn flows will remain a priority, particularly if natural flows subside prior to the commencement of summer. Providing summer/autumn baseflows to Reach 1a is considered a priority objective as this reach is most impacted by Rocklands Reservoir, even under wet catchment conditions. Reach 2 is considered a higher priority than reach 1b as this is where many of the important native fish populations in the Glenelg River are concentrated. Providing flows to target reach 2 will maximise benefits for these fish populations, and provide benefits to reach 1b en route.</p>												

2017-18		
DROUGHT/DRY	AVERAGE	WET
<p>Integrated river health works implemented in combination with environmental water have seen significant improvements in outcomes in reach 2, demonstrated by the increase in range of both estuary perch and tupoing by over 200kms as far as Fulham Reserve (in reach 1b). Continuing to support this reach under a drought/dry scenario in 2017-18 will help to ensure the habitat is maintained, building resilience and enabling populations to continue to expand.</p> <p>Under a drought scenario, reserving water for carryover is not considered critical. The impact of managing under a drought scenario when water availability is not constrained may have significant ecological impacts, putting undue stress on vulnerable populations.</p>	<p>Under an average and wet scenario, conditions are likely to be suitable to support the reestablishment of small-bodied native fish populations in the upper Glenelg River (reach 1a) and Frasers Swamp, which contains ideal habitat and refuge for these species.</p>	<p>Under a wet scenario, reserving water through carryover to support the delivery of outcomes in drier scenarios is considered critical, particularly given the high degree of natural achievement of flows during these conditions.</p>

<sup>1</sup> A trial release to Reach 0 is proposed under average to wet conditions. Reach 0 is an ecologically rich reach located in the Grampians National Park that is relatively undisturbed, with diverse and high-value riparian swamp habitat. A key objective of a trial release to Reach 0 would be to develop an operational understanding of our ability to deliver environmental flows to support values in this reach. Hydraulic models of the reach have not been able to be developed due to the thick vegetation and poorly defined bed within the reach. A pilot flow presents an opportunity to measure rather than model depth and extent of flows at different flow rates, using new gauges which are planned to be installed under a project funded by DELWP in 2016-17.

TABLE 8. ENVIRONMENTAL WATER DEMANDS 2017-18

Note: Priorities under drought and dry scenarios were combined in the previous section (Table 7 – page 20) as the ecological objectives are very similar. Environmental water demands under these scenarios have been separated in Table 8 as there is assumed to be some variation in flow and climatic conditions which alter expected demands.

Scenario	DROUGHT	DRY	AVERAGE	WET
Environmental water requirement	High priority environmental water actions	<ul style="list-style-type: none"> <li>Summer/autumn freshes – R1b &amp; R2</li> <li>Summer/autumn baseflows – R1b &amp; R2</li> <li>Winter/spring freshes – R1b &amp; R2</li> <li>Summer/autumn freshes – R1a</li> </ul>	<ul style="list-style-type: none"> <li>Summer/autumn freshes – R1b &amp; R2</li> <li>Summer/autumn baseflows – R1a, R1b &amp; R2</li> <li>Winter/spring freshes – R1b &amp; R2</li> <li>Summer/autumn freshes – R1a</li> <li>Winter/spring baseflows – R1a</li> <li>Trial release – RO</li> </ul>	<ul style="list-style-type: none"> <li>Summer/autumn baseflows – R1a &amp; R2</li> <li>Summer/autumn freshes – R1a, R1b &amp; R2</li> <li>Summer/autumn baseflows – R1b</li> <li>Winter/spring freshes – R1b</li> <li>Winter/spring baseflows – R1a</li> <li>Trial release – RO</li> </ul>
	High priority demands	12,280 ML	27,760 ML	27,110 ML
Additional priority environmental water actions	<ul style="list-style-type: none"> <li>Summer/autumn baseflows – R1a</li> <li>Winter/spring baseflows – R1a, R1b &amp; R2</li> </ul>	<ul style="list-style-type: none"> <li>Summer/autumn baseflows – R1a</li> <li>Winter/spring baseflows – R1a, R1b &amp; R2</li> </ul>	<ul style="list-style-type: none"> <li>Winter/spring baseflows – R1b &amp; R2</li> </ul>	<ul style="list-style-type: none"> <li>Winter/spring baseflows – R1b &amp; R2</li> <li>Winter/spring freshes – R2</li> </ul>
	Additional priority demands	11,760 ML	18,200 ML	20,780 ML
Total environmental water demand	21,640 ML	22,500 ML	53,240 ML	47,890 ML
	0 ML	1,260 ML	23,660 ML	36,400 ML
Assumed contribution from unregulated or passing flows (excluded from demands)				

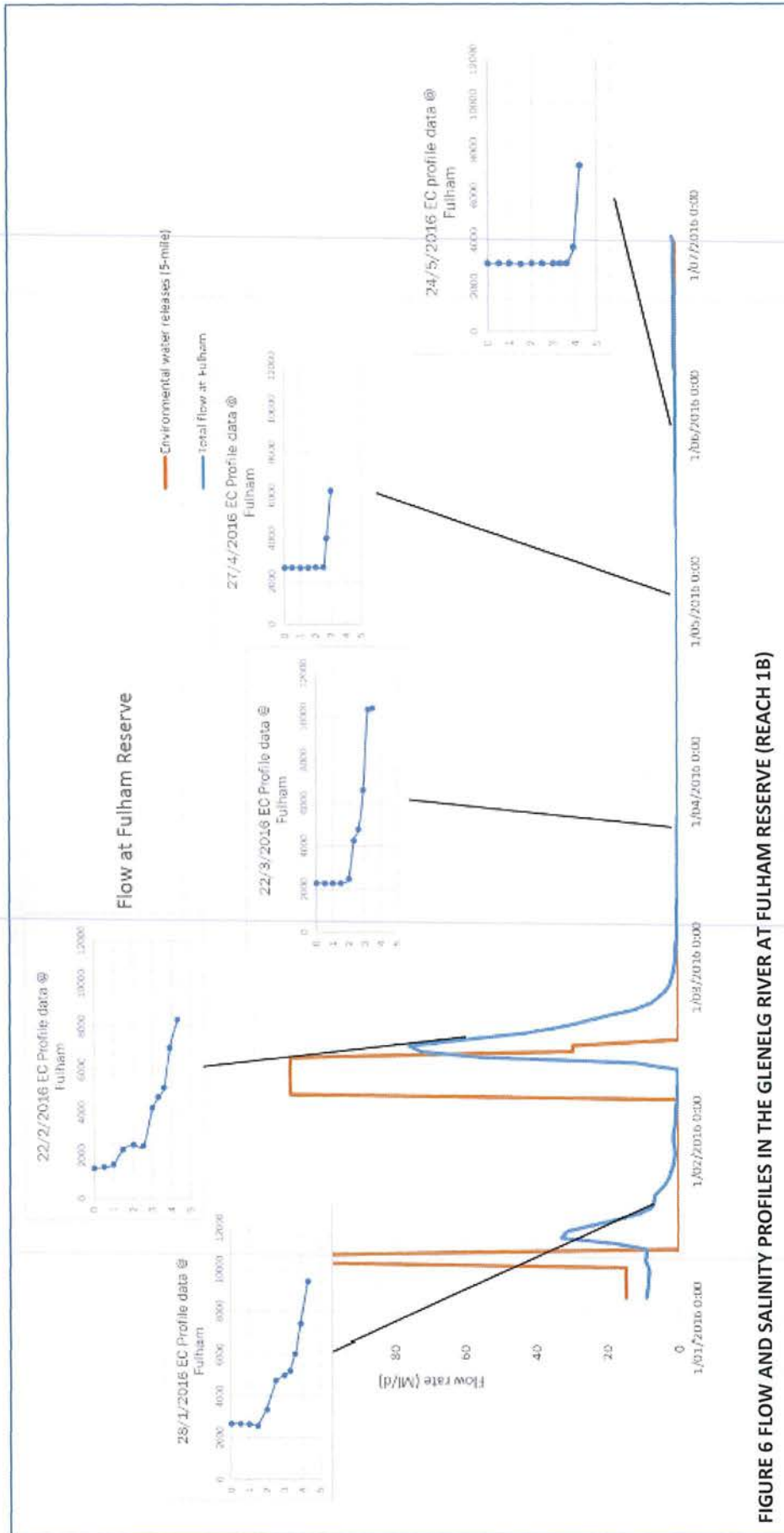
#### CASE STUDY 5. COMPOUNDING RISKS DURING LOW FLOWS – SAND, SALT AND HABITAT

The Glenelg River has been significantly affected by sand slugs generated by sheet and gully erosion of hillslopes and tributaries in the upper and mid reaches of the catchment, reducing channel capacity by up to sixty percent.

The build-up of sand has had many adverse impacts on the system – resulting in smoothing of the river bed, and smothering of coarse substrates, woody debris and macrophytes. This has resulted in the river becoming shallower in parts, with a reduction in the number and depth of deep holes that provide cool and well oxygenated habitat and refuge for aquatic biota.

The impact of this reduced habitat is compounded by saline groundwater intrusion in the deep pools and inflows from highly saline tributaries, where base salinities regularly reach 10,000 EC. Insufficient dilution and mixing of water in the deep pools coupled with sand deposition further reduces the availability refuge habitat for biota, particularly during the warm summer and autumn periods.

During summer and autumn, baseflows assist in maintaining a freshwater lens on the surface of stratified pools, providing some refuge habitat with suitable water quality. However, baseflows alone are insufficient to mix or improve water quality throughout the water column, with freshes critical in achieving this objective. Fresh events are effective at breaking down stratification and restoring water quality, as can be seen in Figure 6 (page 24), where a fresh released in February 2016 halved the surface water salinity levels and reduced the salinity at depth by over 1,000 EC. This was particularly significant given the extremely dry conditions and reduced habitat availability experienced during 2015-16.



**FIGURE 6 FLOW AND SALINITY PROFILES IN THE GLENELG RIVER AT FULHAM RESERVE (REACH 1B)**



## Shared community benefits

In general, stakeholders and the community are broadly supportive of environmental watering in the Glenelg River and believe that the objectives and priorities identified for environmental watering in 2017-18 were appropriate.

There are however many elements of environmental water management that are still largely unknown or unclear to community, which were reiterated in our recent consultation. A summary of the key questions that were raised through the community consultation process are listed below.

### *Common questions on environmental watering in the Glenelg River*

- Isn't the water just wasted out to sea?
- Why does environmental water get released when there is already water in the river?
- How does the Compensation Flow fit in?
- Why do we put water down the river in summer, when it would naturally have been dry?
- When are environmental water releases going to be made?
- Does environmental watering happen during floods?
- Why can't we hold passing flows off during winter so they can be used in summer?
- Why does so much of the inflow to Rocklands Reservoir go north?
- The river used to be a chain of pools – why can't it stay that way?
- Release rates are sometimes so high that they inundate wetlands and billabongs along the river (in the upper reaches particularly). Do they need to be this high? Is this a waste of water?
- How does environmental watering effect fishing?
- Where are yabbies/fish? Is there anything biting?

These questions will inform our areas of focus for ongoing communication and engagement activities.

A range of opportunities to maximise shared benefits were identified through our community consultation process. The alignment of these opportunities to environmental watering objectives, and consideration of the feasibility of actioning these opportunities in 2017-18 is outlined in Table 9 (page 26).

**TABLE 9. DELIVERING ON SHARED BENEFITS IN 2017-18**

Stakeholder	Connection to the river	Shared benefit opportunities identified through engagement	How will this opportunity be considered environmental watering in 2017-18
Indigenous groups	Maintaining healthy Country is vitally important to the Traditional Owners of the Glenelg River, who have a continuing connection to the system.	Supporting the health of cultural heritage sites, such as scar trees and the health of native plants which are sources of traditional foods and medicines  Supporting contemporary cultural events, such as the Johnny Mullagh Cup by improving water quality and amenity for river users during this event (refer to Case study 4 for further information).	Environmental watering aims to maintain the health of instream and riparian vegetation, which includes many culturally important species. However, further work is required to understand the feasibility of using environmental water to maintain the health of scar trees located on the floodplain.  The Johnny Mullagh Cup is typically held on the March long weekend. Depending on the climate and catchment conditions, a summer/autumn fresh may need to be delivered around this time of year. GHCMA will continue to liaise with Traditional Owners regarding the feasibility of providing a fresh in the lead-up to this event.
Landholders	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.	Delivery of environmental water in addition to the Glenelg River Compensation Flow is considered important to support stock and domestic needs, particularly during the summer period.  Landholders reinforced the importance of the Compensation Flow in supporting their businesses. They were generally supportive of this being prioritised for use during low inflow years when users are most reliant on the river to support their stock watering needs	The delivery of environmental water, in addition to the Glenelg River Compensation Flow, helps to increase flow and improve water quality for stock and domestic use. The highest priority time of year for the use of both these water products is summer/autumn, which aligns with the feedback from landholders. This is the period when risks to the environment are highest, and when there is often the greatest reliance on the Compensation Flow to support stock and domestic needs.  The identified priority for the use of the Compensation Flow during the summer period in dry years will be used to inform the development of the Annual Operating Plan for the use of the Glenelg Compensation flow (developed by GHCMA in consultation with VEW and GWMWater).
Recreational users	Recreation plays an important role in the region, both within the river and at Rocklands Reservoir.  There are varied views on how environmental water could be used to support recreational use, largely depending on the type of recreation being undertaken and the preferred location of these activities.	Retaining water in Rocklands Reservoir for recreation (such as water skiing and angling), with less water being released or transferred from the reservoir.	Rocklands Reservoir is an important asset to many recreational users. The reservoir is also the only source of supply for the Glenelg River. As such, maintaining levels in Rocklands would come at a direct cost to the health of the Glenelg River. From an ecological perspective, the benefits of releasing water to the Glenelg River, which provides important benefits throughout the 350 kilometre of river, are considered greater than retaining water in Rocklands Reservoir.  There are competing demands from communities throughout the Glenelg catchment. These communities all appreciate water in their towns particularly during holiday periods. Reservoirs such as Rocklands is an important community asset, as are river-based camping areas such as Fulham Reserve near Balmoral, which experiences significant visitation during these

Stakeholder	Connection to the river	Shared benefit opportunities identified through engagement	How will this opportunity be considered environmental watering in 2017-18
		<p>Extending the target location of flows in the Glenelg River to maximise fishing opportunities, improve amenity, and water quality for communities in the upper and mid reaches of the system (at least to Casterton).</p> <p>Environmental flows facilitate improved access for activities such as canoeing, with flow supporting paddling trips on the Glenelg River. Greater access to information would improve opportunities in the upper reaches of the system.</p>	<p>Further work is required to understand how to best balance community values in relation to recreation throughout the catchment.</p> <p>The priority for 2017-18 will be extending flows to achieve outcomes in reach 2, to maximise connectivity throughout the upper reaches of the system. This will support improved amenity, fishing opportunities and water quality for communities throughout the upper and mid reaches of the Glenelg catchment. The releases support numerous fishing competitions ran by the Balmoral, Casterton and Dartmoor angling clubs. Our ability to deliver these outcomes will be dependent on decisions made by the VEWH regarding the volume of water available for use in the Glenelg River.</p> <p>Environmental water releases will continue to provide opportunities for activities such as canoeing, through increased flow and improved longitudinal connectivity, particularly in the upper reaches of the system.</p> <p>GHCMA have increased communications around planned environmental water releases through inclusion of information in local newspapers, on social media, and text message notifications. We are continuing to expand our networks and the reach of our communications to capture audiences such as canoeist and other river users.</p>
Environment groups	<p>Environmental groups are supportive of environmental watering and have long been advocates of maintaining the health of the Glenelg River.</p>	<p>Ensuring sufficient environmental water is made available to support the important environmental values in the Glenelg River, particularly in drier years.</p>	<p>This seasonal watering proposal specifies the volumes of water required to maintain and improved the health of the Glenelg River under a range of climatic conditions. Decisions on the volume of water allocated to the river are made by the VEWH, drawing on information from this proposal.</p>
Local businesses	<p>Views on how benefits to local businesses can be maximised from environmental watering are varied throughout the catchment.</p>	<p>Retaining water in Rocklands Reservoir to support tourism in towns in the upper Glenelg</p>	<p>Rocklands Reservoir is an important asset to many recreational users. The reservoir is also the only source of supply for the Glenelg River. As such, maintaining levels in Rocklands would come at a direct cost to the health of the Glenelg River. From an ecological perspective, the benefits of releasing water to the Glenelg River, which provides important benefits throughout 350 kilometre of river, are considered greater than the ecological benefits of retaining water in Rocklands Reservoir.</p> <p>There are competing demands from communities throughout the Glenelg catchment, who all appreciate water in their towns particularly during holiday periods. Further work is required to understand how to best balance community values in relation to recreation throughout the catchment.</p>

Stakeholder	Connection to the river	Shared benefit opportunities identified through engagement	How will this opportunity be considered environmental watering in 2017-18
		<p>Accumulating passing flows during the winter/spring period, to ensure that sufficient water is available to support flows throughout the summer period, particularly in the mid-reaches of the Glenelg River (around Casterton)</p>	<p>There are some provisions within the environmental entitlement that allow for passing flows to be accumulated for ecological reasons (subject to agreement of the GWM/Water Storage Manager).</p> <p>Passing flows delivered during winter/spring support important environmental outcomes, such as increasing the wetted area of the banks from lower flow periods in summer, maintaining shallow water habitat and facilitating the annual dispersal of juvenile platypus. Accumulating passing flows for delivery during summer would need to consider the impacts on these outcomes.</p> <p>The environmental watering priorities identified in this proposal have been designed to provide sufficient water to achieve environmental outcomes extending to reach 2, particularly during the summer period. The ability to deliver these flows will be subject to sufficient water being authorised for use by the VEWLH.</p>

## 6. Delivery Constraints

Headworks system infrastructure constraints have been documented in operating arrangements (VEWH 2016). In planning for the delivery of environmental water, the delivery constraints outlined in Table 10 (page 29) have been identified as being noteworthy for the 2017-18 year.

**TABLE 10 SUMMARY OF DELIVERY CONSTRAINTS**

Site	Reach	Issue and impact
All reaches	All	GWMWater has limited resources available for delivery operations at Rocklands Reservoir. Issues may arise where not all flow plans are delivered in line with agreed flow plans. Staff availability, equipment failures and emergencies can impact on flow resulting in under or over delivery of flows. Close communication between GWMWater and Glenelg Hopkins CMA will aim to develop pragmatic solutions when these issues arise.
Frasers Swamp	1a	River channel constraints in reach 1a result in inundation of private land when release rates exceed 100 ML per day. As a result, no flows above this rate are planned.  If downstream release points are unavailable, larger releases may be required through this reach. However, landholder agreements will be sought and it is expected that agreement could be reached, if required.
5 and 12-Mile outlets	1b	Funding is currently being sought for repairs and improvements of infrastructure at the 5-Mile channel outlet on the Rocklands-Toolondo channel. These works are likely to require an empty channel, and therefore GHCMA will work closely with GWMWater to manage any impact to environmental flow releases.  The 12-Mile outlet to the Glenelg River has not been used since 2015-16 to deliver freshes to Reach 1b. Safety concerns prevent active regulation at this outlet when the channel has water in it. Upgrade works are also planned to improve operational flexibility of this outlet in future.

## 7. Increasing knowledge

The Glenelg River has been part of the VEFMAP for several years. However, VEFMAP entered a new phase in 2016-17, with more targeted monitoring to address key knowledge gaps. For the Glenelg River, monitoring is focussed on the impact of flow on fish movement, specifically tupong and estuary perch, in addition to some additional fish surveys.

Current monitoring activities and their purpose are outlined in Table 11 (page 30). These basic monitoring activities are critical to ensure we can demonstrate the environmental benefits of environmental watering in the Glenelg River. Information gathered through these projects helps to provide confidence that we are getting outcomes from environmental watering, which is critical in maintaining and increasing community support for the environmental watering program.

**TABLE 11 CURRENT GLENELG RIVER ENVIRONMENTAL FLOW MONITORING**

Reaches	Monitoring	Measures	Monitoring sites and frequency	Purpose	Funding certainty in 2017-18
1a, 1b, 2 & 3	Migratory fish tracking (VEFMAP)	Fish movement (Tupong and Estuary Perch)	18 sites monitored over a 3-18 month period	Tracking fish movement in response to flow using acoustic tags	TBC – the VEFMAP monitoring program is currently unclear
1b & 2	Deep pool monitoring (February to June 2017 – VEWH)	Salinity and dissolved oxygen	3 sites monitored monthly	Monitoring of water quality parameters at various depths to track response to flow	No
1a, 1b, 2 & 3	Fish monitoring (VEFMAP)	Abundance and species richness	TBD	Monitor fish abundance and species richness	TBC – the VEFMAP monitoring program is currently unclear
1a, 1b, 2 & 3	Hydrology	Gauged flow	6 sites - continuous	Monitor hydrological response of releases at various locations throughout the system	Yes – funded under the South-west Surface Water Monitoring Partnership (with the exception of the PALS at reach 1a)
1a & 1b	Stream condition	Photo points	5 sites – ad hoc	Track long-term changes in stream condition over time	Yes – DELWP funded through EC4

This seasonal watering proposal has been developed using the best available information. Priority areas to increase knowledge, and the impact these knowledge gaps have on environmental water management are outlined in Table 12 (page 30).

**TABLE 12 KNOWLEDGE GAPS**

Area	Knowledge gap	Impact on environmental water management	Funding certainty to address knowledge gap?
Flow gauging/metering	Gauging in Reach 1a to assess flow performance	The PALS unit used in 2015-16 and 2016-17 provided critical information on the performance of environmental flows in this reach. Information from this gauge guides decisions to adapt release plans and provides information on the impact of Frasers Swamp on releases under differing flow conditions.  A permanent flow rated gauge will be important to ensure we are delivering environmental water in the most efficient way possible, particularly during low flow conditions.	No

	Gauging in Reach 0 to understand flow paths and environmental water requirements	Additional gauging is required to improve information about flows currently occurring in this regulated river reach along with further analysis to identify gaps between the current and recommended flow regime. Installation of three temporary stream flow gauges with analysis of flow data is required to inform management of future environmental releases from Moora Moora Reservoir to the Glenelg River.	Yes, funded through DELWP in 2017-18
Environmental flow requirements	Environmental flow requirements under low flows	The current flow study has drought conditions defined as <75% probability of exceedance (POE) inflow. This does not allow for effective management decisions under lower POEs, as experienced during 2015-16. Having recommendations for flows at 90% POE will improve the information available to inform management decisions and assist in protecting environmental values during these periods, which are becoming more frequent.	No
	Defining an 'or natural' flow state for base flow conditions	The flow study for the Glenelg River includes an 'or natural' flow state for baseflow conditions. However, the application of this condition is not well understood. Understanding how this should be factored into decision making would enable us to ensure we do not exceed dry tolerances, but also potentially allow us to make the most efficient use of available water during lower flows.	No
	Glenelg Spiny Crayfish flow requirements	There is currently limited information available on the flow requirements of the endangered Glenelg Spiny crayfish. Further research is required to ensure flows support this important threatened species.	No
Ecological response	Seasonal responses of fish to flows	<p>Little is understood about how fish population composition changes with seasonal flow conditions, particularly migratory species.</p> <p>For example, estuary perch within the Glenelg River have demonstrated a strong response to environmental flows in recent years, migrating much further upstream than has been observed in other parts of Victoria. Understanding the drivers of this migratory behaviour will help to ensure environmental water is managed in a way to best suit the needs of the species.</p> <p>Further investigations, similar to that undertaken as part of the VEFMAP program in 2016-17 is required to ensure we have solid evidence that flows are achieving their intended objectives in the most efficient way possible.</p>	Possibly as part of VEFMAP

## 8. Risk management

Intervening in waterways through environmental flow management has inherent risk. A risk management workshop involving GWMWater, VEWH, Wimmera CMA and Glenelg Hopkins CMA was held in February 2017. This workshop produced the risk assessment and mitigation presented in Table 13 (page 32). Risks have been discussed, described and assessed with actions developed to manage and mitigate these risks.

TABLE 13 RISK DESCRIPTION, ASSESSMENT AND MITIGATION

Risk category	Risk description	Likelihood	Consequence	Risk rating	Mitigation	Coordinating agency
Environment/ sustainability	Flow rate at environmental flow compliance point not able to be demonstrated, which may lead to failure to achieve target flows and environmental benefits not being achieved.	Likely	Moderate	High	Install/upgrade stream gauge monitoring, in collaboration with GWMWater, to improve ability to demonstrate target flow rate achieved.	VEWH
	Target flow rate at environmental flow compliance point not achieved due to environmental conditions, (for example high losses at very dry sites, hot weather causing excessive evaporation, antecedent conditions and inflow rates) and environmental benefits not being achieved.	Likely	Moderate	High	Monitor flow rate and adjust delivery volume within approved volume.	CMA
	Target flow rate at environmental flow release or measurement point not delivered as ordered, leading to sub-optimal environmental outcomes.	Unlikely	Moderate	Medium	Monitor flow rate and adjust delivery to meet ordered flow rates. Ongoing communication with the CMA to manage infrastructure or maintenance constraints.	GWMWater GWMWater
	Environmental deliveries create improved conditions for non-native species (e.g. carp, invasive weeds) leading to adverse environmental impacts.	Possible	Minor	Medium	Adaptively manage flow to incorporate new knowledge from monitoring and research. Monitor invasive species extent and control existing populations (e.g. opportunistic removal of carp in dry conditions). Install physical barrier to prevent translocation (e.g. carp barriers). Develop management agreements with landholders that include pest plant and animal control measures.	CMA CMA CMA CMA
	Insufficient water available for proposed watering actions to meet environmental objectives.	Possible	Major	Extreme	Adaptively prioritise and revise watering actions to optimise outcomes from water available considering seasonal conditions. Prioritise sites and/or watering actions. Maximise use of consumptive water en route for environmental benefit. Consider reserving contingency volume for current year and balancing against carryover needs for future years. Communicate with community and stakeholders around planned watering actions and any revisions required. Undertake complementary actions (e.g. carp removal, fencing).	CMA VEWH GWMWater VEWH CMA CMA
	Environmental water deliveries may generate or mobilise poor quality water (e.g. blackwater, BGA), with adverse water quality and environmental outcomes ; or Areas not targeted for environmental watering actions experience poor quality water (e.g. blackwater, BGA), with adverse water quality and environmental outcomes	Possible	Moderate	High	Ongoing monitoring to inform water deliveries, including arranging improved access to data. Adapt flow management based on antecedent conditions and local knowledge. Maximise use of consumptive water en route for environmental benefit. Establish environmental reserve to manage needs. Communicate around current conditions and revised objectives. Undertake complementary actions, including provision of information to the community	CMA CMA GWMWater VEWH CMA CMA
	Environmental releases create rapid or unexpected changes in flow conditions, resulting in personal injury to river user.	Rare	Extreme	High	Communicate around flow deliveries to downstream communities and avoid rapid changes in water level during periods of high river use (e.g. using community SMS update service).	CMA
	Environmental releases cause unauthorised inundation of private land, resulting in impacts on landowner activities and assets	Possible	Moderate	Medium	Ongoing communications with GWMWater and land managers in planning and delivery phases. Consider weather forecasts when planning releases and reschedule deliveries if forecast indicate potential for flooding. Test and monitor delivery rate and respond to potential incidents. Maintain and inspect infrastructure, including upgrading infrastructure where required for deliveries.	CMA GWMWater GWMWater GWMWater CMA



Risk category	Risk description	Likelihood	Consequence	Risk rating	Mitigation	Coordinating agency
					Identify likely areas of impact by understanding historical impacts/ previous experiences and modify flow plans, or undertake works to reduce risk of inundation.	
	Where deliver structures are unsafe and have limitations on their operation, planned environmental deliveries may not be feasible leading to a failure to achieve environmental outcomes.	Rare	Extreme	High	Upgrade or modify infrastructure to improve safety. Modify method of operation to avoid unsafe work practices and update safety procedures to reflect this (note: safe work procedures may need to be communicated to community/volunteer resources as well as agency staff where they undertake structure operations).	Asset owner
Business cost	Insufficient staff resources available to deliver all planned environmental watering actions, leading to cancellation or interruption of deliveries.	Possible	Moderate	Medium	Ongoing communication with the GWMWater to understand constraints and develop a schedule of delivery to manage staff resources. Implement remote monitoring to minimise staff time in the field, within available funding. Continue to actively prioritise actions to match available resources and ensure key actions are delivered.	CMA GWMWater CMA
	Volume delivered or released exceeds volume approved and/or ordered for use in the event or year.	Rare	Moderate	Low	Communicate seasonal watering statements to all partners. Monitor delivery rate, provide delivery data to CMA/VEWH and respond to potential incidents. Monitor water use against volume approved for use in seasonal watering statement and adapt water orders if required. Monitor water use against volume approved and undertake regular communications with CMA and GWMWater as part of portfolio management activities. Prioritise sites and/or watering actions if insufficient water is available.	VEWH GWMWater CMA VEWH VEWH
Political/ reputational	Stakeholders and community groups are not supportive of environmental watering delivery.	Likely	Major	High	Engage with the local community through a variety of avenues (e.g. workshops, forums, individually to communicate benefits of environmental watering. Develop Statewide communication products and engage with peak bodies Each organisation will share their intended environmental water related communications plans with all partners.	CMA VEWH CMA/VEWH
	Inability to provide evidence that watering actions are achieving objectives, which may lead to a loss of public/political support for activities.	Likely	Moderate	High	Seek additional funding for and undertake targeted local monitoring (leveraging existing data sets where possible). Invest in monitoring and research to address knowledge gaps and influence existing monitoring programs. Share new knowledge to promote adaptive management. Communicate monitoring results to local communities	CMA VEWH VEWH CMA

9. Approval and endorsement

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This seasonal watering proposal was approved at the April 2016 meeting of the Glenelg Hopkins Catchment Management Authority Board of Directors.

APPROVAL

I, the authorised representative of the Glenelg Hopkins CMA, approve the Seasonal Watering Proposal for the Glenelg River 2016-17.

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**SIGNED FOR AND ON BEHALF OF Glenelg Hopkins Catchment Management Authority**



Signature of authorised representative

KEVIN WOOD CEO

Name of authorised representative

Date: 11 May 2017

## 10. Appendix 1

**TABLE 14. GLENELG RIVER ENVIRONMENTAL FLOW REQUIREMENTS AND ASSOCIATED OBJECTIVES**

Potential environmental watering	Environmental objectives
Summer/autumn freshes targeting reach 1a (2 freshes of 60 ML/day for 2–3 days each in December–May)	<ul style="list-style-type: none"> <li>• Provide variable flows during low-flow season to support diverse habitats</li> <li>• Facilitate localised scouring of sand for fish habitat</li> <li>• Maintain condition of emergent vegetation by wetting lower banks</li> <li>• Flush pools to prevent water quality decline during low flows</li> </ul>
Summer/autumn freshes targeting reaches 1b (2 freshes of 100 ML/day for 2–3 days each in December–May)	
Summer/autumn freshes targeting reach 2 (2 freshes of 150 ML/day for 2–3 days each in December–May)	
Summer/autumn baseflows targeting reach 1a (10 ML/day or natural in December–May) <sup>1</sup>	<ul style="list-style-type: none"> <li>• Protect against rapid water quality decline over low-flow period</li> <li>• Maintain edge habitats, pools and shallow water habitat availability for fish, waterbugs and platypus</li> <li>• Maintain a near-permanent inundated stream channel to prevent excessive in-stream terrestrial species growth and promote in-stream vegetation</li> </ul>
Summer/autumn baseflows targeting reach 1b (15 ML/day or natural in December–May) <sup>1</sup>	
Summer/autumn baseflows targeting reach 2 (25 ML/day or natural in December–May) <sup>1</sup>	
Winter/spring freshes targeting reach 1b (1–5 freshes of 250 ML/day for 1–5 days in June–November) <sup>2</sup>	<ul style="list-style-type: none"> <li>• Wet benches to improve condition of emergent vegetation and maintain habitat diversity</li> <li>• Increase the baseflow water depth and connectivity to provide stimulus and opportunity for fish movement</li> <li>• Facilitate localised scouring of sand for fish habitat</li> <li>• Maintain pools and inundate benches to improve in-stream habitat and vegetation diversity</li> </ul>
Winter/spring freshes targeting reach 2 (1–5 freshes of 300 ML/day for 1–5 days in June–November)	
Winter/spring baseflows targeting reach 1a (60 ML/day or natural in June–November) <sup>1</sup>	<ul style="list-style-type: none"> <li>• Provide desirable water quality conditions for fish, waterbugs and aquatic vegetation</li> <li>• Maintain seasonality of flows and improve habitat diversity by increasing wetted area from summer period</li> <li>• Maintain shallow water habitat availability for fish and waterbugs and facilitate annual dispersal of juvenile platypus</li> </ul>
Winter/spring baseflows targeting reach 1b (100 ML or natural per day in June–November) <sup>1</sup>	
Winter/spring baseflows targeting reach 2 (160 ML/day or natural in June–November) <sup>1</sup>	

In addition to these priorities, a pilot release to Reach 0 is proposed in 2017-18, subject to conditions. Refer to Section 5 - Scenario planning and prioritisation for further information.

<sup>1</sup> Cease-to-flow events occur naturally in the Glenelg River and may be actively managed. In the most recent flows study, the recommendation is that cease-to-flow events should occur as infrequently as possible and not exceed the duration of events that might have occurred naturally, to reduce stress on environmental values. Cease-to-flow events should be followed with a fresh.

<sup>2</sup> Winter/spring freshes in reach 1a are important to the health of the Glenelg River but due to operational constraints and potential flooding risks achievement relies solely on natural events.

11. Appendix 2

TABLE 15 DETAILED ENVIRONMENTAL WATER DEMANDS UNDER VARIOUS CLIMATIC SCENARIOS

DROUGHT		DRY								
Relative priority	System	Flow type	Season	Total volume required	Relative priority	System	Flow type	Season	Total volume required	
Very high	Glenelg River R1b	Freshes	Summer/autumn	2,000	Very high	Glenelg River R1b	Freshes	Summer/autumn	2,200	
	Glenelg River R2	Freshes	Summer/autumn	920		Glenelg River R2	Freshes	Summer/autumn	920	
	Glenelg River R1b	Baseflows	Summer/autumn	2,100		Glenelg River R1b	Baseflows	Summer/autumn	2,100	
	Glenelg River R2	Baseflows	Summer/autumn	2,240		Glenelg River R2	Baseflows	Summer/autumn	2,240	
High	Glenelg River R1b	Freshes	Winter/spring	1,360	High	Glenelg River R1b	Freshes	Winter/spring	3,560	
	Glenelg River R2	Freshes	Winter/spring	440		Glenelg River R2	Freshes	Winter/spring	440	
	Glenelg River R1a	Freshes	Summer/autumn	820		Glenelg River R1a	Freshes	Summer/autumn	820	
	Glenelg River R1a	Baseflows	Summer/autumn	1,120		Glenelg River R1a	Baseflows	Summer/autumn	840	
Medium	Glenelg River R1a	Baseflows	Winter/spring	2,240	Medium	Glenelg River R1a	Baseflows	Winter/spring	1,960	
	Glenelg River R1b	Baseflows	Winter/spring	3,360		Glenelg River R1b	Baseflows	Winter/spring	2,940	
	Glenelg River R2	Baseflows	Winter/spring	5,040		Glenelg River R2	Baseflows	Winter/spring	4,480	
	<b>Total demands</b>		<b>High priority</b>			<b>9,880</b>	<b>Total demands</b>		<b>High priority</b>	
Low	<b>Total demands</b>		<b>All priorities</b>		<b>21,640</b>	<b>Total demands</b>		<b>All priorities</b>		<b>22,500</b>

AVERAGE				WET					
Relative priority	System	Flow type	Season	Total volume required	Relative priority	System	Flow type	Season	Total volume required
Very high	Glenelg River R1b	Freshes	Summer/autumn	1,860	Very high	Glenelg River R1a	Baseflows	Summer/autumn	2,730
	Glenelg River R2	Freshes	Summer/autumn	630		Glenelg River R2	Baseflows	Summer/autumn	5,460
	Glenelg River R1a	Baseflows	Summer/autumn	2,730	High	Glenelg River R1b	Freshes	Summer/autumn	1,400
	Glenelg River R1b	Baseflows	Summer/autumn	4,550		Glenelg River R1a	Baseflows	Summer/autumn	3,640
	Glenelg River R2	Baseflows	Summer/autumn	5,460		Glenelg River R2	Freshes	Summer/autumn	700
	Glenelg River R1b	Freshes	Winter/spring	2,360		Glenelg River R1a	Freshes	Summer/autumn	740
	Glenelg River R2	Freshes	Winter/spring	1,730		Glenelg River R1b	Freshes	Winter/spring	5,060
	Glenelg River R1a	Baseflows	Winter/spring	7,280		Glenelg River R1a	Baseflows	Winter/spring	7,280
	Glenelg River R0	Baseflow	TBC	100		Glenelg River R0	Baseflow	TBC	100
	Glenelg River R1a	Freshes	Summer/autumn	1,060		Glenelg River R1b	Baseflows	Winter/spring	5,460
Glenelg River R1b	Baseflows	Winter/spring	10,920	Glenelg River R2		Freshes	Winter/spring	4,400	
Low	Glenelg River R2	Baseflows	Winter/spring	14,560		Low	Glenelg River R2	Baseflows	Winter/spring
<b>Total demands</b>				<b>27,760</b>	<b>Total demands</b>				<b>27,110</b>
<b>All priorities</b>				<b>53,240</b>	<b>All priorities</b>				<b>47,890</b>

