Lower Broken Creek

Seasonal Watering Proposal 2012/13

Goulburn Broken Catchment Management Authority

FINAL

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EXECUTIVE SUMMARY

This proposal details the rationale and quanta of environmental water entitlements, deployed in conjunction with other consumptive and seasonal flows, to realise designated environmental outcomes in the lower Broken Creek during 2012/13. Broken Creek is a popular recreational fishery, and supports substantial populations of the following threatened fish species: Murray Cod, Golden Perch, Silver Perch, Northern River Blackfish, Murray Rainbow Fish and Unspecked Hardyhead. Broken Creek enters the Ramsar-listed Barmah Wetland Forest downstream of Nathalia. It also acts as a major part of the irrigation distribution system for the (Victorian) Murray Irrigation Area.

Flows for the 2011/12 year were reasonably typical for a system with an inverted flow regime. Dry winter conditions saw passing flows at Rice's Weir fall to zero in July. Augmented flows occurred during spring and summer, enabling passing flows to continue through this period, and culminating in substantial floods in March 2012. Up until the end of February 2012, 2,388 ML of Murray in-transit water, 8,216 ML of Goulburn Water Quality Reserve, 9,803 ML of CEWH water, and 5,758 ML Inter-Valley Transfer has passed down the system with the objective of improving environmental outcomes, totalling 26,165 ML, of which 9,803ML was from environmental entitlements.

The focus in 2012/13 is to continue to provide the desirable flow regimes to protect and improve the native fish populations in the lower Broken Creek. This includes providing fish passage, providing improved fish habitat between September and December during the migration and breeding seasons, and importantly management of the threats to fish from excessive Azolla growth and low dissolved oxygen levels. Low dissolved oxygen (including that resuting from excessive azolla growth) prevents fish from breathing, dramatically redcuing the amount of suitable habitat and potentially leading to fish deaths as occurred in 2002.

The volumes of water required to provide for the all desirable environmental outcomes in the lower Broken Creek are shown in Table 1. Up to 59,000ML is required under the driest planning scenario.

Importantly, there is significant potential to use water-in-transit in the Murray and Goulburn River systems to provide much of these needs. Murray River water can be potentially diverted through the Broken Creek as well as Goulburn River Inter-Valley Transfers (to the Murray River) and returned to the Murray River. If these sources can be maximised, the need for additional environmental entitlement from the Goulburn system is substantially reduced. Predicting availability is, however, problematic.

The Goulburn Water Quality Reserve of up to 30,000 ML is also available to deal with emergency water quality issues (such as blackwater events).

The key risk to providing the desired environmental outcomes in the lower Broken Creek is the limitations placed on delivery of environmental water by irrigation demand. This limits the available channel capacity for delivery of water to the creek for environmental flow management, particularly to minimise the risk from low dissolved oxygen and Azolla accumulations. To minimise this impact as much as possible, the proposal seeks to have water available from both the Goulburn and Murray Rivers, to allow use of any available channel capacity to be maximised. It is also proposed to release high creek flows pre-emptively when high irrigation demand is imminent.

This proposal does not take account of competing needs for environmental water use from either other river/creek systems or downstream along the Murray River. However, water deployed in the creek returns to the Murray River and is available for use downstream.

As all of the flows proposed are well within the creek channel, there is very low risk of adverse outcomes to private assets or the general public from releasing environmental water.

Table 1: Environmental Water required under a range of planning scenarios in the Lower Broken Creek system

	Scenario		
	Drought (90% PoE)	**Average (50% POE)**	**Wet (30% PoE)**
Expected availability of water holdings	220 GL IVT 30 GL WQR	183 GL IVT 30 GL WQR	147 GL IVT 30 GL WQR
Targeted environmental objectives	Maintain critical refuge habitat and allow for movement through fish passages Avoid destructive accumulations of Azolla Maintain DO at non-lethal levels Provide fish spawning and migration activities		
Flow components	Passing flows all year =>40 ML/day Azolla management, Aug – Nov =>120 ML/day, plus 250 ML/day x 14 days for Azolla flushing DO management, Oct – May =>150 ML/day, plus 250 ML/day x 60 days for DO freshes Migration flows, Sep – Dec =>250 ML/day		
Likely volume required from water holdings	Max 59 GL	Max 40 GL	Max 35 GL

Contents

1 INTRODUCTION

This seasonal watering proposal describes the Goulburn Broken CMA's priorities and recommendations for use of environmental water and 'consumptive' water delivered to achieve environmental outcomes) during the 2012 – 13 year. The recommendations focus on flows required to achieve 4 key objectives (see s. 4).

This proposal helps inform the Victorian Environmental Water Holder, which is responsible for the development of a state-wide Seasonal Watering Plan, of proposals for environmental water allocation relevant to the Broken Creek system.

2 SYSTEM OVERVIEW

2.1 Catchment Condition

The Broken Creek is an effluent stream that flows north-west from the Broken River to its confluence with the Boosey Creek near Katamatite. At this point the Broken Creek then follows a generally westerly direction until it meets the Murray River at Barmah (Figure 1).

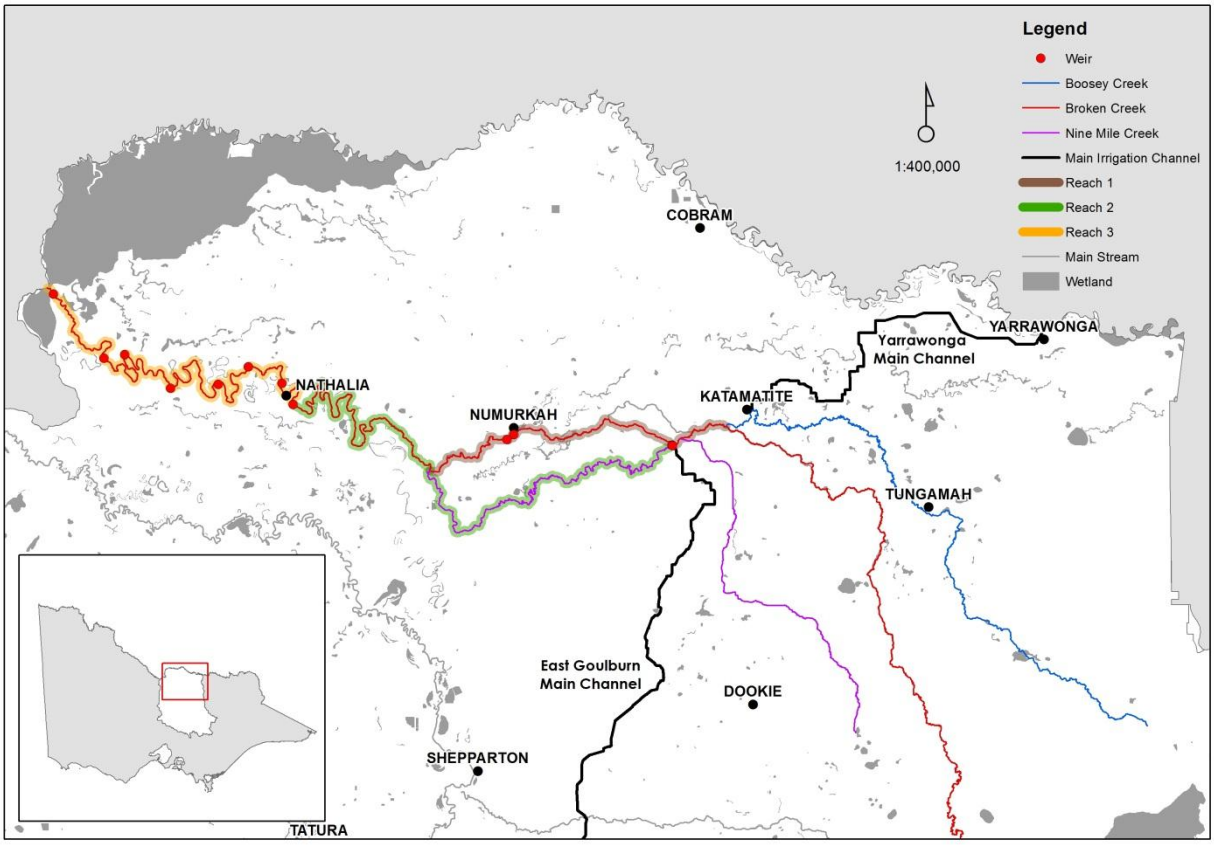

Figure 1: Broken Creek catchment

Prior to regulation, the Broken Creek was an ephemeral stream, with regular cease-to-flow events over the summer and autumn interspersed with flows resulting from high summer storms. The Broken River and Broken Creek are predicted to have been connected by flood flows approximately one in every five years prior to regulation (Water Technology, 2010). The upper Broken Creek continues to be ephemeral. However the lower Broken Creek (below Katamatite) is now a highly regulated stream, and has been for more than 50 years. Flow is maintained in the

summer and autumn months as a result of the system in this part being used for irrigation water delivery; in the winter months flow is dominated by catchment run off.

The lower Broken Creek is juxtaposed with two Victorian irrigation areas - the Shepparton Irrigation Area and the Murray Valley Irrigation Area. Irrigation water, and environmental water, is delivered to the Broken Creek via the East Goulburn Main channel (from the Goulburn River), the 7/3 Main channel (from Lake Mulwala on the Murray River), and a few smaller channels. Due to capacity constraints in the Broken River system, environmental water to Broken Creek can only be delivered via irrigation channels downstream of Katamatite; above this flows are dependent on catchment run-off (Fig 1). The irrigation channels have a limited capacity, and environmental flows are only delivered when irrigation demand leaves spare channel capacity. Most of the environmental water added to Broken Creek flows back to the River Murray.

Land-use in the catchment is dominated by agriculture - mainly dairy, horticulture, cropping, and grazing. The floodplain is extensively cleared with only narrow remnants of the original Creek-line Grassy Woodland / Riverine Swampy Woodland remaining. It is noted that the vegetation has been reserved through the establishment of the Broken Boosey State Park in recognition of its conservation significance and regional biodiversity values (ECC 2001). Woodland, wetland and in-stream ecosystems provide habitat for threatened species such as Murray Cod, Crimson-spotted Rainbowfish, Brolga, Bush-stone Curlew, Leafless Bluebush, Mallee Wattle and Buloke (ECC 2001; Water Tech 2010).

There have been six native fish species identified during surveys conducted in the lower Broken Creek with the main species being Murray Cod, Golden Perch, Silver Perch, Unspecked Hardyhead and the Crimson-spotted Rainbowfish. Electrofishing surveys along the lower Broken Creek showed that fish diversity and abundance are highest downstream of Nathalia (i.e. in Reach 3, Fig. 1), reflecting enhance habitat quality, and connectivity with the River Murray (ARI, 2006).

2.2 Sources of water

There are no environmental entitlements specifically for the Broken Creek system. If required, environmental water can be sourced from the Goulburn or Murray system and delivered via the channel systems. As stated above, there is little capacity to deliver water from the Broken River system.

Water-in-transit within the Murray and Goulburn River systems can be diverted via the Broken Creek on route to the lower Murray River system. In the Goulburn system, this water is called 'Inter-Valley Transfer'. Environmental entitlements are also held in both the Murray and Goulburn systems.

Water available in the Goulburn and Murray system that may be able to be delivered to / through the Broken Creek system includes:

- Goulburn and Murray Irrigation supplies
- Murray River flows,
- Goulburn Inter-Valley Transfers,
- Commonwealth Environmental Water Holder holdings,
- Victorian Environmental Water Holder holdings (including Murray Flora and Fauna, Goulburn River entitlements), and
- Goulburn Water Quality Reserve.

Features of these water resources are summarised in Table 2. In planning for the 2012/13 year, the *availability* of water is assumed to be not limiting on the required flow regimes in the lower Broken Creek. The rate of delivery is however potentially tightly constrained by the capacity and demands of users on the irrigation system, particularly the East Goulburn and Yarrawonga channels (Fig 1).

Table 2: Water sources available for the Lower Broken Creek

Water Source	Management responsibility	Flexibility of management	Conditions of availability / use
Goulburn & Murray Irrigation supplies	G-MW	Very little	Supply is dictated by demand, limited by channel capacity, Operational Guidelines to complement environmental objectives as far as possible. Total irrigation diversion is c. 40 GL/yr.
Murray River flows	MDBA	Flow rate potentially variable	Can be available when Murray flow is unregulated
Goulburn River IVT	MDBA (& G-MW)	Limited in timing of availablility, usually flexible in flow rate	Availability determined by Murray system needs; delivery limited by channel capacity
Commonwealth Environmental Water Holder holdings	CEWH	Highly flexible	Availability determined by agreement with CEWH; delivery limited by channel capacity
Victorian Environmental Water Holder holdings (incl. Murray Flora and fauna BE)	VEWH	Highly flexible	Availability determined by agreement with VEWH; delivery limited by channel capacity
Eildon-Goulburn Bulk Entitlement (Goulburn River Water Quality Reserve)	G-MW	Limited in purpose, highly flexible in use	Generally available for addressing significant emergency water quality issues; delivery limited by channel capacity. Total Goulburn WQR is 30 GL/yr;
Catchment runoff	GBCMA	No flexibility	Availability dependent on seasonal conditions

3 ECOLOGICAL OBJECTIVES

3.1 Environmental objectives and flow recommendations

Environmental objectives for the Broken Creek system sit within a hierarchy generated through a number of studies and planning exercises over the past 12 or so years (Cottingham et al 2001; GBCMA 2005; GHD & URS 2005; GBCMA 2008; DSE 2009; and Water Technology 2010). In preparing an Environmental Watering Plan for the lower Broken Creek, Water Technology (2010) developed specific flow recommendations to maintain sufficient water quality and flows to sustain fish populations (migration, breeding and habitat refuge at minimum), as well as document broader environmental values relating to physical form, vegetation, wetlands and macroinvertebrates. These values, management objectives, and flow recommendations are presented in Table 3.

Environmental flow objectives have been developed for the Broken Creek for three specific reaches (Fig. 1), as follows:

- Reach 1 - Broken Creek downstream of the Yarrawonga Main Channel outlet (Boosey Creek confluence at Katamatite) to the Nine Mile Creek confluence west of Numurkah (approximately 32 km in length)
- Reach 2 - Broken Creek (and Nine Mile Creek) downstream the East Goulburn Main Channel to the upstream end of the Nathalia weir pool (approximately 87 km in length)
- Reach 3 - From the Nathalia weir pool to the Murray River (approximately 65 km in length).

The key environmental objective is the protection and improvement of native fish populations and their habitat in weir pools in Reach 3. In particular, low dissolved oxygen level do not allow the fish to breathe, and so reduce the suitable habitat fish can occupy, potentially killing fish as occurred in November 2002. Azolla buildups reduce oxygen levels, and warm temperatures in summer also reduce oxygen levels. Hence management of these risks is a key priority.

Flow recommendations have been developed for the following four main ecological objectives in the study area:

1. Provide native fish passage through all fish ladders, particularly the fish ladder at Rice's Weir. Passage is desirable throughout the year, with the September to December breeding and migration period being the most important component to maintain. It also allows fish to escape from pools with low dissolved oxygen.
2. Manage the biomass of Azolla (*Azolla filiculoides*) during its growth season (July to November) to limit impacts on dissolved oxygen levels. Management seeks to provide flows sufficient to export it from the system at the same rate as it develops (c. 100 – 200 ML / day). Pulses may be required to move built-up mats beyond obstructions within the stream.
3. Maintain dissolved oxygen levels above 5 mg/L (i.e. at levels that are not life threatening to aquatic ecosystems) through the delivery of constant flows. Higher flows are required during periods of elevated water temperature. There are eight weirs in the Broken Creek downstream of Nathalia that can have very low levels of dissolved oxygen and subsequent risk of fish death, particularly in summer and autumn (December to March/April), with the most downstream (Rices Weir) considered the most susceptible.
4. Ensure persistence of native fish habitat during migration and breeding seasons, particularly for Murray Cod (*Maccullochella peelii peellii*) and Golden Perch (*Macquaria ambigua*) , by providing flows sufficient to allow dispersal throughout the system. Critical time is September to December.

Delivery of environmental water to Broken Creek can only be managed through the use of irrigation channels and therefore can only be undertaken during the irrigation season (i.e. mid-August – mid May). There are substantial impediments to deliver flows during the irrigation off-season and so objectives need to be met during such periods through catchment run-off as far as possible. There is a risk that azolla buildup can occur during the non-irrigation period with no managed flow response possible.

The key reach is the weir pools from Nathalia to the Murray River (Reach 3). Flow requirements are set as passing flows at Rices Weir (the most downstream of the weirs) where flows are lowest. Depending on growth rates of Azolla in spring and water temperature in summer, the minimum flow required will need to be increased (above passing flow) to meet the Dissolved Oxygen and Azolla objectives. A rapid increase in flow rate can also be required in response to swiftly changing conditions or to break up a localised Azolla build-up. Highest flows will enable connectivity between pools and throughout the system to promote breeding and dispersal.

3.2 Rationale

3.2.1 Fish Passage and Habitat

Key native fish species that have been recorded in the lower Broken Creek include the Murray Cod (*Maccullochella peelii peelii*), Golden Perch (*Macquaria ambigua*), Crimson-spotted Rainbowfish (*Melanotaenia fluviatilis*) and the Unspecked Hardyhead (*Cretarocephalus stercusmuscarum fulvus*). Habitat requirements and migration patterns for these species are listed in Table 3.

Table 3: Key native fish species in the lower Broken Creek (adapted from Water Technology, 2010)

Species	Preferred habitat	Spawning migration patterns
Murray Cod	Deep pools with cover undercut banks and overhanging vegetation, and snags	Murray cod migrate upstream in late winter/early spring for spawning. Migration is triggered by rising water temperatures; i.e. exceeding 15°C, increased daylight and rising water levels. It's believed Murray Cod will breed with or without spring floods. The species spawn in spring and early summer, and then move downstream to the same area they occupied before the spawning migration. (www.nativefish.asn.au)
Golden Perch	Deep, slow flowing pools with cover from snags and overhanging vegetation	Golden perch migrate upstream from spring to summer for spawning. The following are needed for the initiation of migration: • rising water temperatures exceeding 20°C • increased daylight • rising water levels Studies suggest Golden perch are able to spawn during stable, bank-full irrigation flows. Most movement occurs between October and April (Lintermans 2007)
Silver Perch	As for Golden Perch and Murray Cod	Not known, possibly similar to Golden Perch, Murray Cod
Northern River Blackfish	Found in a wide variety of habitat, upland to lowland rivers and streams	Not known, possibly similar to Golden Perch, Murray Cod
Murray- Darling Rainbowfish	Slow flowing rivers, wetlands and billabongs	Breeding occurs in spring and summer when water temperatures exceed 20°C. These fish have been recorded moving through fishways (www.nativefish.asn.au)
Unspecked Hardyhead	Slow flowing or still habitats with aquatic vegetation	Spawning occurs between October and February, and when water temperatures are above 24°C in spring. They have been recorded moving through fishways (www.nativefish.asn.au)

3.2.2 Low dissolved oxygen (DO) and Azolla *(A. filiculoides)* blooms

Water quality in the Broken Creek is generally considered degraded (Sinclair Knight Merz, 1996). Monitoring at Rices Weir shows high turbidity, suspended solids and nutrient concentrations, low dissolved oxygen levels. The monitoring data at Rices Weir indicates that water quality in Broken Creek generally does not meet the water quality objectives of the State Environment Protection Policy (SEPP) – Waters of Victoria (WoV) (GHD, 2005).

The dynamics of oxygenation are complex, with inter-relationships and feedback loops existing amongst process drivers - air and water regimes; relative concentrations of phosphorous and nitrogen; decay of organic matter; photosynthetic activity in the water column; aquatic herbivore grazing; turbidity; sunlight; and physical aeration of water.

It is accepted that dissolved oxygen (DO) concentrations of less than 5mg/l can be lethal to aquatic biota (Koehn & O'Connor 1990; ANZECC 2000). It is noted that there have been conditions of lower DO concentrations in Broken Creek with no evidence of major fish death.

Azolla blooms can exacerbate dissolved oxygen depletion by which impact one or more of the following process:

- Smothering and eventually killing macrophytes and algae which leads to reduced macrophyte-supplied oxygen to the water column,
- Increased demand for available oxygen, and changes in water chemistry, as the increased organic matter decomposes (nitrification / denitrification);
- Blanketing the water surface and so inhibit oxygen exchange with the atmosphere;
- Exacerbating death of fish and macroinvertebrates by changing water chemistry and their exposure / susceptibility to toxins.

Azolla growth is thought to be enhanced by high phosphate levels, slow flowing water and rising (spring) temperatures, although persistence declines once water temperatures get above about 28^0 C. Management of Azolla may be required between July and November. It is important to note that low DO conditions do occur in the absence of any Azolla, particularly in warmer summer months.

3.3 Optimal flow components and critical tolerances

In the lower Broken Creek, the recommended flows can only be provided through irrigation channels, and thus only provided during the irrigation season. This limits the ability to deliver fish passage requirements throughout the year as recommended. Further, channel capacity is a major constraint in delivering environmental water in years where there is high irrigation demand and hence restricted capacity in the channel to provide additional (environmental) water.

For the purposes of this proposal the following optimal flow deliveries and timing are listed in Table 4.

Table 4: Optimal flow deliveries for the Broken Creek

Ecological objective	Flow requirement	Optimal flow delivery (period and quantity)	Contingent flow delivery
Native fish passage	40 ML/day	mid-August to May = 10,880 ML	
Azolla management	120 ML/day	Mid-August to November = 12,840 ML	For high growth or blockage management, two events of 250 ML/day for 14 days = 7,000 ML total (or 3,640 ML in excess of 120 ML/day)
Low DO management	approx. 150 - 250 ML/day (including fish ladder flow)	October to mid-May at 150 ML/day = 24,900 ML	3 months at 250 ML/d = 22,500 ML total (or 9,000 ML in addition to 150 ML/day)
Native fish habitat during migration and breeding seasons	250 ML/day	September to December = 30,500 ML (or 15,570 ML above 120/150 ML/day)	

Maximum flow required is approximately 59,000 ML / yr.

4 CURRENT SITUATION

4.1 Recent (>2001 - 2011) Conditions

Flows in Broken Creek at Rices Weir were relatively high and variable prior to the extreme drought year of 2002/03, typically averaging 200 ML/day or more. In 2002/03, flows at Rices Weir dropped to zero for most of the winter/spring. In November 2002, a major fish death incident occurred in the Rices Weir pool. This is thought to have been caused by a major build-up of the floating plant *Azolla filiculoides*, the decay of which lead to loss of dissolved oxygen in the water, killing the fish either directly or through associated chemical reactions. Since that time, management effort has been directed towards developing and providing flows to limit Azolla build-up in the creek and to maintain dissolved oxygen levels. The current flow targets have evolved through experience over this time. Table 5 shows flow performance against the current flow targets, and not the flow targets at the time.

Table 5: Past achievement of flow recommendations (@ Rice's Weir)

Flow Objectives		2002/3	2003/4	2004/5	2005/6	2006/7	2007/8	2008/9	2009/10	2010/11	2011/12
Spring	Obj 1 – fish passage										
	Obj 2 – limit Azolla										
	Obj 3 – maintain DO										
	Obj 4 – maintain habitat / allow migration										
Summer / Autumn	Obj 1 – fish passage										
	Obj 2 – limit Azolla										
	Obj 3 – maintain DO										
	Obj 4 – maintain habitat / allow migration										

Key:

- No substantial part of flow component provided by natural &/or managed flows (target met for <50% required duration / vol)
- Flow component partially provided by natural &/or managed flows (target met for m>50% required duration / vol)
- Flow component substantially / fully provided by managed &/or natural flows (target met for required duration / vol)
- Objective not relevant for this period

NB: Winter flows cannot influenced by environmental flow management

The years from 2002/03 to 2009/10 were very dry years, especially 2002/03 and 2006/07. Flow events greater than 500 ML/day (generated by catchment runoff) only occurred for short durations in 2003/04 (3 events), 2004/05 (1), and 2005/06 (1). No bank-full events (~2,600 ML/day) occurred.

In 2010/11, 3 natural flood events occurred, with flows up to 2,140 ML/day in September, 3,570 ML/day in December, and 1,880 ML/day in February. A blackwater event accompanied the December event with associated fish deaths.

While current Azolla target flows were not met through much of the period from 2004/05 to 2010/11, Azolla accumulation was largely avoided. In 2010/11 and 2011/12, there has been very little Azolla in the creek in comparison to earlier years when it grew prolifically.

Dissolved oxygen levels however have been more problematic, with the summer/autumn problem emerging during the last 8 years as improved water quality monitoring was deployed, and flow targets have been progressively raised to better manage this threat over time.

Prior to 2010/11, there was no environmental water available for Broken Creek, and flow management was provided by redirecting (via Broken Creek) Goulburn River and Murray River water passing to the Murray River downstream, and by deployment of the Goulburn River Water Quality Reserve. In 2010/11, environmental water was used between November and May.

4.2 Current conditions (2011/12) and outlook for 2012/13

Flow conditions during 2011/12 have reflected that of a typically 'flow-inverted' stream, with generally low flows over winter and low levels of dissolved oxygen in summer in response to high ambient temperatures.

Flows at Rice's Weir were minimal (<20 ML/day) during July 2011, dropping to zero in early August; insufficient to provide passing flows for fish but as usual unable to be rectified due to constraints inherent with the irrigation system being closed for maintenance works at this time of year. Local rainfall and subsequent catchment runoff, particularly from the Boosey Creek system in late August generated substantial, but short-lived, freshes peaking at 420 ML/day (at Rice's Weir) on August 27 (Figure 2).

Between September and December 2011, flows varied from 30 to 330 ML/day as variable irrigation demand made target flows at Rices Weir hard to maintain. Irrigation allocations of 100% were declared for the Goulburn system on October 3 and for the Victorian Murray system on November 15. Fish ladders at all weirs were opened on August 19 and have remained open since. 40 ML/day of Murray River unregulated water was used to provide a flow to the fish ladders between 19 August and 24 October.

Fortunately, and somewhat inexplicably, there has been little Azolla growth in Broken Creek during 2011/12, and hence no flows have been required to be deployed to meet this objective.

Periods of low flow have coincided with short periods of low dissolved oxygen, particularly as ambient temperatures increased during late December / early January.

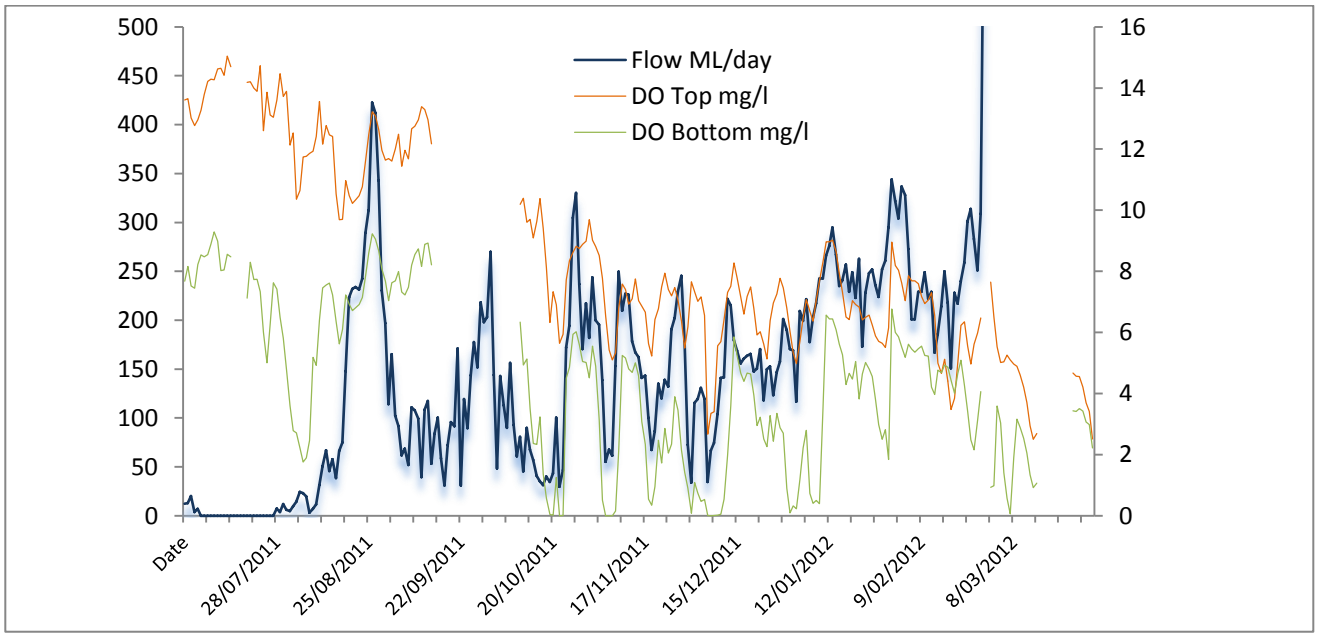

Figure 2: Relationships between flow and DO at Rices weir. Note the greater influence of flow as temperatures increase into summer. Recorded flows went off the scale during the March floods, with the GBCMA Flood Management Team recording flows of over 15,000 ML/day at Nathalia on March 8, 2012.

Given the low flows and falling dissolved oxygen levels in mid-October, Goulburn-Murray Water was requested to commence deploying the Goulburn Water Quality Reserve to maintain a passing flow of 150 ML/day. Flows have then averaged around 150 ML/day, but with significant fluctuations between 30 and 250 ML/day.

Dissolved oxygen levels varied from October to December, with dissolved oxygen levels towards the bottom of the water column at Rices Weir generally varying from 2 to 4 mg/l and frequently falling to zero. Surface dissolved oxygen levels generally stayed above 4 mg/l, but reduced at the same time as the bottom dissolved oxygen levels, reaching 1 mg/l on one occasion. The reductions in dissolved oxygen correspond to period of low flows.

With the channel delivery capacity restricting environmental water supply on 21 December from the Goulburn system, supplementary water was provided from the Murray River. With low dissolved oxygen levels and the prospect of very hot weather, the target flow was increased to 200 ML/day. The Commonwealth Environmental Water Holder agreed to provide environmental flows from both the Murray River and the Goulburn River at this time.

Hot weather (up to 40^{o}C) in late December/early January, resulted in water temperatures progressively increasing (to around 30^{o}C) and surface dissolved oxygen levels steadily decreased (still above 4 mg/l). Bottom dissolved oxygen levels again dropped to near zero at the start of this period. Given the sensitivity of the creek to periods of hot weather, the target flow was increased to 250 ML/day on 3 January to better protect against these periods of hot weather over the next few months.

Inter-Valley Transfer water (from the Goulburn system to the Murray system) became available on approximately 7 January and continued to provide the Goulburn flows until 25 February. Commonwealth environmental water was then provided until 28 February.

To 28 February, 2,388 ML of Murray in-transit water was used, 8,216 ML of Goulburn Water Quality Reserve was used, some 9,803 ML of Commonwealth environmental water was used (8,219ML from the Murray and 1,584 ML from the Goulburn), and 5,758 ML of Inter-Valley Transfers has been used. In total, 26,165 ML has been used to achieve environmental outcomes, of which 9,803 ML was from environmental water entitlements.

In March, a major flood event (greater than 1 in 100 year event) occurred, with bank-full flows continuing into April. This was accompanied by a blackwater event with low dissolved oxygen and some fish deaths. Once the flood subsided, dissolved oxygen levels recovered and so the deployment of additional flow to flush any lingering poor water quality was not required.

Fish monitoring undertaken post floods in 2010 and 2011 identified 12 species in the lower Broken Creek including Murray Darling Rainbowfish, Unspecked Hardyhead, Flat-headed Gudgeon, Golden Perch, Silver Perch, and Murray Cod, along with exotic Carp and Oriental Weatherloach (see Table 3). Monitoring in 2010/11 showed greater species richness in the Broken Creek than monitoring results in the last three years. However, abundance and biomass was lower (URS, 2011).

Overall, prior to the current blackwater event, fish populations were good, and the current event does not yet appear to have had a disastrous impact on fish numbers. Dissolved oxygen levels were not consistently maintained through October to January, and higher pre-emptive flows may be more appropriate. In the absence of Azolla management flows, dissolved oxygen was an issue earlier than expected - in October, rather than December. The expected limitations on environmental water delivery from insufficient channel capacity largely did not eventuate, with only short periods of restriction around the end of December. Deploying environmental water (as planned) from both Murray and Goulburn supply systems may have assisted the apparent lack of constraint.

There is no particular evidence to provide guidance on the climatic outlook for 2012/13, and the proposal for 2012/13 is not particularly influenced by climatic conditions (except to use less than the maximum volumes of water). In only one area, Inter-Valley Transfers, is the outlook for 2012/13 important. Given the likely meeting of South Australian water needs from the Darling system in 2012/13, as in 2011/12 Inter-Valley Transfers will be

driven by irrigation demand in the mid-Murray and will likely be of shorter duration and more variable in availability than in the recent drought years.

5 Priority Watering Actions

5.1 Seasonal water planning

Lower Broken Creek is a series of weir pools interconnected by spring/summer/autumn irrigation deliveries and potentially some winter/spring catchment runoff flows. Catchment runoff, when sufficient, may flow through all weir pools along the length of the lower Broken Creek, while irrigation deliveries can provide flows through the upstream weir pools, but generally no flow out of the last weir pool (Rices Weir). The Broken Creek floods of December 2011 and March 2012 were exceptional events.

Environmental flow planning is normally about providing required flows past the most downstream Rices Weir, and where possible, utilising catchment runoff to meet these needs. For the 2012 / 13 watering year, planning and implementation will need to particularly focussed on limiting low dissolved oxygen and Azolla buildup to maintain habitat for fish as a result of the influx of organic matter and nutrients from the floodplain and surrounding lands during the aforementioned floods.

There are no environmental entitlements (or water storages) in Broken Creek. All water to achieve environmental outcomes must be delivered to the creek through irrigation channels from the Murray River or the Goulburn River.

Plans are prepared for a range of possible climatic scenarios to understand how the required volumes for deployment of water change, and importantly the likely availability of channel capacity to deliver the required flows at different times of the year (see Table 7).

Given the flow needs of the lower Broken Creek are small relative to the water resources available to meet them from the Murray and Goulburn River systems, the plans define the ecological needs of the creek and are not constrained by resource availability. However, they do depend on access to water-in-transit down the Goulburn and Murray Rivers, with environmental entitlement water used to meet gaps in water-in-transit availability and delivery.

Importantly, the actual management of water through the season needs to be adaptive, with water deployment decisions adjusting as the season unfolds, particularly in response to timing issues within the season and the variable flow needs of Azolla and dissolved oxygen management.

5.2 Priority flow objectives

The environmental flow needs of the lower Broken Creek are relatively fixed from year to year. 40 ML/day is required to keep open the fish ladders along the creek, but particularly at Rices Weir. This allows fish to migrate and move for breeding, and also potentially to escape poor water quality in a particular weir pool.

Two of the priority flow components are heavily driven by the last 8 years of Azolla and dissolved oxygen management experience. Experience has shown that Azolla clusters can be managed by a steady base-flow of 120 ML/day, with occasional flushes up to 250 ML/day to meet high growth periods. Dissolved oxygen can be managed by a steady base-flow of 150 ML/day, but can need up to 250 ML/day for extended periods (particularly in response to very hot weather).

The flows required to manage Azolla and dissolved oxygen are a very high priority, given they reduce the habitat available to and potentially kill the fish populations the plan is seeking to maximise.

A flow of 250 ML/day to improve fish habitat during the migrating/breeding season is also desirable.

The priority flow components are summarised in Table 6 and Figure 3.

Table 6: Summary of priority environmental flow components

Priority	Flow component	Daily Flow (ML)	Component Volume (ML)	Cumulative Volume (ML)	Reach
1	Mid-August to May fish ladder passage flow of 40 ML/day	40	10,900	10,900	Past Rices Weir
2	Mid-August to November Azolla management flow of additional 120 ML/day	120	12,800	19,500	Past Rices Weir
3	October to May dissolved oxygen management flow of 150 ML/day	150	34,100	39,600	Past Rices Weir
4	December to mid-May high flow of 250 ML/day for up to 60 days for DO management	250	22,500	48,600	Past Rices Weir
5	August to November flush of 250 ML/day for 14 days for Azolla build-up management	250	7,000	51,400	Past Rices Weir
6	September to December fish habitat / migration flow of 250 ML/day	250	30,500	58,600	Past Rices Weir

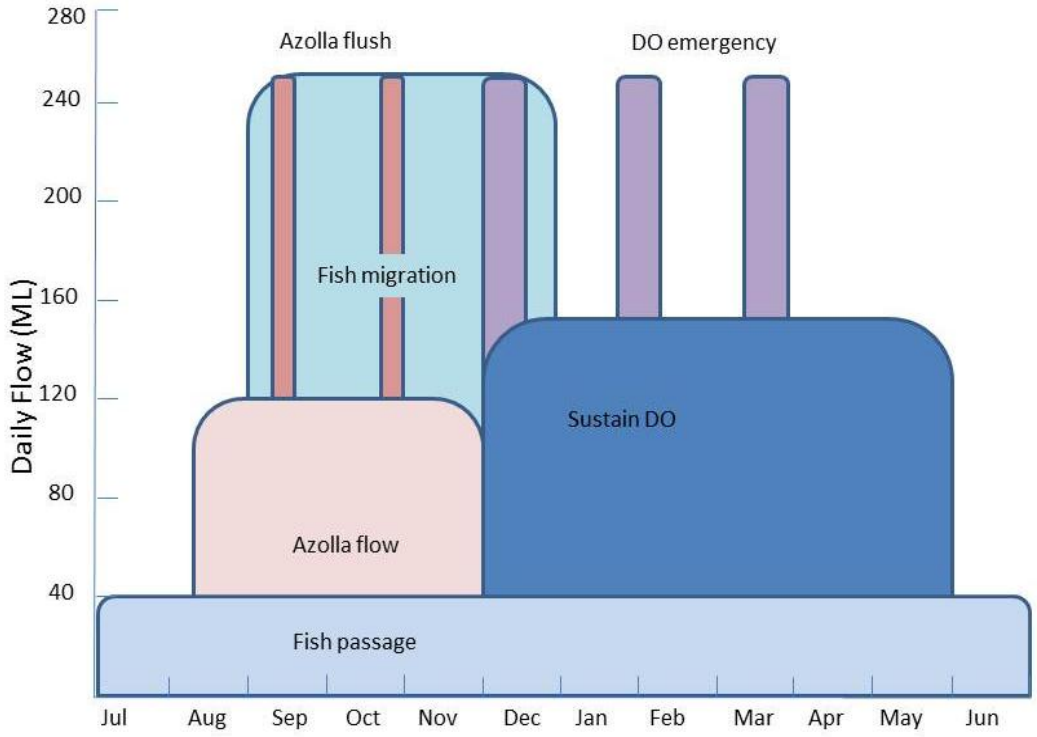

Figure 3: Schematic representation of priority watering actions

5.3 2012/13 Scenario planning

Table 7 outlines a range of scenarios for water use in the lower Broken Creek in the 2012/13 year. Climatic scenarios are based on receiving catchment inflows (to Broken Creek, the Goulburn system and the Murray system)

with a particularly Probability of Exceedence (POE). Hence the very dry scenario receives flows which have a 90% chance of being exceeded.

Table 7: Scenario summary descriptions for the Broken Creek

BROKEN CREEK – DOWNSTREAM REACH	SCENARIO 1 VERY DRY 90% POE	SCENARIO 2 AVERAGE 50% POE	SCENARIO 3 WET 30% POE
Water Supply	100% HRWS Murray and 75% HRWS Goulburn allocations. Perhaps 100% available as private carryover	100% HRWS Murray and Goulburn allocations Perhaps 40% available as private carryover	100% HRWS Murray and Goulburn allocations Perhaps 10% available as private carryover
Expected Creek Flow and Water Management	18-20 ML/day in July	25 ML/day from August to November, with a 700-900 ML/day high flow and 200-300 ML/day freshes	45-50 ML/day from August to October, with a 2,500-3,000 ML/day high flow and 600 ML/day fresh
	No flow past Rices Weir from August to May	No flow past Rices Weir from November to May	No flow past Rices Weir from November to May
	220 GL of IVT available to deploy	183 GL of IVT available to deploy	147 GL of IVT available to deploy
	30 GL Water Quality Reserve available	30 GL Water Quality Reserve available	30 GL Water Quality Reserve available
Environmental Entitlement Volumes Available	Murray and Goulburn	Murray and Goulburn	Murray and Goulburn
Environmental Objectives	Maintain fish passage	Maintain fish passage	Maintain fish passage
	Prevent Azolla build-up to maintain fish habitat	Prevent Azolla build-up to maintain fish habitat	Prevent Azolla build-up to maintain fish habitat
	Maximise dissolved oxygen levels to maintain fish habitat	Maximise dissolved oxygen levels to maintain fish habitat	Maximise dissolved oxygen levels to maintain fish habitat
	Maximise fish habitat	Maximise fish habitat	Maximise fish habitat
Preferable Murray Diversions and Inter Valley Transfer (IVT) Water Use	No water available to divert	Divert unregulated Murray water from mid-August to October at 100 ML/d, (up to 8 GL- say 4 GL)	Divert unregulated Murray water from mid-August to November at 100 ML/d (say 4 GL)
	Divert IVT water from December to March at up to 200 ML/day (up to 24 GL – say 13 GL)	Divert IVT water from January to March at up to 200 ML/day (up to 18 GL – say 9 GL)	Divert IVT water from January to March at up to 200 ML/day (up to 18 GL – say 5 GL)
Preferable Environmental Water Use	Use Goulburn and Murray environmental water from August to May at up to 250 ML/day (up to 59 GL – say 46 GL)	Use Goulburn and Murray environmental water in August to May at up to 250 ML/day (up to 40 GL)	Use Goulburn and Murray environmental water in August to May at up to 250 ML/day (up to 35 GL)
	Release Water Quality Reserve water in response to emergency water quality problems (e.g. blackwater)	Release Water Quality Reserve water in response to emergency water quality problems (e.g. blackwater)	Release Water Quality Reserve water in response to emergency water quality problems (e.g. blackwater)

Importantly, if diversion of Murray River water or Goulburn Inter-Valley Transfers is not available, additional environmental entitlement water is required. If all flows come from environmental entitlements, up to 59 GL could be required. If channel capacity constraints limit supply from one side of the creek, the maximum use from the other side of the creek could be 27 GL from Murray entitlements and up to 50 GL from Goulburn entitlements.

5.4 Adaptive management

The lower Broken Creek has relatively fixed environmental watering needs (i.e. largely independent of annual climatic conditions). Catchment runoff may contribute to meeting early base-flows and some Azolla flushing flows. However, for the large part, flows must be brought in from the Murray and Goulburn Rivers. The environmental watering needs are however variable on a short term basis, depending on the occurrence of Azolla and dissolved oxygen problems.

As flow from Broken Creek is returned to the Murray River, water-in-transit along the Murray River or water being sent from the Goulburn River to the Murray River can be diverted via Broken Creek to meet significant parts of the environmental flow needs. The availability of these sources will need to be confirmed with River Murray Water as seasonal conditions unfold.

Unregulated Murray water is potentially available in spring, providing Murray Valley channel capacity is available for use.

However, the Goulburn Inter-Valley Transfers have a limited period in which they can be delivered (which depends on seasonal conditions and Murray system supply needs) and potentially a limited volume for transfer. Hence the proposal identifies the need for Goulburn environmental entitlement water to be available to supply the creek from the Goulburn supply system in the months when Goulburn Inter-Valley Transfers are not available.

Water will also be required to enable managers to respond to 'low dissolved oxygen emergencies', and it is proposed the Goulburn Water Quality Reserve is held to meet these needs.

The key issue for this proposal is the potential difficulty in gaining access to enough channel capacity to provide the required flow rates at different times of the year, and particularly in spring and autumn. The proposal therefore aims to have water available via both the Goulburn and Murray Rivers at the same time, so that water can be delivered through any available channel capacity, hence maximising the flows achieved in the creek.

In addition, when irrigation demand is about to increase significantly in the spring, it is proposed to provide a flush through the creek to reduce Azolla build-up if necessary before the period of high irrigation demand and hence low environmental water delivery.

As the proposal is maximising the availability of water for delivery through constrained channel systems, the volumes specified in Table 8 will not be used in total. Hence, the proposal envisages these as maximum potential usage from each source and would expect some or all of these sources using less than the maximum volumes given. The maximum overall water required could be up to 59 GL.

Under the proposal, if channel capacities allow, flows would be added to the creek as necessary to maintain the required flows at Rices Weir:

- Unregulated flows in Broken Creek will determine how much additional water needs to be added to meet flow targets.
- The minimum flow of at least 40 ML/day would commence in mid-August 2011 to allow fish ladders to be opened, preferably sourced from the Murray River unregulated flows.
- If Azolla accumulation is occurring, a flow of 120 ML/day would be commenced (if as in 2011/12 no azolla grows, no flow is needed to prevent buildup).
- The minimum flow would increase to 250 ML/day in September to the end of December (or as long as possible) for improved fish habitat. This would require from both the Murray and Goulburn systems as the Murray channels are limited to a maximum delivery to the creek of 170 ML/day.

- If 250 ML/day could not be provided consistently, surges to 250 ML/day for up to 2 weeks would be pursued (if required) to minimise Azolla build-up, and particularly pre-emptively if a period of low channel delivery capacity availability is imminent. Prolific Azolla growth increasingly blanketing areas of the creek water surface would trigger fresh releases.
- Once dissolved oxygen levels start to decrease towards 4 mg/l, (from October onwards), the minimum flow of 150 ML/day would be provided if possible, increasing up to 250 ML/day as temperatures rise and dissolved oxygen levels decrease. Decisions will aim to pre-empt issues rather than wait for problems to manifest.
- Flows would be reduced (probably in April) as the dissolved oxygen threat passes.
- Flows would cease in mid-May when the channel system closes

In summary, this proposal nominates the use of in-transit water from the Murray River and Goulburn Inter-Valley Transfers, with additional Goulburn environmental water as summarised in Table 8.

Table 8: Summary of environmental water volumes required to support this proposal (GL)

LOWER BROKEN CREEK	VERY DRY	AVERAGE	WET
Murray unregulated water planned	0 GL	Up to 4 GL	Up to 5 GL
Inter-valley water planned	Up to 13 GL	Up to 9 GL	Up to 5 GL
Murray environmental water planned	Up to 27 GL	Up to 23 GL	Up to 23 GL
Goulburn environmental water planned	Up to 37 GL	Up to 41 GL	Up to 45 GL

Overall, the maximum total water required is 59 GL.

5.5 Implementation Arrangements

5.5.1 Delivery losses and re-crediting

Under an agreement between Goulburn-Murray Water and the Victorian Environmental Water Holder, environmental water delivered through the channel systems incurs a 10% loss. That means that 90% of the water added to the Broken Creek is available to be re-credited to the Murray system for further use downstream.

Murray unregulated flows diverted through Broken Creek incur no loss, and whatever flow returns to the Murray adds to the unregulated flows passing at that point.

Inter-Valley Transfers from the Goulburn River incur no loss and flow returning to the Murray is credited as an Inter-Valley Transfer supplied from the Goulburn supply system to the Murray supply system.

5.5.2 Costs

The Environmental Water Manager does not have to make any payment for headwork costs relating to the environmental entitlements. If chargeable, these costs are met by the entitlement holders.

Delivery of environmental water entitlements with interruptible supply incurs out-of-pocket expenses for delivery costs. Under agreement between Goulburn-Murray Water and the Victorian Environmental Water Holder, delivery

using Shepparton irrigation channels costs $11.35/ML[1] and using Murray Valley irrigation channels costs $5.48/ML[1]. If Murray system delivery is optimised, delivery of up to 59,000 ML could cost up to $420,000[1]. These costs will need to be funded by environmental entitlement holders.

Inter-Valley Transfers and unregulated Murray flows incur no charge for delivery through Broken Creek.

5.5.3 Notice and time required

Four days' notice is generally required for ordering water from Goulburn or Murray system storages.

Releases from Lake Eildon take approximately 2½ days to reach Goulburn Weir. Flows through the Shepparton channel system can occur within hours. If outfalled from the East Goulburn Main channel, water can take 7 days to reach Nathalia, and potentially a further day to reach Rices Weir (by manipulating the weirs). The smaller capacity Hicks and Holland's outfalls flow directly into weir pools at Nathalia and downstream.

Releases from Hume Dam take 2 days to reach Lake Mulwala, with a further day to reach Broken Creek through the Yarrawonga main channel and spur channels. The main 7/3 channel outfall enters the creek upstream of the East Goulburn Main channel, while other smaller outfalls can input water into the downstream weir pools.

[1] 2011/12 prices (2012/13 prices not available)

6 Risk Management

6.1 Key risks

There are some risks involved in deploying environmental water. Listed below are a number of key risks faced in the Broken Creek:

- Restricted channel capacity in high irrigation demand periods may result in limited ability to provide water to mitigate low dissolve oxygen levels, or excessive Azolla accumulation, resulting in fish deaths. This is a high risk to the Broken Creek, to be somewhat mitigated by having water available from both the Murray and Goulburn systems to maximise use of any available channel capacity.
- Improved environmental conditions for Carp – providing environmental flows to increase the area of slackwater habitats for native fish may also increase the habitat availability for introduced pest species such as Carp. Currently there is little known about the dispersal and proliferation of pest species specifically in relation to environmental flows, but it's likely the benefits provided for native species are also enjoyed by introduced species also (Chee et al, 2006). In June 2011, very large numbers of Carp were found in the Rices Weir fish ladder and were manually removed. No other management of this risk is currently available.
- Overbank flows could result in flooding private property. No overbank flows are proposed in this proposal.
- As in 2010/11, a blackwater event can be generated in the Broken Creek catchment from overland flooding, with decomposition of detritus resulting in very low dissolved oxygen levels, particularly at depth. Given the high flows usually accompanying these events, there is little that can be done to avoid the impact of the event. The best management response is to provide an environmental flow after the high flows have passed to improve the water quality in the lower Broken Creek as quickly as possible. Some of the Goulburn Water Quality Reserve should be held in reserve for this purpose.

A risk assessment has been carried out by GBCMA personnel is summarised below in Table 9.

6.2 Mitigation

Key risks are to be mitigated through the following measures:

- **Limited channel capacity:** Maintain continued dialogue with G-MW to identify synergies between delivery of irrigation water / environmental water through both the Goulburn and Murray irrigations systems.
- **Carp:** Explosions in carp populations are difficult to directly mitigate. Monitoring data indicate that large bodied native fish have also bred successfully over that past few years and larger fish may provide some competition for juvenile carp.
- **CMA Resources:** Limited CMA resources available to deliver program are highly unlikely, but of major consequence. Multiple staff capacity mitigates risk.
- **Evidence of meeting objectives:** The risk of being unable to demonstrate evidence of meeting environmental objectives is being addressed through an on-going research and management program. The GBCMA is working with University of Melbourne researchers and the eWater CRC to increase the amount and quality of evidence used in river health management.
- **Inaccurate flow recommendations:** Maintain rigorous research and monitoring program to improve accuracy and lower risk over time.
- **Loss of stakeholder support:** Maintain open and informed dialogue with stakeholders

Table 9: Risk assessment of environmental water delivery for Broken Creek 2012 – 13

			Summer			Autumn	Winter	Spring	
Risk Category	**Risk #**	**Risk Type**	**Low flow**	**Fresh**	**High flow**	**Fresh**	**Fresh**	**Fresh**	**High flow**
Quality issues lead to no achievement of objectives	1.0	Release volume is insufficient in meeting required flow at target point	Low	Low	Low	Low	Low	Low	Low
	1.1	Current recommendations on environmental flow inaccurate	Medium	Medium	Medium	Medium	Medium	Medium	Medium
	1.2	Storage Operator maintenance works affect ability to deliver water	Low	Low	Low	Low	Low	Low	Low
	1.3	Resource Manager cannot deliver required volume or flow rate (outlet/capacity constraints, insufficient storage volume)	Low	High	High	Low	Medium	Low	High
Time	2.0	Limited CMA resource to deliver environmental release	Low	Medium	Medium	Low	Medium	Low	Medium
Cost	3.0	Cost of delivery exceeds available funding	Low	Low	Low	Low	Low	Low	Low
Human	4.0	Environmental release cause personal injury to river user	Low	Low	Low	Low	Low	Low	Low
Environmental	5.1	Releases cause water quality issues (e.g. blackwater, low DO, mobilisation of saline pools, acid-sulphate soils, etc.)	Low	Low	Low	Low	Low	Low	Low
	5.2	Improved conditions for non-native species (e.g. carp)	Medium	Medium	High	Low	Low	Medium	High
Compliance	6.0	Environmental water account is overdrawn	Low	Low	Low	Low	Low	Low	Low
	6.1	Environmental releases causes flooding of private land	Low	Low	Low	Low	Low	Low	Low
	6.2	Environmental release cause flooding to public infrastructure	Low	Low	Low	Low	Low	Low	Low
	6.3	Environmental releases causes flooding of Crown land	Low	Low	Low	Low	Low	Low	Low
Reputation	7.0	Unable to provide evidence in meeting ecological objective	Low	Medium	Medium	Low	Medium	Low	Medium
	7.1	Key stakeholders not supportive of environmental water release	Low	Low	Low	Low	Low	Low	Low

7 MONITORING AND REPORTING

7.1 Current monitoring programs

A number of programs are currently conducted by the Goulburn Broken CMA to monitor environmental flow and river and ecological conditions. The main program for environmental flow monitoring is the Victorian Environmental Flows Monitoring and Assessment Program (VEFMAP). This program is being undertaken at sites along the Broken Creek from the confluence with the Broken River to the Murray River. The program is monitoring vegetation, fish, macroinvertebrates, channel features, and physical habitat. Not all parameters are measured at each site. These assessments are carried out on a range of timeframes (varying from annually, to when a channel changing event occurs) and are a long-term assessment (5 - 10 years) of the impacts of and changes from environmental flows. Monitoring has been occurring since 2008 and a preliminary summary of sampling results is presented in Figure 4 & Figure 5. 2010/11 was the first year of the monitoring to have significant flows and hence the first year that any response to flows may occur with previous years providing base line data only.

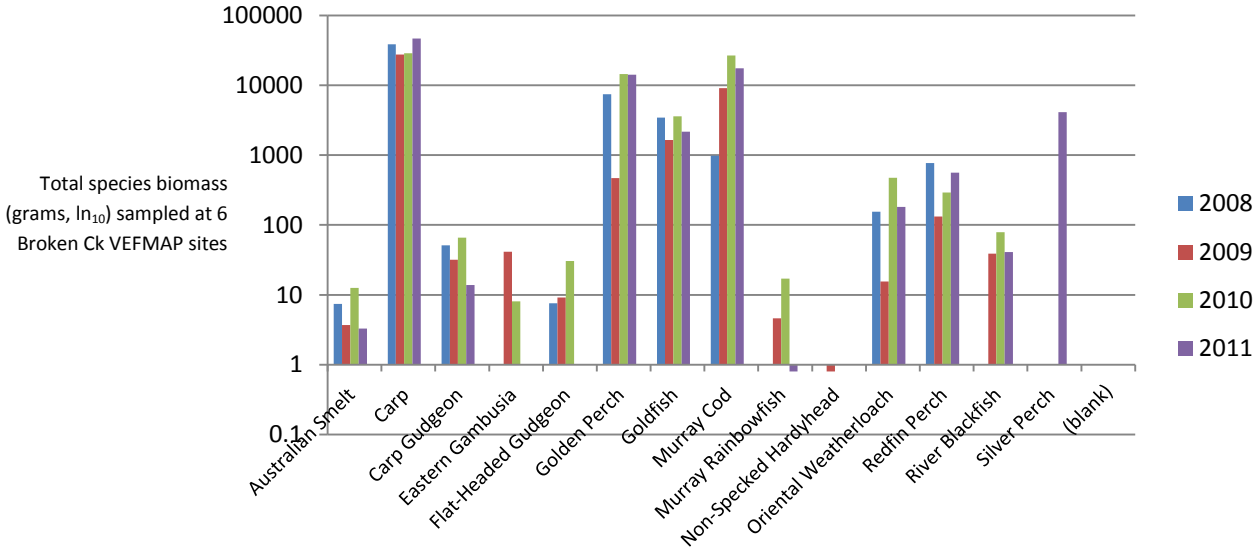

Figure 4: Changes in fish biomass sampled during Broken Ck VEFMAP surveys 2008 – 2011

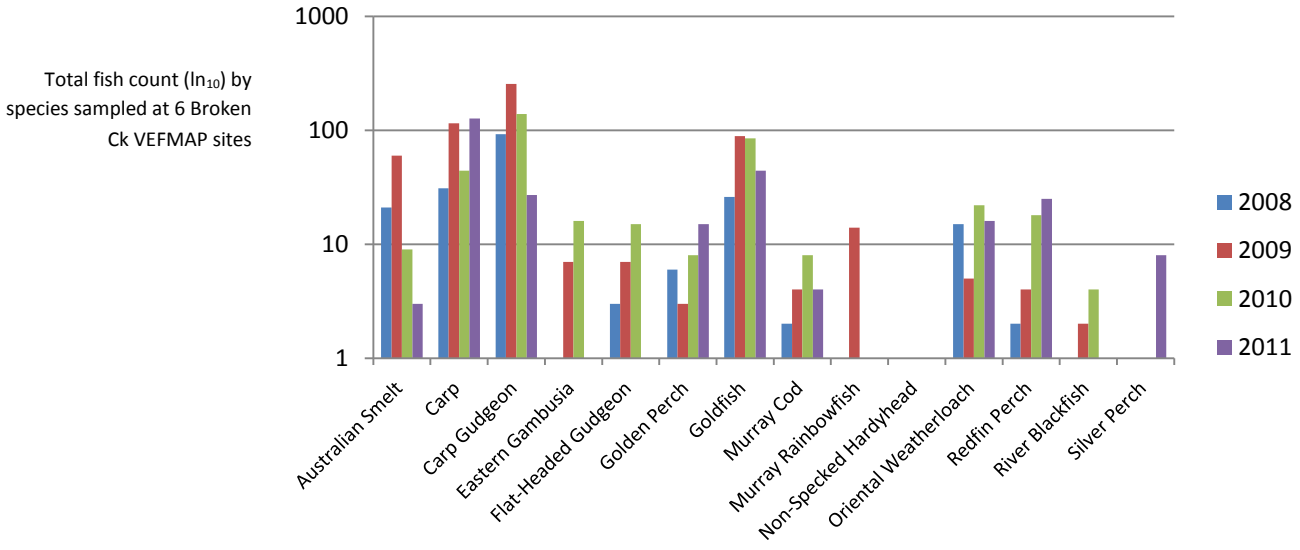

Figure 5: Changes in fish count sampled during Broken Ck VEFMAP surveys 2008 - 2011

The Arthur Rylah Institute for Environmental Research is also undertaking fish monitoring for the Goulburn Broken CMA. This is aimed at understanding fish dynamic and movement in the weir pools from Nathalia to the Murray River. The work involves electrofishing and pit tag readers on several weirs and fish ladders.

Flows are measured in the Broken Creek catchment at four hydrographic gauging stations along the Broken Creek and one on the Boosey Creek. The majority of dryland catchment inflows come from the upper catchment and are measured at the Boosey Creek at Tungamah and the Broken Creek at Katamatite. The key flow monitoring site is at Rices Weir. Goulburn-Murray Water also measure outfalls from channels into the creek, and flows past each of the weirs.

Water quality monitoring on the Broken Creek has been in place for a number of years. Continuous monitoring (i.e. 15 minute intervals) is located at Rices Weir (2 sites) and monitors temperature, dissolved oxygen, wind direction and speed, and hourly photos upstream of Rices Weir. Goulburn-Murray Water also continuously monitors temperature and dissolved oxygen at Rices Weir as well as at Hardings Weir (3 weirs upstream from Rices Weir). Goulburn-Murray Water also undertakes routine spot readings of dissolved oxygen, temperature and Azolla cover along the reach from Nathalia to Rices Weir. Continuous dissolved oxygen and temperature monitoring occurs at the Boosey Creek at Tungamah and the Broken Creek at Katamatite. Nutrients and turbidity are also measured weekly at Rices Weir.

7.2 Monitoring 2012/13 environmental flow outcomes

Monitoring of environmental flows in 2012/13 will continue as in previous years. Flows, dissolved oxygen levels, water temperature and Azolla levels at Rices Weir will be used to determine the adequacy of flows provided to maintain dissolved oxygen levels and limit azolla buildup. VEFMAP and Arthur Rylah Institute for Environmental Research fish monitoring in particular will determine the longer term fish outcomes from overall flow management.

7.3 Reporting

The first level of reporting is on use of environmental entitlements. Weekly reporting is planned to advise environmental entitlement holders of progressive water use, and on any adaptive water deployment decisions made.

The second level of reporting is on flows occurring in the creek system. Weekly reporting is planned to advise environmental entitlement holders of current flows and the effectiveness of environmental water deployed in achieving desired flows.

The third level of reporting is on environmental outcomes achieved. During the year, this will tend to be more anecdotal in nature.

An annual report will be prepared after the end of the 2012/13 year to collate all information on the use of environmental water, the river flows achieved, and the environmental outcomes observed.

7.4 Knowledge gaps and limitations

Recent monitoring activity (see s. 7.1) is beginning to yield valuable information on the fish communities within the Broken Creek, with increases in values correlating with improved seasonal conditions and environmental flow management. On-going participation in the state-wide VEFMAP will continue to increase understanding of the relationship of biota and environmental flows. In addition, the GBCMA is involved with researchers looking to improve access to, and use of, evidence-based decision-making in delivery of environmental water.

The dynamics of Azolla growth and dissolved oxygen levels requires further elucidation: there is clear evidence that excess Azolla is problematic for dissolved oxygen and aquatic biota, although recent experience has shown that dissolved oxygen levels can fall below critical thresholds, particularly at depth, in the absence of Azolla. Somewhat fortuitously, critically low levels of DO have not necessarily resulted in substantial fish depth in the system, with

real-time monitoring of parameters used to invoke flow delivery sufficiently quickly to ameliorate low DO in the creek.

Whilst there is a reasonable amount of information and understanding of water flow and quality issues in the lower Broken Creek, further information on the processes by which bed sediments drive low dissolved oxygen levels and higher flows in turn drive higher dissolved oxygen levels. This would allow more predictability of the flows required based on a range of parameters.

The Broken Creek already has low dissolved oxygen levels which fish seem to be surviving. It would be useful to know how they survive (eg by moving vertically or horizontally or by 'hibernating') to improve our understanding of their susceptibility to or tolerance of these conditions and the duration of events that can be tolerated.

The flow and water quality issues in the upper reaches (between the Broken River and Katamatite) are not as well known as in the lower reach. It is reasonable to assume that poor water quality issues in this part of the system may be having a substantial impact on problems manifesting in the lower system.

There is likely to have been substantial inputs of nutrients and organic matter (and possibly some toxins) as a result of the unprecedented floods in February / March 2012; the magnitude and longer-term implications of this will require further investigation.

8 COMMUNICATIONS AND ENGAGEMENT

8.1 Stakeholders

There are two key audiences for communications under the proposal. The primary audience are those involved in delivering the proposed flow management.

Goulburn-Murray Water is the key flow delivery agency. When the final proposal for 2012/13 is agreed, communications with Goulburn-Murray Water are aimed at making clear what the intended environmental flow release plans are and their intended purpose. Then, throughout the season, there will be regular communications (phone, email) directly with the Goulburn-Murray Water water resource management group to understand unregulated flows, Goulburn-Murray Water planned consumptive use releases, and to organise environmental flow releases.

River Murray Water is responsible for calling out Inter-Valley Transfers and for approving diversion of Murray River water through Broken Creek. Communications (phone, email) will primarily be via Goulburn-Murray Water, and aimed at initially planning Inter-Valley Transfers and Murray flow diversions to achieve Murray system operational objectives and lower Broken Creek environmental objectives, and then regularly throughout the season, adjusting the plans to conditions as they unfold.

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

Commonwealth Environmental Water Holder may have allocated water to the Seasonal Watering Plan which is based on this proposal, and are responsible for achieving further benefits from the water at downstream environmental sites. Routine communication will be via the Victorian Environmental Water Holder.

The secondary audience is those potentially affected by or interested in environmental flows and/or the health of the river environment. This includes Parks Victoria and DSE (public land managers), water users along the river (Goulburn-Murray Water diversion licence holders), campers and recreation users, local government, environment groups and the general public. As the effect of the proposal on these groups is expected to be minimal, the communication objective is to provide information about the decision to provide environmental flows and what it is trying to achieve. These communications will be through media articles and potentially talks directly with special interest groups.

8.2 Consultation

Table 10 outlines the consultation process the Goulburn Broken Catchment Management Authority (CMA) has undertaken during the development of this seasonal watering proposal.

On-going dialogue with key stakeholder agencies (esp. G-MW) and adjoining landholders is maintained throughout the year. In addition, regular press releases are issued by the GBCMA to inform the community of activities and outcomes relevant to environmental flow management in the Broken Creek.

To assist with the environmental water management program, the Goulburn Broken CMA is establishing a Broken Environmental Water Advisory Group to provide advice on planning environmental water use (including seasonal watering proposals and water management plans) and on any environmental health trends occurring in the rivers, creeks and wetlands. The focus of the group will be the Broken River from Lake Nillahcootie to Shepparton, the Broken Creek from Casey's Weir to the Murray River, and wetlands associated with these system (including wetlands close to and away from the river/creek).The group is expected to be established by May 2012 and will comprise 6 members (including Chair), who will come from a range of geographic locations along the Broken River and Broken Creek. Representatives from key agency partners (such as the Department of Primary Industries,

Department of Sustainability and the Environment, and Goulburn-Murray Water) and indigenous groups will be consulted.

Table 10 Consultation during proposal preparation

STAKEHOLDER	PURPOSE	ENGAGEMENT TYPE	METHOD	TIMING
Proposal development				
G-MW	Seek information on water system outlooks and river management, and feasibility of proposal	Involve/consult	Personal discussion with key staff	March – April 2012
CMA Board	Approval of the proposal	Approve	Board Meeting Paper/Presentation	13 April 2012
Proposal implementation				
Indigenous Groups	Inform Indigenous Groups on the proposal and seek advice on indigenous related issues	Inform/consult	Personal discussion with key staff	May 2012 – April 2013
Broken Environmental Water Advisory Group	Inform the Broken Environmental Water Advisory Group on the proposal and seek advice on community and river health related issues	Inform/consult	Meetings	April 2012 – April 2013
VEWH	Report on deployment of water under the plan, and seek to modify release plans to align with downstream site needs as the year unfolds	Inform/consult	Telephone and email	May 2012 – May 2013
River Murray Water	Planning Inter-Valley Transfers to achieve Murray system operational objectives and lower Goulburn River environmental objectives, and adjusting the plans to conditions as they unfold	Inform/consult	Telephone and email	May 2012 – May 2013
G-MW	To understand unregulated flows, planned consumptive use releases, and to organise environmental flow releases	Inform/consult	Telephone and email	May 2012 – May 2013

9 APPROVALS

I, the authorised representative of the agency shown below, approve the 2012/13 Seasonal Watering Proposal for the Broken Creek system.

Signed for and on behalf of the

Goulburn Broken Catchment Management Authority
168 Welsford St, Shepparton, 3630

Signature of authorised representative……

Name of authorised representative…… Date……..

10 REFERENCES

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