

## **Implementation of the Barmah-Millewa Forest Environmental Water Allocation 2005 - 2006.**

**'A Case Study of the successful delivery of the largest environmental water allocation in Australia and possibly the world'.**

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## **INTRODUCTION**

The Barmah-Millewa Forest is a highly significant floodplain wetland complex on the Murray River in south-eastern Australia bordered by the Echuca to the west, Deniliquin to the north and Tocumwal to the east. The natural hydrology of the Forest floodplain, and consequently complex ecosystems, have been significantly affected by the rivers now highly regulated flow regime. In an attempt to alleviate some of these effects, the floodplains water regime is highly managed and includes targeted environmental water allocations. Environmental flows are commonly targeted at enhancing the ecological values of the Forest ecosystem and are now managed to improve the health of the Key Indicator attributes of Vegetation, Birds and Fish.

In 2002, the Murray Darling Basin Ministerial Council established 'The Living Murray' (TLM) – a long-term program of collective actions aimed at returning the River Murray system to a healthy working river. The First Step Decision under TLM aims to recover up to 500 GL per year (long-term average) of "new" water over a period of five years to improve environmental flows and to achieve ecological objectives at six Icon sites along the River Murray, including the Barmah-Millewa Forest. In June 2004 the First Step Decision was given effect when Ministers from Victoria, New South Wales, South Australia, the ACT and the Commonwealth Government signed the *Inter-governmental Agreement on Addressing Water Over-allocation and Achieving Environmental Objectives in the Murray-Darling Basin*. In 2005/2006, the Barmah-Millewa Icon

site achieved the largest water delivery under the new TLM management arrangements at 513 GL. This delivery was undertaken, not by using new water recovered under TLM, but by using the existing accrued Barmah-Millewa Forest account.

## **BACKGROUND**

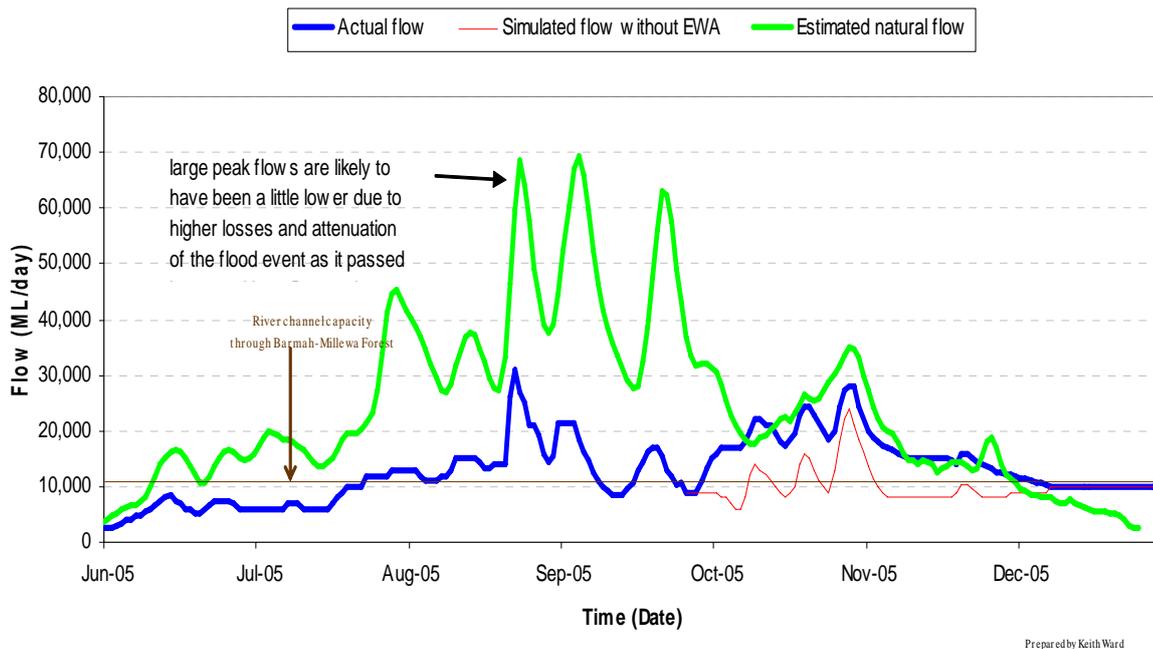
The fourth call on the Barmah-Millewa Forest Environmental Water Allocation (EWA) in 2005-06, and the first under 'The Living Murray' management arrangements, resulted in the largest environmental water delivery ever undertaken in Australia. At 513 GL it surpassed the previous 300 GL Barmah-Millewa Forest EWA event in 2000.

Over the preceding period of dry years leading up to the 2005-06 event, the entitlement had been drawn down by providing additional water to irrigators. In May 2005 there was considered only to be a 10% chance that there would be enough rainfall in the catchment to put the volume in storage for the pay back triggers to be reached. By September 2005 however, following a return to better than average rainfall across the Upper Murray and north-east Victorian catchments, payback and release triggers were met.

As natural flooding of the Forest floodplain continued from September into October, with flows coming out of the unregulated Kiewa and Ovens river catchments, the decision to undertake the EWA delivery was agreed and signed off by all levels of government. The release was commenced on 10 October 2005 with flows being put down the Murray River channel from volumes stored in Lakes Hume and Dartmouth. The environmental water was used to extend the depth and duration of the natural flood peaks coming out of the unregulated catchments and provide good medium level flooding to 57% of the Barmah-Millewa floodplain. The delivery was undertaken between October 2005 and March 2006 and was managed for the first time to achieve multiple objectives including flow variation, (enhancement of flood peaks), to encourage the breeding of native fish. To provide inundation at the required depths and duration to maximise vegetation response and regulated flows to colonial waterbird breeding colonies to sustain a major breeding event.

The Hydrograph for the 2005-06 EWA flood event is depicted in the following figure and shows from the top of the graph down, the green line, showing inflows to the catchment which put the EWA volume in store and provided the natural cues for the Forest ecosystem. The middle blue line showing the flows during the EWA event as it was managed, to replicate and build on the natural flood peaks and to prevent flows from going below channel capacity (as it would have done on four occasions without management intervention). The bottom, red line, showing what would have occurred without the EWA delivery with flows dropping below the 10,400 ML channel capacity threshold of the constrained Murray River channel through the 'Barmah Choke'.

## Effect of EWA release on Murray River flow downstream of Yarrowonga - 2005/06



Prepared by Keith Ward

In order to manage the EWA delivery an Operations Committee was established with key agency operations and management staff involved. The committee was convened weekly by tele-conference, this enabled decisions to be made directly in response to what was taking place in the field and to plan management actions for the week/s ahead. Details of how the combined interstate operations committee monitored and managed the event, which complimented specifically commissioned research and monitoring projects and the value of such programs for adaptive management are highlighted in this paper.

## DISCUSSION

Overall the managed flooding of the Barmah-Millewa Forest floodplain and its associated wetlands and lakes can be viewed as having had significant environmental benefits.

The key aspect of assessing the managed flood was however to see what ecological responses were triggered and what if any management may need to be applied with particular regard to the response of the key Ecological Indicators ie. Vegetation (River Red Gums, Rushes, Reeds & Moira Grass), Colonial Waterbirds and Native Fish. The focus on the extension of the managed flood event through the EWA delivery via the manipulation of river flows and through the management of selected Forest regulators was a result of water-management options and areas being defined by Agency staff in consultation with the community in the Barmah-Millewa Forest Environmental Management Plan. The annual operations component of the plan identifies the objectives and watering strategies where management intervention could be applied to ensure successful ecological outcomes.

As a result of the managed 2005-06 EWA event the floodplain vegetation including the majority of River Red Gum forest and some of the River Red Gum woodland responded to the flooding with new growth and vigour, and many of the flood-dependant and flood-tolerant understorey species, including aquatic plants and terrestrial grasses were able to complete their lifecycles.

The amount and extent of Wavy Marshwort with this flood surpassed the previous managed event in 2002-03 and the response of Moira grass was significant with broad areas of the Moira grass plains having flowered and set seed in response to the extended flooding.

The extent of the flooding and the response of the River Red Gums to the event was mapped by a combined approach of field survey and remote sensing, with the final result revealing that approximately 57% of the combined Barmah-Millewa Forest floodplain was inundated taking in the majority of the River Red Gum forest and parts of the River Red Gum woodland.

The EWA delivery resulted in the successful breeding of approximately 52,000+ colonial waterbirds with multiple colonies established throughout the Barmah-Millewa Forest wetland system. This included the establishment of a mixed colony of the listed Nankeen Night Herons and 3 species of Egret, (ie. Great Egret, Intermediate Egret and Little Egret), in Barmah with over a thousand nests, the first time these species have bred in Barmah in over 40 years and the first recorded breeding of Little Egrets in Victoria in 25 years. Sacred Ibis, Straw-necked Ibis and Royal Spoonbills also bred throughout in numbers exceeding previous events.

Significant numbers of waterfowl including Grey Teal, Black Duck, Wood Duck and Black Swan also breed as a result of the flood conditions that would not have done so on such a scale if it had not been for the extent and duration of this flood. The extent to which some of these early flood responding waterbirds bred is difficult to assess as many could not be seen from the air during the aerial surveys as they were tucked well away under the fresh cover of the forest canopy during this time. Yet they, along with their young, were observed in significant numbers during boating and ground based field assessments of the Forest. Similarly, some of the more cryptic species such as Crakes and Rails and others such as Bitterns which were heard during monitoring but are difficult to locate, are likely to have bred given the favourable conditions.

The flooding also provided a much needed drought refuge and a feeding resource for significant numbers of other waterbirds such as Ducks, Egrets, Herons, Spoonbills and Pelicans, many of which had bred-up previously in inland Australia prior to the current drought conditions. These species, and numerous others such as a diverse array of raptors and bush birds that we don't generally associate with wetlands and flooding, were also beneficiaries of the flood event, as was a host of reptiles, amphibians and mammals. At the height of the flooding, raptors, snakes and water rats could be found along with numerous scavengers such as ravens working in, over or around the breeding colonies looking for a feed. In making these observations it was apparent how the flooding had kick started a whole food chain ecological response.

A number of Fish research and monitoring projects were being undertaken throughout the Barmah-Millewa Forest floodplain at the time of the event and what was shown was quite remarkable in the establishment of an unequivocal link between the spawning of native fish species and flooding. Golden and Silver perch were found to be spawning in unprecedented numbers in response to the managed flood peaks while Murray cod were also found to have spawned, their spawning tended to be more to regular pattern of timing. Trout cod were also observed for the first time to have spawned as a result of this managed flood event and the spawning and recruitment of many of the smaller native forage fish species was also significant.

Monitoring the flood event (including the first time targeted use of the environmental flow for fish breeding) did show a number of positive benefits for native fish. The most obvious being the increased spawning activity in Golden perch and Silver perch, and the increased number of young-of-year Murray cod, Trout cod and Southern pygmy perch. Flooding was also shown to have played an invaluable role in habitat maintenance and connectivity of floodplain habitats such as wetlands and creeks for a variety of fish residing and recruiting on the floodplain. Indirectly it also provided a boost of nutrients and prey items in returning waters to permanent waterbodies such as the main river channel and the Forest wetlands and Lakes.

Pre and post event monitoring has further shown that the Barmah-Millewa Forest contains a high diversity of native fish, and is a significant area for native fish conservation, with a number of species of conservation significance detected. The majority of native species known to exist in the region utilised a variety of Forest habitat types for both residence and recruitment, during flood and non-flood conditions. This suggests that the diversity of the Forest's aquatic habitat types needs to be maintained to ensure conservation of the regions fish fauna. Abundant breeding populations of five introduced species have also been recorded in the Forest waterways.

Frog breeding occurred in most water management areas of the Barmah-Millewa Forest wetland system. Species identified included: Peron's Tree Frog, Pobblebonk Frog, Barking Marsh Frog, Spotted Marsh Frog, Plain's Froglet and Common Froglet. All species were found to have successfully bred during this event.

The EWA volume diverted into the Barmah-Millewa Forest wetlands equated to 513 GL, though an estimated 92-95% (as measured by the Forest hydrographic recorders and confirmed by the newly developed Barmah-Millewa Hydrological Model), returned in through-flows to the River Murray. These return flows to the river system were able to be reallocated to other Icon Sites down-stream of the Barmah-Millewa Icon for River Red Gum rescue projects in Victoria and for consumptive use in NSW. The flows through the Forest wetland system also resulted in the drop out of significant loads of nutrient rich sediment and importantly, because of the connection between floodplain and river, saw carbon vital for the ecology of the river recycled back to the river system.

The results from monitoring this event has implications for water management activities in other catchments and for future EWA deliveries. In particular, special note needs to be made to ensure satisfactory delivery performance exists when attempting to deliver an EWA to wetlands particularly if it involves delivery during high evaporation periods. The timing of water delivery also needs to account for the needs of the Key Indicator species, and to minimise any negative ecological outcomes such as pest species proliferation, summer weed invasion or Giant Rush or River Red Gum encroachment where it is not appropriate.

As a result of the field staff monitoring and having the weekly operations committee tele-conference and of documenting the beneficial results of supplying water to a drought-stressed floodplain, it has provided greater support for similar future requirements for water management activities. Furthermore, actual adaptive management of the flooding was only possible with knowledge gained from the intensive monitoring. Less intensive monitoring, say on a monthly interval, may have missed important observations such as the scope for fine-tuning river flows, depths and flood duration in the face of pending Colonial waterbird breeding abandonment or native fish entrapment on the floodplain. A greater knowledge base of floodplain dynamics is also obtained from more intensive monitoring, plus has provided results that adequately reports responsible management and outcomes arising from use of a precious volume of stored water.

The adaptive management and monitoring of the 2005-06 Barmah-Millewa EWA delivery has increased our knowledge and understanding of biodiversity and provided for better conservation and management outcomes by:-

- Ensuring through monitoring and adaptive management the successful breeding of significant colonial nesting waterbirds in the Barmah Forest wetlands for the first time in 40 years.
- Provided for the first time the evidence of the link between floodplain inundation and the spawning and recruitment of significant species of native fish.

- Demonstrated conclusively through the hydrographic recording and the hydrological monitoring of the EWA delivery event the high volumes of water that actually return from the Barmah-Millewa Forest wetland system to the Murray River.
- Provided for the first time the recorded location of all nesting sites and territories of the listed White-bellied Sea Eagle including two previously unrecorded sites.
- Identified the links with the inundation of the Barmah-Millewa Forest wetlands and waterways with the recruitment of both Native and Introduced fish species to the Murray River system.
- Demonstrated the vital effects of floodplain inundation and river channel connectivity with regards to water quality and biodiversity.
- Enabled the mapping of the extent and distribution of the invasive aquatic weed Arrowhead in the Barmah-Millewa Forest wetlands to provide the foundation for future control.

Having had success with managing an EWA delivery it is important to communicate the results, as learning by doing is integral to Adaptive Management, sharing that knowledge gained is equally important. Communication of the results of the adaptive management of the 2005-06 Barmah-Millewa Forest EWA delivery was therefore undertaken by a range of activities including:-

- Presentations to a wide range of State and Interstate agency and community forums including; Living Murray forums, Forest Management and Biodiversity and Water forums, Catchment Management Authority forums, Land care and Service Club forums, Conservation Group forums, Icon Site tours and through presentations at River and Waterway management conferences.
- Publication of scientific reports and conference papers / proceedings. Plus a wide range of media coverage during and following the event including newspaper articles, radio interviews and television news and current affairs programs such as the ABC Stateline program.

The environmental, economic and social impacts of the 2005-06 Barmah-Millewa Forest EWA delivery were also assessed by a variety of means and these included:-

- Environmental impacts both positive and negative have been assessed through a number of research and monitoring projects as funded through The Living Murray program. The impact of the EWA delivery was assessed against The Living Murray benchmarks for Vegetation, Fish and Colonial Waterbird breeding as set out in the First Step decision (2002).
- Economic and Social impacts have been gauged from the high visitor numbers to the area and the amount of recreational activity that took place during the event. Impacts can also be gauged as a consequence of the high degree of media interest that was generated at the time and the community interest that has continued to flow on since the EWA delivery was undertaken.
- Environmental, Economic and Social impacts should also be considered with regards to the effects of the return flows to the Murray River system after it had passed through the Barmah-Millewa Forest and the fact that this meant that significant volumes of water were able to be allocated for environmental and commercial purposes downstream in both Victoria and other States.

## **SUMMARY OF OUTCOMES**

### ***Notable Ecological Issues Vegetation:***

- The managed flood provided drought relief for 57% of the forest floodplain flora giving stressed River Red Gums and Flood dependent understorey a timely and much needed drink.
- The extent and proliferation of Wavy Marshwort with this flood was significant, surpassing the 2002-03 managed flood event.

### ***Notable Ecological Issues Waterbirds:***

- The successful breeding and fledging of 52,000+ colonial nesting waterbirds despite some adverse weather conditions gave these populations a much needed boost.
- The breeding of threatened species was particularly of note with Little, Intermediate and Great Egrets breeding in the Barmah Forest in a mixed colony with Nankeen Night Herons for the first time in 40 years.
- Monitoring of this event located two new territories for the EPBC listed White-bellied Sea Eagle taking the number of known nest sites in the Barmah-Millewa Forest from 5 to 7 with breeding occurring at each site.
- Significant numbers of waterfowl (eg. Grey Teal, Black duck, Wood duck and Black Swan), bred as a result of the flood conditions that would not have done so except for this flood.
- The flooding provided drought refuge and a feeding resource for significant numbers of waterbirds such as Egrets, Herons, Spoonbills and Pelicans.
- The flooding also triggered an ecological response in a host of other species not typically associated with flooding eg. Raptors, Bushbirds etc.

### ***Notable Ecological Issues Fish:***

- The unequivocal link between the spawning of some native fish species and flooding established.
- Golden and Silver perch found to be spawning in unprecedented numbers in response to the managed flood peaks.
- Silver perch had an unexpected second major spawning run at the end of December 2005 when the flood was receding, correlated with a week long spike in temperatures.
- The spawning and recruitment of both Murray cod and Trout cod was significant as a result of this managed flood event, with Trout cod being recorded breeding in the Forest waterways for the first time.
- The spawning and recruitment of many of the smaller native forage fish species was also significant with many threatened species being recorded.

### ***Issues arising from monitoring:***

- It was confirmed that the monitoring of EWA deliveries needs to be at a minimum, weekly if the response of Key Indicator species is going to be detected and changes in water management adapted.
- The use of aerial surveys as a technique to cover broad areas of the Forest wetlands and waterways in order to locate and pin-point target species for on ground investigation and monitoring was again proven to be a useful and cost effective tool, when time and physical constraints are limiting.
- Utilising GPS and Remote sensing technologies for mapping the location / extent of flooding or a particular species was found to be invaluable, particularly when repeated access to pin point an attribute is required in difficult terrain / by different monitors.
- The use of digital cameras was again demonstrated to be an effective tool for monitoring and documenting the response of Key Indicator species providing both a visual and date / time specific reference.

### ***Outcomes for water management planning:***

- Management arrangements for securing and delivering an EWA need to be flexible and cooperative at all decision making levels particularly in times of special need when access to Key decision makers may be limited.
- The adaptive management of this flood event / EWA delivery with the use of the inter-agency operations committee and the weekly tele-conferences has provided a useful model for decision making for future EWA deliveries.

## **SCIENTIFIC OUTPUTS RELATED TO EWA MONITORING**

### ***Peer-reviewed Journal Articles:***

Crook, D.A. and Gillanders, B.M (2006). Use of otolith chemical signatures to estimate carp recruitment sources in the mid-Murray River, Australia. *River Research and Applications* 22, 871-879.

Tonkin, Z., A. King, J. Mahoney & J. Morrongiello (In Press). Diel and spatial drifting patterns of silver perch *Bidyanus bidyanus* eggs in an Australian lowland river. *Journal of Fish Biology*.

King, A.J. (2005). Fish in the Barmah-Millewa Forest – history, status and management challenges. *Proceedings of the Royal Society of Victoria*, 11, (1) 117-126.

King, A.J., Crook, D.A., Koster, W.M, Mahoney, J. and Tonkin, Z. (2005). Comparison of larval fish drift in the Lower Goulburn and mid-Murray Rivers. *Ecological Management and Restoration*, 6, (2), 136-138.

King, A.J., Tonkin, Z., Mahoney, J. (2006). Effects of an environmental flow on spawning and recruitment of four native fish.

King, A.J., Tonkin, Z., Mahoney, J. (2006). Fish spawning and recruitment in Barmah-Millewa Forest. 1. Temporal variability.

King, A.J., Tonkin, Z., Mahoney, J. (2006). Fish spawning and recruitment in Barmah-Millewa Forest. 2. Habitat use.

King, A.J., Tonkin, Z., Mahoney, J. (2006). Testing a modification to a standard passive drift net to capture larval and juvenile fish

Macdonald, J.I. and Crook, D.A. (2006). Identifying natal sources of common carp (*Cyprinus carpio* L.) in the mid-Murray River, Australia, using otolith chemical analysis.

Jones, M. (2006). Regulated floodplains: a trap for unwary fish. *Journal of Fish Biology*

### **Reports:**

Abuzar, M. and Ward, K.A. (2006) Flood and vegetation mapping in the Barmah-Millewa Forests during October – November 2006 using satellite remote sensing technology. Report prepared for GBCMA. Department of Primary Industries, Tatura.

Crook, D. (2004). Contribution of the Barmah-Millewa Floodplain lakes to carp populations in the mid-River Murray. Final report to Barmah-Millewa Forum. Freshwater Ecology Section, Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, Heidelberg, Victoria.

H. Gigney, R. Petrie, B. Gawne, D. Nielsen and J. Howitt (2006) The Exchange of Organic Material between the Murray River Channel and Barmah-Millewa Forest during the 2005/2006 Floodplain Watering. A Murray Darling Freshwater Research Centre consultancy report for: Murray Darling Basin Commission & Goulburn Broken Catchment Management Authority, 24 July 2006

Jones, M. and Stuart, I. (2004). Impact of flow regulation structures on fish in the Barmah-Millewa forest: a report for the Barmah-Millewa Forum. ISBN: 1 741069173

Jones, M. (2004). Effects of Environmental Flow Allocations on the lateral movements of native fish in the Barmah-Millewa forest. Progress report for the Barmah-Millewa Forum and the Murray-Darling Basin Commission.

Jones, M. (2005). Effects of Environmental Flow Allocations on the lateral movements of native fish in the Barmah-Millewa forest. Progress report for the Barmah-Millewa Forum and the Murray-Darling Basin Commission.

Jones, M. (2006). Assessment of fish accumulations behind Gulf and Mary Ada regulators. Progress report for the Murray-Darling Basin Commission.

Jones, M. (2006). Effects of Environmental Flow Allocations on the lateral movements of native fish in the Barmah-Millewa forest. Final report for the Murray-Darling Basin Commission. 84pp ISBN:1 921257032

King, A.J., Tonkin, Z. and Mahoney, J. (2005). Assessing the effectiveness of environmental flows on fish recruitment in Barmah-Millewa Forest – 2004/05 Progress report. Report to Murray-Darling Basin Commission. Freshwater Ecology, Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment.

King, A.J., Mahoney, J. and Tonkin, Z. (2004). Assessing the effectiveness of environmental flows on fish recruitment in Barmah-Millewa Forest – 2003/04 Progress report. Report to Murray-Darling Basin Commission. Freshwater Ecology, Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment.

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Maxwell, R. (2006) Scoping survey of the Barmah and Millewa Forests to identify the extent of invasion of Arrowhead in June-July 2006. Draft report prepared for DSE. Department of Primary Industries, Tatura.

Parks Victoria (2006) Monitoring the number of breeding pairs of White-Bellied Sea-Eagles within Barmah-Millewa Forest 2005/06. Parks Victoria, Melbourne.

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Ward, P.A. (2006) Monitoring frog response to flooding in Barmah-Millewa Forest: 2005/06. Monitored month report – December 2005. Report prepared for the Murray-Darling Basin Commission, Canberra.

Ward, P.A. (2006) Monitoring frog response to flooding in Barmah-Millewa Forest: 2005/06. Monitored month report – February 2006. Report prepared for the Murray-Darling Basin Commission, Canberra.

### ***Media Liaisons:***

A range of print and electronic media were used to convey water management activities as they were progressing and of the outcomes achieved. This included at least 16 articles appearing in regional and national newspapers (including The Australian, The Age and The Weekly Times), and feature stories on local radio and on local and national television (including ABC's Stateline program and 'Two men in a tinnie' documentary).

- "River water delivery helps environment" DSE-DPI Bush and Land column – McPherson Press newspapers northern Victoria and southern NSW, by Paul O'Connor 10 October 2006.
- DSE Inform article September 2006. "Two men in a tinny" February 2006
- Interviewed for article on Murray cod breeding for Herald Sun Newspaper. "The cod is back", Sunday Herald Sun, 5<sup>th</sup> February 2006
- Publication of article in Victorian Fishing Monthly. "Natives flourish in Barmah-Millewa floods", by Alison King, Victorian Fishing Monthly, February 2006. January 2006
- DSE Inform article January 2006 "Native fish flourish in Barmah-Millewa Forest floods"
- "Invigorating the Barmah-Millewa Forest", Victorian Fishing Monthly, January 2006. December 2005
- Interviewed for an ABC TV documentary to be screened in June/July 2006, "Two men in a tinny".
- Interviewed for newspaper article, Sunraysia daily, 21/12/06, "Flooding livens Barmah"

- Interviewed for information for Environment Victoria's website news article "Booming fish numbers prove need for more flows"
- "Flushing flows for Forest and fish" Victorian fishing monthly, November 2005, December 2005.
- Interviewed for various newspaper articles on fish response to Barmah-Millewa Environmental Flow.
- "Flood spawns breeding of Murray's native perch" The Australian, 23/11/05
- Breeding frenzy in Barmah, The Age article, 26/11/05
- "Native fish species spawning", Sunraysia Daily, 9/11/05
- "Fish spawn in Barmah wetlands", Numurkah Leader, 16/11/05
- Filmed and interviewed on ABC TV Stateline, screened 2/12/05.

## ACKNOWLEDGEMENTS

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Flooded River Red Gums in the Barmah-Millewa Forest (Photo Paul O'Connor).

