The Living Murray Barmah-Millewa Forest Icon Site

Annual Report 2010-2011

Prepared by the
Goulburn Broken Catchment Management Authority

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Cover photographs by Keith Ward (GB CMA)
Main: Intermediate Egret at nest at Picnic Point, taken 17 Dec 2010
Left: Moira Grass (*Pseudoraphis spinescens*) at Little Rushy Swamp, taken 7 Feb 2011
Right: Barmah Lake from the air, taken 22 Nov 2011

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Acronyms and Abbreviations

B-M	Barmah-Millewa
B-MF	Barmah-Millewa Forest
B-MOP	Barmah-Millewa Operations Committee
CAMBA	Chinese-Australia Migratory Bird Agreement
CMA	Catchment Management Authority
CMP	Condition Monitoring Plan
CRG	Consultation Reference Group
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
DSE	Department of Sustainability and Environment
DVD	Digital Versatile Disc
EWA	Environmental Water Allocation
EWMP	Environmental Works and Measures Program
GB CMA	Goulburn Broken Catchment Management Authority
GL	Gigalitre
ICC	Icon Coordinating Committee
JAMBA	Japan-Australia Migratory Bird Agreement
MDB	Murray-Darling Basin
MDBA	Murray-Darling Basin Authority
MDBC	Murray-Darling Basin Commission
MDFRC	Murray-Darling Freshwater Research Centre
ML	Megalitre
NP	National Park
NPWS	National Parks and Wildlife Service
NSW	New South Wales
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
TAC	Technical Advisory Committee
TLM	The Living Murray
WMA	Water Management Area

1 Summary

The 2010/11 flood event in Barmah-Millewa Forest has ended a drought sequence not previously experienced in 105 years of records, and reached unprecedented summer flood levels (*Figure 2*, Appendix 1). The flood has brought flows in the Murray downstream of Yarrawonga of more than 100,000 ML per day, which is about ten times the channel capacity through the Forest.

The last flood (2005) was only a 'medium-sized' event in which about 55% of the floodplain was inundated (with assistance from the last release of the Barmah-Millewa Environmental Water Allocation (EWA)). Since then, there have been only very minor floodings of selected wetlands and waterways, and these have primarily been due to release of EWAs to provide drought refuge for aquatic-dependent biota.

The dry conditions since 2005 meant that there were no major waterbird breeding events. There was some minor breeding of ducks and swans in isolated areas, but it's only in the past year that significant species such as a variety of colonial waterbirds have bred. This includes the largest population of nesting Egrets (Great, Intermediate and Little) and Nankeen Night Herons in Victoria.

The last widespread flood event to inundate the entire Barmah-Millewa floodplain was in the spring of 2000, when there was a significant flora and fauna response.

This year's flood event is similarly very significant in boosting the health of floodplain-dependant biota and assisting in recovery from the drought conditions. Native wetland vegetation has responded with vigorous new growth, although patchy for some species, and significant colonial waterbird breeding events may be among the largest such events for around 50 years.

The flooding has also resulted in spawning of native fish species such as Silver Perch, Golden Perch and Murray Cod, although the impact of blackwater (as a consequence of warm water dissolving red gum leaf litter accumulated during the drought) may limit their recruitment this year (previous monitoring has shown flood years to strongly promote breeding and recruitment of perch and cod). Furthermore, Southern Pygmy Perch has now not been recorded for several years and may be locally extinct. By contrast, the major exotic fish species, Common Carp and Gambusia, appeared to have had a particularly strong breeding success.

Recent condition assessments of the River Red Gum forest show that large areas of the Barmah-Millewa floodplain have declined from 'in good health' to 'stressed' over the period 2003 to 2009. Stands that have remained in relatively good condition are restricted to areas surrounding the river, creeklines and wetlands. The recent flooding will reinvigorate the health of the forests, though sadly this has come too late for some sections of the forest.

The overall environmental condition of Barmah-Millewa Forest is regarded as 'moderate' with a declining trend for most condition indicators expected to be reversing for most aspects of the forest ecosystem because of the recent flooding.

Although very beneficial, the recent flooding will not completely re-set the health of the floodplain ecosystem. Flora and fauna populations have been reduced by the ravages of the prolonged drought, and will take time to recover. Meanwhile, the impacts of river regulation, competition with exotic flora and fauna, man-made barriers and the like continue to have a negative influence on the natural ecosystem.

The Living Murray Initiative and state management strategies and actions aim to redress many of these impacts. Greater returns and management of water for environmental outcomes will assist in ensuring

that key environmental requirements are met. EWAs are also likely to be used to extend the benefits of the natural flood, such as to ensure that major waterbird breeding events are successfully completed.

1.1 Key Learning and Recommendations

Key Learning's and Recommendations

While not intending to be a comprehensive list, documenting some key learning's from 2010/11 is an opportunity to highlight aspects of management or issues for discussion and future reference.

Event Issues - Blackwater

The hypoxic blackwater event triggered water quality monitoring to follow and document the event. For native aquatic species that inhabit the Murray River there is the potential for a negative impact on total population as result of this hypoxic blackwater event (see reports in Section 4.5). For species subject to licensed and restricted recreational fishing, such as large-bodied native fish and Spiny Freshwater Crayfish, a potential negative impact on the population on a local and catchment scale should raise concern about population sustainability, at least in the short-term.

The successful communication around concerns to native fish and crayfish populations as a result of the hypoxic blackwater event to stakeholders outside of the Barmah-Millewa forums was a challenge identified by the Barmah-Millewa Technical Advisory Committee in 2010/11.

Recommendation

To improve the flow and timeliness of communication with relevant stakeholders external to the B-M TLM forums in relation to potential and emerging issues, such as the potential impact of a hypoxic blackwater event on native aquatic species.

Partnerships

The Barmah-Millewa Operations Committee (B-MOP) is a multi-agency committee of managers and practitioners who contribute to timely decision making processes concerning water management requirements in Barmah-Millewa Forest. The B-MOP is an example where active partnerships between relevant authorities can rapidly co-manage active water management events, under direction of water management operating plans previously considered by exiting TLM structures. Weekly teleconferences permit ready participation where ecological advice and on-ground reports can be incorporated into timely consideration for management of environmental flows. B-MOP teleconferences are chaired by the MDBA and only convened during times where active water management considerations are required for Barmah-Millewa Forest (especially when EWA releases are being made). The group first convened in 2005/06 to oversee the B-M EWA event in that year, and now again in 2010/11 to successfully achieve the ecological objectives of the environmental watering.

While all relevant authorities are encouraged to participate across a range of forums, linkages between on-ground water management committee's such as B-MOP and strategic forums such as the Icon Site Coordinating Committee can be improved.

Recommendation

That the MDBA continue to lead multi-agency forums appropriate to the management of current issues, while developing improved communication flow to established Icon Site committees.

2 Introduction

2.1 Background

In 2002, the Murray-Darling Basin Ministerial Council established The Living Murray initiative - a long-term program of collective actions aimed at returning the River Murray system to a healthy working river. The First Step decision was made in 2003 to create a process of implementing the longer term goals of The Living Murray program. This was followed by the signing of an intergovernmental agreement in 2004 by Victoria, New South Wales, South Australia, the Australian Capital Territory and the Australian Government to address water allocation in relation to environmental objectives affecting six nominated Icon sites, one of which the Barmah-Millewa Forest.

The Barmah-Millewa Forest Icon Site, consisting of the Barmah Forest in Victoria and the Millewa group of forests in New South Wales, is the largest River Red Gum forest in Australia. It covers approximately 66,000 ha of floodplain between the townships of Tocumwal, Deniliquin and Echuca. The forest floodplain vegetation communities in Barmah-Millewa Forest includes a range of habitats, including swamps and marshes, rush beds, lakes and billabongs, open grassland plains (including large Moira Grass plains), River Red Gum forests, River Red Gum woodlands and Black Box woodlands.

In its decision on the First Step for The Living Murray, the Murray-Darling Basin Ministerial Council set interim ecological objectives and expected outcomes for each of the Icon Sites. For the Barmah-Millewa Icon Site, the interim ecological objective is to enhance forest, fish and wildlife values, ensuring:

- successful breeding of thousands of colonial waterbirds in at least three years in ten; and
- healthy vegetation in at least 55% of the area of the forest (including virtually all of the Giant Rush, Moira Grass, River Red Gum forest, and some River Red Gum woodland).

The refined ecological objectives for the Barmah-Millewa Icon Site are documented in the *Barmah-Millewa Icon Site Environmental Water Management Plan* (GB CMA, 2011a). The refined objectives are as follows:

- Promote healthy and diverse vegetation communities, with an emphasis on restoring natural extent and distribution of Giant Rush, Moira Grass, River Red Gum forest and River Red Gum woodland in at least 55% of the area of Barmah-Millewa Icon Site.
- Facilitate healthy and diverse vegetation to provide suitable, breeding and foraging habitat for a diverse range of waterbirds and bush birds.
- Promote and/or sustain successful breeding events of multiple thousands of colonial and migratory waterbirds in at least three years in ten, by inundating selected floodplain and wetland areas to provide suitable nesting and feeding habitat.
- Promote successful recruitment of native fish species by improving flow variability in spring and early summer to replicate natural cues, and by inundation of floodplain and wetland areas to provide breeding and nursery habitat.

- Facilitate successful breeding and feeding opportunities for native frog species by seasonal inundation of selected floodplain and wetland areas for appropriate season and duration as required for each species.
- Facilitate successful breeding of native turtle species by inundation of selected floodplains and wetland areas to provide suitable breeding and nursery habitat.
- Facilitate appropriate management to ensure the sustainability of crayfish populations.
- Facilitate appropriate management measures to control the abundance and spread of invasive aquatic species.
- Facilitate appropriate geomorphic management in selected waterways.

Specific targets are being developed to measure the ecological objectives for Barmah-Millewa Forest and are due for completion in 2011/12 (L. Davis, DSE, pers. comm. 2011). This will complement the *Barmah-Millewa Icon Site Condition Monitoring Plan* (GB CMA 2011b).

Ongoing management of the Barmah-Millewa Forest Icon Site under The Living Murray program is undertaken by the Icon Site Coordinating Committee with support from various subcommittees, as detailed in Section 3.

2.2 Land Tenure

Barmah (Vic)

Barmah Forest is a 28,521 hectare National Park that formally came into existence in mid-2010 as the Barmah National Park. This new reservation status replaced the previous land tenures of Barmah State Forest and Barmah State Park. The exception is Barmah Island (previously State Forest), which was incorporated into the Murray River Regional Park. The legislation, titled the *Parks and Crown Land Legislation Amendment (River Red Gum) Act 2010*, commenced on the 29th of June, 2010 (DSE, 2011).

Millewa (NSW)

Millewa Forest, which was a collective name for the Millewa group of forests that included Gulpa Island Forest, Moira Forest, Tuppal Forest and Millewa Forest, now forms part of the 41,600 hectare Murray Valley National Park that formally came into existence in mid-2010. Approximately 33,400 hectares of this new National Park replaced the previous State Forests of Tuppal, Millewa (part), Moira (part) and Gulpa Island (part). The entire Murray Valley National Park incorporates all or part of additional former State Forests. The remaining parts of Millewa, Moira and Gulpa Island State Forests were incorporated into the Murray Valley Regional Park. The legislation, titled the *National Park Estate (Riverina Red Gum Reservations) Act 2010*, commenced on 1 July, 2010 (OEH, 2011).

Figure 1: Steamer Plain near Budgee Creek, 11 October, 2010 (photo: Keith Ward)

2.3 Hydrograph

Flooding in Barmah–Millewa Forest generally occurs when Murray River flows exceed ~10,500ML/d downstream of Yarrawonga. The hydrograph of the river at this location throughout 2010/11 is presented in Figure 2, and shows the river having exceeded channel capacity at the Barmah-Millewa Forest for around ten months of the year and on two occasions exceeded channel capacity by an order of magnitude.

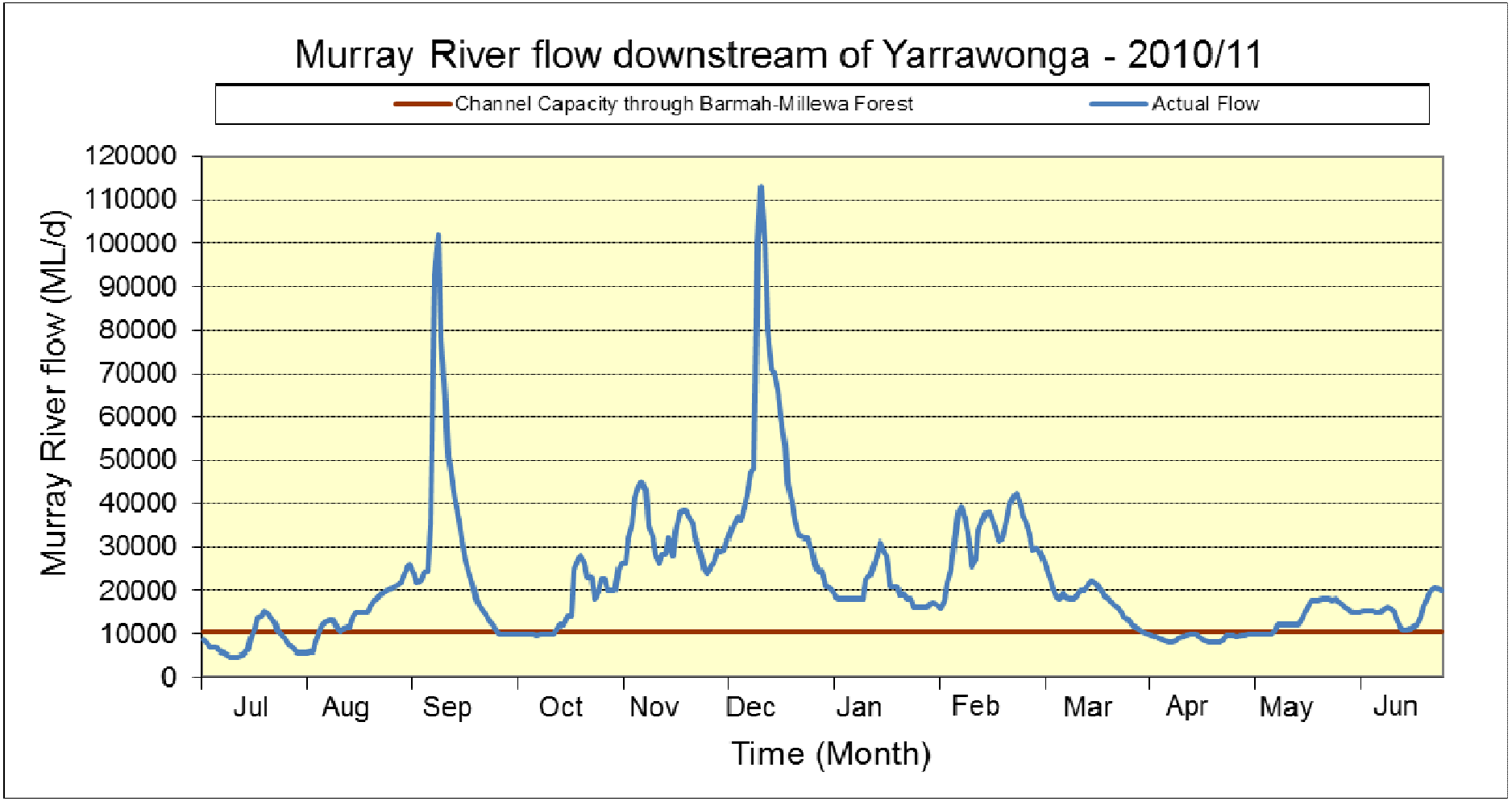

Figure 2: 2010-11 hydrograph showing Murray River flow downstream of Yarrawonga Weir.

3 Management and Committee Structure

The key structural arrangements developed to manage Icon Sites such as the Barmah-Millewa Forest are outlined below.

3.1 The Living Murray

Activities within The Living Murray are delivered according to the requirements of *The Living Murray Business Plan* (MDBC, 2004) which sets out terms and conditions agreed by the Ministerial Council. The Business Plan defines the role of Icon Site Manager, Integrated Coordinating Committee and other structural arrangements.

Programs and works are delivered by the States under contract with Murray Darling Basin Authority (MDBA). The contracts are:

- Environmental Delivery Program:
- Environmental Works and Measures Program;
- Monitoring;
- Indigenous Program (commenced 2007/08);
- Communications (commenced 2007/08)

Additional contracts are written as required for environmental water delivery events including intervention monitoring.

State jurisdictions engage partner organisation, often catchment management authorities or water authorities to deliver specific activities within each of these contracts.

For detailed information on the management structure of Barmah-Millewa Forest refer to the Barmah-Millewa Icon Site Environmental Water Management Plan, 2011 (GB CMA, 2011a).

3.2 Icon Site Manager

Each state has a nominated Icon Site Manager from the principal land management agency. A Lead Icon Site Manager, who also acts as the Chairperson of the Barmah-Millewa Icon Site Coordinating Committee (B-M ICC), is nominated for a period of one year. The role alternates between the two State Icon Site Managers, the Goulburn Broken Catchment Management Authority (Vic) and the New South Wales National Parks and Wildlife Service. The Victorian Icon Site Manager took the lead role during 2010-2011.

3.3 Icon Site Coordinating Committee

The B-M ICC consists of representatives from federal and state (New South Wales and Victoria) agencies, as outlined in the table below (Table 1). On occasions, guests are invited to attend in relation to specific matters/agenda items.

The purpose of the committee is to advise the Icon Site Managers on matters relating to the Barmah-Millewa Icon Site.

The committee met on 3 occasions (2 teleconferences and 1 meeting) during the 2010-2011 financial year. The committee's actions during the year included;

- Overseeing the development of the Barmah-Millewa Icon Site Environmental Watering Management Plan (B-M EWMP).
- Overseeing the development of the Barmah-Millewa Icon Site Condition Monitoring Plan (B-M CMP).
- The Living Murray project I20 completion (hydrodynamic model and Kynmer regulator & Gulf Fishway designs).
- Supported the development of the Barmah-Millewa DVD.

Table 1: Barmah-Millewa Icon Site Coordinating Committee attendees 2010-2011.

Members	Organisation	Meetings attended
Chris Norman (Chair)	Goulburn Broken CMA	3
Susan Buckle	MDBA	3
Paul Childs	NSW NPWS	2
Chris McCormack	Parks Victoria	2
Linda Broekman	Forests NSW	1
Meaghan Rourke	Agriculture & Fisheries NSW DPI	1
Tracey Brownbill	Murray CMA	1
Allan Lugg	Agriculture & Fisheries, NSW Dept Industry & Investment	1
Dan McLaughlin	Parks Victoria	1
Emmo Willnick	Murray CMA	1
Julia Reed	Department of Sustainability and Environment	1
Jade Miller	Yorta Yorta Nation Aboriginal Corporation	1
Lee Joachim	Yorta Yorta Nation Aboriginal Corporation	1
Andrew Warden	Department of Sustainability, Environment, Water, Population and Communities	1
Jennifer Martin	Department of Sustainability, Environment, Water, Population and Communities	1
Guests		
Keith Ward	Goulburn Broken CMA	3
Brian Royal	Murray CMA	1
David Hohnberg	MDBA	1
Rebecca White	MDBA	1
Jill Whiting	MDBA	1

3.4 Icon Site Technical Advisory Committee

The Barmah-Millewa Technical Advisory Committee (B-M TAC) consists of representatives from federal and state (New South Wales and Victoria) agencies, as outlined in the table below (Table 2). On occasions, guests are invited to attend in relation to specific matters/agenda items.

The committee met on 2 occasions during the 2010-2011 financial year. The committee's actions during the year included;

- Contributed to the development of the B-M EWMP
- Contributed to the development of the B-M CMP
- Overseen the management and reporting of various monitoring projects.

Table 2: Barmah-Millewa Technical Advisory Group attendees 2010-2011.

Members	Organisation	Meetings attended
Keith Ward (Chair)	Goulburn Broken CMA	2
Bruce Wehner	Parks Victoria	2
Damian Green	River Murray Water	2
Shar Ramamurthy	Dept of Sustainability & Environment	2
David Hohnberg	Murray Darling Basin Authority	2
Meghan Rourke	Dept Industry & Investment NSW	2
Bill Viney	Goulburn Murray Water	1
Jade Miller	Indigenous Facilitator Barmah-Millewa	1
Karen Hudson	Forests NSW	1
Vince Kelly	NSW Dept of Water & Energy	1
Alison King	Arthur Rylah Institute	1

3.5 Icon Site Consultation Reference Group

The Barmah-Millewa Consultation Reference Group (B-M CRG) met on 2 occasions during the 2010-2011 financial year. Members and guests are listed below (Table 3). The committee's actions during the year included;

- Contribution to B-M EWMP & B-M CMP development
- Input into public communication of projects (ie: monitoring)
- Input into the development of the Barmah-Millewa DVD

Table 3: Barmah-Millewa Consultation Reference Group attendees 2010-2011

Members	Organisation	Meetings attended
Russell Pell (Chair)	Goulburn Broken CMA Board Member	2
Gordon Ball	Basin-wide TLM Community Reference Group Member	2
Brian Royal	Murray CMA Board Member	1
Louise Burge	Adjacent Landholder/Community Member	1
Peter Gibson	Irrigator/Community Member	1
Keith Stockwell	Recreation/Tourism/Community Member	1
Guests		
Lucy Alderton	Dept of Sustainability & Environment	2
Keith Ward	Goulburn Broken CMA	2
Paul Childs	NSW NPWS	1
Tracey Brownbill	Murray CMA	1
Linda Broekman	Forests NSW	1
Jamie Hearn	Murray CMA	1

3.6 Icon Site Indigenous Partnership Project

The Icon Site Indigenous Partnerships Project has overtaken the Indigenous Reference Group as the forum for indigenous issues and input to be provided to the B-M ICC.

3.7 Barmah-Millewa Operations Committee

The B-MOP was a weekly teleconference, convened by the Murray-Darling Basin Authority. The group was formed following flows of ~26,000 ML/day downstream of Yarrawonga at the end of August 2010, with the best flows since 2005 passing through the forest at this time.

The aim of the B-MOP was described at the first meeting on 02/09/2010 as being to;

> *…provide ecological advice and on-ground observations that will assist with the management of environmental flows through the Barmah-Millewa Forest over the next few months* (MDBA 2011).

Thirty-three weekly teleconferences were held between 02/09/2010 and 03/05/2011. The final eight month operational duration for this committee reflected the unusually wet summer and prolonged above channel capacity flows through the Barmah Choke experienced during 2010/11, and reflected in the annual hydrograph (see Section 2.3)

Fifty people phoned in to the teleconference throughout the eight months and are listed below (Table 4). The number of meetings attended is also included. Note this list is adapted from the *Barmah-Millewa Environmental Watering teleconference notes (all)* document (MDBA, 2011) and may not be complete. Some agency names may have changed.

Table 4: Operations Committee teleconference attendees 2010-2011

Name	Organisation	Meetings attended
Adam Cotterill	Environmental Delivery, Murray-Darling Basin Authority	16
Alison King	Arthur Rylah Institute, Vic Department of Sustainability and Environment	17
Andrew Bishop	River Murray Operations, Murray-Darling Basin Authority	1
Anthony Scott	River Murray Operations, Murray-Darling Basin Authority	1
Bill Viney	Goulburn-Murray Water	1
Brad Neil	External consultant	1
Bruce Wehner	Parks Victoria	9
Col Hood	NSW State Water	13
Damian Green	River Murray Operations, Murray-Darling Basin Authority	19
Danielle McCalister	NSW Department of Environment, Climate Change and Water	2
Digby Jacobs	NSW Office of Water	4
Emma Wilson	NSW Department of Environment, Climate Change and Water	10
Erica Keely	Environmental Delivery, Murray-Darling Basin Authority	11
Frank Sita	Department of Environment, Water, Heritage and the Arts	2
Gary Rodda	NSW Murray CMA	1
Geoff Earl	Goulburn Broken CMA	1
Gerhard Schulz	NSW Office of Water	13
Hugh Christie	Department of Environment, Water, Heritage and the Arts	11
Jade Miller	Yorta Yorta Nations Aboriginal Corporation	1
Jenny Hale	External consultant	1
John Conallin	NSW Murray CMA	16
John Waterworth	River Murray Operations, Murray-Darling Basin Authority	13
Julia Reed	Vic Department of Sustainability and Environment	2
Justen Simpson	NSW Department of Environment, Climate Change and Water	7
Karen Hudson	NSW Sate Forests	1
Keith Chalmers	Goulburn Broken CMA	3
Keith Ward	Goulburn Broken CMA	23
Kerry Greenwood	River Murray Operations, Murray-Darling Basin Authority	20
Kris Kleeman	Natural Resource Management, Murray-Darling Basin Authority	2
Kudabanda Nawaratne	NSW State Water	16
Lee Joachim	Yorta Yorta Nations Aboriginal Corporation	1
Luke Pearce	NSW Department of Primary Industries	4

Marcus Cooling	External consultant	1
Mark Bailey	Goulburn-Murray Water	20
Megan Rourke	NSW Department of Primary Industries	1
Mick Caldwell	Parks Victoria	19
Mick Lalor	NSW Department of Environment, Climate Change and Water	1
Mike Jensz	Vic Department of Sustainability and Environment	23
Ned Hamilton	NSW State Water	1
Neville Atkinson	GB CMA / YYNAC	2
Paul Childs	NSW Department of Environment, Climate Change and Water	6
Paula D'Santos	NSW Department of Environment, Climate Change and Water	18
Rebecca Gee	Department of Environment, Water, Heritage and the Arts	18
Rick Webster	NSW Department of Environment, Climate Change and Water	15
Ryan Breen	Department of Environment, Water, Heritage and the Arts	1
Sarah Commens	Operations Review, Murray-Darling Basin Authority	6
Shar Ramamurthy	Vic Department of Sustainability and Environment	1
Susan Buckle	Environmental Delivery, Murray-Darling Basin Authority	5
Tamara Boyd	Parks Victoria	6
Vincent Kelly	NSW Office of Water	1

The outcomes of the weekly teleconference included:

- Informing stakeholders of the current status of Murray River operations, including use of environmental water to date;
- Stakeholder reporting of current conditions on the ground;
- Cooperative decision making for the foreseeable future (1-2 weeks) regarding the proposed duration and magnitude of flow through the Barmah-Millewa Forest, the proposed volume of environmental water to be used, and information sharing around why decisions are being made (ie: significant factors);
- Tentative plans for the use of environmental water for the remainder of the season;
- Sharing of information between stakeholders to facilitate on-ground monitoring and appropriate response to issues (such as dissolved oxygen readings);
- The ability of all stakeholders to share within their own networks what, why and how issues associated with Barmah-Millewa are being addressed;
- Successful multi agency cooperation over a prolonged period of time (13 agencies were represented plus two consultants over the 33 meetings).

3.8 Blackwater Committee

A weekly teleconference specifically related to the blackwater event was convened by the MDBA and operated over summer (mainly from January 2011 to March 2011). Its focus was the blackwater issue on a Murray-Darling Basin scale. For the Barmah-Millewa Forest, options for blackwater mitigation were regularly discussed, although few realistic management options existed. Outcomes included reducing the proportion of flows through the forest in favour of boosting river levels in attempt to dilute blackwater coming from the forest, and increasing water quality monitoring and its coordination and timely data use.

4 Activities and Achievements

The following section details the activities and achievements for 2010/11.

4.1 Environmental Delivery Program

Planning for water management in the Barmah-Millewa Forest.

Decision support for Environmental Watering at the Icon Site is managed through the TLM Icon Site committee structure, outlined above. The B-M TAC, in representing agencies and other appropriate consultation, develop proposals for e-watering, identifying ecological targets, priorities and options for delivery. The recommended proposals identified by the B-M TAC are then put to the B-M ICC for endorsement. The prioritised options may be further refined ass seasonal conditions or other issues dictate, making the annual watering plan section of the Icon Site Asset Environmental Management Plan an adaptive document. The B-MOP may then provide timely advice to the Icon Site manager(s) during times of active water management.

Ongoing water management planning includes the Barmah-Millewa Forest 'Time-share flooding' arrangement. This arrangement, developed by Barmah and Millewa Forest managers in the early 1990s, provides for the annual alternation of generally unwanted 'unseasonal' flooding between Barmah (Vic) or Millewa (NSW) at river flows between 10,500 ML/day to 15,000 ML/day. Such unseasonal flows generally occur as a result of rain-rejection events associated with river regulation, where river flows temporarily exceed channel capacity to cause some minor flooding at a time of year when under natural conditions such flood events rarely occurred. The enactment of the time-share flooding arrangement allows for at least some low-laying wetlands to seasonally dry when otherwise they would have been inundated with splitting the unseasonally water equally between the states. Although Barmah was designated to receive these flows in 2010/11, the large size of the events, combined with the use of the water for active waterbird breeding attempts at the time, meant that both Barmah and Millewa Forest shared the flows this year

The prioritisation table below (Table 5) shows a flooding score for each Water Management Area (WMA) from 1998 to 2009. This score is measured against the 'ideal' score for the predominant habitat within that WMA (follows Maunsell McIntyre Pty Ltd, 1999). The ideal score was determined by calculating the proportion of wetlands and River Red Gum areas in each WMA and applying their associated preferred flood frequency. Wetlands were considered to flood annually, while River Red Gum areas were split into three categories, site quality (SQ) I, SQ II and SQ III. SQ I are trees with a mature top height exceeding 30.5 metres, SQ II trees have a mature top height of between 21 and 30.5 metres and SQ III trees have a mature top height of less than 21.3 metres (Smith 1983). The flood frequency associated with each site quality class is 8 years in 10 for SQ I, 5 years in 10 for SQ II and 3 years in 10 for SQ III. The final ideal flood frequency for each WMA is then applied as a percentage of the maximum flood score of "3". Therefore, a WMA with a higher proportion of wetlands and SQ I River Red Gum area would have a greater ideal annual flood frequency and a higher ideal flood score than a WMA with a higher proportion of SQ III River Red Gum area.

Priority can then be ranked, with WMA's with the lowest (negative) differential between the actual and ideal scores the highest priority. Drought and low incidence of widespread flooding over the past decade in Barmah-Millewa Forest has resulted in all WMA's recording a negative flooding score using this method, thereby highlighting the requirement for widespread flooding across all of Barmah-Millewa Forest floodplain.

Table 5: Barmah-Millewa Forest flood prioritisation based on the past 12 years flood history and scored against ideal flood scenarios scores. (Prepared by Keith Ward, GB CMA).

Water Management Area	Observed flooding score												Ideal average annual flood score#	Accumulated score 1998-2009	Ideal score	Departure from ideal flood score	Watering priority for 2010	ICC preference
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009						
Kynmer Creek (A)	1	1	2	0	1	0	0	1	0	0	0	0	1.3	6	15.6	-9.6	Priority	Preference
Tongalong Creek (B)	1	1	3	0	1	1	1	2	0	0	0	0	1.5	10	18	-8	Priority	Preference
Smiths Creek (C)	3	1	3	0	1	0	0	2	0	0	0	0	1.5	10	18	-8	Priority	Preference
Yielima (D)	2	1	3	0	0	0	0	2	0	0	0	0	1.5	8	18	-10	Priority	Preference
Black Swamp (E)	2	1	3	0	0	0	0	1	0	0	0	0	1.6	7	19.2	-12.2	Priority	Preference
Gulf Creek (F)	2	1	3	0	2	1	1	3	0	0	0	1	1.9	14	22.8	-8.8	Priority	Preference
Boals Deadwood (G)	2	1	2	0	1	1	1	3	0	0	0	1	1.9	12	22.8	-10.8	Priority	Preference
Top Island (H1)	2	1	3	0	1	1	1	3	0	0	0	0	1.9	12	22.8	-10.8	Priority	Preference
Steamer/War Plain (H2)	2	1	3	0	2	2	2	3	1	0	0	1	2	17	24	-7	Priority	Preference
Goose Swamp (H3)	1	1	3	0	1	1	0	0	0	0	0	0	1.55	7	18.6	-11.6	Priority	Preference
Barmah Island (H4)	2	1	3	0	2	2	2	1	0	0	0	0	2	13	24	-11	Priority	Preference
Aratula Creek (J)	3	0	3	0	0	0	0	1	0	0	0	0	1.5	7	18	-11	Priority	Preference
Plantation (L)	2	0	3	0	0	1	0	1	0	0	0	0	2	7	24	-17	Priority	Preference
Mary Ada (M)	3	0	3	0	0	1	1	2	0	0	0	0	1.9	10	22.8	-12.8	Priority	Preference
Edward River (N)	3	1	3	0	0	1	1	2	0	0	0	0	2.3	11	27.6	-16.6	Priority	Preference
Towrong Creek (P)	3	0	3	0	0	0	1	2	0	0	0	2	1.4	11	16.8	-5.8	Priority	Preference
St Helena Swamp (Q)	2	1	3	0	0	1	1	2	0	0	0	0	2.2	10	26.4	-16.4	Priority	Preference
Gulpa Creek (R)	2	1	3	0	0	1	2	1	0	0	0	0	2.2	10	26.4	-16.4	Priority	Preference
Moira Lake (S)	2	1	3	0	2	1	2	2	1	0	0	0	2	14	24	-10	Priority	Preference

Notes:

Flood scores:

0	"no flooding the WMA"
1	"some flooding the WMA"
2	"lot of flooding"
3	"completely flooded"

Notes:

Based on the proportion of wetlands, SQI, SQII, SQIII in each WMA and desirable flooding frequencies of 10 years out of 10 for wetlands, 8 years, 5 years and 3 years out of 10 for SQI, SQII and SQIII.

Caution should be applied when using the flood prioritisation table. While it provides a historical summary of flooding, determining the departure from an ideal flood score over a long period of time becomes questionable. A more relevant assessment of actual flooding compared to ideal flooding can be made using the past 5 years of data. Regardless, the table provides a useful simplistic assessment of historical flood frequency.

A proposed Barmah-Millewa Environmental Water Allocation release discussion paper (Appendix 2) was prepared in September-October 2010 for the B-M ICC and its subcommittees. The purpose of the discussion paper was to propose use of environmental water to bridge the gap between rainfall-induced flood events in the forest to achieve icon site ecological objectives for flora and fauna. Bridging the gap between 'natural' events aims to maintain elevated water levels in selection wetlands which, due to their flat shedding bathymetry, would otherwise drain when the feeding river levels fall.

Ongoing management decisions about the use of environmental water to support the Barmah-Millewa Forest were made through the weekly teleconference operational meetings described in Section 3.7. The actual flow downstream of Yarrawonga for 2010/11 is presented below (Figure 3 & Figure 4), along with the modelled 'natural' flow (pre river regulation) and the expected flow without the use of environmental water. The figure shows the impact of releasing environmental water allocations (EWA) on the river levels during 2010/11, with river levels being maintained at or above channel capacity to continue flooding whereas on three occasions when river levels would have otherwise fallen below bank capacity where the wetlands would have further drained. The figure also highlights the impact of river regulation on the river flows, with most flood peaks being heavily mitigated, especially in October.

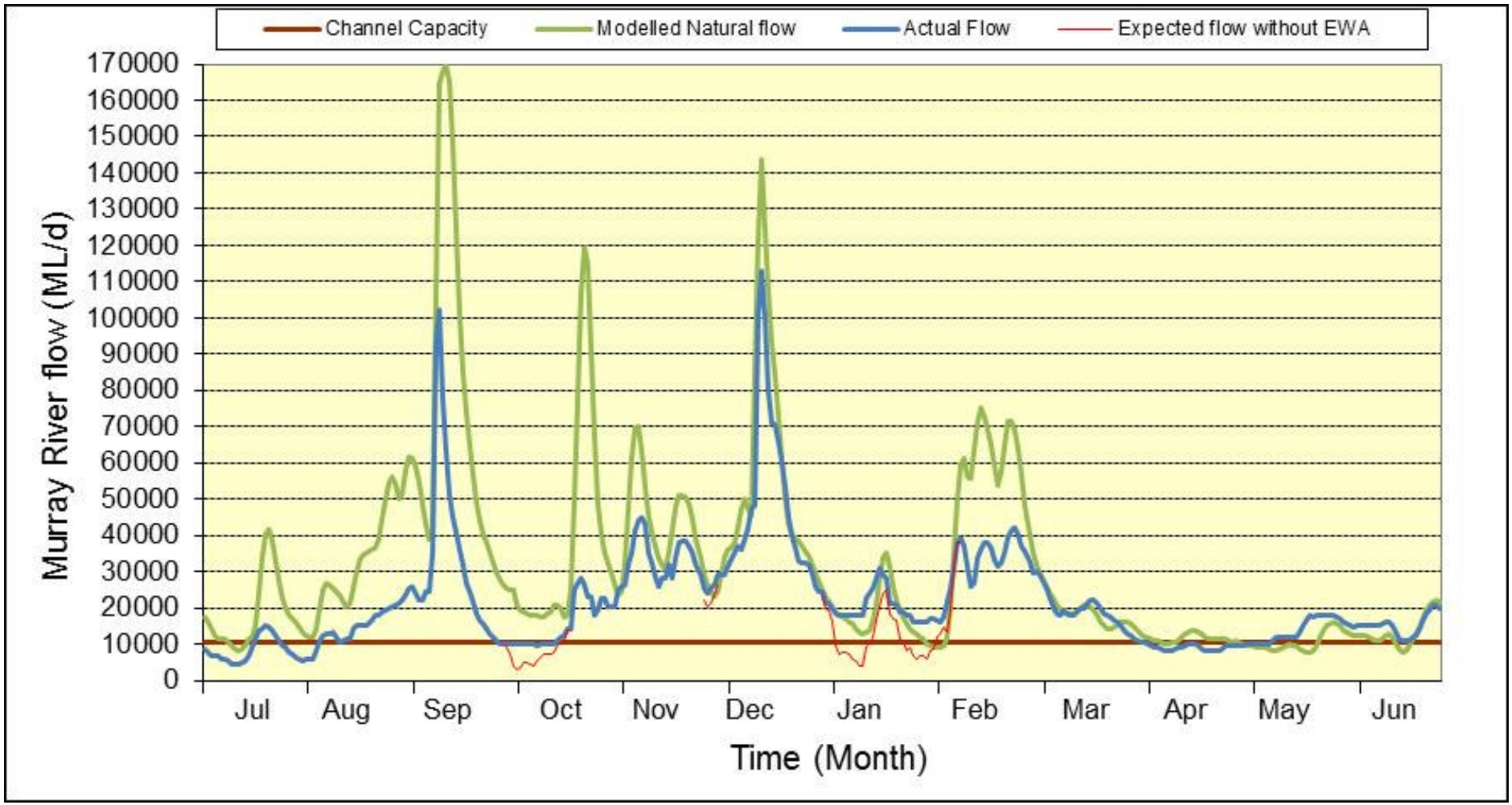

Figure 3: Murray River flow downstream of Yarrawonga in 2010/11 exhibiting actual flow (which includes EWA releases), expected flow without EWA releases, and modelled natural flow simulating flow if no diversions or impoundments had been in place.

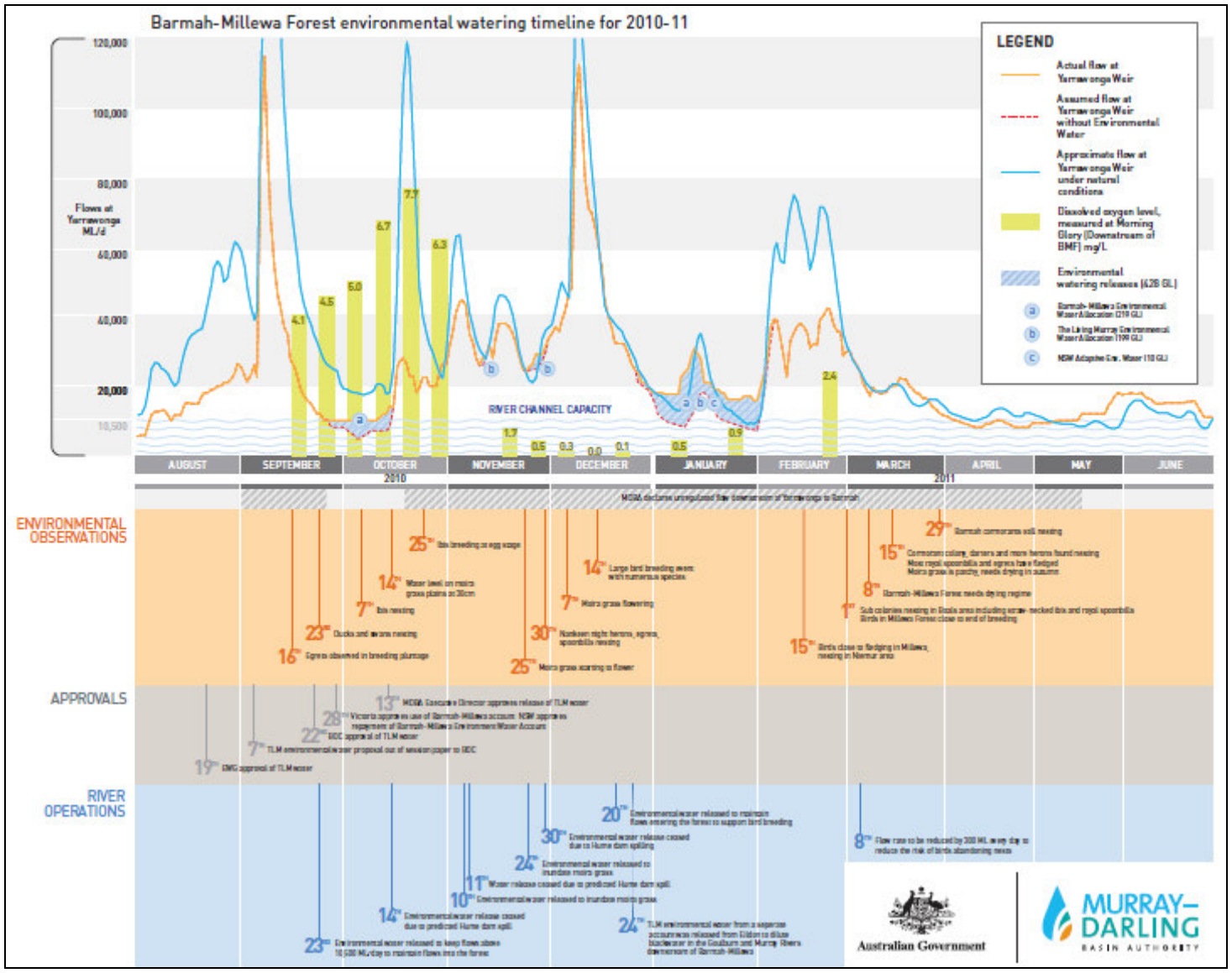

Figure 4: Timeline of the watering event. Draft document. Source: MDBA.

2010/11 Flood Event

The following description was provided by the MDBA:

> Higher than average rainfall during 2010–11 has dramatically reversed the extreme dry conditions of recent years, with floods occurring multiple times along parts of the Murray, Goulburn, Ovens, Kiewa and many other rivers in the Basin. Flow through the Murray River downstream of Yarrawonga Weir exceeded the channel capacity of 10,500 ML/day through the Barmah-Millewa Forest for extended periods during the year.
>
> In mid-July 2010, high inflows from the Ovens and Kiewa Rivers passed through Yarrawonga Weir, giving the Forest its first natural watering since 2005. As the flows receded to channel capacity in late July, further rain again boosted the tributary inflows and the flow downstream of Yarrawonga Weir gradually increased to about 25,000 ML/day by the end of August.
>
> In early September, rainfall in excess of 100 mm in the upper catchments of the Murray, Ovens and Kiewa Rivers caused flooding along parts of these rivers. Hume Reservoir was filling at this time and hence releases from the reservoir were at the normal minimum. At Yarrawonga Weir, releases reached a peak of 112,000 ML/day on 8 September as a result of the high inflows from the Kiewa and Ovens Rivers.
>
> In late September/early October, water from environmental accounts was used to supplement existing flows to maintain about 10,000 ML/day downstream of Yarrawonga Weir. This water enabled flows to be maintained into key wetland areas in the Forest where waterbirds were breeding.
>
> In mid-October, there was another large rainfall event—this time centred on the upper catchments of the Murray and Murrumbidgee Rivers. This event was sufficient to fill the remaining capacity in Hume Reservoir and 'spills' contributing to flows of up to 25,000 ML/day at Doctors Point commenced in late October. Inflows from the Ovens River were more modest from this event and the flow through Yarrawonga Weir peaked at 26,000 ML/day.
>
> Further rainfall in November resulted in high flows through Yarrawonga Weir from the Murray, Kiewa and Ovens Rivers. The first peak was about 45,000 ML/day while the second peak was 38,000 ML/day. A relatively dry period in late November prompted the use of a small volume of environmental water to maintain flows downstream of Yarrawonga Weir at about 22,000 ML/day
>
> Rain again in December caused renewed flooding along many rivers in the Murray-Darling Basin. Releases from Hume Reservoir peaked at 40,000 ML/day, and these releases combined with inflows from the Kiewa and Ovens Rivers caused the flow past Yarrawonga Weir to rise to 113,000 ML/day. In late December, water from environmental accounts was used to maintain flows downstream of Yarrawonga Weir between 17,000 and 20,000 ML/day. These flows were aimed at encouraging nesting waterbirds continue fledging their chicks.
>
> Yet more rain in January caused another small peak in flow through Yarrawonga Weir, up to 31,000 ML/day. After this event, water from environmental accounts was used to supplement natural inflows and maintain flows above 16,000 ML/day downstream of Yarrawonga.
>
> In February, three modest rainfall events kept flows downstream of Yarrawonga Weir between 25,000 and 42,000 ML/day. In late March, the flow through Yarrawonga Weir had dropped to 15,000 ML/day, which was the lowest flow since mid-October.

Throughout most of April, the release from Yarrawonga Weir was about 10,000 ML/day enabling many parts of the Barmah-Millewa Forest to partially dry out. However, by the late May, flows were increased again—initially to lower the level of Lake Mulwala and, later, in response to higher inflows. During June, flow rates have varied between 10,000 and 20,000 ML/day as a result of rainfall. While flows during April–June were average to above average, rainfall during these months has been slightly below average. Due to the high summer rainfalls, the catchments have remained wet with relatively high volumes of runoff.

With the exception of the December flood, each of the peak flows past Yarrawonga Weir during the last 12 months has been less than half of the estimated natural flow. Until mid-October, Hume Reservoir was capturing a large proportion of these flows. Use of water from Hume Reservoir, mainly during January, for environmental and other purposes again increased the capacity of Hume Reservoir to mitigate the flow peaks in February. Dartmouth Reservoir, which is yet to fill, also stored inflows from its catchment and contributed to lower flow peaks.

The total flow past Yarrawonga Weir during 2010-11 was about 7,920 GL, including the 428 GL of water from environmental water accounts. For the same period, the modelled natural flow (assuming no diversions or storage in Hume and Dartmouth Reservoirs) would have been about 11,490 GL. This difference between the actual and modelled flows highlights the flood mitigation ability of Hume Dam when it is below full supply level. Clearly, until Hume Reservoir is at or near full supply level—or environmental water is passed through Hume Reservoir—the flooding of Barmah-Millewa Forest is more dependent on inflows entering the Murray River downstream of Hume Reservoir, particularly from the Ovens River catchment.

Use of Environmental Water

The *Barmah-Millewa Forest Environmental Flow Event: 2010-2011* hydrograph (Figure 3) shows the occasions where Environmental Water was used to hold the water levels higher than would normally occur. The objectives of using the Environmental Water during 2010/11 included:

- Holding the water level at or above river capacity (~10,500 ML/day flow) to prevent the draining of adjacent wetlands and flooded lowland forest;
- This in turn maintained water levels in colonial waterbird breeding areas and avoided birds abandoning nests and or young before fledging;
- Also targeted flow rates at about 20,000 ML/day for Moira Grass areas.

428 GL of Environmental Water Allocation was released from the Barmah-Millewa EWA account (219 GL), the TLM EWA account (199 GL) and the NSW AEW account (10 GL) and a monthly breakdown is provided below (Table 6).

Table 6: Environmental water use (GL) from B-M EWA, TLM and NSW AEW accounts (Source: MDBA).

	B-M EWA			**TLM**			NSW AEW	Total
	NSW	Vic	Total	NSW	Vic	Total		
September	4.90	4.90	9.80					9.80
October	29.55	29.55	59.10					59.10
November				9.15	9.15	18.30		18.30
December				2.35	2.35	4.70		4.70
January	79.55	39.55	119.10	87.50	88.50	176.00	10.00	305.10
February	20.50	10.50	31.00					31.00
Total	134.50	84.50	219.00	99.00	100.00	199.00	10.00	428.00

The delivery of environmental water is adaptively managed, meaning plans are made for its use and altered to suit the conditions as they occur. Following the large natural September flood event, water planning focused on maintaining flows below channel capacity to support small flows to critical habitats (creek systems and low-laying wetlands). This management option commenced, with flows held near channel capacity using environmental water in early October, before further rainfall resulted in higher natural flows.

Once these higher natural flows occurred through October to December, the aim of environmental water use was changed to maintaining critical flows to benefit vegetation and waterbirds. This resulted in the use of environmental water from late December to early February to maintain flows between 15,000 and 20,000 ML/day downstream of Yarrawonga to meet flooding requirements for Moira Grass, River Red Gum and nesting waterbirds.

To support the volumes of environmental water in the Barmah-Millewa Environmental Water Allocation account, environmental water held by The Living Murray was provided to ensure sufficient water was available to meet the ecological outcomes of the flooding.

The use of environmental water to maintain minimum required flows predominantly during October and January occurred between very large natural flow events. This major flooding stimulated the environment in September, however, the natural flooding through November and very large peak in December resulted in the blackwater event. The timing of very large flows across the floodplain in early summer, with warm water temperatures, combined with 10 years of drought and organic matter build up was the cause of the blackwater event. Environmental water was not released onto the floodplain at this time so as to minimise further blackwater development. Rather, EWA was utilised to maintain high in-channel flows in the Murray River to dilute floodplain recession.

Operation of regulators

Throughout the 2010/11 year regulators were opened or closed according to river conditions and/or water management objectives. The graphs below (Figure 5, Figure 6 and Figure 7) show the open, partially open or closed status of each regulator over time. Comparison of the regulator operation with the annual hydrograph (Figure 2 or Figure 3) highlights the operation of regulators in relation to the flow in the Murray River. For specific dates of regulator operation (colour coded to indicate what action occurred) refer to Appendix 4.

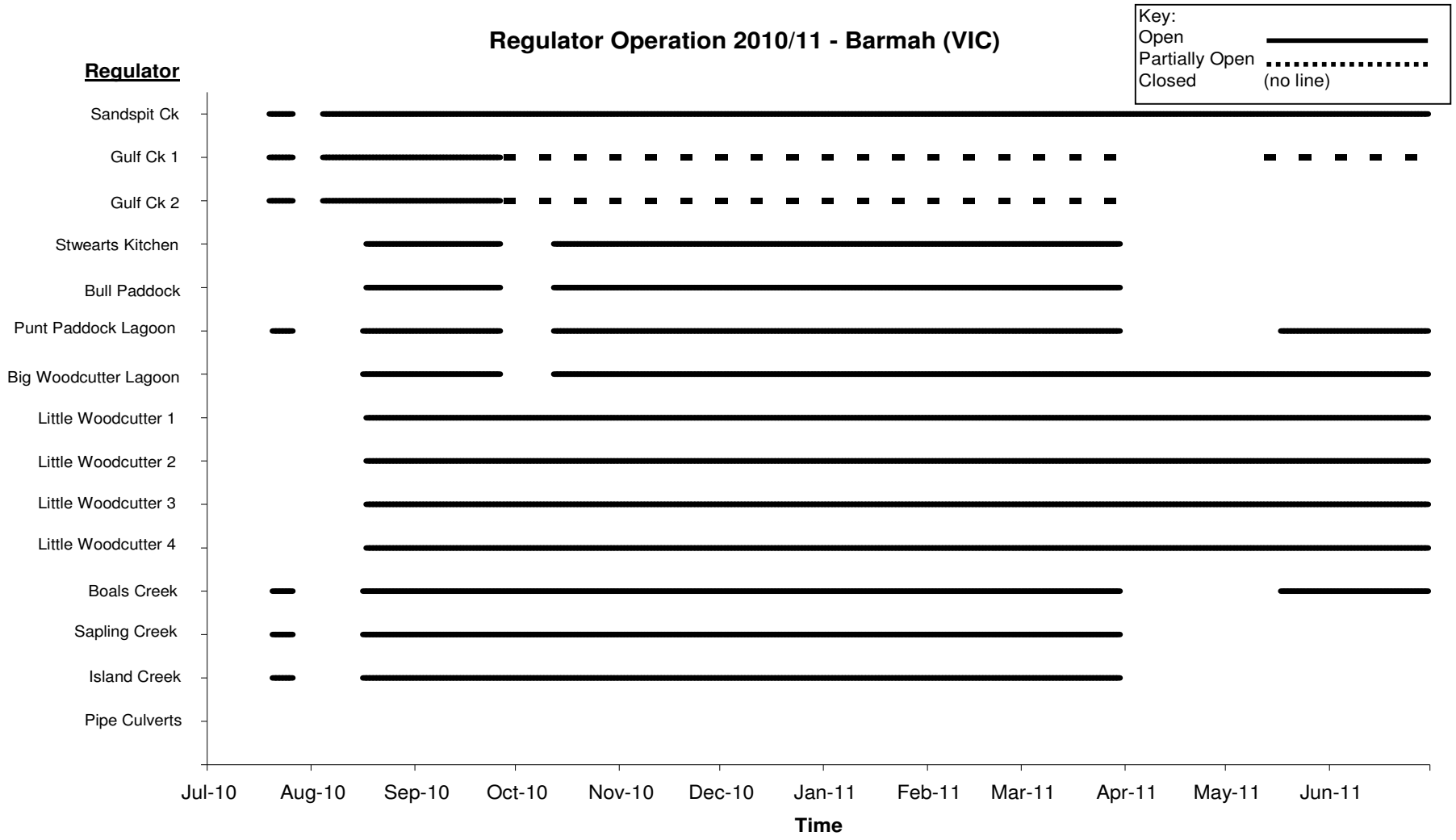

Figure 5: Operation of Victorian regulators

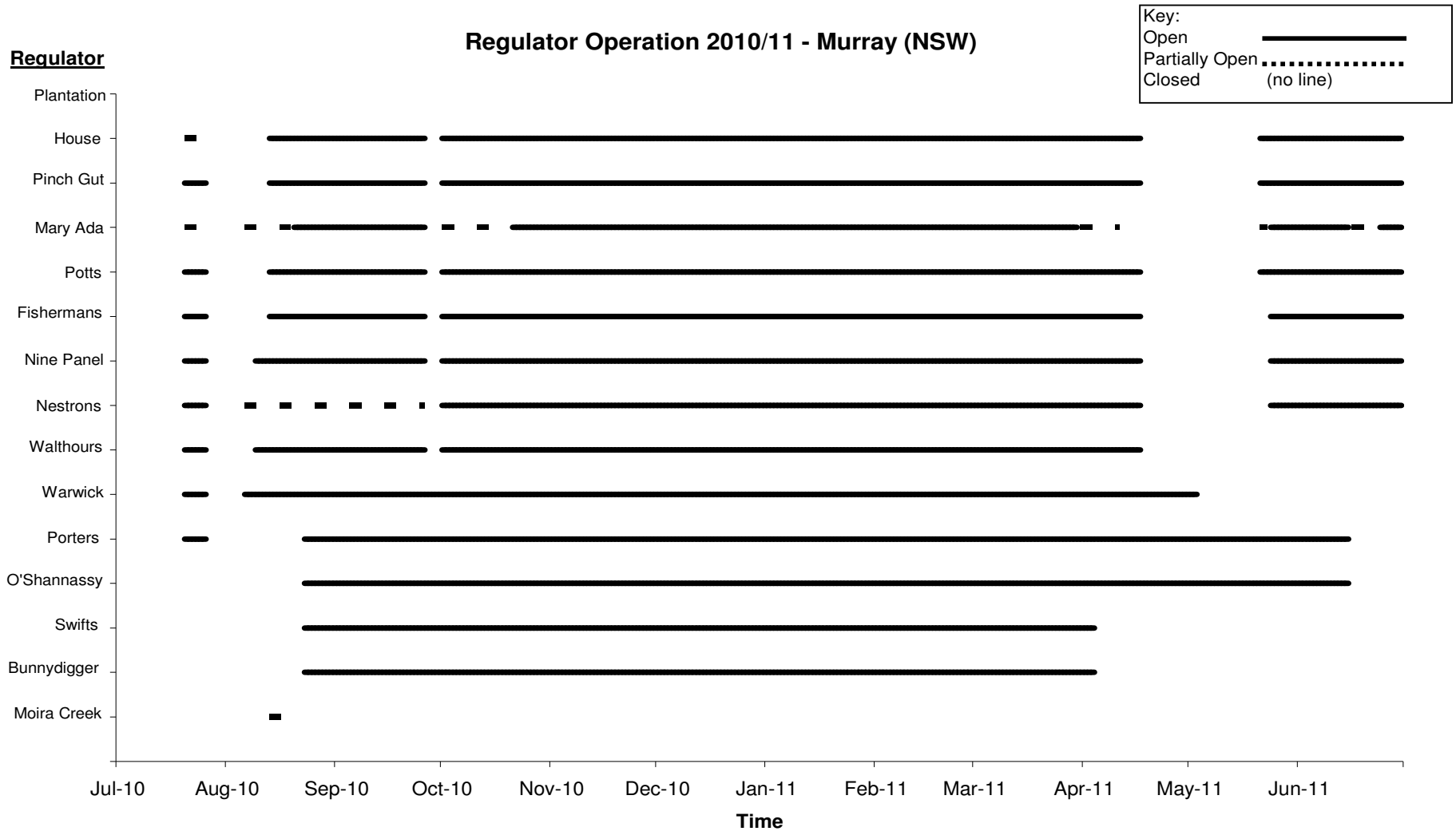

Figure 6: Operation of NSW Murray River regulators

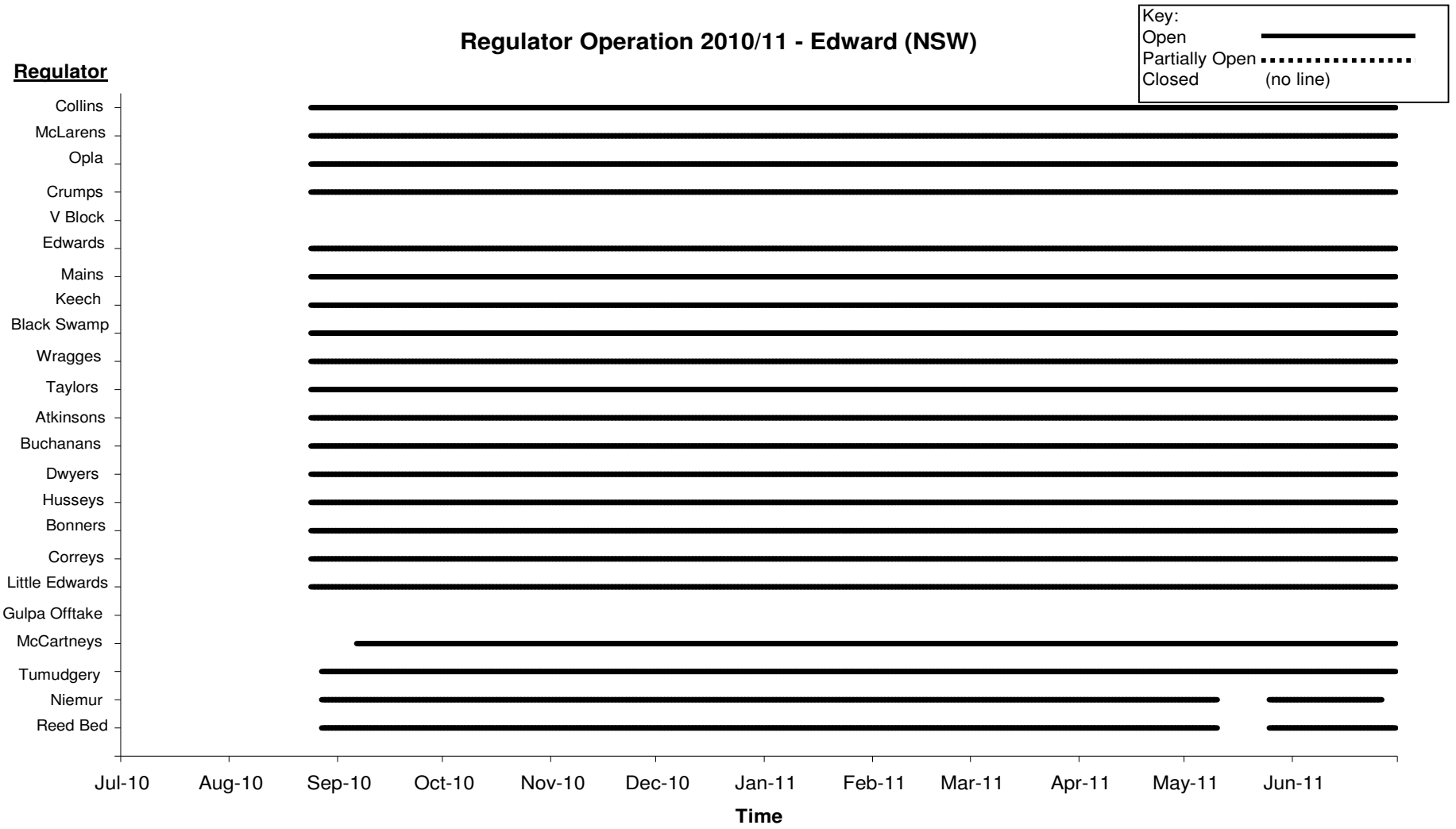

Figure 7: Operation of Gulpa/Edward River regulators.

4.2 Environmental Works and Measures Program

Barmah Choke Study

The Murray-Darling Basin Authority is conducting a study on the Barmah Choke. In relation to the Barmah-Millewa Forest, the study aims to "*reduce the incidence and magnitude of undesirable (generally unseasonal) watering…*". It was also to address a number of irrigation and water transfer issues associated with the Choke, as well as consider improving "*the efficiency of delivering water to the icon sites*" (MDBA 2008).

Progress update from MDBA (20 July 2011)

> The final report of the Individual Options Phase (Phase 3) of the Barmah Choke Study is completed and is available on the Murray-Darling Basin Authority website at: http://www.mdba.gov.au/programs/tlm/programs_to_deliver/works_measures/barmah-choke-study.
>
> In Phase 3, a comprehensive list of 17 identified options and their sub-options were modelled and assessed. The development of options associated with Mulwala Canal has included input from Murray Irrigation Limited.
>
> The Phase 3 assessment results were framed around the relative performance of options in terms of their potential effectiveness, cost and risk. Please note that, in Phase 3, the assessment focuses on the technical capability of each option, on its own, to address the issues associated with the Barmah Choke. A key finding of Phase 3 is that no single option adequately addresses all of the issues; therefore it is now necessary to move to Phase 4 to investigate the better performing options in combination.
>
> The outcome of Phase 4 will be a 'preferred package' of options for managing the issues associated with the Barmah Choke. Any significant elements of the 'preferred option package' will be subject to further assessment, including giving greater attention to social and economic factors, prior to proceeding with implementation.
>
> Further updates on the progress of the study will be provided at key stages.

Gulf Creek Fishway and Kynmer regulator

A detailed design for both the Gulf Creek fishway and the Kynmer Creek regulator has been completed. Further funding will be required to proceed to construction.

Edward River and Gulpa Creek Fishway

Construction of the Denil fishway on the Gulpa Creek regulator was completed approximately November 2010. This was a NSW State Government funded project (J. Sheahan, pers. comm. 2011).

The majority of construction of the Edward offtake regulator fishway was complete at the end of 2010/11, with access difficulties due to wet track conditions delaying completion. Construction is expected to be completed during September 2011. This project was funded under The Living Murray program (J. Sheahan, pers. comm. 2011).

Moira Lake Stage 3

The objective of this project is to facilitate a simulated drying cycle for Moira Lake through the construction of drainage infrastructure. This will support ecological processes, improve carp harvesting/removal and has an element of water savings. The detailed design was completed for the proposed scope of works in 2010/11. A request for funding has been submitted to the NSW State Government (V. Kelly, pers. comm. 2011).

4.3 Environmental Water Management Plan

Environmental Water Management Plans (EWMP) have been developed for each Icon Site with the aim of describing the TLM management objectives and targets, water delivery arrangements and the specific watering regimes for each site. The Barmah-Millewa EWMP final draft was completed in 2010/2011, with the MDBA progressing endorsement of the plan into 2011/12. It supersedes the Barmah-Millewa Environmental Management Plan 2005/2006.

4.4 Condition Monitoring Plan

The draft Barmah-Millewa Condition Monitoring Plan (CMP) identifies the monitoring programs to be undertaken in Barmah-Millewa Forest. Some of these programs are repeated each year to monitor change over time, while some programs are run on a short-term or as needs basis. 'A' category programs are conducted across all icon sites using comparable methods, while 'B' and 'C' category programs are conducted specific to Barmah-Millewa Forest.

'A' and 'B' monitoring programs are funded through The Living Murray (TLM) program and aim to determine whether the ecological objectives for Barmah-Millewa are being met. 'C' category programs are not directly related to TLM First Step ecological objectives, however, they do cover important aspects of the ecology of Barmah-Millewa Forest and require funding independent of TLM (GB CMA 2011b).

The CMP groups monitoring projects into 3 categories, 'A', 'B' or 'O' and identifies which monitoring activities fit into which category. Refer to Figure 8 and Table 7 below. This structure is used in the summary of monitoring project outcomes for Barmah-Millewa Forest in 2010-2011 (Section 4.5 Monitoring).

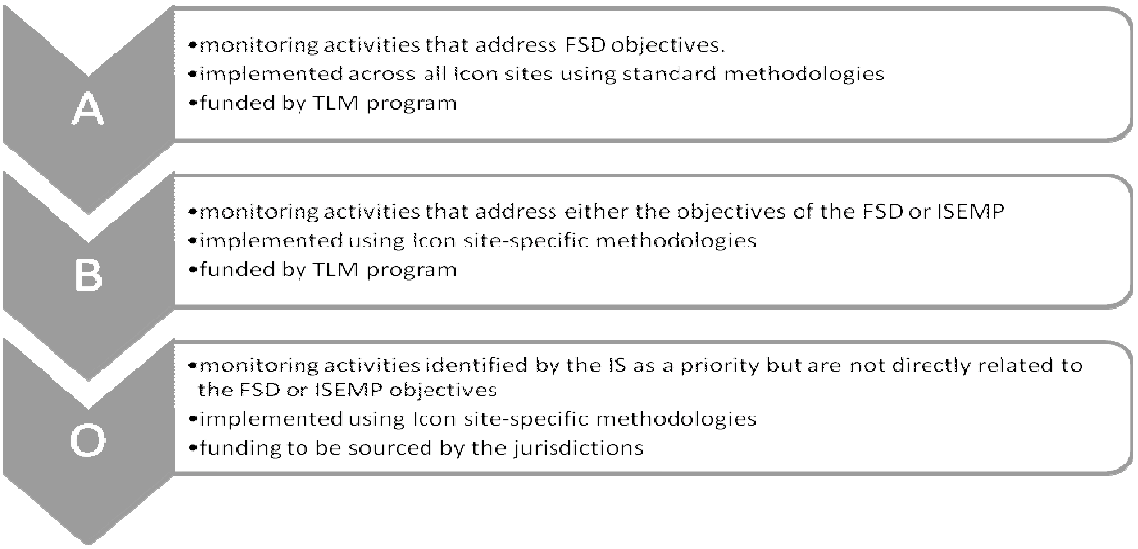

Figure 8: Monitoring Program Categories

Table 7: The respective components of the monitoring program and their relationship within the "A", "B" and "O" categories of monitoring

Component	A	B	O
Vegetation - overstorey			
Vegetation mapping (spatial character)	Y		
TLM stand condition assessment	Y		
TLM tree condition assessment	Y		
Vegetation - understorey			
Understorey condition assessment		Y	
Understorey vegetation mapping		Y	
Birds			
Waterbird condition monitoring – ground survey	Y		
Aerial Survey – (coordinated with annual eastern Australian waterbird Survey)	Y		
Woodland birds		Y	
White-bellied Sea-eagles (*Haliaeetus leucogaster*)			Y
Fish			
Fish condition monitoring	Y		
Event driven fish survey	Y		
Fish spawning and recruitment		Y	
Spawning of large-bodied fish		Y	
Crayfish populations		Y	
Amphibians & Reptiles			
Frogs			Y
Turtles			Y

Source: Barmah-Millewa Forest Icon Site Condition Monitoring Plan (2011)

The final draft of the CMP was completed in 2010/11 and the MDBA is conducting a review of all icon site CMPs during 2011/12, before final publication.

4.5 Monitoring

4.5.1 'A' category monitoring programs

Vegetation mapping (spatial character)

NSW Millewa Forest Vegetation Communities mapping project.
The vegetation communities of the Millewa Forest were mapped in 2010 (Figure 9). This information is being used as the basis to develop consistent vegetation mapping units for Barmah and Millewa Forests, enabling a like for like comparison of vegetation either side of the river.

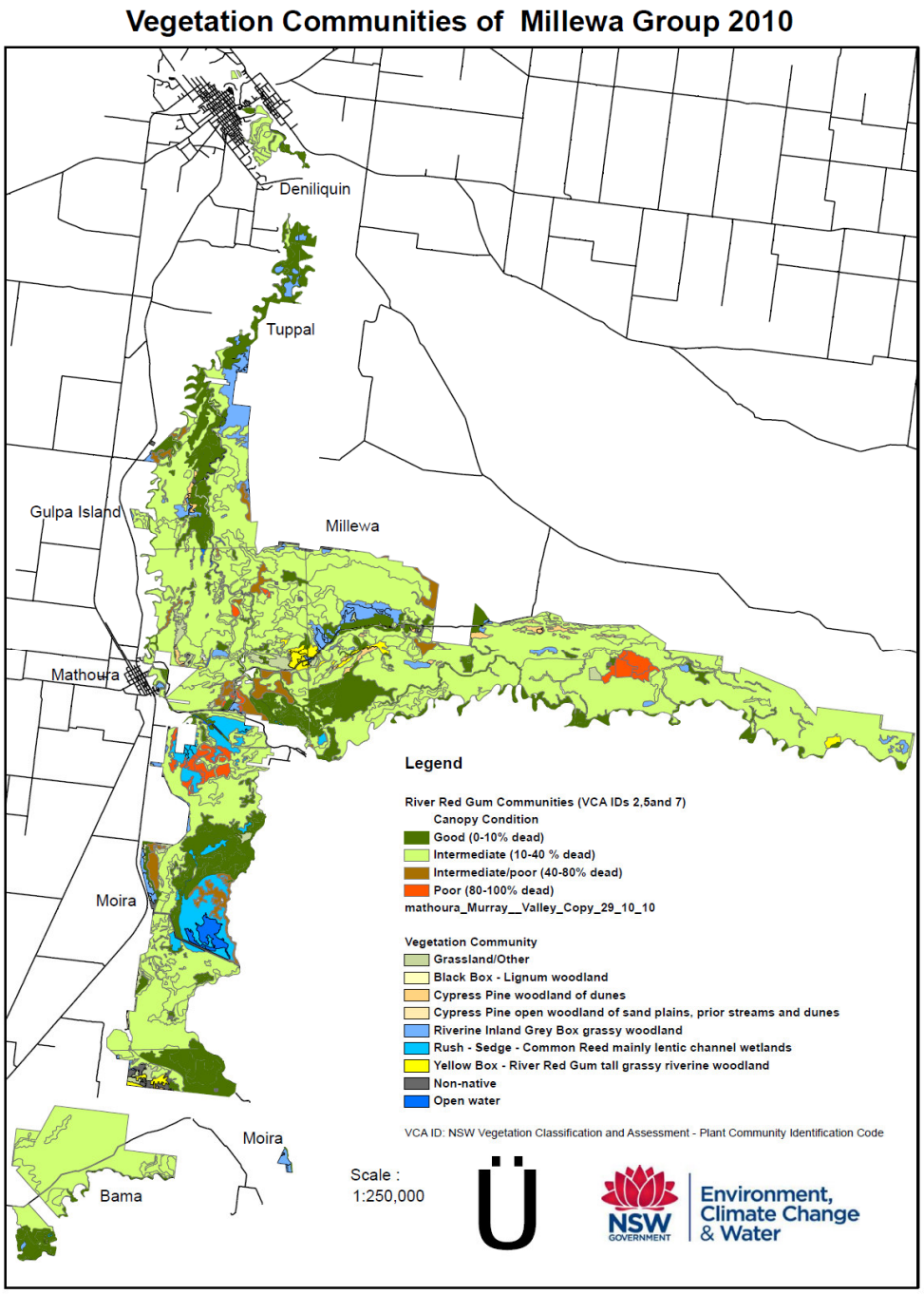

Figure 9: NSW vegetation communities

TLM stand condition assessment
No projects were completed under this category.

TLM tree condition assessment
Annual monitoring of tree condition was not undertaken due to flooding restricting access to monitoring sites.

Waterbird condition monitoring – ground survey
Author: R. Webster (NSW NPWS)

Project Title
Waterbird Monitoring in Barmah-Millewa Forest.

Funding Source
The Living Murray initiative of the Murray-Darling Basin Authority.

Project Aims
To monitor changes in waterbird populations during 2010.

Background
Monitoring of waterbird populations has been on-going within Barmah-Millewa since spring 1999. A baseline set of data was collected between spring 1999 and winter 2002. Since the baseline data was collected additional data was collected in 2008. The collection of data in 2010 continues the program of collecting data within Barmah-Millewa to monitor changes in waterbird populations over time and also to monitor the response of waterbird populations to environmental or flood flows that occur during the monitoring year.

Results
Monitoring of waterbird populations was undertaken on four occasions during 2010 (February, May, July, September-November). The majority of wetlands during the summer, autumn and winter surveys were dry. Those wetlands containing water during these surveys supported between 530 (autumn) and 2000 (summer) birds. In all three seasons the majority of birds where found on Moira Lake.

During the spring survey all wetlands within New South Wales were visited during September and the wetlands within Victoria were visited during October-November. During spring all wetlands were flooded except for Horseshoe Lagoon (filling) and Goose Swamp (drying). The total number of waterbirds recorded on the wetlands was 1083. Breeding waterbirds were recorded on the following wetlands: Moira Lake, Reed Beds North, Reed Beds South, St Helena Swamp, Boals Deadwoods, Goose Swamp and Steamer Plain.

Over 1000prs of waterbirds were estimated to be nesting during the spring surveys. This included a number of colonial nesting species:

- Australasian Darter *Anhinga novaehollandiae* – 4prs;
- Little Pied Cormorant *Microcarbo melanoleucos* – 79+prs;
- Great Cormorant *Phalacrocorax carbo* – 6+prs;
- Little Black Cormorant *Phlalcrocorax sulcirostris* – 44+prs;
- Eastern Great Egret *Ardea modesta* – 55+prs;
- Intermediate Egret *Ardea intermedia* – 5+prs;
- Nankeen Night Heron *Nycticorax caledonicus* – 96+prs;
- Australian White Ibis *Threskiornis molucca* – 240+prs;

- Straw-necked Ibis *Threskiornis spinicolis* – 400+prs; and
- Royal Spoonbill *Platalea regia* – 70+prs.

As well as these colonial nesting species numerous duck spp. (e.g. Musk Duck *Biziura lobata* Grey Teal *Anas gracilis*), grebes (e.g Great Crested Grebe *Podiceps cristatus*) and raptors (e.g. White-bellied Sea-eagle *Haliaeetus leucogaster*) were also recorded breeding.

Discussion

The drought conditions that have prevailed within the southern Riverina bioregion since 2006 continued during the first three surveys in 2010. The water found within Barmah Lake, Steamer Plain and Reed Beds South during summer is due to the Murray River and Gulpa Creek carrying regulated flows which cannot be kept out of these wetlands. This results in Barmah Lake and Reed Beds South being full in most summers although they usually only support a small number of waterbirds due to the lack of an extended annual drying phase. The high water level in Moira Lake and Reed Beds North is due to environmental flows being supplied to these wetlands as part of The Living Murray program. Water from The Living Murray program was also delivered to St Helena but only resulted in the bottom of the wetland being covered in shallow water (i.e. <5cm).

The species diversity recorded during spring 2010 was higher than in spring 2008 (10 species). The spring seasons in the baseline study (1999-2002) had a species diversity varying from 24 species in 2002 up to 38 species in 2000. Therefore the species diversity present during the current survey is within the range previously identified. This variation in species diversity during spring is a result of how much water is in the individual wetlands within the Barmah-Millewa forest during the seasonal surveys. During 2008 the majority of the wetlands were dry or contained very little water compared to 1999-2002 and 2010 the majority of the wetlands contained water or were flooded. Figure 10 shows the change in species diversity within the icon site since spring 1999.

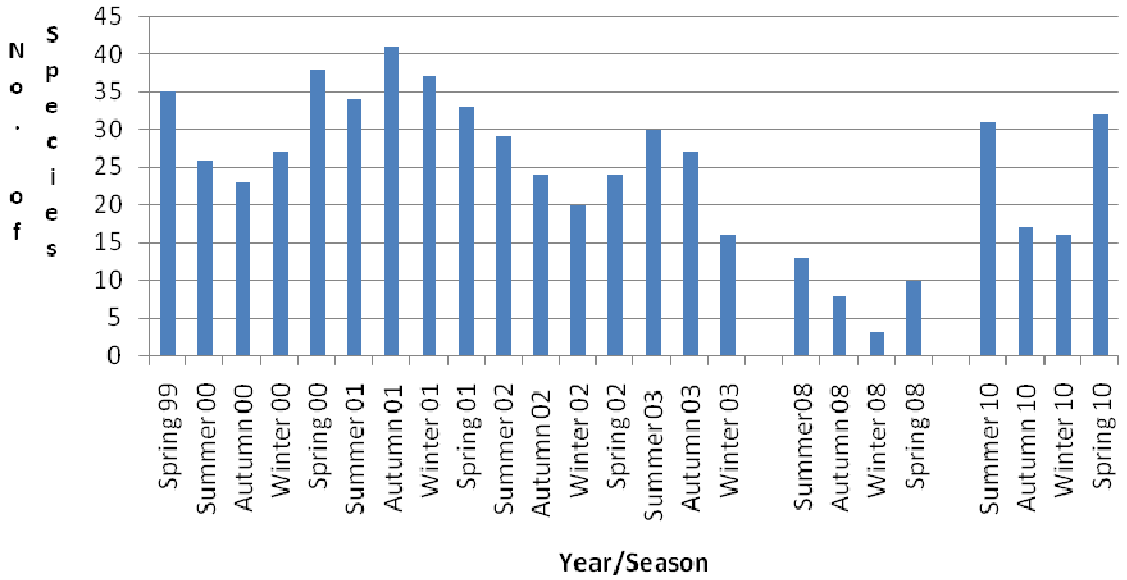

Figure 10: Species diversity on wetlands monitored within the Barmah-Millewa Icon site.

The trends in waterbird numbers on the individual wetlands during the monitoring surveys within Murray Valley National Park (NP) are shown in Figure 11. Since the flood in spring 2000/summer 2001 the total waterbird numbers recorded during the monitoring programs (1999-2003 and 2008), on individual wetland sites within NSW have generally totalled less than 200 birds. The exception to this is Moira Lake which has provided habitat for between 700 and 1 400 birds in a number of

seasons (see Figure 11). As a natural flood event has occurred during spring 2010 the flooding regime and waterbird response observed during the current survey period is described below for the individual wetlands monitored. It should be noted that only a single visit is made to the wetlands as part of this monitoring program. Individual State agencies (i.e. Parks Victoria and NSW Office of Environment & Heritage) are monitoring the size and success of breeding events occurring in Barmah NP and Murray Valley NP respectively.

The trends in waterbird numbers during the monitoring surveys on individual wetlands within Barmah NP are shown in Figure 12. Since the flood in spring 2000/summer 2001 the total waterbird numbers on individual monitoring sites within Victoria have generally totalled less than 200 birds. The exception to this is Barmah Lake and Steamer Plain in the summer/autumns of 2002 and 2003. Waterbirds were probably attracted to these wetlands during these seasons as they both received water as a result of the Murray River running at high levels to supply irrigation demand. The large numbers of birds on these wetlands is possibly due to the range of habitats they provide and that most of the other wetlands within Barmah-Millewa forest would have been dry at this time. During 2008 waterbird numbers were very low, this trend has continued during 2010 until spring 2010 when all the wetlands within the monitoring program experienced a flood.

Three international agreements for migratory birds are recognised under the Federal Government's *Environment Protection and Biodiversity Conservation Act*. These are the China Australia Migratory Bird Agreement (CAMBA), the Japan Australia Migratory Bird Agreement (JAMBA) and the Republic of Korea Australia Migratory Bird Agreement (ROKMBA). Each agreement lists a number of migratory bird species for which conservation measures should be undertaken within each country. The 2010 counts identified a number of species (Eastern Great Egret, White-bellied Sea-eagle) listed under CAMBA and JAMBA utilising wetlands within Barmah-Millewa Forest

A number of threatened species were also recorded. Within NSW these species were:

- Australasian Bittern *Botaurus poiciloptilus* ;and
- Brolga *Grus rubicunda*.

Within Victoria the threatened species recorded were:

- Musk Duck;
- Australasian Shoveler *Anas rhynchotis* ;
- Royal Spoonbill;
- White-bellied Sea-eagle

Reports

Webster, R. 2010a. Quarterly Report: Summer Bird Monitoring within Barmah-Millewa Forest. A Living Murray Icon Site. Unpublished report to Forests NSW. Ecosurveys Pty. Ltd., Deniliquin.

Webster, R. 2010b. Quarterly Report: Autumn Bird Monitoring within Barmah-Millewa Forest. A Living Murray Icon Site. Unpublished report to Forests NSW. Ecosurveys Pty. Ltd., Deniliquin.

Webster, R. 2010c. Quarterly Report: Winter Bird Monitoring within Barmah-Millewa Forest. A Living Murray Icon Site. Unpublished report to Forests NSW. Ecosurveys Pty. Ltd., Deniliquin.

Webster, R. 2010d. Quarterly Report: Spring Bird Monitoring within Barmah-Millewa Forest. A Living Murray Icon Site. Unpublished report to Forests NSW. Ecosurveys Pty. Ltd., Deniliquin.

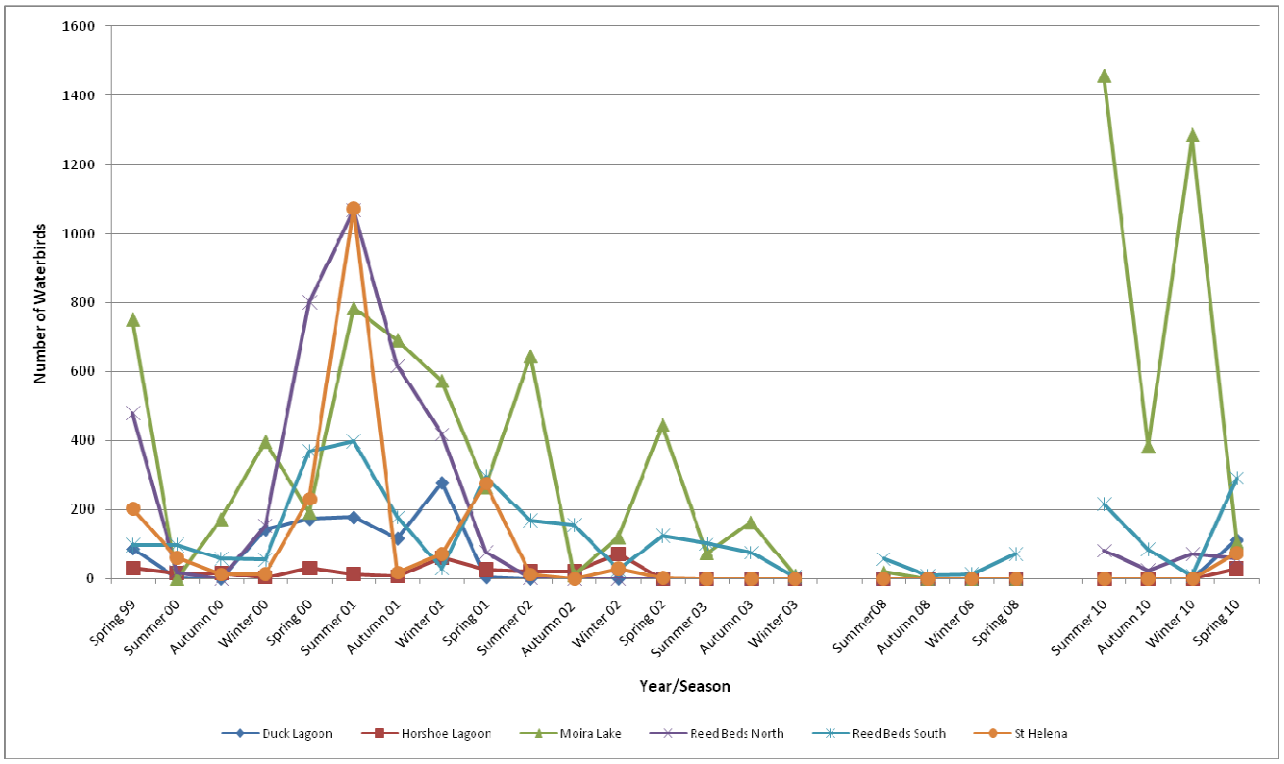

Figure 11: Total number of waterbirds recorded on the six NSW monitoring sites between spring 1999 and spring 2010.

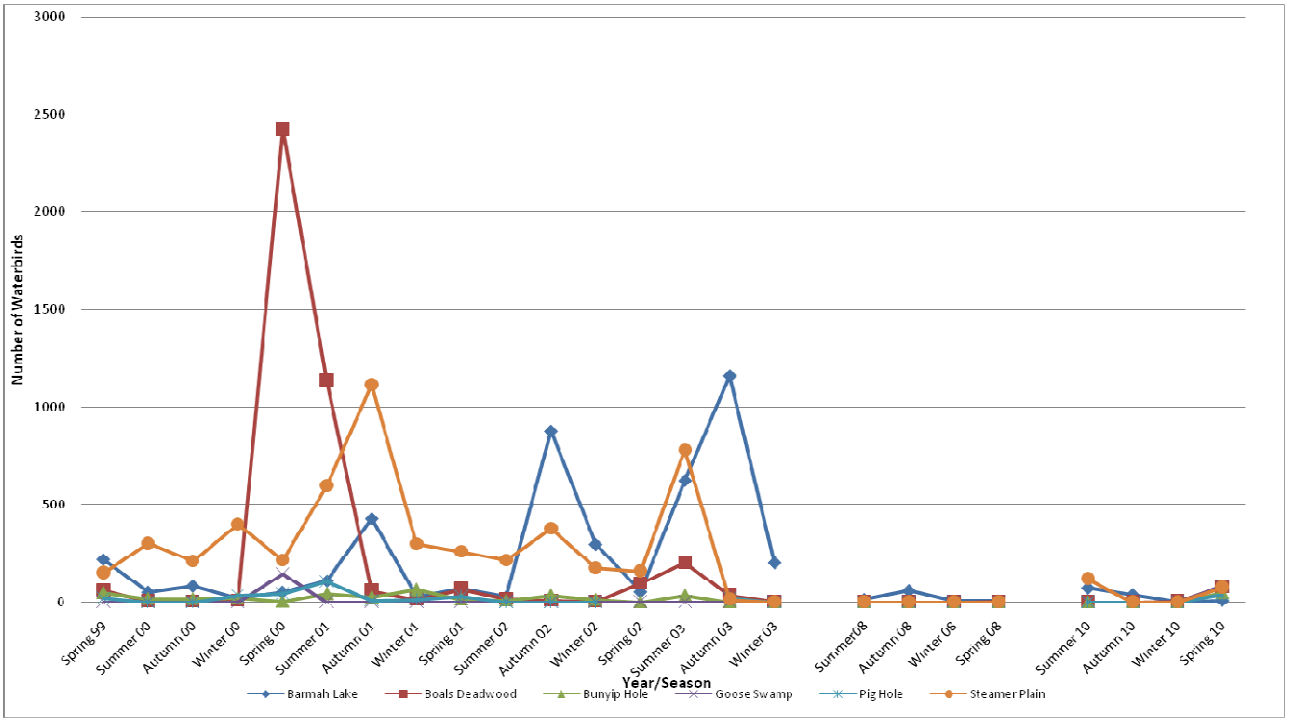

Figure 12: Total number of waterbirds recorded on the six Victorian monitoring sites between spring 1999 and spring 2010.

Figure 13: Ibis colony Reed Beds South, 28th September, 2010 (photo Rick Webster)

Aerial survey – (coordinated with annual eastern Australian waterbird Survey)

Author: R. Webster (NSW NPWS)

Project Title
Waterbird Monitoring: 2010-2011 Flood Event

Funding Source
Office of Environment & Heritage.

Project Aims
Monitor waterbird breeding event within Murray Valley National Park.

Background
Murray Valley National Park supports a number of known colonial waterbird nesting sites. Since 1999 monitoring of waterbird breeding events has been undertaken by Forests NSW. With the change in land managers this monitoring is now undertaken by NSW National Parks & Wildlife Service. This monitoring is undertaken in addition to the quarterly monitoring which is completed as part of The Living Murray program funded by the Murray Darling Basin Authority. The quarterly monitoring does not provide comprehensive information about breeding events that occur due to either environmental flow or flood events. To address this, monthly monitoring of all known breeding sites was completed during the 2010-2011 flood event.

Results
Monitoring of breeding waterbird populations was undertaken from late September to early April. Breeding was confirmed at the following locations:

- Black Swamp;
- St Helena Swamp;
- Reed Beds North;
- Reed beds South;
- Porters Plain;

- Moira Lake (western and south-western sides); and
- Albgeboia Plain.

A total of 24 species and at least 7 420prs of birds were recorded nesting on these wetlands. The most common species were:

- Straw-necked Ibis *Threskiornis spinicolis* – 3 300prs;
- Australian White Ibis *T. molucca* – 1 950prs;
- Little Pied Cormorant *Microcarbo melanoleucos* – 690prs;
- Little Black Cormorant *Phalacororax sulcirostris* – 650prs;
- Eastern Great Egret *Ardea modesta* – 300prs;
- Nankeen Night Heron *Nycticorax caledonicus* – 250+prs; and
- Royal Spoonbill *Platalea regia* – 133prs.

Discussion

A comparison of the waterbird breeding events within each of the wetland sites supporting nesting waterbirds during the 2010-11 flood event is discussed below. This flood event was an exceptionally long event (September-March) with a major flood peak in September followed by additional peaks in October, November, December and February. The initial peak in September resulted in small numbers (hundreds) of waterbirds starting to nest (e.g. Ibis/Spoonbills creating nesting platforms, Cormorants building nests) but it was not until the following flood peaks in October and November that the majority of the birds began to nest. The follow-up peaks also resulted in the majority of the Royal Spoonbill nests built in September being flooded and this species re-nesting in December. The majority of the Ibis and Cormorants had begun nesting by November whereas the Egrets and Nankeen Night Herons did not begin until December. This resulted in a very late nesting season. The additional flood peaks in December and February resulted in some species re-nesting (e.g. Ibis spp., Cormorant spp.) and therefore most colonies still contained nesting pairs with large young in March/April.

Moira Lake

No breeding was recorded on Moira Lake proper. Surveys undertaken during the 2010-11 flood event included the adjoining floodplain on the western side of the lake. Previous surveys have not included this portion of the floodplain and therefore there are no detailed records of nesting waterbirds from this area. This area supported Cormorants and Darters.

Reed Beds North

Surveys completed during the current flood event identified 32 species utilising this wetland. Over 350prs of waterbird (predominately Australian White Ibis and Royal Spoonbill) were recorded nesting during this event. The spring 2000 flood event identified 23 species of waterbird on Reed Beds North and 259 nests consisting of Australian White Ibis (225) and Royal Spoonbill (37).

Reed Beds South

Surveys completed during the current flood event identified 29 species utilising Reed Beds South. In addition approximately 6100prs of waterbird were estimated to be nesting within this wetland. This is a significant increase on the species diversity (16) and number of nesting pairs (142) recorded during the 2000 flood event.

St Helena Swamp

Surveys completed during the current flood event identified 21 species utilising St Helena Swamp. In addition approximately 300prs of waterbird were estimated to be nesting on this wetland. In spring 2000 St Helena supported a species diversity of 12 and 81prs of nesting waterbirds. Historically (early 1900's) St Helena was known to support a nesting colony of Egret species.

However this colony was decimated by plume hunters (Mattingley 1907a, b) and Egrets have not been recorded nesting in St Helena Swamp for at least 100 years.

Black Swamp
No surveys were undertaken on Black Swamp during the 2000 flood event and therefore the current results cannot be compared against any earlier nesting events. During the 2010-11 flood event 12 species were recorded utilising Black Swamp and at least 250prs of waterbird were confirmed nesting.

Algeboia Plain
No surveys were undertaken on Algeboia Plain during the 2000 flood event and therefore the current results cannot be compared against any earlier nesting events. During the 2010-11 flood event 4 species were recorded utilising Algeboia Plain and at least 25prs of waterbird were confirmed nesting.

The difference in species diversity and nesting response during the two surveys within wetlands containing nesting waterbirds during the 2010-11 flood event was probably best explained by the size and duration of the 2010-11 flood event compared to the 2000 event which was much smaller and shorter in duration. The 2000 event was also supported by a release from the Barmah-Millewa environmental water account.

Reports
No report has been produced as a result of this work.

Fish condition monitoring

Authors: Scott Raymond, Zeb Tonkin (Arthur Rylah Institute - DSE) and Meaghan Rourke (NSW Department of Trade and Investment).

Project title
Barmah-Millewa Fish Condition Monitoring

Funding source
Part of the Icon Site CMP

Project aims
Monitor the health and status of the Barmah-Millewa fish community through annual sampling. Assess long term changes in fish populations and correlate any observed changes with factors such as flow, climate and thermal regimes. To provide information that provides feedback into management plans and reporting on condition for the Asset.

Background
Condition monitoring of the fish community within Barmah-Millewa Forest is necessary to provide ongoing information on the 'health' of this Icon site. To assess the condition of fish communities, methods have been developed to maintain compatibility with current Sustainable Rivers Audit protocols. Sampling is carried out in rivers, creeks, lakes and wetlands. The project also assesses fish spawning by sampling drifting eggs and larvae at river sites during the spring/summer peak spawning period. A larval component adds confidence to the data collected on large-bodied fish, by giving researchers an indication of native fish spawning activity in response to environmental variables such as environmental watering events. In addition, the population of the recreationally

and culturally important Murray Crayfish is also monitored at river sites using baited Munyana crab traps. This is the fifth year that the fish community has been assessed in the Barmah-Millewa Forest.

Results

- Creek sites contained similar abundances of native fish in 2010/11 to previous years, however, the abundance of alien fish (Common Carp, Goldfish, Oriental Weatherloach and Eastern Gambusia) in creek sites increased from 2009/10 to 2010/11
- The abundance of native fish collected in river sites in 2010 was lower compared with 2009/10 while the abundance of alien fish increased
- Large numbers of young-of-year Common Carp were sampled in both river and creek sites while the abundance of larger Carp was much lower compared with previous years
- Only five Murray Crayfish were sampled
- The Murray River site at Morning Glory (which was affected by blackwater) had a very low abundance of native fish and an extremely high abundance of Common Carp. No Murray crayfish were sampled at this site, despite it being one of the most productive sites in previous years
- No Southern Pygmy Perch were sampled
- Peak density of drifting Murray Cod larvae was lower in 2010 compared with 2009 and 2008
- The majority of drifting Murray Cod larvae were captured from Ladgroves Beach (upstream of the blackwater event) in contrast with previous years where most larvae were captured from the bottom two sites (Barmah Choke and Morning Glory)
- The peak density of drifting Golden Perch eggs was higher in 2010 compared with previous years with the majority off eggs captured from Ladgroves Beach. However, densities were well below those following the 2005/06 flood.
- No drifting Trout Cod or Silver Perch eggs or larvae were recorded from the three Murray River sites in 2010. It is noted that Silver Perch larvae and/or eggs were recorded from Ladgroves Beach in February 2011 (King *et al*., 2011).

Discussion

Sampling in 2010/11 occurred following a significant flood event through the forest, which subsequently triggered a large-scale blackwater event. Total native fish numbers in rivers were lower compared with previous years of the study. In contrast, native fish abundance in creeks was similar to previous years. The disparity in abundances of native and alien fish species between years may also be influenced by changes in electrofishing efficiency due to the higher water levels present during the time of the 2011 surveys compared with surveys conducted over the past four years.

In general, abundances of drifting eggs and/or larvae of native and exotic fish species within the B-MF were lower compared with 2008 and 2009 findings. While the abundance of drifting Murray Cod larvae was consistent with previous years, the majority of larvae were captured up-stream of the blackwater event which is in contrast with Murray Cod larvae captured in previous years. Similarly, the majority of Golden Perch eggs recorded were also captured from Ladgroves Beach. Thus the flood did not seem to trigger a large native fish breeding and recruitment event within the forest. This is an unexpected result as the flood was predicted to promote native fish spawning and recruitment throughout the forest. The lower than expected numbers of native fish may be a direct result of the blackwater that developed on the floodplain, which may have killed adult fish, or hindered the survival of fish eggs and larvae.

Introduced species have undergone significant increases in all forest habitats, particularly the creeks and wetlands. The Common Carp catch was dominated by young-of-year fish (<150mm in length), indicating the flooding provided ideal spawning and recruitment conditions for this species. Furthermore, Common Carp may have a competitive advantage over some native species given they

are tolerant to very low dissolved oxygen levels. One river site badly affected by blackwater (Morning Glory) had similar numbers of native fish (13 Australian Smelt, 2 Golden Perch, 2 Silver Perch and 1 Trout Cod) sampled this year, as well as nearly 600 Common Carp, which was much higher than in any other river site. This site had no large-bodied natives at all when sampled in November 2010 and February 2011 as part of a blackwater assessment (King *et al.* 2011), however the current data suggests that some large-bodied native fish have begun to re-colonise Morning Glory following the cessation of the blackwater event. Cod species, which are the most frequent reported in fish kills as a result of blackwater events, may not re-colonise impacted regions as rapidly as other more mobile large bodied species such as Silver and Golden Perch (which do not exhibit as high site fidelity).

A curious finding from the last two years of sampling is the reduction in adult Common Carp that have been sampled. Length-frequency histograms from the past five years show that there was the full size range (young-of-year to over 800mm) of Common Carp present in the first three years of the study. However, the captured Common Carp population over the last two years of the study has been heavily dominated by young-of-year fish. It is not known whether adult fish have migrated from the study area, or whether young fish are not reaching maturity, perhaps due to unfavourable conditions during the recent drought.

Murray Crayfish were only caught at Picnic Point, and were not caught at any other river site above the blackwater affected sites (Morning Glory and the Barmah-Moira Lake area). This is of concern given the anecdotal reports of high abundances caught by recreational anglers further upstream in the Albury area and that the majority of Murray Crayfish over the past four years have been captured from Morning Glory in previous sample years.

Reports produced
The annual report is in preparation.

Event driven fish survey

Author: L. Beesley (Arthur Rylah Institute - DSE)

Project title
Blackwater

Funding source
MDBA TLM one-off funding

Project Aims
The distribution and abundance of fish in the 40-50 km reach of the Murray River downstream of Barmah-Millewa Forest affected by blackwater.
The abundance of fish in the region immediately surrounding the reach affected by blackwater.
The distribution and abundance of crustaceans (specifically Murray Crayfish, yabbies and shrimp) in the reach affected by blackwater.
Whether these effects changed between early and late in the season.

Background
After five years of very low flows in the Murray River, substantial areas of the Barmah-Millewa Forest (B-MF) floodplain started to flood in July 2010, and continued flooding until at least mid-March 2011. This resulted in a significant volume of blackwater flowing into the Murray River from mid-November 2010 to at least mid-March 2011, and dissolved oxygen levels in the river falling

from 8-10 mg L^{-1} to <1 mg L^{-1} between the B-MF and at least Echuca (some 40-50 km downstream). Initial anecdotal reports, suggested large numbers of crayfish were emerging from the water and there were also some reports of dead fish. This study aimed to determine the short-term effects of the B-MF blackwater event on fish and crayfish in the region by conducting quantitative surveys at sites in and immediately around the blackwater area.

Results

Results indicated some major detrimental short-term effects of the hypoxic blackwater, generated from B-MF in 2010/11, on a number of aquatic taxa, including fish, shrimp, and crayfish; although the severity of the blackwater on fauna varied across taxonomic groups. Effects included:
the emersion of large numbers of Murray Crayfish at blackwater affected sites early in the event, leaving them vulnerable to predation and exploitation;
the death of a large number of shrimp and yabbies;
the apparent tolerance of exotic fish species (particularly Common Carp) to the blackwater;
an initial increase then a reduction in the abundance (probably from reduced recruitment this season) of small-bodied fish within the blackwater affected sites; and
reduced abundance of large-bodied native species, such as Murray Cod, Trout Cod, Silver Perch and Golden Perch at sites affected by blackwater compared to unaffected sites, during both sampling events.

Discussion

At this stage, the mechanism behind the decline in abundance of large-bodied native species is unknown. It maybe due to either the death of large numbers of these species, or increased abundance of these species at non-affected sites, perhaps due to the movement of fish away from blackwater affected sites. If the blackwater event resulted in the death of a significant number of individuals of these species, then the effects of this blackwater event are likely to be substantial and may take years to recover. However, if most individuals were able move to reaches with better water quality, then there is likely to be little overall loss of individuals from the populations, and fish are likely to return as water quality improves. It is critical to determine which of these two plausible scenarios has occurred to establish the long-term importance of this event for fish and crayfish in the region. This can only be achieved by further comparative surveys at sites with long term, pre-blackwater datasets.
The findings of this study have significant implications for flood and environmental water management on floodplains, particularly after prolonged drought conditions; and suggest that consideration be given to facilitating more naturally timed flooding events, even during drought years. The timing of environmental flows is critical and must be considered in planning to reduce the likely risk of undesirable ecological consequences. Additionally, many of the new off-stream regulating structures proposed under The Living Murray initiative may increase the risk of blackwater events. The additional risk created by these artificial structures needs to be carefully managed to reduce the likelihood of undesirable outcomes for aquatic fauna.

Reports

King, A.J., Tonkin, Z. and Lieshcke J. (2011) Short-term impacts of hypoxic blackwater on fish and crustaceans in the Barmah-Millewa Region, 2010/2011. Arthur Rylah Institute for Environmental Research, unpublished client report. Department of Sustainability and Environment, Heidelberg, Victoria.

4.5.2 'B' category monitoring programs

Understorey condition assessment

Author: P. Ward (independent ecological consultant)

Project Title:
Monitoring understorey vegetation response to flooding in Barmah-Millewa Forest, 2010/11

Undertaken by:
Paula Ward (independent ecological consultant)

Funding Source:
TLM Condition Monitoring Program (Project Type B)

Project Aims:
To seasonally monitor understorey vegetation within Barmah-Millewa Forest by measuring species diversity, % cover and flowering at sentinel transect sites representing common wetland and surrounding forest floodplain environments.

Background:
This project commenced in 2005/06 to continue monitoring original sentinel study sites using the same methods that had been established in five Barmah Forest wetlands by the Department of Conservation and Environment in 1991-93. One additional study site in Barmah Forest was opportunistically added in 2006 to capture post-fire response at the site, and five sites in Millewa Forest were added in 2006/07. Monitoring has occurred each season since establishment by this project to date (except spring 2009 due to late funding authorisation).

Methods:
Eleven wetland study sites, collectively having 72 quadrats confining 720 sub-quadrats, were surveyed in each of the four seasons of 2010/11. Vegetation species and their respective percentage cover estimates were recorded for each sub-quadrat, as was water depth. Basic water quality assay was undertaken at each quadrat, consisting of turbidity, temperature, pH and conductivity, and a photograph was taken of each quadrat. A basic topographic survey was also undertaken by using water depth measurements from each site.

A detailed progress report was written following the conclusion of each monitored season (Ward 2010, 2011a,b,c), each including management recommendations based on results and observations made. A final report summarising the annual monitoring results is currently in preparation (Ward *in prep.*).

Results:
Higher than average rainfall and widespread prolonged flooding occurred in 2010/11, and hence strongly contrasts to previous five years of this project's monitoring activities.

A relatively large number of species (121 - 129 species from 46-52 families) were recorded from the established quadrats each season, with 65 - 71% of the species being native. In terms of conservation significance, one nationally-listed vulnerable species (Swamp Wallaby-grass *Amphibromus fluitans*) was found at a number of wetland study sites, while samples taken from potentially three Victorian-listed vulnerable species currently await taxonomic confirmation.

Many species were found to have flowered within the year, which was often observed to be prolific and, for some species, not commonly encountered in previous years of monitoring. Moira Grass (*Pseudoraphis spinescens*) remained in its wet growth phase and flowering when encountered in spring, summer and into autumn, until senescing in winter. This contrasts to previous years where the species had generally entered into its dry phase of growth and had stopped flowering by summer due to flood recession. Potential exists for a strong seed set from most species this year.

Quadrat cover data and associated photo-points demonstrate that the largest increase in understorey species diversity and cover was where flood depth was shallow or intermittent. Deeply flooded sites generally possessed only a few species. Ironically, the prolonged deep flooding (up to 2.8m deep) appears to have suppressed wetland species in the deeper zones of wetlands this year.

Of particular significance is the poor response of Giant Rush (*Juncus ingens*) on many deeply flooded wetlands, especially where the species was in poor health prior to this year's flooding. Despite some re-shooting from rhizomes having occurred in autumn and winter, the species has had its rate of encroachment onto the Moira Grass plains reduced by this year's deep and protracted flooding. Only at sites where environmental water allocations had been delivered to sustain the health of the rush (for waterbird breeding habitat) is the species still healthy, thereby ratifying the success of those EWA deliveries.

Patches of Tall Spike-sedge (*Eleocharis sphacelata*) had developed on Steamer Plain in Barmah Forest. This species has not previously been observed on the wetland and is a species known to be particularly susceptible to grazing pressure. Although the species has no particular conservation significance, it is very uncommon in Barmah-Millewa Forest and therefore may represent a flagship species heralding further species change associated with changes in flooding and grazing regimes at the site.

A number of other significant observations were made while undertaking monitoring, including opportunistic recordings of threatened fauna species such as Bitterns and Superb Parrots, and locating a number of waterbird nesting sites. Additional notes and photographs of other species presence and breeding activities were also made. Many of these records and photographs have been used by agency staff to assist with active natural resource planning activities, reporting and media promotions.

Conclusion:
Understorey vegetation at monitored sites in Barmah-Millewa Forest has shown a mixed response to the prolonged natural flooding in 2010/11. Species in the deeper flooded wetland zones currently appear to have been adversely impacted, although the persistence of this condition after a drying regime is as yet unknown. By contrast, species occurring where flooding was shallower (<0.5m) or less prolonged (<3 months continuous) in 2010/11 have generally responded positively with substantial re-growth and flowering by predominantly native species. Higher terrain that remained unflooded (although had experienced higher than average rainfall conditions) had also shown strong re-growth, although this included a high proportion of exotic species.

The benefits of environmental water application in 2008/09 and 2009/10 can still be observed in Giant Rush stands where this was being promoted, whereas un-broken drought conditions had caused poor response in the species that continues to remain despite now being flooded.

Intermittent flooding has therefore advantaged a number of native wetland species and disadvantaged most exotic species at monitored sites. Extrapolated, this has resulted in strong re-establishment of indigenous species across a large component of the Barmah-Millewa floodplain.

This outcome reverses the declining trend in the presence of understorey vegetation observed during the previous five years of monitoring that were mostly of drought conditions.

Reports produced:

Ward, P.A. (2010) Monitoring understorey vegetation response to flooding in Barmah-Millewa Forest, 2010/11: Progress report - Spring 2010. Consultant progress report prepared as part of the Living Murray Condition Monitoring Program for the Barmah-Millewa Icon Site, managed by the NSW Department of Environment, Climate Change and Water, Griffith, on behalf of the Murray-Darling Basin Authority, Canberra. 128pp.

Ward, P.A. (2011a) Monitoring understorey vegetation response to flooding in Barmah-Millewa Forest, 2010/11: Progress report - Summer 2010/11. Consultant progress report prepared as part of the Living Murray Condition Monitoring Program for the Barmah-Millewa Icon Site, managed by the NSW Department of Environment, Climate Change and Water, Griffith, on behalf of the Murray-Darling Basin Authority, Canberra. 126 pp.

Ward, P.A. (2011b) Monitoring understorey vegetation response to flooding in Barmah-Millewa Forest, 2010/11: Progress report - Autumn 2011. Consultant progress report prepared as part of the Living Murray Condition Monitoring Program for the Barmah-Millewa Icon Site, managed by the NSW Department of Environment, Climate Change and Water, Griffith, on behalf of the Murray-Darling Basin Authority, Canberra. 152pp.

Ward, P.A. (2011c) Monitoring understorey vegetation response to flooding in Barmah-Millewa Forest, 2010/11: Progress report - Winter 2011. Consultant progress report prepared as part of the Living Murray Condition Monitoring Program for the Barmah-Millewa Icon Site, managed by the NSW Department of Environment, Climate Change and Water, Griffith, on behalf of the Murray-Darling Basin Authority, Canberra. 205pp.

Ward, P.A. (in prep.) Monitoring understorey vegetation response to flooding in Barmah-Millewa Forest, 2010/11: Final report. Consultant report prepared as part of the Living Murray Condition Monitoring Program for the Barmah-Millewa Icon Site, managed by the NSW Department of Environment, Climate Change and Water, Griffith, on behalf of the Murray-Darling Basin Authority, Canberra.

Understorey vegetation mapping

See 'Vegetation mapping (spatial character)'

Woodland Birds

This monitoring program was not undertaken as a result of restricted access to monitoring sites.

Fish spawning and recruitment

Author: L. Beesley (Arthur Rylah Institute - DSE)

Project title

Monitoring fish recruitment, water quality and secondary production in Barmah-Millewa Forest

Funding source

MDBA Native Fish Strategy one-off funding

Project aims

- Continue monitoring the amount of spawning and recruitment in a systematic manner and compare with the conclusions drawn from previous years;
- Determine the changes in zooplankton communities (richness and abundance) in response to water management regimes; and,
- Establish how fish spawning and recruitment responds to broad changes in the patterns in water quality and zooplankton.
- Sampling the fish community during the flood also provided an opportunity to assess the resilience of the fish community, as it had been significantly impacted by five previous years of consecutive drought. As a consequence an additional aim was to:
- Determine the resilience of fish populations and their capacity to recover in the region after an extreme drying event.

Background

The effective use of environmental flows in the Murray-Darling Basin (MDB) requires a sound understanding of the relationships between flow regime components and water quality, primary production, and secondary production (e.g. invertebrate, fish, frog, bird etc). While research in this field is increasing, there is still much we do not understand. For example, little is known about the relative importance of various flow components on fish spawning and recruitment, and as such we know relatively little about how to efficiently and effectively deliver managed flows to target increasing native fish recruitment. A greater number of long-term studies that encompass a range of flow scenarios are required to improve scientific knowledge and management practices.

Barmah-Millewa Forest (B-MF) on the Murray River is the site of one long-term study. Here, the relationship between flow and fish recruitment has been studied over a five year period (2003/04 to 2007/08), encompassing one managed (spring & summer) flood year, two spring flood years, and two non-flood years. The broad aim of this five year research program was to evaluate the response of fish (both native and alien) to various water management regimes, and generate critical knowledge of the flow requirements of native MDB fish species – to inform decisions on the use of environmental water throughout the MDB. Research at this site commenced again during 2010/11, a year of predicted large-scale, protracted flooding. Collaborative research with the Murray-Darling Freshwater Research Centre (MDFRC) enabled a more holistic, food-web approach to understanding the fish responses. This study investigated the effect of large-scale flooding on water quality (including nutrients and primary production), low-order secondary production (zooplankton) and fish spawning and recruitment during 2010/11 at B-MF.

Results

The main findings were:

- High levels of dissolved organic carbon (DOC) and nutrients (total nitrogen and total phosphrous) were released from the floodplain into aquatic habitats during flooding.
- High levels of DOC, coupled with rising water temperatures caused severe reduction in dissolved oxygen (DO) levels in November and December, causing an extended and severe blackwater event. However, after this time, even though flooding continued, DO levels partially recovered at most sites throughout the Forest, except in the River channel downstream of the forest where blackwater continued until the end of sampling (late February 2011).
- Blackwater did not reduce planktonic algae growth.
- Water quality (including DOC) and measures of algal production (Chlorophyll a) were poor descriptors of zooplankton density and community structure.

- The density of microcrustacean zooplankton during spring was markedly higher in wetland habitats compared to river, lake or creek habitats; suggesting that wetland habitats may disproportionately generate this important food source for larval fish.
- The blackwater flood event reduced the spawning and recruitment of the majority of fish species. Native species with poor tolerances to hypoxia, such as Australian Smelt and Unspecked Hardyhead, were more impacted than alien species with higher tolerances, such as Common Carp and Eastern Gambusia.
- Four species (Trout Cod, Dwarf Flat-headed Gudgeon, Southern Pygmy Perch and Redfin Perch), recorded in previous surveys in the forest were not recorded in 2010/11. Unspecked Hardyhead, which typically make up 30% of the total juvenile fish assemblage in the river, were virtually absent during 2010/11.
- Golden and Silver Perch spawning activity was low compared to the previous flood season. Suggesting that blackwater flood events do not support the spawning of Golden and Silver Perch, and that negative factors associated with hypoxia override any flooding requirements or benefits to spawning which have been previously reported for these species.
- B-M region continues to be a source of Common Carp recruitment, even during blackwater conditions.
- The blackwater conditions that arose during the flood had a negative impact on native fish in the B-M region, which made any assessment of the resilience of the fish community to drought difficult.

Discussion

The findings from this study are a timely reminder for environmental water managers that flooding does not always deliver short-term benefits for native fish populations. Information on the positive and negative threshold flow requirements are still poorly understood for fish and many other organisms, and are critical for the effective management of future environmental watering strategies.

Management recommendations include:

- To reduce the likelihood and severity of hypoxic blackwater events, forested floodplains should be inundated frequently enough to prevent the build up of large amounts of organic carbon (leaf litter etc). The natural, pre-regulation rate of inundation should be used as a guide.
- Flows that inundate significant areas of previously dry forested floodplains in summer, when water temperatures are >20ºC, are highly likely to generate hypoxic blackwater. Although blackwater is a natural ecological phenomenon, the severity of impact on fish communities can be reduced by avoiding managed flow events during these conditions and maintaining open floodplain connections to assist in free fish passage and water movement.
- The natural hydrological variability encountered this season at B-MF suggests that hypoxic blackwater conditions are unlikely to be alleviated by delivering large pulses of managed water that further inundate the floodplain.

- Wetlands support abundant zooplankton communities that are likely to provide important food resources to larval and juvenile fish. As such, these habitats should be watered during cooler times of the year (autumn-spring), to enable abundant zooplankton generation that can support fish recruitment.
- Floodplain inundation results in highly successful Common Carp spawning and recruitment, even under hypoxic blackwater conditions. Given the necessity to water floodplains for natural ecological functioning, other management practices (such as Common Carp screens or harvesting) should be used to minimise Common Carp recruitment.

Reports
King A.J, Beesley L., Petrie R., Nielsen D., Mahoney J. and Tonkin Z. (2011) Monitoring fish recruitment, water quality and secondary production in Barmah-Millewa Forest, 2010/11. Arthur Rylah Institute for Environmental Research, Unpublished client report. Department of Sustainability and Environment, Heidelberg, Victoria

Spawning of large-bodied fish
See various fish monitoring reports above.

Crayfish populations
See 'Event driven fish survey' section.

4.5.3 'C' category monitoring programs

White-bellied Sea-eagle
Author: B. Wehner (Parks Victoria)

Project title
Monitoring the Number of Breeding Pairs of White-Bellied Sea-Eagles within Barmah-Millewa Forest

Funding source
Icon Site CMP

Project aims
To continue investigations into whether the number of pairs of White-bellied Sea-eagles induced to breed, the number of breeding locations and breeding success is positively correlated to the size and duration of a spring flood and to increase knowledge of the requirement of the species.

Background
It is thought that the forest can only support seven White-bellied Sea-eagle breeding pair territories. Our minimum objective is to maintain at least seven pairs of White-bellied Sea-eagles at seven locations with at least one pair breeding in at least two years in ten (and instances of breeding separated by no more than five years).

Results
At least two nests produced young and another two had adults sitting on the nest but no young were observed. Continual flooding throughout the entire year led to some nests not being monitored at all (as access was extremely difficult) so some further breeding may have occurred. A number of immature birds were also observed.

Discussion
The Environmental Target for the species using the current B-MF EWA of at least one pair breeding in at least two years in ten (and instances of breeding separated by no more than five years) was met. The continuing survival and development of several immature White-bellied Sea-eagles of

different age classes and at widespread locations within the forest indicates that the recruitment of the species is persisting.

Reports
Nil

Frogs

No formal frog monitoring project was undertaken in 2010/11. Anecdotal reports of tadpoles being found in isolated pools (ie: tyre ruts), rather than flooded areas, possibly as a result of high numbers of Eastern Gambusia (K. Ward, Environmental Water Reserve Manager Goulburn-Broken Catchment Management Authority, pers. obs.), which is listed as a key threatening process for frog populations in NSW (Lintermans, 2007).

Turtles

Author: L. Beesley (Arthur Rylah Institute - DSE)

Project title
Cultural conservation of turtles

Funding source
TLM funding (second year)

Project aims

- To monitor the health and status of turtle populations within Barmah-Millewa Forest (B-MF).
- To collaborate with the Yorta Yorta people and share knowledge about turtles, and the health of the turtle population in B-MF.
- To provide training to an Indigenous Ranger from Yorta Yorta Nation Caring for Country program based in Parks Victoria with the aim that future survey work can be conducted by the Yorta Yorta community.
- To support capacity building within Yorta Yorta community by employing a youth one day per field week (mid November through to 30th June 2011) to conduct cultural investigation of oral stories which provide information to creation stories, landscape formation, recipes, breeding/hunting areas. This is to capture Yorta Yorta knowledge and through informed consent processes include in broader management planning for Barmah and Millewa National Parks.

Background
B-MF is home to three species of freshwater turtle: 'Bayadherra', the Broad-shelled Turtle; 'Djirrungana Wanurra Watjerrupna', the Common Long-necked Turtle; and 'Dhungalla Watjerrupna', the Murray River Turtle. Although these species have wide-ranging distributions, occurring in South Australia, Victoria, New South Wales and Queensland (Wilson and Swan 2008), the Murray River Turtle and Broad-shelled Turtle are listed as threatened in Victoria (DSE 2007); the former is listed as 'data deficient' and the latter as 'endangered'.

Concern for the turtles has increased in recent years following anecdotal reports that unusually high numbers of dead turtles were being found in the forest, and surrounding Murray River. Turtles are long-lived animals with delayed maturation, low fecundity and low egg and hatchling survival. Consequently, turtles cannot quickly re-establish their numbers if a significant number die, making them more susceptible to population decline and local extinction than most other species.

The Yorta Yorta people, the traditional owners of the land surrounding the Murray River (Dhungalla) in this region, are particularly concerned about the recent turtle mortalities as Bayadherra, the Broad-shelled Turtle, is an animal totem associated with their creation stories. Indigenous knowledge suggested that a lack of flooding in the forest was responsible for the turtle's current plight.

In 2009/10 a program to monitor the health and status of the turtles, to strengthen Yorta Yorta connection to country, and facilitate knowledge sharing between scientists and indigenous owners was established. The program was led by Yorta Yorta Nation, and partnered by scientists from the Arthur Rylah Institute of Environmental Research. The scientific surveys revealed that turtle abundance was greater in 'refuge' habitats, such as the river and permanent wetlands, and lower in ephemeral habitats. Evidence of dead turtles (i.e. their shells) were greater in ephemeral habitats and lower in permanent habitats. Together these findings provided evidence that at least one species, the Common Long-necked Turtle, had suffered recent mortality - likely due to the drought.

While the first year of data, provided a snap-shot of the turtle populations in the forest, the data could not be compared against anything, so it was not possible to determine if the mortality observed was normal or unusually high. Ongoing monitoring is necessary to understand the relationship between flooding and drying cycles in the forest and the survivorship and health of turtle populations. It is also important to determine the extent to which turtle populations are able to bounce back from drought-associated mortality. Alongside the scientific inquiry, the program aimed to enhance the effort allocated to transferring technical skills to the Yorta Yorta community.

Results

- Similar numbers of Common Long-necks and Murray River Turtle were collected in 2010/11 compared to 2009/10; however, fewer Broad-shelled Turtles were caught. Reduced numbers of Broad-shells is likely due, in-part, to the fewer number of river sites sampled in 2010/11 (due to high flows), and because sampling of river sites was delayed by two months in 2010/11 (because of high flows) when water temperatures were approximately 10°C cooler.
- The distribution of turtles in the forest differed from 2009/10 to 2010/11. In 2009/10 all turtle species were predominantly caught in river and permanent creek/wetland habitats. In 2010/11 considerably fewer turtles were caught in the river; most Murray River Turtles were caught in one hypoxic permanent wetland adjacent to the river (Millewa River Rd Wetland); and all Common Long-necked Turtles were caught in more ephemeral, non-river habitats (permanent or ephemeral creeks). Too few Broad-shelled Turtles were collected to make a statement about their distribution; however, none were caught in the permanent wetland (Millewa River Rd Wetland) which had turned hypoxic (blackwater), even though relatively high numbers were caught there last year.
- The body condition of Murray River and Common Long-necked Turtles was higher in 2010/11 than 2009/10. Too few Broad-shelled Turtles were collected to make a statement about their condition.
- The size-frequency distribution of turtles in 2010/11 was similar to that for 2009/10; juvenile turtles were only collected for the Murray River Turtle.
- Two Murray River Turtles, one juvenile and one adult female, marked in 2009/10 were recaptured in 2010/11. Both turtles had increased in size, with the juvenile growing in length twice as much as the adult. Both turtles put on weight, increasing their body condition by 5 and 6.5% respectively.
- Terrestrial surveys found markedly fewer turtle shells, but more nests in 2010/11 compared to 2009/10.

Discussion
The limited results we have (2 years only) suggest that flood and drought bring about marked changes in turtle population dynamics within B-MF. The Common Long-necked Turtle, which occupies ephemeral habitats, appears to be the species most affected by flood and drought. During drought this species is restricted to riverine 'refuge' habitats and displays poor body condition and relatively high mortality. Following flooding, the abundance of turtles in the river declines, presumably as individuals disperse in to ephemeral habitats. Turtles may also move away from the main-channel of the river to avoid high flows. Unfortunately, high flows were confounded with temperature, as river sampling in 2010/10 was delayed until April, when water temperatures were 10°C cooler and turtle movement, hence capture in nets may be lower than during previous sampling (February). Turtle occupancy of the main-channel during floods requires further investigation.

The results from this study provided preliminary evidence that turtle distribution may be linked to dietary requirements. In February 2010, all three species of turtle occupied the permanent wetland on Millewa River Road, but in February 2011 only the Murray River Turtle was caught at this site (n=34). Murray River Turtles are the only species which are omnivorous, meaning they are not reliant on fish, yabbies, or other invertebrates for food - taxa which may have perished or migrated during the protracted blackwater event in the Forest. Broad-shelled Turtles are obligate carnivores and this species may have migrated to non-affected sections of the main-channel to hunt for fish. Unfortunately, little is known about the movement biology of this species.

Evidence of nesting activity was greater in 2010/11, compared to 2009/10. Rainfall is known to cue nesting in turtles, and the greater frequency of rain events in 2010/11 may be responsible; however, improved body condition may also have contributed. Presently we are unable to distinguish with certainty between successful nests and those destroyed by predators. Only long-term monitoring will reveal if increased nesting activity translates into increased turtle recruitment.

In summary, turtles are patchily distributed in B-MF and their distribution, body condition, likelihood of mortality and nesting activity changes between years, seemingly in relation to the availability and quality of aquatic habitats. Floods and drought appear to be the dominant factor shaping the quality of habitats, but other factors such as predation, water quality, and landscape factors such as distance between water bodies, are likely to play a role. Effective management of the turtles requires that we have a better understanding of how these factors affect turtle populations. A recent survey by Bruce Chessman (NSW OEH, pers. comm.) near Yarrawonga has revealed that turtle abundance has declined dramatically since the early 1980's. In view of this long-term finding, it appears imperative that we continue to learn about the turtles and put in place management practices that protect turtle populations, and aid their recovery (i.e. environmental water management, protection of nesting habitat, predator management).

Reports
Report in preparation (available late August 2011)

Ulupna broad-shell turtle monitoring project

The DSE, in collaboration with the Australian Freshwater Turtle Conservation and Research Association, conducted Broad-shell Turtle (*Macrochelidina expansa*) surveys at Ulupna Island in early 2011.

Eight Broad-shell Turtles were found, the first formal recordings of this species along the Murray River between Cobram and Torrumbarry. 11 Common Long-necked Turtles (*Chelidina longicolis*) and 38 Murray River Turtles (*Emydura maquarii*) were also found during the surveys.

4.6 Other Projects

CFOC PPA project

Through Caring for our Country funding, a pest plant eradication program was undertaken in 2009/10. This project commenced in March 2010 and was carried over into the 2010-2011 financial year and completed in August 2010. A summary of the outputs of the spraying program is provided in provided in Table 8.

A newly funded three year pest plant and pest animal control program was funded by Caring for our Country for 2010/11. Of a planned 108 hectares of pest plant control and 50 hectares of pest animal control, only eight hectares of pest plant control was undertaken. The significant flood event in Barmah-Millewa during 2010/11 caused the low area of on-ground work. Planning commenced in May 2010 for the 2011/12 financial year and this project will now aim to deliver 208 hectares of weed control (and 50 hectares of pest animal control) in 2011/12.

Table 8: CfOC funded pest plant eradication program 2009/10 outputs.

Project Outputs *Current estimates of infestation of weed in Barmah is shown in the following table (together will deliverables under CfOC investment:*

Weed	*Area of Infestation (ha / linear km)*	*Focus of this project*	*CfOC investment: By what degree will infestations be reduced?*	*Project achievements (March - August 2010)*
~~*Arrowhead*~~	~~*10 ha*~~	~~*5 ha*~~	~~*50 %*~~	–
Giant Rush	*10 ha*	*5 ha*	*50 %*	*0 ha*
Blackberry	*30 ha*	*20 ha*	*66 %*	*498 ha*
Briar Rose	*30 ha*	*10 ha*	*33 %*	*25 ha*
Patersons Curse	*120 ha*	*30 ha*	*25 %*	*791 ha (+ proportion of 585 ha where Horehound and Patersons Curse was mixed)*
Willow	*2-3 km*	*2-3 km*	*100 %*	*0 ha*
St Johns Wort	*5 ha*	*5 ha*	*100 %*	*44 ha*
Horehound	*20 ha*	*5 ha*	*25 %*	*188 ha (+ proportion of 585 ha where Horehound and Patersons Curse was mixed)*
Other: Bindii, Noogoora Burr, Bathurst Burr, Spiny Burr Grass, etc		*+ 5 ha (in-lieu of Arrowhead control not able to be undertaken this year given need for revised permit arrangements)*		Bathurst Burr = 16 ha Thorn Apple = 83 ha Woody weeds general = 4,260 ha
	215 ha + 2-3 km	*80 ha*	*25 – 100%*	*6,490 ha*

The project will integrate pest animal and plant initiatives with public land managers and the traditional owners on country (including Yielima).

Blackwater

In addition to the blackwater event fish monitoring at Barmah-Millewa (see King et al 2011 – Section 4.5), a report on blackwater monitoring between Tocumwal and Torrumbarry in the Murray River was completed by the Murray-Darling Freshwater Research Centre (Cook, 2011). A draft paper examining the drivers behind the hypoxic blackwater event has been prepared by Whitworth et al. (2011).

> Cook R (2011) Blackwater Monitoring 2010: Tocumwal to Torrumbarry Weir. Final Report prepared for the Goulburn Broken Catchment Management Authority by The Murray-Darling Freshwater Research Centre, MDFRC Publication 08/2011, June, 21pp.

This collection of data showed that the blackwater event began with the September flooding of the floodplain. At this time dissolved organic carbon increased and dissolved oxygen decreased (but not enough to cause anoxic conditions for biota). The large November flood event added more organic material and anoxic conditions occurred with the warmer temperatures (Cook, 2011).

> Whitworth, K.L., Baldwin, D.S. and Kerr, J.L., 2011. Drivers of a prolonged and extensive hypoxic blackwater event in a major river system. Unpublished draft. Murray-Darling Freshwater Research Centre, La Trobe University and CSIRO Land and Water, Wodonga, Victoria.

This paper analysed the 2010/11 hypoxic blackwater event in the southern Murray-Darling Basin and discusses the multiple drivers that contributed to this particular event. The drivers examined included altered flow seasonality, inundation of forested and agricultural floodplains, upper catchment effects, carbon reactivity and weir discharge. Implications for the management of regulated river systems in relation to hypoxic blackwater events and the predicted impact of climate change on key drivers is discussed (Whitworth et al. 2011).

Figure 14: Blackwater from the forest mixing with a turbid Murray River, 5 October 2010 (photo Keith Ward)

Fish in midden project

This project, managed by the Yorta Yorta Nation Aboriginal Corporation with assistance from Charles Sturt University, will investigate the species and age of fish traditionally utilised by Aboriginal people in Barmah Forest. This will involve the analysis of fish otoliths, or ear bones, collected from middens.

The fieldwork for this project will commence when flooding recedes in the Barmah Forest.

CSIRO 'Water for a Healthy Country' Flagship Program

CSIRO researchers are studying the ever increasing expansion of Giant Rush into open wetlands previously dominated by Moira Grass. Specific areas of study include the comparison of burnt and unburnt patches of Giant Rush (following control burns conducted in 2007 and 2008), the species composition at specific sites and the seedbank of the soil (especially for Moira Grass seed and implications for future Giant Rush control programs).

5 Communication

5.1 Barmah-Millewa Engagement Strategy

The Living Murray communication activities are guided by the *Barmah-Millewa Forest Icon Site Engagement Strategy 2010-11*. This strategy in managed through TLM forums and advisory committees (see section 3), primarily the Barmah-Millewa Consultation Reference Group.

The strategy outlines the issues, opportunities, goals, objectives, tools, evaluation and key messages for effective engagement with all stakeholders, from government departments to the general public.

2010/11 saw various external media activities related to Barmah-Millewa Forest, including media releases, interviews for television and radio and the release of a DSE YouTube video (see Section 5.3). Topics were primarily based on the environmental benefits of the floods, the use of environmental water and the blackwater event. A significant project is to develop a DVD promoting the Barmah-Millewa icon site, its values and management. There are other opportunities for improving external communications, including improved on-line web information, which will be considered in 2011/12.

Barmah-Millewa DVD production (under development).

Once completed, the Barmah-Millewa DVD will be a communication tool to foster education about the Barmah-Millewa Forest to a wide range of stakeholders, particularly the general public. It will cover such topics as government and agency involvement, traditional owners, geomorphology, ecology, water, infrastructure and management. This is being developed through the Icon Site Coordinating Committee and sub-committees.

5.2 Reports and Publications

Colloff, MJ, Mayence CE and Ward KA (2010) The ecology of Moira grass or spiny mudgrass, *Pseudoraphis spinescens* (R. Br.) Vickery, an important plant of Australian wetlands – draft with comments.

The ecology and biology of *Pseudoraphis spinescens* (R.Br.) Vickery (Poaceae) and its functional role in Australian wetlands as a keystone species in Australian floodplains is reviewed. This review presented here is intended to provide a better understanding of the ecology of *P. spinescens* in order to help inform its management and conservation.

Cook, 2011.

Discussed (with full reference) in Section 4.6

Greet J, Webb JA and Cousens RD, (2011). The importance of seasonal flow timing for riparian vegetation dynamics: a systematic review using causal criteria analysis. Freshwater Biology doi:10.1111/j.1365-2427.2011.02564.x

The importance of the natural flow regime to sustain riverine ecosystems is widely recognised. This paper discusses a literature review to investigate the "*extent of knowledge on the importance of seasonal flow timing for riparian plants*".

Hydro Environmental (2010) Victorian Living Murray Icon Site Water Measurement: Assessment and advice on appropriate water measurement for Victorian Living Murray Icon Sites - Volume 1. Prepared for the Department of Sustainability and Environment. Hydro Environmental, Not Recorded. (116 pp)

Hydro Environmental (2010) Victorian Living Murray Icon Site Water Measurement: Assessment and advice on appropriate water measurement for Victorian Living Murray Icon Sites - Volume 2 - Appendices. Prepared for the Department of Sustainability and Environment. Hydro Environmental, Not Recorded. (133 pp)

The purpose of this Report (and Volume 2 – Appendices) is to provide the Department of Sustainability and Environment's (Office of Water) Living Murray Project Team with a broad set of potential options for measuring environmental consumptive water (water measurement options) at each Victorian Living Murray Icon Site and advise a preferred option for the most practicable and cost effective water measurement option.

King A.J, Beesley L., Petrie R., Nielsen D., Mahoney J. and Tonkin Z. (2011)

Discussed (with full reference) in Section 4.5

King, A.J., Tonkin, Z. and Lieshcke J. (2011)

Discussed (with full reference) in Section 4.5

Palmer G, Cahir, F (2010) Fire in River Red Gum Communities – Literature Review. Draft Final Report. Centre for Environmental Management, University of Ballarat. Prepared for Parks Victoria.

The objective of this project was to undertake a literature review of the key literature in relationship to fire (planned fire and wildfire) in River Red Gum communities.

Ward K and King A (2010) Proposed Barmah-Millewa EWA release for Spring 2010. Goulburn Broken Catchment Management Authority and Department of Sustainability and Environment. Internal paper to the B-M ICC, B-M TAC & B-M CRG.

Discussed in Section 4.1 and included in full as Appendix 2.

Ward, P., 2010, Ward, P. 2011a, Ward, P. 2011b, Ward, P. 2011c and Ward, P. in prep.

Discussed (with full reference) in Section 4.5

Webster 2010a, Webster 2010b, Webster 2010c & Webster 2010d

Discussed (with full reference) in Section 4.5

Whitworth et al. (2011)

Discussed (with full reference) in Section 4.6

5.3 Media

Some of the media coverage relating to the Barmah-Millewa Forest has been listed below. This is not intended to be comprehensive list and is likely to include more of the Victorian media coverage, having been collated by the GB CMA. It should not be assumed that no media coverage related to Barmah-Millewa occurred in months where no media activity is listed.

Two key events gained strong media attention. The first was the flooding and the positive environmental response, while the second was the blackwater event.

References marked * are blackwater related coverage that may not directly mention Barmah-Millewa.

July 2010

2010-07-16 Parks Victoria. Media Release: *Barmah Gates to Close due to Flooding*.

August 2010

2010-08-26 Shepparton News. (Page 8 - Letters to the Editor submitted by N. Teese). *Rain brings fuel for fire.*

September 2010

2010-09-01 WIN News (TV). News item on flooding of Barmah Forest, including comments from Peter Newman, Barmah Forest Preservation League.

2010-09-03 ABC (Goulburn-Murray radio breakfast). Barmah flooding report including interview with Keith Ward (GB CMA).

2010-09-09 ABC news (TV ABC2 News Breakfast). News item about environmental response to floods in River Red Gum forest, including interview with Keith Ward (GB CMA).

2010-09-09 ABC news (TV ABC24 9am bulletin). News item about environmental response to floods in River Red Gum forest, including interview with Keith Ward (GB CMA).

2010-09-09 ABC news (TV ABC24 10am bulletin). News item about environmental response to floods in River Red Gum forest, including interview with Keith Ward (GB CMA).

2010-09-11 The Age. (Page 4). *A year ago, this spot needed backburning, now life flourishes and song fills the air.*

2010-09-14 ABC news (774 radio). News item about the positive effects of flooding of Barmah Forest including comments from Andrew McDougall (PV).

2010-09-20 The Age. Page 5. *Ecologists fishing for facts knee-deep in Barmah Forest.*

October 2010

2010-10-01 ABC (radio Country Hour). Barmah-Millewa Environmental Water Entitlement, interview with NSW Water Commissioner David Harris.

2010-10-01 Parks Victoria. Media Release: *80 Billion Litres of Water for Barmah National Park.*

2010-10-04 Riverine Herald. Page 3. *Barmah Forest to have another drink.*

2010-10-04 Shepparton News. Page 5. *Environment Boost – Water release at Barmah to help breeding conditions for birds.*

2010-10-18 DSE. YouTube video. *Environmental Watering at Barmah-Millewa Forest*.

2010-10-23 ABC (radio Science Show). Interview with Keith Ward (GB CMA), talking about the Barmah forest and response to flooding. Interview with Rob Cook (MDFRC), talking about value of the flood to the productivity of the ecosystem.

November 2010

2010-11-26 ABC (Bendigo radio breakfast). Discussion between presented and Echuca tourism operator on the Murray River and blackwater event.

December 2010

2010-12-01 Numurkah Leader. Page 8. *Crays crawl from blackwater*.

2010-12-01 Riverine Herald. Page 8. *Water kills cod*.

2010-12-01 Riverine Herald. Page 10 – Letters to the editor (submitted by H Farrell, Moama). *Black water disaster.*

2010-12-03 Riverine Herald. Page 17. Photo with caption, taken by Member for Murray Sharman Stone. *Concern.*

2010-12-04 Shepparton News. Page 12. *Fish kill will continue.*

2010-12-06 Stone, Sharmon. (Media Release). Environmental flows need to be controlled in MDBA Plan

2010-12-09(?) Not Recorded (radio breakfast with Gaye Pattison). Benefits of Barmah-Millewa flooding, including interview with Keith Ward (GB CMA).

2010-12-13 ABC (GV? radio). Interview with Paul Weller re: reintroduction of grazing into Barmah and Gunbower forests.

2010-12-15 The Age. Page not recorded. *Fish dying in 'blackwater'.*

2010-12-16 * EPA Victoria. Media Release. *EPA Confirms Lower Goulburn Blackwater Event.*

2010-12-17(?) WIN News (TV Not recorded). News item about the blackwater event in the Murray, Goulburn and Broken Rivers, referencing the EPA.

2010-12-23 * EPA Victoria. Media Release. *EPA Confirms Murray River Blackwater Event.*

January 2011

2011-01-03 ABC news (TV ABC1 7pm bulletin). News item about Murray tourism, including interview with Barmah Kingfisher cruise operator Benita Cox.

2011-01-06 * Sunraysia Daily (page 1). *Fish Deaths: Ecological disaster is unfolding along the Murray River.*

2011-01-06 * Sunraysia Daily (page 24 - Sport). *A management disaster. Worst blackwater event in living memory sweeps along the Murray.*

2011-01-07 3AW breakfast (radio). Discussion on blackwater and Murray River operations, including interview with David Dreverman (RMW – MDBA)

2011-01-07 * ABC news (774 radio 12pm). News item on EWA release to mitigate Lower Goulburn blackwater event, including comment from Jane Doolan (DSE)

2011-01-07 * MDBA (Media Release). *The highs and lows of floods in the River Murray.*

2011-01-07 * Sunraysia Daily (page 1). *Blackwater – Authorities blamed for fish deaths* & *Act of nature: expert.* (page 4) *Eco-flow blast* & *Deaths act of nature: expert.*

2011-01-10 * ABC breakfast (774 radio). Discussion about the Murray-Darling Basin floods and blackwater, including interview with Ben Gawne (MDFRC).

2011-01-10 * MTR Breakfast (radio). Interview with Jodie Ross (Weemen Store) discussing Murray River flooding and blackwater.

2011-01-10 * Wangaratta Chronicle (page 7). *Flush of water to save fish.*

2011-01-11 * Kyabram Free Press (page 3). *Blackwater action taken.*

2011-01-12 GB CMA: Tour: Kingfisher cruise on Barmah Lakes with media representatives.

2011-01-12 * Mansfield Courier (page 8). *Lower Goulburn in for a big flush.*

2011-01-12 * Seymour Telegraph (page 6). *Water flow to save fish.*

2011-01-12 * Weekly Times (page 6). *Murray cod's black plague*.

2011-01-12 Weekly Times (page 20 Letters). *Blackwater needs good flushing*. J. Pettigrew – Environmental Farmers Network.

2011-01-13 * Sunraysia Daily (page 5). *Dead fish seen at Mildura.*

2011-01-14 * Ararat Advertiser (page 6 Letters). *How 'natural' is natural?* J. Pettigrew – Environmental Farmers Network

2011-01-14 * Mildura Weekly (page 5). *'Dark Days' for Murray River health.*

2011-01-14 Riverine Herald. (Page 9). *Forest's wet December.*

2011-01-14 * Sunraysia Daily (page 5). *Small fish dying in Murray.*

2011-01-14 * Sunraysia Daily (page 14 Inbox). *Floods are too quick to blacken the water.* Colin Ransome.

2011-01-15 Shepparton News. Weekend Life section. *Going Wild in Barmah. Cruising through the wetlands.* (2 pages + front cover)

2011-01-17 Country News. Page 12. *Floods offer habitat bonanza.*

February 2011
No records.

March 2011
No records.

April 2011

2011-04 Trackwatch magazine (page 31). *Barmah – a breeding oasis.*

2011-04-14 GB CMA (media release). *Boom for waterbirds at Barmah.*

2011-04-16 Shep News (page 21). *Egret chicks take flight.*

May 2011

2011-05-02 DSE (media release). *Big wet helps Broad-shelled turtles bounce back.*

2011-05-03 ABC radio – Shepparton. Interview with Rolf Weber (DSE) about Ulupna Island Broad-shell turtle survey results.

2011-05-10 ABC Goulburn-Murray radio. Interview by Warick Long with Keith Ward (GB CMA) regarding waterbird breeding in Barmah Forest.

2011-05-17 ABC central radio. Interview with Paul Weller regarding the proposed reinstatement of the Barmah Forest Advisory Committee.

2011-05-20 DSE (media release). Local project acknowledged for World Turtle Day

2011-05-23 ABC radio (774 drive). Interview with Lee Joachim (YYNAC) regarding Broad-shell turtle survey results.

June 2011

No records.

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GB CMA 2011b. Barmah-Millewa Icon Site Condition Monitoring Plan final draft version 9. Prepared by the Goulburn Broken Catchment Management Authority for the Murray-Darling Basin Authority. Not Recorded.

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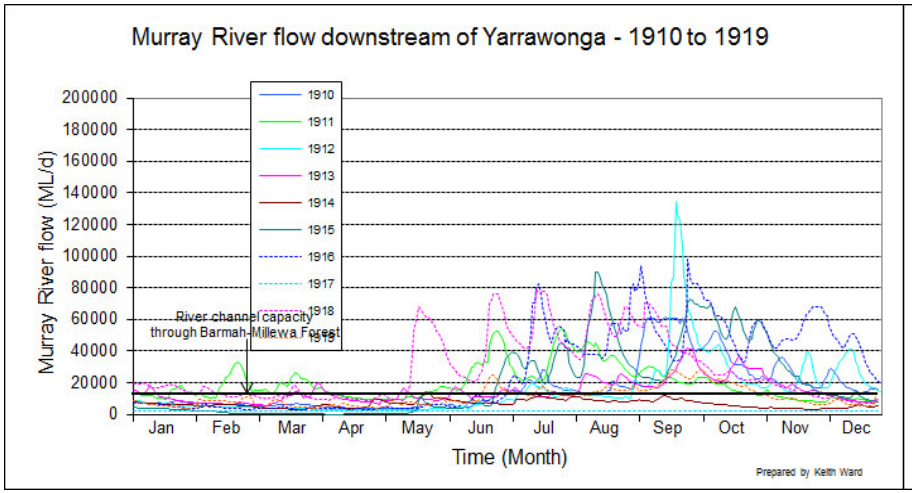
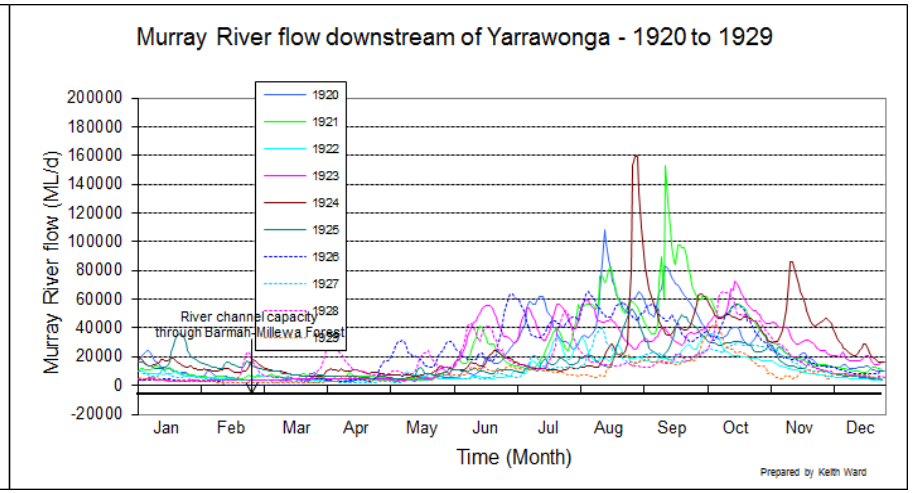
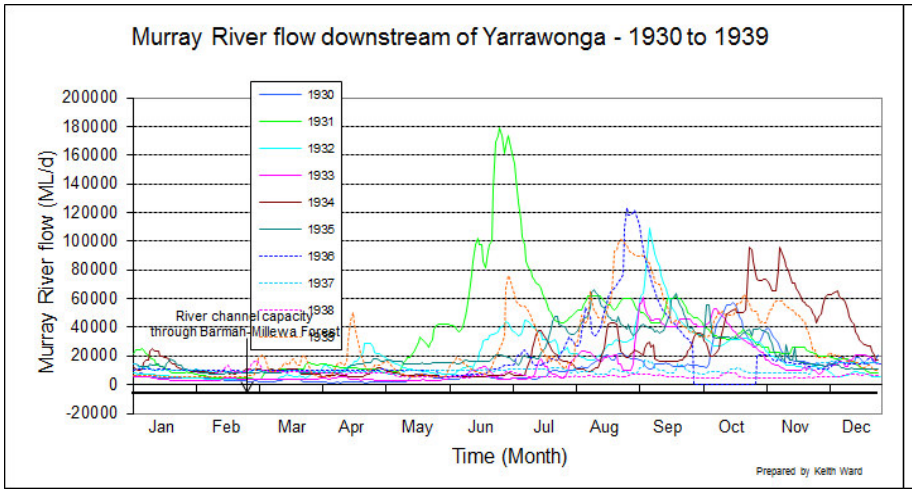
7 Appendix 1: Murray River hydrographs (depict river flows) downstream of Yarrawonga

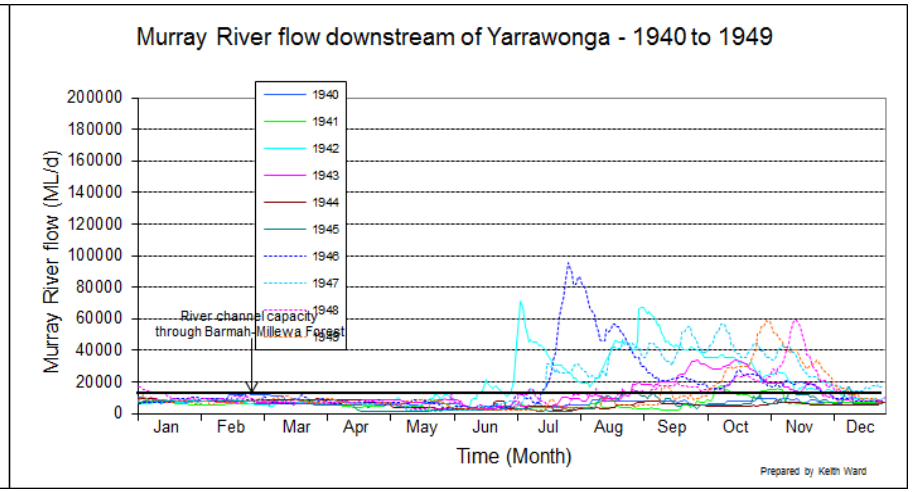
Flooding of the significant Barmah-Millewa wetlands are directly related to river flows in the Murray River. Flows in excess of 10,500 ML/d commence to flood many open wetland systems. Flows in excess of 60,000ML/d (if they occur for a month) flood the majority of the floodplain.

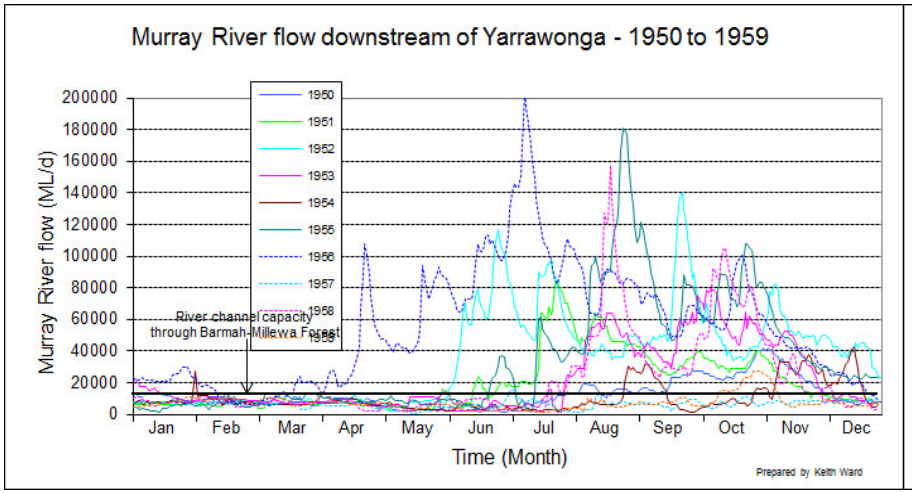
The charts below show that the flood peak of December 2010 was at least twice the size of any other peak at that time of year in the past 105 years. They also show that this flood breaks the longest drought sequence that Barmah-Millewa Forest has experienced in the last 105 years of recorded history.

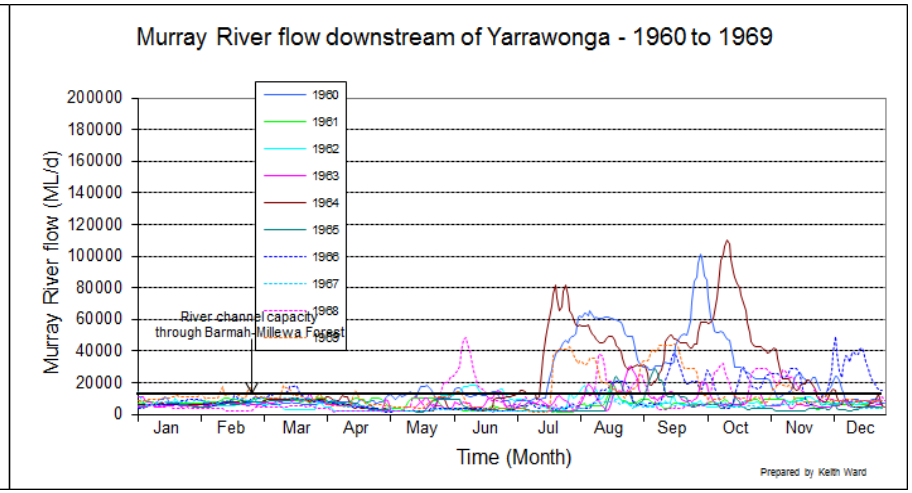

Murray River flow downstream of Yarrawonga - 1910 to 1919
Murray River flow (ML/d)
Time (Month)
River channel capacity through Barmah-Millewa Forest
Prepared by Keith Ward

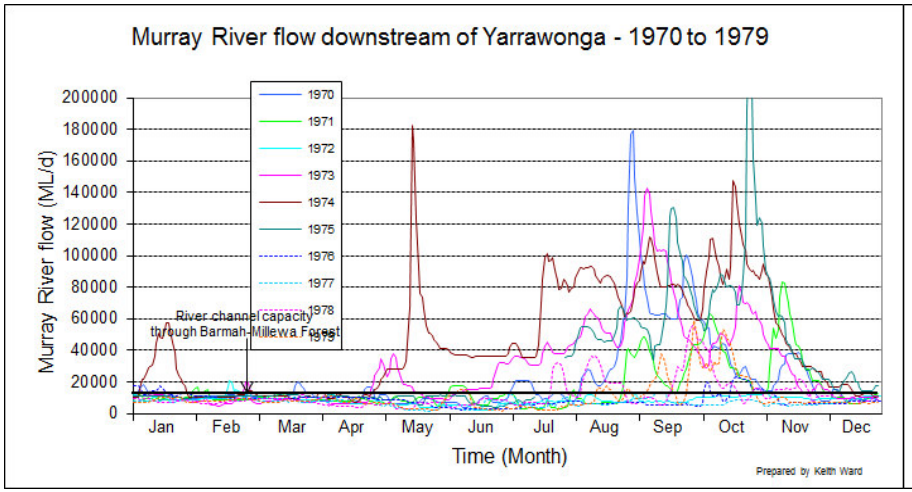

Murray River flow downstream of Yarrawonga - 1920 to 1929
Murray River flow (ML/d)
Time (Month)
River channel capacity through Barmah-Millewa Forest
Prepared by Keith Ward

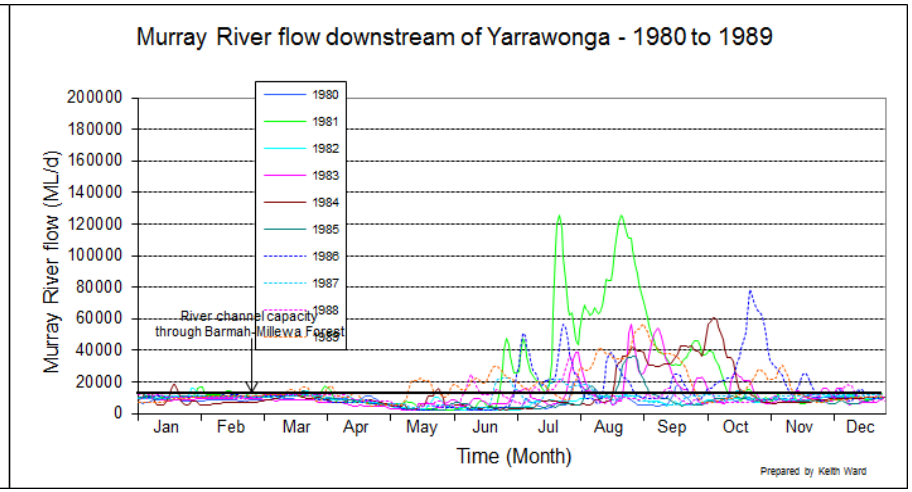

Murray River flow downstream of Yarrawonga - 1930 to 1939
Murray River flow (ML/d)
Time (Month)
River channel capacity through Barmah-Millewa Forest
Prepared by Keith Ward

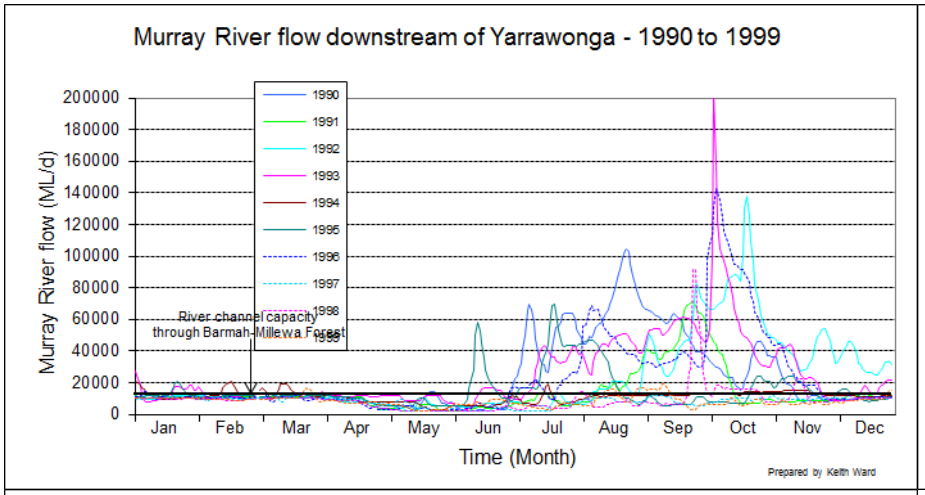

Murray River flow downstream of Yarrawonga - 1940 to 1949
Murray River flow (ML/d)
Time (Month)
River channel capacity through Barmah-Millewa Forest
Prepared by Keith Ward

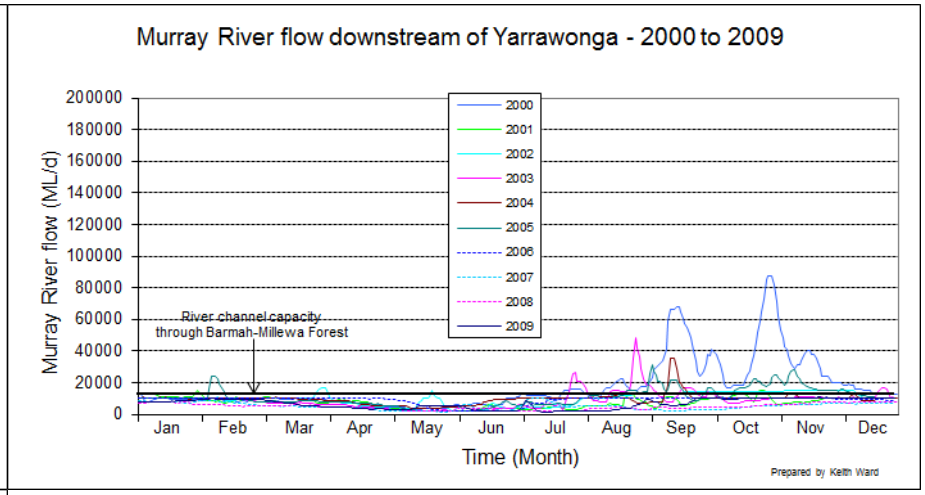

Murray River flow downstream of Yarrawonga - 1950 to 1959
Murray River flow (ML/d)
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Time (Month)
1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
River channel capacity through Barmah-Millewa Forest
Prepared by Keith Ward

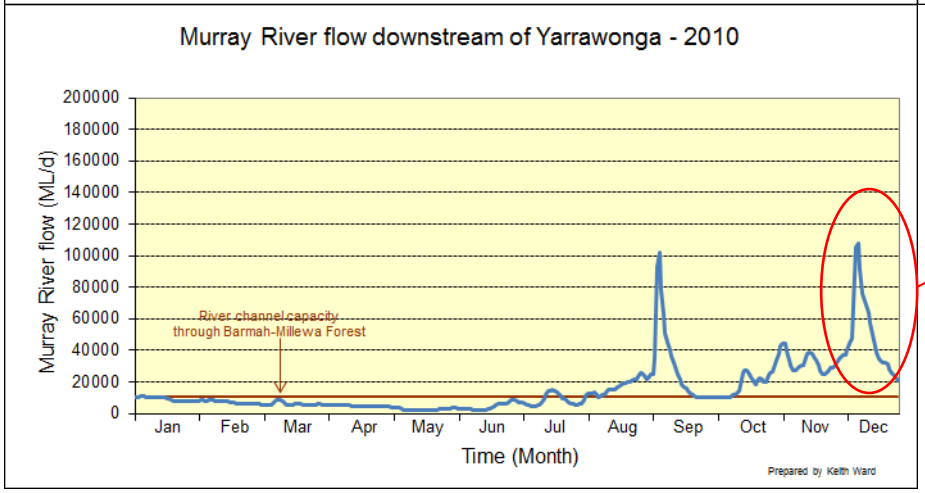

Murray River flow downstream of Yarrawonga - 1960 to 1969
Murray River flow (ML/d)
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Time (Month)
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
River channel capacity through Barmah-Millewa Forest
Prepared by Keith Ward


Murray River flow downstream of Yarrawonga - 1970 to 1979
Murray River flow (ML/d)
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Time (Month)
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
River channel capacity through Barmah-Millewa Forest
Prepared by Keith Ward

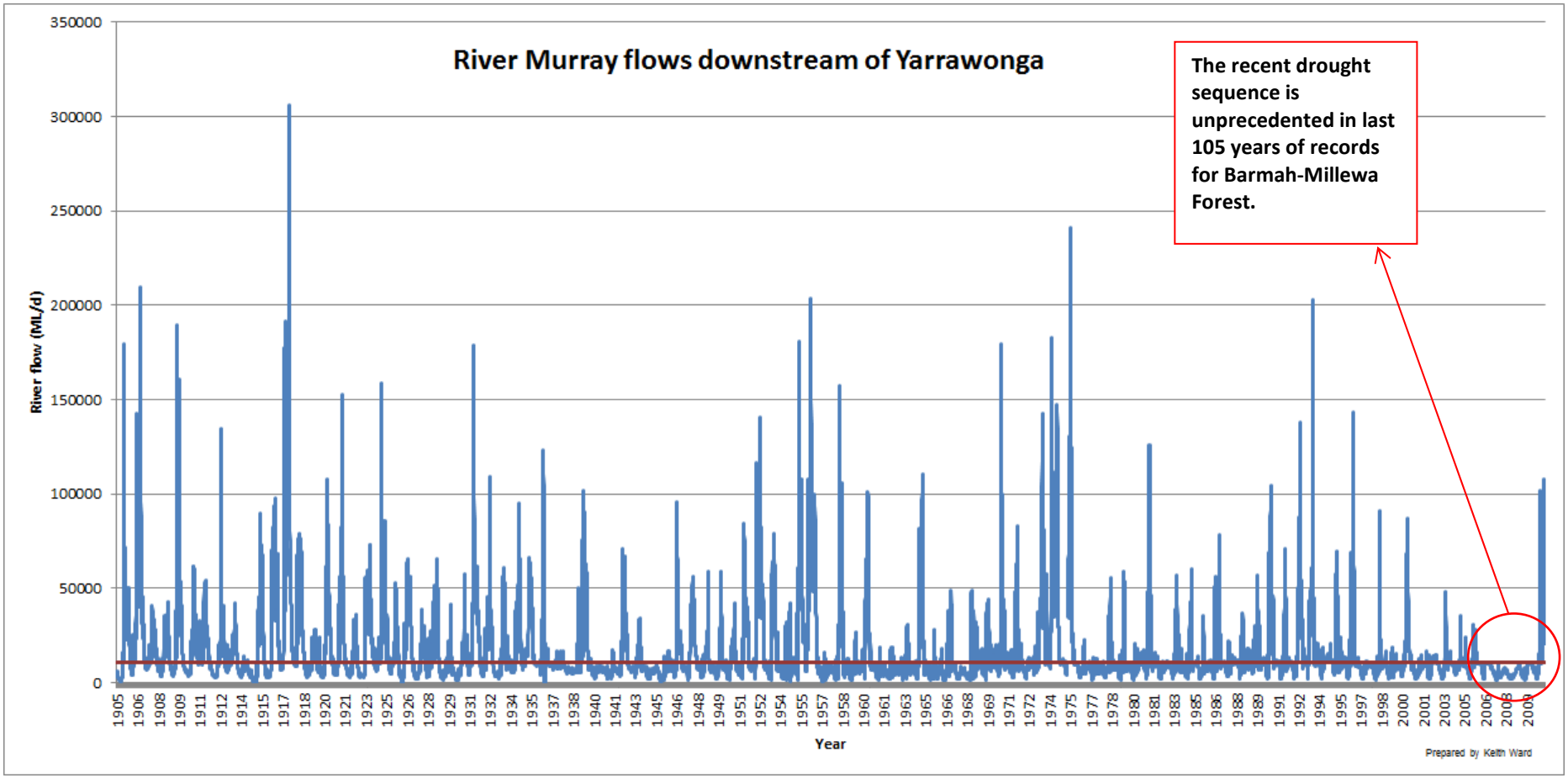

Murray River flow downstream of Yarrawonga - 1980 to 1989
Murray River flow (ML/d)
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Time (Month)
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
River channel capacity through Barmah-Millewa Forest
Prepared by Keith Ward







The recent high flow event in December is a very rare occurrence, and the height at this time of year through Barmah-Millewa Forest is unprecedented in last 105 years of records.



For further information about Murray River flows and river management, contact the Murray-Darling Basin Authority, Canberra. Barmah water management enquiries can be directed to the Goulburn Broken Catchment Management Authority, Shepparton, or Parks Victoria, Nathalia.

Appendix 1 Prepared by: Keith Ward. Wetland Ecologist, GB CMA. Ph; (03) 5820 1100 07/01/2011

8 Appendix 2: Proposed Barmah-Millewa EWA release for Spring 2010

Prepared by Keith Ward (GB CMA) & Alison King (ARI DSE)
- *last updated version dated: 04/10/2010*

Introduction:

The following water management proposal has been developed as a brief discussion paper for consideration by the Barmah-Millewa Icon Coordinating Committee and its supporting sub-committees (Barmah-Millewa Technical Advisory Group and Barmah-Millewa Operations Committee). It is also expected that Indigenous involvement will be held when available.

The need for water management considerations has been made urgent following the passing of a large natural flood in September that has now declined rapidly without there being immediate prospects of additional natural flooding. However, forecasts of a generally wet Spring raise hopes of such an event occurring, and hence a bridging release of environmental water to maintain elevated water levels in selected wetlands is therefore deemed to be a valid target, especially if many of the Icon Site's ecological aims are to be achieved.

The ecological objectives for the Barmah-Millewa Icon Site include the following (as per draft B-M EMP 2010-2015):

- Promote healthy and diverse vegetation communities, with an emphasis on restoring natural extent and distribution of Giant Rush, Moira Grass, River Red Gum forest and River Red Gum woodland in at least 55% of the area of Barmah-Millewa Icon Site.
- Promote and/or sustain successful breeding events of multiple thousands of colonial and migratory waterbirds in at least three years in ten, by inundating selected floodplain and wetland areas to provide suitable nesting and feeding habitat.
- Promote successful recruitment of native fish species by improving flow variability in spring and early summer to replicate natural cues, and by inundation of floodplain and wetland areas to provide breeding and nursery habitat.
- Facilitate successful breeding and feeding opportunities for native frog species by seasonal inundation of selected floodplain and wetland areas for appropriate season and duration as required for each species.
- Facilitate healthy and diverse vegetation to provide suitable, breeding and foraging habitat for a diverse range of waterbirds and bush birds.
- Facilitate successful breeding of native turtle species by inundation of selected floodplains and wetland areas to provide suitable breeding and nursery habitat.
- Facilitate appropriate management to ensure the sustainability of Crayfish populations.
- Facilitate appropriate management measures to control the abundance and spread of invasive aquatic species.
- Facilitate appropriate geomorphology management in selected waterways.

Background:

- It has been 5 years since the last medium level flood (55% of forest inundated) and 10 years since last widespread flood where the most of the floodplain was inundated.
- Current conditions have flooded most of floodplain (85% of forest inundated), thereby achieving the 'flood extent' aim, though short duration and early season timing has meant that not all biota and vegetation communities have yet benefited fully. Flood levels are now dropping rapidly.
- Irrigation water demand is currently very low, causing river operating levels to now be run around 5-7000ML/d downstream of Yarrawonga for the immediate future. This level requires all forest regulators to be closed and hence all wetlands and waterways will drain down to low levels. Fish will attempt to return to deeper waterways, and most waterbirds will abandon nesting attempts.
- Opportunity therefore exists to release a component of the B-M EWA in attempt to keep some waterways flowing and key wetlands flooded.
- The natural flooding in September has triggered a strong aquatic invertebrate and chemical response. Returning floodwaters to the river is rich in this food resource, which directly and/or indirectly, provides benefits for the river ecosystem (particularly fish).
- Maintaining some return flow through the floodplain will assist with continuing the supply of the rich floodwater back into the river to provide these broader and downstream benefits.
- Some waterbirds (eg, swans and ducks) are currently breeding, and the maintenance of flows to those wetlands will assist with the successfully completion of the breeding attempt.
- Other waterbird species, such as ibis and spoonbills, are colonial-nesting species that are expected to have only just started nest-building in known rookery sites. Maintenance of water levels in these sites is critical to ensuring that the waterbirds do not abort their nesting attempt.
- Bureau of Meteorology forecasts for Spring are for further wetter conditions, with the strong possibility of additional natural flooding. The strategy of the EWA release is to link the recent natural flood event to the probable next flood event, and thereby extract the maximum ecological benefit from the continued flood duration in the wetlands than would otherwise occur with two separate flood peaks.
- Water temperatures are currently relatively low (13-15^{o}C), and hence most native fish species are currently not spawning (though are taking advantage of the increase in food resources being delivered from the floodplain inundation). The increase in body condition is likely to result in a strong spawning response once additional flooding occurs during spring (expected from mid-October to December). Keeping flood connectivity throughout the main forest waterways is expected to enhance fish movements, minimise strandings, and facilitate a rapid breeding response once cues are experienced.
- Blackwater is currently not a risk due to low water temperatures, and the previous pulse has provided a flushing flow of large amounts of carbon into the waterways. The risk of blackwater will increase if another flood peak occurs and water temperatures are higher.
- A range of wetland vegetation species will also benefit with the maintenance of water levels. Moira Grass is recognised as a key indicator species and forms part of the Ramsar ecological character of the B-MF. This species requires flood depth of at least 500mm to be maintained into late-Spring so as to achieve flowering and seed-set. Punctuated periods of drying conditions would otherwise see the species change from its flood-growth to a dry-growth phase, where flowering does not occur and therefore reproduction in the species compromised.
- River flows downstream of Yarrawonga are expected to drop to between 5,000 to 7,500ML/d without additional EWA release.

- EWA release should be considered to maintain the river level at a minimum of 1000ML/d above the otherwise required operated river level for downstream demand, except were flows are less than 7,000ML/d in which case release more EWA to maintain river at least at 8,000ML/d. Natural flood peaks are to be incorporated into the forest flooding where ever possible, where EWA release can be either temporarily saved from release (in the event that the available volume is at risk of premature exhaustion) or used to enhance a natural flood peak (where possible within available river capacity constraints and available water volumes).

Proposal:

As a short-term measure, we propose that in the next two weeks:

- The Murray River channel be held between 8,500 to 10,000ML/d for as long as possible before a gradual decline in river levels (unless natural flow peaks occur).
- A small flow of approximately 400ML/d should be maintained into Boals Deadwoods wetland (which has a CTF threshold of 7,500ML/d downstream of Yarrawonga) from now until late-spring (or as otherwise directed through environmental monitoring) so as to maintain elevated water levels into this otherwise shedding wetland to encourage colonial waterbirds to nest.
- A small flow of approximately 500ML/d is to be maintained into the Gulf Creek system (which has a CTF threshold of <3000ML/d downstream of Yarrawonga) from now until late-spring (or as otherwise directed through environmental monitoring).
- A flow of at least 400ML/d (of which some will be existing minimum flows and passing flows for downstream irrigation) be maintained into Gulpa Creek from as soon as the Gulpa fishway work is completed until late-spring (or as otherwise directed through environmental monitoring) so as to inundate Reed Beds and Duck Lagoons (which both have a CTF threshold of >350ML/d in Gulpa Creek) to encourage a variety of significant waterbird species to nest.
- The section of the Gulf Creek regulators to be opened to pass the required flow should be operated and maintained at ½ opening capacity if possible. In particular the declining river hydrograph should be allowed to be transmitted into the Gulf system to reduce the likelihood of fish strandings in the creek that would otherwise occur with sudden regulator closure.
- We **DO NOT** recommend providing any pulse events in the next two weeks due to the risk of enhancing carp breeding while there is limited likelihood of benefiting native species because the waters are currently too cool for most native fish species.
- Water management is to continue to be adaptively managed based on monitoring results and field observations obtained so as to aim for achieving the maximum number of ecological objectives for the site.
- Figure 1 shows a hydrograph of the potential EWA releases in the absence of additional natural flood events and continuing low operating river levels. If the downstream river demand was 7,500ML/d for the remaining days in the calendar year, then pulsing the river as depicted would require the release of between 160 to 390GL.

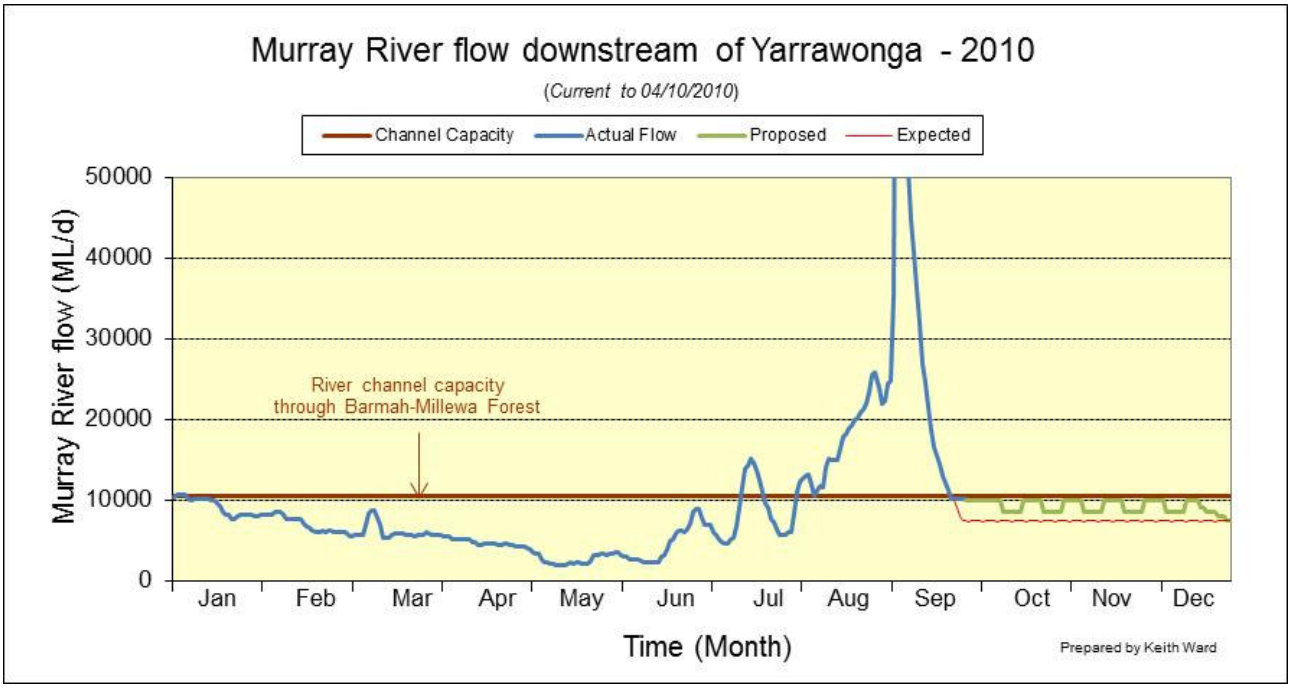


Figure 1: Murray River hydrograph downstream of Yarrawonga, exhibiting river levels (as indicated by daily flow volumes) current to 04/10/2010 (blue line) and potential EWA releases (green line) in the absence of additional natural flood events and continuing low operating river levels.

Monitoring:

- Monitoring of fish spawning and recruitment is occurring on a fortnightly basis, and water quality and zooplankton are also being monitored on a monthly basis (ARI and MDFRC).
- Waterbird monitoring is occurring on a seasonal basis by a consultant, with the Spring monitoring program occurring in early-October. Specific event-based monitoring is now commencing by agency staff, and will occur on a weekly/fortnightly basis while active water management planning is required.
- Understorey vegetation monitoring has yet to commence, pending consultant appointment. This is required to be undertaken ASAP so as to capture spring vegetation response to the flooding, especially given that this event represents the most widespread inundation of existing sentinel sites since TLM monitoring had commenced.

9 Appendix 3: Birds that have bred in Barmah-Millewa Forest 2010/11

1. Great Crested Grebe
2. Hoary-headed Grebe (suspected)
3. Australasian Grebe
4. Darter
5. Pied Cormorant
6. Little Pied Cormorant
7. Great Cormorant
8. Little Black Cormorant
9. Pacific Heron
10. White-faced Heron
11. Little Egret
12. Intermediate Egret
13. Great Egret
14. Rufous Night Heron
15. Little Bittern (suspected)
16. Australasian Bittern (suspected)
17. Australian White Ibis
18. Straw-necked Ibis
19. Royal Spoonbill
20. Yellow-billed Spoonbill
21. Black Swan
22. Australian Shelduck (suspected)
23. Pacific Black Duck
24. Grey Teal
25. Chestnut Teal (suspected)
26. Hardhead
27. Maned Duck
28. Musk Duck
29. White-bellied Sea Eagle
30. Buff-banded Rail (suspected)
31. Lewins Rail (suspected)
32. Baillons Crake (suspected)
33. Australian Spotted Crake (suspected)
34. Spotless Crake (suspected)
35. Black-tailed Native-hen (suspected)
36. Dusky Moorhen
37. Purple Swamphen
38. Eurasian Coot
39. Brolga
40. Masked Lapwing (suspected)
41. Whiskered Tern (suspected)
42. Azure Kingfisher (suspected)
43. Scared Kingfisher (suspected)

10 Appendix 4: Dates of operation of regulators in 2010/11.

Key: Open (green), partially opened (blue) and closed (pink).

		Jul-10	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	1-Jul-11 Status
Victoria	Sandspit Creek	19/07/10 27/7/10	4/08/10											open
	Gulf Creek 1	19/07/10 27/07/10	4/08/10	27/09/10	12/10/10					31/03/11		12/05/11		part open
	Gulf Creek 2	19/07/10 27/07/10	4/08/10	27/09/10	12/10/10					31/03/11				closed
	Stewarts Kitchen		17/08/10	27/09/10	12/10/11					31/03/11				closed
	Bull Paddock		17/08/10	27/09/10	12/10/11					31/03/11				closed
	Punt Paddock Lagoon	20/07/10 27/07/10	16/08/10	27/09/10	12/10/10					31/03/11		17/05/11		open
	Big Woodcutter Lagoon		16/08/10	27/09/10	12/10/10									open
	Little Woodcutter 1		17/08/10											open
	Little Woodcutter 2		17/08/10											open
	Little Woodcutter 3		17/08/10											open
	Little Woodcutter 4		17/08/10											open
	Boals Creek	20/07/10 27/07/10	16/08/10							31/03/11		17/05/11		open
	Sapling Creek	20/07/10 27/07/10	16/08/10							31/03/11				closed
	Island Creek	20/07/10 27/07/10	16/08/10							31/03/11				closed
	Pipe Culverts													unknown
NSW Murray	Plantation													unknown
	House	20/07/10 27/07/10	13/08/10	27/09/10	1/10/10						18/04/11	21/05/11		open
	Pinch Gut	20/07/10 27/07/10	13/08/10	27/09/10	1/10/10						18/04/11	21/05/11		open
	Mary Ada	20/07/10 27/07/10	6/08/10 20/08/10	27/09/10	1/10/10 21/10/10					31/03/11	12/04/11	21/05/11 24/05/11	16/06/11 24/06/11	open
	Potts	20/07/10 27/07/10	13/08/10	27/09/10	1/10/10						18/04/11	21/05/11		open
	Fishermans	20/07/10 27/07/10	13/08/10	27/09/10	1/10/10						18/04/11	24/05/11		open
	Nine Panel	20/07/10 27/07/10	9/08/10	27/09/10	1/10/10						18/04/11	24/05/11		open
	Nestrons	20/07/10 27/07/10	6/08/10	27/09/10	1/10/10						18/01/11	24/05/11		open
	Walthours	20/07/10 27/07/10	9/08/10	27/09/10	1/10/10						18/04/11			closed
	Warwick	20/07/10 27/07/10	6/08/10									4/05/11		closed
	Porters	20/07/10 27/07/10	23/08/10										16/06/11	closed
	O'Shannassy		23/08/10										16/06/11	closed
	Swifts		23/08/10								5/04/11			closed
	Bunnydigger		23/08/10								5/04/11			closed
	Moira Creek		13/08/10 20/08/10 23/08/10											closed

		Jul-10	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	1-Jul-11
NSW Gulpa/Edward	Collins		24/08/10											open
	McLarens		24/08/10											open
	Opla		24/08/10											open
	Crumps		24/08/10											open
	V Block													unknown
	Edwards		24/08/10											open
	Mains		24/08/10											open
	Keech		24/08/10											open
	Black Swamp		24/08/10											open
	Wragges		24/08/10											open
	Taylors		24/08/10											open
	Atkinsons		24/08/10											open
	Buchanans		24/08/10											open
	Dwyers		24/08/10											open
	Husseys		24/08/10											open
	Bonners		24/08/10											open
	Correys		24/08/10											open
	Little Edwards		24/08/10											open
	Gulpa Offtake													unknown
	McCartneys			6/09/10										open
	Tumudgery		27/08/11											open
	Niemur		27/08/11									11/05/11 25/05/11	27/06/11	closed
	Reed Bed		27/08/11									11/05/11 25/05/11		open