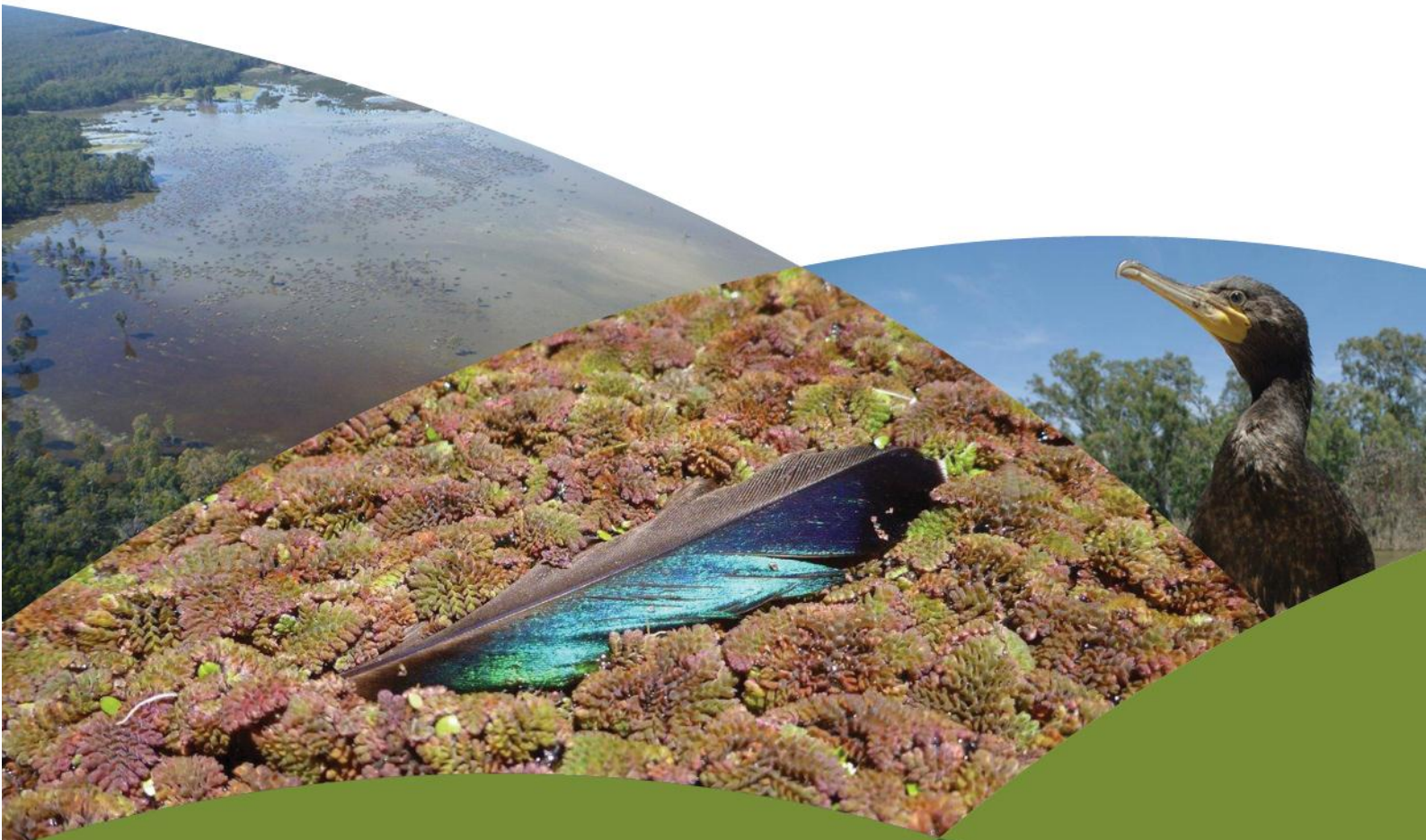
The Living Murray Barmah-Millewa Forest Icon Site

Annual Synthesis Report 2011-12



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The MDBA and their funding support through The Living Murray Initiative are acknowledged. Appreciation is also extended to the numerous agency staff and contractors who submitted project summaries and/or contributed to other sections of this report.

Cover Images by Keith Ward (GB CMA):

Left: *Steamer Plain clear water mixing with turbid inflows (27/10/2011).*

Centre: *Pacific Black Duck (*Anas superciliosa*) feather on top of Pacific Azolla (*Azolla filiculoides*) at Boals Deadwoods wetland (04/01/2012).*

Right: *Great Cormorant (*Phalacrocorax carbo*) at Barmah Lake (18/11/2011).*

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Acronyms and Abbreviations

AAV	Aboriginal Affairs Victoria
AEW	Adaptive Environmental Water (NSW)
B-M	Barmah-Millewa
B-MF	Barmah-Millewa Forest
B-MOC	Barmah-Millewa Operations Committee
B-MWOP	Barmah-Millewa Water Operation Plan
BNP	Barmah National Park
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
CSU	Charles Sturt University
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
EWMaP	Environmental Water Management Plan
GB CMA	Goulburn Broken Catchment Management Authority
GL	Gigalitre
G-MW	Goulburn-Murray Water
ICC	Icon Coordinating Committee
IPP	Indigenous Partnership Project
IRG	Indigenous Reference Group
JAMBA	Japan-Australia Migratory Bird Agreement
MDB	Murray-Darling Basin
MDBA	Murray-Darling Basin Authority
MDBC	Murray-Darling Basin Commission (now MDBA)
MDFRC	Murray-Darling Freshwater Research Centre
ML	Megalitre
MVNP	Murray Valley National Park
NP	National Park
NPWS	National Parks and Wildlife Service
NSW	New South Wales
PV	Parks Victoria
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
SEWPaC	Department of Sustainability, Environment, Population and Communities
SQ	Site Quality
TAC	Technical Advisory Committee
TLM	The Living Murray
VEWH	Victorian Environmental Water Holder
WMA	Water Management Area
YYN	Yorta Yorta Nation
YYNAC	Yorta Yorta Nations Aboriginal Corporation

1 Executive Summary

The Barmah-Millewa Icon Site, consisting of Barmah National Park and River Reserve in Victoria and the former Millewa group of forests within the new Murray Valley National Park 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 2011/12 year saw widespread natural flooding continue from the previous year being extended into late spring. Nevertheless, a total of 424.6GL of environmental water was released to maintain waterbird breeding during otherwise low flow events in spring, and a strong flow pulse was provided in early December for perch spawning. A large natural flood event had then occurred in late-February, which is highly unusual for that time of year, where it re-flooded up to half of the floodplain and caused near continuous flooding of low laying wetlands since winter 2010. Fortunately no significant Blackwater events occurred this year, likely due to the widespread flushing of the floodplain last year which was associated with a major Blackwater event at that time.

Mixed environmental outcomes were documented. Tree canopy condition has continued to improve with the flooding and strong rainfall events (although actual monitoring results have yet to be reported), whereas some native understorey vegetation species exhibited improvements while other species, such as Moira Grass, displayed concerning lack of growth where continuously flooded. A strong waterbird breeding response did occur, although was down on levels recorded in the previous year which broke records for 60 years. Bush-bird activity was high with 70 species representing the greatest diversity since monitoring began in 1999, and White-bellied Sea-eagles had successfully bred with five juvenile having been observed. Fish response appeared to be low, even for exotic Common Carp, although spawning was found to have occurred in the large native species Murray Cod, Silver Perch and Golden Perch. Of particular concern was that no Murray Crayfish were found in the Murray River below Barmah Lake, which had been affected by blackwater last year. Frog response could not be quantified as no monitoring was undertaken for this fauna group this year; however turtle monitoring found good numbers of all three turtle species active at Barmah-Millewa Forest this year.

Overall, a return to strong flooding conditions appears to be having mostly beneficial impacts on the native flora and fauna of the Barmah-Millewa Icon Site, although some longer-term impacts of previous drought conditions are still evident. A return to natural summer-autumn dry conditions followed by strong winter-spring flooding is expected to show greatest benefit for re-improving the health of the floodplain ecosystem.

1.1 Key Messages, Lessons for adaptive management

Issue:

Lack of Moira Grass growth at most sites in Barmah-Millewa Forest, especially where the species was previously a strong dominant, is of concern for the potential loss of the species and hence a potential trigger for a change in Ramsar ecological character.

Recommendation

Continue to monitor Moira Grass health, especially following a good seasonal dry and then deep flooding, to ascertain the extent of the species rebounding with a return of a more natural food regime. Map the distribution of Moira Grass within the forest to compare to previous recorded measures.

Issue:

The strong growth of Giant Rush where flooded during the drought to maintain the species as a suitable habitat for future nesting waterbirds appears to have worked well. By contrast, drought the species for 5 years, followed by complete submergence for a couple of month, appears to substantially weaken the species from areas where it is not wanted.

Recommendation

As implementing long duration drought conditions is not favourable for most other local wetland species, nor practical, nor is creating long-duration high-level flooding to keep the species submerged, then management ought to prevent Giant Rush from establishing in the first instance by ensuring wetlands remain inundated during the germination period in spring (following recommendations by Ward 2011 and Lesley *et al.* in prep.).

Issue:

Local extinction of Murray Crayfish in the Murray River below Barmah Lake requires a fishing ban on the species to assist with re-establishment of this long-lived slow-growing species.

Recommendation

Formally advise NSW state fisheries of the crayfish results and anecdotal evidence (collated by Parks Victoria & NSW National Parks and Wildlife Service via Technical Advisory Committee) following the 2010-11 hypoxic blackwater event.

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 is 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 (Figure 1). 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.

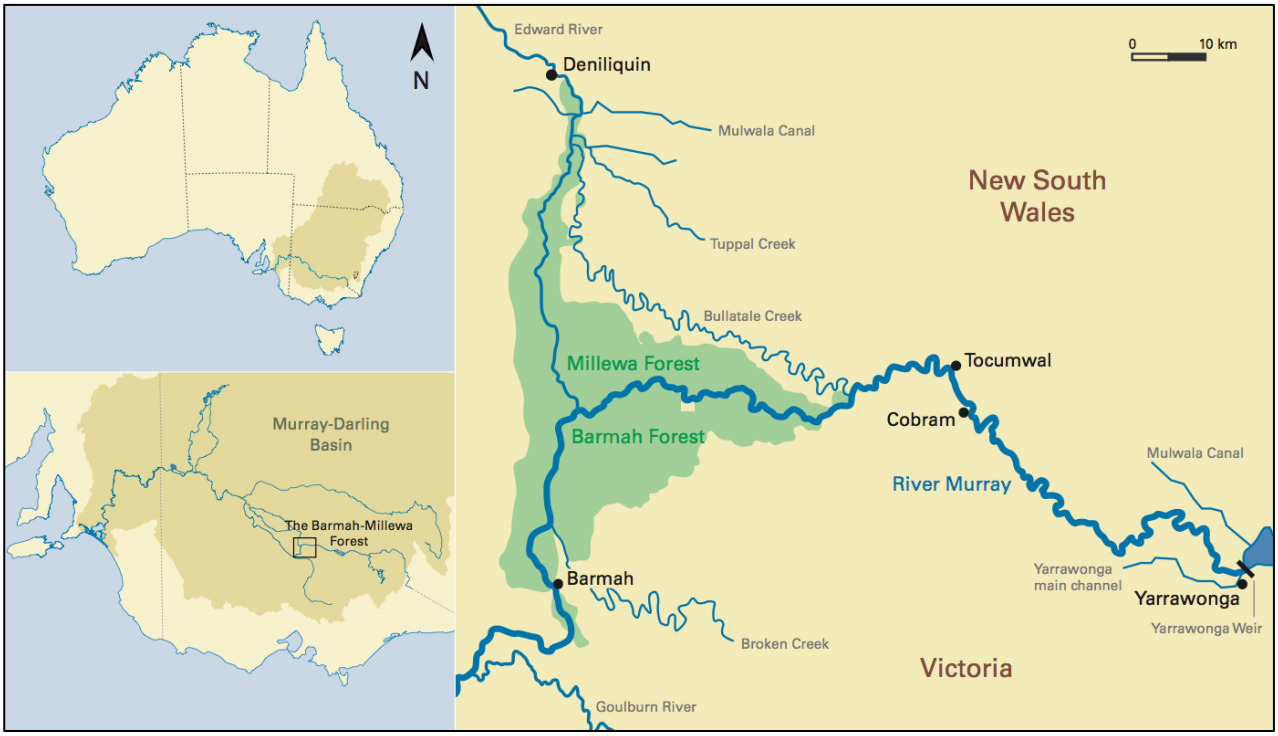

Figure 1: Location of the Barmah-Millewa Icon Site (modified from MDBA).

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 inclusion in the Barmah-Millewa Ecological Operating Strategy, drafted in 2011-12 and due for completion in 2012-13. 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 (Management and Committee Structure).

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 (DEPI, 2012).

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, 2012a).

2.3 Hydrograph

Flooding in Barmah–Millewa Forest generally occurs when Murray River flows exceed 10,400ML/d downstream of Yarrawonga. The hydrograph of the river at this location throughout 2011-12 is presented in Figure 2, and shows four large natural flood peaks in winter-spring, followed by a very large flood event in late-February/early-March that caused the drying floodplain to be re-flooded.

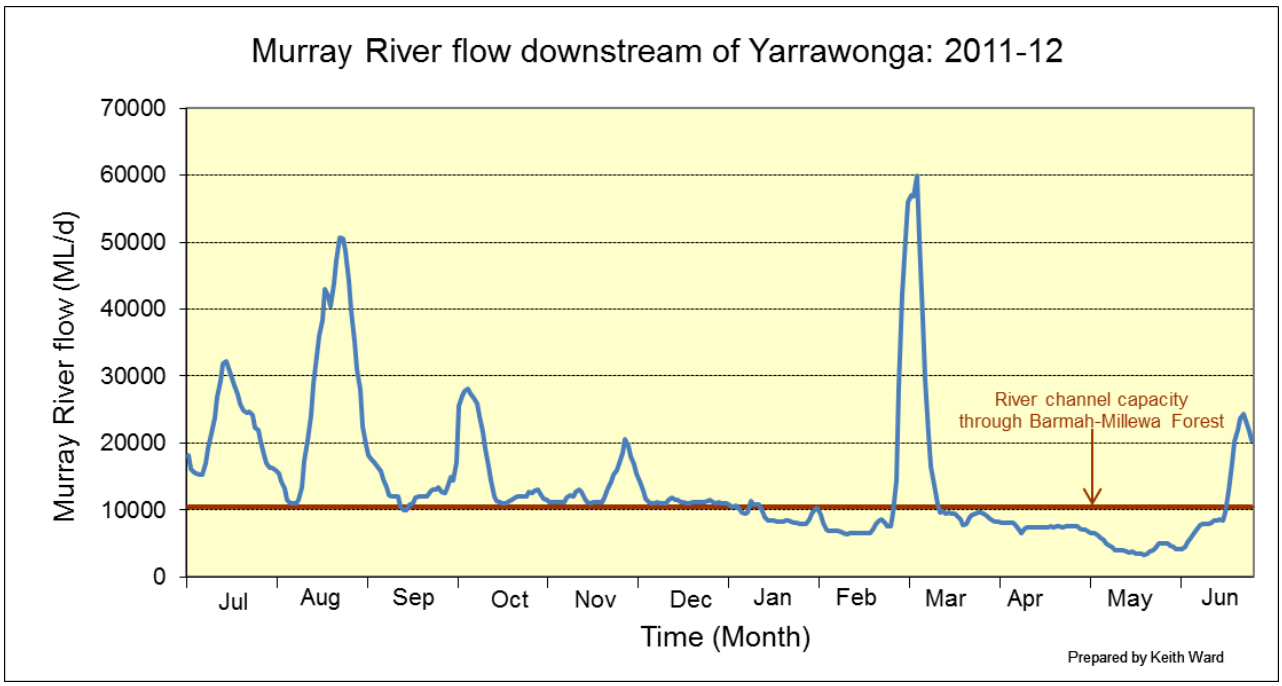

Figure 2: 2011-12 hydrograph showing Murray River flow downstream of Yarrawonga Weir.

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 Integrated 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 New South Wales Icon Site Manager took the lead role during 2011-12.

3.3 Icon Site Integrated 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 one occasion during 2011-12 (meeting number 20, held 31 January 2012). The committee's actions during the year included:

- Reviewed the Consultation Reference Groups' Communication Strategy to ensure it met the needs of the ICC.
- Provided comment on the 2010-11 Annual Report for Barmah-Millewa and endorsed this and the EWMP being publically available on agency websites.
- Supported the request for Yorta Yorta/Cummeragunja membership on the Technical Advisory Committee.

Table 1: Barmah-Millewa Icon Site Coordinating Committee attendees 2011-12.

Member	Organisation	Meetings attended
Paul Childs (Chair)	NSW National Parks & Wildlife Service	1
Craig Subbing	Parks Victoria	1
Jade Miller	Yorta Yorta Nation Aboriginal Corporation	1
Jennifer Martin	Department of Sustainability, Environment, Water, Population and Communities	1
Luke Pierce	NSW Department of Industry and Investment (Agriculture & Fisheries)	1
Greg Raisin	MDBA	1
Susan Buckle	MDBA	1
Lisa Blanche	MDBA	1
Trish Bowen	Murray CMA	1
Guest		
Keith Ward	Goulburn Broken CMA	1
Rick Webster	NSW National Parks & Wildlife Service	1
Emma Wilson	Office of Environment & Heritage	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 held five meetings during 2011-12, two of which were teleconferences.

- Meeting 24, held 12 July 2011
- Meeting 25, held 15 September 2011
- Meeting 26, held 14 November 2011 (teleconference)
- Meeting 27, held 1 February 2012
- Meeting 28, held 25 June 2012 (teleconference)

The committee's actions during the year included;

- Overseeing the management and reporting of monitoring projects.
- Supporting the development of the 2010-11 Annual Report.
- Provided technical input into water management for 2011-12.

Table 2: Barmah-Millewa Technical Advisory Group attendees 2011-12.

Members	Organisation	Meetings attended
Paul Childs (chair)	National Parks & Wildlife Service (NSW)	3
Rick Webster	National Parks & Wildlife Service (NSW)	5
Keith Ward	Goulburn Broken CMA (Vic)	5
Andrew Shields	Goulburn-Murray Water (Vic)	3
Bruce Wehner	Parks Victoria	4
Damian Green	River Murray Water - Murray Darling Basin Authority	1
John Waterworth (*for Damian Green*)	River Murray Water - Murray Darling Basin Authority	3
Lee Joachim	Indigenous Facilitator Barmah-Millewa	2
Shar Ramamurthy	Dept of Sustainability & Environment (Vic)	3
Louisa Davis (*for Shar Ramamurthy*)	Dept of Sustainability & Environment (Vic)	2
Lee Baumgartner	Dept Industry & Investment (NSW)	1
Meaghan Rourke (*for Lee Baumgartner*)	Dept Industry & Investment (NSW)	3
Leah Beesley	Arthur Rylah Research Institute, DSE (Vic)	2
Scott Raymond (*for Leah Beasley*)	Arthur Rylah Research Institute, DSE (Vic)	1
John Conallin	Murray CMA (NSW)	1
Anthony Conallin (*for John Conallin*)	Murray CMA (NSW)	1
Trish Bowen (*for John Conallin*)	Murray CMA (NSW)	1
Jason Sheehan (*for Digby Jacobs*)	Dept of Water & Energy (NSW)	2
David Hohnberg	The Living Murray – Murray Darling Basin Authority	2
Guests		
Keith Chalmers	Goulburn Broken CMA (Vic)	5
Amanda Lynch	Monash University	1
Browyn Button (minutes)	National Parks & Wildlife Service (NSW)	1
Stuart Little (*for Greg Raisin*)	TLM-MDBA	1
Tim O'Kelly (minutes)	National Parks & Wildlife Service (NSW)	1
Emma Wilson (minutes)	National Parks & Wildlife Service (NSW)	2
Mark Grant	TLM - MDBA	1
Mark Vanner	TLM – MDBA	1
Wayne Robinson	Charles Sturt University	1

3.5 Icon Site Consultation Reference Group

The Barmah-Millewa Consultation Reference Group (B-M CRG) met on 1 occasion during 2011-12, meeting number 10, held on 26/10/2011. Members and guests are listed below (Table 3). The committee's actions during the year included;

- Seeking clarification on their terms of reference and role from the ICC.
- Reviewed the Communications Plan.
- Proposed options for the communication of key documents (GB CMA, 2011a).

Table 3: Barmah-Millewa Consultation Reference Group attendees 2011-12

Members	Organisation	Meetings attended
Brian Royal (Chair)	Murray CMA Board Member	1
Gordon Ball	Basin-wide TLM Community Reference Group Member	1
Louise Burge	Adjacent Landholder/Community Member	1
Keith Stockwell	Recreation/Tourism/Community Member	1
Guests		
Paul Childs	NSW Parks & Wildlife Service	1
Keith Ward	Goulburn Broken CMA	1
Garry Rodda	Murray CMA	1
Bronwyn Button	NSW Parks & Wildlife Service	1

3.6 Icon Site Indigenous Partnership Project

The Icon Site Indigenous Partnerships Project (IPP) has overtaken the Indigenous Reference Group (IRG) as the forum for indigenous issues and input to be provided to the B-M ICC. It is facilitated by the Department of Sustainability and Environment. The B-M IPP met on two occasions during 2011-12 (meeting number 3 held on 17 August 2011 and meeting number 4 held on 6 December 2011; Table 4).

- Finalisation of a Yorta Yorta Nation The Living Murray (YYN TLM) communication strategy.
- Continuing to improve Yorta Yorta Nation (YYN) involvement in environmental water management. For example, inclusion of YYN representation on the Barmah-Millewa Operations Committee teleconferences.
- Oversaw YYN managed projects, including the freshwater turtle monitoring project.

Table 4: Barmah-Millewa Indigenous Partnership Project attendees 2011-12

Members	Organisation	Meetings attended
Lee Joachim	Yorta Yorta Nation Aboriginal Corporation (Vic)	2
Roley Williams	NSW Office of Environment and Heritage (NPWS)	1
Rick Webster	NSW Office of Environment and Heritage (NPWS)	2
Shar Ramamurthy	Department of Sustainability and Environment (Vic)	2
Louisa Davis	Department of Sustainability and Environment (Vic)	1
Keith Ward	Goulburn Broken Catchment Management Authority	2
Keith Chalmers	Goulburn Broken Catchment Management Authority	1

3.7 Barmah-Millewa Operations Committee

The Barmah-Millewa Operations Committee (B-MOC) was a weekly teleconference, convened by the Murray-Darling Basin Authority. This forum has operated with the same objectives during previous environmental watering events in the Barmah-Millewa Forest (2005-06 and 2010-11).

The aim of the B-MOC was described at the first meeting of 2010-11 and applies to the 2011-12 event. The aim is to *"…provide ecological advice and on-ground observations that will assist with the management of environmental flows through the Barmah-Millewa Forest…"* (MDBA 2011a).

Weekly teleconferences commenced on 13 September 2011 and concluded on 7 February 2012, following the end of the environmental water delivery. The scope of the teleconferences was expanded during 2011-12 to include management of environmental water deliveries in the Goulburn and Campaspe Rivers.

Twenty one teleconferences were held, including one meeting held over two days, with the meetings occurring almost weekly over a five month period. Sixty five people attended over the duration, with between 14 and 26 people attending each meeting and an average of 20.6 people per meeting (K. Greenwood, MDBA, electronic communication 09/02/2012; Table 5).

Table 5: Operations Committee teleconference attendees 2011-12

Attendees	Organisation	Meetings attended
Adam Cotterill	Murray Darling Basin Authority	3
Adam McLean	Murray Darling Basin Authority	12
Alison King	Dept of Sustainability & Environment (Vic)	2
Andrew Bishop	Murray Darling Basin Authority	19
Andrew Shields	Goulburn-Murray Water	9
Ben Dyer	Murray Darling Basin Authority	3
Bill Johnson	Murray Darling Basin Authority	1
Bruce Wehner	Parks Vic	11
Catherine Goonan	Murray Darling Basin Authority	4
Damian Green	Murray Darling Basin Authority	10
Darren White	North Central CMA	7
David Parker	SEWPAC	1
Denise Fowler	Murray Darling Basin Authority	2
Digby Jacobs	NSW Water	6
Emer Campbell	North Central CMA	1
Emma Wiadrowski	Dept of Sustainability, Environment, Population and Communities	12
Geoff Earl	Goulburn Broken CMA	12
Gerhard Schulz	NSW Water	16
Greg Jones	StateWater	9
Greg Raisin	Murray Darling Basin Authority	3
Jo Kneebone	Murray Darling Basin Authority	3
Heather Hill	South Australia	6
Jack Smart	Murray Darling Basin Authority	5

Jeff Carboon	Parks Vic	2
John Conallin	Murray CMA	9
John Waterworth	Murray Darling Basin Authority	2
Julia Reed	Dept of Sustainability & Environment (Vic)	1
Justen Simpson	NSW Environment	9
Katherine Tibbitts	Murray Darling Basin Authority	12
Keith Ward	Goulburn Broken CMA	14
Keith Chalmers	Goulburn Broken CMA	20
Kerry Greenwood	Murray Darling Basin Authority	15
Kirsten Scott	Murray Darling Basin Authority	1
Kris Kleeman	Murray Darling Basin Authority	9
Leah Beesley	Dept of Sustainability & Environment (Vic)	3
Lee Joachim	Yorta Yorta Nations Aboriginal Corporation	5
Lisa Blanch	Murray Darling Basin Authority	1
Luke Pearce	NSW Industry	3
Mark Bailey	Goulburn-Murray Water	12
Michael Jensz	Victorian Environmental Water Holder	14
Mick Caldwell	Parks Victoria	6
Nawa	StateWater	12
Ned Hamilton	StateWater	1
Paul Childs	NSW Environment	4
Paul Doyle	SEWPAC	2
Paula D'santos	NSW Environment	10
Peter Shaw	Murray Darling Basin Authority	5
Rebecca Gee	Dept of Sustainability, Environment, Population and Communities	13
Rick Webster	NSW Environment	18
Rob Kingham	Murray Darling Basin Authority	1
Ryan Breen	Dept of Sustainability, Environment, Population and Communities	10
Sarah Commens	Murray Darling Basin Authority	2
Scott Raymond	Dept of Sustainability & Environment (Vic)	1
Sascha Healy	NSW Environment	6
Sean Kelly	Murray Darling Basin Authority	9
Sharon Koh		1
Simon Banks		1
Stephanie Straub		6
Susan Buckle	Murray Darling Basin Authority	14
Tom Zouch	Murray Darling Basin Authority	10
Tony Herbert	South Australia	9
Tori Perrin	Victorian Environmental Water Holder	3
Tracey Steggles	South Australia	1
Vince Kelly	State Water NSW	11
Wayne Morgan	Parks Victoria	1

The outcomes of the weekly teleconference for 2011-12 continue that of previous watering events, although this year additional systems and their interested stakeholders from further downstream in the Murray River system were included. Key outcomes 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; and
- Expansion of the committee to incorporate stakeholders including South Australian agencies as well as water managers involved in environmental water events in the Goulburn River (Goulburn Broken CMA) and Campaspe River (North Central CMA).

3.8 Blackwater Committee

No “Blackwater Committee” was required this year following its inaugural formation in 2010-11 during a period of widespread blackwater events in the Murray River system (GB CMA 2010). This had been a weekly teleconference convened by the MDBA and operated during the period of blackwater occurrence and management in summer. The expansion of committee representatives in the B-MOC (outlined above) was felt sufficient to manage blackwater issues had they arose.

4 Activities and Achievements

The following section details the activities and achievements for 2011-12.

4.1 Environmental Delivery Program

4.1.1 Planning for water management in the Barmah-Millewa Forest.

Environmental water planning for Barmah-Millewa Forest is managed through the TLM icon site committee structure as outlined in Section 3 (Management and Committee Structure). Environmental water managers for the icon site prepare a watering proposal through the B-M TAC, with input from the B-M IPP (or representatives) and submit this to the B-M ICC for endorsement. This proposal is then submitted to state water management agencies and the MDBA's TLM program (Appendix 1).

The proposal for 2011-12 covered four scenarios. The scenarios were based on achieving ecological targets in line with the level of expected flooding under a variety on flow conditions.

- **Scenario 1 (11-12,000 ML/day @ Yarrawonga)**
  18% of Barmah floodplain (3% Millewa floodplain; 10% BM floodplain)
- **Scenario 2 (18,000 ML/day @ Yarrawonga)**
  33% of Barmah floodplain (15% Millewa floodplain; 23% BM floodplain)
- **Scenario 3 (20,000ML/day @ Yarrawonga)**
  ~44% of Barmah floodplain (~37% Millewa floodplain; ~40% BM floodplain)
- **Scenario 4 (25,000ML/day @ Doctors Point)**
  >54% of Barmah Floodplain (>58% Millewa floodplain; >56% BM floodplain)

In the event of extremely dry conditions, environmental water delivery to individual wetlands was proposed. These extreme dry conditions proposals were based on providing extended connectivity and spawning opportunities for fish and improved feeding and breeding opportunities for colonial water birds and turtles. A range of wetland flora and some river red gum forest would also benefit. The wetlands under this scenario were Boals deadwoods wetland in Barmah Forest, and Reed Beds/Moira Lake wetland complex in Millewa Forest.

The prioritised options were able to be further refined as seasonal conditions or other issues dictated. This adaptive management was recorded in the Barmah-Millewa Water Operation Plan. The B-MOC teleconference provided timely advice to the icon site manager(s) during times of active water management.

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 (mid to late summer and autumn) 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 unseasonal water equally between the states. Millewa was designated to receive these flows in 2011-12, which were unusually absent over summer due to consumptive use demands well below channel capacity, before a major autumn event flooded both Millewa and Barmah Forest.

Table 6 indicates a flooding score for each Water Management Area (WMA) from 1998 to 2011. 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) SQ I, SQ II and SQ III (Figure 3).

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 (Figure 3).

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, even though all WMA's scored "3" in 2010 with the drought breaking floods.

Caution should be applied when relying on the flood prioritisation table alone for water management decisions. 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.

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 (Barmah-Millewa Operations Committee). The actual flow downstream of Yarrawonga for 2011-12 is presented in Figure 4 and 5, along with the modelled 'natural' flow (pre river regulation) and the expected flow without the use of environmental water. These figures shows the impact of releasing environmental water allocations (EWA) on the river levels during 2011-12, with environmental water used to maintain above channel capacity flows between natural events in September and from mid-October. It is worth noting that the intention was the same for the mid-October release – to fill a gap before the next natural above channel capacity event – although a lack of late spring rain resulted in prolonged environmental water use to maintain targeted minimum flows.

Table 6: Barmah-Millewa Forest flood prioritisation based on the past 14 years flood history and scored against ideal flood scenarios scores.

Water Management Area	Observed Flooding Score														Ideal average annual flood score #	Accumulated score 1998-2011	Ideal score	Departure from the ideal flood score	Watering Priority for 2012	Ranking
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011						
Kynmer Creek (A)	1	1	2	0	1	0	0	1	0	0	0	0	3	2	1.3	11	14.3	-3.3	Priority	19
Tongalong Creek (B)	1	1	3	0	1	1	1	2	0	0	0	0	3	3	1.5	16	24.0	-8.0	Priority	12
Smiths Creek (C)*	3	1	3	0	1	0	0	2	0	0	0	0	3	2	1.5	15	22.5	-7.5	Priority	13
Yielima (D)	2	1	3	0	0	0	0	2	0	0	0	0	3	2	1.5	14	21.0	-7.0	Priority	16
Black Swamp (E)*	2	1	3	0	0	0	0	1	0	0	0	0	3	2	1.6	12	19.2	-7.2	Priority	14
Gulf Creek (F)	2	1	3	0	2	1	1	3	0	0	0	1	3	3	1.9	21	39.9	-18.9	Priority	6
Boals Deadwood (G)	2	1	2	0	1	1	1	3	0	0	0	1	3	3	1.9	18	34.2	-16.2	Priority	8
Top Island (H1)	2	1	3	0	1	1	1	3	0	0	0	0	3	2	1.9	17	32.3	-15.3	Priority	9
Steamer/War Plain (H2)	2	1	3	0	2	2	2	3	1	0	0	1	3	3	2.0	23	46.0	-23.0	Priority	1
Goose Swamp (H3)	1	1	3	0	1	1	0	0	0	0	0	0	3	2	1.6	12	19.2	-7.2	Priority	15
Barmah Island (H4)	2	1	3	0	2	2	2	1	0	0	0	0	3	2	2.0	18	36.0	-18.0	Priority	7
Aratula Creek (J)	3	0	3	0	0	0	0	1	0	0	0	0	3	2	1.5	12	18.0	-6.0	Priority	18
Plantation (L)	2	0	3	0	0	1	0	1	0	0	0	0	3	2	2.0	12	24.0	-12.0	Priority	11
Mary Ada (M)	3	0	3	0	0	1	1	2	0	0	0	0	3	3	1.9	16	30.4	-14.4	Priority	10
Edward River (N)	3	1	3	0	0	1	1	2	0	0	0	0	3	3	2.3	17	39.1	-22.1	Priority	2
Towrong Creek (P)	3	0	3	0	0	0	1	2	0	0	0	2	3	2	1.4	16	22.4	-6.4	Priority	17
St Helena Swamp (Q)	2	1	3	0	0	1	1	2	0	0	0	0	3	3	2.2	16	35.2	-19.2	Priority	4
Gulpa Creek (R)	2	1	3	0	0	1	2	1	0	0	0	0	3	3	2.2	16	35.2	-19.2	Priority	5
Moira Lake (S)	2	1	3	0	2	1	2	2	1	0	0	0	3	3	2.0	20	40.0	-20.0	Priority	3

Notes:

Flood Scores	
0	"no flooding in the WMA"
1	"some flooding in the WMA"
2	"lot of flooding in the WMA"
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.

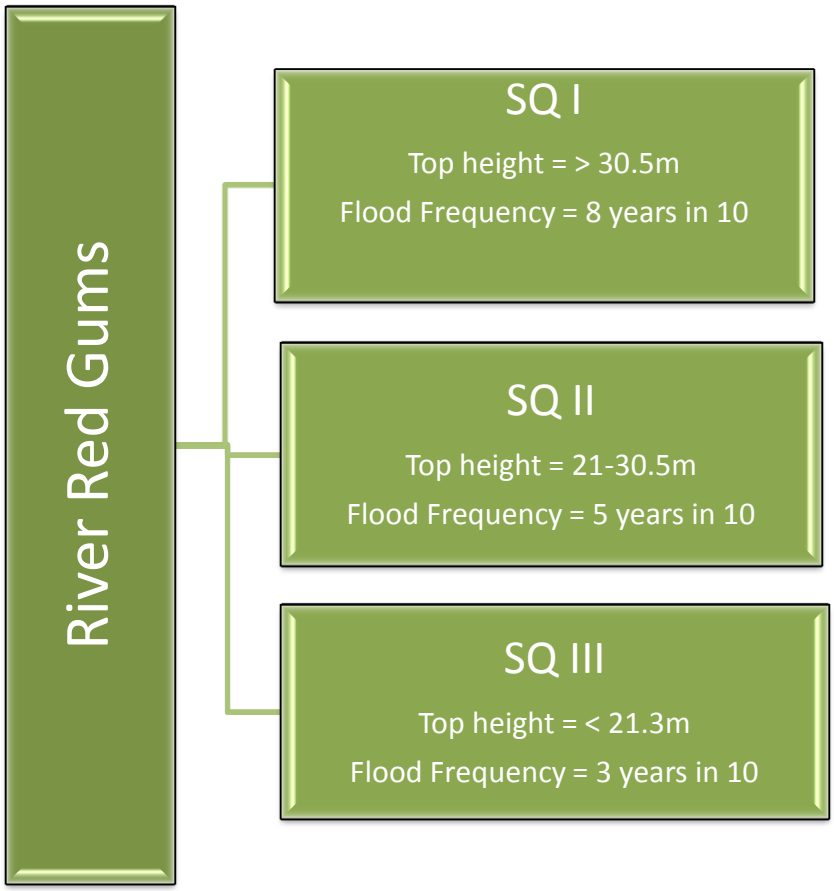

Figure 3: River Red Gum Site Quality measurements.

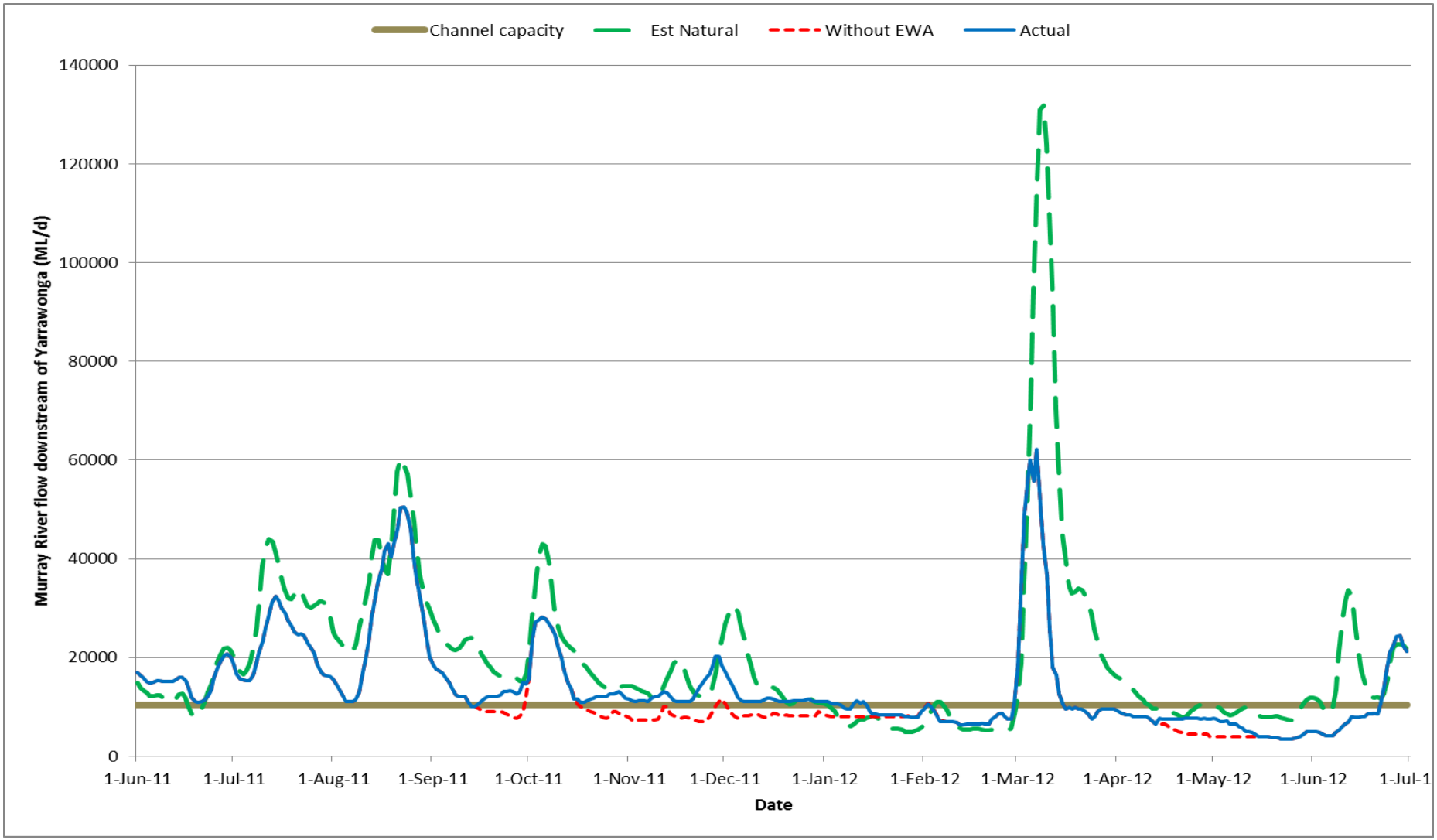

Figure 4: *Murray River flow downstream of Yarrawonga in 2011-12 exhibiting actual flow (which includes EWA releases), expected flow without EWA releases, and modelled natural flow simulating flow if no diversions or impoundments had been in place.*

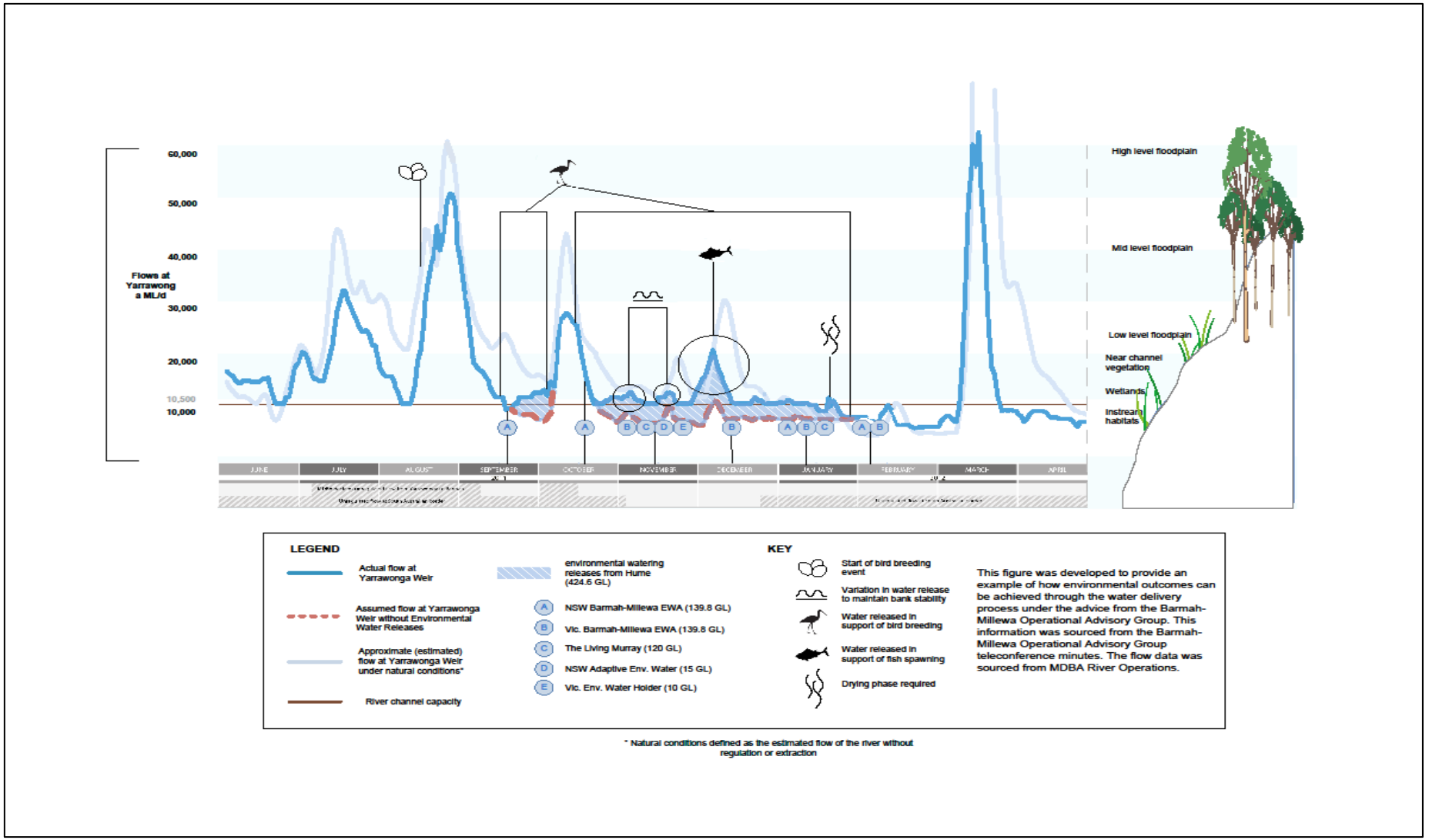

Figure 5: Timeline of the watering event. Source: MDBA.

4.1.2 Description of 2011-12 Flood Event

Continued prolonged flooding of Barmah-Millewa Forest occurred throughout most of 2011-12, particularly of low-lying wetlands. This wet period for wetlands built on the prolonged flooding of 2010-11, resulting in little opportunity for these ecosystems to have a dry cycle for almost two years. Quite a remarkable turn-around following the 'millennium drought' of the preceding 10 years, prior to 2010-11.

Above channel capacity flows occurred through winter and early spring, with peaks of 32,500 ML/day through Yarrawonga Weir in July and 50,500 ML/day in August. These flow events provided a flushing of the floodplain. The August peak recession approached channel capacity in mid-September, as Hume Dam reached capacity.

Environmental water was released from mid-September to maintain flows around 11,000 to 12,000 ML/day before a rainfall event resulted in over 100mm of rain falling in upper parts of the catchment. Hume releases peaked at 25,000 ML/day and combined with Ovens River flows of around 10,000 ML/day to record a peak flow of over 28,000 ML/day on 5 October.

Environmental water release recommenced on 15 October to maintain 11,000 to 12,000 ML/day flows. Rainfall for the remainder of spring was light, before moderate falls resulted in a small rise in flows at the end of November. A 'pulse' of environmental water was approved to create a 15,000 ML/day peak, which combined with additional rainfall flows to result in a peak through Yarrawonga Weir of 20,000 ML/day.

Rainfall during December was light and environmental water releases continued to target between 11,000 and 12,000 ML/day downstream of Yarrawonga Weir. On 5 January 2012 environmental flows were gradually reduced, however a summer storm event resulted in increased Murray River and tributary flows, which held flows through Yarrawonga Weir around 11,000 ML/day in mid-January. Following these small flows, environmental water delivery continued to wetlands on the Gulpa Creek at 100 to 300 ML/day until mid-February.

Flows downstream of Yarrawonga Weir were generally below channel capacity through February. Heavy rainfall during late February and early March occurred across the catchment. While Lake Mulwala was surcharged to try and maintain within channel capacity flows downstream of Yarrawonga Weir and through the Barmah Choke, around 200mm of rainfall fell locally and flows increased to around 62,000 ML/day on 7 March. During this event, the Ovens River peaked at close to 40,000 ML/day, 525mm was recorded at Mt Buffalo and major flooding occurred above Hume Reservoir (132,000 ML/day at Jingellic), although this was mostly captured in the storage. A peak of over 130,000 ML/day would have occurred under 'natural' conditions through Yarrawonga Weir. Autumn flooding is unusual and untimely for the forest. This March flood event was the largest March flood through the Barmah-Millewa Forest in 105 years of records, with the second largest March event occurring last financial year, in March 2011.

Flows then receded below channel capacity through the Barmah choke. Commonwealth environmental water was released from mid-April to provide dilution flow following hypoxic blackwater events flowing into the Murray River from the Broken Creek and Murrumbidgee River, as well as in the Edward-Wakool system. These flows were maintained below channel capacity through the Barmah Choke.

In late June rainfall resulted in flows of 10,000 ML/day in the Ovens River, which combined with 15,000 ML/day pre-releases from Hume Reservoir (to manage airspace as the dam approached 95% capacity) and resulted in a peak of 24,000 ML/day downstream of Yarrawonga Weir. This peak had started to recede on 30 June. [1]

[1] This description sources information from the live document Water Operations Plan: Barmah-Millewa EWA release in Spring 2011 (maintained by the GB CMA & NSW NPWS, see section 4.3.3 C Category Monitoring Programs), as well as River Murray Water (MDBA) data provided to the authors and weekly reports available at http://www.mdba.gov.au/water/river_info.

4.1.3 Use of Environmental Water

On 11 September, Hume Dam reached capacity, making spills and therefore forest flooding more likely than just relying on Ovens/Kiewa River flows alone. At the same time, on-ground monitoring reported that colonial waterbirds had commenced nesting in Barmah and Millewa forests.

Based upon the water planning previously undertaken and following NSW government approval of 150 GL of environmental water from their component of the Barmah-Millewa Environmental Water Allocation (B-M EWA) for use, the decision was made to target scenario 1 of maintaining flows around 11,000 to 12,000 ML/day downstream of Yarrawonga Weir to meet ecological targets, particularly for waterbirds. Releases commenced in mid-September, as the natural recession reached channel capacity, to prevent the draining of wetlands and abandonment of nesting waterbird colonies.

Following natural Murray River and tributary flows in early October, environmental water was released from mid-October to continue to meet the same objective. By mid-November, environmental water from the Victorian component of the B-M EWA, TLM water, Victorian Environmental Water Holder (VEWH) water and NSW Adaptive Environmental Water (NSW AEW) was available for use in Barmah-Millewa Forest. The VEWH and NSW AEW water parcels combined with some TLM water to create the 'pulse' flow at the end of November, which specifically targeted stimulating the breeding of native perch species.

Scenario 1 flows of 11,000 to 12,000 ML/day continued until early January, before on-ground monitoring reported that most of the colonial waterbird breeding was successfully completed and flows were progressively reduced. The exception was Egret and Ibis breeding in the Reed Beds wetland complex on the Gulpa Creek in Millewa Forest, which was supported by flows of 100 to 300 ML/day until 7 February.

In total, 424.6 GL of environmental water was delivered to the Barmah-Millewa Forest in 2011-12 (Table 7). Interestingly and coincidently, this figure almost exactly matches the 428 GL of environmental water delivered in 2010-11. The Commonwealth environmental water released through the Murray River system in April/May 2012 for in-channel dilution of poor water quality was not part of the Barmah-Millewa Forest watering event and was maintained below channel capacity.

Table 7: Environmental water use (ML) for Barmah-Millewa Forest in 2011-12 (Source: MDBA).

2011-12 EWA use (ML)	Barmah	Millewa	Barmah-Millewa
B-M Account	139,800	139,800	279,600
TLM Account	20,000	100,000	120,000
VEWH (*Flora and Fauna*) Account	10,000	-	10,000
NSW AEW Account	-	15,000	15,000
Total	**169,800**	**254,800**	**424,600**

4.1.4 Operation of regulators

Throughout the 2011-12 year regulators were opened or closed according to river conditions and/or water management objectives. The graphs below (Figures 6-8) show the open, partially open or closed status of each regulator over time. Comparison of the regulator operation with the annual hydrograph (Figure 2 and 4) highlights the operation of regulators in relation to the flow in the Murray River.

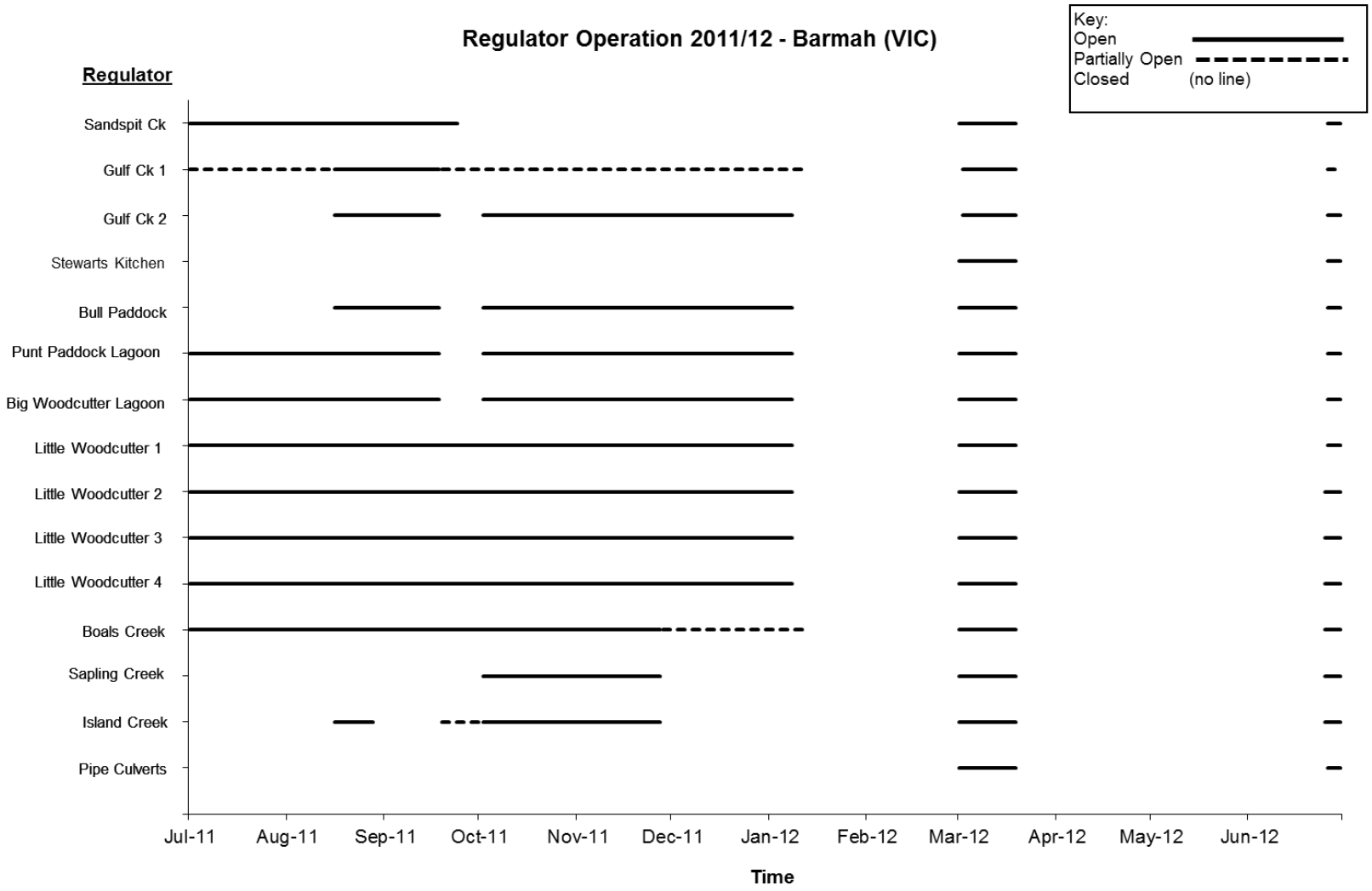

Figure 6: Operation of Victorian regulators

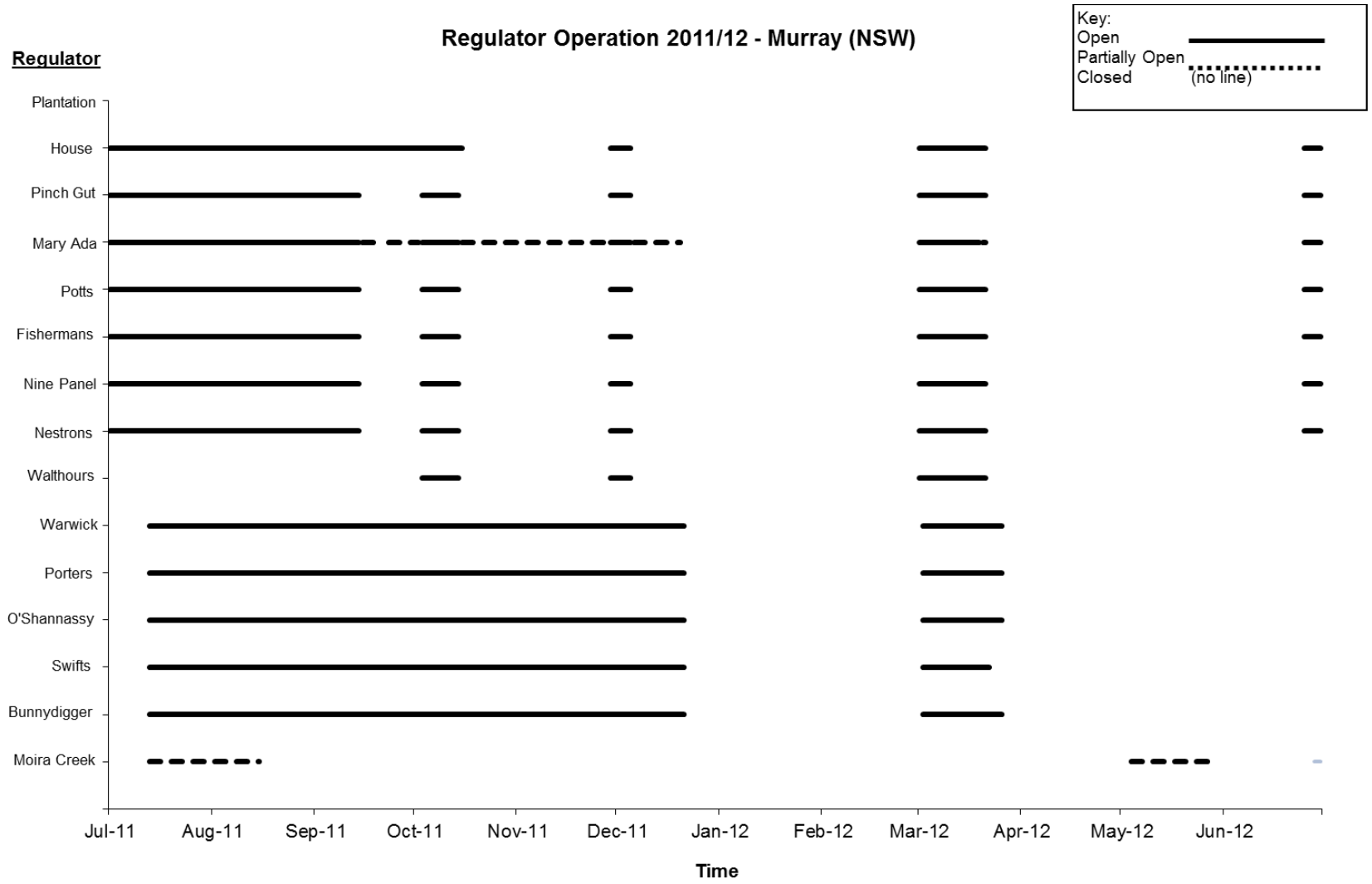

Figure 7: Operation of NSW Murray River regulators

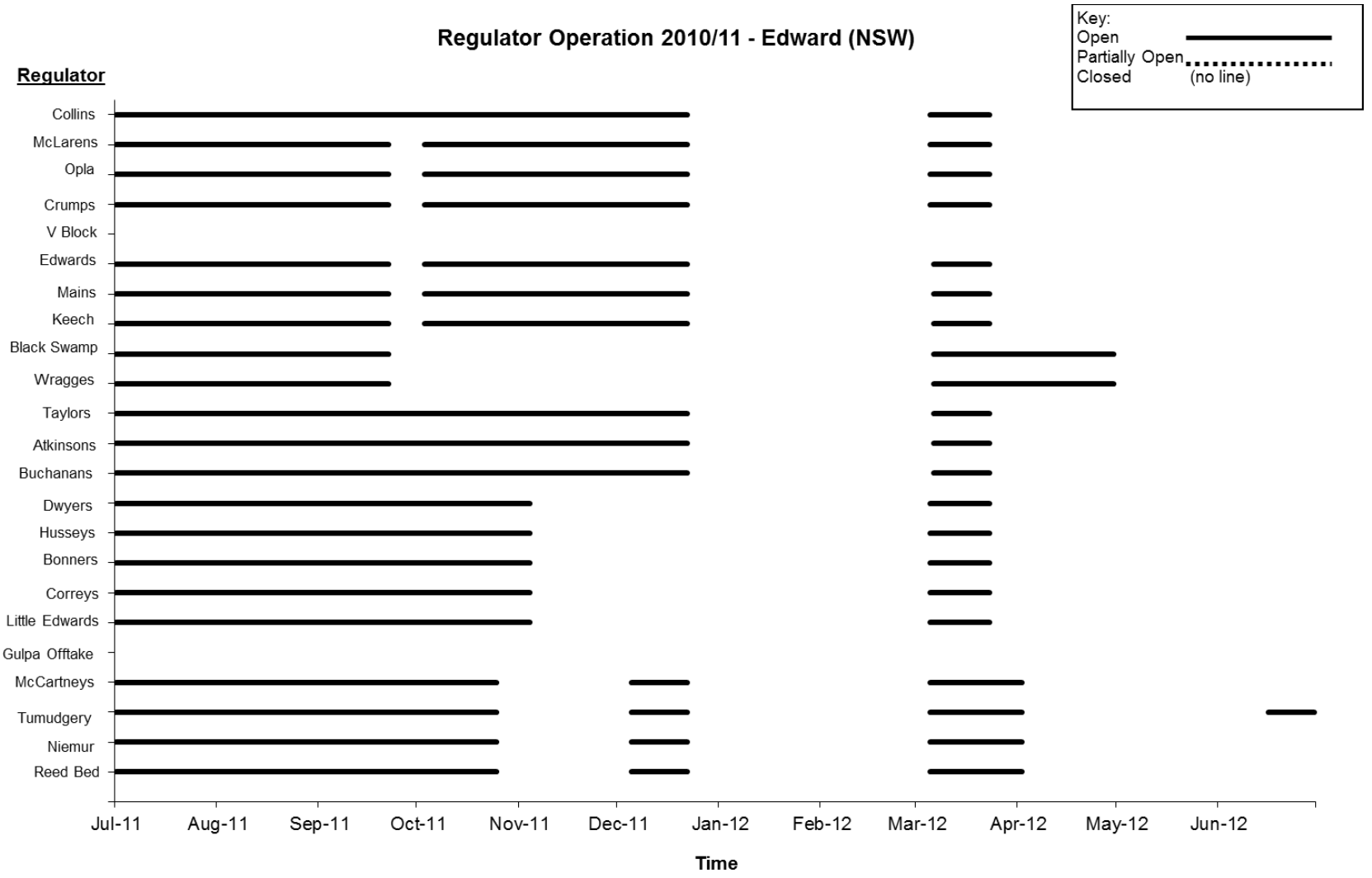

Figure 8: Operation of Gulpa/Edward River regulators.

4.2 Environmental Works and Measures Program

4.2.1 Gulf Creek Fishway and Kynmer regulator

No progress with these projects in 2011-12. The designs were completed in 2010 and construction is yet to be funded. For further information, contact Keith Ward (03 5820 1100).

4.2.2 Edward River and Gulpa Creek Fishway

Both the fishways on the Edwards River and Gulpa Creek were completed during 2011-12. For further information, contact Jason Sheanan (03 5898 3909).

4.2.3 Moira Lake Stage 3

This project is on hold due to prolonged flood conditions. For further information, contact Vince Kelly (03 5898 3946).

4.3 Environmental Water Management Planning Documents

A suite of documents have been, or are currently being prepared as part of managing environmental water objectives, delivery, risk management, monitoring and review (Figure 9).

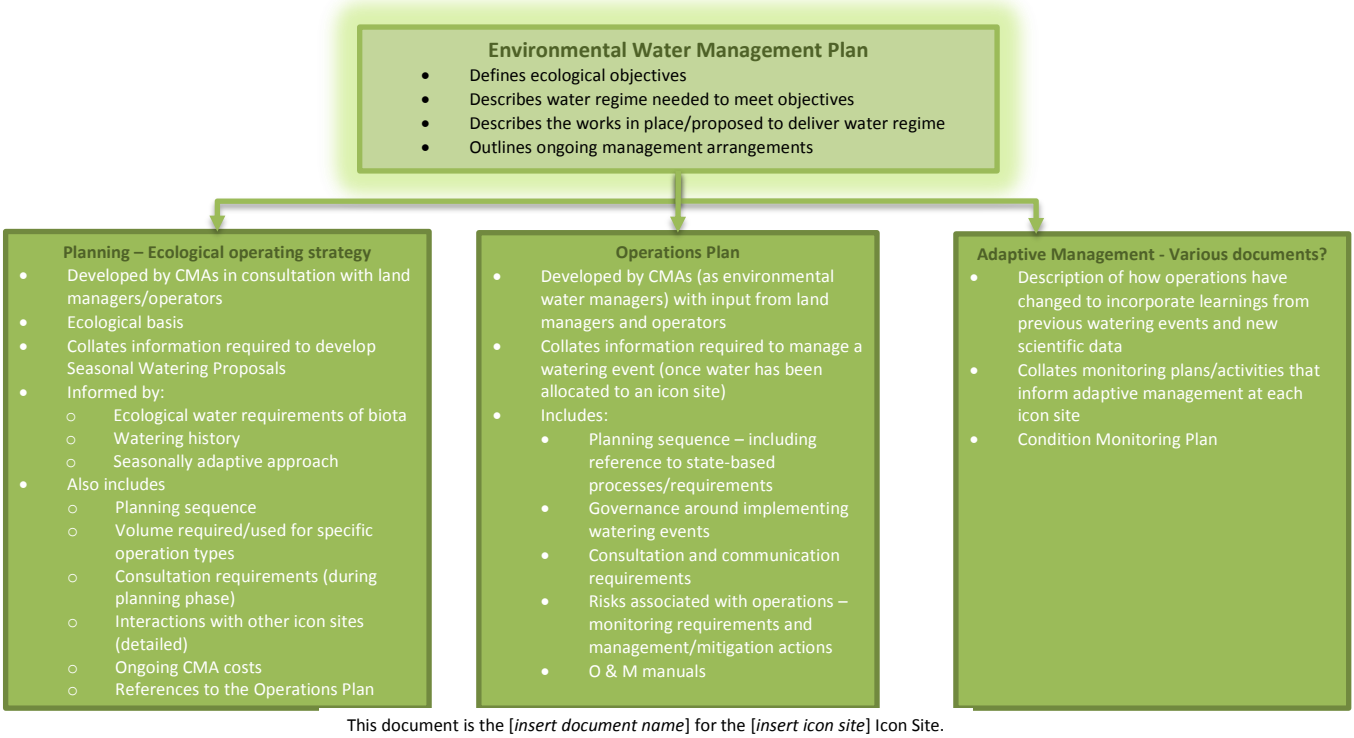

Figure 9: Living Murray Icon Site Document Map (Victoria). Draft (DSE 2012).

4.3.1 Environmental Water Management Plan

Environmental Water Management Plans (EWMaP) 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 2010-11, with the MDBA endorsing and publishing the plan in 2011-12. It supersedes the Barmah-Millewa Environmental Management Plan 2005-06.

4.3.2 Ecological Operating Strategy

Development of the Barmah-Millewa Forest Ecological Operating Strategy commenced in 2011-12. It forms a schedule to the EWMP. The Ecological Operating Strategy collates the key ecological information to inform environmental water management at this icon site. It is intended to provide a key planning resource for icon site managers and a scientifically defensible basis for environmental watering decisions. The Ecological Operating Strategy is intended to be a live document based on currently available scientific information. It will be updated as necessary as new information comes to light (GB CMA 2012).

Significant work is continuing to expand the detail of ecological objectives for the icon site.

4.3.3 Operations Plan 2011-12

The Operations Plan for 2011-12, titled *Water Operations Plan: Barmah-Millewa EWA release for Spring 2011*" (Ward *et al*. 2012), was an adaptive document, prepared to record watering objectives, planning, risk management and monitoring projects.

Water managers from Victoria and NSW maintained the document on a monthly or bi-monthly basis for the duration of the environmental watering event. Actual water delivery and monitoring results were continuously recorded and document control managed to ensure content describing proposed monthly actions then overwritten by actual outcomes was not lost.

This document provided a basis for the description of the environmental water planning, as well as actual Murray River flows, environmental water use and monitoring outcomes in Section 4.1 (Environmental Delivery Program).

4.3.4 Condition Monitoring Plan

The final draft of the Barmah-Millewa Condition Monitoring Plan (CMP) was completed in 2010-11 and the MDBA is conducting a review of all icon site CMPs. This review process will continue into 2012-13.

The 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 10 and Table 8. This structure is used in the summary of monitoring project outcomes for Barmah-Millewa Forest in 2010-11 (Section 4.4 Monitoring reports).

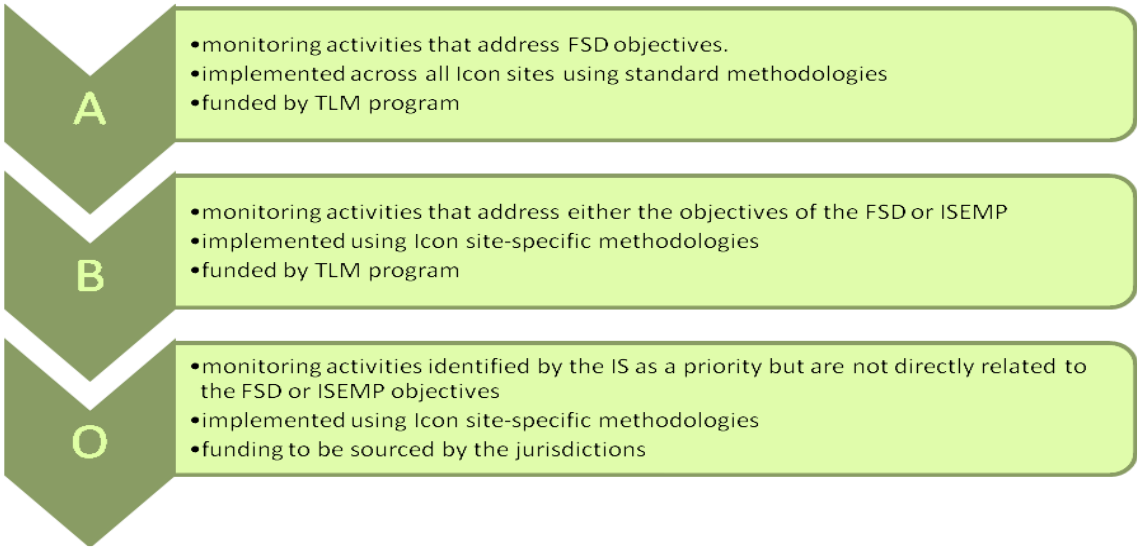

Figure 10: Monitoring Program Categories

Table 8: 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)

4.4 Monitoring reports

4.4.1 'A' category monitoring programs

Vegetation mapping (spatial character)

No mapping was undertaken in 2011-12 due to persistent flooding reducing accessibility. For further information, contact Sharon Bowen (02 9995 5636).

TLM stand condition assessment

Authors: Shaun Cunningham (Monash University) and Stuart Little (MDBA)

Project Title

Mapping of stand condition for The Living Murray icon sites.

Funding Source

The Living Murray Condition Monitoring program, Murray-Darling Basin Authority.

Project Aims

- SURVEY condition of river red gum (*Eucalyptus camaldulensis*) and black box (*E. largiflorens*) stands across all Icon Sites excluding the Lower Lakes, Coorong and Murray Mouth
- VALIDATE the existing model for river red gum condition in Victoria in 2006 at a new time (2009), in new areas (NSW and SA sites) and for a new tree species (black box).
- MAP tree condition of the treed icon sites in 2003, 2008, 2009, 2010 and 2012. (Note: 2011 condition data was unable to be collected due to flooding)
- REVIEW available remotely sensed data sets that could improve predictions of stand condition and COMPARE the predictive power of stand condition models built with different remotely sensed data VALIDATE the predictions of the stand condition models using an independent ground survey
- BUILD a tool that can be used to predict tree condition of the Icon Sites annually using ground assessment and Rapideye imagery.

Background

This project adopts a remote sensing approach to provide a consistent assessment necessary for monitoring tree condition across The Living Murray Icon Sites. The approach follows from the research team's previous quantification of river red gum stand condition across the Victorian Murray River floodplain using a combination of quantitative ground surveys, remotely-sensed data and several modelling methods (Cunningham *et al*. 2009b) to predict forest condition on this floodplain with high accuracy and resolution.

Results

Ground surveys of the 50 references sites across the Barmah-Millewa Forest were conducted in autumn 2012 by NSW OEH staff. Ground surveys at each reference site collect data used to calculate Live Basal Area %; hemispherical photographs used to calculate Plant Area Index; and crown extent scores of 30 trees to calculate average crown extent. The data collected is provided to the MDBA and Monash University and is combined with data from a further 125 reference sites within the Living Murray Icon Sites of Gunbower-Koondrook-Perricoota, Hattah Lakes, and the Chowilla Floodplain and Lindsay-Mulcra-Wallpolla Islands. The relationship between the stand condition assessed at reference sites and remotely sensed variables is then used to produce stand condition mapping across the Living Murray Icon Sites.

Monash University is currently drafting the report for the 2012 results due to delays associated with changing remote sensing imagery to Rapideye as a result of the temporary loss of Landsat imagery over Australia. This project should be completed by June 30, 2013. We are currently investigating the expansion of the technique to the floodplain forests of the whole Murray-Darling Basin.

Discussion

The 2012 results are not yet available due to changing remote sensing imagery following the temporary loss of Landsat imagery over Australia, however this is expected to be reported by 30 June 2013. The addition of survey data and modelling in 2012, particularly as there have been several flood events across the floodplain since June 2010, will increase the predictive power of the final Stand Condition Tool.

References

Cunningham SC, Mac Nally R, Griffioen P and White M (2009a) Mapping the Condition of River Red Gum and Black Box Stands in The Living Murray Icon Sites. A milestone report to the Murray-Darling Basin Authority as part of Contract MD1114. Murray-Darling Basin Authority, Canberra. MDBA Publication No. 51/10.

Cunningham S.C., Mac Nally R., Read J., Baker P.J., White M., Thomson J.R., & Griffioen P. (2009b) A robust technique for mapping vegetation condition across a major river system. Ecosystems 12: 207-219.

Cunningham SC, Griffioen P, White M and Mac Nally R (2011) Mapping the condition of River Red Gum (*Eucalyptus camaldulensis* Dehnh.) and Black Box (*Eucalyptus largiflorens* F.Muell.) stands in The Living Murray Icon Sites. Stand Condition Report 2010. Murray-Darling Basin Authority, Canberra.

Waterbird condition monitoring – ground survey

Author: Rick Webster (NSW NPWS)

Project Title

Waterbird Monitoring in Barmah-Millewa Forest.

Funding Source

The Living Murray Condition Monitoring program, Murray-Darling Basin Authority.

Project Aims

To monitor changes in waterbird populations during 2011-12.

Background

Monitoring of waterbird populations has been on-going within Barmah-Millewa Forest since spring 1999. A baseline set of data was collected between spring 1999 and winter 2002. Since the baseline data was collected additional data has been collected in 2008 and 2010. The collection of data in 2011-12 continues the program of monitoring waterbird populations within Barmah-Millewa Forest. This monitoring program monitors 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 2011-12 (July-August, November, January-February, April-May). The hydrology sentinel wetlands included in the monitoring program followed a more normal pattern of wetting and drying during 2011-12. That is flooded during winter and spring with water levels dropping in the majority of wetlands during summer and autumn with 50% of the wetlands either below capacity or dry during autumn. Those wetlands containing water during these surveys supported between 4661 (spring) and 767 (autumn) birds. Within Murray Valley National Park (MVNP) Moira Lake supported the majority of birds in three seasons while in Barmah National Park (BNP) Steam Plains supported the majority of birds throughout the year.

During spring all wetlands were flooded or at capacity except for Steamer Plain (below capacity) and Goose Swamp (dry). The total number of waterbirds recorded on the wetlands was 4661. Breeding waterbirds were recorded on the following sentinel wetlands: Horseshoe Lagoon, Moira Lake, Reed Beds North, Reed Beds South St Helena Swamp in MVNP, and Barmah Lake and Bunyip Hole in BNP.

Over 830 pairs of waterbirds were estimated to be nesting on the sentinel wetlands during the spring surveys. This included a number of colonial nesting species:

- Australasian Darter *Anhinga novaehollandiae* – 7 pairs;
- Little Pied Cormorant *Microcarbo melanoleucos* – 49 pairs;
- Great Cormorant *Phalacrocorax carbo* – 1pr;
- Little Black Cormorant *Phlalcrocorax sulcirostris* – 123 pairs;
- Eastern Great Egret *Ardea modesta* – 31 pairs;
- Intermediate Egret *Ardea intermedia* – 1pair;
- Australian White Ibis *Threskiornis molucca* – 238+ pairs;
- Straw-necked Ibis *Threskiornis spinicolis* – 364+ pairs; and
- Royal Spoonbill *Platalea regia* – 21+ pairs.

As well as these colonial nesting species Black Swan *Cygnus atratus*, Australian Wood Duck *Chenonetta jubata*, Great Crested Grebe *Podiceps cristatus*, White-breasted Sea-Eagle *Haliaeetus leucogaster*, Dusky Moorhen *Gallinula tenebrosa* and Yellow-billed Spoonbill *Platalea flavipes* were also recorded breeding.

Discussion

The drought conditions that have prevailed within the southern Riverina bioregion between 2006 and 2010 ended with flooding between September 2010 and March 2011. Following a drop in flows during autumn 2011 flooding within Barmah-Millewa Forest re-commenced during winter and spring with flows dropping below channel Murray River channel capacity during summer and autumn. Water levels within the Reed Beds wetland complex along Gulpa Creek were maintained using environmental water to ensure colonial nesting waterbirds successfully completed breeding. These flows were supplied from the following environmental water accounts:

- Barmah-Millewa;
- The Living Murray;
- Victorian Environmental Water Holder (flora and fauna); and
- NSW Adaptive Environmental Water.

The species diversity recorded during spring 2011 was higher than in 2008 (10) and 2010 (32), and within the upper end of the range recorded during the spring surveys between 1999 and 2002 (24-38). Therefore the species diversity present during the current survey is within the range previously identified. This variation in species diversity during spring depends on whether or not the icon site receives a flood and on how big this flood event is. During 2008 the majority of the wetlands were dry or contained very little water compared to 2000 to 2002 period when the majority of the wetlands contained water or were flooded.

Reports produced

OEH (2012b). Quarterly Report: Waterbird Monitoring within Barmah-Millewa Forest – Winter 2011. Office of Environment and Heritage, New South Wales.

OEH (2012c). Quarterly Report: Waterbird Monitoring within Barmah-Millewa Forest – Spring 2011. Office of Environment and Heritage, New South Wales.

OEH (2012d). Quarterly Report: Waterbird Monitoring within Barmah-Millewa Forest – Summer 2012. Office of Environment and Heritage, New South Wales.

OEH (2012e). Quarterly Report: Waterbird Monitoring within Barmah-Millewa Forest – Autumn 2012. Office of Environment and Heritage, New South Wales.

Fish condition monitoring

Author: Dr Meaghan Duncan, NSW DPI (Fisheries).

Project title

Barmah-Millewa Fish Condition Monitoring.

Funding source

The Living Murray Condition Monitoring program, Murray-Darling Basin Authority.

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.
- Provide information that provides feedback into management plans and reporting on condition for the icon site.

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

- The total catch was the lowest since monitoring began in 2006/07. Just 31% of the catch was represented by native fish, compared to an average of 80% from 2006/07 to 2009/10. The only native species to increase in numbers in 2011/12 were Carp Gudgeons and Golden Perch.
- The fish assemblage differed significantly between creek and river habitats (pseudo $F_{1,59} = 22.6$, $P < 0.0001$) and across years (pseudo $F_{5,59} = 3.2$, $P < 0.0001$). The lake assemblage continues to be dominated by alien fish including Gambusia, Goldfish and Common Carp, though the numbers of the latter two species has declined from last year. Interestingly, three silver perch were collected from the lakes this year, the first record of a large-bodied native fish from this habitat since this monitoring program began.
- Common Carp were the most commonly collected fish from the river sites (59%). However the abundance of this species at the site affected by blackwater in 2010/11 (Morning Glory) was down from 591 individuals to just 23. Fifteen Murray cod were sampled and five (33%) were over the recreational size limit (≥ 600 mm). Only two young-of-year (YOY) fish were collected, a Trout Cod and Common Carp. This represents a drastic reduction of Common Carp YOY from a high of 1,105 last year. It is also the first year since the study commenced that Murray Cod YOY have not been collected from River sites.
- Fourteen Murray Crayfish were collected and similarly to last year, none were collected from the previously productive Morning Glory site (affected by blackwater last year). Ten of the Murray Crayfish were male, one was an immature female and three were mature females in berry. Three individuals of each sex were over the legal size limit of 90mm.
- A total of 386 eggs and larvae were collected from six native and one alien species. Murray Cod was the most abundant larval fish collected (seven larvae) while Silver Perch dominated the abundance of fish eggs (252 eggs). No drifting Trout Cod larvae and/or eggs were sampled and only one Golden Perch larva was recorded from Ladgroves Beach. All larval fish and the majority of drifting eggs were recorded from Morning Glory (most downstream site) and Ladgroves Beach (most upstream site) with only 14 eggs recorded from Barmah Choke (middle site).
- Peak densities of drifting Murray Cod larvae were approximately 3 / 1000 m-3 compared to 65 / 1000 m-3 recorded last year, but average densities have changed relatively little over the course of the study. The highest density of drifting Murray Cod larvae occurred in late November compared to early November last year. Peak densities of drifting Common Carp eggs/larvae was also lower this year compared to last year (4 and 17 larvae respectively).

Discussion

All of the large-bodied native fish species (Murray Cod, Trout Cod, Golden Perch and Silver Perch) were collected within the B-MF this year; however, YOY fish were either, absent or in very low numbers. A single YOY Trout Cod and Golden Perch were collected while no YOY Murray Cod or Silver Perch were caught. Few YOY Golden Perch (and silver perch) are typically caught during condition monitoring, reasonable numbers of YOY Murray cod were caught prior to the blackwater event. While this result suggests that Murray cod recruitment has been adversely impacted by the blackwater and has not recovered, we cannot rule out that reduced electrofishing efficiency due to higher water levels in river sites may be in part responsible.

The number of Murray Crayfish collected increased in 2011/12 following a marked decline in 2010/11 after the blackwater event. However, the increase in numbers was not due to the rediscovery of individuals in blackwater affected sites, it was due to the increased capture of crayfish in upstream unaffected sites. Murray Crayfish have not been recorded from the Edwards River since the current monitoring program was initiated six years ago, suggesting they are absent or in low numbers in this reach of the river.

The total abundance of Common Carp captured in 2011/12 was much lower (~ 60%) than during 2010/11. This decrease was driven by the collection of fewer YOY Common Carp in creeks, wetlands and lake habitats. This result indicates that environmental conditions were less suitable for Common Carp recruitment this year. We propose that Common Carp had a competitive advantage over many small and large-bodied native fish species during the floods and the hypoxic blackwater, and that this advantage was diminished following the floods and a return to normal oxygen levels in 2011/12.

The collection of eggs and/or larvae in drift nets set in river sites indicate that Murray Cod, Silver and Golden Perch, Carp Gudgeons, Flat-headed Gudgeon and Australian Smelt all spawned during the spring/summer of 2011/12. There was no evidence of Trout cod spawning this year, similar to the flood year of 2010/11. The magnitude of Murray Cod spawning this year was lower than the previous two years. However, the capture of two larvae from the blackwater-affected site, where none were caught last year (Morning Glory), indicates that either some adult Murray Cod persisted in this reach during the blackwater, or that they have re-colonized the region. The appearance of early life stages for Silver Perch and other small bodied natives at Morning Glory this year provides evidence that the native fish assemblage is recovering from the negative impact of blackwater.

The sixth year of sampling has provided additional insight into the flow related dynamics of native and alien fish species in this icon site. Importantly, it has highlighted that large-scale flooding and/or increased flows do not always deliver short to medium-term benefits to native fish. While we suggest that mortality (or avoidance movement) caused by the flow-related hypoxic blackwater event has contributed to the reduced abundance of native fish, we cannot rule out that flow-related variation in electrofishing efficiency and downstream displacement of small-bodied species during flood have contributed to these results. The paucity of information available for these three factors makes it difficult to identify the key mechanism(s) shaping the fish assemblage. This highlights the need for additional research. We recommend that additional effort be used to investigate (i) flow-related changes in detectability (i.e. mark-recapture studies), (ii) downstream displacement or movement of fish during flooding and (iii) growth and survivorship of native fish under a range of increasingly hypoxic conditions.

Reports produced

Raymond, S. Beesley, L. and Robinson, W. (2012). Barmah-Millewa Fish Condition Monitoring: 2011/12 Annual Report. Department of Trade and Investment NSW, Narrandera Fisheries Centre, Narrandera NSW and Arthur Rylah Institute for Environmental Research. Department of Sustainability and Environment, Heidelberg, Victoria. Unpublished report submitted to the Murray-Darling Basin Authority, Canberra.

4.4.2 'B' category monitoring programs

Understorey condition assessment

Author: Paula Ward (ecological consultant)

Project Title

Monitoring understorey vegetation response to flooding in Barmah-Millewa Forest: 2011-12.

Funding Source

The Living Murray Condition Monitoring program, Murray-Darling Basin Authority.

Project Aims

- Providing a wetland understorey monitoring program within Barmah-Millewa Forest (enacting a monitoring recommendation by MDBC 2005 and McCarthy et al. 2006);
- Appraising understorey vegetation response to flooding (and other variables, such as rainfall and bushfire) by measuring species diversity, cover and flowering outcome within existing sentinel transect sites representing common wetland and surrounding forest floodplain environments;
- Providing enhanced quantitative evidence of species variation on the threatened Moira Grass plains and open wetland habitats (including seasonal and annual variation, and longer-term change at sites from previous monitoring up to 20 years ago);
- Providing quantitative and qualitative information to support recommendations for improved water management activities;
- To monitor post-fire recovery of a typical wetland system by continued monitoring of transects recently established at a burnt site, and a site that was burnt during the monitoring program;
- Permitting accurate reporting of understorey wetland health (and of other monitored variables) for the Barmah-Millewa Forest Icon Site;
- Complimenting broader monitoring programs (e.g., Eucalyptus camaldulensis inventories, hydrographic recorder correlations, fish and waterbird monitoring) by providing data on understorey vegetation and other monitored attributes.

Background

This project commenced in spring 2006 by re-establishing transect sites that had originally and progressively been established by the then Department of Conservation & Environment in 1990 & 1991 (and had been monitored through to 1994) within five major wetlands in Barmah Forest. One additional new site was added to the monitoring in Barmah Forest to capture the effects of a recent bushfire. In 2007, comparable transects were established at five wetland sites in Millewa Forest, with some extensions to transect length undertaken from spring 2010 onwards when drought conditions highlighted vegetation communities existing in lower elevated sections of the floodplain. The project continues to monitor the cover-abundance of all understorey species at permanent located quadrats each seasons (hence four measures per year). Photos of each quadrat at established photo-points are also taken.

Results

Monitoring results in 2011-12 reflected an understorey vegetation community that had experienced further extended periods of heavy rainfall and prolonged flooding in most study-site quadrats. A total of 197 species from 54 Families were found during the monitoring program in 2011-12, with 60% being native species. Most surveyed wetland species were native (93%), whereas less than half of terrestrial species

were native (43%). Three quarters of species found in all four seasons were native (76%), whereas under half of species found in only one single season was native (44%). These figures accord remarkably similar to last year (a similar wet year), but slightly greater percentage native species compared with 2009/10.

Giant Rush (*Juncus ingens*) was found to have remained relatively thin only at locations where drought conditions had occurred largely uninterrupted for 5 years prior to the flooding that commenced in spring 2010. Signs of recovery have commenced, with occasional culms supporting new long stems. Sites where environmental water allocations were provided in 2009/10 (such as at Boals Deadwoods, Wathours Lagoon and Reed Beds Swamp) maintained the strongest growth, while Top Island Burnt Site and Steamer Plain have strong regrowth of Giant Rush only in some regions (where influenced by bushfire, as observed last year).

Moira Grass (*Pseudoraphis spinescens*) was observed in high cover abundance only at Quadrat 2.2 of Little Rushy Swamp (>77% cover), whereas elsewhere at Boals Deadwoods, Top Island Burnt Site and Top Lake (the only three other locations where the species was found) it had a cover abundance of less than 5%.

Discussion

Results from the 2011-12 monitoring period were found to greatly contrast to the previous drought years of monitoring between 2006 – 2008, but be similar to 2010/11 following flooding and high rainfall totals. Giant Rush was found to have responded well to environmental water allocations where these were supplied to enhance rush growth as a waterbird nesting habitat in the previous year, compared to relatively poor growth where the species had experienced continuous drought prior to the recent years of flooding. This was especially so on Steamer Plain where the initial stressed state of the rush, having been droughted for many years, to then be further stressed by being over-topped by floodwater, appears to have been a double blow for the health of the plant. However, this is considered to be a favourable outcome because rush has had recent expansion onto the former Moira Grass plain at this location. By contrast, concern remains of the apparent poor 'health' of Moira Grass at most monitored wetland sites, especially where the species was known to dominate up to 100% cover in the 1990s (Ward 1994). Future monitoring will be important to observe the response of the species after seasonal dry conditions (if such conditions eventuate) followed by appropriate seasonal flooding (if this also eventuates).

Reports produced

Ward, P.A. (2011) Monitoring understorey vegetation response to flooding in Barmah-Millewa Forest, 2011/12: Progress report - Spring 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.

Ward, P.A. (2012a) Monitoring understorey vegetation response to flooding in Barmah-Millewa Forest, 2011/12: Progress report - Summer 2011/12. 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.

Ward, P.A. (2012b) Monitoring understorey vegetation response to flooding in Barmah-Millewa Forest, 2011/12: Progress report – Autumn 2012. 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.

Ward, P.A. (2012c) Monitoring understorey vegetation response to flooding in Barmah-Millewa Forest, 2011/12: Progress report – Winter 2012. 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.

Ward, P.A. (2012d) Monitoring understorey vegetation response to flooding in Barmah-Millewa Forest: 2011-12 – 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.

Woodland Birds

Author: R. Webster (NSW NPWS)

Project Title

Bush Bird Monitoring in Barmah-Millewa Forest.

Funding Source

The Living Murray Condition Monitoring program, Murray-Darling Basin Authority.

Project Aims

To monitor changes in bush bird populations during 2011-12.

Background

Monitoring of bush bird populations has been on-going within Barmah-Millewa Forest since spring 1999. A baseline set of data was collected between spring 1999 and winter 2002. Since the baseline data was collected additional data has been collected in 2008 and 2011-12. The collection of data in 2011-12 continues the program of monitoring bush bird populations within Barmah-Millewa Forest. This monitoring program monitors the response of bush bird populations to environmental or flood flows that occur during the monitoring year.

Results

Monitoring of bush bird populations was undertaken on three occasions during 2011-12 (January-February, April-May, June). No surveys were conducted during spring due to flooding within the icon site preventing access to the monitoring sites.

A total of 70 bush bird species were recorded during the surveys. This included six threatened/significant species (NSW *Threatened Species Conservation Act* [*TSC Act*] 1995 and DSE, 2007). The threatened/significant species recorded during the current round of surveys included:

- Square-tailed Kite *Lophoictinia isura* (Millewa Forest);
- Superb Parrot *Polytelis swainsonii* (Millewa Forest);
- Black-chinned Honeyeater *Melithreptus gularis* (Barmah Forest);
- Varied Sittella *Daphoenositta chrysoptera* (Millewa Forest);
- Scarlet Robin *Petroica boodang* (Millewa Forest); and
- Diamond Firetail *Stagonopleura guttata* (Millewa Forest).

Seventeen species identified as declining in southern Australia (i.e. between latitudes 29-38^{o}S, part of the temperate agricultural zone of southern Australia) were recorded from the monitoring plots. All of these

species had been recorded previously (i.e. during earlier surveys). Based on all the surveys conducted within Barmah-Millewa Forest since spring 1999, this forest provides habitat for at least 17 declining bird species.

Discussion

Although only three surveys for bush birds were completed during 2011-12 the highest species diversity (70) recorded since monitoring began Although the highest diversity was recorded in 2011-12 it was not substantially different from other years with 68 species recorded in 1999-2000 and the lowest diversity (63 species) recorded in 2000-01. A total of nine threatened species have been recorded since monitoring began. During 2011-12 two new threatened species were recorded; Square-tailed Kite and Scarlet Robin. Three threatened species recorded previously were not recorded during 2011-12; Gilbert's Whistler *Pachycephala inornata*, Flame Robin *Petroica phoenica* and Hooded Robin *Melanodryas cucullata*.

Reports

OEH (2012f). Quarterly Report: Bird Monitoring within Barmah-Millewa Forest – Summer 2012. Office of Environment and Heritage, New South Wales.

OEH (2012g). Quarterly Report: Bird Monitoring within Barmah-Millewa Forest – Autumn 2012. Office of Environment and Heritage, New South Wales.

Spawning of large-bodied fish

Refer to "Fish Condition Monitoring" report (above).

Crayfish populations

Refer to "Fish Condition Monitoring" report (above).

4.4.3 'O' category monitoring programs

White-bellied Sea-eagles

Author: B. Wehner (Parks Victoria)

Project title

Monitoring the number of breeding pairs of White-bellied Sea-Eagles within Barmah-Millewa Forest 2011-12.

Funding source

None. Undertaken by Parks Victoria as an anecdotal observational data collation exercise from field reports submitted by agency staff, tourist operators and general public.

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 the 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

There is evidence of the breeding of five juvenile White-bellied Sea-eagles within Barmah-Millewa forests in 2011-12. Some further breeding may have occurred however, flooding of the forest led to some sites being inaccessible and not being monitored. 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

Frog monitoring was not conducted in 2011-12 due to no funding being available.

Understory vegetation biomass assessments

Parks Victoria and DSE established 36 sites within Barmah Forest in 2006 to undertake understorey vegetation condition monitoring every 6 months (if areas have been accessible). Sites were selected using the Landscape Units method (which is a larger version of EVCs). Table 9 shows results taken from 2010-12.

Table 9: Vegetation biomass assessment results 2010-12

Landscape Unit	Site	Sample	Wet/ Dry	Vegetation	% Cover	DM t/ha
Marshes Landscape unit	Hut lake	Nov 2011	Water 20cm deep	Moira Grass 50cm high	55%	1.7
		May 2012	Dry	Moira Grass 15cm high	80%	1.5
	Steamer Plain	Nov 2011	Flood receding after 15 months wet	Spike Sedge	10%	0.2
		May 2012	Dry	Spike Sedge Joy weed	10% 30%	0.2 0.2
Riverine Swampy Woodland	Bucks Lake	Nov 2011	Water 50cm deep flooded continuously for 15 months	-	-	-
		May 2012	Flood receded for 1 month	Knotweed (had just begun germinating at time of sampling)	2%	-
	Tarma	May 2010	Dry	Warrego Summer Grass	3%	0.3
		May 2012	Flood receded for 1 month	Rush/ Sedge Warrego Summer Grass Swamp Dock	6%	0.05
	Thorpe's Gate	April 2010	Dry	Warrego Summer Grass	3%	0.3
		May 2012	Dry (has been flooded previously)	Rush/ Sedge 130cm high	20%	3 (most productive site)

Barmah-Millewa Midden Fish Study

Authors: Lee Joachim (Yorta Yorta Nations Aboriginal Corporation) and Dr Paul Humphries (Charles Sturt University)

Funding source

The Living Murray Indigenous program, Murray-Darling Basin Authority.

Project aims

This project aims to establish a reference collection of fish bones, scales and otoliths for identification of fish remains by the excavation of one or more middens in the Barmah-Millewa district. The extraction of fish and other faunal remains will allow the determination of composition, size and age of fish that were eaten by local people at known dates up to 5000 years ago. The projects principle aim is to engage the local Aboriginal community in the study.

Background
This collaborative study will describe the composition and condition of River Murray fish assemblage in pre-European times and establish benchmarks upon which future restoration can be based. This work will include a description of the significance of fish as food for Indigenous people.

Results & Discussion
The Barmah Fish Midden Fauna Study, being carried out by the Yorta Yorta Nation Aboriginal Corporation (YYNAC) in partnership with Charles Sturt University (CSU), is well underway and initial test sampling was carried out in December 2012. After lengthy planning and consultation throughout 2011-12 between the Yorta Yorta Elders Council, Aboriginal Affairs Victoria, Parks Victoria, YYNAC, and CSU; a Cultural Heritage Permit was granted from Aboriginal Affairs Victoria (AAV) in October 2012. A National Parks Act 1975 Research Permit, was also issued in August 2012 to allow the research work to be carried out in the Barmah National Park.

In December 2012, the Project Team, including Yorta Yorta Elders and community members, representatives from the YYNAC, researchers from CSU, archaeologist Alan Williams from Australian National University, Parks Victoria Rangers, and a representative from AAV, carried out 20 test cores as specified under the required permits. This material will be examined and analysed to determine the content and age of the midden / oven mound sites that were tested, and enable the sites to be ranked according to their potential to contain fish bone material and deliver the project goals.

Funds are being sought to enable carbon dating of the samples, and for the continuation of the project.

Reports
Nil to date.

Naturewise Medicinal Plants
Author: Lee Joachim (Yorta Yorta Nations Aboriginal Corporation)

Methodology has been developed for this research project and the project will commence in the seasonal cycle of the Yorta Yorta. Yorta Yorta youth have been receiving training with this methodology with ongoing development of potential tourism opportunities related to this project. This has required mapping of all Barmah-Millewa by Yorta Yorta.

Turtles
Author: L. Beesley, K. Howard (Arthur Rylah Institute – DSE), Lee Joachim (Yorta Yorta Nations Aboriginal Corporation).

Project title
Cultural Conservation of Freshwater Turtles in Barmah-Millewa Forests, 2011-12.

Funding source
The Living Murray Indigenous program, Murray-Darling Basin Authority (third 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 2012) 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

Ninety –seven turtles were captured in Barmah-Millewa Forest, the highest number trapped in one study season. Of these, 14 were Broad-shelled Turtles, 21 were Common Long-necked Turtles and 62 were Murray River Turtles. Turtle populations were dominated by adults with only one juvenile Broad-shelled

Turtle, two juvenile Common Long-necked Turtles and eight Murray River Turtles were trapped. Four previously tagged turtles were recaptured during the 2012 study season. Three Murray River turtles were recaptured in the survey with two of the three having being captured in during the 2011 study and one having been captured in the 2010 study. One Broad-shelled Turtle captured in 2010 was recaptured during the 2012 study.

Discussion

This program has amassed three years of data of the turtle populations within Barmah-Millewa Forest, enabling a robust assessment of their current health and status. Data gathered spanned from drought to flood, allowing an assessment of how the three species respond to differing climatic conditions. This knowledge will assist Yorta Yorta Nation to manage and conserve turtles inhabiting their land including the totem, Bayadherra.

Reports

Beesley, L., Howard, K. and Joachim, L. (2013). Cultural conservation of freshwater turtles in Barmah-Millewa Forest, 2011-12. August 2012. Arthur Rylah Institute for Environmental Research unpublished client report for the Water Group DEPI, Department of Environment and Primary Industries, Victoria.

Monitoring Giant Rush encroachment on Barmah Lake

This project occurred as an opportunistic event upon discovering Giant Rush establishing on the bed of Barmah Lake during in October 2007 during unusually very low water levels. The site was re-monitored in October 2011 to show that the deep extended flooding of the previous year appears to have killed nearly all of the rush from the lake bed. Future monitoring will determine if any of the rush re-sprouts from rhizomes. A brief report is intended to be compiled of this event after some more years of data collection. Contact Keith Ward (GB CMA) for more information if required.

Barmah Forest groundwater monitoring

Groundwater bores in Barmah Forest have been monitored under Goulburn-Murray Water (G-MW) management up until the end of 2011-12. Funding for the data collection has not been renewed for 2012-13. The last time the data was analysed in detail was by Sinclair Knight Merz for G-MW and utilised data collected to May 2004 (SKM 2005).

There is an opportunity for a project to analyse the existing data set and for future funding to continue monitoring the bore network in Barmah Forest.

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).

The Barmah Choke Study is effectively complete (as at June 2012). The Study, which commenced in 2008, has progressed through four 'phases' of work to date in collaboration with governments through the MDBA's working groups. The work has included modelling and assessment of seventeen options and sub-options individually, and in combination, to develop recommendations in relation to preferred options and

packages of options to reduce the impact of the Barmah Choke on the operation of the River Murray System, while maintaining its beneficial influence on flooding the Barmah-Millewa Forest.

The Barmah Choke Study made recommendations in relation to a range of structural, policy and operational options to reduce the impact of these issues. A key finding was that no single option represents a complete solution to these issues; rather a package of options would be required. Further, the issues persist under possible future scenarios of drier climate and of an increased volume of water being managed for environmental purposes.

The results and outcomes of the Study indicate that:

- the incidence and magnitude of shortfalls can be mainly eliminated through measures that are low cost and could be readily developed toward full implementation (Option Package 1) where they have not already been implemented. Option Package 2 builds upon the benefits of Option Package 1 and further improves management of shortfalls;
- the incidence and magnitude of *undesirable unseasonal watering* of the Barmah-Millewa Forest can be materially reduced with investment of about $10 million at the Edward River Escape to Mulwala Canal (Option Package 3) or by lowering Lake Mulwala by 0.1m over the unseasonal flooding period (Option Package 4), subject to further consideration of social and economic impacts and noting that Option Package 4 is considered to be high risk because of the social and community economic implications of operating Lake Mulwala 0.1m lower over summer.

Final reports are expected to be available on the MDBA website at a later date.

CSIRO 'Water for a Healthy Country' Flagship Program - Giant Rush/ Moira Grass Study.

Project Title
Assessing the response of floodplain vegetation to the Millennium Drought and recent floods

Funding Source
Water for a Healthy Country flagship program, CSIRO

Project Aims
- To quantify the response of *Pseudoraphis spinescens* and invasive *Juncus ingens* populations to deep, prolonged flooding in 2010-2012.
- To develop a better understanding of the capacity for using environmental water allocations to limit *J. ingens* invasion and promote *P. spinescens* recovery.
- To determine constraints on rehabilitating degraded MDB wetlands following a history of river regulation.

Background
Altered flood regimes have resulted in widespread changes to wetland vegetation across the Murray Darling Basin. Current strategies adopted by the MDBA, CMAs and other management bodies focus on using environmental water allocations (EWAs) to restore, protect and maintain these ecosystems. During the 2001-2009 "Millennium Drought" such releases were often the only source of water available for many wetlands in SE Australia. However, the response of floodplain plant communities to EWAs remains poorly quantified. Indeed, it is unknown whether most flood-dependent ecosystems can persist under current

EWAs, or whether degraded wetland communities are resilient to drought and can recover after renewed flooding. In this project, we have focused on addressing this key question in two important floodplain plant communities – *Pseudoraphis spinescens* (Moira grass) grassland and *Juncus ingens* (giant rush) rushland - in Barmah Forest in northern Victoria. Over the past century *P. spinescens* has contracted dramatically in response to altered hydrology, and many areas have been invaded by *J. ingens*. This is of serious conservation concern because these communities provide crucial habitat for migratory waterbirds; indeed, the Barmah-Millewa Forest has been listed as a Ramsar site and icon site of the Living Murray Program.

Results

Results from our field studies at Steamer Plain showed that *J. ingens* stem density, survival, recovery rate and replacement rate were strongly negatively log-log correlated with submergence duration of stems during the 2010-2012 floods. For example, new stem density declined from a maximum of 100 m-2 to ≤ 5 m-2 in plots where submergence duration was ≥ 85 days. However, despite stem declines during the first phase of submergence, a second period of flooding, which was too shallow to submerge most stems and instead provided conditions of partial submergence, was correlated with strong stem recovery. Glasshouse studies of *J. ingens* from rhizomes also showed strong re-sprouting ability. *Juncus ingens* recovery rates were lower at Barmah Lake than in Steamer Plain, where flooding during 2010-12 was deeper. Cover of *Pseudoraphis spinescens* at Steamer Plain was very low, and occurred predominantly around the western and northern perimeter. Average and maximum stem length was 373 cm and 475 cm respectively, with 11.5% of *P. spinescens* stems flowering during March 2011. Dry biomass of *P. spinescens* was highly variable, ranging between 0.18 and 3.28 kg m^2.

Discussion

Deep, prolonged floods that submerge *J. ingens* plants are effective at reducing stem densities and rates of survival, recovery and replacement. However, *J. ingens* can rapidly produce and elongate new stems under partially flooded or soil-saturated conditions. These findings demonstrate a preference for *J. ingens* growth under wet or partially flooded, but not submerged, conditions. Floods that overtop stems for short lengths of time are likely to be ineffective at reducing or removing established stands of *J. ingens*. Furthermore, although a single flood that is long enough to submerge stems for two or more months may considerably reduce stem densities, if this is preceded or followed by especially favourable conditions for growth – such as shallow flooding – then any reduction in stem densities will be short-lived. These results suggest that the degraded state of many of the extensive *J. ingens* stands at Barmah Forest appear to be resistant to change, particularly for well-established, tall plants that are difficult to completely submerge, particularly using EWAs. Nevertheless, even if successful control of *J. ingens* is achieved in its invaded range, this alone is unlikely to return *P. spinescens* to its historical extent at Barmah Forest. Further research is required on the flooding and regeneration requirements of *P. spinescens*, particularly on the potential contribution of any seed bank to re-establishment.

Reports

Vivian LM and Godfree RC (2012) The response of a degraded Murray River floodplain wetland to extreme drought and flood. Proceedings of the 6th Australian Stream Management Conference, Canberra 2012: 340-346.

Oral presentation at Ecological Society of Australian Annual Conference, Hobart, November 2011.

2011-12 Intervention Monitoring Projects

Intervention Monitoring projects are annually funding through TLM to monitor specific actions or expected outcomes from environmental water delivery in a given year. This covers monitoring that does not occur under the Condition Monitoring program. For 2011-12, Intervention Monitoring projects were undertaken by the GB CMA and NSW NPWS, with both agencies working collaboratively to achieve objectives and report findings to direct water management, particularly through the Barmah-Millewa Operations Committee teleconference (see Section 3.7 Barmah-Millewa Operations Committee).

Goulburn Broken CMA managed intervention projects

Agency Flood Compliance Monitoring

Objectives

- Provide Victorian water managers with an enabling budget to build time within their works program (above normal 'duty-of-care' responsibilities) to directly inspect and monitor aspects of their water management activities, and hence build an increased capacity to contribute to B-M Operations Committee discussions on water management decisions in a timely manner (especially given on-site field reports/observation form a critical component to decisions made on water releases);
- Assist managers with decision making associated with environmental flooding requirements via direct observation of waterbird nesting activity (presence, identification, nesting stage, chick development, site disturbance, etc), plant response, flood distribution, etc, especially where sentinel condition monitoring sites are not located;
- Reduce costs associated with contracting consultants to undertake basic field assessments, whilst increasing corporate knowledge capacity;
- Potentially increase response time to issues affecting water management given direct observation and understanding by water managers.

Outcomes

- Real-time ecological advice provided to Barmah-Millewa Operations Committee, contributing to the broader ecological outcomes of the environmental watering event.
- Waterbird nesting activity located, counts and/or estimates completed and fledging success confirmed. Presence of cryptic species (ie: Bitterns) confirmed through call recognition.
- Vegetation response observed and recorded.
- Partnerships between Barmah-Millewa stakeholders strengthened through collaboration in monitoring activities.
- Challenges to on-ground monitoring activities identified.

Reports

Ward, K.A. & Chalmers, K.D. (2012) Agency Flood Compliance Monitoring in Barmah Forest: 2011-12 Environmental Watering Event. Report prepared as part of the Living Murray Intervention Monitoring Program for the Barmah-Millewa Icon Site, on behalf of the Murray-Darling Basin Authority, Canberra.

Remote Cameras

Objectives

- Provide managers with real-time data (visual and possibly audio) of colonial waterbird nesting at Boals Deadwood;
- Assist managers with decision making associated with flooding (height, duration, required river flows, etc) with respect to waterbird nesting activity (presence, identification, nesting stage, chick development, site disturbance, etc);
- Reduce field time and disturbance to waterbird nesting;
- Potentially promote public education through on-line access (yet to be approved, although could occur through the Barmah Forest Information Centre in Nathalia).

Outcomes

- Purchased two camera systems with different capabilities. One designed for landscape images and the other better suited to smaller targets.
- Designed and purchased freestanding and portable stands suitable for the floodplain environment.
- Due to delays in funding approval and complications with final equipment specifications both cameras will be installed and field tested in 2012-13.
- Web platform text prepared to establish a public accessible website for the camera images and updates.

Reports

Chalmers, K.D. & Ward, K.A. (2012) Remote Monitoring Cameras in Barmah Forest: Report 1 – Camera purchases. Goulburn Broken Catchment Management Authority, Shepparton.

MDFRC & Waterwatch Blackwater Monitoring

Objectives

- Provide managers with timely water quality data and trends on the potential for development of low oxygenated blackwater (and thereby permit managers with the improved ability to manage towards/minimize the development or impact);
- Increase knowledge on causes of blackwater development (including ability to value add to other research and monitoring projects);
- Reduce community concerns regarding the potential for re-development of blackwater and associated fish death incidents given active monitoring would be undertaken;
- Improved ability to accurately report on water quality issues (especially given active water management activities this year).

Outcomes

- Murray-Darling Freshwater Research Centre was contracted to undertake water quality and dissolved oxygen concentrations in the Murray River above and below the Barmah-Millewa Forest during the environmental watering activities between 21 November 2011 and 1 February 2012. Results found no major decline in dissolved oxygen concentrations within the Murray River channel and would have had no detrimental impact on the aquatic life.
- WaterWatch was contracted to undertake water quality and dissolved oxygen concentrations in the Murray River and surrounding tributaries of Barmah-Millewa Forest during the environmental watering activities on an intermittent basis varying between 7 to 12 occasions in the period 09 December 2011 and 19 April 2012. Results found only one period of major decline in dissolved oxygen concentrations at Barmah Lake, although this is expected to have been localised and short-lived as a result of major Broken Creek flooding passing through Goose & Rowes Swamps.
- Results from MDFRC and WaterWatch monitoring were fed directly into the weekly Barmah-Millewa Operations Committee teleconferences and Murray River Blackwater teleconferences for considerations towards refining water management planning.

Reports

Cook R, Nielsen D and Petrie R (2012) Monitoring dissolved oxygen and water quality around the Barmah-Millewa Forest. Final Report prepared for the Goulburn Broken Catchment Management Authority by The Murray-Darling Freshwater Research Centre, MDFRC Publication 09/2012, May, 19pp.

WaterWatch (2012) Waterwatch Barmah Wetland Project. Waterwatch at Goulburn Valley Water, Shepparton.

NSW NPWS managed projects (NSW)

Waterbird (Millewa Forest - Murray Valley National Park) Intervention Monitoring

Author: Rick Webster (NSW NPWS)

Project Title

Waterbird Monitoring: 2011-12 Flood Event

Funding Source

Murray Darling Basin Authority

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 and 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, monitoring of all known breeding sites was completed every 2-4 weeks during the 2011-12 flood event.

Results

Prior to on ground surveys commencing aerial surveys were undertaken to determine whether or not any unknown sites were being used by colonial nesting waterbirds and to determine the extent and numbers of colonial nesting waterbirds within wetlands that were not completely accessible on ground. 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; and
- Moira Lake (western side);

A total of 14 species and at least 1804 pairs of birds were recorded nesting on these wetlands. The most common species were:

- Australian White Ibis *T. molucca* – 540 pairs;
- Straw-necked Ibis *Threskiornis spinicolis* – 450 pairs;
- Royal Spoonbill *Platalea regia* – 212 pairs;
- Little Black Cormorant *Phalacororax sulcirostris* – 154 pairs;
- Little Pied Cormorant *Microcarbo melanoleucos* – 153 pairs;
- Eastern Great Egret *Ardea modesta* – 120 pairs; and
- Australasian Darter *Anhinga novaehollandiae* – 93 pairs.

The event monitoring identified 40 species of waterbird utilising the sentinel wetland sites within Murray Valley National Park (MVNP). This included two species listed as threatened (Blue-billed Duck *Oxyura australis* and Australasian Bittern *Botaurus poiciloptilus*) under the NSW threatened species legislation. The

Australasian Bittern is also listed as endangered under the Commonwealth *Environmental Protection and Biodiversity Conservation Act* (EPBC Act) 1999.

Eastern Great Egret, Glossy Ibis *Plegadis falcinellus* and White-bellied Sea-Eagle *Haliaeetus leucogaster* are listed on the China-Australia Migratory Bird and Japan-Australia Migratory Bird Agreements and were recorded during the intervention monitoring program in 2011-12.

A single Pied Cormorant *Phalacrocorax varius* was recorded on Moira Lake during surveys in October 2011. Since regular monitoring began (spring 1999) this species has only been recorded during the 2010-11 flood/environmental event (R. Webster pers. obs.).

Discussion

The 2011-12 flow event resulted in 1,804 pairs of colonial waterbirds nesting in the MVNP. To ensure these birds successfully fledged young 257GL (total Barmah-Millewa use 428GL) of environmental water was used. Use of environmental water for other colonial waterbird nesting events has occurred in 2000-01 (5,008 pairs, 335GL B-M icon site), 2005-06 (5,350pairs, 513GL) and 2010-11 (7,420 pairs, 428GL). The larger response of colonial nesting waterbirds in 2000-01, 2005-06 and 2010-11 compared to 2011-12 could be due to one of the following reasons but is more likely to be due to a combination of these factors:

- The larger breeding populations in 2000-01 and 2010-11 could be due to the larger flow events that occurred in these two years compared to 2011-12. In 2000-01 peaks of ~70GL and ~90GL were recorded in September and October/November, in 2010-11 peaks of ~100GL and ~110GL were recorded in September and December compared to ~50GL and ~30GL in August and September 2011-12. The smaller flows and earlier occurrence in 2011-12 may have resulted in smaller numbers of colonial nesting waterbirds utilising MVNP.
- The 2000-01, 2005-06 and 2010-11 breeding events occurred during flood events following extended dry (4-5 years) periods when very little flooding occurred within the park compared to the 2011-12 breeding event which followed a larger flood event in 2010-11. The inundation of wetlands and surrounding floodplains following extended dry periods appears to result in large numbers of waterbirds moving into these areas to take advantage of increased resources.
- The lack of a drying phase following the 2010-11 flood event did not allow the floodplain ecosystem to reset itself. That is a complete drying of wetlands to allow plants to complete life cycles, die and break down so that when the wetlands re-flood there is a flush of ecological activity potentially resulting in a colonial waterbirds nesting. The smaller breeding event in 2011-12 could be a result of reduced health in the wetlands due to a lack of a drying phase.

The provision of environmental water during the 2011-12 flood event ensured that the flood recessions were slowed thus preventing the draining of the wetlands supporting the breeding species and therefore the abandonment of nests. During the 2011-12 flow event environmental water was supplied from the following sources:

- Barmah-Millewa environmental water allocation;
- TLM environmental water allocation;
- NSW environmental water allocation; and
- Victorian environmental water holder.

Reports

OEH (2012h). Monitoring waterbird activity on selected wetland sites within Millewa Forest as a result of the 2011-12 flood/environmental flows within the Murray River. Office of Environment & Heritage, New South Wales.

NSW NPWS (OEH) Blackwater Monitoring

Authors: P. Childs, D. McAllister, R. Webster, E. Wilson, P. Norris.

Funding source

The Living Murray Intervention Monitoring program, Murray-Darling Basin Authority.

Project aims

This monitoring program aims to:

- Establish long-term water quality monitoring sites;
- Identify where in the landscape blackwater is most likely to originate;
- Identify actions that can be undertaken to minimize the risk of hypoxic blackwater occurring in the Baramah-Millewa forest and discharging into the major waterways and;
- Providing 'real time' information to water authorities to assist in the mitigation of hypoxic blackwater during flooding events.

Background

Approximately 80% of the Barmah-Millewa Forest and large areas of the central Murray River Floodplain was flooded in 2010-11. This was the first time in approximately 10 years, and provided significant benefits to the forest ecosystem. However, hypoxic blackwater affected all major rivers and their tributaries for the duration of the flood, causing widespread negative effects to native fish and crustaceans.

The water quality monitoring program for Barmah-Millewa forest was initiated by NSW National Parks and Wildlife Service in September 2010 and continued for the duration of the flood event until April 2011. The NSW National Parks and Wildlife Service recommenced water quality monitoring at the beginning of the 2011-12 flood event, which was incorporated into the Murray-Darling Basin Authority Intervention Monitoring Program for the Barmah-Millewa Icon Site.

A total of 16 sites within the Barmah-Millewa forest and the River Murray Channel were selected and sampled from November 2011 to February 2012.

Results

Dissolved oxygen concentrations in the Barmah-Millewa forest and Murray River sites were much improved in 2011-12 flood event compared to 2010-11 event. The Barmah-Millewa Forest is vulnerable to producing hypoxic blackwater especially after extended dry periods such as the 1999 to 2010 drought. The Hydro Dynamic Model and water quality monitoring data indicate that Barmah National Park and Gulpa Island Precinct are the most susceptible.

Discussion

A suggestion of increasing the frequency, duration and extent of flooding to at least 1 in 5 years where the flow peak exceeds 60,000ML day $^{-1}$ on several occasions during each event, and the timing of flooding emulates a natural winter-spring flood pattern. There may be considerations in the future when this scenario is not always achievable, especially considering predictions of an increasing dry climate. A proposal of water delivery works to improve flow and native fish movement into Barmah-Millewa Icon Sites could be supported by government agencies and stakeholder groups.

Reports

Nil

4.5 Summary of 2011-12 monitoring against ecological objectives

The monitoring projects summarised in Section 4.4 (Monitoring reports) aim to record ecological response and conditions, which can then be related back to the icon sites' refined ecological objectives (see Section 2.1 Background). Table 10 provides a summary of objectives and outcomes for 2011-12.

Table 10: Summary of monitoring program results against the refined ecological objectives

Ecological Objective	Monitoring Program (Table 8)	Category	Results	Achieving the objective?
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	Vegetation mapping (spatial character)	A		
	TLM stand condition assessment	A		
	TLM tree condition assessment	A		
Facilitate healthy and diverse vegetation to provide suitable, breeding and foraging habitat for a diverse range of waterbirds and bush birds	Vegetation mapping (spatial character)	A		
	Understorey condition assessment	B		
	Understorey vegetation mapping	B		
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	Waterbird condition monitoring – ground survey	A		
	Aerial Survey – (coordinated with annual eastern Australian waterbird Survey)	A		
	White-bellied Sea-eagles (*Haliaeetus leucogaster*)	O		
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	Fish condition monitoring	A		
	Event driven fish survey	A		
	Fish spawning and recruitment	B		
	Spawning of large-bodied fish	B		
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	Frogs	O	No formal monitoring undertaken in 2011-12	
Facilitate successful breeding of native turtle species by inundation of selected floodplains and wetland areas to provide suitable breeding and nursery habitat	Turtles	O		
Facilitate appropriate management to ensure the sustainability of crayfish populations	Crayfish populations	B		
Facilitate appropriate management measures to control the abundance and spread of invasive aquatic species	n/a			
Facilitate appropriate geomorphic management in selected waterways	n/a			
Ecological objective not defined	Woodland birds	B		

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 – Management and Committee Structure), 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.

Although the B-M CRG only meeting once in 2011-12, actions under the engagement strategy continued. The GB CMA website information on Barmah Forest was updated and expanded, along with links to Victorian land managers, TLM and information centres. The 2010-11 Barmah-Millewa Annual Report was also added and is able to be downloaded by the public.

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. Video and still images have been collated and the narrative completed. This is planned to be completed in 2012-13.

5.2 Reports and Publications

Ecological Associates and SKM (2011). Environmental Water Delivery: Yarrawonga to Tocumwal and Barmah-Millewa. Prepared for Commonwealth Environmental Water, Department of Sustainability, Environment, Water, Population and Communities

GB CMA (2012). Barmah-Millewa Forest Annual Report: 2010-11. Goulburn Broken Catchment Management Authority, Shepparton.

MDBA (2011b). The Living Murray Annual Environmental Watering Plan 2011-12. Murray-Darling Basin Authority, Canberra.

VEWH (2011). Seasonal Watering Plan 2011-12. Victorian Environmental Water Holder, Melbourne.

5.3 Media

Known media relating to Barmah-Millewa Forest in 2011-12 is listed below. It should not be assumed that no media coverage related to Barmah-Millewa Forest occurred in months where no media activity is listed.

July 2011
No media specific to Barmah-Millewa Forest is known for this month.

August 2011

23-08-2011 VEWH media release. *Seasonal watering plan released for Victoria's rivers and wetlands.*

September 2011

14-09-2011 NSW Office of Water media release. *NSW releases environmental water to the Barmah Millewa forest*.

20-09-2012 Deniliquin Pastoral Times, page 7. Wetlands water a win for all says Harriss (NSW Office of Water releases water into the Barmah–Millewa Forest).

28-09-2011 Riverine Herald Page 5. *Concerns about black water*.

28-09-2011 Riverine Herald Page not recorded - Letters to the editor. *More blackwater.*

October 2011
No media specific to Barmah-Millewa Forest is known for this month.

November 2011

10-11-2011 MDBA media release. *Environmental watering to benefit The Living Murray's icon sites.*

28-11-2011 Riverine Herald Page 18. *Expression of Interest: General Members – Yorta Yorta Traditional Owner Land Management Board.* Public Notice advertisement.

28-11-2011 The Age page 4. Old Man River Murray rolls on but will the locals? (Lee Joachim about cultural sites throughout the Barmah).

December 2011

02-12-2011 VEWH media release: *Summer pulse of environmental water to benefit fish.*

02-12-2011 MDBA (TLM) media release. *Summer pulse of environmental water to benefit fish.*

07-12-2011 ABC online. *NRC backs red gum thinning trial.*

12-12-2011 Country News insert page 18. Flow to help river health (extra env water to benefit waterbird nesting in Barmah Forest).

16-12-2011 Riverine Herald Page 17. *Flood 'pulses' restrict access but benefit fish*.

16-12-2011 Riverine Herald Page 18. *Barmah board interest*.

January 2012

23-01-2012 Country News Page 3. *Survey no threat to brumbies*.

23-01-2012 Country News Page 4. *Healthy interest in Barmah board*.

30-01-2012 Country News Page 3. *Mare feared injured*.

February 2012

07-02-2012 ABC Goulburn Murray; Louise Burge explains how environmental flows will impact on Barmah–Millewa Forest.

10-02-2012 Shepparton News. *Park access a car hazard.*

18-02-2012 Australian Financial Review page 6. Concerns raised that over-watering of the Barmah–Millewa Forest could endanger river red gums in the national park.

March 2012
No media specific to Barmah-Millewa Forest is known for this month.

April 2012
No media specific to Barmah-Millewa Forest is known for this month.

May 2012
No media specific to Barmah-Millewa Forest is known for this month.

June 2012
No media specific to Barmah-Millewa Forest is known for this month.

6 References

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OEH (2012d). Quarterly Report: Waterbird Monitoring within Barmah-Millewa Forest – Summer 2012. Office of Environment and Heritage, New South Wales.

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Appendix 1: Barmah Forest Seasonal Watering Proposal for 2011-12

Name/Contact details:	Date:
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Icon site name:	Barmah-Millewa Forest
Location within site:	Four Scenarios Scenario 1 (11-12,000 ML/day @ Yarrawonga) 18% of Barmah floodplain (3% Millewa floodplain; 10% BM floodplain) This scenario primarily targets nesting waterbirds at colony sites in Barmah-Millewa Forest (other than Boals Deadwoods which is subject of a separate proposal). It anticipates another strong colonial waterbird breeding response in spring 2011 given the flood conditions of 2010-11 continuing into winter 2011. Many waterbirds have remained in the Barmah-Millewa wetlands over winter, and indications are now that breeding of some species is already commencing (observation of cormorants lining nests). A threshold flow of 11-12,000ML/d in the Murray River (as measured at Yarrawonga) is known to be the minimum volume of water to cause low level flooding at Steamer and War Plains in south-west Barmah Forest and Reed Beds complex, Porters Plain and Moira Lake in southern Millewa forest. Steamer and War Plains contained the largest cormorant colony experienced in Barmah Forest for approximately 40 years (during 2010-11), containing many hundreds of Little Pied Cormorant and Little Black Cormorants, along with up to a hundred Darter and Night Herons. Reed Beds, Porters Plain and Moira lake supported the majority of colonial nesting birds within Millewa Forest during 2010-11 flood event. Breeding and feeding opportunities for Bitterns and Sea-eagles are also expected to be greatly enhanced by low-level flooding. Flow diversion into Barmah Forest, via the Gulf Creek, will also renew connectivity in this major waterway for benefits to fish, turtles and waterbirds through the middle of Barmah Forest. NB: EWA release is that required to fill remaining river channel capacity above irrigation releases being made at the time, and hence the 11-12,000ML/d flow target is not all EWA release (could potentially be 1,500ML/d above 10,500ML/d regulated level: less if return flow can be re-credited or re-used).

	Scenario 2 (18,000 ML/day @ Yarrawonga) 33% of Barmah floodplain (15% Millewa floodplain; 23% BM floodplain) This scenario primarily targets critical thresholds for open wetland environments to assist achieving management plan targets for Moira Grass plains. A threshold flow of 18,000ML/d in the Murray River (as measured at Yarrawonga) is known to be the minimum volume of water to cause 0.5m deep flooding of most Moira Grass plains, which has been the recognised minimum depth required to maintain the species in active wet growth phase. The end target is to achieve widespread flowering, which will occur in late-spring if flooding has been continuous. The river flow will necessitate all of Barmah Forest regulators to be open and most of Millewa Forest regulators to be open to maximise flood depth in Barmah-Millewa Forest Moira Grass plains, but can still achieve approximately 0.4m flood depth if shared equally with Millewa Forest. The enhanced flooding throughout all open wetlands in Barmah-Millewa Forest will also improve conditions for other fish, waterbirds frogs and turtles. NB: EWA release is that required to fill remaining river channel capacity above irrigation releases being made at the time, and hence the 18,000ML/d flow target is not all EWA release (could potentially be 7,500ML/d above 10,500ML/d regulated level; less if return flow can be re-credited or re-used). Scenario 3 (20,000ML/day @ Yarrawonga) ~44% of Barmah floodplain (~37% Millewa floodplain; ~40% BM floodplain) This scenario primarily targets all Barmah and Millewa Forest waterways and wetlands given that all forest regulators have to be fully opened at this river flow. All wetland grass plains, giant rush swamps and partial red gum forest will be inundated. Improved benefit is expected from these vegetation communities, in addition to providing superior conditions for waterbirds at all recent colony sites, connecting all primary and secondary waterways for improved fish and turtle conditions, and assist with further organic loading assimilation. NB: EWA release is that required to fill remaining river channel capacity above irrigation releases being made at the time, and hence the 20,000ML/d flow target is not all EWA release (could potentially be 9,500ML/d above 10,500ML/d regulated level; less if return flow can be re-credited or re-used). Scenario 4 (25,000ML/day @ Doctors Point) >54% of Barmah Floodplain (>58% Millewa floodplain; >56% BM floodplain) This scenario aims to achieve maximum forest inundation at maximum manageable levels without incurring flooding of private land downstream of Hume Reservoir en-route to Barmah-Millewa Forest. Maintaining river

	levels at maximum river channel capacity between Hume Reservoir and Lake Mulwala (25,000 ML/d as measure at Doctors Point) can then combine with unregulated flows entering Lake Mulwala from the Ovens River, to promote a maximum variable flood levels into Barmah-Millewa Forest. A similar approach was undertaken in 2005-06 EWA release. NB: EWA release is that required to fill remaining river channel capacity above irrigation releases being made at the time, and hence the 25,000ML/d flow target is not all EWA release. Environmental targets are to re-flood maximum Barmah-Millewa floodplain possible under managed flows. This higher terrain has experienced the greatest reduction in flood frequency (small to medium floods have been most reduced following river regulation). Enhanced forest, fish and wildlife values will also be obtained above those with small releases. Natural pulsing of flows (as a result of Ovens River influences) are expected to best improve native fish spawning response (given fluctuating water levels, tied with natural cues, have in the past been shown to promote perch spawning activity, and expected to improve Murray cod breeding success). However, the relative importance of re-flooding at this level has now been reduced following recent large flood peaks (winter 2011) to have passed through the forest, and a high likelihood of addition natural peaks occurring in spring 2011. Preference is now instead towards the other Scenarios depending on water availability.	
Significance of site:	TLM icon site, Ramsar site, JAMBA, CAMBA, RoKAMBA & BONN species	
Site details:	Area/perimeter to be inundated:	6,000 - >34,000ha (varies depending on scenario)
	Timing:	1/09/2011 - 31/11/2011
	TLM water volume required: (GL)	?? GL - 450 GL
	Net volume used at site (GL)	Calculations from MDBA river operations indicate that losses last year were between 28 - 49%. This was the total overbank loss from Hume to SA. The flows target are below the levels last year.
	Return flows (GL)	51 - 72%
TLM icon site objective	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).	
Delivery mechanism and complementary works	Gravity fed delivery is achieved to all targeted Barmah-Millewa Forest wetlands through natural waterways. River flows up to 15,000 ML/d day (as measured at Yarrawonga) can be diverted into either Barmah Forest regulators or Millewa Forest regulators, or a combination of both. Flows between 15,000 and 18,000ML/d require most Barmah and Millewa Forest regulators open, whereas flows above 18,000ML/d require all Barmah-Millewa Forest regulators to be open. Targeted flow rates are based on the assumption that the average daily flow at Yarrawonga is at that rate over a rolling 4 day period between	

	September and November. Note: volumes are minimum values to reach targeted wetlands. Greater gains are usually achieved with additional volumes of water. No complimentary works are required to achieve water management activities, although some site specific pest animal control is intended to occur at particularly vulnerable waterbird breeding colonies (funded under other existing programs).

Water resource scenario	Management objectives (please check the box indicating the relevant scenario and objective(s) expected to be achieved.)	
Extreme dry ☐	Prevent critical loss of species	☐
	Avoid irreversible loss/catastrophic event; or	☐
	Provide drought refuge	☐
	(describe how criterion will be met)	
Dry ☐	Maintain river functioning with reduced reproductive capacity	☐
	Maintain key functions of high priority wetlands	☐
	Manage within dry-spell tolerances	☐
	Support connectivity within sites	☐
	(describe how criterion will be met)	
Median ☒	Enable growth, reproduction and small-scale recruitment	☒
	Promote low-lying floodplain connectivity	☒
	Support medium flow river and floodplain functional processes	☒
	Watering will provide low level flooding of the forest for state targets, although the larger flooding scenarios will achieve progressively greater outcomes including enhancing connectivity and spawning opportunities for fish, small-scale recruitment of colonial water birds, breeding opportunities for turtles, and improve vegetation including giant rush, Moira grass, river red gum forest.	
Wet ☐	Enable growth, reproduction and large scale recruitment	☐
	Promoted higher floodplain-river connectivity	☐
	Support high flow river and floodplain functional processes	☐
	(describe how criterion will be met)	

Ranking criteria (provide a preliminary ranking of high, medium or low for each of the criteria)		
Significance of ecological outcomes	Amount of benefit for the volume of water	☒☐☐ (H/M/L)
	Risk of not watering	☐☐☒ (H/M/L)
	Certainty/likelihood of benefit	☒☐☐ (H/M/L)
Operation criteria	Risks associated with watering	☐☐☒ (H/M/L)
	Cost effectiveness	☒☐☐ (H/M/L)
Summary of costs: (Inclusive of GST)	Infrastructure	N/A
	Pumping charges	N/A
	Delivery charges	N/A

	Other charges (specify below)		
	Total		~$75,000 (for compliance monitoring of flows and distribution)
Cost effectiveness of watering action	Cost per ML	0	
	Comments	A SWET model may be used to calculate the usage. Additional monitoring would be required to improve associated water usage including: -Use forest hydrograph recorders to monitor flow heights and transmission times. - Undertake monitoring of key regulators to calibrate usage to increase sensitivity of SWET model. -Use BM hydrodynamic model to predict area and depth covered.	

Rationale for watering

Key rationale:	Barmah Forest was flooded in spring/summer 2010-11, representing the first substantial flooding since 2005, and resulted in the best bird breeding occurring for 40-60 years (depending on species). Providing managed flows during spring 2011 will build on the improvements made by the 2010-11 event, specifically targeting open wetland vegetation, providing fish connectivity and spawning opportunity (including Murray cod and golden perch) and providing habitat for turtles. Watering will also provide opportunity for colonial waterbird breeding and feeding in wetlands through the forest. The provision of environmental water in 2010-11 provided clear evidence of the benefit of environmental water delivery in ensuring the successful completion to colonial waterbird breeding events. The large accumulation of leaf litter during the drought increased the organic matter and the potential for a large scale blackwater event as observed last year. Application of water in 2011-12 will further assist with mobilising organic material on the lower floodplain and hence reduce accumulation and blackwater risk.
Risks associated with water activity, and proposed mitigation:	The requested water is best achieved when base river levels are flowing as close as possible to the targeted EWA release, otherwise large volumes of EWA is being released to merely elevate river levels. Decision on which proposed scenario to target will depend on predicted base flows and environmental requirements (if particular waterbird species breed or new colonies established at other wetland locations). A risk exists if base river levels fall too far below intended EWA targets because this potentially exhausts EWA accounts prior to targeted outcomes being achieved. Once waterbird breeding targets are being actively aimed for, then a duty of care tends to exist to achieve successful fledging (because thousands of dying waterbirds makes for bad press!). Minimal other risks are associated with the proposals because of they are generally site-specific and mostly low-medium flood level and have been achieved on other occasions with previous river freshes and EWA deliveries.

Water requirements

Delivery schedule: (indicate water volume required each month)

Jul 2010	Aug 2010	Sep 2010	Oct 2010	Nov 2010	Dec 2010	Start date	1/08/2011
		90 - 150 GL	93 - 155 GL	90 - 150 GL			
Jan 2011	**Feb 2011**	**Mar 2011**	**Apr 2011**	**May 2011**	**Jun 2011**	End date	**30/11/2011**