Constraints Management Strategy annual progress report 2013–14

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Cover image: *Goulburn River near Alexandra, looking upstream Photo Janet Pritchard, 2013, MDBA.*

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Acknowledgement of the Traditional Owners of the Murray–Darling Basin and its waterways
MDBA acknowledges and pays its respects to the Traditional Owners of the land in the Murray–Darling Basin. MDBA recognises and acknowledges that the Traditional Owners and their Nations have a deep cultural, social, environmental, spiritual and economic connection to their lands and waters.

Australian Government

MURRAY–DARLING BASIN AUTHORITY

Office of the Chair

Letter of transmittal

Dear Murray–Darling Basin Ministers,

I provide to you the Murray–Darling Basin Authority's annual report on progress with matters covered by the Constraints Management Strategy.

This year MDBA has undertaken the prefeasibility phase of the Strategy. We presented our key findings to you at the Murray–Darling Basin Ministerial Council meeting on 17 October this year where you agreed to a series of recommendations resulting from those key findings.

In the attached report we present the key findings and recommendations to you again, along with the supporting information and details of the analyses that we used to arrive at them.

The next phase of work under the Strategy is to develop specific proposals for addressing constraints and mitigating any impacts that may be caused by higher flows. As per your agreement at the 17 October Ministerial Council meeting, the Murray–Darling Basin Authority is happy to develop proposals for the constraints in the River Murray on behalf of Basin governments, subject to agreement on administrative arrangements, and will assist state governments in developing proposals in the other key focus areas. In doing so, we will continue to work collaboratively with Basin governments and communities.

Yours sincerely,

Craig Knowles
Chair

26 November 2014

Foreword from the Chair

For the past century, the Murray–Darling Basin has been developed in a way that can best provide water to towns, supply water for irrigation and industry, support recreational activities, and store water for drier times.

Regulating the river system has allowed us to manage water for more reliable supply for people, crops and livestock in what is one of the most variable river systems in the world. These changes have led to considerable economic and social benefit, but the regulation over the decades has changed how and when the rivers run, and has had a significant effect on the river environment.

In the past, the rivers had a wide variety of moderate and high flow events in winter and spring, and some very low or no flows over summer.

Now, we capture most of those higher peak flows in dams and redistribute the water in a more managed way within channels, and in late spring, summer and autumn to suit the irrigation season.

Over time, people have built their farms and businesses around these new flow regimes.

The current work by governments in the Basin aims to restore and protect the health of the Basin so it can continue to support communities and industries.

In order to do this, we need to be able to restore some small part of the natural flow patterns to the river, and get water into areas and at times that most benefit the environment.

In some cases, the places we need to get water to have had structures and properties developed nearby, which might be affected if higher flows were to be restored.

This is why Basin ministers requested the development of a Constraints Management Strategy to explore smarter ways to manage the rivers for improved environmental outcomes, which the Murray–Darling Basin Authority published in 2013. The Strategy maps out 10 years of work to examine and solve these problems. This report marks the first phase of that work.

This year, the Murray–Darling Basin Authority has been talking with community members in the key focus areas of the Basin to draw on their knowledge about how water flows affect land and infrastructure. The involvement has been strong and the knowledge passed on has been plentiful and is now incorporated into our findings.

The time and effort taken by community members to provide constructive feedback shows the great benefits of localism and I would like to thank everyone who contributed. This will continue to be a vital part of the work over the next few years.

In addition to the local knowledge we received, this report is also based on improved mapping and modelling, and includes our advice to ministers about the worthiness of the investment and the work to progress in the next phase of the Strategy.

In some areas, the work program involves developing proposals to mitigate the potential effects of higher flows, such as building bridges, improving access roads and acquiring easements. In other areas, it may mean doing survey work and improving our understanding of where the water goes when it flows out of the main channel.

Basin Ministers have agreed that the Murray–Darling Basin Authority will develop proposals for constraints in the River Murray on their behalf. We will also help Basin governments to develop proposals in the other key focus areas. In doing this, we will continue to work cooperatively with the states and communities to develop proposals, and improve the way we can run the river for better outcomes for the environment and the community.

Contents

Recommendations

The Constraints Management Strategy (2013) is looking at ways to ensure that the environmental benefits of water returned to the river system are maximised and the community has neutral or better outcomes — such as improved capacity to cope with flows up to or about minor flood levels. The Strategy will help to inform future decisions by Basin governments, who may choose to address priority constraints to water delivery, to achieve better outcomes from the use of environmental water. Developing the Strategy was the first step in a long-term commitment by governments to address key constraints.

In 2014, the Murray–Darling Basin Authority (MDBA), working with Basin states and communities, completed the first phase of the Constraints Management Strategy — the prefeasibility phase. As a result of this work, MDBA made recommendations to ministers about what should be done in the next phase of the strategy. Basin governments, through their ministers:

> **agreed** that the seven key focus areas for physical constraints identified in the MDBA's key findings from Phase 1 of the Constraints Management Strategy advance to Phase 2 (business case development) under the Intergovernmental Agreement on Implementing Water Reform in the Murray-Darling Basin and Phase 2 of the Constraints Management Strategy
>
> **agreed** that the three River Murray constraint measures be developed as integrated business cases as the first priority
>
> **noted** that the proponent Basin governments intend for the Murray-Darling Basin Authority to lead the development of the three River Murray constraint measures on their behalf, reporting to the Basin Officials Committee, subject to agreement on administrative arrangements and noting that such arrangements do not preclude states accessing funding for business case development.

At the conclusion of the prefeasibility phase, MDBA also makes the following further recommendations for action in the next phase of the strategy to:

- Develop a business case for constraint measures in the Goulburn key focus area.
- Develop a business case for constraint measures in the Murrumbidgee key focus area.
- Develop a business case for constraint measures in the Lower Darling key focus area
- Develop a business case for constraint measures in the Gwydir key focus area, noting that more investigations will need to be undertaken to demonstrate feasibility.

- Out of the nine operational and management constraints identified in the constraints management strategy, the following should be implemented as a matter of priority:
    - delivering environmental water on top of other instream flows
    - using environmental water throughout the length of a river
    - protecting environmental flows from extraction and re-regulation
    - developing an equitable and transparent arrangement for channel capacity sharing.

  Addressing operational and management constraints, in particular those that overlap with the prerequisite policy measures in the sustainable diversion limit (SDL) adjustment mechanism, are critical for achieving the outcomes of the Basin Plan and a failure to adequately implement these policies may reduce or entirely offset the SDL adjustment resulting from supply measures.

In the second phase of the Strategy, the feasibility phase, MDBA and Basin states will do more detailed hydrologic analysis to determine the best flow rates to relax constraints to in each key focus area; assess inundation impacts and options to mitigate those impacts down to an individual property level of detail; do more detailed costings; and perform further community consultations, including at the individual level. At the conclusion of the second phase, Basin ministers will decide which constraint measures should be implemented.

Goulburn River near Killingworth Road, 2013. *Janet Pritchard, MDBA.*

Introduction

Background

When the Murray–Darling Basin Plan was completed in 2012, Basin ministers requested that the plan include a requirement that Murray–Darling Basin Authority (MDBA) develop a Constraints Management Strategy (the Strategy) to explore how the plan could deliver better environmental outcomes by relaxing major river operation constraints. A constraint is any river management practice or structure that restricts the volume and timing of water we can deliver through the river system.

In November 2013, MDBA released the Strategy, which outlined three phases to take place over 10 years:

1. prefeasibility (to the end of 2014)
2. feasibility (to June 2016)
3. implementation (until 2024).

The first of those phases, the prefeasibility phase, is now complete. The prefeasibility phase involved collecting information to allow a first-pass analysis of constraints to determine which constraints may be feasible to address and should progress to a feasibility assessment. By analysing constraints in our key focus areas, we have been able to undertake the first assessment of the potential local-scale impacts, likely benefits, mitigation options and costs. The results of this analysis were published in seven reach reports.

The Basin Plan and the Strategy include a commitment for MDBA to provide updates on progress with matters covered in the Strategy to Basin ministers each year.

This annual report includes a summary of the reach reports, and MDBA's advice and analysis about the mix of constraints projects that will best deliver environmental outcomes.

Principles of the Strategy

The Strategy has the following principles:

- The Strategy aims to maximise environmental outcomes that can be obtained from managing all water available for environmental use.
- Affected communities, including landholders and managers, water entitlement holders, Traditional Owners, management agencies and local government, need to be involved from the beginning to identify potential impacts and solutions.
- In pursuing environmental outcomes through the relaxation or removal of constraints, solutions need to:
  - recognise and respect the property rights of landholders and water entitlements holders
  - not create any new risks to the reliability of entitlements

    - be identified in consultation with affected parties to determine if effects can be appropriately addressed and mitigated to enable changes to proceed
    - identify and aim to achieve net positive impacts wherever possible
    - be worked through in a fair, transparent and equitable way
    - work within the boundaries defined by the *Water Act 2007,* the Basin Plan, and relevant state water access and planning systems.
- All water holders, whether existing consumptive users or environmental water holders, should be able to use their water efficiently to meet the needs of that use, while not adversely affecting other entitlements.
- Potential changes will be worked through with relevant Basin governments and relevant stakeholders to resolve issues before changes to on-ground arrangements are made.
- Decisions to proceed with removing constraints will be made by Basin governments, with investment being decided by the Australian Government on the collective advice of governments. Investment should:
    - prioritise addressing the constraints that will provide the best Basin-wide environmental outcomes, taking into account economic and social considerations
    - focus on lasting solutions to provide certainty and protection to stakeholders over time
    - focus on avoiding and addressing any effects on communities.

Context

Over 100 years of development, the way that rivers flow in the Murray–Darling Basin has significantly changed. By building dams and irrigation infrastructure, we've provided for the growth of industries, towns and agriculture. That development has had a lot of benefits for all Australians, but it has often come at a cost to the health of the river system, including its floodplains, particularly downstream of dams and weirs.

Water used to regularly flow out of the main channels into surrounding creeks and flood runners, and onto the floodplains adjacent to the river, especially in late winter and spring. River regulation means that those creek flows and small overbank flows happen a lot less often than they used to. Instead, in many parts of the Basin, we now capture those flows in dams and release them as more constant flows during summer and autumn when irrigators need water. Of course, the big floods still happen and will continue to happen, and river operators will continue to provide as much protection from those damaging floods as they can.

Over the past few decades, Basin governments and communities have made substantial efforts to maintain and restore the health of the rivers and their floodplains. The Basin Plan and the Strategy aim to build on those achievements to restore a small part of the natural flow pattern. We'll never return the rivers to what they were before the development of the past 100 years, but we can try to restore some of the smaller flows that are critical for the environment to stay resilient and healthy.

The Strategy is looking at new ways to manage water delivery through the waterways to ensure their long-term health, while avoiding or mitigating the effects on people who also depend on the floodplain and these waterways.

Addressing constraints is one of the ways we can improve our ability to do that. It means that environmental water holders can use their water in the most efficient and effective way possible, and we can get the best value out of other parts of the Basin Plan, like the supply and efficiency measures in the sustainable diversion limits (SDL) adjustment mechanism.

Before development, overbank flows of the order that we are seeking to reinstate (such as a flow of 80,000 ML/day at the South Australian border for 30 days) happened in the River Murray around 35% of years. At the 2009 level of development, the frequency of these flows had reduced to about 10% of years. Through the Strategy, we are trying to restore the frequency of these flows to around 15–25% of years. This will still be considerably less than what would have happened naturally, but it is expected to make a significant difference to restoring floodplain health (MDBA 2012).

Importantly, we are only talking about changing managed flows on the lowest parts of the floodplain, in areas often designated as floodways or 'flood country'. Generally this is not where there are buildings or crops, but it is where a range of native species will benefit.

Based on the key findings of this report, MDBA made recommendations to Basin ministers about the work to be done in the next phase of the Strategy. Business cases will be developed to put forward in the package of measures considered in the SDL adjustment mechanism in 2016. The decision about which projects will be fully implemented will be made before the SDL adjustment in 2016, when more information is available through business cases.

Purpose of this report

This report represents the end of the prefeasibility phase of constraints assessment, and provides the background and detail of the MDBA's key findings and recommendations to governments about which constraints measures should progress to the next phase for further investigation. It includes the results of the work done in key focus areas, the progress that has been made in prioritising the operational and management constraints, and the analysis and prioritisation of constraints.

Separate technical reports that provide more detail about the analyses and how they were undertaken are available on the MDBA website.[1] They include:

- Hume to Yarrawonga reach report
- Yarrawonga to Wakool Junction reach report
- South Australian Murray reach report
- Lower Darling reach report

1 www.mdba.gov.au/what-we-do/water-planning/managing-constraints

- Goulburn reach report
- Murrumbidgee reach report
- Gwydir reach report
- Flow inundation mapping and impact analysis technical report
- Cost estimates report
- Priority constraints analysis.

Phase 1 — Prefeasibility assessment

In 2014, MDBA performed the first phase of the Constraints Management Strategy — the prefeasibility assessment. This involved several different bodies of work.

In each key focus area identified in the Strategy, MDBA:

- obtained inundation mapping to assess the impacts of various flow heights on land and infrastructure
- analysed hydrologic modelling to assess the potential frequency, timing and duration of higher environmental flows
- consulted with key landholders, councils and community members about the potential impacts of higher flows and options to mitigate those impacts
- estimated the costs for options to mitigate impacts of higher flows.

We prioritised the operational and management constraints. We assessed all nine operational and management constraints identified in the Strategy, and determined the four that are most important for achieving environmental outcomes.

We also did a Basin-scale analysis of constraints. This followed a hydrological analysis to explore how we can combine releases in multiple rivers, based on natural cues, to build events that benefit the whole southern-connected Basin. This fed into an assessment of which constraints are most important to achieve whole-of-Basin outcomes.

This report summarises each of these analyses, which combined lead to our key findings and recommendations. Basin governments, through their ministers and officials, have adopted our recommendations and are committed to addressing them in the next phase of the Strategy.

River red gum forest at Shepparton. ***Photo: Janet Pritchard, MDBA.***

Inundation mapping

MDBA used the latest hydraulic modelling to create flow inundation maps for each key focus area to provide a general indication of which areas are likely to get wet from different flow rates. The flow inundation maps provide a footprint of the inundation of each of the flow scenarios being investigated. We used the footprints to identify what land, roads and infrastructure were affected at each flow rate.

The hydraulic models use topographical data, such as digital elevation models, and observations of historical events to provide a modelled picture of the extent of inundation associated with river flows measured at individual flow gauges.

We worked with the CSIRO to use their latest ‘River Murray Floodplain Inundation Model’ to map inundation for the following key focus areas:

- Lower Darling
- Lower Murrumbidgee
- Yarrawonga to Wakool Junction.

Figure 1 is an example of this type of map from the Lower Murrumbidgee. It shows a section of the Berry Jerry State Forest and surrounding area. At flows of 30,000 to 40,000 ML/day the levee keeps the water mostly in the state forest; however some grazing land on the southern side of the creek is also inundated.

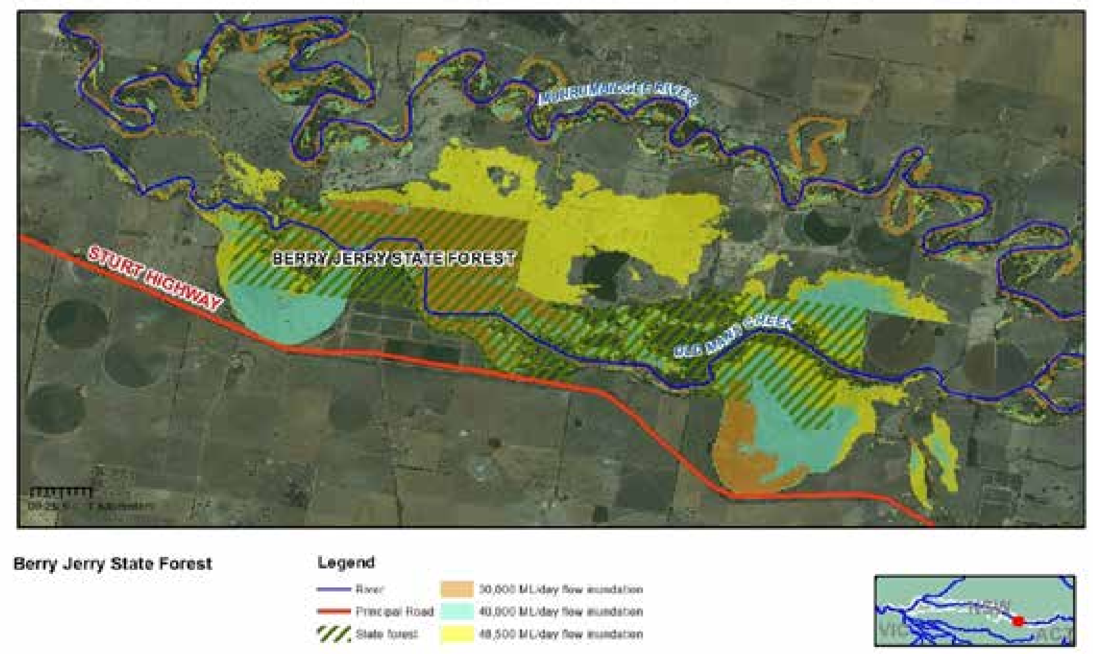

Figure 1: Inundation footprint of the Berry Jerry State Forest area at 30,000 to 48,500 ML/day

In some key focus areas CSIRO's latest modelling was not yet available, so we used the slightly older MIKE 11 hydraulic modelling software developed by the Danish Hydraulic Institute. We used this modelling in the following key focus areas:

- Goulburn
- mid- and upper Murrumbidgee
- Hume to Yarrawonga.

Figure 2 shows an example of this kind of mapping for an area downstream of Loch Garry in the Goulburn key focus area. The inundation footprint shows Yambuna Bridge Road being affected at flows of 30,000 ML/day, shown by the area in green.

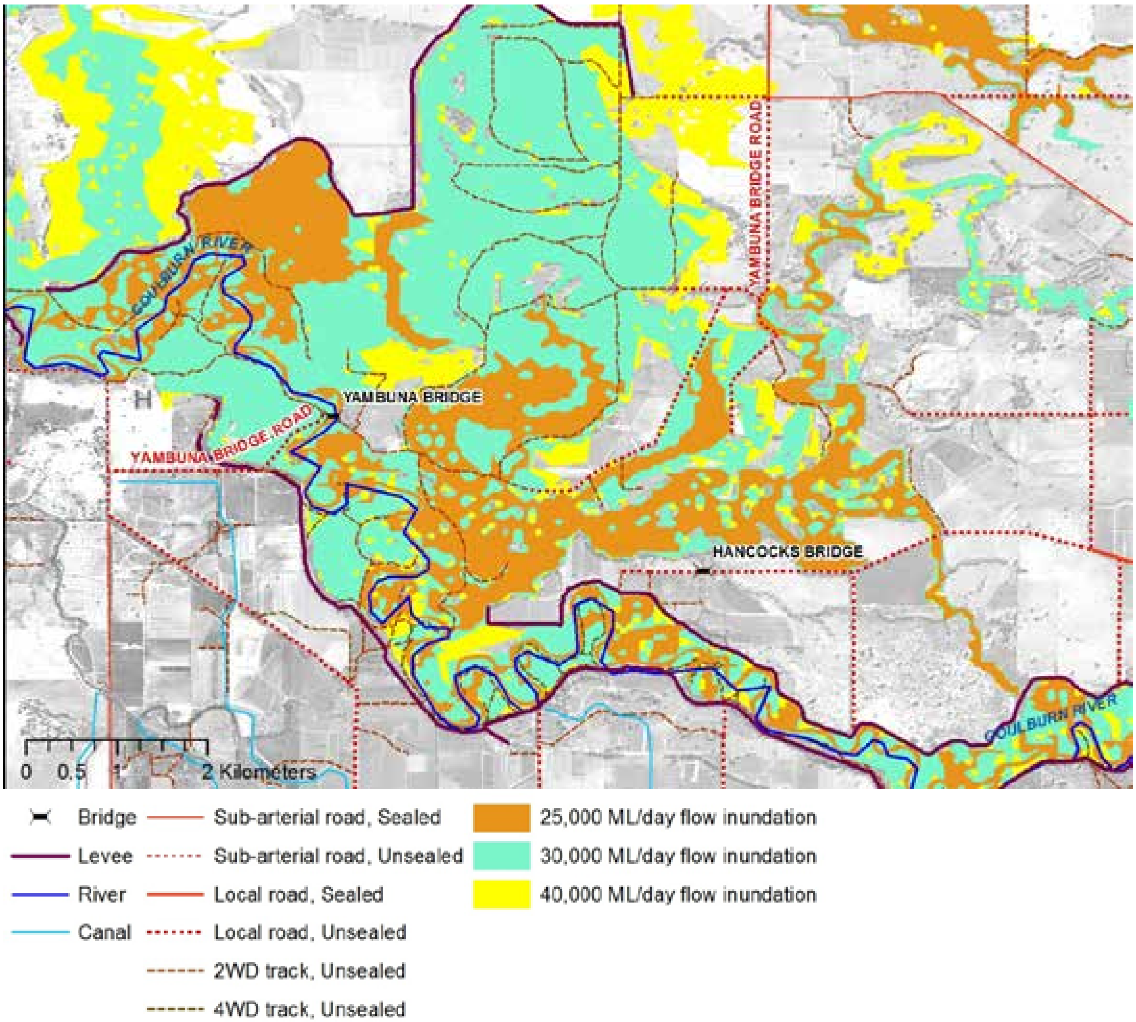

Figure 2: Inundation footprint downstream of Loch Garry in the Goulburn at 25,000 to 40,000 ML/day

In the South Australian River Murray key focus area, the South Australian Government used MIKE 21 hydraulic modelling (also developed by the Danish Hydraulic Institute) to map inundation.

We've used these maps to determine the potential impacts of higher flows in each key focus area so that we can estimate costs. We've consulted with local councils, communities and land owners on the maps, and used their feedback to help validate their accuracy.

In general, the mapping showed that the main infrastructure being inundated at the flows we are investigating are access roads, creek crossings and fences. The land is typically 'flood country', which is not cropped and generally does not have houses or significant sheds on it. However, there are some hotspots where access, crops, livestock, sheds and pumps can be affected. We will need to examine these further in the next phase of the Strategy.

Costing methodology

Delivering higher flows would in many cases cause some negative effects for landholders, which can be mitigated. We have investigated the potential costs associated with mitigating these impacts — in particular, the costs associated with two types of activity:

- the establishment of easements with landholders, or other arrangements, which would allow higher flows over their land
- infrastructure works to mitigate the impacts of higher flows (e.g. works on roads or waterway crossings).

These are not the only options that are possible. For example, another option would be the provision of flow advice so landholders know in advance when an environmental flow will happen and can take appropriate action. However, they are the options that are likely to be most material to the potential costs that may be associated with mitigation.

We used inundation footprint maps to work out how many properties, roads, bridges and crossings would be affected at different flows. Then we used hydrologic modelling to assess how often those things would be affected, for how long and at what time of year.

The MDBA engaged independent consultants to assist in developing the cost estimates.

GHD estimated the costs of easements in five key focus areas (Goulburn, Hume–Yarrawonga, Yarrawonga–Wakool, Lower Darling and Murrumbidgee). In South Australia, GHD estimated the costs of land management arrangements using a similar (but modified) approach to the method used for estimating easement costs. A modified method was used because, in South Australia, the main impacts of higher flows would be on shacks (i.e. houses next to the Murray, used largely for recreation) rather than on agriculture.

URS Corporation estimated the costs of infrastructure works on roads, bridges and crossings. The model they used assumed a given unit cost for certain types of works, and then estimated what types of works would be needed based on how often and for how long flows would affect a given road, bridge or crossing. The MDBA also engaged URS to estimate costs associated with some more specific works, such as potential upgrades to regulators in the Goulburn, Lower Darling and Murrumbidgee. The MDBA also took into account work by SKM (2013) and Water Technology (2013 and 2014) to estimate costs of potential upgrades to the Mundarlo Bridge and levee-related works in the Goulburn.

The cost estimates are subject to several assumptions and caveats:

- They were based on very specific hydrological assumptions, essentially that the constraints-relaxed flow regime can be adequately represented by the specific hydrologic model scenario we used.[2]
- They were based on a desktop analysis, drawing largely on geographic information systems spatial data.
- Easement estimates assume that land values, agricultural gross margins and impacts of higher flows can be generalised in a model. In reality they would vary from property to property.
- Infrastructure cost estimates make generic assumptions about the nature of works required.
- Estimated costs of crossings and bridges assume that only 75% of the full estimated cost would be paid. This is intended to account for the fact that:
    - a proportion of works on crossings would not be required, as interrupted access might also be addressed through easements
    - there would be scope for cost sharing, as upgrades to bridges and crossings would also provide considerable benefits to stakeholders, above and beyond mitigating the impacts of a constraints-relaxed flow regime.

It is also important to recognise that some potential costs were not estimated in the prefeasibility phase. This is because there is not enough information yet to estimate these costs on a consistent or robust basis. Costs were not estimated for the Gwydir key focus area, or mitigating impacts on specialist businesses, such as caravan parks and golf courses. There has been no costing of potential works on levees in the Yarrawonga–Wakool region, and no costing of upgrades of the real-time operating system, including developing rainfall run-off models.

Overall, the costing methods used are considered to be appropriate for prefeasibility purposes — that is, they provide cost estimates that can inform Basin ministers' decisions on whether to progress to feasibility, not specific investment decisions.

The estimated costs at this stage of the assessment are presented in Table 1.

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[2] Refer to MDBA 2012, *Hydrologic modelling of the relaxation of operational constraints in the southern connected system: methods and results.* Note that the BP2800RC model run assumed managed flows of up to 40,000 ML/day downstream of Yarrawonga Weir. Given this assumption, it was not possible using modelled flow data to estimate costs associated with flows of above 40,000 ML/day downstream of Yarrawonga Weir. To develop indicative cost estimates for the higher flow rates under consideration (50,000 ML/day and 77,000 ML/day) in the Yarrawonga–Wakool, alternative hydrological assumptions were used, which were not based on modelling.

Table 1: Preliminary cost estimates for relaxing constraints in key focus areas

Key focus area	Preliminary cost estimates (moderate estimate – high estimate)
Hume–Yarrawonga	$16–22 million
Yarrawonga–Wakool Junction (50,000–77,000 ML/day)[a]	$105–218 million
South Australian River Murray	$5 million
Lower Darling	$4–6 million
Goulburn	$31–47 million (assuming levee upgrades)
Murrumbidgee	$66–80 million
Gwydir region	Uncertain

a Note that cost estimates for Yarrawonga–Wakool potential flows of 50,000–77,000 ML/day are based on different hydrological assumptions to cost estimates for other key focus areas. Estimates presented in this table assume two additional events per decade at all flow rates.

Although we have identified a range of costs, the uncertainty of the variables those costs are based on means that the costs may still change as the details of constraint measures in each key focus area become more certain through the feasibility assessment. If the Constraints Management Strategy were to progress to the feasibility phase, further work could be undertaken, including on a property-by-property level, to develop more detailed and robust cost estimates.

Pelicans on Lake Pamamaroo, 2014. *Photo: Rachel Clarke, MDBA*.

Key focus areas

The Strategy identified seven key focus areas that have physical constraints worthy of further investigation in the prefeasibility phase, shown in Figure 3.

Separate reach reports detail the prefeasibility consultation and analysis that was done in each focus area, and a summary of the main findings is provided here. The reach reports are available on the MDBA website.[3]

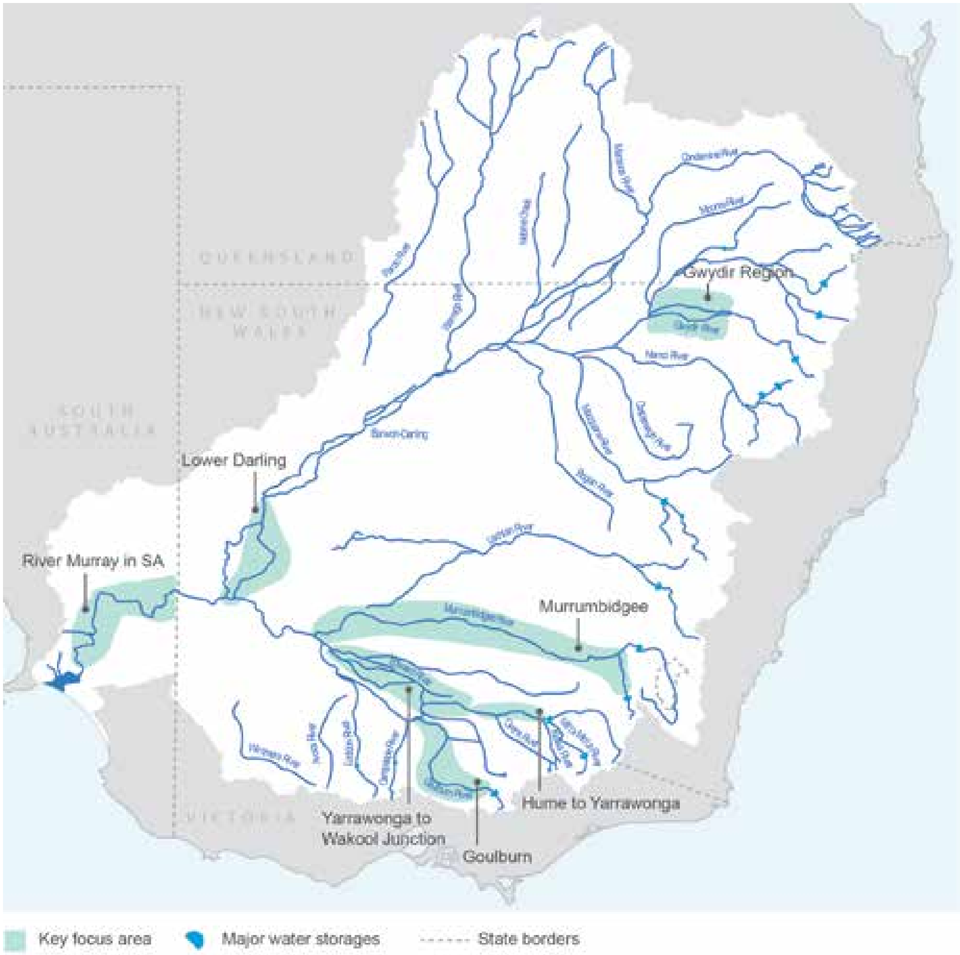

Figure 3: Key focus areas for constraints in the Murray–Darling Basin

3 www.mdba.gov.au/what-we-do/water-planning/managing-constraints/reach-reports

Hume to Yarrawonga (upper regulated River Murray)

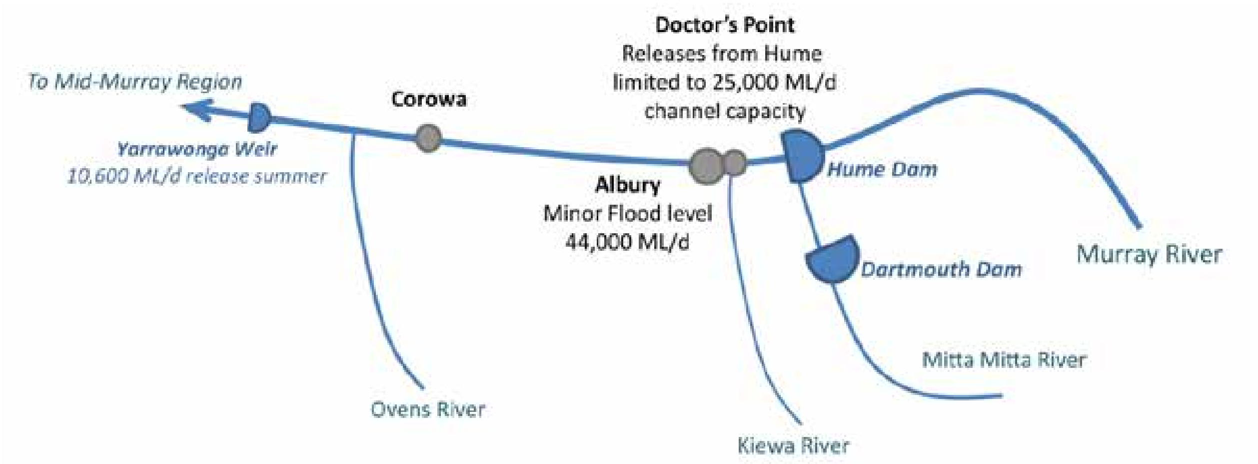

Figure 4: Hume to Yarrawonga key focus area

The Hume to Yarrawonga key focus area covers the River Murray channel and associated anabranches between Hume Dam and Yarrawonga Weir (Figure 4). This region receives the main flows from the headwaters of the River Murray, with rainfall and some snowmelt contributing the main inflows in the winter period. This part of the River Murray is a meandering system, with a multibranched channel and well-defined floodplain. The network of anabranches on the floodplain creates a number of billabongs that are connected to the river at various flow heights.

Hydrology

Hume Dam and Dartmouth Dam have dramatically changed the flow regime of this part of the River Murray. Prior to regulation, the Hume–Yarrawonga stretch of the Murray would have experienced peak flows in winter and early spring, and low flows in the summer period. Hume Dam now catches high flows in winter and spring, with peak irrigation demand causing high releases downstream during summer and autumn to supply irrigation water both locally, via the Mulwala and Yarrawonga irrigation channel system, and further downstream.

We are investigating the potential to increase the regulated flow limit in the Hume–Yarrawonga stretch of the river from 25,000 to 40,000 ML/day, as measured at the Doctors Point gauge around 15 km downstream of Hume Dam. Computer modelling shows that achieving flows in this range would allow for greater flows into the lower parts of the River Murray.

Flows in the range that MDBA is investigating are still relatively common, and MDBA is looking at only a modest increase in the frequency of these events. We are looking to have flows of this magnitude for longer and at times when they will get the most benefit (i.e. when flows from Hume Dam can be used to connect with tributary flows downstream to increase the size of the peak event and water more floodplain, or to extend the duration of a natural flow event to keep water on the floodplain for longer).

The timing of these flows would be between June and November when natural tributary flow events typically happen, and when the floodplain needs the water most. This timing also minimises competition for channel space by avoiding peak irrigation demands in late spring and summer.

Flows at Doctors Point of between 25,000 and 40,000 ML/day could be created by releases from Hume Dam in combination with tributary flows from the Kiewa River. These flows may be further added to by unregulated flows from tributaries further downstream. A flow of 40,000 ML/day at Doctors Point may be supplemented with flows from the Ovens River to contribute to a bigger peak flow downstream of Lake Mulwala.

Consultation

Compared with other areas in the Basin, MDBA's understanding of potential impacts and landholder concern is better developed for the Hume to Yarrawonga key focus area. Landholders within this area have a long-standing connection with MDBA (and previously the Murray–Darling Basin Commission). The Murray River Action Group, a representative riparian landholder group, provides an important and coordinated voice for most riparian landholders within the area, and has played a valuable role in helping us to understand the impacts of higher flows in this area.

There has been extensive community consultation around the prospect of increasing flows in the Hume–Yarrawonga key focus area of the Murray for more than a decade.

In 2011, a survey of 112 landholders in the area was conducted by GHD on behalf of the Murray River Action Group into the potential effects and mitigation options for flows of 40,000 ML/day. Issues raised in the survey focused on the effects on the following:

- farm infrastructure, such as bridges, crossings, tanks/troughs and haysheds
- crop and pasture, including cropped area (dryland and irrigated), and native, improved and unimproved pasture
- stocking rates
- impeded access
- management issues, such as animal health, weeds, clean up and farm planning.

There is general acceptance among landholders that 40,000 ML/day at Doctors Point will be the upper limit for flows to be investigated. However, there is still concern among some landholders that it would not be possible to mitigate the effects of flows at this upper limit.

Consultation with Albury City Council and Corowa Shire Council has also identified that there could be impacts on some low-lying, recreational land and businesses in their council areas.

Benefits to the environment and the community

There are a number of possible benefits to the environment in the Hume–Yarrawonga area. MDBA's inundation mapping showed that around 4,900 ha of flood-dependent vegetation and approximately 3,800 ha of wetlands would be inundated at flows of 40,000 ML/day.

In addition, enabling higher regulated environmental releases from Hume Dam would mean that floodplain communities downstream would also be able to be watered at times when they would get the most benefit.

Individual landholders may also benefit from mitigation measures like upgrading creek crossings. In most cases, land is affected and crossings get washed out or cut-off by unmanaged flows that happen already. While we are looking to increase the frequency of these flows, landholders will get the benefit of the mitigation measures even for unmanaged flows that would have happened anyway.

Possible mitigation options

Mitigation measures can be put in place for small overbank flows, but the community needs reassurance that the risks of unintended adverse consequences are being planned for and managed.

The current regulated flow limit of 25,000 ML/day was agreed to after extensive consultation by MDBA with landholders in this stretch of the river. The purchase of easements, riverbank stabilisation works and some infrastructure upgrades, such as improved road crossings, were undertaken to confirm this as the upper band of the in-channel regulated flow rate. It is likely that a combination of similar measures would be appropriate to mitigate the effects of a higher flow rate.

Anticipated costs

Costs in the Hume–Yarrawonga key focus area are estimated to fall in the range of $16 million (moderate estimate) to $22 million (high estimate). The main components of this estimate are:

- easements — approximately $6 million
- roads — less than $1 million
- bridges and crossings — from $9 million to $16 million.

The estimated costs for bridges and crossings take into account:

- work on crossings that would be affected by higher managed flows of between 25,000 and 40,000 ML/day
- potential further upgrades to some crossings on which works were undertaken under the Hume–Yarrawonga Access Works Program for managed flows of up to 25,000 ML/day.

Downstream of Yarrawonga Weir to Wakool Junction (mid-River Murray)

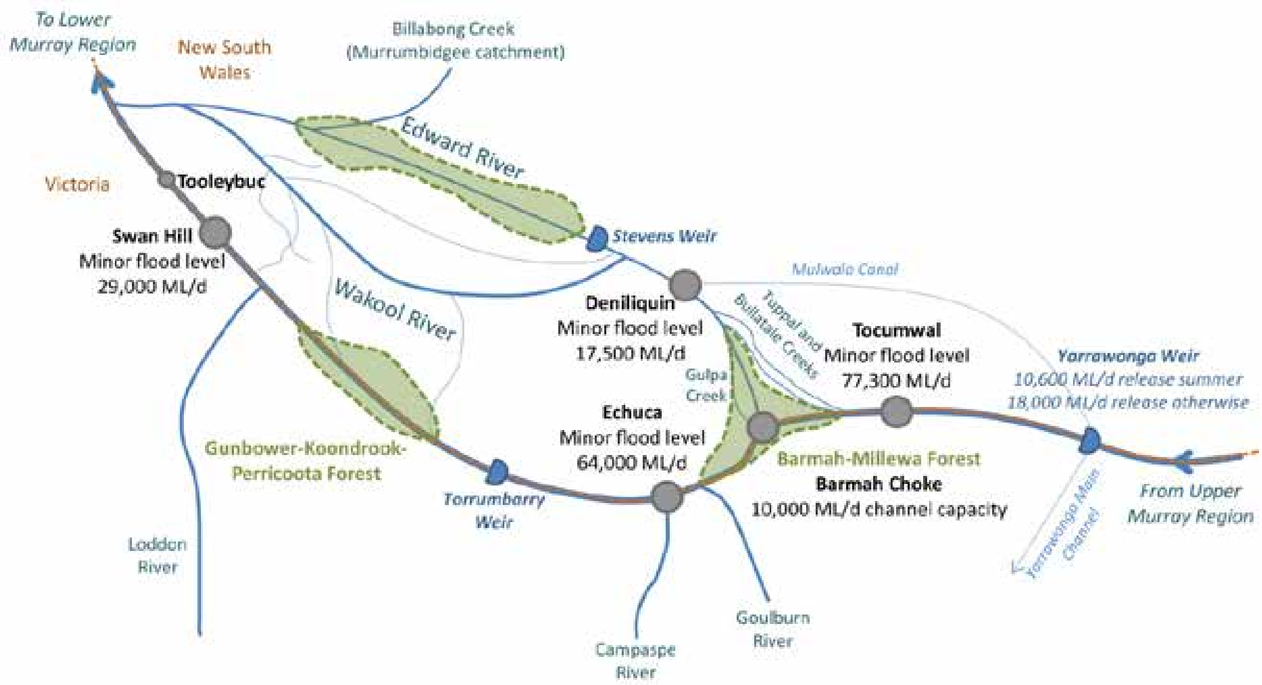

Figure 5: Yarrawonga to Wakool Junction key focus area

The key focus area from Yarrawonga Weir to Wakool Junction includes the mid-River Murray and the Edward–Wakool River system, but is also influenced by the Goulburn River and other Victorian waterways (Figure 5). The combined length of the major rivers in this area is more than 700 km. Around 30,000 people live within this area and the region makes a significant contribution to Australia's agricultural output for both irrigated and dryland farming. Agriculture is the Murray Region's leading sector by value, representing 14.1% of the regional economy (Murray NOW Inc. 2014).

The area includes key floodplain forests such as Barmah–Millewa, Werai and Gunbower–Koondrook–Pericoota forests. All three are listed under the Ramsar Convention[4] and the Barmah–Millewa and Gunbower–Koondrook–Perricoota floodplain forest networks are also icon sites under the Living Murray initiative.[5] This is a key region for environmental assets that we are seeking to sustain through increased environmental watering.

Generally, upstream landholders enjoy relatively high rainfall and the productivity of the floodplain depends more on rainfall than overbank flows. Properties further downstream are generally more reliant on overbank flows, or irrigation. This trend can

4 The Ramsar Convention is an international treaty for the conservation and sustainable use of wetlands.

5 www.environment.gov.au/water/environment/living-murray-initiative

be observed in many parts of the Basin, but is particularly evident from Yarrawonga Weir to the Wakool Junction.

Over time, the waterways within this key focus area have been modified and are now highly regulated. Hume, Dartmouth and Eildon dams store and deliver water for irrigation and consumptive needs.

One of the main effects of increased regulation has been a change in hydrology, resulting in less variability of instream flows, reduced flood frequency, a reduced area of extent (or overland flows) and changes in duration (Green 2001). Small and mid-sized flows that used to connect the rivers and creeks to the floodplain and its wetlands are now captured in dams. As a result, land that was naturally inundated annually or every two or three years is now only being inundated one in five or six years — or sometimes even less frequently.

This reduced frequency of flows has resulted in increased development of the floodplains. It has meant that some land that was predominantly unviable (due to excess flooding) could now be developed. Some of this land is used for grazing, whereas other areas are opportunistically cropped. Much of the floodplain that is cropped is protected by levees and is not expected to be threatened at the flow rates being considered, although in some cases additional levees may be needed to provide protection from increased flows.

The reduction in flow also means that some of the land is not as productive as it once was. Some landholders on such country are keen to have a few more small freshes or floods to ‘wet the country up’.

The environmental objective for the Yarrawonga to Wakool area is to allow a wider range of flows, and for the waterways to connect with the floodplain and its wetlands more often.

Hydrology

Before river regulation, larger winter and spring flows were commonplace and summer flows were typically very low. Flows along this part of the river have been modified by the three major upstream dams, and the various demands for water upstream, downstream and within this area.

To restore some of the small overbank winter and spring freshes, we are investigating a range of flows from 20,000 to 77,000 ML/day as measured downstream of Yarrawonga Weir. This range of flows will help to improve the health within the rivers and creeks of this area, but the higher flows are also able to reach wetlands and flood-dependent vegetation higher on the floodplains. These flows are generally contained within existing floodway and levee networks. Higher flows will also contribute to improving downstream environmental outcomes.

The Strategy is investigating adding an extra two to four flows every decade in the flow range between 20,000 and 35,000 ML/day (as measured downstream of Yarrawonga

Weir). For flows between 50,000 and 77,000 ML/day, we are looking at adding an extra one or two flows per decade.

These flows are likely to be delivered between June and November when natural flow events typically happen and when the floodplains need the water most. This timing also minimises competition for channel space by avoiding peak irrigation demands in late spring and summer.

To deliver and sustain flows of around 35,000 ML/day and higher, river operators would need to supplement contributions from unregulated rivers like the Ovens and Kiewa rivers in Victoria, with regulated releases from storages. Delivering flows between 50,000 and 77,000 ML/day would be strongly driven by additions to unregulated flows in a number of rivers.

Consultation

During 2013–14, MDBA held a series of meetings with a representative group of potentially affected landholders, local government councils, regional and state government agencies, and private irrigation companies. The MDBA also held local targeted meetings with landholders to seek local waterway views about different river and creek systems.

Overall, there was strong concern about an increased risk of creating or exacerbating large or unmanaged floods, especially with the largest flow rate being studied — 77,000 ML/day downstream of Yarrawonga Weir. While people broadly recognised the need to provide water to wetlands and to support aquatic wildlife, there was concern that the flat landscape and complex hydrology would combine to increase the risk of uncontrolled flooding. Landholders were also concerned that increasing the number of overbank flows would 'wet-up' the country more often and make it more likely to flood in subsequent rainfall and flow events.

At the smaller and mid-sized flow rates (20,000 to 50,000 ML/day), landholders also noted impacts, most commonly access issues from low-lying water crossings getting washed out or flooded, and remained concerned about flood risk. This is often disruptive to farming operations and livestock management. Conversely, there was a recognition that the effects of smaller flows could potentially be managed, and that these flows could have environmental and community benefits. We need to do further work to explore these opportunities for mutual benefits.

Improving understanding of potential flood risk from higher and more frequent managed flows, and how we can manage that risk, may help to build community confidence in refining suitable future flow rates.

The community identified a number of specific issues:

- If unregulated and unpredictable tributary flows and/or rainfall events coincide with regulated releases from Hume Dam, this may result in higher than planned river flows and unintended adverse consequences. Unregulated tributaries and local rainfall can significantly influence flows on the River

Murray and within the Edward–Wakool system, and should not be underestimated.

- Catchment conditions can significantly alter the extent of a flow event or flood. Delivering a regulated flow onto a 'wet' floodplain will likely result in flooding across a larger area than a 'dry' floodplain.
- Flows below 'minor flood level' at Tocumwal have effects on private landholdings along most of the waterways in the area. The higher flows are likely to result in inundation of areas of private land, particularly 'flood country'.
- The hydrology of this key focus area is complex and there has been considerable development of the floodplain. Levees and other structures may have changed how water moves through the landscape. Trials of potential flows should be conducted on an incremental basis to test for effects on people before larger flows are trialled.

Benefits to the environment and the community

By making our waterways and wetlands healthier, these flows have the potential to benefit fish, birds and other wetland animals. Woodlands and forest that line the waterways will also get watered more often. These flows also have the potential to improve soil and water quality.

Different levels of change would bring about different effects for the Yarrawonga to Wakool Junction key focus area.

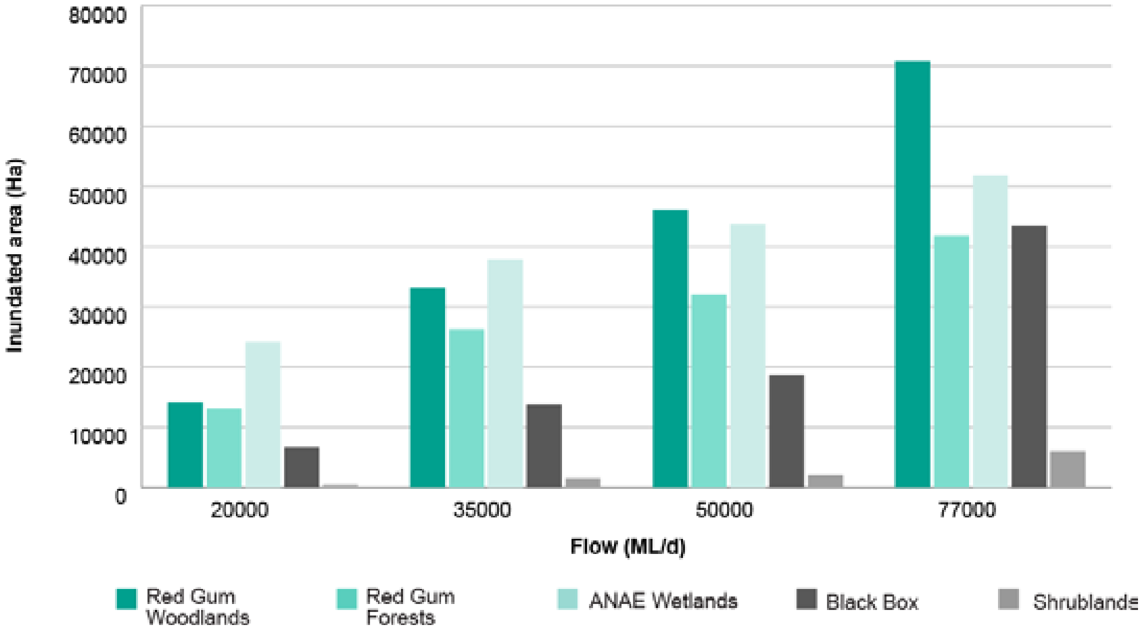

Figure 6 shows the increase in the areas of vegetation inundated by different flow rates.

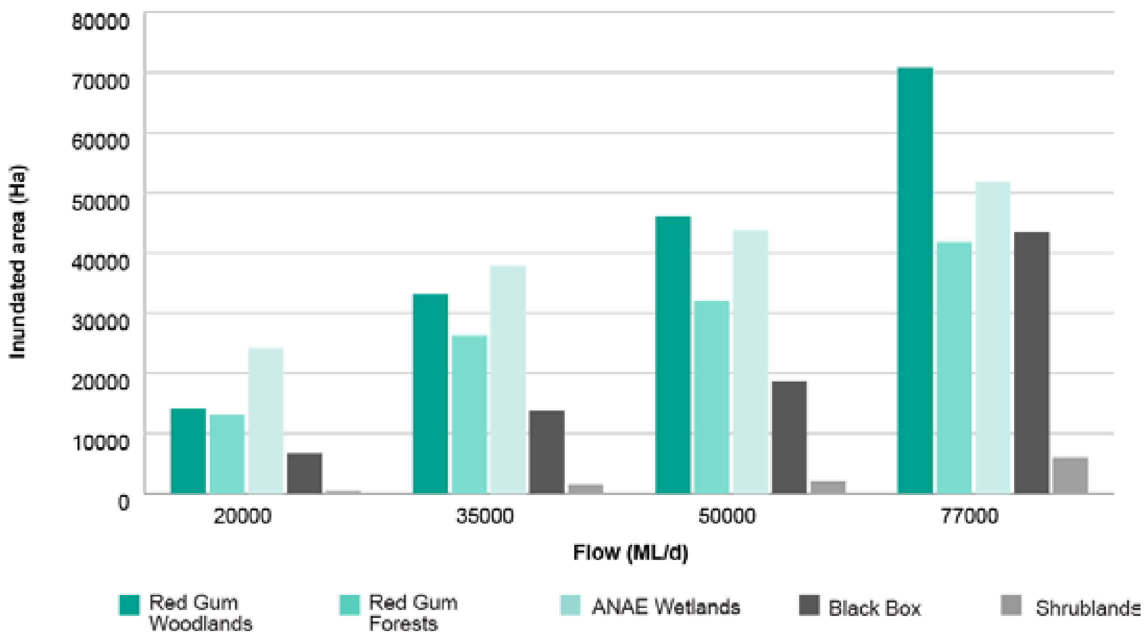

Figure 6: Inundated vegetation area in the Yarrawonga to Wakool Junction key focus area

At the lowest flow rate, more than 90% of flows are contained within designated floodways and the public floodplain forest network. At flows of 77,000 ML/day, more than 85% of flows are contained within designated floodways.

As in the Hume to Yarrawonga key focus area, individual landholders would also benefit from mitigation measures, such as upgraded creek crossings, even for unmanaged flows that would have happened anyway.

Possible mitigation options

Mitigation measures can be put in place for increased in-channel flows and small overbank flows, but the community needs reassurance that the risks of unintended adverse consequences are being planned for and managed.

Potentially affected low-lying bridge on Bullatale Creek. *Photo: Terry Korodaj, MDBA*.

Mitigation options could include:

- Information systems that inform communities of environmental flows in advance so people can take whatever preventative steps they need to take well before the arrival of water.
- Replacing on-farm, low-lying crossings with more permanent structures that enable access during both regulated and unregulated flows. These crossings need to allow passage of farm machinery, be fish friendly and meet floodway planning requirements. (An example of the type of crossing that would be replaced is shown in the photograph above.)
- Works to fix existing minor flooding issues, including road upgrades, bridge improvements and upgrading existing flood control structures.
- Negotiated agreements with landholders to create easements that enable regulated water to access the privately owned parts of the floodplain.
- Investigating new engineering options to eliminate effects caused by small overbank flows.

Anticipated costs

Prefeasibility costs for this area focused on infrastructure, such as roads, bridges and crossings, and easements. Flood-protection levees are potentially an important mitigation action for parts of this area. However, data on the floodplain levee network were not available for assessment.

Modelled hydrological data — to assess the frequency, timing and duration of impacts — were only available for flows of up to 40,000 ML/day downstream of Yarrawonga Weir. The costs for mitigating impacts for flows just below this rate (at up to 35,000 ML/day downstream of Yarrawonga Weir) were estimated to be between $84 million (moderate estimate) and $107 million (high estimate), excluding levees.

To understand potential costs at other flow rates, in particular, flows of up to 50,000 ML/day or 77,000 ML/day downstream of Yarrawonga Weir, we also estimated costs based on an assumed increase in the frequency of flows. These frequencies do not indicate the likelihood or feasibility of this type of flow regime, but help to provide an indication of costs.

If there are two additional events per decade, the costs have been estimated to be $105 to $131 million (for flows of up to 50,000 ML/day) or $174 to $218 million (for flows of up to 77,000 ML/day).

If there are four additional events per decade the costs have been estimated to be $114 to $147 million (for flows of up to 50,000 ML/day) or $195 to $254 million (for flows of up to 77,000 ML/day).

There are a number of other mitigation and operational measures that may be needed that have not been costed. These include:

- upgrades to the stream-gauging network
- upgrades to drainage or stormwater management systems
- management costs of major irrigation system infrastructure
- mitigating impacts on specialist businesses
- upgrades of existing or construction of new levees.

South Australia (Lower Murray)

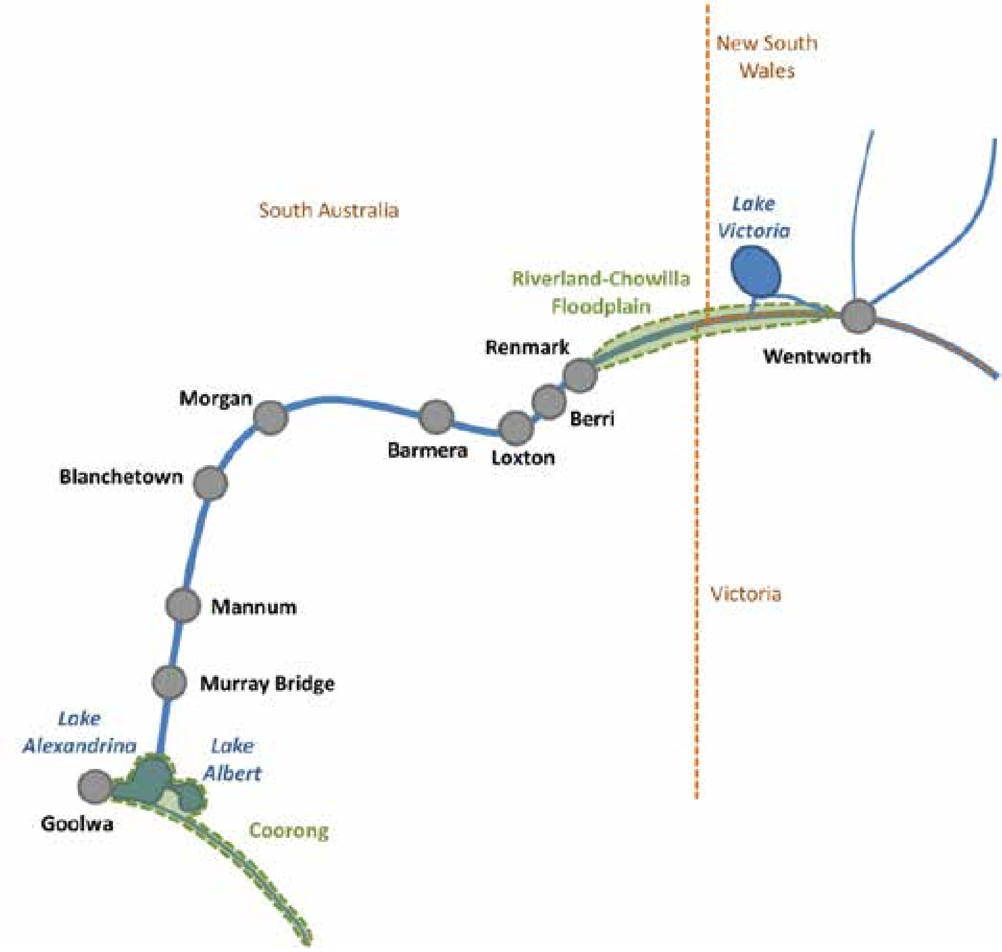

Figure 7: Lower Murray key focus area

The South Australian River Murray is a diverse system comprising the main river channel; extensive areas of floodplain; temporary and permanent creeks and wetlands; sprawling floodplains; swamps; the large freshwater Lakes Albert and Alexandrina; and the unique Coorong and estuarine Murray Mouth region (see Figure 7).

Hydrology

The River Murray system has been significantly changed by river regulation, reducing the natural variability of flows that keep the wetlands and floodplains healthy.

Today, minimum flows into the South Australian River Murray tend to be around 3,000 to 6,000 ML/day according to monthly entitlement flows. Environmental water can be added to river flows to facilitate biological processes such as fish spawning, or to inundate local wetlands to encourage frog and bird breeding. During moderate-flow periods, the addition of environmental water can be used to increase the area of floodplain inundated, which helps drive biological processes, improves water quality and removes salt from the system.

Without a headwater storage in South Australia, achieving flows of above 60,000 ML/day at the South Australian border through environmental watering is dependent on achieving the higher flow thresholds in the upstream key focus areas.

Flows of 60,000 to 100,000 ML/day are described as a ‘high flow’ for the river generally, but is described as a ‘minor flood’ for the shack areas from around Morgan to Mannum. These shacks (i.e. houses that are largely used for recreation) are generally located close to the river’s edge and have been constructed with knowledge that, from time to time, the land will be flooded as river levels rise. Consequently, many shacks have been built on stilts, with elevated living areas above the level of most floods, although the design and construction of these shacks vary greatly. Floodplain landholders, including shack owners, are required to secure or remove loose items, and prepare their properties when the river levels rise.

An analysis of area of wetland and floodplain inundated at particular flow rates in South Australia has shown that the greatest increase in vegetation and wetlands area occurs between 60,000 and 80,000 ML/day at the South Australian border.

From recent high flow events in 2011 and 2012, it was evident that some shack areas start to be affected from flows of 60,000 ML/day at the South Australian border. MDBA modelling indicates that flows of approximately 80,000 ML/day represent an upper threshold of the range of flows that could be practically delivered to South Australia within the limits identified for upstream areas. Therefore, MDBA has investigated the impacts of flows between 60,000 and 80,000 ML/day at the South Australian border. The modelling shows that flows of 80,000 ML/day for 30 days or more would have occurred in 34% of years naturally, compared to only 10% of years in the developed system (MDBA 2012). If constraints were relaxed, environmental flows in this range could happen more often, but the exact frequency would depend on the ability to coordinate flows from the River Murray and other tributaries upstream.

Consultation

In 2013, MDBA and the South Australian Government consulted representatives from the river communities about the implications of flows of 60,000 and 80,000 ML/day in the South Australian River Murray. According to the local councils and Indigenous leaders we spoke to, the majority of issues that occur would be manageable provided adequate warning is provided. The main issues raised were:

- Some council assets along the riverbank (e.g. barbeques, public toilet blocks and boat ramps) are unusable at flows of above 60,000 ML/day, but the majority can either be secured, removed or were constructed to tolerate inundation.
- Maintenance of these assets can be required after the river returns to normal level.
- High flow rates could affect tourism if they occur during the peak tourism periods around Christmas and Easter, which may have follow-on effects for the local economy.

- In the shack areas downstream of Morgan, there can be adverse effects on private land and property. In some shack areas, flows of above 60,000 ML/day may damage some property (e.g. shacks, sheds and jetties) or cause inconvenience to the owners. Some roads may be inundated, which would restrict access to some shacks in these areas.

The findings of these meetings were presented to representatives from the community in a workshop in Mannum in 2013 and in Murray Bridge in 2014. Participants considered that, in general, river communities understood these flows to be an essential part of the river environment and any issues experienced could be mitigated.

Benefits to the environment and the community

River red gum, river cooba and black box trees need regular flooding to survive and reproduce. The higher the flow, the more area of floodplain can be inundated. Increasing a flow of 60,000 to 80,000 ML/day inundates an extra 30,000 ha of wetlands and floodplain vegetation.

Flows of 80,000 ML/day will help to:

- maintain and improve the health of river red gum and black box woodlands
- maintain and improve the health of lignum shrublands
- stimulate fish spawning, provide access to the floodplain and provide nutrients
- inundate temporary wetlands and vegetation to provide habitats and food for birds, fish and frogs
- provide the mosaic of habitats required by different species in the system
- improve water quality by flushing salt out of the system
- assist in maintaining an open Murray Mouth by flushing large volumes of sand to the sea
- assist in maintaining appropriate salinity levels in the Coorong, Murray Mouth, and lakes Alexandrina and Albert.

As in other key focus areas, individual landholders may also benefit from mitigation measures, such as improving roads, which would still be in place for those unmanaged flows that would have happened anyway.

Possible mitigation options

Initial investigations and consultation has indicated that the majority of issues that occur are minor and manageable, provided adequate warning is provided and peak tourist season is avoided. Possible mitigation options include:

- long-term forecasting of overbank flows to enable councils and the local community to plan for effective management of flows
- advice and warnings of higher river flows to assist landholders, the community and visitors to take actions to effectively manage the effects of these flows
- environmental water planning (i.e. the timing for delivering overbank flows) should take into account, where possible, the effects on tourism

- educating the general public about a healthy and sustainable river system to help people manage different flows and encourage a range of tourism ventures in the region
- land management arrangements or measures to address inconveniences and mitigate adverse effects on private land and property, although actual options would require further investigation with potentially affected landholders.

Anticipated costs

The South Australian Government undertook a desktop assessment of the impacts on private property, which has informed the costings section of this report.

Costs in South Australia are estimated to be up to around $5 million. The main components of this estimate are:

- land management arrangements — approximately $2 million.
- roads — up to approximately $3 million.

It has been assumed for prefeasibility costings purposes that cost estimates in South Australia should consider only impacts on shacks and on access to those shack areas (i.e. upgrading affected roads).

Adverse impacts on other land (e.g. agricultural land or other types of land use) could not be accurately assessed from desktop methods alone without on-ground verification, and hence costs (if any), will be considered during the feasibility phase.

Lower Darling

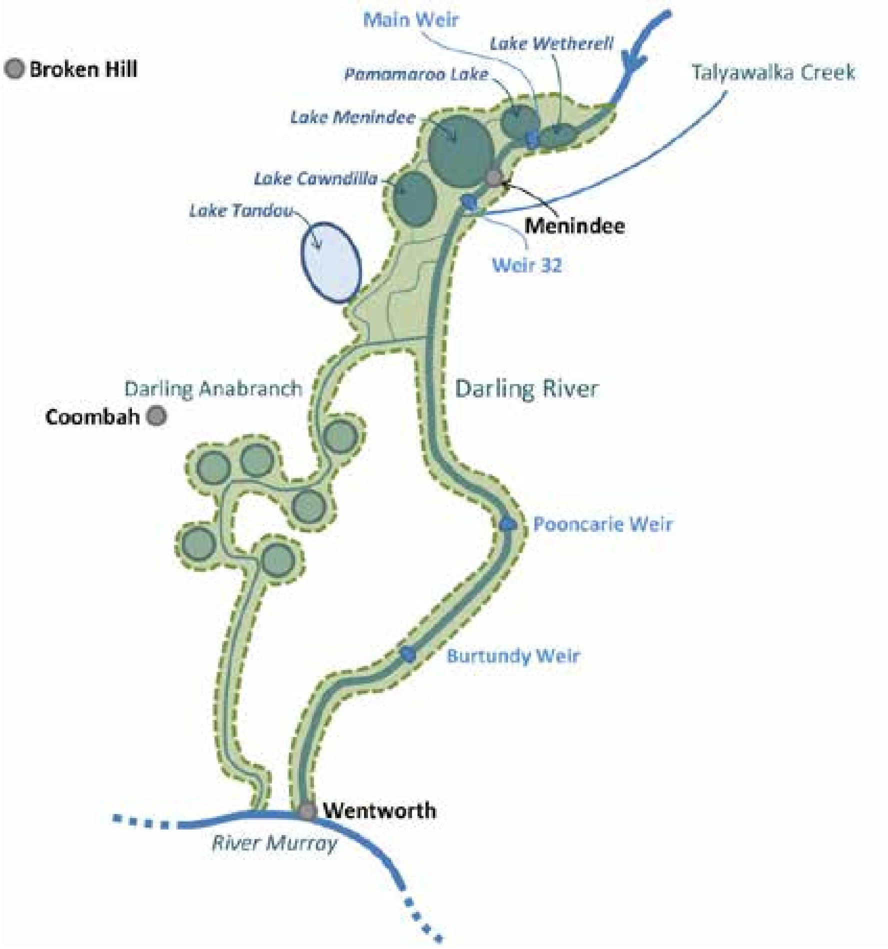

Figure 8: Lower Darling key focus area

The Lower Darling key focus area is the section of the Darling River between Menindee Lakes and where the Darling joins the River Murray at Wentworth (see Figure 8).

The water that flows into the Menindee Lakes system comes from the rivers that flow south from southern Queensland and the uplands of northern New South Wales. Flows in the Darling are driven by episodic and variable rainfall events, as well as summer storms.

Below the Menindee Lakes, the Lower Darling has two large and distinct channels: the Lower Darling main channel and the Great Darling Anabranch. The Great Darling Anabranch is the ancestral channel of the Lower Darling and features a number of overflow lakes that can hold water for prolonged periods following a flood event. It branches off from the main channel about 55 km south of Menindee and joins the Murray downstream of Wentworth.

In the past, the Lower Darling provided significant contributions to high flow events into the River Murray in South Australia. However, the completion of the Menindee Lakes

Storage Scheme in the 1960s meant that these flows are now mostly being captured and stored. Water in Menindee Lakes is shared by New South Wales and Victoria.

Hydrology

Before the construction of the Menindee Lakes Storage, flows in the Lower Darling generally occurred in spring or autumn. However, the regulation of the lakes means that high flows are now regularly delivered in summer.

The current regulated flow limit for the Lower Darling is 9,000 ML/day at Weir 32. Flows above this height start to run into the Great Darling Anabranch and to fill some other billabongs and wetlands.

MDBA has investigated the potential for flows of 14,000 and 17,000 ML/day at Weir 32. To deliver these flows, it would be necessary to put regulators on the Great Darling Anabranch and Yartla Lake.

Environmental flows would generally be between June and November when natural flows in the River Murray typically happen. Historical records show that the Lower Darling regularly experienced high flow volumes during this time as well, so these flows are also likely to benefit wetlands in the Lower Darling. Research shows that 50% of wetlands on the Lower Darling channel are inundated at flows of 13,000 ML/day.

The New South Wales Office of Water is delivering the Menindee Lakes Water Savings Project, in partnership with the Australian Government. Among other things, this project is investigating the potential to increase the size of the Menindee Lake outlet regulator to 14,000 ML/day. This means that the flows under investigation could be delivered solely from Menindee Lake, or supplemented with a release from one of the upper storages or by a translucent flow, depending on the desired flow rate.

Consultation

Consultation in the Lower Darling has been fairly limited to date to avoid stakeholder confusion with the Menindee Lakes Water Savings Project, which is being consulted on at the same time. However, several meetings were held with community stakeholders in the region in both 2013 and 2014 to understand the potential effects of higher flows and to share the inundation mapping that we have developed.

Landholders are generally not concerned about the inundation footprint of the flows being delivered, but are concerned that delivering such large volumes may pose a risk to the reliability of their entitlements. Landholders on the Lower Darling main channel are very protective of the water resource held in the upper two lakes — Lake Wetherell and Lake Pamamaroo — viewing the water in these storages as their drought supply. Landholders are strongly opposed to any suggestion that some environmental flows could be sourced from those storages.

Landholders on the Great Darling Anabranch are strongly opposed to the idea of a regulator on the anabranch. Although a regulator would only be used one or two times in a decade, they feel that once it is installed it will be used all the time for both regulated and unregulated flows, and then the Great Darling Anabranch will not receive the flows it needs.

Additional concerns about the proposed flows included:

- the potential for livestock to get bogged in the mud as the flow recedes
- erosion of the riverbanks
- inundation of low-level crossings
- additional work or expense involved in raising pumps and excluding stock from riparian areas.

Benefits to the environment and the community

There a number of possible benefits to the environment in the Lower Darling key focus area. Inundation mapping conducted by MDBA showed that more than 2,500 ha of flood-dependent vegetation and approximately 400 ha of wetlands would be inundated at flows of 14,000 ML/day, with more than 4,000 ha of flood-dependent vegetation and nearly 1,200 ha of wetlands inundated at flows of 17,000 ML/day. Given that this mapping excluded the anabranch, but did not account for the downstream effects of installing regulators on the anabranch or Yartla Lake, the area of vegetation inundated is likely to be even larger.

Enabling higher regulated flows from the Menindee Lakes would also mean that environmental flows from the Lower Darling could also contribute to improvements in outcomes downstream in the Murray.

Possible mitigation options

The flows under consideration in the Lower Darling are unlikely to cause significant adverse effects for landholders on the Lower Darling. The most serious issues that landholders raised were concerns about the potential for effects on reliability of supply and the fear of a decline in flows in the Great Darling Anabranch as a result of construction of a regulator. Additional work is required to demonstrate that the flows and infrastructure works on the Lower Darling will not increase the risk to reliability of water for either extractive users or for flows to the Great Darling Anabranch.

Landholders in the Lower Darling are eager to be involved in a transparent process with good, two-way communication going forward.

Anticipated costs

Costs in the Lower Darling are estimated to fall in the range of $4 million (moderate estimate) to $6 million (high estimate). The main components of this estimate are:

- easements — less than $1 million
- bridges and crossings — less than $2 million
- works on regulators on the Great Darling Anabranch and Yartla Lake — from $2 million to $4 million.

Potentially, some of the costs on regulators could be met from other programs or processes, such as the Menindee Lakes Water Savings Project.

Goulburn

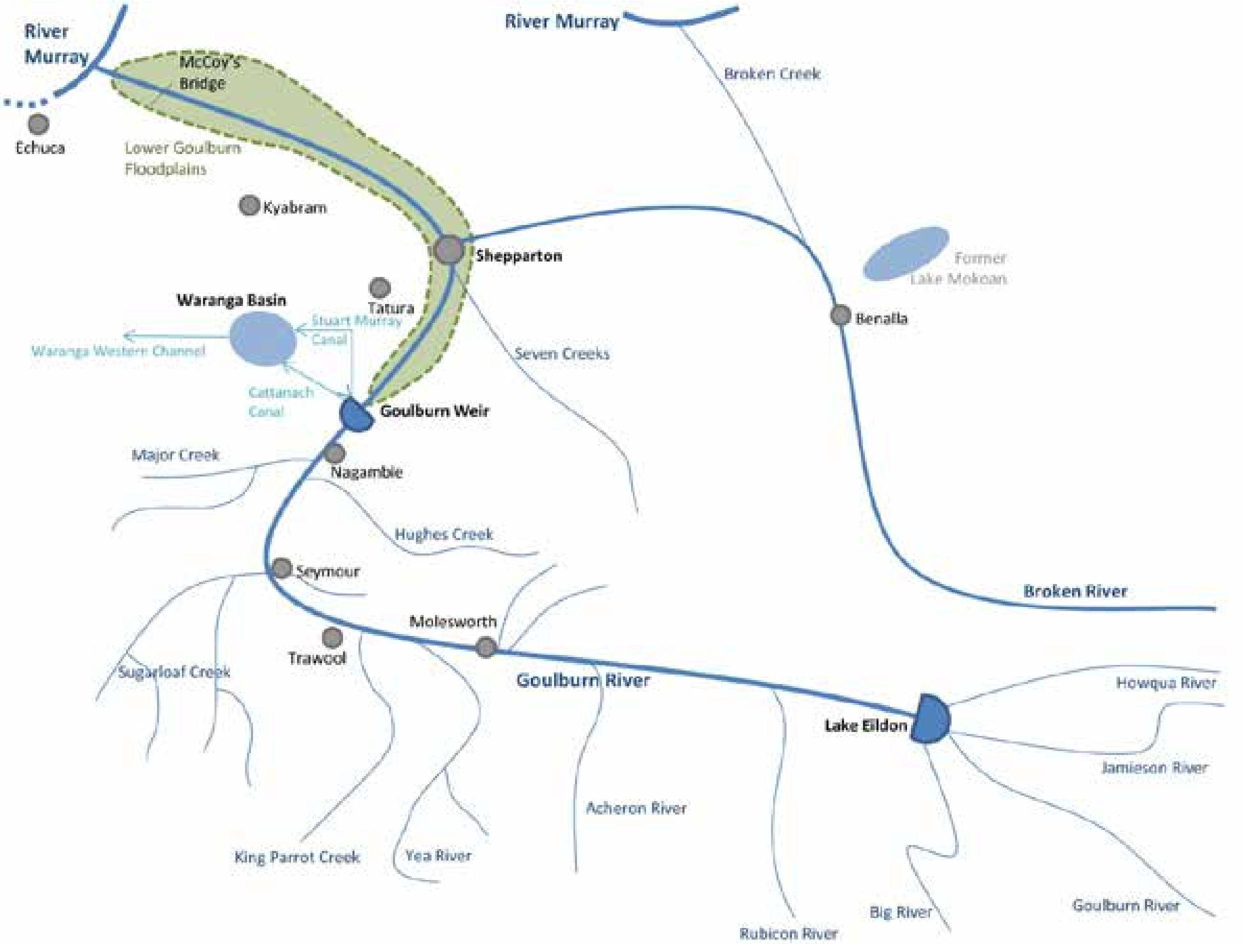

Figure 9: Goulburn key focus area

The Goulburn River is 570 km long and around 215,000 people call the Goulburn region home (Figure 9). The Goulburn region encompasses some of Victoria's most productive land. Around 20% of the total value of Victoria's agricultural production is generated in this area.

The region is rich in natural assets, being home to a significant proportion of the Basin's biodiversity, with nature reserves, forests and wetlands recognised as being significant for supporting migratory waterbirds.

However, a series of studies have consistently said that the current frequency of overbank flows is less than what is needed to maintain the health of the lower Goulburn floodplain.

The environmental objective for the Goulburn is to allow the river to connect with its floodplain more often. This means delivering overbank flows around minor flood level.

This will allow water to reach creek networks, billabongs, wetlands and floodplain vegetation in the lower Goulburn, as well as delivering freshes to the River Murray downstream.

To allow the Goulburn River to connect with its floodplain more often, we are looking at possible new ways to increase regulated flows in the Goulburn River. Increasing watering flexibility will require measures to be put in place to protect communities and businesses from minor flooding issues and risks.

Hydrology

Over time, the hydrology of the Goulburn River has been modified and become highly managed. Two major features, Lake Eildon and Goulburn Weir — which regulate river flow and supply water for irrigation, urban and environmental purposes — have principally modified river flow along the Goulburn River. Changing the flow pattern affects where, when and how often water spreads across the landscape. This disrupts natural cues that stimulate feeding, growing and breeding for many plants and animals, contributing to the decline of many native species in the region.

Lake Eildon is a relative large storage (3,390 GL), with a storage capacity of twice its annual average inflow (1,700 GL). It is also worked hard each year to support large-scale irrigation. As a result, it only spills rarely. This means that many of the small overbank flow events that would occur without Lake Eildon no longer occur.

The filling and release patterns of Lake Eildon typically dominate the flow regime in the Goulburn River between Eildon and Goulburn Weir. However, to some extent, this is lessened by a number of unregulated tributaries which add water downstream of Lake Eildon. Together, the unregulated tributaries in the mid-Goulburn contribute as much water as the upper Goulburn tributaries above Lake Eildon. The additional water from the tributaries means releases from Eildon would most likely be limited to around 15,000 ML/day, but tributary inflows may make the total flow higher further downstream.

At Shepparton, the flow regime is largely influenced by unregulated tributary inflows (Broken River and Seven Creeks). This is because most of the Lake Eildon releases and mid-Goulburn tributary flows are diverted at Goulburn Weir across to Waranga Basin to supply a number of high-value irrigation districts.

Because of river regulation, and the way Lake Eildon and Goulburn Weir are managed, flows in the range of 25,000 to 55,000 ML/day between Murchison and Shepparton are:

- a lot less common (occuring at 20% to 30% of their natural frequency)
- do not last as long (lasting 50% to 70% of their natural duration)
- have a longer gap between events (having a maximum period between events that is 2.5 to 3.5 times longer than natural) (DSE 2011).

The Strategy is investigating if it is possible to restore a range of small overbank flows, of between 25,000 to 40,000 ML/day at Shepparton, to achieve specific lower Goulburn floodplain outcomes.

This range of flows waters the majority of wetlands and flood-dependent vegetation on the lower Goulburn floodplain (mainly native vegetation and the Lower Goulburn National Park), while avoiding the risks and liabilities of flooding productive land outside of the levee network, and aims to avoid triggering the opening of the Loch Garry regulator, Opening the Loch Garry regulator allows large volumes of water to flow out through the Bunbartha–Deep–Sheepwash–Skeleton Creek complex and can be very damaging to landholders in the Bunbartha region.

Flows at Shepparton of between 25,000 and 40,000 ML/day, around minor flood level, could be created by regulated releases from Lake Eildon and/or Goulburn Weir to top up unregulated flows from the tributaries.

These flows would occur between June and November, when natural tributary flow events typically happen and when the Goulburn floodplain needs the water most. This timing also minimises competition for channel space by avoiding peak irrigation demands in late spring and summer. Based on initial overbank flow recommendations for the lower Goulburn in 2011, the flows would occur at least once every three years. Given that these flows sometimes happen naturally, this means an extra one to two managed overbank flows each decade to achieve environmental outcomes in the lower Goulburn.

Future development and testing of real-time catchment and river models would provide water managers, river operators and community with the confidence to further enhance watering within the target flow range. This would take the floodplain closer to an environmentally sustainable watering regime. Further analysis of how governments might manage the river in the future may provide different opportunities to achieve these flows; however any increase in managed overbanks flows will only occur when likely effects are able to be managed.

Consultation

In 2013, MDBA formed three advisory groups of a range of local residents and businesses from along the Goulburn River, and their input is included in the Goulburn reach report.

While there are concerns about flows happening too often (more than a few extra times a decade), lasting too long (longer than a week), or happening too late in spring (October to November), it is generally recognised that water on river flats can be good for farming, the environment and the productivity of the land. Some long-time residents believe that the river flats are not as healthy as they used to be when smaller floods used to happen more often.

People in the Goulburn community are willing to continue to work with MDBA, especially around exploratory feasibility and technical work. They want proof that managers know enough and that the system can be controlled and managed at the flows being proposed. Their feedback to date has identified a number of key points:

- The Strategy is an opportunity to fix up long-standing minor flooding issues for people — this is an important benefit that should be promoted.

- There are community members who identify themselves as being direct beneficiaries of floodplain watering in the lower Goulburn — they would like to see flexibility to fill up creeks and wetlands when the waterways need it, not just putting water down the main Goulburn River channel.
- Even small increases in regulated water levels immediately downstream of Lake Eildon can start inundating private land. This is because the channel capacity of the Goulburn is very limited around Alexandra and Molesworth and there are a number of unregulated tributaries that add water to this stretch of river as well as Lake Eildon regulated releases.
- Flow events can be quite different and the wetness of the catchment (or recent previous flow events) has a big influence on how far the river rises or spreads. This needs to be taken into account.
- People want the Strategy to plan for residual risk — what if something goes wrong, what if the flow is larger than expected, what happens? How will people be protected? Where does the financial liability lie? Importantly financial risk and liability should not be shifted onto the affected individual or business.
- A flow of 40,000 ML/day at Shepparton is too close to triggering the Loch Garry flood protection scheme. Opening the regulator is very damaging to landholders in the Bunbartha region.
- Assessment of backing-up effects on tributaries needs to be included in any further work (high Goulburn River water levels and the potential for extended releases from Lake Eildon).
- If unregulated and unpredictable tributary flows and/or rainfall events coincide with environmental releases from Lake Eildon, this may result in higher than planned river flows and unintended adverse consequences. Unregulated tributaries are a significant influence on the regulated Goulburn River and should not be underestimated.
- Work is needed to scope improvements to the stream-gauging network that will lead to more accuracy, confidence and forecasting power. This is especially relevant for addressing limited rainfall and flow gauging in the unregulated tributaries. Improvements will allow river operators to more confidently make regulated releases from storage to combine with unregulated tributary flows to create downstream flows of a desired peak flow rate and duration.
- Detailed planning is needed around how small overbank flows could be created and managed under a range of catchment condition and tributary flow scenarios. Planning should include worst-case risks (e.g. an unexpected rainfall event after water has been released from storage).

Benefits to the environment and the community

The flows have the potential to benefit a number of species, particularly wetland plants, river red gum forests and a range of fish species. They also have the potential to improve soil and water quality. Businesses and communities also rely on the good health of the waterways, as they are the economic lifeblood of the region.

Increases in regulated flows would allow water to reach different parts of the lower Goulburn floodplain. For example, 25,000 ML/day at Shepparton would reach 45% of flood-dependent vegetation on the floodplain, 30,000 ML/day would reach 74% and 40,000 ML/day would reach 89%.

As in other key focus areas, individual landholders may also benefit from mitigation measures, such as improving critical access routes, even for unmanaged flows that would have happened anyway.

Possible mitigation options

Mitigation measures can be put in place for small overbank flows, but the community needs reassurance that the risks of unintended adverse consequences are being planned for and managed. Options could include:

- works to fix existing minor flooding issues in rural and urban areas (e.g. road closures that already happen often, such as Yambuna Bridge Road)
- upgrading roads, bridges and other infrastructure to make sure critical roads and access routes are kept open
- upgrading ageing flood-control measures (i.e. ensuring Goulburn levees are to a enough standard and strong enough to contain flows)
- investigating new engineering options to eliminate or mitigate nuisance caused by small overbank flows
- easements or other agreements with private landholders
- property-level protective infrastructure works
- upgrading tributary rainfall run-off gauging network for improved forecasting power and accuracy
- developing detailed planning around how overbank environmental flows could be created and managed under a range of scenarios, including worst case
- sensitivity analysis to better understand how the scale of minor flooding issues vary by frequency, time of year and duration
- reviewing Loch Garry trigger rules to ensure Loch Garry is only opened when it needs to be.

Anticipated costs

MDBA costed some of the key mitigation measures that would be needed to protect communities and businesses from the effects of higher regulated flows. We investigated costs for roads, bridges and easements, as well as what might be involved in making sure that the levees are to a high enough standard and are strong enough to contain the largest environmental flows being considered.

In 2014, it was not possible to model every possible combination of flow rates. So the mitigation cost for the Goulburn is based on flow footprints of up to 20,000 ML/day between Eildon dam and Goulburn Weir, and flow footprints of up to 40,000 ML/day downstream of Goulburn Weir. Lower flow rates may result in lower costs.

Goulburn mitigation costs are estimated to be between $19 million (moderate estimate) and $27 million (high estimate), or between $31 and 47 million if lower Goulburn levee upgrades are included. These totals can be broken down into the following components:

- easements — approximately $7 million (if inside and outside the levee system), which would fall to approximately $6 million if works on levees are undertaken to keep flows within the leveed floodplain
- roads — approximately $7–11 million ($6–10 million if works on levees are undertaken to keep flows within the leveed floodplain)
- bridges — approximately $1 million
- levee-regulating structures — approximately $4–8 million
- other works on levees — approximately $14–22 million.

There are a number of other mitigation and operational measures that may be needed that have not been costed. These include:

- upgrading the stream-gauging network, especially for the unregulated tributaries; this is needed to improve operational forecasting and confidence to make regulated releases from Eildon Dam on top of unregulated tributary flows
- potential costs associated with any upgrades needed to drainage or stormwater systems
- potential costs associated with mitigating impacts on specialist businesses in the Goulburn — for example, impacts on caravan parks and other tourist-focused businesses, and quarries and trout farms
- upgrading the real-time operating system, including developing rainfall run-off models.

Murrumbidgee

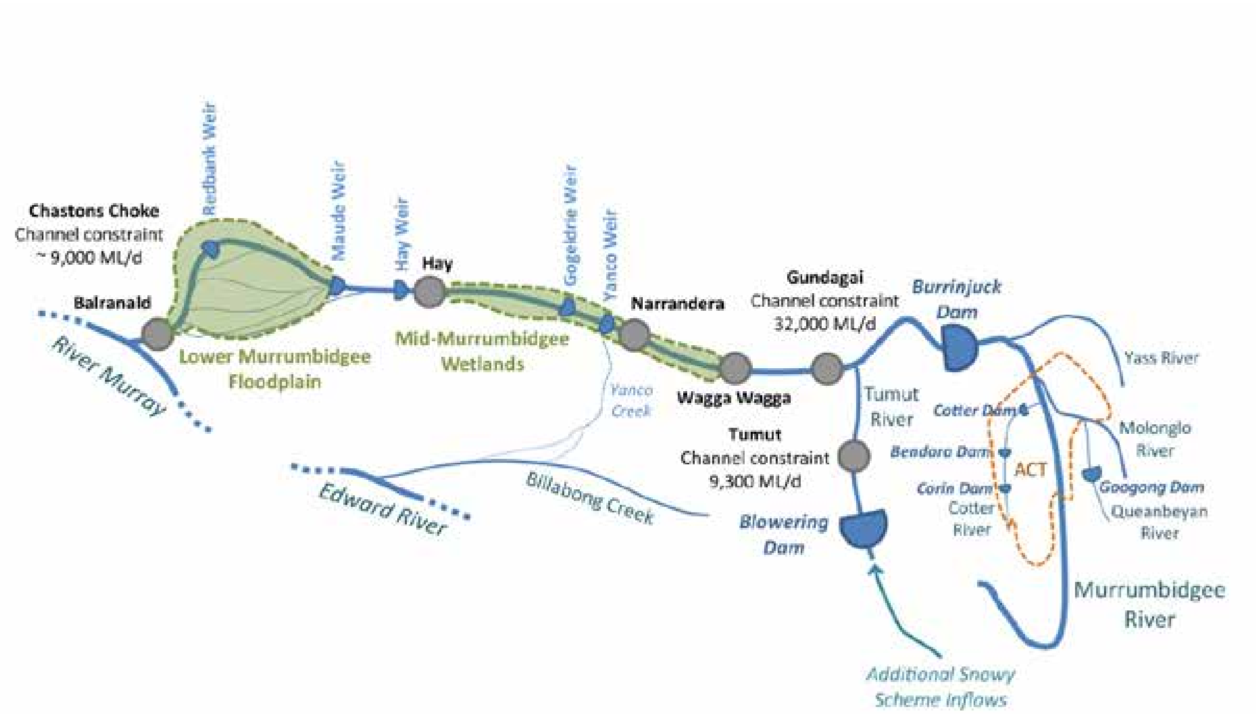

Figure 10: Murrumbidgee key focus area

The Murrumbidgee River spans almost 1,600 km from its headwaters in the Snowy Mountains upstream of Tantangra Dam, to its junction with the River Murray downstream of Balranald (Figure 10). The Murrumbidgee supports highly productive irrigation areas, including the Murrumbidgee Irrigation Area and the Coleambally Irrigation Area.

Hydrology

The headwaters of the Murrumbidgee system are regulated by a number of dams. The main ones are Burrinjuck Dam on the Murrumbidgee, and Blowering and Talbingo dams on the Tumut River. Flows have been greatly modified and many of the flows that would have filled lagoons and anabranch streams on the lower floodplain now no longer get through.

The Sustainable Yields Project in the Murrumbidgee (CSIRO 2008) found that the frequency of flows of 28,600 ML/day at Narrandera had halved, and the maximum period between flows of this size had more than tripled, from 2.8 years to 9.7 years. The 28,600 ML/day flow is equivalent to a flow of between 30,000 and 40,000 ML/day at Wagga Wagga.

We are investigating a range of flows from 30,000 to 48,500 ML/day (5.22 to 7.15 m) at Wagga Wagga. The bottom of this range has been delivered before and is the level at which Mundarlo Bridge (a low-lying bridge between Gundagai and Wagga Wagga) should not be inundated. The top level is beneath the minor flow level at Wagga Wagga (7.3 m or 50,100 ML/day) with a small buffer.

The flow levels would generally be achieved by delivering water when tributaries below the dams were responding to rainfall. This would take advantage of natural triggers and reduce the volume of water needed to be delivered from Burrinjuck and Blowering dams.

Downstream of Wagga Wagga, the flow level will gradually decrease as water seeps into creekbeds and floodplains.

The flows would be delivered in winter and spring when natural tributary flow events typically happen. The peak would be three to five days, followed by a natural rate of recession. Further work is required to determine the ideal frequency of flow deliveries, but initial investigations suggest the range may be around three to four additional flows per decade.

Only limited investigations have been done to date on the Tumut River, an important tributary of the Murrumbidgee. Flows there are limited to 9,300 ML/day through Tumut town. Increasing this limit would improve the flexibility for managed flows; however, the Tumut River is a smaller river than the Murrumbidgee and it is already passing unnaturally high flows because contributions from the Snowy Mountains Hydro-electric Scheme are routed through it. The current flow limit is already very close to bankfull, so any increase would be very difficult.

In the Lower Murrumbidgee, the channel capacity decreases significantly. Flows above 8,000 to 9,000 ML/day spread across the extensive Lowbidgee Floodplain. As such, contributions to the Murray are limited in the peak height they can provide. The Murrumbidgee's value to the Murray is by providing longer duration flows that could provide a base for high flows in the Murray. Although work in the Nimmie–Caira may allow some additional flows (up to 3,000 ML/day) through to the end of the system, the flow that reaches the end of the system is driven by the overall volume of the event, not the peak upstream. The objective of higher peak flows in the Murrumbidgee is to be high enough in the river channel to start filling wetlands in the Mid-Murrumbidgee, not to achieve higher peaks at the end of system.

The hydrology of the River Murray area between Wakool Junction and Euston has noticeably changed, especially during high flow periods, since construction of engineering works in the Lowbidgee. This change is evident from the differences in flow peaks observed at Euston compared to Wakool Junction, and the flow contribution from the Murrumbidgee River as recorded at Balranald gauge. More detailed studies are needed to understand the reasons for these changes and how the proposed changes at Nimmie–Caira will restore the hydrologic responses as seen before the undertaking of engineering works in the Lowbidgee.

Consultation

Since 2013, MDBA has been talking with a number of landholders, councils and Indigenous community representatives, as well as the Murrumbidgee Environmental Water Advisory Group and the Murrumbidgee State Water Customer Services Committee. Consultation has concentrated on key areas where mapping indicates more of a spread of water onto low-lying areas: Collingullie, upper Yanco Creek, Darlington Point and the Lowbidgee (Hay to Balranald). If this work progresses onto feasibility stage, more extensive consultation will be required.

The way higher flows are perceived by landholders changes the further down the river they are. In the western area, particularly downstream of Hay, inundation is generally seen as beneficial to the country and supports pasture growth. Higher up the river, where rainfall is more reliable, inundation can be disruptive to farmers' operations and can damage pastures. There are also some areas of irrigated lucerne that may be damaged at the higher flow ranges. In addition to effects on land, farmers have noted issues with impeded access, fencing, debris, weeds (particularly lippia) and the need to move stock and pumps.

Councils have also noted issues with low-lying access roads and crossings. The major crossing affected is Mundarlo Bridge, but Mundowy Lane, which provides access to a bridge across the Murrumbidgee 30-km downstream of Wagga Wagga, would be closed at the higher flow ranges. There are also issues with stormwater drainage at Wagga Wagga, Narrandera and Darlington Point, with gates needing to close for some drains that go under the town levees as the river level rises. This poses a risk if there is a downpour inside the levees while the gates are closed.

Communities are also concerned about a number of other issues, including the effect of higher than expected tributary inflows coinciding with dam releases. However, this risk needs to be counterbalanced by the fact that deliveries will create airspace in dams, which reduces the risk of dam spills and larger floods while the airspace remains. River managers will need to be conscious of these risks during the planning and management of events, taking into account weather forecasts and catchment conditions. Another concern is tree fall and erosion occurring during high flows. It will be important to plan events so river levels can rise and fall at a natural rate to reduce this risk.

Irrigator representatives are concerned that delivery of higher flows may require more water to be delivered from Burrinjuck Dam than Blowering Dam due to flow restrictions in the Tumut River. Further work will need to be done to model any potential dam imbalance issues to ensure that the reliability of water entitlements would not be adversely affected.

Benefits to the environment and community

The condition of the aquatic vegetation communities of the Mid-Murrumbidgee Wetlands declined dramatically during the millennium drought, which lasted from 2000 to 2009 in much of the Basin. However, modelling shows that there were events during this drought that would have reached the wetlands under 'without development' conditions. Being able to provide connecting flows to these wetlands will help these communities to recover and reduce the likelihood of another similar decline. This would provide habitat and food for a number of native animals including fish, frogs, turtles, waterbirds and woodland birds.

The area of floodplain vegetation and wetlands that could benefit from these flows is substantial. At flows of up to 48,500 ML/day (7.15 m at Wagga Wagga), around 8,000 ha of wetland and 25,400 ha of floodplain vegetation is watered upstream of Hay, and a further 11,600 ha of wetland and 69,900 ha of floodplain is watered downstream.

The flows will flush out organic matter from these inundated areas. This is an important process to reduce the severity of future blackwater events. The organic matter is also important in driving the food web of the river system, and is particularly important for providing food for fish larvae and juvenile fish.

As in other key focus areas, mitigation measures, like upgrading creek crossings and improving levees, may benefit individual landholders even for unmanaged flows that would have happened anyway.

Possible mitigation options

With these flows mitigation measures can be put in place, but the community needs reassurance that the risks of unintended adverse consequences are being planned for and managed. Mitigation options could include:

- upgrading roads, bridges and other infrastructure to keep roads and access routes open (e.g. raising Mundarlo Bridge)
- installing pumps for stormwater systems where gates may have to close
- installing a regulator at the Yanco Creek Offtake so that high flows down the creek could be controlled to avoid overbanking when it was not desired
- negotiating agreements with landholders for easements or other measures to allow low-lying land to be wet.

Another option that was considered was whether en route storages, such as Lake Coolah or turkey nest dams, could be used to provide a portion of the peak, thereby reducing the height of the flow needed upstream. However, analysis of previous work done on this, particularly GHD (2002), found that these options did not provide enough benefits for the costs.

Anticipated costs

As an initial range-finding exercise, the cost of roads, bridges, stormwater pumps and easements were estimated. Together, these are some of the key mitigation measures that would be needed to protect communities and businesses from the effects of higher regulated flows.

The mitigation cost for the Murrumbidgee that would allow managed flows up to 48,500 ML/day at Wagga Wagga is estimated to fall in the range of $66 million (moderate estimate) to $80 million (high estimate).

These totals can be broken down into the following components:

- easements — approximately $18 million
- roads — approximately $12–20 million

- bridges — approximately $10 million, mostly associated with potential works on the Mundarlo Bridge near Gundagai
- other crossings — approximately $11–14 million
- specific works on a regulator at Yanco Creek — in the order of $8–10 million
- specific works on Wagga stormwater gates — in the order of $5–8 million
- specific works on Narrandera stormwater gates — in the order of $1 million.

There are other programs and processes looking at items like the Mundarlo Bridge and Yanco Creek regulator, and some of these costs may be met by these other programs.

Gwydir region

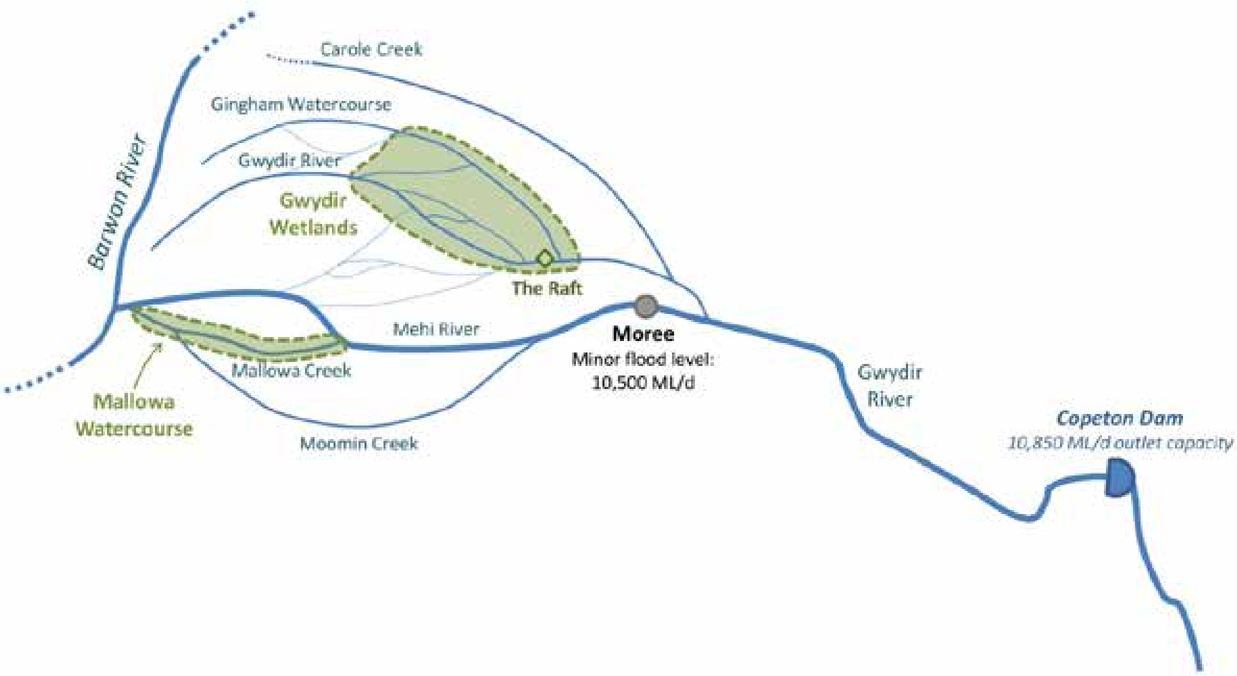

Figure 11: Gwydir region key focus area

The Gwydir key focus area in north-west New South Wales includes the Gingham Watercourse, Lower Gwydir River and wetlands, and Mallowa Watercourse and wetlands (Figure 11). This region is a significant location for waterbirds in Australia, providing habitat and breeding sites for several threatened migratory and resident species. It is also an important site in the region, as it contains threatened wetland plant communities and is a refuge for native fish.

Delivering water to these assets is currently restricted by timing and volume. Water managers need to plan environmental water delivery around harvest and peak irrigation delivery times. The limitations in water delivery threaten the health of Gwydir ecosystems, and are the reason the Gwydir region was identified as a key focus area in the Strategy in 2013.

River regulation in the Gwydir region has significantly changed the landscape and ecology of the region during the past 40 years. The construction of Copeton Dam has resulted in a significant reduction in the frequency of flows that fill the wetland and wet the floodplain in the Lower Gwydir. This has made grazing less productive and caused a shift towards dryland farming and a reduction in native vegetation and wetland area. The reduced inundation has led some farmers to crop right to the edge of waterways and in the wetlands.

Hydrology

Flows in the Gwydir region are dependent on rainfall in the upper catchment and are highly variable. The natural flow regime in the Gwydir has been significantly altered by river regulation and increased water consumption. Since the construction of Copeton Dam in 1976 and on-farm storages to support irrigation, there has been a 75% increase in the average length of time between flood events and a 64% increase in the maximum length of time between flood events (a rise from 7 to 11.5 years). The reduction in flood frequency means that the average annual flooding volume has been reduced by 42% (CSIRO 2007). These changes have contributed to the stressed ecological condition of the wetlands (CSIRO 2007), and the poor condition and health of floodplain soils.

Despite significant volumes of held environmental water in the Gwydir, there are limitations on the time of year that this water can be sent to the wetlands. Water managers need to plan environmental water delivery around other needs, such as harvest and peak irrigation delivery times.

Benefits to the environment

The Gwydir system remains a very significant wetland ecosystem despite river regulation, removal of native vegetation and alteration of the landscape. The Gwydir system contributes to the environmental health of the whole Basin, and four sites have been listed as wetlands of significant international importance under the Ramsar Convention.

Restoring and protecting the Gwydir and Mallowa wetlands will provide many environmental benefits, including:

- maintaining habitat suitable for waterbird breeding
- contributing to restoration of the ecological character of sites listed as internationally important under the Ramsar Convention
- protecting and restoring endangered ecological communities
- maintaining wetland refuges for a range of species
- improving the condition and extent of permanent and semipermanent wetland vegetation communities
- maintaining adequate soil moisture in core wetlands to allow improved responses to water deliveries
- assisting the recovery of the wetland plant marsh club rush, a critically endangered ecological community.

Consultation

In 2014, MDBA and the New South Wales Office of Environment and Heritage met with the majority (approximately 90%) of landholders and land managers in the Gwydir region in a series of face-to-face meetings. The remaining 10% of landholders were unavailable at the time of consultation. Overall, those we spoke with said they were happy to see the project progress to the next phase and wanted to be involved in the next stage of development.

During this consultation, we asked landholders and managers about the types of effects they have experienced when the wetlands areas are full of water and during recent natural events. Several issues were raised that varied depending on the location of the property, and the type and location of agriculture being practiced. The issues raised are summarised below.

When environmental water is sent to the wetlands this can cause issues to cropping including:

- inundation of crops at the wrong time of year can prevent harvest
- if the duration is too long it can prevent sowing
- inundation prevents access to crops and people cannot spray crops.

Other issues that were raised in relation to environmental water in the wetlands were concerns that:

- when the wetlands are full, rain events will cause unintended flooding and damage to crops
- keeping water too long in wetlands can cause issues like preventing stock access and increasing mosquito breeding
- water can spill out of watercourses and prevent access in some regions, though improving crossings may address the issue.

Possible mitigation options

Further work is required to understand the impacts of the flows needed to get water to the Gwydir, Gingham and Mallowa wetlands before we can identify solutions. There is currently no adequate modelling or inundation mapping for the region at the types of flows needed to deliver water to the wetlands.

Landholders and land managers recommended that more work be done to understand the movement of water through the system. The land-use changes in the Gwydir region have also changed the way water flows across the landscape, particularly at the kind of flows that fill the wetlands. If people can better understand where the water is going to flow, they can manage and plan their cropping regime appropriately and take any preventative actions they need to.

A range of investigations could be undertaken, such as fine-scale geomorphic assessments and aerial surveys of flows. It is important that future work is done in collaboration with landholders in the region.

Anticipated costs

More investigations are needed in the Gwydir to prove feasibility before cost estimates could reasonably be provided. If and when relevant information becomes available, it is anticipated that estimates could be developed drawing on the methods applied by GHD and URS Corporation in other areas.

The Gingham Waterhole. 2014. ***Photo: Kelly Marsland, MDBA.***

Prioritising operational and management constraints

In the Strategy, along with examining physical constraints, MDBA examined existing operational and management practices that restrict the use of environmental water in achieving better environmental outcomes (MDBA 2013). The Strategy identified nine operational and management issues for further consideration. They are broadly described as:

- delivery of environmental water on top of other instream flows
- channel capacity sharing
- timing of water availability
- planned environmental water
- environmental water can be used throughout the length of a river
- protection of environmental flows from extraction and re-regulation
- substitution of held environmental water with other water
- coordinated planning and delivery of water delivery
- current river management practices.

In the prefeasibility assessment, MDBA scoped the nine operational and management constraints, and identified those that make the most significant difference to achieving environmental outcomes. Four were identified as a priority. They are:

- protection of environmental flows from extraction and re-regulation
- delivery of water on top of other instream flows
- environmental water to be used throughout the length of a river
- channel capacity sharing.

The first three of these policy measures are also being progressed through the sustainable diversion limit (SDL) adjustment mechanism, where they are a mandated requirement under the Basin Plan for achieving an SDL adjustment, described as 'prerequisite policy measures'.

Allowing environmental water to be used throughout the length of a river — and protecting it from extraction, re-regulation or substitution — overlap with the Basin Plan requirement to allow 'crediting of environmental return flows for downstream environmental use' (section 7.15(2)(a)).

Allowing delivery of environmental water on top of other instream flows, including unregulated events, overlaps with the Basin Plan requirement to 'allow the call of environmental water from storage during unregulated flow events' (section 7.15(2)(b)).

Without these measures, it is likely that it will not be possible to achieve any SDL adjustment from the supply measures that states put forward.

Out of all nine operational and management constraints, these measures are the most significant for maximising the use of environmental water. For this reason, they have been listed as the first priority to address.

MDBA has also conducted a desktop assessment of the potential for held environmental water to cause channel capacity sharing problems, as this was a key concern for stakeholders during the development of the Basin Plan.

Why do we need to address the priority operational and management constraints?

Significant in-valley and Basin-wide environmental benefits would be achieved in all valleys where environmental flows are protected from extraction, can be delivered on top of other instream flows and can be used throughout the length of the river.

Throughout the Basin's regulated rivers there are no specific policies or rules that explicitly restrict delivering environmental water in this way. However, what is needed are enabling policies that ensure we can do so.

For example, the Basin Plan identified both base-flow and in-channel environmental water requirements. This means that, to achieve target outcomes, environmental water needs to be able to flow throughout the length of the river. Currently, a water order is placed at a single licensed location, and the subsequent recognition of the use of that water is at the licensed extraction point. While this does not restrict environmental water delivery, neither does it guarantee that a flow event will be created upstream or downstream of the order point. This limits the capacity to place an environmental water order to apply throughout the length of a river system and hence to meet base-flow or in-channel environmental outcomes.

We need to change our policy settings so that we can do this to maximise the benefits we can achieve for our environmental water.

Where we need to address operational and management constraints

During 2014, an analysis was conducted to determine how critical it is to protect environmental flows from extraction, deliver environmental water on top of other instream flows and use environmental water throughout the length of the river in each of the major valleys in the Basin. This analysis considered the extent that these operational outcomes are already met within the existing systems and frameworks, or whether changes to river operations are needed to achieve them.

This assessment concluded that:

- in all of the Basin's regulated valleys, the ability to protect environmental flows from extraction, deliver environmental water on top of other instream flows and use environmental water throughout the length of the river is required to efficiently and effectively achieve environmental outcomes, such as overbank flows and watering wetlands
- in all of the Basin's unregulated valleys, the protection of environmental flows throughout the length of, and between, rivers is required to achieve environmental outcomes; this would protect environmental water from extraction and allow environmental water to be used along the entire length of the river for multiple outcomes.

How the priority operational and management constraints are being progressed

States have agreed to a process to progress SDL adjustment and constraint projects in the *Intergovernmental Agreement on Implementing Water Reform in the Murray–Darling Basin (2013)* (the Intergovernmental Agreement). As part of that process, states have agreed to bring forward implementation plans by 30 June 2015 to address the crediting of environmental return flows for downstream environmental use and calling of environmental water from storage during unregulated flow events.

Implementing these policy measures is a requirement of the SDL adjustment process in the Basin Plan.

As part of its role in the SDL adjustment process, MDBA will assess whether the policies developed by the states meet the requirements of the Basin Plan. MDBA will develop formal assessment criteria by mid-2015 and undertake the final assessment by the end of 2016.

To help states develop policies that will meet the requirements, MDBA has developed guidelines to assist the states in development of their implementation plans. The guidelines will ask states to demonstrate that their new arrangements are:

- secure and enduring — the policy and implementation frameworks are supported by either statutory enabling provisions or are clearly codified
- operable — demonstrate the mechanisms within delivery frameworks, which provide express powers and protection for river operators to deliver the flow rates that achieve the environmental outcomes in the Basin Plan
- transparent and fair between all users.

When assessing the states' arrangements, MDBA will focus on the outcomes they achieve, rather than the specific policies used to achieve them. We acknowledge that there are several possible ways that states could achieve the intended outcomes and will not prescribe to states how to best implement them.

In 2015, MDBA will do further scoping and analysis of the other operational and management constraints identified in the Strategy.

Analysis of channel capacity competition

The fourth of the operational and management constraints considered during 2014 was channel capacity competition.

MDBA recognised there is a perception, particularly in the southern-connected system, that environmental water delivery may increase the competition for channel capacity, to the detriment of irrigators.

As part of the prefeasibility work in 2014, MDBA undertook a preliminary desktop assessment to determine whether using recovered entitlements to deliver environmental watering events could increase competition for channel capacity.

Environmental water entitlements have the same core characteristics as entitlements held by irrigators. Core characteristics include security, reliability, allocation, charges, tradability and an equal access to a share of channel capacity. This means that environmental water and irrigator entitlements should be treated equally. The analysis considered:

- current management of channel competition
- changed patterns of river flow given the increased amount of environmental water delivery
- flexibility of timing of both irrigation and environmental water delivery
- location of environmental water demand compared to irrigation demand.

MDBA's initial analysis of the likely impacts of channel competition is that:

- held environmental water is generally unlikely to increase and — in some circumstances, may decrease — channel competition
- irrigators are benefiting from the 'good neighbour' policy practised — for example, by the Commonwealth Environmental Water Holder, in which orders for environmental water are voluntarily given lower priority to channel access in situations where environmental water objectives can still be met.

MDBA will undertake further analysis of channel capacity competition as the long-term behaviour of environmental water holders, and any emerging issues, become clear.

McKennas Lagoon near Carrathool, 2000. ***Photo: James Maguire, NSW Office of Environment and Heritage.***

Basin-scale analysis

During 2014, MDBA analysed a modelled selection of flow rates for each key focus area using the same set of hydrologic computer models that Basin states use for their planning and that were used to model the Basin Plan (MDBA 2012). The modelling assumed that both operational and management, and physical constraints were addressed. In 2014, it was not possible to model all potential combinations of flow rates, but the flows we did model were enough to show how small overbank flows could be delivered throughout the southern-connected Basin.

In the majority of key focus areas, addressing constraints will deliver significant in-valley environmental outcomes. Generally speaking, in-valley environmental outcomes increase with increased flow.

However, coordinating flows presents an opportunity for environmental outcomes that benefit the whole Basin. In addition to significant in-valley benefits, our analysis showed that the greatest benefits are achieved when multiple flow events in the Basin are aligned, using natural cues, such as the commencement of unregulated flows from tributaries, to achieve flows of 60,000 to 80,000 ML/day at the South Australian border. Flows of this magnitude water an extra 40,000 ha of wetlands and vegetation in the South Australian River Murray region alone, compared to flows of 40,000 ML/day, with a similar scale of area inundated upstream of this region.

Overbank flows in the mid- to lower Murray derive from widespread and persistent rain across most, if not all, of the catchments from the Goulburn, north to the Murrumbidgee. A localised rain event in a single catchment, no matter how heavy, is unlikely to result in overbank flows in the lower Murray.

Major dams were built to maximise water conservation. They do a very good job — the major dams are capable of entirely capturing all but the largest flood events. Stopping flows past large storages, when tributaries are also flowing strongly, is the major contributor to decline in floodplain health.

Analysis indicates that making releases from storages when tributaries are flowing strongly across multiple valleys is the most effective means of reinstating the small overbank flows vital for floodplain health.

Generally, contributions from at least three rivers are required to maximise the benefits. Flows from different sources do not need to perfectly coincide to be effective. For example, an early event from the Goulburn can act to prime the lower Murray for a later event from the Murray and Murrumbidgee rivers.

Typically, given the widespread nature of the rain event leading to strong tributary flows, inflows to the storages at the time of release will be higher than the release being made. In effect, the regulated release will be a portion of the inflow. This means the dams are still working to protect downstream communities from moderate and major floods.

These relatively small changes to the flow regime can have significant environmental benefits, not only in the lower Murray but in all of the key focus areas, as the water travels through the system. Although the differences in flow rates may seem small, they would allow thousands of hectares of extra wetland and tens of thousands of hectares of extra red gum and black box to be watered in South Australia alone (Figure 12), with additional benefits throughout each of the other key focus areas.

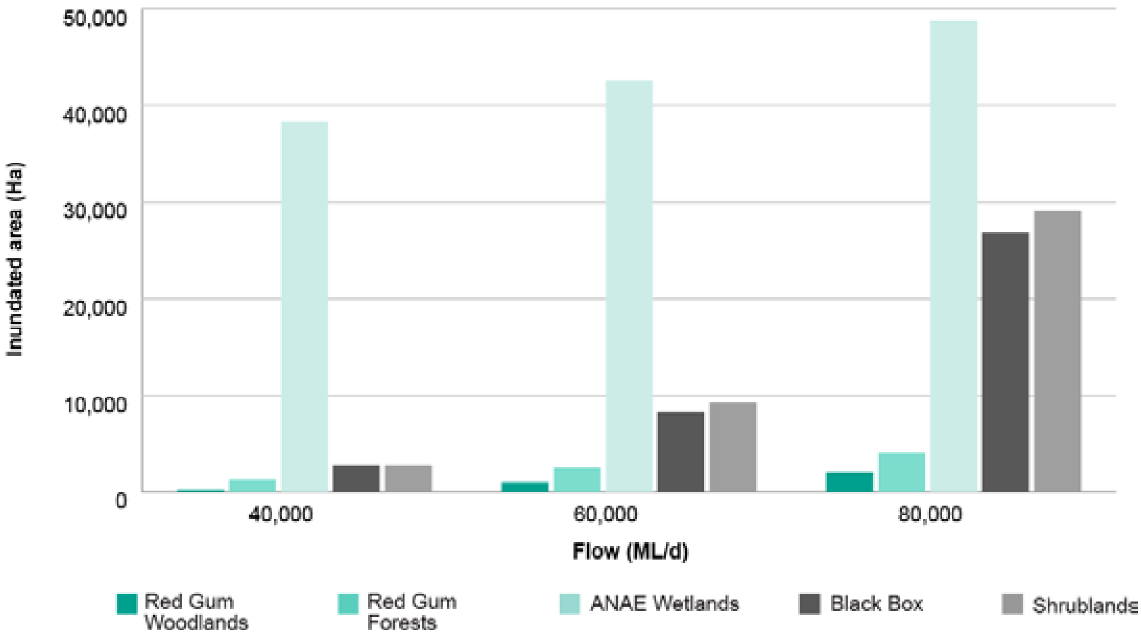

Figure 12: Inundated vegetation in South Australian Murray River key focus area

Improvements in the duration of the environmental flow can also improve the frequency of bird and fish breeding events, and other important biological processes.

Overall, the modelling also shows that we would not be able to top-up flows like this every year. This is partly because of the natural variability in the system, but the opportunities for environmental watering are also limited by the volume of held environmental water in storage and whether it is a wet year or a dry year. However, provided the environmental water is available, relaxing constraints will increase the opportunities to coordinate flows in this way, potentially doubling or more the chances of being able to deliver this kind of event.

In our analysis we also limited the flows we modelled to a level where impacts can be mitigated. In some cases, it might be possible to achieve higher flows than what has been modelled, but further work is required to explore whether this is possible. Either way, the benefits are likely to improve over time as environmental water holders and river operators gain experience in delivering these kinds of flows.

Before development, overbank flows of the order that we are seeking to reinstate happened in about 35% of years (e.g. 80,000 ML/day at the South Australian border for 30 days or more). At the 2009 level of development, the frequency of these flows had reduced to about 10% of years. Through the Strategy we are trying to restore the frequency of these flows to around 15–25% of years. This will still be considerably less than what would have happened naturally, but it is expected to make a significant difference to restoring floodplain health (MDBA 2012).

Prioritising physical constraints

Our Basin-scale analysis and prioritisation drew together all the information gathered in phase one of the Strategy about each of the key focus areas to identify which constraints are the highest priorities to overcome. The analysis compared benefits to the environment and landholders against the impacts and the costs of mitigating the impacts.

The outcomes of the analysis formed the basis of recommendations to governments about which physical constraints should be further assessed under phase two, the feasibility assessment. (The operational and management constraints are discussed in the next section of this report on page 47.)

To assess the benefits associated with relaxing constraints and to prioritise which ones should be progressed further, MDBA examined:

- flow rates determined to have environmental benefits
- the area of ecologically important indicator vegetation species and wetlands inundated under the different flow rates examined
- progress towards achieving the outcomes of Schedule 5 — Enhanced Environmental Outcomes referred to in section 7.09(e) of the Basin Plan
- costs associated with mitigating the impacts of the different flow rates of interest
- the community acceptability of the flow rates being examined.

The methods and results of the independent bodies of work undertaken to analyse the impact of relaxing constraints in the key focus areas are detailed in separate reports on the MDBA website[6].

Table 2 shows the flow ranges worth further investigation, and the supporting environmental outcomes, cost and community acceptance that has been used to determine the package of constraint measures that we recommend move to the next phase.

[6] www.mdba.gov.au/what-we-do/water-planning/managing-constraints

Table 2 Analysis of key focus areas for constraints

Key focus area	Flows that appear feasible	Correlation with peak flow events >60,000 ML/d at SA border (as a surrogate for overall system health)	Total area of red gum and black box inundated (ha)[a]	Total area of Australian National Aquatic Ecosystems wetlands inundated (ha)	Preliminary cost estimate (moderate–high estimate)	Community acceptance for continued investigations
Hume to Yarrawonga (flows as measured at Doctors Point)	Up to 40,000 ML/day	90%	5,000	4,000	$16–22 million	OK, concerns at upper end of flow range
Yarrawonga to Wakool Junction (flows as measured downstream of Yarrawonga Weir)	40,000–77,000 ML/day	50–100%	73,000–156,000	38,000–52,000	$105–218 million	OK at mid-range flows, concerns at upper end of flow range
SA River Murray (flows as measured at SA border)	Up to 80,000 ML/day	0%	33,000	49,000	$5 million	OK
Lower Darling (flows as measured at Weir 32)	Up to 16,000 ML/day	40%	2,500–3,600	400–1,200	$4–6 million	OK
Goulburn (flows as measured at Shepparton)	Up to 40,000 ML/day	58%	19,000	3,000	$31–47 million (assuming levee upgrades)	OK, concerns at upper end of flow range
Murrumbidgee (flows as measured at Wagga Wagga)[b]	Up to 48,500 ML/day	45%	69,000	20,000	$66–80 million	OK, concerns at upper end of flow range
Gwydir	Unknown at this stage	Unknown at this stage	Unknown at this stage	Unknown at this stage	Uncertain	OK

SA = South Australia

a Increase in inundated vegetation is used as a surrogate for in-valley benefits

b Some of the increased benefits in the Murrumbidgee can also derive from other investments such as the Nimmie–Caira project.

Preliminary estimates of cost indicate that addressing constraints in all seven key focus areas may exceed the $200 million set aside for constraints measures in the Water for the Environment Special Account. However, these estimates are preliminary only and will be refined with further investigation in the next phase of the Strategy.

Due to the dependencies between them, the three parts of the Murray — Hume to Yarrawonga, Yarrawonga to Wakool Junction and the lower Murray — should be considered as a single package. Without relaxing constraints in all three key focus areas, it would not be possible to take advantage of relaxed constraints in just one part of the Murray.

Relaxing constraints along the main stem of the River Murray can provide some of the greatest environmental outcomes, particularly if regulated releases can be timed to combine with unregulated flows from the Kiewa, Ovens, Goulburn and/or Murrumbidgee rivers to build a flow of 60,000 to 80,000 ML/day at the South Australian border. Without relaxing constraints in the River Murray, relaxed constraints in the Goulburn, Murrumbidgee and Lower Darling will be limited to in-valley benefits only. As such, it makes sense to consider the package of constraints along the main stem of the Murray to be the first priority for constraint measures.

The best Basin-scale outcomes that could be achieved for around $200 million would arise from addressing constraints along the entire main stem of the River Murray, the Lower Darling as part of the Menindee Lakes Water Savings Project, and one of either the Goulburn or the Murrumbidgee, considering the relative contribution of constraint measures in these areas to both in-valley and system-wide outcomes.

Further work would need to be done on costing work in the Goulburn and Murrumbidgee to prioritise between them, and this should be done by developing business cases.

More investigations are needed in the Gwydir to prove feasibility before cost estimates could reasonably be provided. This work should be done through developing a business case.

Key findings

In 2014, MDBA completed the prefeasibility phase of the 10-year work program identified in the Strategy. The key findings of this work are below.

> Protecting environmental flows from extraction, delivering environmental water on top of other instream flows and using environmental water throughout the length of the river are the most significant factors for achieving environmental outcomes.
>
> These operational and management constraints, in the form of the crediting of environmental return flows for downstream environmental use and ability to call environmental water from storage during unregulated flow events, are also required for the SDL adjustment mechanism to operate fully. In a trial of the SDL adjustment assessment method, these measures contributed to the Basin Plan outcomes by an order of magnitude more than the benefit provided by the Living Murray works and measures. It therefore appears that, unless the crediting of environmental return flows for downstream environmental use and the calling of environmental water from storage during unregulated flow events are enabled, it will not be possible to achieve any significant offsets from the adjustment mechanism. Furthermore, inadequate implementation may reduce or offset the SDL adjustment resulting from supply measures.
>
> MDBA will assess the effectiveness of the states' policies to credit environmental return flows for downstream environmental use and call environmental water from storage during unregulated flow events as part of the SDL adjustment process.
>
> Assuming the priority operational and management constraints are addressed, it is feasible to achieve environmental outcomes, beyond those that can be achieved by the Basin Plan alone, by relaxing constraints and using natural cues as a trigger to make releases from storages to increase the frequency, duration and peak of small overbank flow events, generally below minor flood levels.
>
> The greatest benefits are achieved when multiple flow events in different rivers in the Basin are aligned, using natural cues, such as the commencement of unregulated flows from tributaries, to achieve flows of 60,000 to 80,000 ML/day at the South Australian border. Furthermore, these benefits will improve over time as environmental water holders and river operators gain experience in delivering these kinds of flows.
>
> Flows of this type can be achieved from a combination of the Murray, Goulburn, Murrumbidgee and Darling rivers, as well as unregulated flows from the Ovens and Kiewa, coinciding to create higher flow peaks and longer events. Generally, contributions from at least three rivers are required to maximise the benefits. Flows from different sources do not need to perfectly coincide to be effective.

For example, an early flow event from the Murrumbidgee can act to prime the lower Murray for a later event from the Murray and Goulburn rivers.

Investigations have also shown significant in-valley environmental benefits could be achieved in all valleys where both physical, and operational and management constraints are addressed.

Delivering higher environmental flows is feasible, but it will involve some community impacts which can be mitigated by a range of measures, such as improved creek crossings, easement agreements and other appropriate measures.

As community consultation has progressed and technical analyses such as inundation mapping have improved, communities have shown their willingness to explore options to mitigate impacts around the flow rates being considered. However, there remain significant community concerns at the upper end of the flow ranges under consideration. Further work is required to fully understand the potential impacts of such flows in a way that is both acceptable to the community while also being cost-effective.

The current legal settings have evolved to support historical water delivery needs and prior practices. In seeking new ways to operate the rivers to restore the overbank flows previously eliminated by regulation, it will be necessary to ensure there is an appropriate legal framework to support this new operational environment.

Key findings for physical constraints

Preliminary estimates of cost indicate that addressing physical constraints in all seven key focus areas may exceed the $200 million set aside for constraints measures in the Water for the Environment Special Account. However, these estimates are only preliminary and will be refined with further investigation in the next phase in 2015, with more detailed property-level work and improved modelling of the frequency, timing and duration of flow events. Jurisdictions may also wish to consider how some measures may be integrated with supply measures or other concurrent investment.

The best Basin-scale outcomes that could be achieved for around $200 million would arise from addressing constraints along the entire main stem of the River Murray, the Lower Darling (as part of the Menindee Lakes Water Savings Project), and one of either the Goulburn or the Murrumbidgee.

While constraints measures in the Goulburn would make a more significant difference to achieving downstream outcomes in the lower Murray and have good in-valley outcomes, the in-valley environmental benefits of watering the many wetlands along the length of the Murrumbidgee are substantial environmental outcomes in their own right. Further refinement of the costs associated with mitigation would need to be done in the Goulburn and

Murrumbidgee to prioritise between them, and this is recommended to be done by developing business cases.

More investigations are needed in the Gwydir to prove feasibility before cost estimates could reasonably be provided. This work is recommended to be done through business case development if jurisdictions wish to align proposals with the timelines in the Intergovernmental Agreement.

Key findings for operational and management constraints

As indicated above, the prerequisite policy measures mentioned in the SDL adjustment mechanism are characterised within the Strategy as:

- environmental water to flow throughout the length of a river, and between rivers; and be protected from extraction, re-regulation or substitution (Basin Plan 7.15(2)(a) *Credit environmental return flows for downstream environmental use*)
- releases of environmental water on top of other instream flows, including unregulated events (Basin Plan 7.15(2)(b) *Allow the call of environmental water from storage during unregulated flow events*).

Initial testing of the SDL adjustment assessment method has demonstrated the importance of addressing these constraints by 30 June 2019 as a prerequisite for obtaining any significant adjustment from proposed supply measures. In particular, if the environmental return flows cannot be credited for downstream environmental use and environmental water cannot be called from storage during unregulated flow events, additional water would need to be called from storage to achieve the Basin Plan environmental outcomes, equivalent to an SDL reduction of more than 4,000 GL.

In all regulated valleys, the ability to protect environmental flows from extraction, deliver environmental water on top of other instream flows and use environmental water throughout the length of the river is required to achieve the Basin Plan Environmental Water Requirements, such as overbank flows and watering wetlands.

In all unregulated valleys, the protection of environmental flows throughout the length of, and between, rivers is required to achieve the environmental water requirements. This would protect environmental water from extraction and allow environmental water to be used the entire length of the river for multiple outcomes. As part of the SDL adjustment process, MDBA is working with states to assess the effectiveness of policies to protect environmental flows from extraction, deliver environmental water on top of other instream flows and use environmental water throughout the length of the river. States are being asked to demonstrate that the new arrangements can be fully implemented by 30 June 2019 and are:

- secure and enduring

- operable
- transparent
- fair to all users.

Effectively addressing the operational and management constraints may also require addressing other constraint measures simultaneously, including physical and legal constraints.

MDBA’s initial analysis of the likely impacts of channel competition is that held environmental water is unlikely to increase and — in some circumstances, will decrease — channel competition. In addition, orders for environmental water are currently voluntarily given lower priority to channel access in situations where environmental water objectives can still be met.

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Green, D, 2001, *The Edward-Wakool system: river regulation and environmental flows*, NSW Department of Land and Water Conservation, Murray Region, Deniliquin

MDBA (Murray–Darling Basin Authority) 2012, *Hydrologic modelling of the relaxation of operational constraints in the southern connected system: methods and results*, MDBA publication no. 76/12, MDBA, Canberra.

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Appendix Modelled example environmental watering event

Murray–Darling Basin Authority (MDBA) modelling covers a period from 1895 to 2009. To demonstrate how we are proposing to change flow regimes, we have shown 1984 as an example (Figure 13). In that year, there was a flow event where relaxing constraints would have allowed environmental water managers to supplement existing unregulated flows. This example details the changes to the flow regime and improvements in outcomes that would have been possible if constraints were relaxed. This is just one example, and every event will be different, but it illustrates what is achievable.

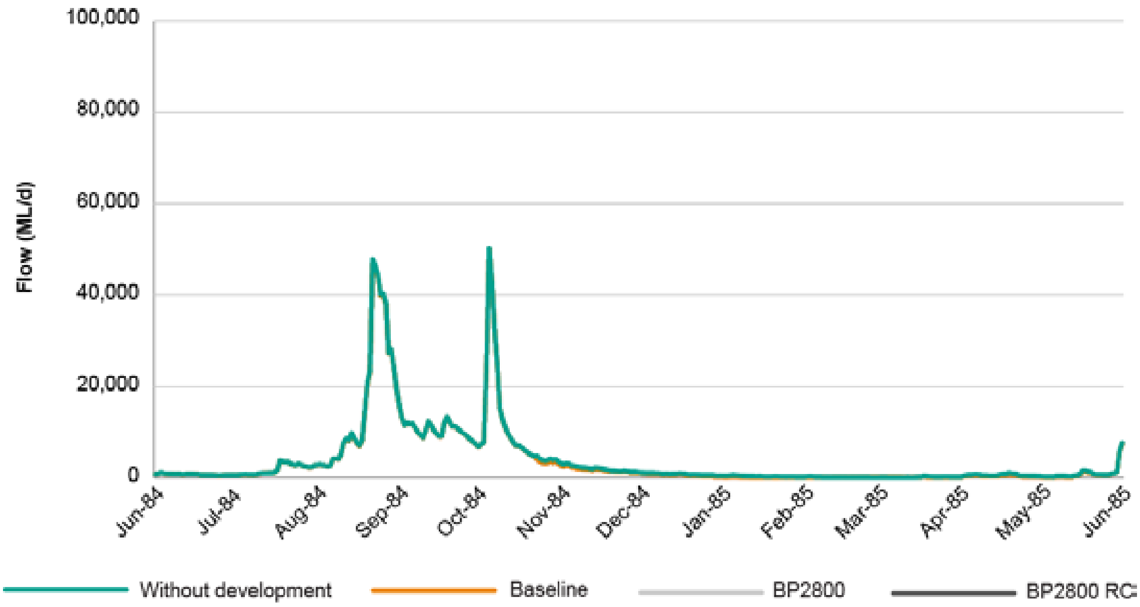

Figure 13: Flow in the Ovens River in the 1984 example flow event

The event starts with unregulated flows in the Ovens and Kiewa rivers of a little below 50,000 ML/day in late August, with a second peak in early October. The major rain events were across a large area, which resulted in strong flows in the upper Murray (upstream of Hume Dam), Kiewa, Ovens and Goulburn rivers.

Without the Basin Plan, most of the run-off in the upper Murray would be captured in Hume and Dartmouth dams. With the Basin Plan, some of this water can instead be released as an environmental flow in September and October, but it is limited by constraints as can be seen in the grey line in Figure 14. If the constraint in the Hume to Yarrawonga key focus area is relaxed to 40,000 ML/day, bigger pulses of environmental water could be released between late August and early October, as shown by the black line in Figure 14.

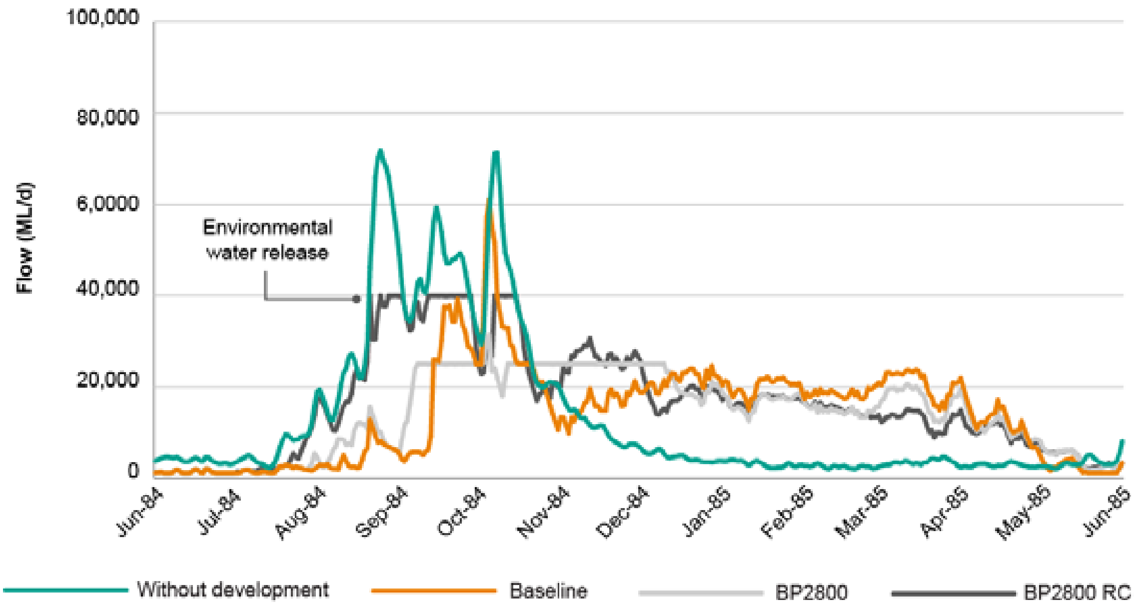

Figure 14: Flow in the Hume to Yarrawonga key focus area in the 1984 example flow event

These higher releases from Hume Dam result in higher environmental flows downstream of Yarrawonga Weir. In this modelled scenario, the flow downstream of Yarrawonga would be limited to 65,000 ML/day, so the flows shown by the black line in Figure 15 would go up to 65,000 ML/day in pulses from late August to the first week of October.

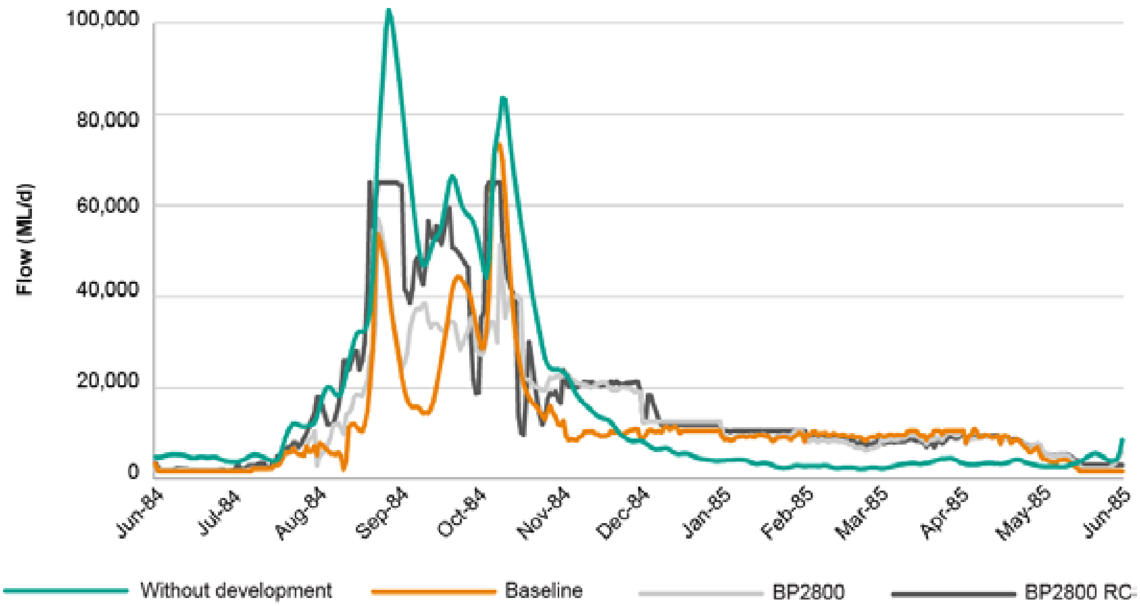

Figure 15: Flows in the Yarrawonga to Wakool Junction key focus area in the 1984 example flow event

In 1984, there were also two short, sharp peak flows in the Goulburn in late August and again in early October, reflecting the widespread nature of the rain events. In the 1984 example, the August flow would be supplemented with environmental water releases to increase the peak above 30,000 ML/day, as shown by the grey line in Figure 16. This would bring benefits to the lower Goulburn floodplain, as well as contributing to the peak flow in the River Murray.

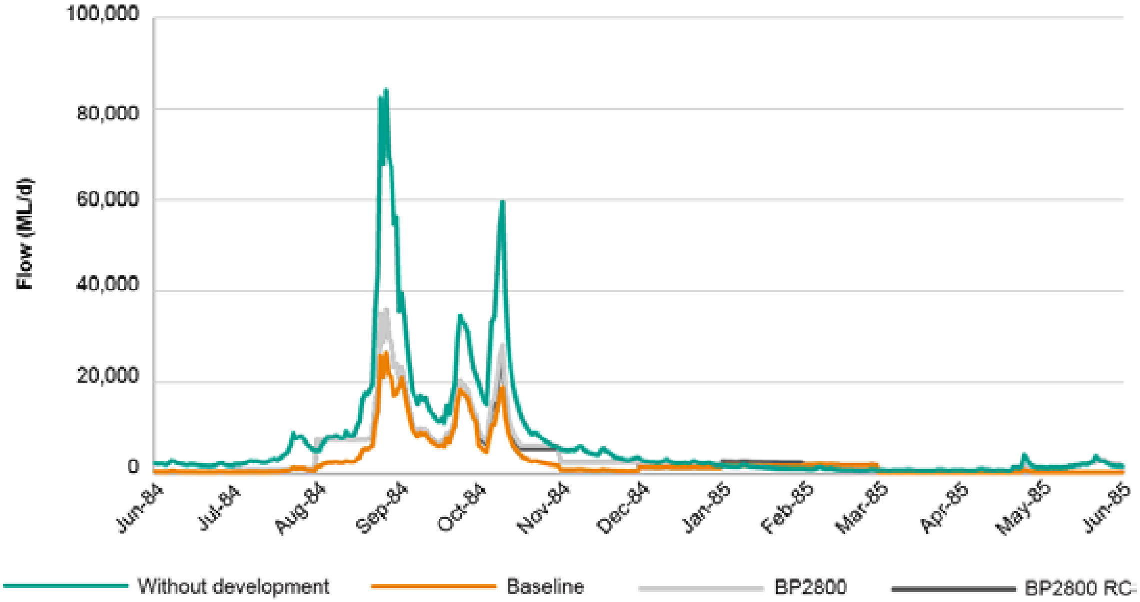

Figure 16: Flows in the Goulburn key focus area in the 1984 example flow event

In the Murrumbidgee, in this case, some small environmental releases would boost flows at Balranald in late July and early August, and extend the flow into late November, as shown in Figure 17. In this case, there is also an unregulated flow in the Murrumbidgee through September and October that would help to fill the channel, and increase and sustain the flow in the lower Murray but in this case it is not boosted by environmental releases during this time.

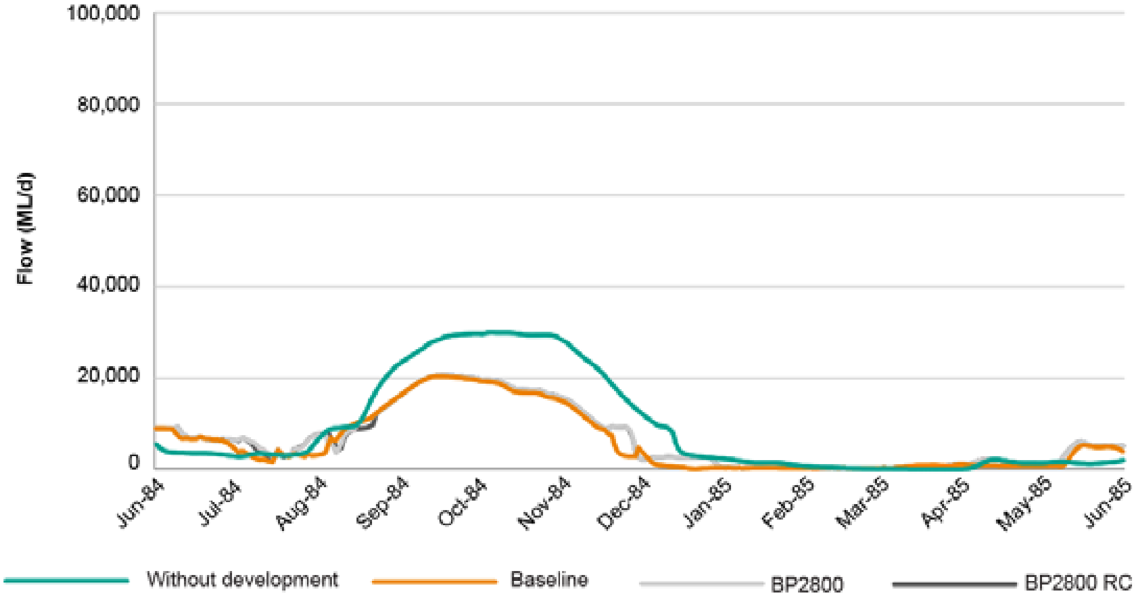

Figure 17: Flow in the Murrumbidgee key focus area in the 1984 example flow event

In 1984, there was also an unregulated flow from the Lower Darling in September and October caused by heavy rain in the northern Basin earlier in the year that would also have contributed to the flow in the lower River Murray, shown in Figure 18.

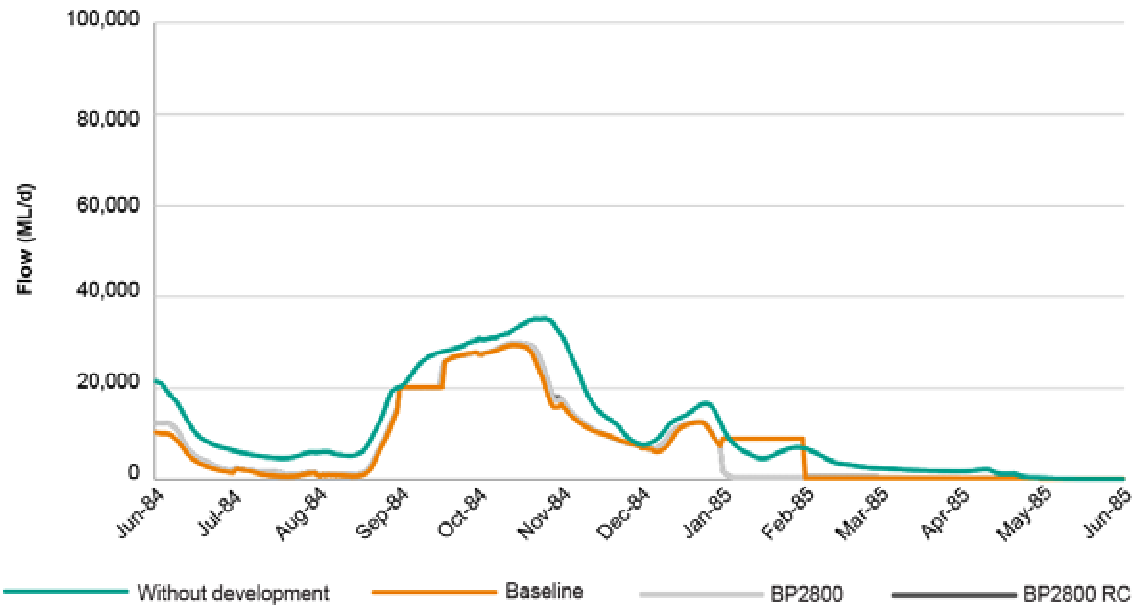

Figure 18: Flow in the Lower Darling key focus area in the 1984 example flow event

These flows would all combine to make a significant difference to the flow to South Australia. The final flow has a significant increase in the peak flow between the normal Basin Plan scenario (the grey line in Figure 19) and the constraints-relaxed scenario (the black line in Figure 19). For most of October and into early November, the flow is increased from around 60,000 to 70,000 ML/day to around 70,000 to 80,000 ML/day, and the top of the peak increases from around 70,000 to just below 80,000 ML/day. The duration of the peak would also be extended slightly into November.

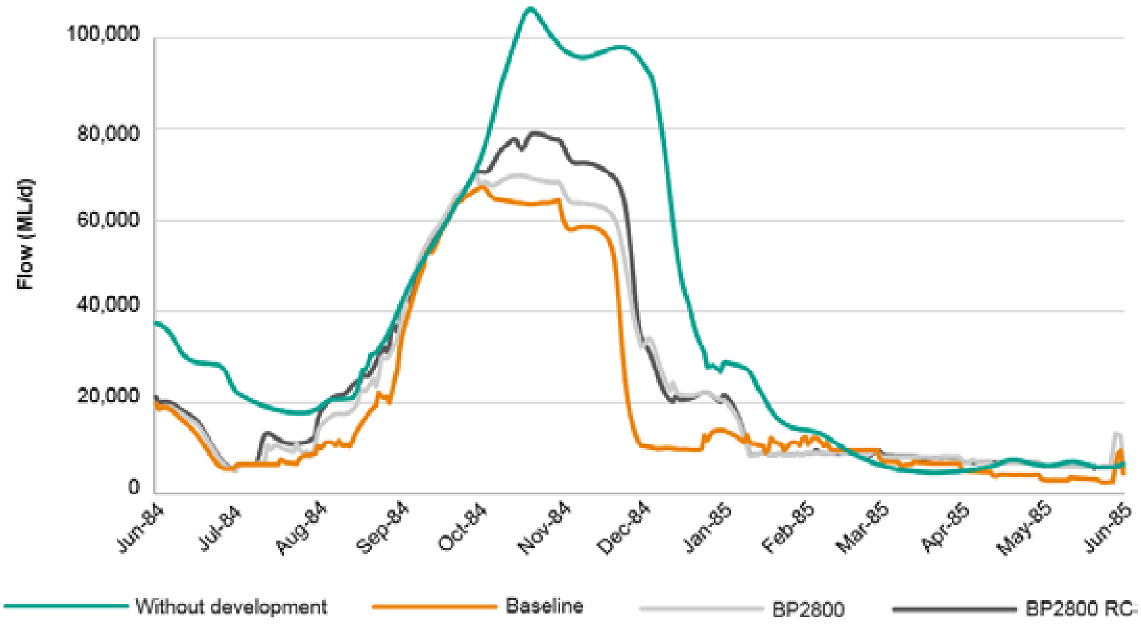

Figure 19 Flow in the South Australian Murray key focus area in the 1984 example flow event

The increased flows in this example would water tens of thousands of additional hectares of wetlands and floodplain between Euston and the Lower Lakes, with similar benefits in the upstream valleys.