



Australian Government



# South Australian River Murray reach report

## Constraints Management Strategy



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## Summary

For the past century, the Murray–Darling Basin (the Basin) has been developed with a focus on delivering water for productive use. Large dams have been built to capture and store as much water as possible to be used later for consumption and irrigation. There have also been many rules put in place across the Basin around how the rivers and dams are managed.

These structures and practices are of great benefit to our industries and have greatly supported the building of our nation, our Basin communities and our economy. However, the changes we have made have affected how, when and where the Basin's rivers flow and how healthy they are. Water that once flowed downstream is now often stored, and delivered in regular patterns at times that suits production, not necessarily in a more natural variable way that most benefits and supports the environment. Only when dams are full and spill over are there any significant overbank flows downstream.

For many floodplain areas of the Basin, the time between drinks is now too long for floodplain plants and animals. Small overbank flows that connect the river to its floodplain are vital to the environment. These overbank flows improve water and soil quality, recharge groundwater, and support native plant and animal species. Before rivers were regulated, these flows were far more common. The lack of these flows is affecting long-term river and floodplain health, and, ultimately, Basin communities and businesses who rely on healthy waterways.

Environmental watering has been successfully done for many years in some parts of the Basin, and is one way we can deliver water to benefit the environment. However, there would be many environmental benefits if we could deliver slightly higher flows in the future (mostly up to minor flood level) to reach the floodplains. So, the Basin governments requested that the Basin Plan include a Constraints Management Strategy (the Strategy) to explore how this might be done.

## The Constraints Management Strategy

The Strategy is about ensuring that water can flow onto the floodplain, while mitigating any effects this water may have on property and people.

For the purpose of the Strategy, constraints are river rules, practices and structures that restrict or limit the volume and/or timing of regulated water delivery through the river system.

Implementing the Strategy will support governments to operate our highly regulated rivers in smarter ways to increase the frequency and duration of small overbank flows to sustain and improve floodplain health.

Given consumption and irrigation needs, it is not possible, nor is it the goal, to return regulated rivers to their 'natural' or 'without development' flows. The Strategy is also not trying to create or change how often moderate and major floods occur. The idea is to make modest regulated releases from storages, generally when higher flows downstream would have occurred if dams were not there. That is, the small overbank flows being proposed will 'top-up' natural rainfall or unregulated tributary flows, to increase either their peak or duration.

In 2013 and 2014, we're doing the first phase of work — the prefeasibility phase — which involves looking at seven areas of the Basin in more detail. The Murray–Darling Basin Authority (MDBA) is collecting information about how small overbank flows, typically up to around minor flood level, affect the environment and people who live and work along this section of the River Murray. We are also collecting information about how such flows can be managed, and what sorts of protective measures are needed first.



## The South Australian River Murray

The South Australian River Murray is one of seven areas of the Basin that the MDBA is studying for the Strategy.

The South Australian River Murray system comprises 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. These parts of the South Australian River Murray play an important role in supporting communities and industry in the region and across South Australia.

The system has many significant environmental values that are important locally, nationally and internationally. The South Australian River Murray system provides habitat, food and breeding grounds for many resident and migratory animals.

Over time, the system has been modified and become highly managed. Dams and weirs store and deliver water for irrigation and consumption, and also significantly alter the flow of the river. Changing the flow patterns disrupts or prevents the natural cycles of feeding, growing and breeding for many plants and animals. Because of this, many native species and migratory birds have significantly declined. Re-introducing more frequent overbank flows in the South Australian River Murray is needed to improve the health of the system and reduce further decline. To do this, we need to boost naturally occurring higher flows (e.g. flows over 60,000 ML/day at the South Australia border) with environmental water out of the storages.

Because the South Australian River Murray receives most of its water from upstream reaches, rather than local rainfall and run-off, it is reliant on what water is available in storages and can be delivered through the system (Lower Darling, Upper Murray, Murrumbidgee and Goulburn rivers). Constraints in these rivers limit the volume of regulated flows that can be delivered, reducing local environmental benefits, while having a compounding effect on the South Australian River Murray.

MDBA have undertaken preliminary investigations to look at ways of boosting natural, unregulated flows in the upstream rivers to achieve higher flows in the South Australian River Murray. Initial results have indicated that the frequency, duration and peak of overbank watering events may be increased by using natural cues to time environmental releases from storages and coordinating these with naturally occurring high flows.

Flows of between 60,000 ML/day and 80,000 ML/day (measured at the South Australia border) are the types of overbank flow rates we are looking at as a part of the Strategy. This range is important for triggering a range of biological processes, and improving water quality in the long term by helping to move salt and sand out to sea, while recognising the operational capacity of environmental watering in a regulated system. This flow regime is also below the minor flood level for the South Australian River Murray which is 100,001 ML/day, measured at the South Australian border.

## The community

This reach report reflects MDBA's current knowledge base after preliminary technical work and what we have heard after talking with people along the South Australian River Murray.

For the past 18 months, MDBA and the South Australian Government consulted with representatives from river communities to further understand the effects of flows between 60,000 ML/day and 80,000 ML/day at the South Australia border.

Through consultation, we heard the majority of issues that could occur are minor and manageable if adequate warning is provided and the following be considered:

- Long-term forecasting of overbank flows would enable councils and the local community to plan for effective management of flows.
- Environmental water planning should take into account, where possible, the effects on tourism.
- Educating the general public about a healthy and sustainable river system would help people manage different flows and encourage a range of tourism ventures in the region.
- Any effects on private land and property at different flow rates require further investigation.

In this report, we present the information that we have collected and invite you to provide feedback about its accuracy. We are keen to make sure that we have our ‘facts right’ so that we can provide the best possible advice to Basin governments.

If we are missing anything, or if you have suggestions for further work, please let us know. Please email [constraints@mdba.gov.au](mailto:constraints@mdba.gov.au), or write to MDBA at:

Constraints Management Strategy  
Murray–Darling Basin Authority  
GPO Box 1801, Canberra ACT 2601.

## Next steps

This is a 10-year process and Basin governments are only at the early stages of finding out what the issues and opportunities are, to support future decision making.

Further work is needed in each of the areas to understand the types of things that need to be in place to deliver the overbank flows being investigated. More computer modelling is also needed to find ways to deliver flows through the system, to the South Australian River Murray, in a way that optimises benefits while limiting impacts.

Information from all seven priority areas of the Basin will be included in the Constraints Management Strategy annual report, which will make recommendations to Basin governments about further investigations. The annual report will be available from the MDBA website in late 2014.

Any further work will depend on the decisions of Basin governments. The first decision, in late 2014, is about whether to proceed with collecting more information. This means beginning detailed planning, technical and community studies to better understand the feasibility of overbank flows and the mitigation measures needed for delivering the proposed flows. The 2014 decision is not a green light to build, do or change anything about how the river is managed.

The second decision, in mid-2016, is about whether to start putting mitigation measures in place, based on recommendations from the range of feasibility studies. Actions would take place between 2016 and 2024 to ensure mitigation measures are in place — such as formal arrangements with landholders, rule or management practice changes, asset protection and infrastructure upgrades — before any managed overbank flows are delivered.

## What is the Constraints Management Strategy?

### At a glance

The Constraints Management Strategy looks at ways to allow rivers to connect to their floodplains more often to improve and maintain the environment, while avoiding, managing or mitigating effects on local communities and industries.

In a river, ‘constraints’ are the things that stop water from reaching some areas.

The constraints can be:

- physical structures, such as bridges, roads or outlet works
- river management practices.

The Constraints Management Strategy (the Strategy) is about ensuring that our rivers — and the environments and communities they support — stay healthy and sustainable.

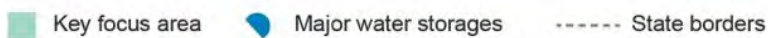
In particular, it is about investigating how to connect rivers with their floodplains more often, while avoiding, managing or mitigating effects to local communities and industries.

By carefully managing constraints, we can ensure that water continues to sustain our vital river environments and communities, both now and in the future.

### What areas are being looked at

The Strategy is looking at seven areas of the Murray–Darling Basin (Figure 1). These areas were chosen because we are likely to get the best environmental benefits by changing constraints to increase regulated flows in these areas. The areas are:

- Hume to Yarrawonga
- Yarrawonga to Wakool Junction
- Goulburn
- Murrumbidgee
- Lower Darling
- River Murray in South Australia
- Gwydir region.



### Figure 1: Areas in the Murray–Darling Basin affected by the Constraints Management Strategy



## What could change

### Current situation:

- The current operation of the river system provides flows within a range that is largely governed by irrigation requirements and minimum flow provisions.
- Rivers are operated to maximise water availability for consumptive use and to limit evaporation losses on floodplains.

Over time, such operations have led to a substantial decline in floodplain health. The Strategy is about identifying smarter ways to manage rivers while still maintaining the role of dams in providing water security for water users and flood protection.

### Possible future situation:

- Flows from unregulated tributaries may be topped-up with regulated releases from storages. Together, these sources of water would combine to become a flow of sufficient size to result in small overbank flows downstream.
- Overbank flows are designed to reach particular parts of the floodplain to achieve specific ecological outcomes.

The ability to do this relies on river managers having information that is accurate enough to enable them to plan, with confidence, when and when not to make regulated releases. It also relies on governments being able to understand and mitigate any impacts on private land and community assets along the entire flow path.

Mitigation measures where required must be in place before regulated overbank flows can be delivered. These include formal arrangements with landholders, rule or management practice changes, asset protection, and infrastructure upgrades. The Strategy is focusing on these types of activities during the next decade.

It is important to note that the Strategy should not increase how often damaging moderate and major floods occur. The Strategy is about delivering small overbank flows (see 'Overbank flows', below).

## Background to the Strategy

The Strategy was developed in 2013 through technical assessments and many conversations with local communities and industries. It incorporated community views and suggestions from a public comment period in October 2013 (see 'What does the community think?' and the [Constraints Management Strategy public feedback report](http://www.mdba.gov.au/sites/default/files/CMS-Public-Feedback-Report.pdf)<sup>1</sup>).

The Strategy is part of the implementation of the Murray-Darling Basin Plan.

The Australian Government has committed \$200 million to carry out approved mitigation works that are identified as priorities by the Basin states in the next 10 years.

### Overbank flows

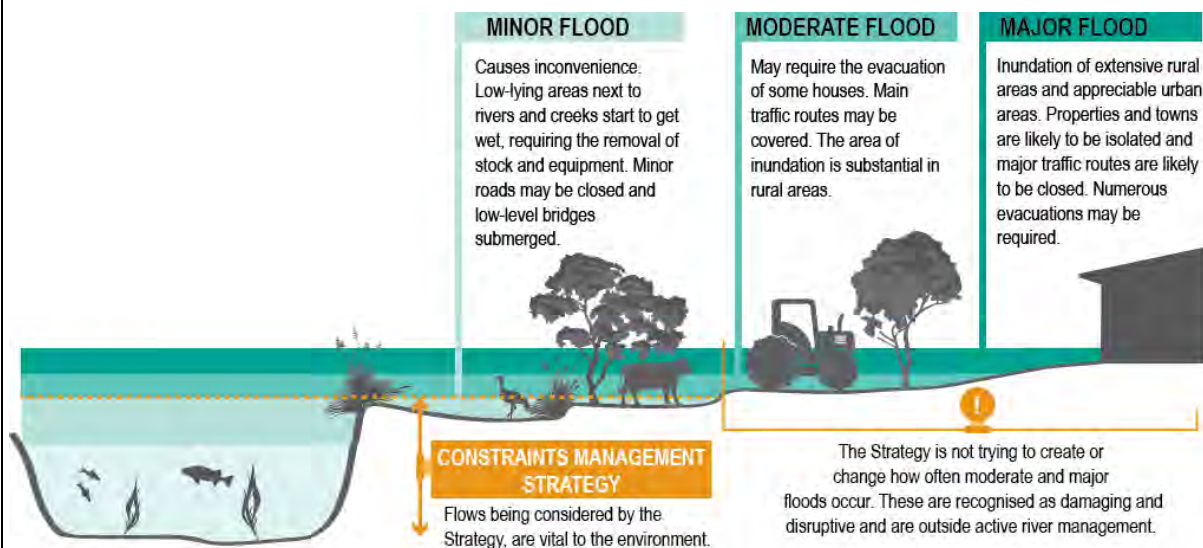
<sup>1</sup> [www.mdba.gov.au/sites/default/files/CMS-Public-Feedback-Report.pdf](http://www.mdba.gov.au/sites/default/files/CMS-Public-Feedback-Report.pdf)

In unregulated river systems, overbank flows occur frequently, wetting the floodplain around the river.

The changes being investigated in the Constraints Management Strategy aim to increase the frequency and duration of some of the small overbank flows, allowing water to reach particular parts of the landscape that haven't been getting water as often as they need, such as creeks, billabongs and floodplain vegetation.

The flows being investigated throughout the Murray–Darling Basin, as a part of the Strategy, are generally below or at the level defined as a 'minor flood' by the Bureau of Meteorology. Bureau of Meteorology flood warnings fall into three categories — minor, moderate and major. The official definition of a minor flood is a flow that causes inconvenience. Low-lying areas next to rivers and creeks start to get wet, requiring the removal of stock and equipment. Minor roads may be closed and low-level bridges submerged.

The Strategy is about delivering small overbank flows, which are below flood levels that are damaging (Figure 2).



Note: The descriptions of minor, moderate and major floods are the [official definitions from the Bureau of Meteorology](https://www.bom.gov.au/water/floods/floodWarningServices.shtml).<sup>2</sup>

**Figure 2: The effects of minor floods compared with moderate and major floods**

The small overbank flows would be created by 'topping-up' unregulated tributary flows with releases from storage to increase the peak or duration of a flow event, and so reinstate some of the flows that have been intercepted and stored by dams.

## Why is the Strategy important?

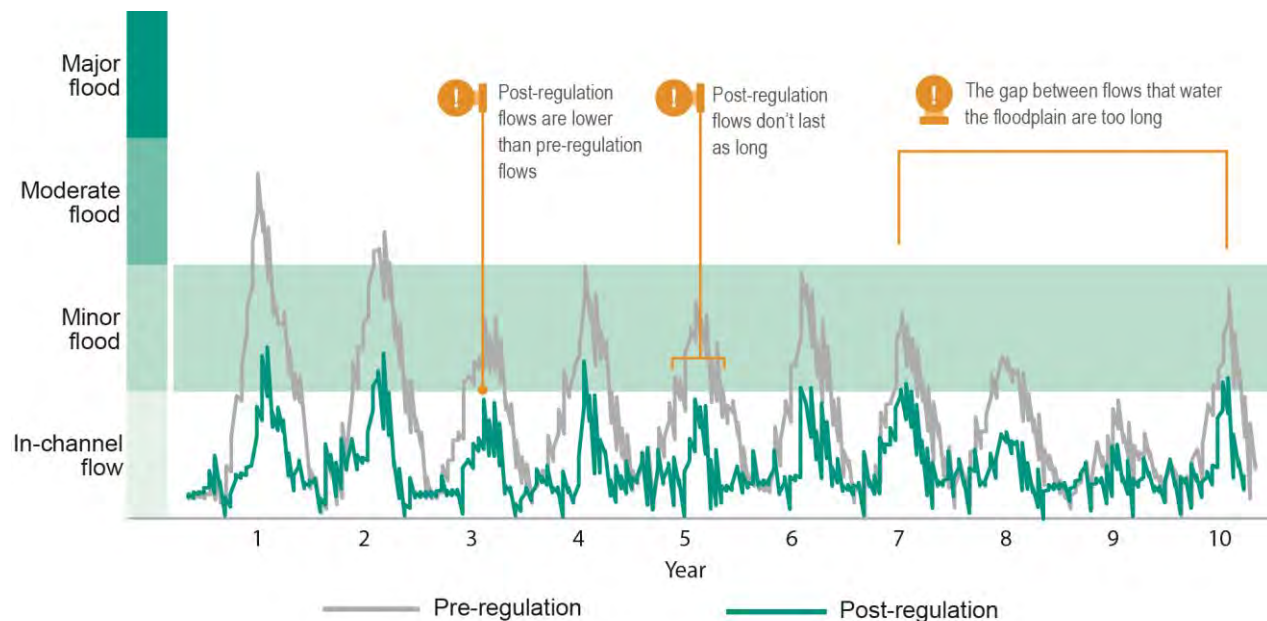
### At a glance

Connecting rivers to their floodplains sustains the local environment and provides benefits to communities, such as improved soil and water quality. River development and regulation have reduced the overbank flows that provide this connection. The Constraints Management Strategy aims to put back some water to the environment to boost riverine productivity, and increase health and resilience.

### Rivers before and after river regulation

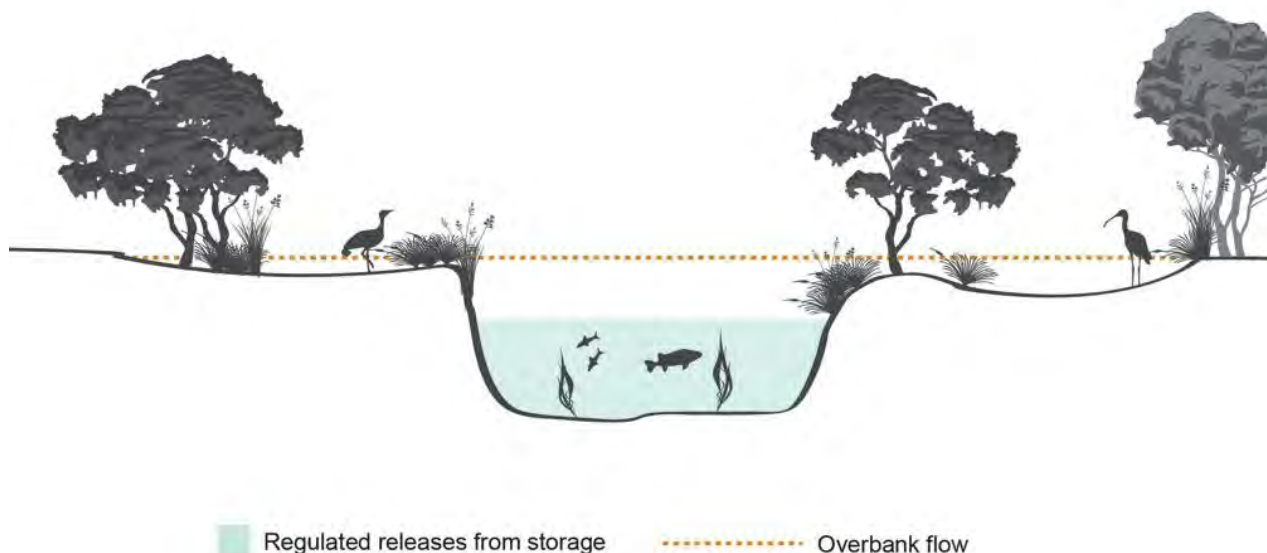
In unregulated river systems, there are no constraints to overbank flows caused by high rainfall and catchment run-off, which regularly spread out across the floodplain and reach floodplain creeks, wetlands and billabongs.

In regulated river systems, dams and weirs capture and control rain water, which significantly reduces the amount of water that flows downstream. The size of flows downstream is reduced and the flows last for a shorter amount of time. The time between flow events can be longer than would happen naturally. Figure 3 shows the type of flows that tend to occur each year before and after regulation. 'Pre-regulation' (grey line) flows used to be more frequent, larger and last longer compared with post-regulation flows (green line).



**Figure 3: Changes to a river's hydrology after river regulation (hypothetical flow curve used to demonstrate concept)**

In the regulated system, water is released from dams most of the time so it stays within the channel and doesn't reach the floodplain (Figure 4). From time to time, water needs to reach the floodplain and its creek network, wetlands and billabongs, because many plant and animal species rely on flows to trigger a range of biological processes (feeding, breeding, moving) and stay healthy.



**Figure 4: Regulated releases from storage are mostly restricted to in-channel flows**

## Regulation in the Murray–Darling Basin

The Murray–Darling Basin (the Basin) has become highly regulated. In 1891, the construction of Goulburn Weir near Nagambie, Victoria, marked the beginning of almost a century of construction of major assets to support irrigation in the Basin.

By the time Dartmouth Dam was completed in 1979, enough dams had been built across the Basin to store more than one year's average inflow. The large dams in the southern Basin — Burrinjuck, Blowering, Hume, Dartmouth and Eildon — were all sited at locations where they could capture and store as much inflow as possible.

These dams typically fill through winter and spring, and are subsequently drawn down through summer and autumn to support large-scale irrigation.

In the southern Basin, where 80% of the Basin irrigation occurs, the combination of dam construction and irrigation changed the rivers from winter–spring flowing to summer–autumn flowing and, in the process, eliminated most small flood events.

With Australia's highly variable rainfall and heavy irrigation use, it became quite common for winter–spring rain events to be almost fully captured in storages. Significant overbank flows only happen when the major storages have filled and, subsequently, spill. Thus, only the wettest 15% of years now result in significant overbank flows in the middle to lower Murray. Before development, such flows would have occurred in almost 50% of years.



The impact on floodplain species has been dramatic, with large areas of floodplain forests and woodlands dead or highly stressed.

## Connecting rivers to their floodplains

The operation of dams and river regulation has reversed the natural seasonal flow pattern. Changing the seasonal flow pattern disrupts the natural cycles of feeding, growing and breeding for many plants and animals. Because of this, many native species have significantly declined in the River Murray system.

Allowing the river to connect with its floodplain and wetlands through small overbank flows will rejuvenate these areas. The benefits of these flows are listed below and described in Figure 5.

Overbank flows:

- **improve water quality and supplies**, by
  - flushing out the salt along riverbanks and floodplains
  - helping recharge groundwater supplies
- **improve soil quality and reduce erosion**, by
  - moving carbon and nutrients between rivers and floodplains
  - stabilising riverbanks through better vegetation growth, thus reducing erosion into the river
- **support native species**, by
  - triggering plants to seed or germinate — for example, river red gums need flooding for their seeds to germinate
  - supporting habitat and breeding of aquatic bugs and insects (the primary source of the river food chain)
  - stimulating animals like native fish to feed and breed — for example, golden perch need high river flows to spawn, and floodplains make great nursery habitats to rear young fish
  - allowing plants and animals to move throughout river systems and colonise new areas.

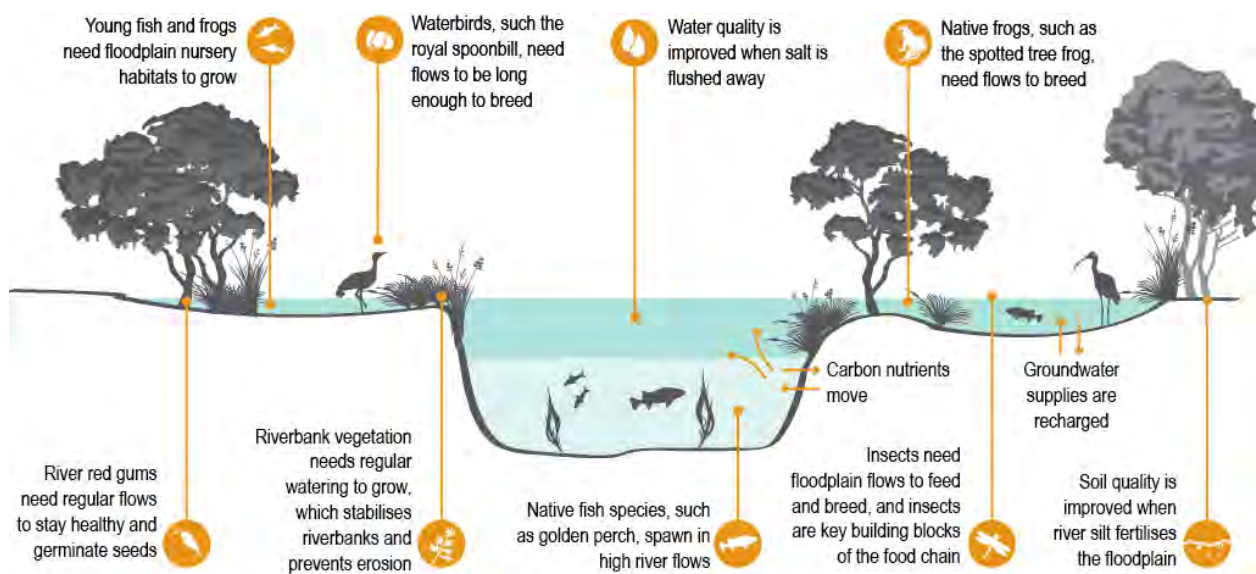
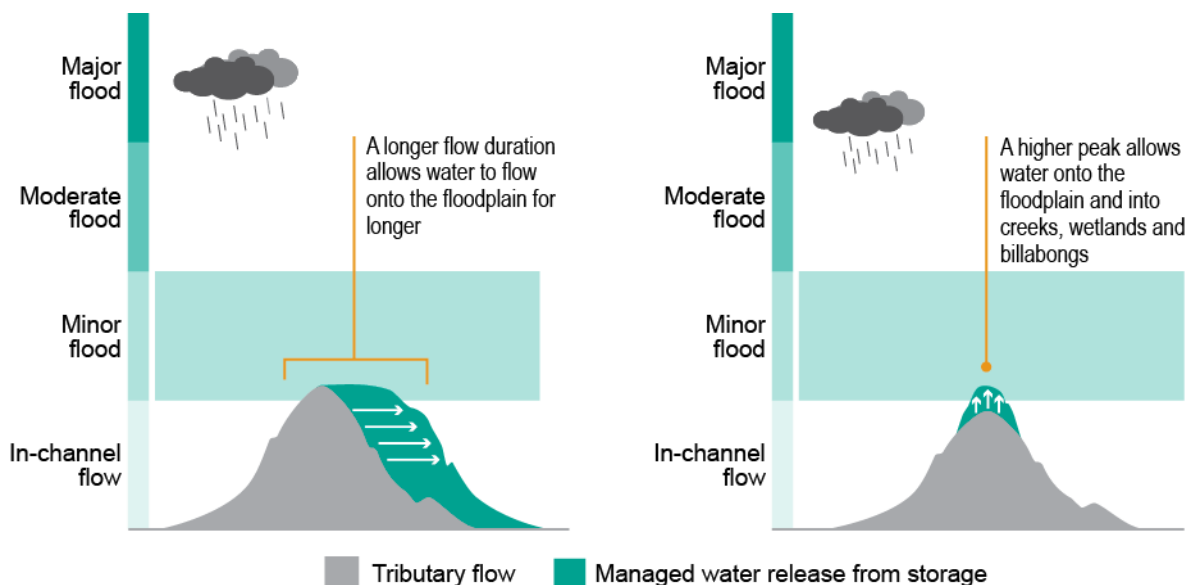


Figure 5: The environmental effects of overbank flows

Many environmental processes, such as breeding and migration, occur with particular flows conditions in rivers (e.g. faster river flows, overbank flows or receding water levels). Remarkably, several riverine plants and animals use weather conditions, such as high rainfall, as triggers in anticipation of a certain flow event that will stimulate their breeding or need to migrate. Coordinating water releases from dams with rainfall events and catchment run-off will help riverine plants and animals make use of natural ecological cues and improve the outcome. Figure 6 shows how these flows could be achieved.



**Figure 6: 'Topping-up' unregulated tributary flows with regulated releases to create small overbank flows**

## What is happening in the South Australian River Murray region?

### Description of the region

The South Australian portion of the Murray–Darling Basin (the Basin) extends from the Mount Lofty Ranges to the borders with Victoria and New South Wales. It covers 5.6 million hectares or 7% of the state (Figure 7). The region consists of important groundwater and surface water resources, with the River Murray being the most significant water resource and the principle supply of water to the state (Natural Resources, SAMDB 2014).

The majority of the region is classified as semi-arid and has low rainfall that is less than 300 mm per year on average in the Riverland (Natural Resources, SAMDB 2014). The region also experiences a Mediterranean climate with average summer temperatures above 30 degrees in the Riverland (Natural Resources, SAMDB 2014).

The River Murray flows into South Australia at the state border with New South Wales and travels more than 640 km to the sea at Goolwa (see photograph below). The River Murray system contains a diversity of habitat types including the floodplain, creeks, lakes and wetlands. The floodplain in the Southern Australia River Murray region is defined as the area of land that was covered by the biggest recorded flood, which occurred in 1956.

From the border to Overland Corner, near lock 3, the floodplain is largely wide and flat (see photograph below). There are numerous, different types of wetlands in this region — some that stay dry until the river is full, and are able to flow out of the channel across the floodplain and into these areas; and others that are connected to the main channel (see photograph below). Creeks and anabranches are also prominent in this region; some extend across two weir pools and are fast flowing (due to the difference in heights of the weir pools), and others that are dry or slow flowing under typical conditions. This section of the river contains a large number of protected areas that are managed for nature conservation, including the Chowilla Floodplain, Riverland Ramsar site, Murray River National Park and Katarapko Conservation Park.

From Overland Corner to Mannum the area of floodplain tends to be smaller, as steep limestone cliffs and highland plains constrain sections of the River (Natural Resources, SAMDB 2014). In this stretch wetlands tend to be permanently connected to the river under normal conditions, and creeks are uncommon. Vegetation along the riverbanks tends to be dominated by reeds, willows and river red gums. Vegetation on the floodplain areas higher in the landscape are typically dominated by lignum shrublands and black box woodlands.

As the river continues south past Mannum, the land becomes flatter and the edges of the river are dominated by swamps and, in some sections, areas of cliffs. In this part of the river, the vegetation is mostly reeds and willows. Red gum trees are largely absent and confined to the cliffs.

At the end of the system, the river water mixes with water from the Eastern Mount Lofty region as it enters the sea through the Murray Mouth (see photograph below). Along the way, the water fills the large freshwater lakes Alexandrina and Albert, and refreshes the salty waters of the Coorong and the estuary environment surrounding the Goolwa channel.

The Coorong, Goolwa Channel and Murray Mouth form the estuary of the Basin. Lakes Alexandrina and Albert are separated from the Coorong by a series of barrages that maintain lake water levels and prevent the incursion of marine water. The maintenance of the relatively freshwater environments of the lakes is important both ecologically and socioeconomically.



Figure 7: Map of the SA River Murray. The green area indicates the Murray–Darling Basin





**River Murray Floodplain upstream of Renmark, November 2004. The photo shows the different habitats on the floodplain (left of photo) including forests, wetlands, creeks and billabongs. Photo: Michael Bell.**



**Monoman Creek, one of the many different types of habitat types found in the South Australian River Murray region, January 2008. Chowilla Game Reserve. Photo: Kelly Marsland.**





One of the many wetlands along the South Australian River Murray. Overbank flows in Berri, South Australia, during the 2011 high flow event in the River Murray peaked at 94,000 ML/day at the South Australia border. There was enough water in the river for it to spill out of the main channel and fill Martin's Bend wetland (visible in the foreground). *Photo: Kelly Marsland.*



The Murray Mouth and Coorong from the air, October, 2008. *Photo: Michael Bell.*

## People and economy

More than 125,000 people reside in the South Australian portion of the Murray–Darling Basin (SA MDB) (Natural Resources, SAMDB 2014). Most of these people live within the Eastern Hills and coastal areas, particularly in the major urban centres of Mount Barker, Strathalbyn and Goolwa (Natural Resources, SAMDB 2014). The Riverland region is home to about one-third of the region's population, especially in and around the town centres of Berri, Renmark, Loxton, Waikerie and Barmera (Natural Resources, SAMDB 2014).

Aboriginal people have been managing the natural resources of the Basin for many thousands of years. Aboriginal culture and the environment are intimately linked, with many species of plants and animals, as well as many features across the landscape, being extremely significant.

Today, Aboriginal people make up 2% of the population of the SA MDB (Natural Resources, SAMDB 2014). In the region, two Traditional Owner groups have entered into agreements with the South Australian Government to strengthen collaborations between the two, and to outline an approach to consultation to improve opportunities for Traditional Owners and Aboriginal people to be involved in water resource planning and implementation. The Ngarrindjeri, represented by the Ngarrindjeri Regional Authority, have entered into the Kungun Ngarrindjeri Yunnan Agreement (KNYA). The First Peoples of the River Murray and Mallee Region were recognised as native title holders and have entered into an Indigenous Land Use Agreement.

The River Murray is a vital asset to the state of South Australia. Water from the River Murray supplies the majority of the water needs for the capital city of Adelaide as well as other towns in the state (Natural Resources, SAMDB 2014). It is also the most productive agricultural region in South Australia. Approximately 80% of the land in the region is used for primary production, including pastoral lands, dryland cropping, grazing, horticulture, irrigation and dairy farming (Natural Resources, SAMDB 2014). Some parts of the South Australian River Murray floodplain support pastoral enterprises. Floodplain country can be a valuable resource for these enterprises given its relatively moist environment compared to the surrounding semi-arid landscape (Natural Resources, SAMDB 2014). In the 2011–12 financial year, the gross regional product for the 11 major Local Government Areas within the SAMDB was approximately \$3.1 billion (DPC 2012).

The region has prosperous tourism and recreation industries. There is a diverse range of recreational opportunities available in the region focused on the River Murray, Coorong and Lower Lakes, and conservation areas such as the Murray River National Park. In 2010–11, there were more than 1.3 million visitors to the region and close to 1.3 million overnight stays (Natural Resources, SAMDB, 2014).

## Environment

The South Australian River Murray contains many valuable environmental assets despite being a highly developed system. The region is home to vast areas of important habitats and vegetation communities that support a diversity of species. The river environment contains many native fish species, including Murray cod and callop (golden perch), crustaceans, turtles and frogs. It also sustains an extensive network of wetlands that are important to the survival of these and other species.

Adjacent to the river and wetlands, vegetation along the floodplain is dominated by river red gum woodlands and river cooba trees, as well as a diversity of grasses, herbs and reeds. Black box woodlands and lignum shrublands typically dominate the higher areas of the floodplain. This vegetation plays a vital role in the health of the region, including providing food and habitat for

animals, limiting erosion of the riverbank, improving water quality and reducing greenhouse gas emissions.

The wetland and floodplain habitats are important refuges for a range of animals, particularly during times of drought and therefore play an important role in the landscape. For example, woodland birds that are typically found in surrounding mallee areas use the floodplain woodlands as a food source, especially during dry times (Natural Resources, SAMDB 2014). In recognition of the importance of these habitats, extensive floodplain areas along the South Australian River Murray have been set aside for conservation, including Chowilla Game Reserve, Katarapko Island (River Murray National Park), Maize Island Conservation Park and Morgan Conservation Park.

Basin governments also recognised the significance of the region. The Living Murray program identified the Coorong, Lower Lakes and Murray Mouth, River Murray Channel and the Chowilla region (as a part of the Chowilla Floodplain and Lindsay-Wallpolla Islands Icon site) as icon sites.

Additionally, the following sites have received international recognition as being important sites for migratory birds under the Ramsar Convention:

- Riverland Ramsar site (an area of 30,600 ha that includes the South Australian portion of the Chowilla Floodplain, and wetland and floodplain areas downstream to Renmark)
- Banrock Station Ramsar site near Kingston on the Murray (1,068 ha)
- the Coorong, and lakes Alexandrina and Albert (140,500 ha).

Maintaining the ecological character of these sites is essential to ensure we meet our obligations under the Ramsar Convention and, importantly, that these areas remain capable of supporting the international migratory birds that rely on their ongoing health.

## How the South Australian River Murray has changed

River regulation has significantly reduced the occurrence and magnitude of medium and small flows to South Australia (MDBA 2012). Modelling results have shown that, under current development conditions in the Murray-Darling Basin, the average annual flow to South Australia has been reduced by 52% compared to without development conditions (CSIRO 2008). Flows of 80,000 ML/d previously occurred once every two years on average, but now occur once every eight years (Cale 2009). CSIRO (2008) found that, as a result of water resource development, the average period between beneficial spring-summer overbank flows has more than tripled (from 2.4 to 9.3 years). Similarly, the maximum period between events under current conditions is five times the maximum period experienced under without development conditions (from 5.7 to 28.7 years). Flood volumes have also been greatly reduced, such that the average annual flood volume is now less than half of the volume compared to without development conditions (from 2431 to 947 GL).

The construction of lock and weirs within the South Australian River Murray has also changed the system. There are six lock and weirs in the South Australian River Murray main channel from Blanchetown (Lock 1) to Lock 6 near the South Australia border, which were constructed in the 1920s to provide year round river navigation. The locks provide passage for boats and the weirs keep water levels in the weir pools fairly stable under 'typical conditions' (i.e. outside floods) (see photograph below). This has had an impact on the vegetation and animal communities along the river. In these weir pools, species that thrive in these conditions (stable water level, low flow) are favoured compared to species that prefer variable water levels and flows.





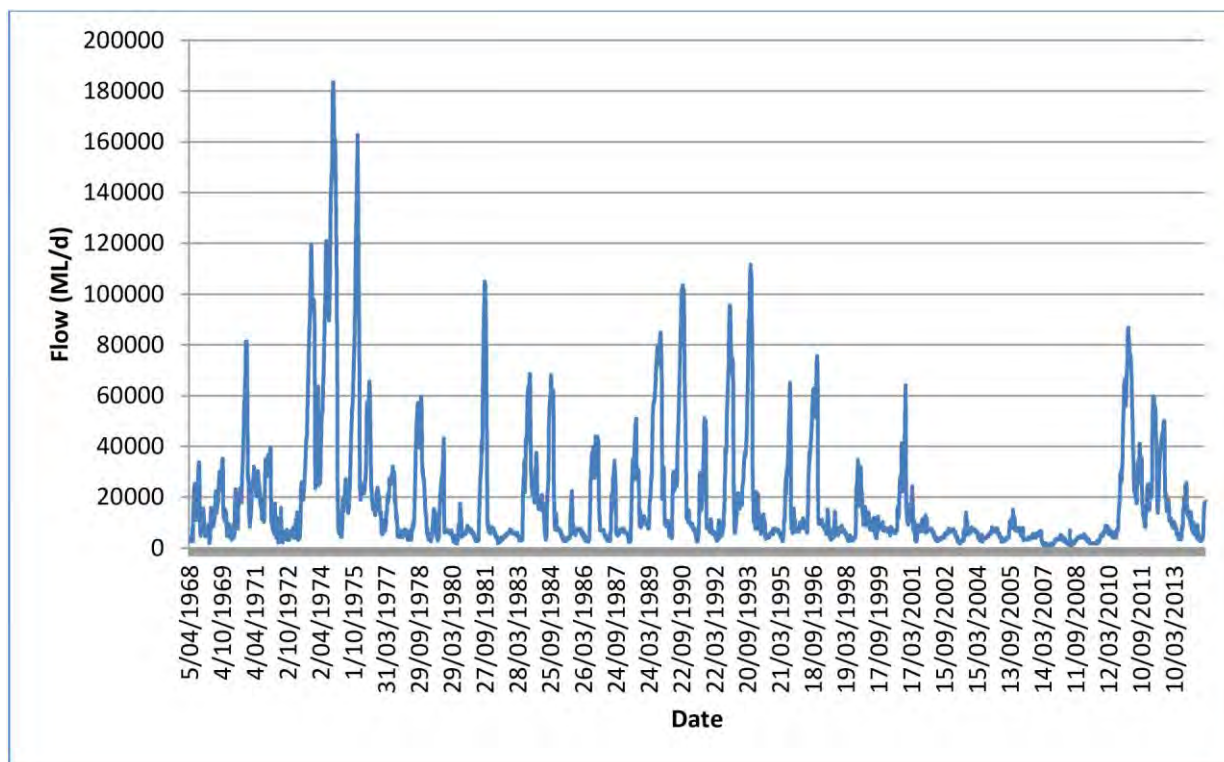
**Lock and Weir Four, near Loxton, South Australia, April 2010. The weir holds the water level higher than the weir pool below. During typical flow conditions, small volumes of water pass over the top to the next weir pool but the majority stays in the weir pool. The lock (left of photo) allows boats to pass from one weir pool to another. Photo: Arthur Mostead.**

Regulation and extraction has also impacted the health of the estuarine environment of the Murray Mouth and freshwater environments of Lakes Alexandrina and Albert. In 1931, it was recognised by the then River Murray Commission and landholders that extraction upstream reduced flows in the River Murray and, as a result, flow control structures were needed to prevent sea water from entering lakes Alexandrina and Albert and diminishing the ecological character of the region (Jacobs 1990).

As a result, five barrages were constructed between 1935 and 1940 (Jacobs 1990): the Goolwa Barrage between the Goolwa Channel and Murray Mouth; Mundoo Barrage between Hindmarsh and Mundoo Islands; and Boundary Creek, Ewe Island and Tauwitchere barrages between Lake Alexandrina and the Coorong. The barrages keep sea water out, especially during periods of low river flows or high storm surges, and also enable a near constant water level to be maintained for navigation and the pumping of water for use in irrigation and towns.

Flows in the South Australian River Murray have varied significantly over time, with several years of higher flows and many years of very low flows. Figure 8 shows flows that have occurred in the South Australian River Murray since the 1960s as measured at the South Australia border. The high flow events in 2011 and 2012 can be seen after a long period of drought, such as the millennium drought that happened between 2001 and 2010.

The historic 'big flood' of 1956 had a maximum flow rate of 341,000 ML/day at the South Australia border. Flooding of this type is very rare and, since 1956, no floods have come close to this rate. The second largest flood in recent years was approximately of 180,000 ML/day in 1974. The high flows experienced in 2011 and 2012 were much lower, peaking at approximately 94,000 ML/day and 60,000 ML/day, respectively.



**Figure 8: Flows (ML/day) in the River Murray since 1960s as measured at the South Australia border**

## How the South Australian River Murray is managed

A decision to share the waters of the River Murray was made in 1914 between the Commonwealth, New South Wales, Victoria and South Australia governments. The agreement – the River Murray Waters Agreement – outlined a plan for regulating the river, the process for decision making between the parties, and cost-sharing and water-sharing arrangements (Jacobs 1990). This included apportioning an entitlement flow for the South Australian River Murray, which was subsequently increased to 1,850 GL per year after the construction of Dartmouth Dam (Jacobs 1990). The original agreement came after several decades of concern, discussion and sometimes conflict about how the River should be controlled and managed, and after many years of a severe drought (i.e. the Federation drought).

South Australia's annual base entitlement flow of 1,850 GL is delivered at the South Australia border at rates ranging from 3,000 ML/day to 7,000 ML/day, depending on the time of year under 'normal' conditions (i.e. outside of droughts or periods of flooding). South Australia's entitlement will be restricted under very dry conditions but flows commonly exceed the annual entitlement volume. Under the Murray-Darling Basin Authority's modelling of current conditions (based on 114 years of data), the average annual flow to the South Australian River Murray is approximately 7,000 GL (J Foreman, October 2014 *pers. comm.*). Annual flows have only dropped below entitlement during extreme drought, as occurred during the recent millennium drought.

In times when flows are at entitlement rates, environmental water may be used to increase flow rates to trigger biological processes such as fish spawning. When there is more water in the river and the flow rates are higher, environmental water can be used to add to the flow to increase the area of floodplain and wetlands that are inundated, which helps drive biological processes,



improves water quality, and assists with the removal of salt out of the system and sand out of the Murray Mouth.

Lake Victoria (see photograph below) is used to regulate water to help secure water availability for South Australia. It was a natural lake until the 1920s, at which time alterations were made to convert it to store water as a part of the River Murray Waters Agreement. Lake Victoria is much smaller than storages upstream — it can only hold 677 GL of water, which is equivalent to approximately three months of South Australia entitlement flow (Jacobs 1990). The lake is managed and operated by SA Water, and used to store water in times of high flow at Wentworth and deliver water during times of low flow.

Lake Victoria is a significant cultural site for Aboriginal people. Management of water levels needs to consider and protect the many culturally significant sites around the lake.



**Lake Victoria, which stores some of South Australia's water, November 2004. Photo: Michael Bell.**

## Flood level descriptions in the South Australian River Murray

As the amount of water flowing down the river can vary significantly, the South Australian Government has developed a classification system to describe the implications of particular flow rates as measured at the South Australia border (Table 1). The South Australian Government is able to provide advice and warnings up to four to six weeks ahead of the projected flow due to the long travel time from upstream storages. More information and maps of the inundation extent at different flow rates can be found on the [South Australian Government's WaterConnect website](http://www.waterconnect.sa.gov.au).<sup>3</sup>

<sup>3</sup>

[www.waterconnect.sa.gov.au](http://www.waterconnect.sa.gov.au)

In South Australia, the minor flood level for the River Murray is 100,001 ML/day, measured at the South Australia border (Table 1). Flows from 40,001 to 100,000 ML/day are classified as a 'high flow', recognising that although inundation of parts of the floodplain occurs, any effects associated with these flows are considered to be minor. Following experiences of the high flows of 2011–12, where the flow peaked at 94,000 ML/day at the South Australia border, the classification system adopts a 'minor flood' warning for the shack areas only downstream of Cadell from flows of 60,001 ML/day, as some impacts began to be felt at this flow rate.

**Table 1: Flood level descriptions adopted for the River Murray in South Australia**

Flow at border	SA River Murray	Shack areas downstream of Cadell (excluding River Murray towns)
200,001 ML/day or more	Major flood	
130,001 to 200,000 ML/day	Moderate flood	
100,001 to 130,000 ML/day	Minor flood	
60,001 to 100,000 ML/day	High flow	Minor flood
40,001 to 60,000 ML/day	High flow	
40,000 ML/day or below	Normal flow range, no warnings	

### Flow footprint maps

To help people living along the river assess the possible extent of inundation for different flow scenarios, the South Australian Government (through the Department of Environment, Water and Natural Resources) have created flow footprint maps for the River Murray at different flow rates. Flow footprint maps let you look at what areas of land are likely to be inundated at different flow rates. An example of one of these maps is shown in Figure 9.

The South Australian Government's WaterConnect website also has:

- [maps of flow footprints at 60,000 and 90,000 ML/day](http://www.waterconnect.sa.gov.au/Systems/FAM/SitePages/Home.aspx)<sup>4</sup>
- [draft maps of inundation at a number of flow rates between 100,000 and 341,000 ML/day](http://www.waterconnect.sa.gov.au/Systems/RMIM/Pages/default.aspx).<sup>5</sup>

<sup>4</sup> [www.waterconnect.sa.gov.au/Systems/FAM/SitePages/Home.aspx](http://www.waterconnect.sa.gov.au/Systems/FAM/SitePages/Home.aspx)

<sup>5</sup> [www.waterconnect.sa.gov.au/Systems/RMIM/Pages/default.aspx](http://www.waterconnect.sa.gov.au/Systems/RMIM/Pages/default.aspx)





Figure 9: An example of a flow footprint map for flows of 60,000 ML/day at the South Australia border

## What is being considered in the South Australian River Murray

Under the Constraints Management Strategy (the Strategy), the effects of flows between 60,000 ML/day and 80,000 ML/day at the South Australia border are being investigated. Before river regulation, these flows were common in the South Australian River Murray, and the lack of these flows is affecting long-term river and floodplain health.

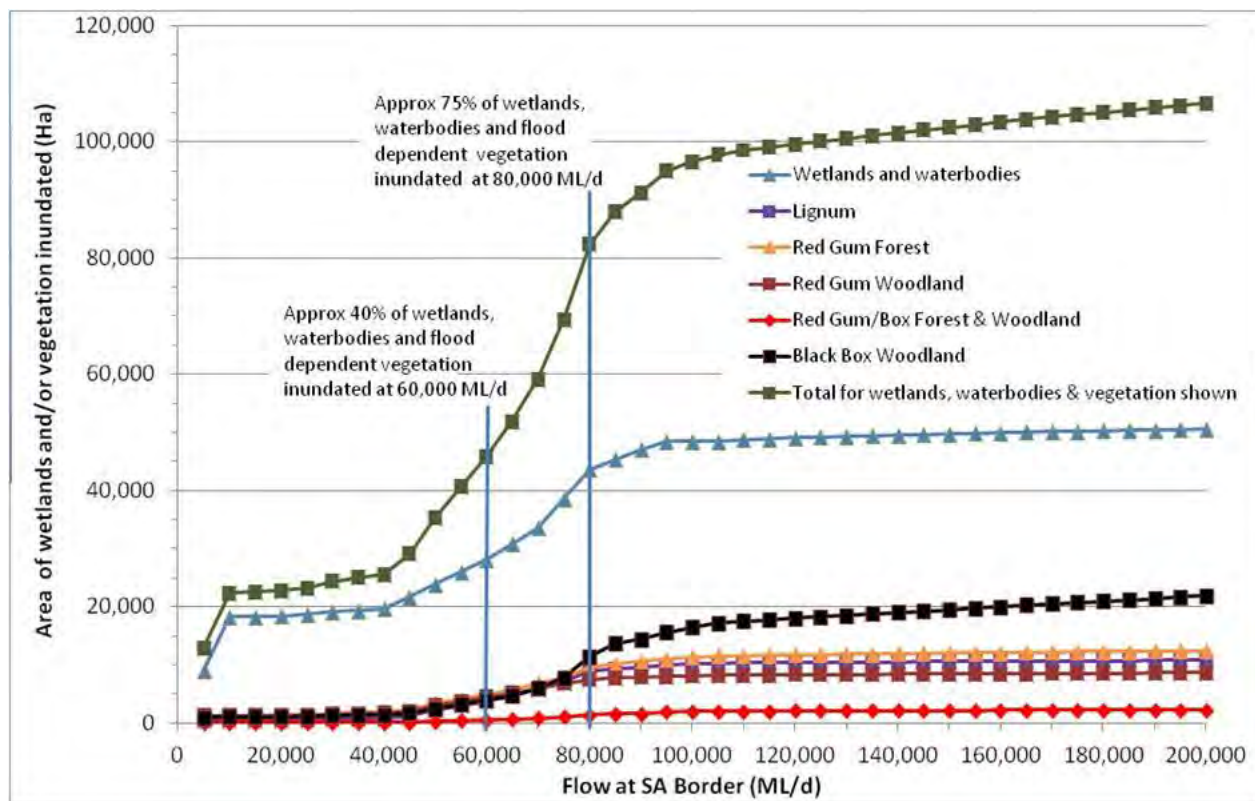
The Murray–Darling Basin Authority (MDBA) investigated the area of floodplain and vegetation communities inundated along the South Australian River Murray at different flow rates. The analysis showed that an extra 30,000 ha of floodplain is inundated as flows are increased from 60,000 ML/day to 80,000 ML/day (Figure 10). Increasing the amount of floodplain that is inundated will improve a larger area of native vegetation; provide a greater area of habitat to support more animal species; provide more water to recharge groundwater aquifers; and improve soil quality across a greater area of the floodplain.

MDBA has undertaken preliminary investigations to look at ways of boosting naturally occurring high flows (termed ‘unregulated flows’) in the upstream rivers to achieve higher flows in the South Australian River Murray. Initial results have indicated that the frequency, duration and peak of small overbank watering events in South Australia may be increased by using natural cues to time environmental releases from storages and coordinating these with unregulated flows.

MDBA modelling indicates that flows above 80,000 ML/day represent an upper threshold of the range that could be practically delivered to the South Australian River Murray through the upstream river systems to the extent that proposed constraints are addressed at upstream locations. This therefore represents the upper range for flows to the South Australian River Murray considered under the Strategy.

After the natural high-flow events experienced in South Australia during 2011 and 2012, the South Australian Government learnt that when flows exceed 60,000 ML/day there is a risk of greater levels of inundation of private land and property along the River Murray, including the shack areas downstream of Cadell. Therefore, before decisions can be made to increase flows of this magnitude with environmental water, the potential impacts to private property in this area and third party impacts generally need to be investigated through the Strategy.





**Figure 10: Change in area of different vegetation groups inundated with an increase in flow rate**

## Environmental benefits of flows up to 80,000 ML/day

We know that overbank flows in river systems are a natural part of the system and are essential for maintaining the health of rivers, wetlands and their floodplains.

In the South Australian River Murray, floodplain forests and woodlands of the Murray–Darling Basin (the Basin) are characterised by river red gum, black box and river cooba trees, which support a diversity of understorey species. River red gum communities fringe rivers and wetlands and form large forests in some areas, particularly in low parts of the floodplain in the southern Basin. Black box communities often occur higher on the floodplains, but grow along watercourses in the more arid regions. River cooba trees can be found along the riverbanks as well as higher parts of the floodplain.

Lignum is the dominant shrub, growing on floodplains and wetlands in the Basin, and forming extensive shrublands in some places. It is also an understorey species in eucalypt woodlands.

Non-woody vegetation such as grasslands, sedgelands and herblands form narrow fringes along rivers, or grow in river channels and wetlands. In some places it can be found across more extensive areas — often in terminal wetlands and frequently inundated floodplains.

In the South Australian River Murray, the objectives of having more flow rates of 80,000 ML/day are to:

- maintain and improve the health of river red gum and black box woodlands, and 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 preventing the build-up of sand
- assist in maintaining appropriate salinity levels in the Coorong, Murray Mouth and lakes Alexandrina and Albert.

Increasing the frequency of 80,000 ML/day flow events is critical for achieving these objectives, and for ensuring the health of the river and river communities in the future.

The photographs below show some of the benefits overbank flows have to the environment along the River Murray after the high flow event in February 2011.



Katarapko National Park during the February 2011 flow event of 94,000 ML/day at the South Australia border. The photo shows the type of plants that get water — black box trees are in the foreground, red gum in the centre and new growth on the lignum shrubs. *Photo: Kelly Marsland.*





**New river red gum trees, shrubs and grasses coming back after overbank flows, September 2011. In the background, there are many river red gums that died after a prolonged period of drought where the creek was dry. Photo: Kelly Marsland.**



Overland Corner, South Australia in March 2011. Trees on the River Murray floodplain require flooding from time to time. The trees sprouted new growth after floodwaters inundated the floodplain. *Photo: Kelly Marsland.*

## Computer modelling to assess changes in flow patterns

MDBA used computer modelling tools to examine the difference in the types of flows that would have occurred naturally, with development, and with and without all constraints upstream being addressed. We have modelled four different scenarios to show the difference in the flow rate at the South Australia border. The scenarios are:

1. Without development: if no dams or infrastructure existed.
2. Baseline: with the current dam infrastructure in place, but without the Basin Plan.
3. Basin Plan 2800 (BP 2800): with current dam infrastructure in place and if extra water was available for the environment as prescribed in the Basin Plan, with existing constraints.
4. Basin Plan 2800 Relaxed Constraints (BP 2800RC): with current dam infrastructure in place and if extra water was available for the environment as prescribed in the Basin Plan, with constraints addressed.

These scenarios give an idea of the type of changes that have occurred and the types of flows that would reach South Australia if constraints are overcome in the upstream areas.

The modelling shows that, before development, overbank flows of the order that we are seeking to reinstate happened in about 35% of years (e.g. 80,000 ML/d at the South Australia border for 30 days). At the 2009 level of development, the frequency of these flows had reduced to about 10% of years. Through the Constraints Management Strategy we are trying to restore the frequency of these flows to around 15–20% 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). See the appendix for a detailed example of these modelled flow events.



## What we learnt through consultation

### Who we talked to

The Murray–Darling Basin Authority (MDBA) and South Australian Government met with representatives from the local river communities including councils, Indigenous leaders and a range of stakeholders to collect information on the issues and benefits of flow events between 60,000 ML/day and 80,000 ML/day in the South Australian River Murray.

Meetings were held in 2013 in Mannum and 2014 in Murray Bridge to inform the representatives about progress and activities planned in 2014. There was discussion about the importance of addressing constraints in upstream areas for achieving the desired flows in South Australia, and the need for governments to continue to work with local communities to understand the implications of changes to flow regimes.

### Key South Australian River Murray community messages

Overall, feedback gathered through consultation activities indicated community support for the Constraints Management Strategy (the Strategy) and the delivery of higher flows into South Australia. Overcoming constraints in the rivers upstream in New South Wales and Victoria (i.e. the Murray, Goulburn, Lower Darling and Murrumbidgee rivers) was seen as essential and the precursor for achieving more frequent higher flows.

Feedback received highlighted the importance in emphasising both the local benefits (environmental, social and economic) of overbank flows and the broader benefits that occur across the Basin. There was recognition that having a Basin-wide view was important for people in all areas, but the issues at the regional and local level often took precedence.

Many people told us that locals used to be accustomed to the variability of flows in the river. However, during the past 20 years, there have been mostly low flows in the South Australian River Murray. Many people now living near and visiting the river are not experienced in dealing with higher flows. As a consequence, many people in the community did not have the knowledge to cope with higher flows experienced in the region in 2011. Additionally, people lack an understanding of the variability of the River Murray and how the overall system works.

We heard that people living along the South Australian River Murray generally viewed environmental flows as essential for river health and that, over time, communities and governments will continue to develop new knowledge about the best way to manage these flows.

Our discussions about the Strategy are summarised below.

### Effects

- Many landholders who have been residents along the South Australian River Murray for several decades have experience in dealing with overbank flows and recognise the benefits of these events for the floodplain as a whole.
- The effects of overbank flows are generally considered to be manageable and minor nuisances.
- Sufficient warning needs to be given to river communities and land managers.
- Overbank flows may cause local access issues for some landholders, and require moving some floodplain infrastructure and/or stock. Appropriate warning systems and better understanding of the river system would allow landholders to appropriately manage effects.



- Access to shack areas can be impeded (e.g. access road covered in water).
- Some public and private facilities, including shacks, sheds, pumps and boat ramps, are unusable during moderate flow events.
- Other infrastructure, such as new environmental watering works, may be affected.
- The delivery of environmental water must consider timing in relation to the season requirements for consumptive water, and recreation and tourism needs.
- Water quality and salt levels need to be considered as well.

Greater detail of the effects of flows above 60,000 ML/day, as identified by people we met with in 2013, is described in Table 2. The photographs below show some of the structures along the riverbank that may be affected by higher flows.



The riverbank at Berri, South Australia, during February 2011 when the flow rate reached 94,000 ML/day. As the water moved out of the channel it wet the grass and picnic furniture along the riverbank. *Photo: Kelly Marsland.*

**Table 2: Effects of 60,000–80,000 ML/day as identified by South Australian stakeholders upon reflection of recent high flow events in 2011 and 2012**

Category	Perceived effects
Environment	All stakeholders noted the significant benefits of overbank flows to the environment including re-sprouting of stressed or almost dead trees; widespread regeneration of plants; and a return of large numbers of yabbies, fish, frogs and birds. Higher flows flushed salt out and improved water quality and volume, especially below Blanchetown, and in lakes Alexandrina and Albert, and the Coorong.
Agriculture	Many noted that agriculture benefited from moderate flows because more water was available, prices decreased and water quality improved in the long term (salt flushing). In many areas, water quality during moderate flow events was poor, as the river had a high sediment and debris load that made irrigation more difficult.
Tourism	In towns reliant on business from shack owners and houseboats (especially Morgan and Blanchetown), tourism was negatively affected during 2011–12 flow events. Moderate flows can be dangerous for some river sports (e.g. boating and waterskiing); this can affect tourism during peak tourism periods and therefore affect the local economy. In low-lying areas, camping is restricted during moderate flow events. Alternative camping areas can be located on higher ground. It was acknowledged that appropriate marketing could promote recreation during higher flows (e.g. canoeing across floodplains). This would mostly benefit tourism in the lower parts of the system (especially through improved fishing in the Coorong, Murray Mouth region).
Local business	The 2011–12 flow events benefited local business as there was a return of business confidence in the community and people started spending locally again. Moderate flow rates negatively affected local business in areas that experienced lower tourism rates because people were unable to waterski, camp and access some shacks above Blanchetown. The opposite was experienced below Blanchetown as the return of normal river and lake levels improved tourism and hence benefited local business. In the Coorong, Goolwa, Lake Alexandrina and Lake Albert region, local business benefited from both an improvement in tourism and local agricultural production.
Recreation	Moderate flow in the river caused dangerous conditions and therefore less waterskiing and other boating activities occurred. Once flow rates begin to recede, yabbing and fishing become popular recreation activities for many in river communities. Indigenous leaders commented that camping, swimming and hunting in their regions is more prominent after overbank flooding.
Community spirit	All groups stated that people were happy to see moderate flows in the River Murray especially following a long drought. Community spirit was high during the 2011–12 events as people were able to water lawns and maintain sporting ovals again. Improved recreation and increased water security resulted in an improvement in consumer confidence.
Education	Moderate flows in the river have benefits to education, especially for educating Indigenous children about traditional methods and cultural practices around water and the river system. Water-based education programs re-commenced in 2011 in areas that experienced significant changes in water level after the drought.
Infrastructure — roads	Some unsealed roads along the floodplain to camp grounds and shacks are inaccessible during moderate flow events. These need to be repaired once the river level recedes.
Infrastructure — leisure (boat ramps, marinas, jetties, picnic and camping facilities)	In many areas, public facilities such as boat ramps, marinas, jetties and picnic facilities along the river are unusable during moderate flow events, as the low-lying infrastructure is inundated. Some 'flood proofing', such as sealing public toilets or removing barbeques, is needed.

Category	Perceived effects
Infrastructure — pumps, sewage works	Irrigation and domestic pumps along the river are designed to withstand varying flow rates and heights in the River Murray and many pumps can be moved to match river heights.
Private property	Shacks are located at various heights along the riverbanks, and are affected at different flow rates and levels. Access roads to some shack areas are unable to be used during moderate flow rates. There can be costs involved to re-locate equipment, prepare properties, undertake repairs and reinstate roads. Development rules require shacks to be built on stilts to withstand overbank flows. However, some shacks were built before these development rules were implemented.



**Shack area near Morgan, 2007. There are lots of different structures that have been built along the riverbank. In this shack area, retaining walls, play equipment and pontoons have been built. When overbank flooding occurs, shack owners are required to secure and/or remove loose items. Photo: Kelly Marsland.**





**Shack area near Blanchetown, 2007. Current development laws require shacks along the South Australian River Murray to be built on stilts to cope with overbank flows. Most shacks are built on stilts to withstand inundation as river levels rise, but some were built before the rules were in place. *Photo: Kelly Marsland.***



## Recommendations from consultation

The people we spoke to during 2013 and 2014 had many suggestions for the next phases of the project, including what should be considered when consulting with the local community. A summary of these suggestions and recommendations are documented below.

### Future community engagement

- There needs to be a distinction between natural high flows that have negative impacts and an overbank flow that is managed. Negative media reports about 'flooding' that occurred during 2011 had severe consequences to local tourism.
- It needs to be clear that there are many constraints and issues that affect the use of water, and the Strategy only covers a specific group of these.
- It should be clear that the environment gets the same proportion of allocation as other users when and if water levels are low in the system.
- Local government and communities have extensive local knowledge that would assist in the development of future projects and should be involved early.

### Management

- The people supported an increase in the frequency of overbank flows, providing that appropriate warning is provided to allow them to minimise 'nuisance' impacts.
- Warnings should be communicated to local communities, councils and landholders, and include detail of timing and duration. Inundation mapping would prove useful in determining any infrastructure that may be affected.
- New developments or investments in infrastructure along the river (including wet-weather tracks to the infrastructure) should consider overbank flows to minimise negative impacts.
- The tourism sector, including the boating industry, recreational fishers and the houseboat industry, should also be consulted and considered when river levels change.
- Upgrades to the barrages should be considered to optimise their effectiveness and improve environmental outcomes in the region.

Most locals and shack owners should be aware of the risks of building on the floodplain and should have measures in place to deal with overbank flows. Educating these groups will be important to ensure that negative effects posed by overbank flows are minimised.

## What happens next?

This reach report and the feedback received will contribute to the development of a Constraints Management Strategy annual report. This report will make recommendations to the Basin governments about next steps. Following this, detailed proposals may be developed in preparation for implementation of the Constraints Management Strategy (the Strategy) and any mitigation activities in 2016.

This reach report is published to stimulate feedback from the community, so that we can improve our understanding of river behaviour and local needs. This community feedback will be incorporated into the final reach report.

We invite the community to contact the Murray–Darling Basin Authority (MDBA) with any information or suggestions they have about the reach reports.

If you would like to provide feedback on this reach report, please email MDBA at [constraints@mdba.gov.au](mailto:constraints@mdba.gov.au) or write to us at Constraints Management Strategy, Murray–Darling Basin Authority, GPO Box 1801, Canberra ACT 2601.

## Timelines of the Constraints Management Strategy

The publication of this reach report and the development of recommendations in the annual report are just the start of a much longer process (Figure 11).

Any further work to progress the recommendations of the Constraints Management Strategy annual report will depend on the decisions of Basin governments.

The two decision points for Basin governments are:

- late 2014 — decide whether to proceed with further investigations and develop detailed proposals
- mid 2016 — decide whether to start planning and implementing mitigation projects.

If Basin governments decide to proceed with implementing projects to address key constraints, works will start in 2016 to ensure that mitigation measures are in place before those flows are delivered.

The implementation phase between 2017 and 2024 will put protective works and measures in place. It is not until the implementation phase is completed that the delivery of overbank flows will become possible.



Figure 11: Decision points and phases of the Constraints Management Strategy

## Appendix Example modelled environmental watering event

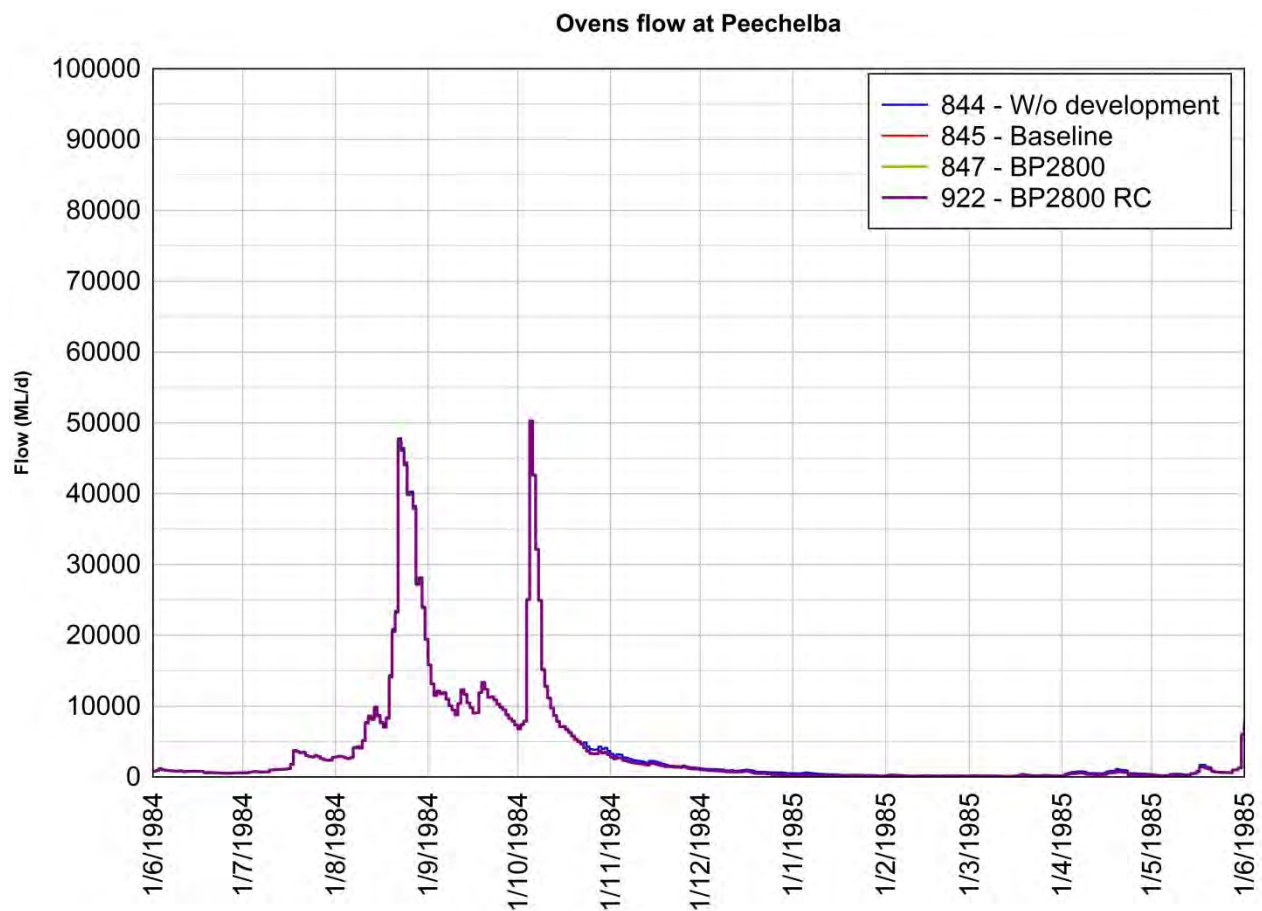
Murray–Darling Basin Authority (MDBA) modelling covers 1895 to 2009. To demonstrate how we are proposing to change flow regimes, we have shown 1984 as an example. In that year there was a flow event where relaxing constraints would have allowed environmental water managers to supplement existing unregulated 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.

For Figures 12–18, the following scenarios are:

1. Without development: if no dams or infrastructure existed (blue line).
2. Baseline: with the current dam infrastructure in place, but without the Basin Plan (red line).
3. Basin Plan 2800 (BP 2800): with current dam infrastructure in place and if extra water was available for the environment as prescribed in the Basin Plan, with existing constraints (green line).
4. Basin Plan 2800 Relaxed Constraints (BP 2800RC): with current dam infrastructure in place and if extra water was available for the environment as prescribed in the Basin Plan, with constraints addressed (purple line).

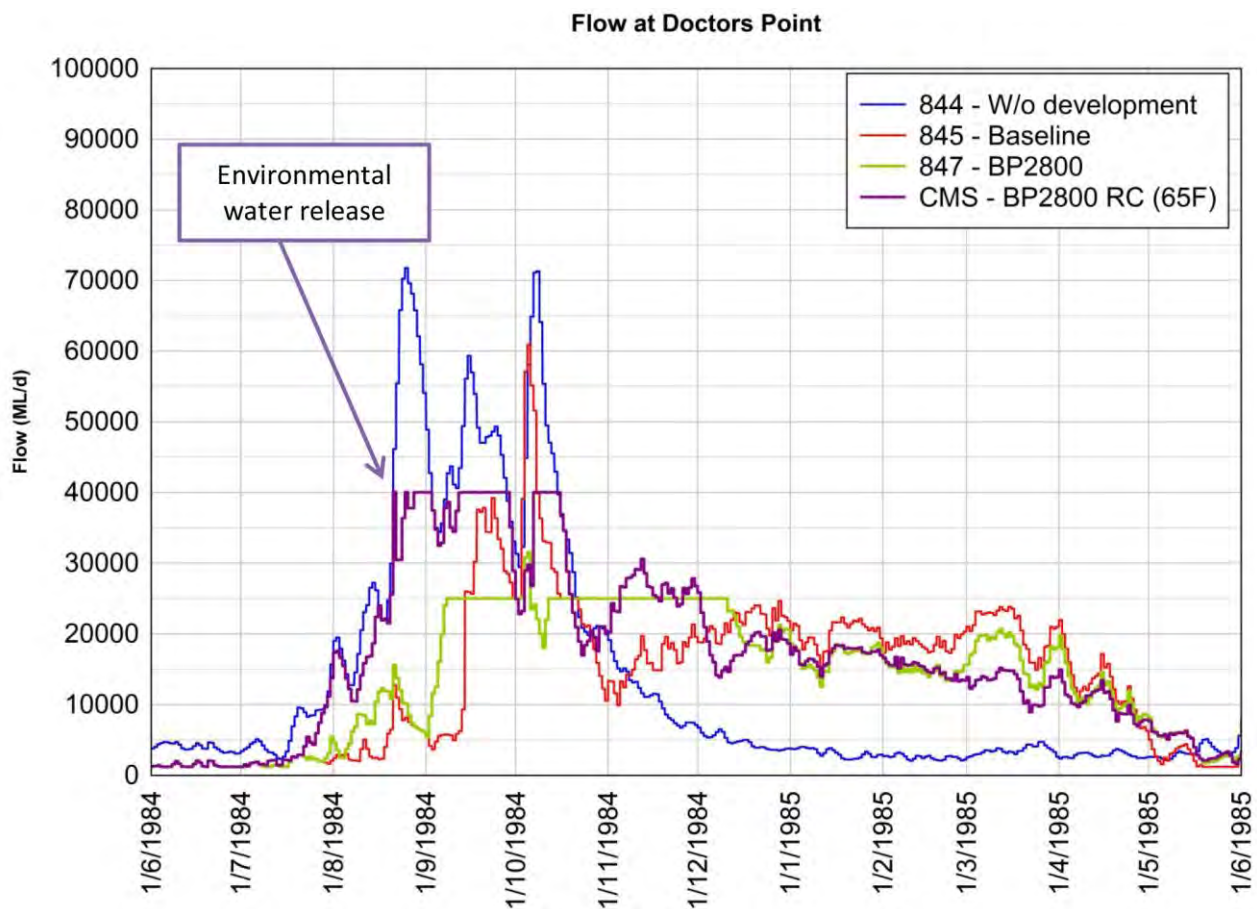
In Figure 12, the event starts with unregulated flows in the Ovens and Kiewa rivers of a little below 50,000 ML/day in late August, with a second peak in early October. The major rain events were across a large area that resulted in strong flows in the upper Murray (upstream of Hume Dam), Kiewa, Ovens and Goulburn rivers.





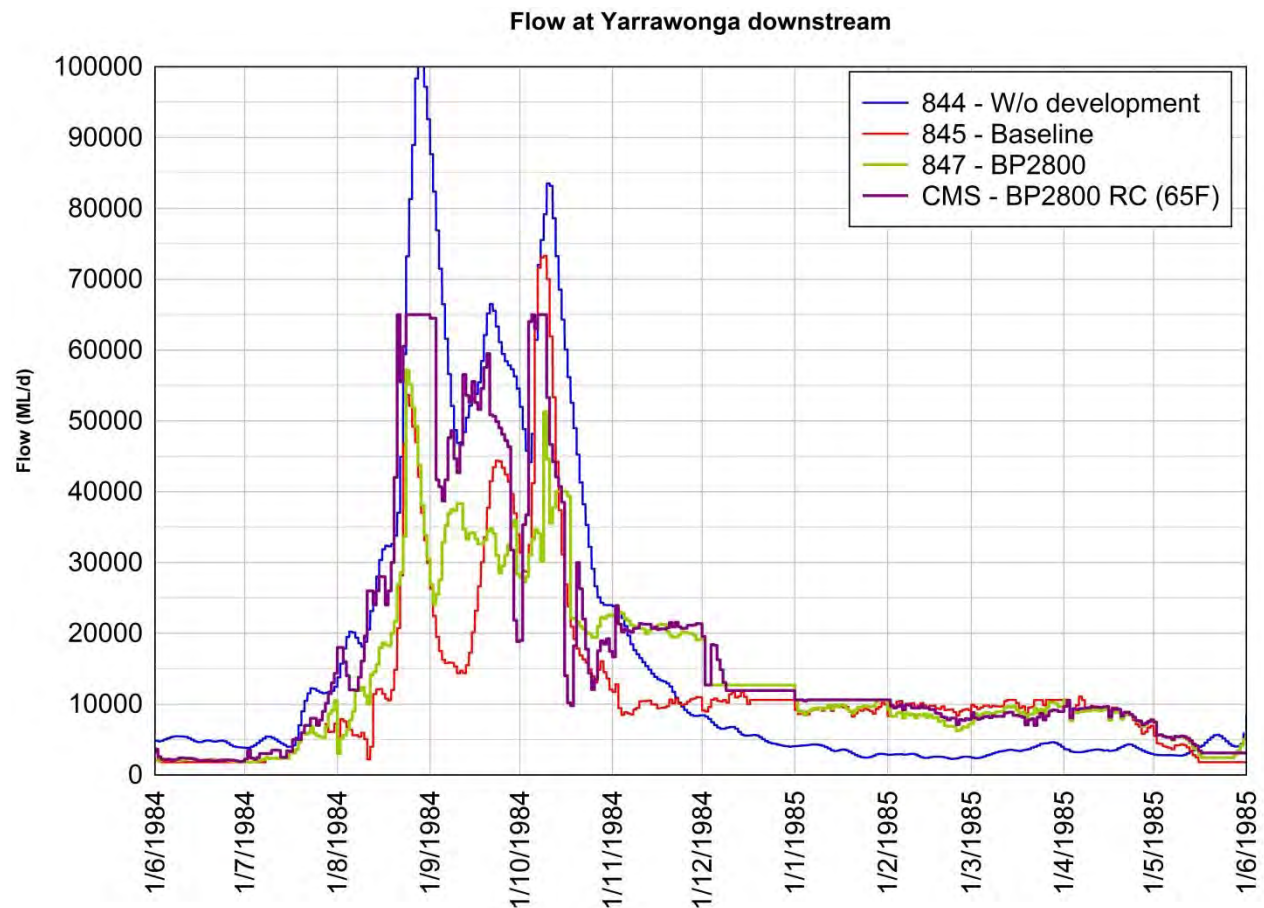
**Figure 12: Flow in the Ovens River in the 1984 example flow event**

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 represented by the green line in Figure 13. If the constraint in the Hume to Yarrawonga key focus area is relaxed to 40,000 ML/day, larger pulses of environmental water could be released between late August and early October, as shown by the purple line in Figure 13.



**Figure 13: Flow in the Hume to Yarrawonga key focus area in the 1984 example flow event**

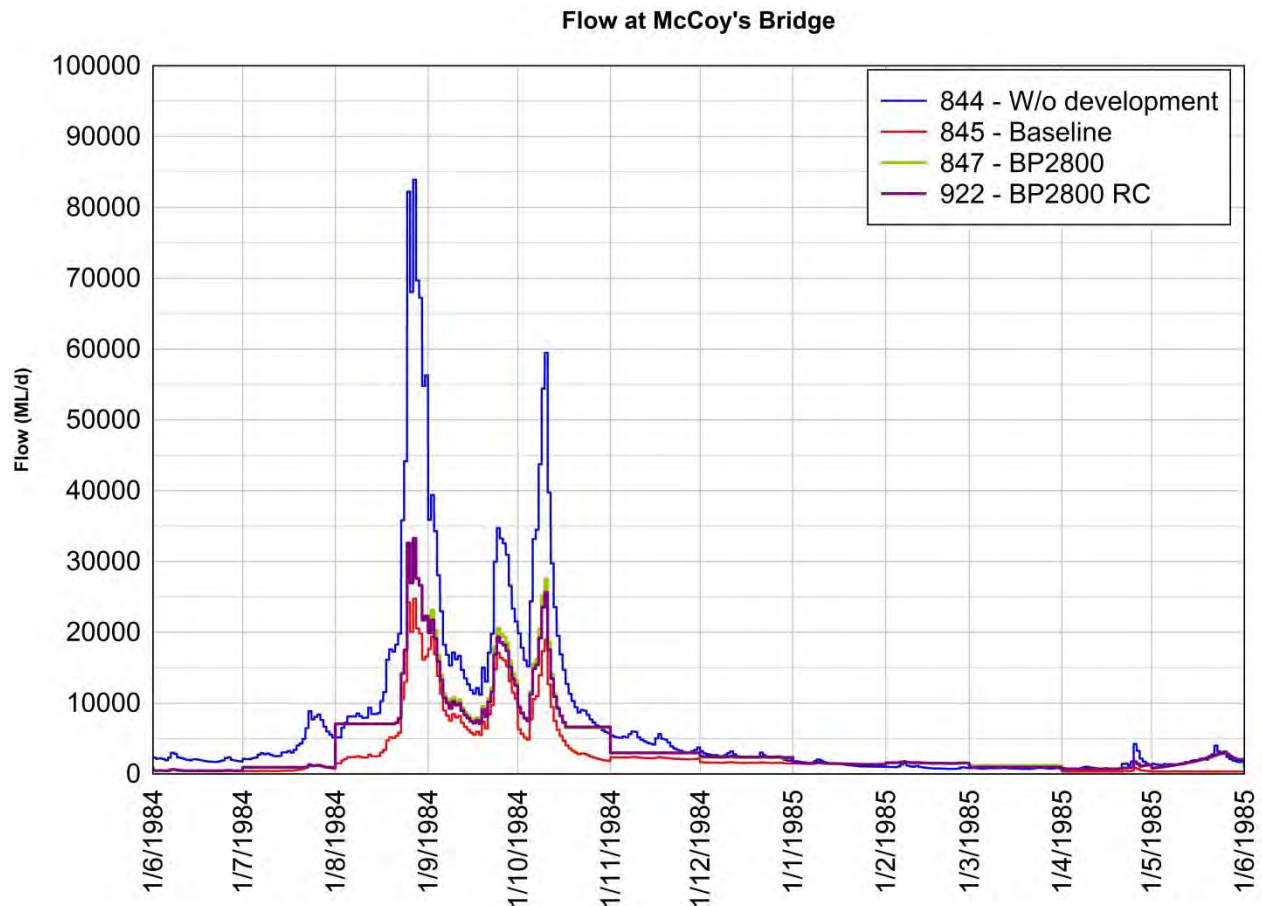
These higher releases from Hume Dam result in higher environmental flows downstream of Yarrawonga Weir. In this modelled scenario, the flow downstream of Yarrawonga would be limited to 65,000 ML/day, so the flows shown by the purple line would go up to 65,000 ML/day in pulses from late August to the first week of October in Figure 14.



**Figure 14: Flows in the Yarrawonga to Wakool Junction key focus area in the 1984 example flow event**

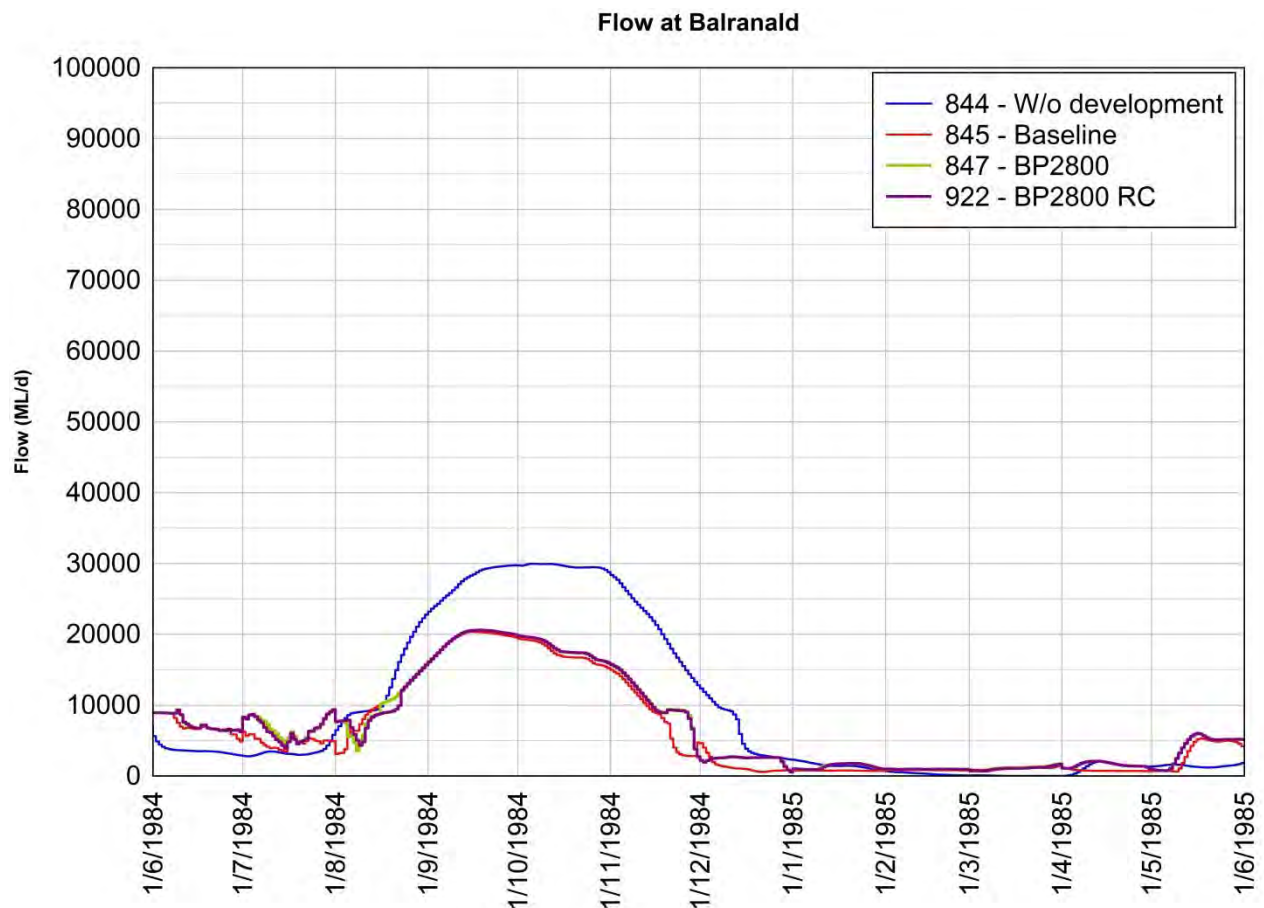


In 1984, there were also two short, sharp peak flows in the Goulburn in late August and again in early October, reflecting the widespread nature of the rain events. In the 1984 example, the August flow would be supplemented with environmental water releases to increase the peak to more than 30,000 ML/day, as shown by the purple line in Figure 15. This would bring benefits to the lower Goulburn floodplain as well as contributing to the peak flow in the River Murray.



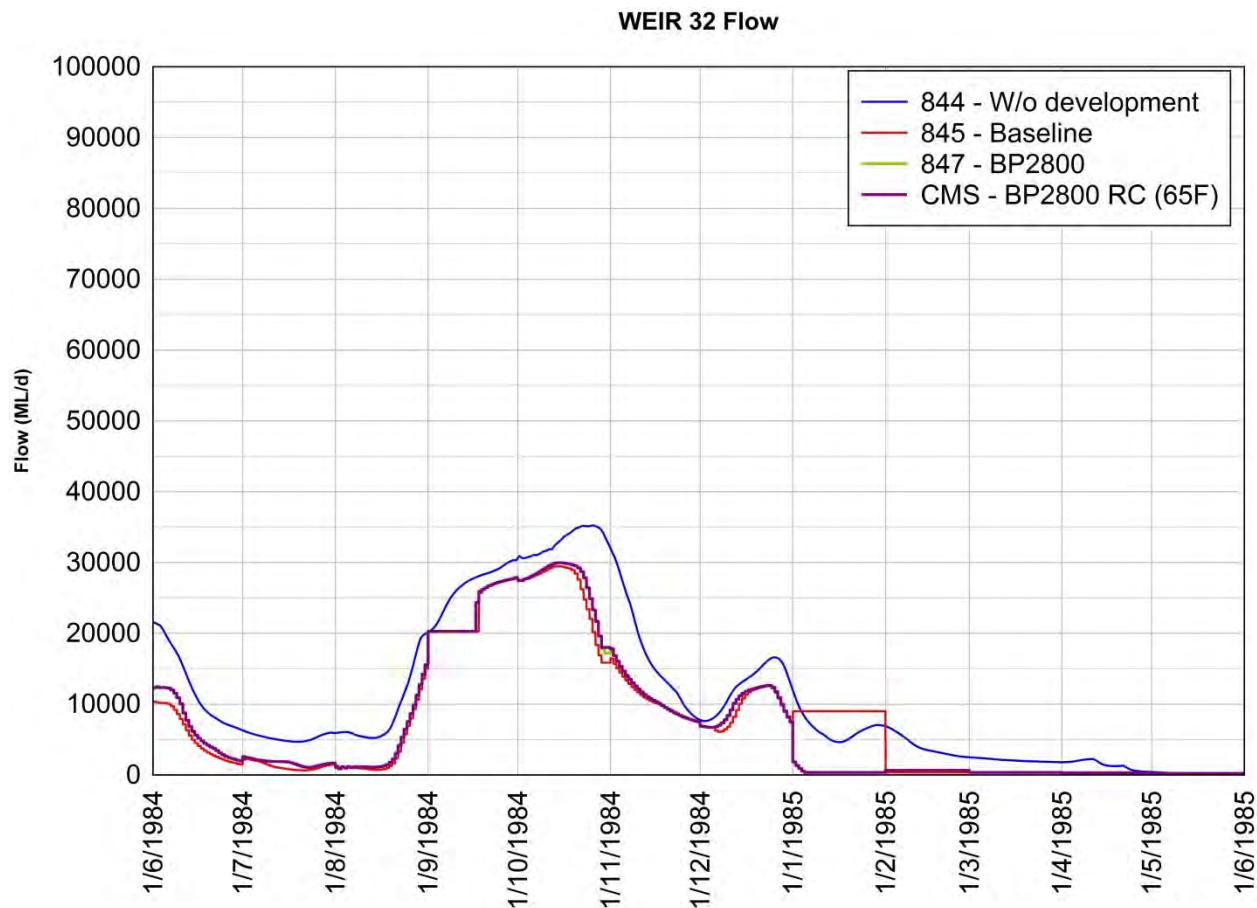
**Figure 15: Flows in the Goulburn key focus area in the 1984 example flow event**

In the Murrumbidgee, 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 16. 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 it is not boosted by environmental releases during this time.



**Figure 16: Flow in the Murrumbidgee key focus area in the 1984 example flow event**

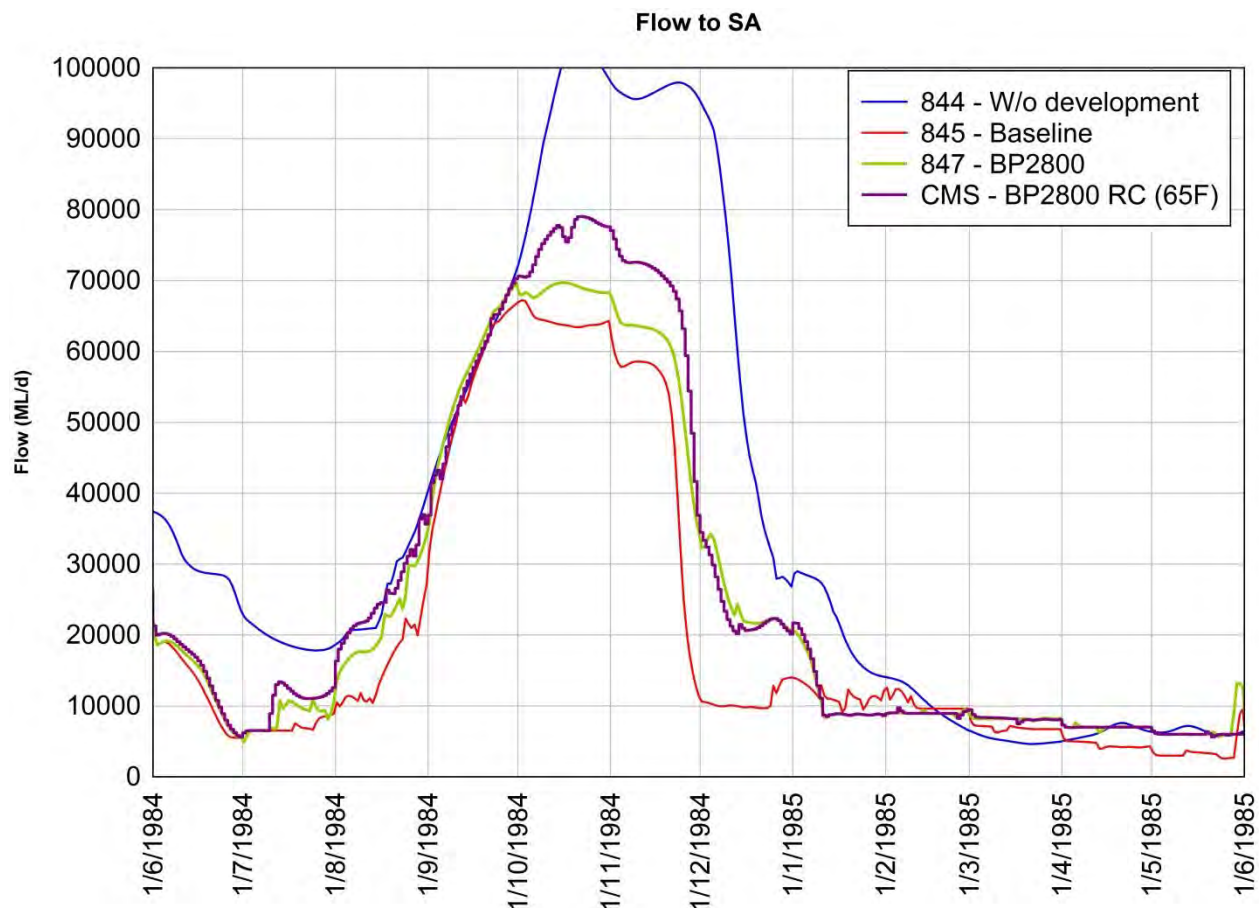
In 1984, there was also an unregulated flow from the Lower Darling in September and October caused by heavy rain in the northern Basin earlier in the year, which would also have contributed to the flow in the lower River Murray, as shown in Figure 17.



**Figure 17: 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 green line in Figure 18) and the constraints relaxed scenario (the purple line in Figure 18). For most of October and into early November, the flow is increased from around 60,000–70,000 ML/day to around 70,000–80,000 ML/day, and the top of the peak increases from around 70,000 ML/day to just below 80,000 ML/day. The duration of the peak would also be extended slightly into November.



**Figure 18: 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.

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