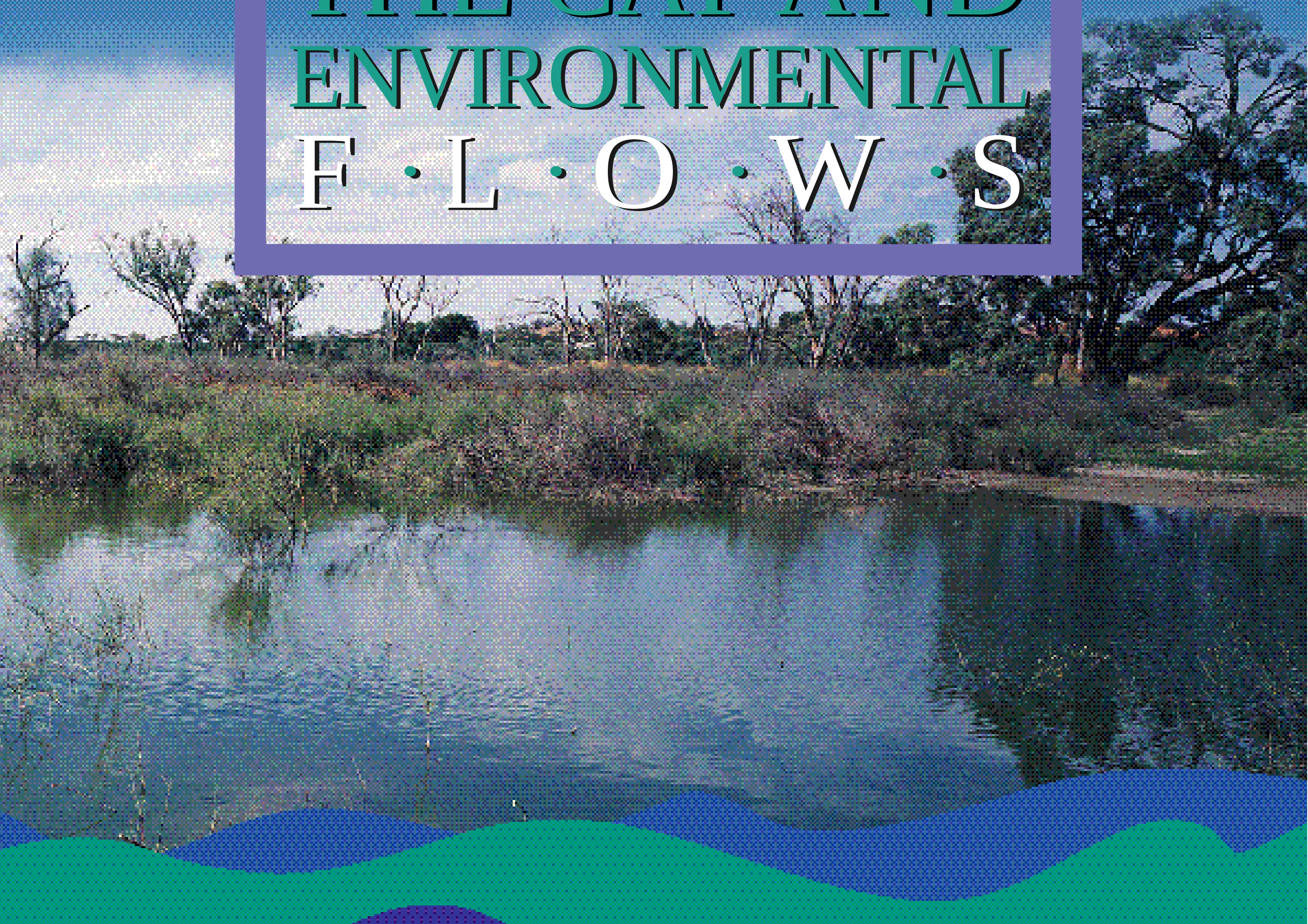
CRC FOR FRESHWATER ECOLOGY

SUSTAINABLE RIVERS: THE CAP AND ENVIRONMENTAL FLOWS



Sustainable Rivers

BY JOHN WHITTINGTON & TERRY HILLMAN

"Let us make no mistake. The Cap is vital. Given the state of knowledge at the time, we could possibly excuse our forebears for developing on the floodplains, over-regulating river systems and alienating the wetlands from their life-giving water.

We now have far better information and substantial evidence to show that it would be short-sighted to allow this to continue unchecked or, far worse, to compound past mistakes.

Whilst the Cap is essential for our future, I say again, it is not about stifling development. Further development within the Murray – Darling Basin will be fostered by more efficient use of the existing regulated supply."

The Hon D.C. Kotz, SA Minister for Environment and Heritage and Minister for Aboriginal Affairs, Murray-Darling Association Annual Conference, 11-9-98.

Trout cod

Photo:Brad Sherman

The Cooperative Research Centre for Freshwater Ecology (CRCFE) exists to improve the condition of Australia's inland waters through collaborative research, education and resource management.

Established in 1993 under the Australian Government's Cooperative Research Centres Program, the CRCFE is a collaborative venture including universities, industry partners and government and research organisations.

Fish ladder

Why do we need the Cap?

By the early 1990s, rivers in the Murray–Darling Basin were literally running out of water. Nearly half of the mean annual runoff from the Basin was being diverted for urban, industrial and agricultural use, and year by year these diversions were increasing. Something had to be done. From July 1997, the Murray–Darling Basin Ministerial Council set an upper limit on the amount of water that could be taken from the river system. This is now commonly known as the Cap.

Rainfall and inflow to the Basin's rivers vary enormously from year to year. If the amount of water promised to downstream users is too high, then in dry years there will not be enough water to go around. This will happen more often as the amount of water extracted increases. Quite simply, over-allocation reduces security of supply and once that happens, relying upon a regular supply—whether you're a farmer or working in a city hospital—becomes increasingly risky.

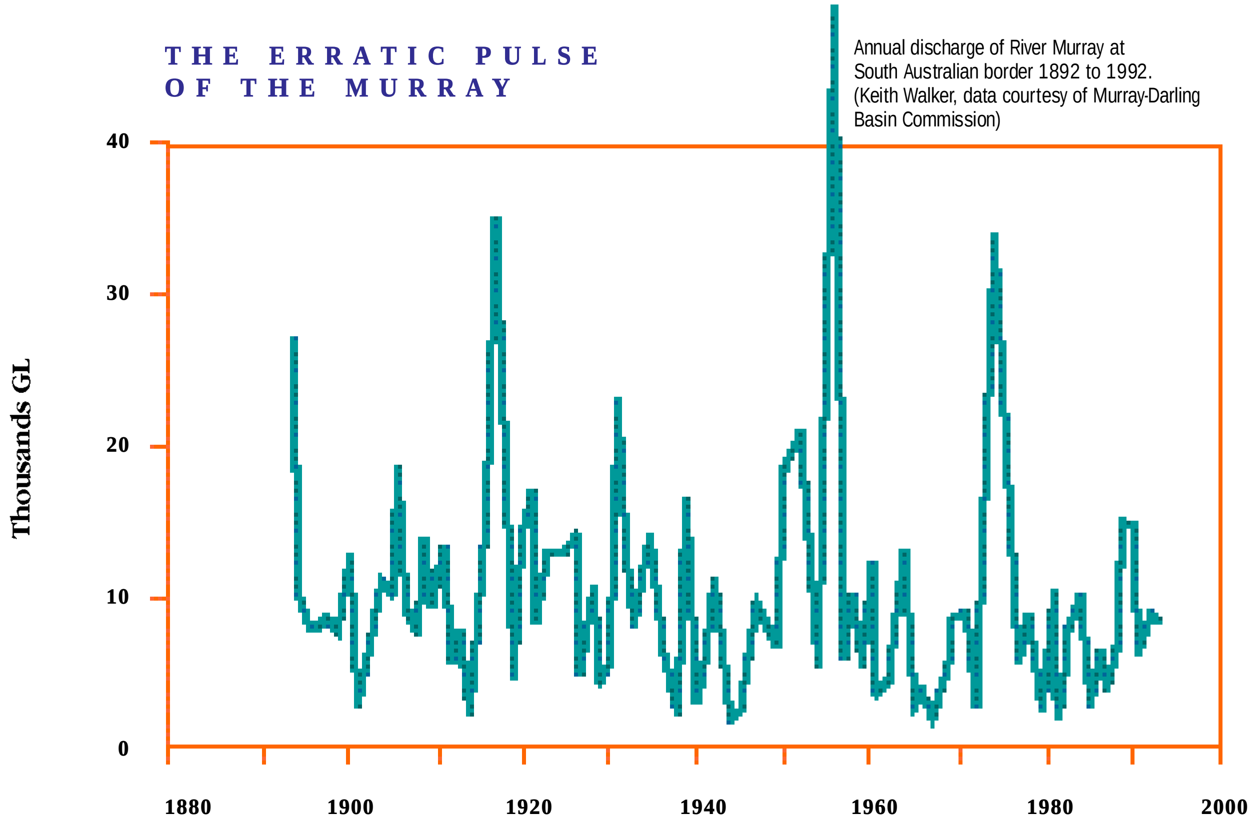
Taking water from the Basin's rivers also means the environment suffers. Signs that the environment is under stress are all too common—increasing turbidity, declining water quality, algal blooms and salinity. Wetlands and billabongs are drying up, reducing the numbers and types of habitats. Less obvious are the changes in river flow, such as fewer small and medium floods, colder river temperatures and unnaturally stable water levels. The loss of places to live, good quality water and altered flow patterns, lead to the decline of many native plants and animals. On the other hand, some plants and animals, like carp and blue-green algae, are well-adapted to the altered conditions and can attain plague proportions.

Historically, every drop of water from rivers within the Murray–Darling Basin was used by the environment, including the plants and animals supported by these rivers. Once we divert any of this water there will be an impact on the environment. The challenge for scientists is to identify, measure and understand that impact. The challenge for the community is to decide how much of an impact is acceptable.

Of the total flow, can we divert a quarter, a half, three–quarters or more? Does it matter when the water is diverted, or where from? River and floodplain ecosystems are extremely complex, and we do not fully understand how they function. However, based on the best available scientific knowledge we are building a picture of how the rivers of the Murray–Darling Basin function and what they need. Our picture will improve and adapt as more research is undertaken and completed. Understanding important ecological processes in the river and on its floodplain will allow us to design better ways of delivering water downstream so that flow patterns, which maintain the health of the river and good water quality, are restored and downstream users are provided with water.

Irrigation in the Oven's Valley. Agricultural systems need a reliable and predictable supply of water—unlike the variability that the Australian climate dishes up.

THE ERRATIC PULSE OF THE MURRAY



Annual discharge of River Murray at South Australian border 1892 to 1992. (Keith Walker, data courtesy of Murray-Darling Basin Commission)

Environmental flows—changes in flow regime that are aimed at achieving environmental benefits—are a logical complement to the Cap. These flows do not have to change the amount of water available for irrigation or town water supplies, but rather how these supplies are delivered. Both the Cap and environmental flows aim to create a sustainable river system.

The damage done to the Basin's rivers by diverting their water is made worse by other changes we have made to the rivers, their floodplains and to the whole catchment. These include installing barriers to fish migration, the introduction of exotic plants and animals, the removal of snags, building levee banks, polluting the rivers with nutrients and chemicals, increasing salinity and poor land management in the catchment.

How do rivers work?

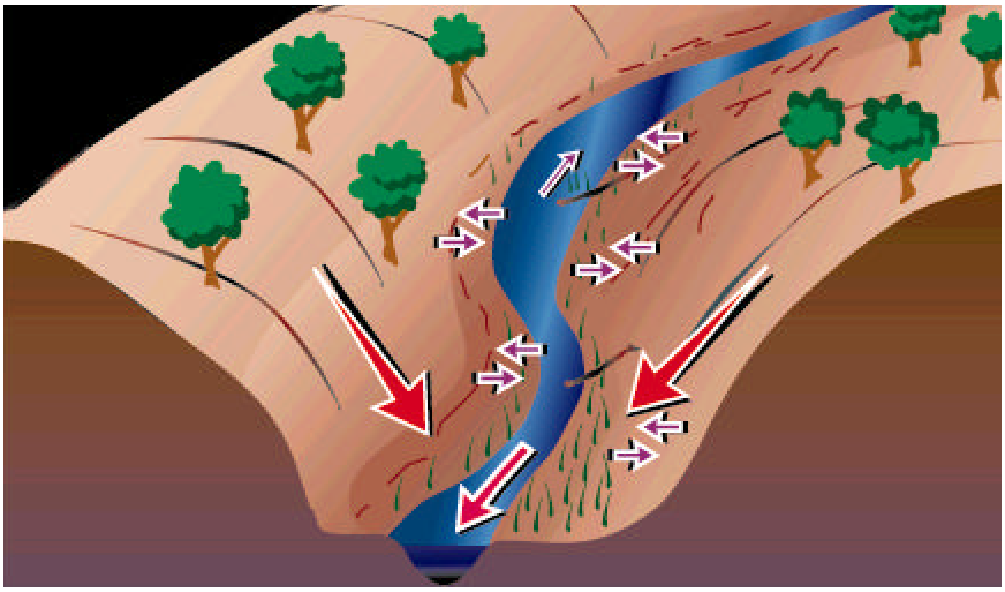
Different types of rivers

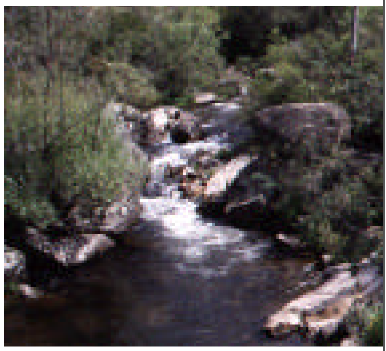
No two rivers are the same. Rivers vary according to the amount of water flowing through them, when and how fast it flows and their interaction with the local landscape. Rivers with similar habitat can be broadly grouped as either upland or lowland constrained or floodplain rivers. (See right) In the Murray–Darling Basin, each type of river is subjected to some level of flow regulation and water diversion.

Natural flows are variable

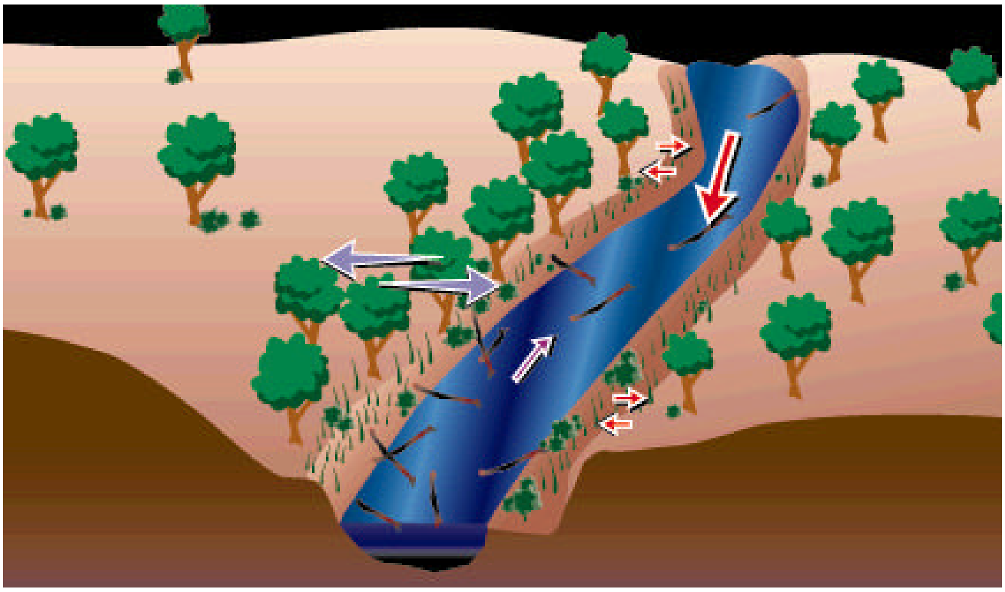
The Murray–Darling Basin has a highly variable and unpredictable climate — rainfall and runoff vary from month to month and from year to year. Within this variability, longer-term cycles of droughts and floods appear; cycles that are strongly influenced by El Niño-Southern Oscillation episodes. Australia's river systems evolved with this variability.

Our native plants and animals are able to survive long periods of drought and then rapidly capitalise on sudden floods. Animals and plants have different flow needs. Some need low flows and still water to breed successfully. Other plants and animals need to

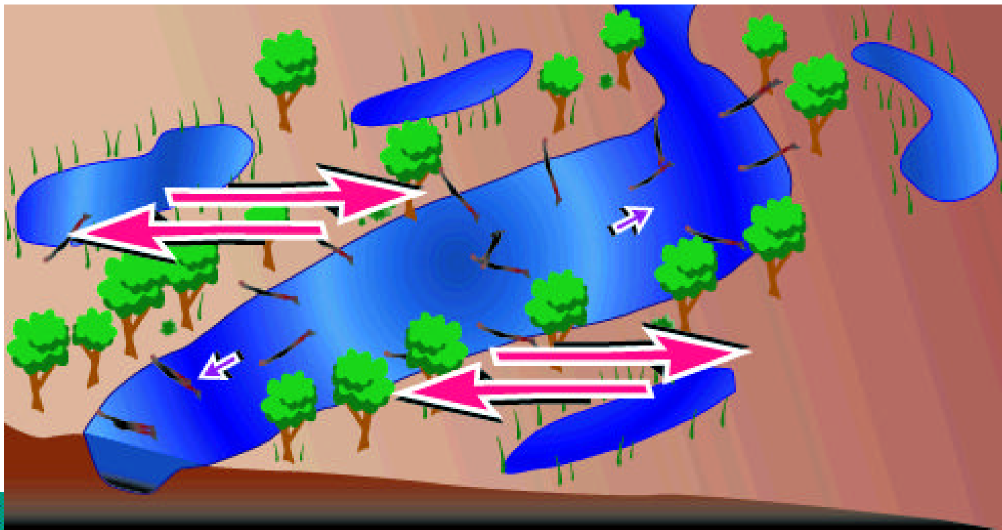




Upland rivers
The ecology of upland streams is strongly linked to runoff from the surrounding catchment. Runoff carries with it organic matter and nutrients which are used by the plants and animals of the stream.



Constrained lowland river
Much of the nutrient and organic matter in constrained lowland constrained rivers is transported from upstream. High flows are important for connecting the channel with the higher riverbanks.



Floodplain river
Flooding is critical to the ecology of floodplain rivers. During floods, animals and nutrients move between the floodplain and the main river channel.

Strong links Moderate links

The Barmah Forest.

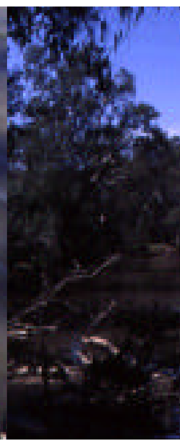
complete their lifecycles during the period of flooding. For a small invertebrate this can be less than a week. Other animals such as birds and fish require much longer flooding. For example, successful bird breeding may require months of flooding. Cutting short a flood, whether by draining a wetland or restricting the supply of water dramatically, reduces its ecological value. High flows are essential to the floodplain.

The floodplain surrounding lowland rivers contains a mosaic of habitats—from permanently wet billabongs, to wetlands that periodically dry out, to areas that are normally dry in all but the biggest floods. Floods are a time when all of these habitats are connected to the river channel: a period when plants, animals and their food can move from one area to another. Determining what and how much moves between these areas during floods is very difficult and is a topic being investigated by the CRC for Freshwater Ecology.

On the usually drier areas of the floodplain, flooding gives plants that are able to withstand waterlogging a competitive advantage over those that cannot. Floods also provide water to young trees, such as river red gums, which enables them to become established. The length of time between floods helps to determine the mix of plants growing on the floodplain. Decreasing the number of floods is likely to decrease the diversity of plants on the floodplain, and this may allow exotic species to invade.

Wetlands and billabongs have their own unique plants and animals, many of which are rare or absent from the main river channel. Reducing the number of floods reduce the areas of wetland on the floodplain and inevitably threatens biodiversity. For example, upstream diversions and the consequent lack of water have seen the Macquarie Marshes of central western NSW decrease in area by about 50%, Victoria's marshlands have decreased in size by 70% and the couch wetlands of the Lower Gwydir have declined by 90%. Some of the wetlands in the Murray-Darling Basin are recognised as internationally important and Australia has agreed to protect them under international treaties. The message is simple: if wetlands do not receive water they disappear and with them the plants and animals that rely on the wetlands for all or part of their lifecycle.

High flows are vitally important to the success of many of the Basin's freshwater fish. Floods stimulate some fish to migrate upstream and reproduce. Golden perch, for example, can migrate over 1000 km. Floodplains can be used as spawning sites. The abundant food of the floodplain, such as small invertebrates, promotes the survival of young fish during the delicate first few months of their life. Some native fish breed only in flood years. Reducing the numbers of floods will surely reduce the numbers and types of native fish in the Basin's rivers.



High flows feed rivers

The supply of organic material—all matter derived from living organisms, including detritus such as leaf litter—underpins all river foodwebs by providing the food energy needed to drive life. Put simply, carbon dioxide is converted into organic material by plants and algae living either in the river or in the surrounding catchment, and once the plants and their products are in the river, animals, fungi and bacteria feed on them. The sources of organic material, the timing of its delivery and how long it remains in a section of river depends on the flow regime.

In lowland rivers without floodplains, such as the Campaspe River, much of the organic material is washed down from the upper catchment. River regulation results in organic matter being trapped behind dams and weirs where it settles to the sediments—often fuelling high rates of bacterial activity which can reduce the oxygen content and increase the dissolved phosphorus levels of the water. Loss of floods and sustained low flows reduce the delivery of organic material from upstream. The combined impacts of dams and water diversions effectively starve the constrained river of food energy.

In floodplain rivers, such as the Murray, it is likely that much of the organic material is transported to the river channel as floodwater returns from the floodplain. Without regular flooding the river is isolated from its main source of food energy.

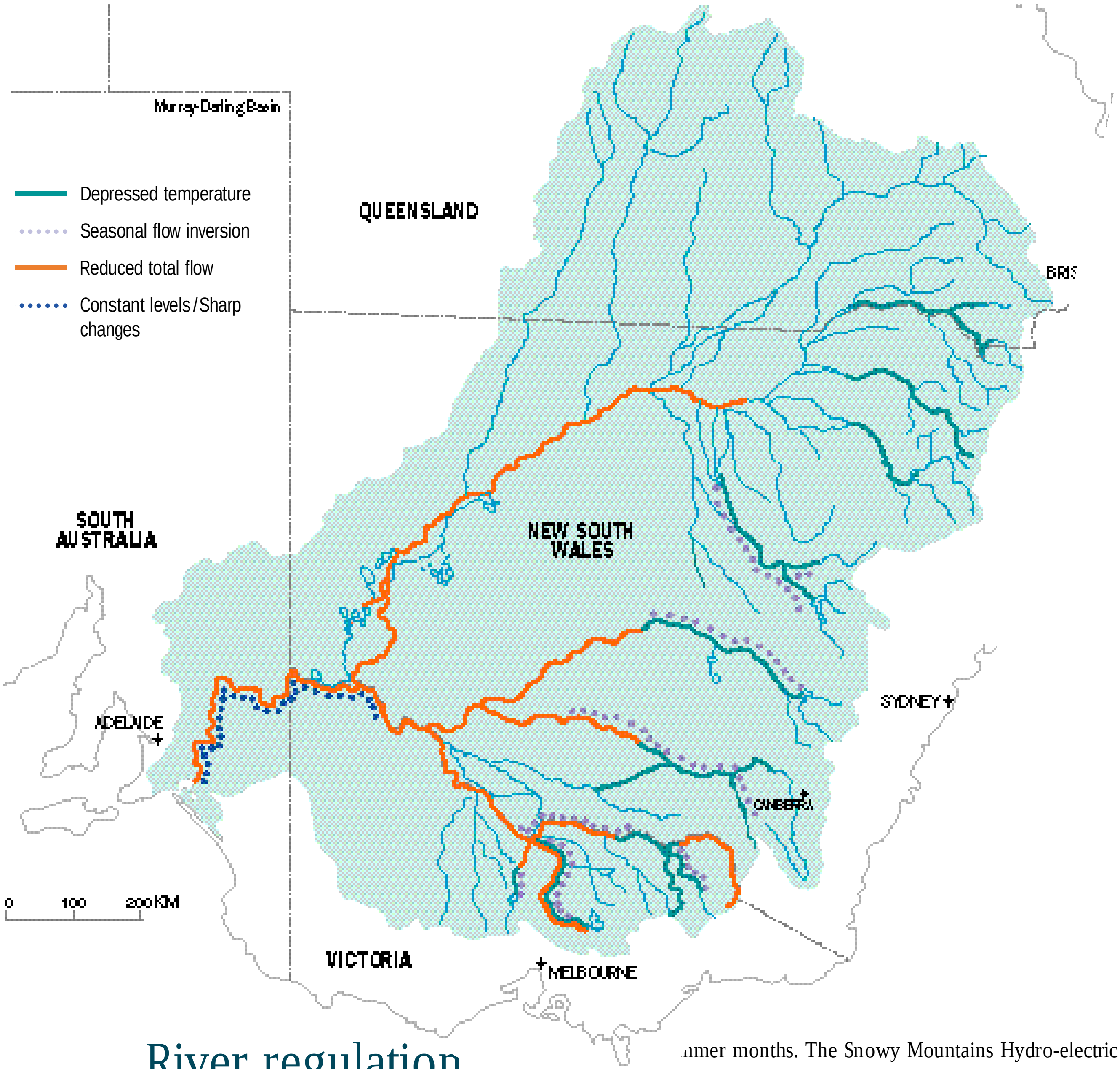
At the same time that the river is being starved of organic material from the floodplain, the amount of nitrogen and phosphorus entering the rivers has risen through changed land management. Increased amounts of these nutrients, combined with periods of low flow, have fuelled the growth of blue-green algae in the river. Reductions in organic material from the floodplain and increased algal growth in the channel have changed the dominant source of food energy in the river. Changing the basic food sources in the river is likely to change the species of animals that feed upon them. Similarly, these animals may have different predators and so on up the food chain. The CRC for Freshwater Ecology is investigating the effects of river regulation on the source and fate of organic matter.

While we are still not sure exactly what impact changing the amount and source of food energy in the river is having, it is likely to be profound. What we do understand is that mid-sized floods are a major factor in controlling the supply of organic material from catchments and also the critical exchanges between the floodplain and the river.

The Campaspe Weir. There are more than 1700 weirs and dams in western NSW alone.

The effects of river regulation vary across the Basin. In the 'winter-rainfall' rivers of the southern Basin there are seasonal flow inversions as irrigation water is delivered during the summer. In the northern 'summer-rainfall' rivers, naturally high flows coincide with irrigation demand—which in some cases is made less seasonally dependent by off-river storage.

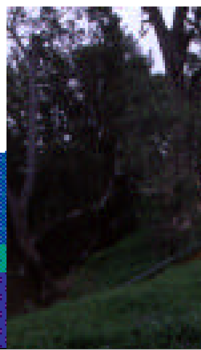
The effects of river regulation can also vary along the length of a river. The water temperature in the River Murray downstream of Hume Dam is depressed and flows are highest in summer, rather than in winter and spring when it would be naturally high. Further downstream water is removed for irrigation, which reduces total flow. In the Lower Murray, the numerous weirs maintain a constant water level.



River regulation. smoothing out the bumps

In contrast to our native plants and animals, many of our agricultural systems are unable to accommodate natural climatic variability. Instead, they require a reliable and predictable delivery of water.

During the last century the challenge was to deliver water on demand—which is typically greatest during summer months. The Snowy Mountains Hydro-electric Scheme brings extra water across the Great Dividing Range into the Murray–Darling Basin. We have built increasingly large dams to collect and store runoff, releasing it according to the demand of downstream users. Today, about 95% of the water diverted from the Basin's rivers is used by the irrigation industry. Most of this water is either used by plants, or evaporates or seeps into the earth. Only a small amount returns to the river, and when it does, it usually contains high levels of nutrients and salt.



When looking at long-term records for rivers such as the Darling, it is clear that much of the total amount of water flows during the big floods. Big floods skew the annual average flow so that it becomes much higher than the usual flow. Therefore, allocating water based on the annual average flow is not sensible—after all, in most years the actual flow will be considerably less than this.

Perhaps the single biggest effect of diverting water from the Basin's rivers has been to reduce the number of small to mid-range floods. Nowadays, these smaller and mid-range floods only occur once reservoirs fill, or from unregulated tributary streams downstream of dams. We have also changed the natural patterns of low flows by releasing water for irrigation in dry months.

While most attention has focused on the effects of larger reservoirs on lowland rivers, small on-farm dams can alter the flow and habitat of an upland stream. Across the Basin we can only guess the effect that the tens of thousands of small dams have on upland streams, and also on the larger lowland rivers.

How does the Cap help?

There is little doubt that the health of the rivers in the Murray–Darling Basin depend upon how much water is removed from them and when it is removed. After all, it has been the historical levels of diversion coupled with river regulation that has resulted in the decline in the health of the rivers and floodplains. The Murray–Darling Basin Ministerial Council's Cap recognises the simple fact that the environment has suffered considerable damage which is likely to increase if further water extraction is not limited. The Cap limits the amount of water that can be taken from the rivers of the Murray–Darling Basin to what could have been diverted under the 1993/94 levels of development—the last full year of irrigation before its introduction. This is the amount of water that could be used with the management rules and level of infrastructure—the capacity of the pumps and channels, the size of farm dams, the areas developed for irrigation—that prevailed at that time. Although set at 1993/94 levels of development, the Cap has the flexibility to take into account different usage in wet and dry years.

The Cap is adjusted for usage in wet and dry years

The Cap is climate adjusted, which means it takes into account the year's weather conditions. Climate adjustment is important because historically the amount of water used each irrigation season depends upon the weather. For example, Victoria's usage is much higher in dry years than in wet years while the reverse is true for the northern part of the Basin where abstraction is limited to high flows. The Cap has the flexibility to consider this. Overall however, usage in wet years and dry years has to balance out. For example, Victoria's long-term average diversion from the Murray has to stay at 1621 GL even though computer modelling indicates usage could vary between 960 GL in wet years and 2045 GL in dry years.

Across the Basin, 14% of water consumed is lost through leaky channels and evaporation.

Simply halting further diversions will not suddenly eliminate carp or enhance native fisheries; it will not eliminate blue-green algal blooms or restore wetlands. However, it is a critical step towards slowing the decline of the rivers. The damage we are now seeing is the likely result of the levels of exploitation a number of years ago, when diversions were lower. The effects of today's diversion levels may not be fully appreciated for decades to come. Some of Australia's leading scientists have argued that setting the Cap at the current level of diversions will not stop the river deteriorating. They argue that the rivers are already seriously overdeveloped and the only hope is to significantly reduce diversions from their present level. This crucial argument needs to be tested by further research.

Does the Cap reduce development?

The Cap was introduced with the intention of limiting diversions, not future development. However, water needs for new developments have to be met from within the Cap.

Across the Basin at least 14% of gross water consumption is lost during transmission—through leaky channels and evaporation. Projects that create a more efficient water delivery network will free up water for the environment or future developments.

Unused water allocations can be traded annually or permanently. The potential environmental benefits from water trading are considerable. Trading encourages more efficient use of water—allocations that are not used can be sold. Trading allows the movement of irrigation to properties that have the most suitable drainage and soils, reducing existing environmental problems such as rising water tables and river salinity.

Water trading will have an impact on the environment. The impact of diversions can be exacerbated or lessened, depending on where along the river they are taken.

As well as aiming to produce economic efficiencies, water trading should have an environmental goal; namely to attempt to restore natural flow patterns to the river. In unregulated and perhaps summer rainfall rivers, diversions will have less impact the further downstream they are taken. Conversely, rivers that run at unnaturally high levels during the irrigation season will be impacted less by diversions that are taken as close as possible to the reservoir so that more natural, lower flows are achieved downstream.

Does the Cap reduce allocations?

Some water users argue that they will lose a considerable amount of their historical water allocation because of the Cap. How does the Cap, which limits further diversions, reduce existing allocations? The answer to this lies within the question 'which user groups have the greatest right to water?'.

In the past, irrigation development was encouraged by government agencies whose aim was to maximise agricultural productivity through the use of water. In different years, many water users were allocated more water than their entitlement depending upon how much water was in storage and how much was likely to be used. Consequently, farming and investment decisions were made with the expectation that this level of water would continue to be available in the future. On the other hand, a large pool of potential water users were using only a small part, if any, of their entitlement. These are called sleeper and dozer licence holders.

If holders of sleeper and dozer licences start to use their entitlements, all else being equal, the volume of water diverted from the river system will increase. However, under the rules of the Cap, water diversions cannot be increased. Therefore, as each sleeper and dozer licence is activated there has to be a

compensatory reduction in other allocations. The first allocations to be cut are those with the lowest security. Generally these are allocations in excess of entitlement and may include access to floodwaters and unused entitlements made available to others. As more sleeper entitlements are activated, other allocations need to be reduced to keep water use within the Cap.

Water trading has exacerbated the problem. Previously unused entitlements can now be traded elsewhere within the Basin, which has led to an increased activation of the sleeper licences.

There is no doubt that some water users are having their allocations reduced. The Cap has simply bought forward arguments over water sharing; arguments that had already begun as the level of allocations became greater than the capacity of the river system to sustain supply in all years. It is for the river communities with their governments to decide how the water is to be allocated within the Cap. Should those with a history of use have a greater right than those who may have entitlement, but no history of use? How can the water that is available be used for the greatest benefit?

"Scrapping the cap on its own won't change the situation. That doesn't actually make more rain or put more water into storage."

Leader, Victorian National Party and
Victorian Agricultural Minister,
Mr Pat McNamara, February 1999.

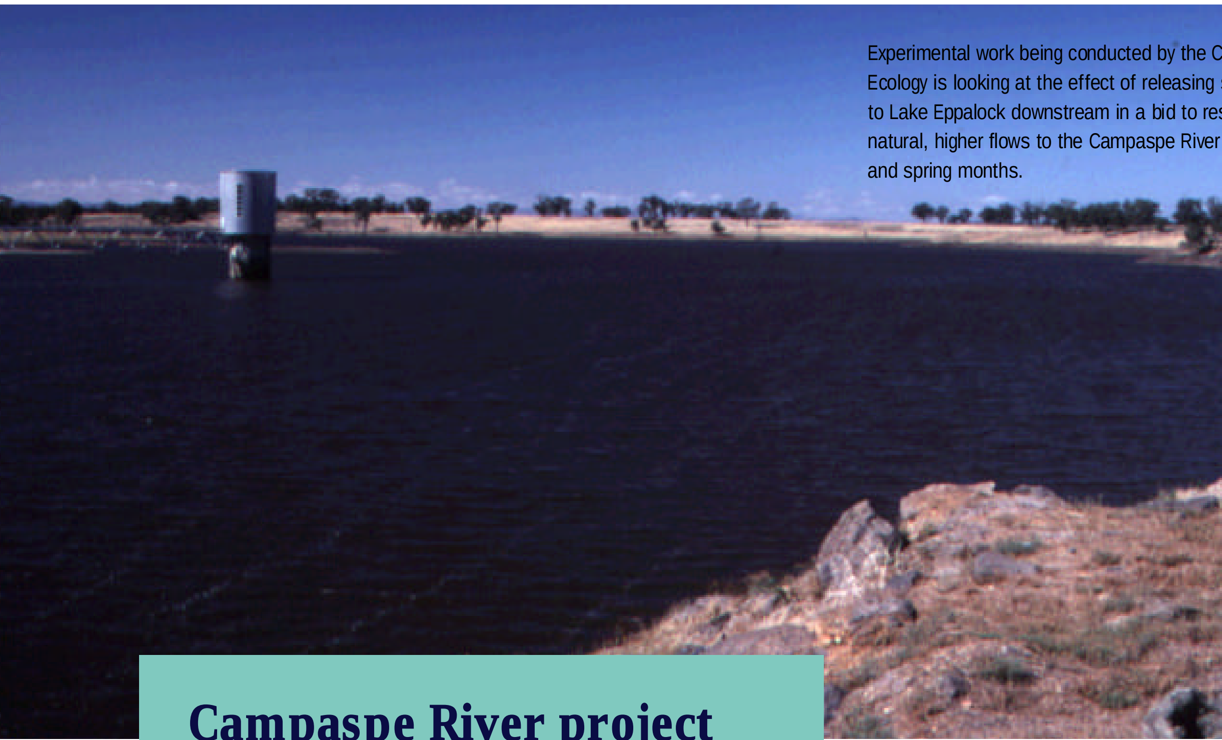
Environmental flows: adding value to the Cap

At about the same time the Cap was introduced it was recognised that by changing the way that the Basin's dams are operated some of the environmental problems associated with delivering water downstream could be overcome. The Cap is crucial to restricting further damage to the river system. How successfully we can preserve and rehabilitate river systems will depend upon how we manage river flows, weirs and levees, diversions and water trading.

Fewer mid-range floods

Reinstating the small to mid-sized floods is a high environmental priority. High flows from tributaries can be topped up with environmental releases from dams to make them large enough to flood key parts of the floodplain. For example, in October 1998 environmental releases from Lake Hume were used to top up floods from the Ovens River to enhance flooding of the Barmah-Millewa Forest.

Another way of introducing some of the natural flooding back into the flow regime is by changing the way we release water from our dams. Releasing some of the inflow downstream from the dam as it arrives—the translucent dam approach—will reinstate the natural high flow periods, albeit at a lower level. We don't yet



Experimental work being conducted by the CRC for Freshwater Ecology is looking at the effect of releasing some of the inflow to Lake Eppalock downstream in a bid to restore more natural, higher flows to the Campaspe River during the winter and spring months.

Campaspe River project

The CRC for Freshwater Ecology is conducting a long-term study to monitor the effects of operating Lake Eppalock as a translucent dam—where some of the inflow is released downstream when it arrives. At present, minimal releases of water are made from the Lake outside of the summer irrigation season. The new flow regime will allow 25% of Lake Eppalock's incoming water to be released between May and October. This will restore some of the natural seasonality and variability that existed before river regulation. The new flow regime does not compromise existing users, security of supply because Lake Eppalock has to reach 64% of capacity before environmental releases begin. It is through long-term flow restoration projects such as the Campaspe River Project, that we will be able to determine the effectiveness of changes in flow management.

know how much water we should be releasing. Should the passing flow be 10%, 20%, 40% or more of the inflow and should we also consider how much is in the storage? The CRC for Freshwater Ecology's Campaspe Project is investigating this issue.

In many dams, water is released in anticipation of floods. The aim of these pre-releases is to reduce the likelihood of floods occurring downstream by providing some storage space in the dam to capture floodwaters. Because they result in the capture of mid-sized floods, it has been strongly recommended that pre-releases, as a routine flood prevention strategy, be abandoned.

Changes to seasonal flows

Rivers in the southern part of the Basin, such as the Murray, Goulburn, Campaspe and Murrumbidgee, naturally had high flows in the winter and spring and the low flows in summer and autumn. However, the release of water for irrigation during the summer months means that these rivers now have high flows during the dry time of the year.

Unseasonable high flows tend to flood wetlands at the wrong time of the year and do not allow natural wetting and drying cycles to occur. During summer and autumn high river flows in the south of the Basin severely reduce the chances of emergent aquatic plants establishing on the riverbed and banks. These plants are one of the most significant agents in bank stabilisation. Cattle further destabilising the banks exacerbate this problem.

Unseasonable high flows are a necessary consequence of supporting an irrigation industry on 'winter-flow' rivers. When particularly valuable floodplain ecosystems are located on these rivers it may be necessary to intervene specifically at these sites—recognising that the section of the river is otherwise a 'sacrifice zone'. Thus, in the case of the Barmah–Millewa Forest, engineering works to divert high summer flows or manage water movement through the forest may be the only realistic way of protecting the forest. In some places it may be beneficial to restore anabranches (including snags and riparian vegetation) as a surrogate for the main stream during periods of artificially high flows.

Constant levels: sudden changes

Supplying water during the irrigation season often results in the river running at a constant height for long periods. Long periods of constant flow can change the shape of the river by causing bank erosion, which results in the channel widening. Sudden changes in the weather, such as a thunderstorm, can dramatically reduce downstream demand for water. Historically, river managers have responded to this by rapidly reducing releases from reservoirs. The resulting sudden drops in flow can lead to water-logged banks slumping into the river, increasing river turbidity.

To overcome the problems of constant water levels, some natural variability needs to be introduced back into regulated flow regimes. For the River Murray, it has been suggested that flow should be altered on a fortnightly cycle, with changes being made gradually to mimic natural flow events. The challenge is to do this while at the same time providing water for downstream users.

Big dams: cold rivers

In many Australian dams a layer of warm water forms which floats at the surface over a layer of colder water—the dam stratifies into two layers. This commonly occurs in summer and autumn. In stratified dams, outflows from near the base of the dam can be very cold, low in oxygen and high in nutrients, particularly phosphorus and ammonium, and also dissolved metals such as iron and manganese. This is a common problem with large, bottom release dams throughout the Basin.

Cold water releases can have impacts on the fish and aquatic insects that live below the dam. The release temperatures from many dams are too cold to support successful native fish spawning. Unless the water temperature in these rivers is increased, sustainable populations of many native fish will not re-establish.

A solution to the problem is to release warmer water from near the surface of the reservoir and multi-level offtakes have been developed for this purpose. Another technique is to artificially mix the water in the reservoir to remove the cold bottom layer.

Carp and river regulation

It was only 35 years ago that carp were first discovered in the River Murray. Since then the carp population has exploded and they are now widespread throughout the Murray–Darling Basin, accounting for most of the total weight of fish. The dramatic expansion in the numbers of carp has occurred at the same time as the levels of diversion have doubled. While there is little doubt that carp do harm the natural environment, are they being used as a scapegoat for the harmful effects of river regulation?

Carp are blamed for a range of the environmental ills, most of which are linked to the way in which these fish feed. Carp suck up the bottom mud that includes their prey and in so doing they may uproot aquatic plants. Carp then separate the food and blow the left over mud out into the water. This may increase turbidity and nutrient concentrations in the water, promoting blue-green algal blooms. Removal of aquatic plants coupled with 'mining' sediments for food is thought to contribute to unstable river banks, erosion and eventual river widening. Some scientists argue that the combined effects of decreasing water quality and competition with carp have led to the reduction in numbers of native fish.

Carp are held responsible for similar environmental degradation to that caused by river regulation and poor catchment management. For example, bank erosion is accelerated by constant river heights, as well as releases from weirs. Trampling of river banks by cattle and clearing of riverside (riparian) vegetation exacerbates the problem. To further complicate the issue, the recent NSW River Survey, conducted by the CRC for Freshwater Ecology and NSW Fisheries, found that carp were most abundant in rivers that are modified by the effects of dams and agriculture. The message is that carp favour regulated rivers. It is extremely difficult to disentangle the effects of carp from poor river and catchment management. However one thing is certain, without addressing the problems of river regulation and land management, efforts to restore the river system by simply removing carp are unlikely to be successful and efforts to reduce carp may be wasted if the regulated river environment stays the same.

Off-river storages are filled during high flows, often reducing the ecological value of small to mid-range floods.

Barriers

There are about 1700 dams and weirs in western NSW alone. Waters back up behind weirs forming stable weirpools or lakes with constant water levels often permanently flooding wetlands. Stable pools provide ideal conditions for the growth of blue-green algae. Experiments conducted on the Darling and Murrumbidgee rivers have shown that regular pulsing of relatively small flows can mix the water column, which inhibits the growth of blue–green algae.

Weirs create barriers to the upstream migration of fish and to the downstream drift of larval fish and invertebrates. Ideally weirs should be removed, but if they are necessary then fish passages, sometimes referred to as 'fish ladders', can be built to allow fish to migrate past weirs. Fish are able to traverse many of the smaller weirs if the flow conditions are high enough. Maintaining sufficient flows through these weirs so that fish are able to swim past them will enhance fish migration into upstream reaches.

Levees and banks

After the extensive flooding of the 1870s many levees were built to protect property and livestock from future floods. Levees do not reduce the volume of water in a flood they simply redistribute the floodwaters, often creating more severe floods elsewhere. Expensive legal battles are still fought between those that have built levees and those who are flooded because of them.

There is no doubt that levees are ecologically disastrous for the sections of the floodplain isolated from the river and equally, the loss of floodplain may also severely impact on the health of the river. As a rule, only activities that can accommodate flooding should take place on a floodplain. In reality there are many valuable developments, including major towns, already on the floodplain which require protection. With improving ecological knowledge we should be able to carry out cost-benefit analyses, factoring in realistic ecological values, to assess which levees can be abandoned and which should be maintained.

Careful thought must be given to the effect of their removal on the floodplain. In regulated rivers where the total flow is now much lower than natural, levees reduce the area of floodplain in contact with the river. There is a tradeoff between conserving a small area of floodplain with the limited water available and trying to water a larger area of floodplain with insufficient water.

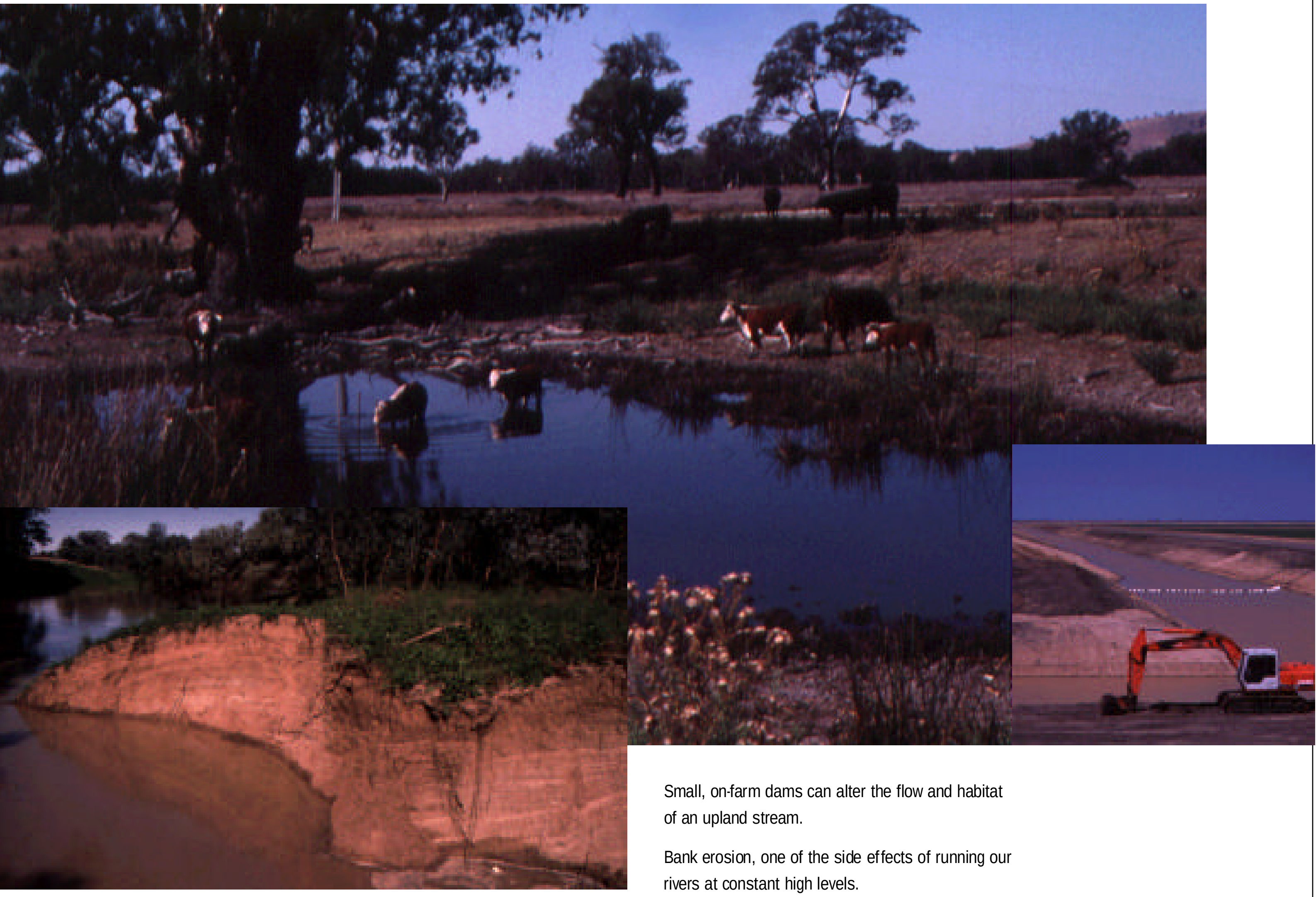
Farm dams—are they a threat to the Cap?

Tensions exist between users in the upper catchment and those downstream over access to water. Many in the upper catchment believe that they have a right to develop the water resource on their properties while those downstream believe further upstream development will reduce their existing water allocations. Obviously, unconstrained upstream development will reduce the volume of water in the lowland rivers.

The Cap protects downstream users from overuse of water in the upper catchment. This is because the volume of water diverted from farm dams in the upper catchment has to be accounted for within the Cap. Theoretically, further diversions in the upper catchment have to be balanced by savings of water in another part of the Basin.

The problem is that we do not know how much water is presently captured and diverted by farm dams. Therefore, changes in on-farm diversions will be extremely difficult to audit. Because of this uncertainty, significant increases in the capacity of on-farm dams threaten the integrity of the Cap as well as the security of downstream users.

In the northern parts of the Basin, it is common to pump large amounts of floodwaters into off-river storages. If the capacity of the pumps and off-river storages are great enough, the size and ecological value of the small to mid-range floods will be severely reduced. Similarly, building levees and drains to divert water travelling over the floodplain into on-farm storages—floodplain harvesting—can reduce the ecological value of floods. To maintain the ecological value of these flows, the size and timing of these diversions need to be managed carefully.



Small, on-farm dams can alter the flow and habitat of an upland stream.

Bank erosion, one of the side effects of running our rivers at constant high levels.

The Cap and environmental flows: can we make them work?

Although the Cap and environmental flows have wide community and industry support, there is still some risk that we will not have what it takes as a Basin Community to make our rivers sustainable. Our history provides little comfort or confidence. In the past 20 years allocation of water from the system has increased by about 30%. The significant increases in storage and improvements in efficiency which have occurred during this period appear largely to have been translated into increased diversions rather than providing the level of flexibility important in managing environmental damage. This has tended to perpetuate the poor health of the system as well as closing options that, in the light of increasing ecological knowledge, may have provided the means of sustaining the resource indefinitely.

History tells us that the Cap is the only way to ensure that our 'room to manoeuvre' is not further constricted. It may already be too tight.

Our best chance for creating a sustainable river system is to maintain the Cap, work toward reducing our current level of diversions and to seek ways of delivering water in a more environmentally friendly manner. The ultimate aim is to maximise the efficient use of water both for production while minimising our long-term impact on the river.

FOR FURTHER INFORMATION

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