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# RHETORIC AND REALITY IN THE ALLOCATION OF WATER TO THE ENVIRONMENT: A CASE STUDY OF THE GOULBURN RIVER, VICTORIA, AUSTRALIA

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## ABSTRACT

In the Goulburn River, located in Victoria (Australia), dams and diversions for irrigation have modified streamflows and water temperature, and contributed to environmental degradation that includes declining native fish populations.

With the passage of a new Water Act in 1989, the Victorian Government proposed to address environmental and water allocation issues through the development of tradeable water entitlements. Initially, these had a strong environmental focus and were to be allocated within an adaptive management framework that involved monitoring and evaluation to refine the total allowable diversion to sustainable levels. The actual specification of tradeable water entitlements for the Goulburn River, undertaken in 1995, differed substantially from those early proposals. Entitlements were largely based on historical use with limited and ineffective allocation of water to the environment because water temperature was not considered. A water market has been established but market failure is likely to result in an under-allocation of water to the environment. Access to the market is restricted except to irrigation authorities and water users, and transaction costs and uncertainties in environmental requirements reinforce the status quo in water allocation which is dominated by production values. Copyright © 2002 John Wiley & Sons, Ltd.

KEY WORDS: Goulburn River; environmental flows; water allocation; water market

## BACKGROUND

Throughout the world there are concerns that human activities have reduced or altered streamflows to the extent that the environmental qualities of many rivers are threatened. Large dams change the timing and quality of instream flows and the extraction of water for irrigation, mining and urban water supply alters the natural flow regime reducing the viability of indigenous plants and animals (Goldsmith and Hildyard, 1984; McCully, 1996). In arid and semi-arid areas, where much of the available water resources have been harnessed as part of economic development, streamflows have been severely depleted. Areas impacted by the significant reductions in streamflow brought about by human activities include China's Yellow River (Yang *et al*., 1999), the Aral Sea (Kotlyakov, 1991), the Murray River and tributaries in Australia's Murray-Darling Basin (Murray-Darling Basin Ministerial Council, 1995) and many rivers in the western US (Gillilan and Brown, 1997). In these areas, flow reduction has contributed to biological impacts that include: declining salmon populations (*Oncorhynchus* spp.) throughout the west of North America where several populations are extinct and others are in danger of extinction (Stouder *et al*., 1997); severely depleted populations of Murray cod (*Maccullochella peelii peelii*) and trout cod (*Maccullochella macquariensis*) indigenous fish of the Murray-Darling Basin (Cadwallader and Gooley, 1984; Harris and Gehrke, 1997); the loss of 24 native fish species in the Aral Sea (Kotlyakov, 1991); and impacts to offshore aquatic life in the coastal areas adjacent to the Yellow River delta (Gao, 1998). There are also economic impacts because of declining fisheries stocks and lack of water for further development and for urban supplies. These issues have led many jurisdictions to seek a balance in water use that recognizes the importance of instream flows to river biota. This paper reviews efforts to establish such a balance for the Goulburn River, Victoria, Australia.

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The Australian water industry has been subject to Commonwealth and State Government reforms to address economic and environmental problems (Working Group on Water Resource Policy Secretariat, 1994). This reform process is advanced in Victoria where the 1989 Water Act included provisions that would allow water to be reallocated by market mechanisms. The Act established *bulk entitlements* to water that define the legal right to take from a river a specified quantity of water over a specified period. Bulk entitlements are owned by water wholesalers such as urban and irrigation supply authorities, who supply smaller quantities of water to urban consumers and irrigators.

The purpose of bulk entitlements is to allow trading of water to assist in market-based solutions to the economic and environmental problems facing Victoria's water industry. In Australia, proposals to use the market to allocate water, rather than the policy of rationing and regulation by a central authority, were considered in the 1970s (Musgrave, 1974). In the early 1980s tradeable water entitlements were proposed to address economic and institutional issues associated with water reallocation (Public Bodies Review Committee, 1984) and environmental issues associated with salinization (Salinity Committee, 1984). The Victorian Department of Water Resources supported transferable water entitlements in 1984 (Department of Resources and Energy and Australia Water Resources Council, 1984) and their 1986/87 annual report further documents the creation of a market for water entitlements and the introduction of a temporary transfer system (Department of Water Resources, 1987) which was trialed in the 1987/88 irrigation season (Langford and Foley, 1990; Pigram and Musgrave, 1990; Pigram *et al.*, 1992; Pigram, 1993). In 1990, bulk entitlements, an instrument to achieve market trading of water amongst water wholesalers, were defined in legislation when Victorian Water Act 1989 came into force. The Water Act is administered by the Department of Natural Resources and Environment (DNRE), which has the task of interpreting and applying the legislation.

Similar types of water reform are also occurring in New South Wales and throughout Australia where there are moves to encourage market trading of water, separate the roles of resource stewardship and water supply, and promote full cost recovery of irrigation operations (Working Group on Water Resource Policy Secretariat, 1994). The implementation of bulk entitlements on the Goulburn River, which is the core issue discussed in this paper, shows there can be deficiencies in the process and outcomes of these water reform efforts and that environmental values may not be adequately considered.

*The Goulburn River system*

The Goulburn River has a long history of development and water resource use. Eildon Reservoir (capacity $3.4 \times 10^9$ m$^3$) supplies water to the Goulburn Weir, 218 km downstream, where there are major diversions to irrigation areas (see Figure 1). The average annual flow of the Goulburn River is $3.04 \times 10^9$ m$^3$ and total annual diversion averages $1.476 \times 10^9$ m$^3$. Water is diverted for use in the Goulburn Catchment for irrigation, mainly for dairying and stone fruit ($740 \times 10^6$ m$^3$), for urban and industrial use ($15 \times 10^6$ m$^3$), and for rural use ($24 \times 10^6$ m$^3$). In addition, $697 \times 10^6$ m$^3$ are exported to neighbouring catchments and to the urban supply system of Melbourne, Victoria's largest city (Department of Water Resources, 1989).

Eildon reservoir has a significant influence on downstream hydrology (Erskine, 1996). Effects include reduced annual flow because of evaporation from the reservoir and changes to monthly runoff that has reversed the natural seasonal flow pattern (see Figure 2). Changes to flow duration are such that high flows (>95 m$^3$ s$^{-1}$) have been reduced, moderate flows (40.5–95 m$^3$ s$^{-1}$) augmented and low flows decreased. For any given frequency, flood magnitudes have been greatly reduced. Near the dam, there is at least a 60% reduction in flood magnitudes and at Seymour, 138 km downstream where the catchment area is 2.2 times the catchment area at Eildon, flood magnitude has been reduced by 20%.

Supply from Eildon dam is drawn off at 52 m below full supply level and because the reservoir is often thermally stratified (Cadwallader and Rogan, 1977), the released water is usually colder than it would be under natural conditions. For example, in January (the most affected month) the median temperature has been reduced from 19.5 °C to 12.5 °C (Gippel and Finlayson, 1993).

There are environmental consequences of these changes. The reduced water temperature means that there are fewer opportunities for native fish to spawn in the 200 km of river downstream of Eildon. A further effect on native fish is the decrease in frequency and magnitude of wetland flooding. Depending on the fish species, wetlands can be important for spawning, nursery habitat and as a source of food. Near Eildon, wetlands that

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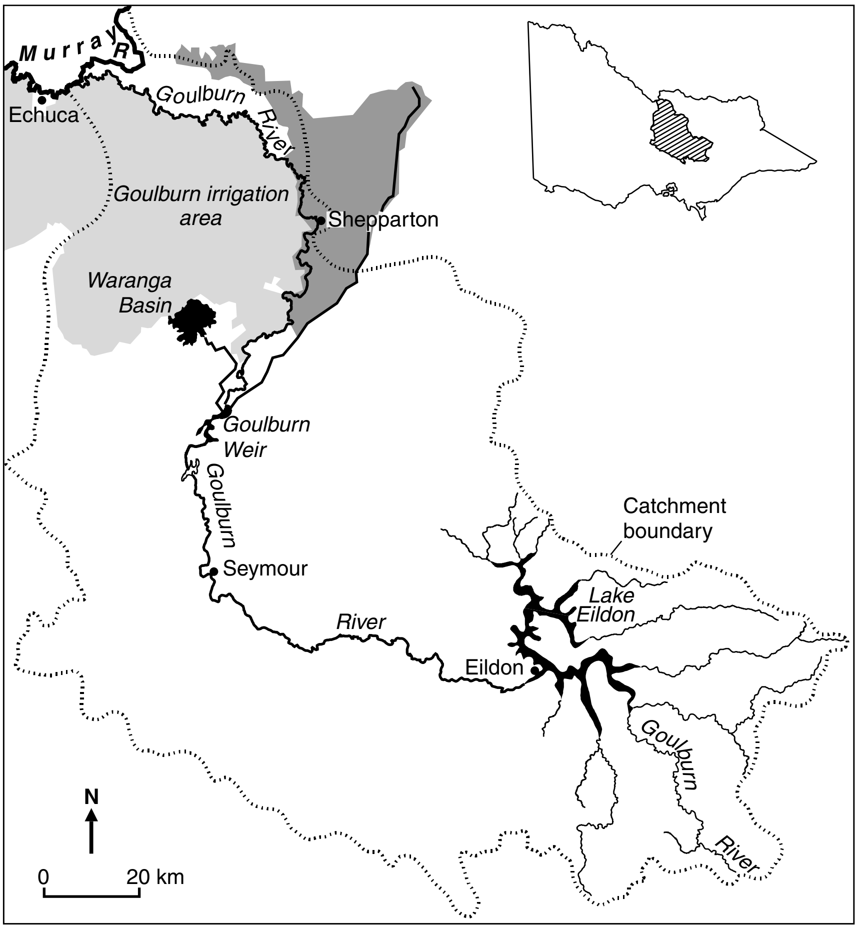


Figure 1. Goulburn River catchment

flooded annually now receive water three years in ten, while wetlands that were flooded on average every two years will now be flooded every 20 years. Hydrological and water temperature changes have contributed to the declines in native fish populations in the Goulburn River (Cadwallader, 1979; Cadwallader and Gooley, 1984). Assessments of the environmental condition of the Goulburn River show that it is in marginal or poor condition downstream from Lake Eildon (DNRE, 2001). The Goulburn River is also an important source of water to the Murray River and harvesting the Goulburn's water contributes to the environmental problems in the Murray (Thoms *et al*., 1998).

Despite these changes, the Goulburn River has high historical and landscape values and part of it has been classified as a heritage river (Land Conservation Council, 1991). The cold water does advantage exotic brown trout (*Salmo trutta*) and the river below Eildon is popular with anglers.

## IMPLEMENTING BULK ENTITLEMENTS ON THE GOULBURN RIVER

A series of reports on bulk entitlements followed the passage of the Water Act, 1989. In 1990, the Department of Conservation and Environment (DCE) produced an information bulletin to highlight the environmental credentials of the new Act (DCE, 1990). It documented that one of the purposes of the Act was to provide formal means to protect and enhance the environmental qualities of waterways and their instream uses. Specifically, it was noted that the Act allowed water to be allocated for environmental uses, required all water management decisions to incorporate environmental considerations, and aimed to ensure that all water

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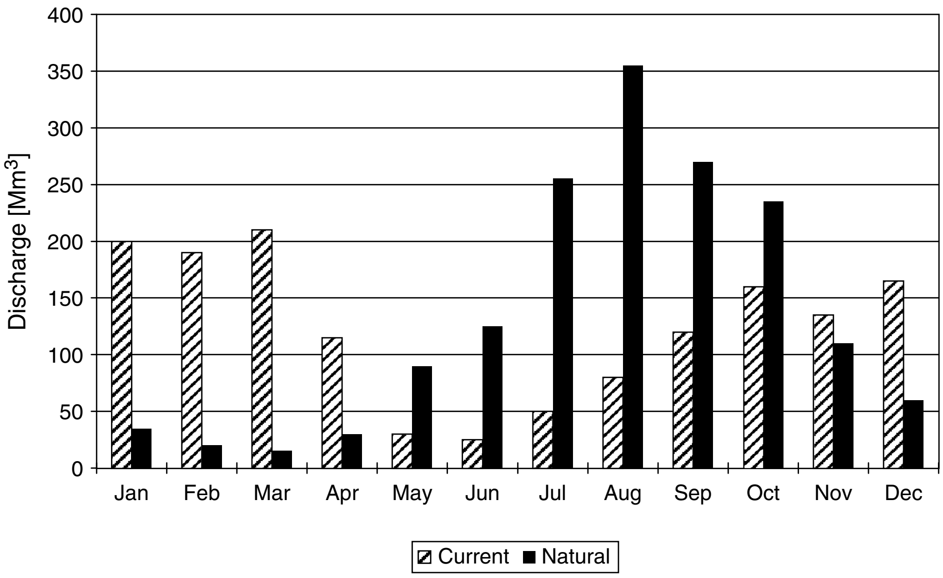


Figure 2. Natural and regulated (current) flows on the Goulburn River downstream of Eildon Reservoir (average for June 1955 to September 1991) (Erskine 1996)

management functions are carried out in an environmentally sound way (McPhail and Young, 1991). Bulk entitlements were considered as an important method of allocating water to the environment although applications could be made only by authorities defined under the Water Act.

There were further details in a 1992 report *The New Framework of Bulk Entitlements and Conversion of Existing Rights* which was produced by the DCE to guide the implementation of the bulk entitlement provisions of the Water Act 1989 (DCE, 1992). Bulk entitlements were intended to achieve: 'provision of greater legislative security and better clarity of the rights held by water authorities and other public bodies over their water assets; and greater efficiency in the allocation of water since the instrument of allocation, the bulk entitlement, can withstand the rigours of market trading' (DCE, 1992, p. 1).

DCE (1992) explains the new framework of bulk entitlements to water and discusses water for the environment and the conversion of existing rights to water to bulk entitlements. DCE (1992) was a planning document, intended to detail the procedure that would be used to specify bulk entitlements when they were established.

The first bulk entitlements in the State were created on the Goulburn River and bulk entitlement orders were documented by the successor to DCE, the Department of Conservation and Natural Resources (DCNR), in a 1995 report *The Bulk Entitlement Conversion Process* (DCNR, 1995). DCNR (1995) also documented the procedure that was used to develop the bulk entitlements. This procedure differed substantially from the 1992 proposals.

The 1992 and 1995 reports stress that bulk entitlements will have environmental as well as economic benefits but emphasis on achieving practical environmental outcomes using bulk entitlements changed over time. DCE (1992) takes a strong stand on the environment. DCNR (1995), completed during the first term of a new government, is focused mainly on the rapid conversion of existing entitlements with limited concern for environmental issues.

*Setting up a water market*

In practice, setting up a water market involves three steps: allocation, distribution, and trading (Daly, 1996). First, in the allocation step, it is necessary to create a limited number of rights to specified quantities of water. In the case of the Goulburn River, these are defined by the bulk entitlements. Secondly, these rights

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(bulk entitlements) must be distributed initially to different people or organizations. Thirdly, once the initial allocation has been made, and the bulk entitlements distributed, reallocation can then occur through trading.

*Initial allocation of water.* In 1992, it seemed that the initial allocation of water on the Goulburn River to bulk entitlements was to take account of environmental requirements: '[bulk entitlements] provide a secure basis for the development of proper water entitlements to meet environmental needs' (DCE, 1992). The procedure for estimating environmental water requirements was to consist of two stages:

1. setting management objectives for each element of a river system (including river reaches, storages, and lakes); and
2. specifying flow events to meet these management objectives (e.g. high flows may be required at certain times of the year to encourage spawning of native fish) (DCE 1992, p. 18).

Once the environmental water requirements were determined, the allocation of water as bulk entitlements for consumptive use could commence.

This environmental emphasis contrasts with the practice of granting bulk entitlements for the Goulburn River that was completed in 1995 and documented in DCNR (1995). The two-stage procedure for estimating environmental water requirements outlined in 1992 was not followed during the specification of bulk entitlements for the Goulburn basin (DCNR, 1995); instead, the needs of consumptive users were considered first, with a trade-off process used to determine environmental flows.

*Initial distribution of bulk entitlements.* As discussed above, it is possible to separate the initial allocation of water to bulk entitlements from the distribution of those bulk entitlements to people or authorities. In the case of the Goulburn River, bulk entitlements were distributed to historical consumptive users with a volume largely determined by their demands.

For urban authorities the volumes specified in bulk entitlements were based on design capacity of works, with water to be supplied with a reliability of 99%. This resulted in allocations 20% to 40% greater than maximum historical use (Marsden Jacob Associates, 2000).

Bulk entitlements to irrigation authorities were based on aggregate demands of individual irrigators, which are made up of their 'water right' and requirements for 'sales' water. A water right specifies high security water (100% of water right would be expected to be supplied in 99% of years) whereas the volume of sales water is declared during an irrigation season by the water authority based on the amount of water in storage and projected demand (Langford and Foley, 1990; Pigram *et al.*, 1992). The use of water by irrigators expands with the amount available so it is difficult to find water 'left over' that can be allocated to the environment. This was confirmed by modelling, which showed that any water allocated to the environment reduced the security of supplies to irrigators (Fitzpatrick and Bennett, 1994).

Under these conditions determining environmental flows requires a trade-off with irrigation demand. A committee, the Goulburn/Broken Bulk Entitlement Forum, was established to make that trade-off.

There were two major outcomes of this trade-off process to specify environmental flows. First, in years where there was sufficient water to provide irrigators with 200% of their water right, minimum flows would be increased from the current discharge of 1.4 $m^3 s^{-1}$ to 2.9 $m^3 s^{-1}$ downstream from Eildon Dam. Secondly, a spring flush was to be provided in November in wet years by a release of a maximum of $8 \times 10^7$ $m^3$ of water over five days, with a flow rate not to exceed 185 $m^3 s^{-1}$ (DCNR, 1995, p. 100; Gippel, 2000). The context and effectiveness of these environmental allocations are now considered.

## EVALUATING THE OUTCOME OF THE BULK ENTITLEMENT PROCESS FOR THE ENVIRONMENT

Both the process of selecting environmental flows, and the outcomes, are of questionable value because of a lack of environmental advocacy, insufficient scientific input, inappropriate application of recognized techniques to select environmental flows, and disregard of information that was already available about environmental requirements including those related to water temperature. There has also been inadequate monitoring of the ecological outcomes of the flow changes resulting from the bulk entitlement process.

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*Lack of environmental advocacy*

First, there was a lack of environmental input to the process of trading off environmental and production values. Although, officers of the DCNR claim that the committee overseeing the creation of bulk entitlements, the Goulburn/Broken Bulk Entitlement Forum, included environmental representation (Fitzpatrick and Bennett, 1994), in fact the committee consisted of three representatives of water supply authorities, two from the DCNR, one farmer representative and one 'community' member who was also a landholder and irrigator (DCNR, 1995). Better environmental representation would have made it more likely that the committee would find an appropriate balance between production and environmental values.

*Lack of scientific input*

There was also a lack of scientific input into the development of environmental flows. The DCNR established *internal* arrangements to provide environmental input into the specification of bulk entitlements (DCNR, 1995). At the June 1993 meeting of the Council of Australian Governments, Victoria agreed that 'environmental requirements, wherever possible, be determined on the best scientific information available' (National Competition Council, 2001). The ability of these internal arrangements to provide best available scientific information can be questioned. Christoff (1998) argues that the government department that oversaw implementation of bulk entitlements lacked both (1) strategic capacity (the ability to recognize environmental problems and develop rational policy responses that would lead to ecologically sustainable outcomes if implemented effectively), and (2) implementation capacity (the staffing levels and skill base capable of implementing policy, reacting to new challenges, and learning from previous experiences). Tan (2001) also suggests that there was organizational instability during this period and a dismantling of mechanisms within the Victorian government for integration of environmental decisions, along with a focus on financial performance. During development of bulk entitlements for the Goulburn River (1992 to 1995) staff levels in the overseeing department were reduced by 39.3% and most divisions were profoundly under-resourced and lacked skills required to implement policy and strategies (Christoff, 1998).

*Inappropriate application of the natural flow paradigm*

Scientific principles to determine environmental flows were inappropriately applied when selecting flows on the Goulburn River. Fitzpatrick and Bennett (1994), both officers of the Department of Conservation and Natural Resources, claim that environmental flow options were developed based on the philosophy that a flow as close as possible to the natural regime would provide the best form of environmental protection. They state that it was expected that environmental flows would improve instream habitat with the greatest benefit being in the reach immediately downstream of Lake Eildon and that fish spawning would be stimulated.

The process was based on the 'natural flow paradigm'–the assumption that reintroducing elements of the natural flow regime to a regulated river will increase environmental values. Although the natural flow paradigm may result in environmental improvement if a range of flow facets are considered (Poff *et al.*, 1997; Richter *et al.*, 1997), there are reasons to question the way it was used to guide water allocation in the Goulburn River.

First, the objectives of introducing a more natural flow regime were compromised by the requirement to limit impacts on irrigators. The goal of the flow changes, as discussed by Fitzpatrick and Bennett (1994), were, if possible, to reintroduce some aspects of the natural flow regime, while having minimal impact on security of water supply to existing users. Rather than using the opportunity of implementing bulk entitlements to rehabilitate the river system, only minor flow changes were proposed and limited outcomes expected: 'at a minimum, the current environmental values of the Goulburn River will be preserved...' (Fitzpatrick and Bennett, 1994).

As a result, the proposed flow changes are small, perhaps too small to have a measurable effect, because of the constraint of minimizing the impact on irrigation security. For example, consider the specified spring flush. The volume of this event is too small to achieve significant inundation of wetlands on the Goulburn River floodplain. For the proposed five day flood, a maximum of $1.3 \times 10^6$ m$^3$ will inundate the floodplain

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which is less than 0.3% of the average annual volume of $4.6 \times 10^8$ m$^3$ that occurred as overbank flow prior to regulation (Gippel, 2000). The spring flush is also of short duration, which limits the opportunity for the growth of algae and macroinvertebrates in wetlands that could then be transported back to the river. Opportunities for fish spawning and migration are also limited (Young, 2001). Measurable objectives have not been specified for the spring flush nor has monitoring been established to determine what effect it will have.

Secondly, the influence of exotic species is not taken into account. The Goulburn River has been colonized by willows (*Salix* spp.), a weed of national significance (ANZECC, 1999), which are thriving under the current regulated flows (Erskine, 1996). The effect of changing to a more natural flow regime is unknown but it could promote willow populations as increasing flood frequency could inadvertently provide more opportunities for vegetative reproduction or more sites capable of producing viable seedlings (Cremer *et al*., 1995). There are also exotic fish, both desirable (brown trout) and undesirable (carp, *Cyprinus capio*). The presence of exotic species complicates the application of the natural flow paradigm as their response to flow changes needs to be considered. Using the natural flow paradigm as justification for assuming that a small change toward natural flows will be beneficial is an inappropriate rationale for suggesting minimalist changes to the flow regime. With small changes in flow, there may be no change in river condition, or conditions could move closer to, or further from, a desirable state. It is appropriate to investigate and understand likely changes rather than just assuming a minor change toward natural flow will be better for the environment.

*Lack of consideration of water temperature*

The low temperature of water released from Eildon Reservoir at the time of the specified spring flush means any environmental benefit is limited. The released water is too cold to support native fish in the (138 km) section of the river between Eildon and Seymour (Gippel and Finlayson, 1993). The temperature of water released from Eildon Dam in November, the proposed time of the spring flush, is about 12 °C (Gippel and Finlayson, 1993). November is a preferred time for the spawning of some native fish and carp (see Table I) and increased water levels and access to floodplains are important spawning cues; however, water

Table I. Spawning temperate and cues for indigenous and exotic fish in the Goulburn River (adapted from Gippel and Finlayson (1993) except where noted)

| Species | Common name | Spawning season | Spawning temp. (°C) | Spawning flood cue | Conservation status[b] |
|---|---|---|---|---|---|
| *Macquaria australascia* | Macquarie perch | Late Oct.–early Dec. | 16.5 | Not critical | Vulnerable |
| *Maccullochella peelii peelii* | Murray cod | Oct.–Dec. | 20 | Not critical | Vulnerable |
| *Gadopsis marmoratus* | River blackfish | Nov.–Jan. | 16 | Not critical | Indeterminate |
| *Tandanus tandanus* | Freshwater catfish | Oct.–Mar. | >24 | May nest on floodplains | Vulnerable |
| *Bidyanus bidyanus* | Silver perch | Oct.–Dec. | >23 | Flood required, cue plus habitat | Vulnerable |
| *Macquaria ambigua* | Golden perch | Nov.–Mar. | >23 | Flood required, cue plus habitat | Potentially threatened |
| *Salmo trutta* | Brown trout | Apr.–Aug.[a] | 10 | Spawning is often after floods[a] | Exotic |
| *Cyprinus carpio* | Carp | Sep.–Dec.[a] | 17–25[a] | Floods increase spawning habitat | Exotic |

[a] McDowell (1996).
[b] Koehn and Morison (1990).

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temperatures greater than 15 °C are required before spawning will take place. The proposed spring flush is too cold for native fish to spawn and the extent of floodplain inundation is severely limited as discussed above. The November flush is not expected to benefit trout spawning as this occurs earlier in the year.

Increasing the water temperature would require artificial destratification of Eildon reservoir or construction of facilities to allow selective withdrawal of water, neither of which were proposed as part of the bulk entitlement process. If the cost of destratification and an annual spring flood are prohibitive then it may be more pragmatic to manage this section of the river for recreational fishing of introduced species and instead restore other reaches or other streams where there are fewer barriers to rehabilitation (Gippel and Finlayson, 1993).

The other adopted environmental flow option, an increase in minimum flows, is also likely to be ineffective in restoring environmental values because of cold water releases. The impact of these low water temperatures is largest in the reach immediately downstream of Lake Eildon, which is the area where the greatest environmental benefits were claimed by Fitzpatrick and Bennett (1994) for the flow changes.

### *Inadequate monitoring of the bulk entitlement process*

In 1992 it was acknowledged by the Government that: '[bulk entitlements] will prevent any further degradation of the State's water resource if an appropriate standard of monitoring and reporting of entitlements is achieved' (DCE, 1992). It was argued that as there is limited understanding of river environments, it was important to measure the response of the natural system to change and modify management intervention if necessary. A comprehensive monitoring programme was proposed that would include ecological surveys, catchment surveys, river channel surveys, and water quantity and quality monitoring.

This proposed monitoring effort contrasts with actual procedures that were specified as part of the granting of bulk entitlements on the Goulburn River in 1995 (DCNR, 1995). A much narrower range of reporting requirements was proposed for organizations granted bulk entitlements. For example, the reporting obligations for the Eildon-Goulburn Weir bulk entitlement (DCNR, 1995, Section 17, (a) to (o)) relate exclusively to water quantity. This is to ensure that the amount of water extracted from the river is within the licensed conditions.

There are environmental obligations of authorities granted a bulk entitlement but in practice they are restricted to developing a programme to manage the local environmental effects near an authority's structures such as silt removal from offtakes and operational rules to control releases (DCNR, 1995, Section 15, p. 89). No monitoring is proposed that could be used to evaluate if the environmental flows result in improved river condition or to guard against adverse consequences.

Not only is environmental monitoring much reduced from what was proposed at the start of the bulk entitlement conversion process, but the ability of other authorities to address environmental concerns has been restricted by legislative action. Waterway management authorities, whose functions include identification and protection of environmental values of waterways, are prevented by 1995 amendments to the Water Act from acting inconsistently with bulk entitlement orders: '[A waterway management authority] must not exercise its functions or powers... in a manner which is inconsistent with any provision of an Order granting a declared bulk entitlement and any purported exercise of a function or power in such a manner is, to the extent to which it is so inconsistent, of no effect' (Water Act, section 186 1A). Therefore, the granting of a bulk entitlement to an irrigation or urban water supply authority reduces the ability of a waterway management authority to address environmental issues that could be caused by the extraction of water under the bulk entitlement.

## WILL THE WATER MARKET RESULT IN REALLOCATION OF WATER TO THE ENVIRONMENT?

Restricting the ability of third parties to have input into the allocation of water does offer the advantage of strengthening property rights and makes market trading of water more viable. So, even if the initial allocation of water in the Goulburn River is not the most advantageous, as argued herein, can the water market be relied upon to create a socially optimal reallocation? Economic theory (the Coase theorem) suggests that a perfectly operating market will result in socially optimal allocation of resources regardless of the initial allocation, provided transactions are costless (Coase, 1960). However, there are several reasons to expect that

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a water market on the Goulburn River will not operate efficiently and that the amount of water allocated to the environment will be less than is socially desirable.

There are five reasons why market failure is likely. First, access to the market is restricted. Bulk entitlements can be traded only between authorities defined under the Water Act 1989, and private individuals, or environmental groups, would have to negotiate with these authorities to buy water for the environment on their behalf as they are restricted from directly entering the market. The whole or part of a bulk entitlement can be transferred to a person but only if they (1) own or occupy a holding in an irrigation district, or (2) hold a licence to take and use water. Although there is a framework to allow the granting of a licence for instream use of water (Water Act, section 52), administrative procedures are yet to be established. Australian environmental groups have also so far resisted involvement in water markets (NCC, 2001) and to date, in Victoria, no water has been purchased on the market to achieve environmental benefits.

A second reason for market failure is that transaction costs are likely to be a barrier to allocation of water to the environment. Transaction costs include the cost of gathering information about how much water is required to maintain environmental values and overcoming administrative hurdles (Gillilan and Brown, 1997). There is also likely to be considerably more uncertainty in determining environmental requirements compared to assessing the cost of alternative uses of the water in irrigation. This greater uncertainty favours maintenance of the status quo. Transaction costs also discourage the collective action that would be required to obtain sufficient funding for environmental groups to enter the water market even if their access were not restricted (Hardin, 1982; Olson, 1982).

Thirdly, there may be external effects from market activities that have environmental costs. Water trading can affect instream flows, by, for example, moving the point of diversion upstream, or requiring the delivery of water from headwater storages to urban areas outside the catchment (Bjornlund and McKay, 1996). Since these negative effects need not be considered by market participants, it is likely that resulting allocation of water will not be socially optimal.

A fourth reason is that environmental flows may be under-supplied by a water market because there may be benefits to those not directly involved in the transactions. The ‘public good’ nature of environmental flows provides a justification for government intervention (Musgrave and Kaine, 1991; Gillilan and Brown, 1997). For example, purchasing an instream flow entitlement to supply water for a particular fish species may also provide water for swimming, canoeing and enhancing the river landscape (Loomis, 1987; Brown *et al*., 1991; Gillilan and Brown, 1997). The water may also provide substantial offsite values (Sanders *et al*., 1990). Because of these positive externalities, benefits of environmental flows are likely to exceed the amount of money that will be available for their purchase by market participants so they will be under-supplied without government intervention. Musgrave and Kaine (1991) describe the public good nature of environmental flows as a ‘problem that won’t go away’ and state that the only practical solution to providing sufficient water to the environment is to constrain the extent to which markets can operate, through control by regulation.

Finally, it is politically difficult for the government to enter the water market to purchase water for the environment. Although this has not been discussed for the Goulburn River, plans by the Victorian Government to purchase water on market to enhance the environmental condition of the Snowy River in the east of the state were strongly attacked by irrigators and opposition politicians. Irrigators were concerned that prices would be distorted because of government intervention and water and wealth would be transferred away from irrigation areas. There was extensive reporting of these issues in Victorian newspapers (Anon., 2000; Bolt, 2000). In response to hard questioning by the rural press, the Minister of Natural Resources and Environment stated there would be ‘an absolute commitment from this government that there will be no distortion of water prices’ (Hamblin, 2000), which brings into question the use of the water market to provide environmental flows.

The issue was also discussed in the Victorian Parliament where, between 24 October and 28 November 2000, the Government was asked 18 questions by the opposition relating to the purchase of water from irrigators to provide environmental flows. An example of the issues raised is this question by Hon. B. W. Bishop, member for North Western Province, an electorate with many irrigators: ‘. . . the minister should now be aware that the prospect of having the government step into the market to purchase existing water

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entitlements to deliver a commitment on environmental flows to the Snowy River has sent shock waves through the entire irrigation industry. Given the minister's most recent assurance that direct water purchases would be only a last-resort strategy, on behalf of Victorian irrigators, I ask the minister to take the next logical step and rule out such an option completely.' (Victoria, Parliament, 2000a).

There is also likely to be pressure on the government not to remove water from production because of implications for the revenue base of irrigation authorities (Willey, 1991). In a situation where there are high fixed costs, transferring water from irrigation to environmental use is likely to increase the unit price for water for the remaining irrigators which could leave the perception that they are paying for increased environmental flows (Victoria, Parliament, 2000b). Already in Victoria, during times of drought when less water can be sold to irrigators, the financial viability of authorities can be threatened. For example, Goulburn-Murray Water, the largest irrigation authority in Victoria, lost $66.1 million between 1995/96 and 1999/2000 during a period of record low inflows to reservoirs because there was less water available to be sold and water prices had been determined on expected average conditions (Borchard, 2000).

Problems with the operation of water markets have been confirmed through empirical research. In their study of five water markets in the American west, Salba *et al*. (1987) found that the markets deviated substantially from the competitive model and that the price of water deviated from its social value. They recommended that when considering reallocation of water, market prices be supplemented with other measures of value such as the contingent valuation of water in recreation, or its marginal product in alternative uses. In their review of water trading in the Goulburn-Murray Irrigation Area, which is supplied by the Goulburn River, Bjornlund and McKay (1995) argued that water transfer policies needed to provide environmental criteria to assist the operation of market tools.

While Victoria has set up strong property rights for water in an effort to stimulate market trading and more efficient allocation, different approaches have been used in other jurisdictions where the difficulties of market approaches are recognized. For example, since 1928 California has moved toward greater public participation, and now water use can be viewed as a privilege granted by the government that is monitored by agencies and the courts and can be reallocated among competing users to achieve the greatest social good (Schulz and Weber, 1988; Haddad, 2000). Public trust considerations, such as protection of fisheries, riparian ecosystems and recreation, must be satisfied in deciding how much water can be taken from a river and where diversions can be made (Sax, 1990). For example, the Supreme Court of California decided to protect the environmentally significant Mono Lake by reducing tributary diversions, even through the city of Los Angeles had held a permit since 1940 to appropriate most of the inflows (Sax, 1990; Hart, 1996; Gillilan and Brown, 1997). Although there have been efforts since 1980 to establish a market in California to achieve reallocation of water, these have so far been unsuccessful (Haddad, 2000).

A 'cap and trade' approach to water allocation has been suggested as a way to protect the environment by capping diversions and then allowing trading of the excess water to provide the advantages of market-based redistribution while protecting the environment (Daly, 1996). For example in the Goulburn River, if the total amount of water available to be traded by bulk entitlements could be based on principles of ecological sustainability, rather than on historical demands by consumptive users, reallocation of the portion of flow in excess of environmental requirements could then occur through markets in the interests of efficiency. In the Goulburn River, bulk entitlements have capped diversions; however, the cap was based on unfettered consumptive demand, not on consideration of environmental requirements. Setting an appropriate level of any cap will always be difficult but there is an opportunity for the bulk entitlements process to lead to environmental protection if the cap on diversions could be adjusted adaptively. This would require monitoring of river conditions and comparison to a desired sustainable state. Similarly, there may be an opportunity to use the spring flood, proposed for the Goulburn, if issues such as cold-water releases and the influence on exotic pest species can be addressed. Similar concerns are present in the Colorado River, USA, yet a partnership was formed between scientists and managers that allowed an experimental flood to take place which achieved improvements in environmental condition and increased understanding of the river system (Marzolf *et al*., 1999). Such a partnership represents a way forward for the Goulburn River but would require a commitment by stakeholders to experimentation and learning.

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## CONCLUSION

The history of the allocation of bulk entitlements to water shows a narrowing of management focus that occurred between the initial discussion in 1990 (DCE, 1990), planning in 1992 (DCE, 1992) and their definition for the Goulburn River system in 1995 (DCNR, 1995). During this time, the core proposals are similar and are consistent with the economic rationalist approach to reform of the Victorian water industry that has been occurring since the early 1980s. The differences highlight a perceived decrease in environmental concern and include:

- a decrease in the amount of environmental monitoring required as part of the granting of bulk entitlements;
- establishing internal procedures to review environmental requirements rather than seeking input from external scientific experts;
- restricting the water extracting authority's responsibility for any environmental damage;
- restricting third party rights, in particular, restricting the ability of waterway management authorities to address environmental concerns that arise from the extraction of water granted under a bulk entitlement;
- decreasing the reporting requirements of authorities that are granted a bulk entitlement;
- reducing the requirement for the setting of management objectives as part of the bulk entitlement process; and
- reducing the need to specify objectives for environmental flow events.

There are many possible reasons for these suggested changes. There may have been a fear amongst the economic reformers that environmental issues would delay the introduction of bulk entitlements. They may have considered it better to introduce the reforms and then address any environmental issues later if they engendered public concern. It is also possible that the reform agenda was captured by production interests keen to maximize the amount of water that could be extracted and to limit the liability for any environmental damage.

Many of these changes have strengthened property rights by limiting the opportunities of third parties to have input into decisions about water diversions. These types of changes make bulk entitlements less risky to purchase, and easier to sell and so facilitate a water market that has the promise of efficiently allocating water resources. However, it is unlikely that a water market will achieve a socially optimal outcome because it will under-supply environmental requirements. On the Goulburn River, access to the water market is restricted, transaction costs associated with environmental purchases are likely to be high, and the public good nature of environmental flows means that the amount of water purchased for the environment will be less than socially optimal.

The lack of opportunities for intervention by government authorities and the limited monitoring combined with the inflexible nature of bulk entitlement order means that the environment may not be adequately protected. Bulk entitlements are granted in perpetuity, and analysis to determine a suitable quantity for a bulk entitlement was based on historical records and did not consider issues such as climate variability or changes in land use (DCNR, 1995). Preliminary analysis of the possible impact of climate change suggests that for some climate scenarios there could be substantial reduction in Goulburn River flows (Schreider *et al.*, 1997). Other influences on water availability include timber plantations, which are expected to reduce runoff (Government of Victoria, 1999), and construction of farm dams could also have a substantial influence on tributary inflows (ICAM, 1999). Examples in other systems that involve exploitation of natural resources show that a lack of monitoring can lead to a crisis when inflexible, narrowly focused organizations are confronted with environmental problems (Holling, 1995). It seems unlikely that the Goulburn River will avoid this crisis given current institutional arrangements.

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