Balancing resource protection and development in a highly regulated river: The role of conjunctive use

DA Still[1]*, C Dickens[2], CM Breen[3], M Mander[4] and A Booth[1]

[1] Duzi-uMngeni Conservation Trust, Pietermaritzburg, South Africa; dave@pid.co.za
[2]Institute of Natural Resources; Pietermaritzburg, South Africa; dickensc@ukzn.ac.za
[3]University of KwaZulu-Natal, Pietermaritzburg, South Africa; breen@mweb.co.za
[4]Eco-Futures, Everton, South Africa; myles@eco-futures.co.za

Abstract

The central position of water in social and economic development drives the imperative for water storage, particularly in water-stressed parts of the world. A consequence is that rivers are perceived primarily as locations for water storage as we seek to manage risks to social welfare and development. Assurance of supply becomes the dominant paradigm shaping decisions about allocation of water from impoundments. When this paradigm is deeply ingrained it constrains decision-making around flow management for other purposes, particularly for sustaining ecological systems. Ten years ago South Africa introduced progressive legislation for water resource management (the National Water Act of 1998) which enshrines the ecological Reserve. This requirement for the environment is not considered as a water use, because the environment is the resource. However, due to the very complex Reserve determination process, and perhaps a lack of political will, the ecological Reserve has proved difficult to implement and has only now started to be implemented in some river systems. In the case of the lower uMngeni River in KwaZulu-Natal, besides releases to maintain a minimum river flow (the so called 'compensation flows', which were never designed as environmental flows), for nearly 20 years there has been an unofficial policy to allow spates on between 1 and 4 days per year to make possible the continuation of the prestigious Dusi Canoe Marathon. The total amount of water involved is just over 1.2% of the river's virgin MAR, although in years perceived to be dry the releases may be cut to as little as 0.3% of the virgin MAR. While these releases have been tolerated for the continuation of a high-value recreational industry, they are in fact aligned, albeit with a fraction of the necessary volume, with the environmental flows that would be required if the ecological Reserve had been determined. The releases for these events therefore have a dual or conjunctive value, serving both environmental and recreational purposes at the same time. We suggest that considerations of conjunctive use offer practical opportunities for balancing resource protection and development in regulated rivers.

Keywords: resource protection, regulated rivers, assurance of supply, conjunctive use, ecological Reserve, environmental water allocation, environmental flows, recreational use, canoeing

Introduction

South Africa is characterised by low and highly variable rainfall and so it is not surprising that, more than thirty years ago, concern was expressed that economic development could become compromised due to inadequate supplies of water, and that an unusually high proportion of runoff is stored (Commission of Enquiry into Water Matters, 1970; Basson, et al., 1997). Under these conditions we naturally become averse to risk and so the more water that can be stored and kept stored the more secure we feel. The compelling link made between water storage, development and human wellbeing entrenches attitudes to water resource management in which water for the environment and recreation are perceived as luxuries that we cannot afford. Such attitudes are founded on the assumption that water allocated for these purposes, if not wasted, at least has less value than if it were allocated to 'productive use'. These attitudes persist in many quarters despite the National Water Act of 1998 giving water resource protection, including the ecosystem, a high priority emphasis.

The traditional risk-based management philosophy for large dams has, in theory, been replaced by the more progressive and environmentally intelligent philosophy included in the 1998 Water Act in which '...the quantity and quality of water required….to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource' defines the ecological Reserve (Republic of South Africa, 1998). This Reserve has been determined for in excess of 900 sites (Grobler, 2007); however, it has not been fully implemented anywhere in South Africa, mainly because it has not been aligned with user requirements in the catchments, as will be done once the Classification System has been implemented. The classification of all rivers is also a primary requirement of the National Water Act (1998). In this paper we show that the practical concession made for the continuation of high profile canoeing events below the Inanda Dam has led to the implementation of an informal release policy which partially meets the needs of the environment while simultaneously making possible a high value niche industry. This example illustrates the potential of conjunctive use in realizsng social, economic and environmental benefits.

* To whom all correspondence should be addressed.
☎ +2733 342 3012; fax: +2733 342 0636;
e-mail: dave@pid.co.za
Received 26 October 2009; accepted in revised form 14 April 2010.

The legal requirement for resource protection

As water resources worldwide have become increasingly subject to various forms of use and abuse, it has become apparent that a certain quantity and quality of water needs to remain within river and wetland systems in order to maintain the ecosystems which are responsible for so many benefits to society. The South African Water Act of 1998 emphasizes this need to protect the resource by stating in an explanatory note to Chapter 3 that 'The protection of water resources is fundamentally related to their use, development, conservation, management and control' (Republic of South Africa, 1998, Ch. 3). The water that needs protection has become recognized as the 'environmental water requirement' of an aquatic system, and is known as the ecological Reserve.

It is an unfortunate reality that, due to the need for development of society, it is impractical to protect all rivers in their natural state. Instead the National Water Act (Republic of South Africa, 1998) accepts that some rivers will be 'harder working' than others and accordingly the objectives of the protection effort would be aimed somewhat lower for those situations. In order to make sense of this, the National Water Act provides the following steps to arrive at the management objectives for any water resource:

- The water resource needs to be classified according to the National Water Resource Classification System, i.e. what kind of resource does society desire in a particular place? This may be a hardworking river in the city but natural in a sanctuary.
- The Classification System will provide a Management Class to describe what this means
- The Reserve needs to be determined which establishes how much water needs to be reserved for the ecosystem itself
- Resource Quality Objectives are described, which provide objective measures for management

Given that the purpose of the policy on Resource Protection is to secure water for sustainable development and use, there needs to be a strong linkage to the way that the water is used. Clearly, while there is abundant water, the provisions of both users and the ecosystem may easily be catered for, but in a water-scarce situation it is inevitable that there will be competition for allocation of water.

The National Water Resource Strategy raises the issue of competition between the protection of the Reserve and the use of the water as follows: 'It is important to note that the Reserve has priority over all water uses and that the requirements of the Reserve must be allowed for before any use is licensed. Authorisation of all water use in terms of a licence is therefore conditional on a Reserve determination being carried out, and the requirements of the Reserve being taken into account when determining the water available for allocation. However, where water is already allocated for use, the requirements of the ecological Reserve may be met over time by progressively adjusting allocations.'(DWAF, 2004).

Unfortunately there remains a lot to be done to implement the National Water Act. The status quo in relation to resource protection is as follows:

- The Classification System has not been Gazetted and thus no rivers in the country have been classified. There is thus no properly derived Management Class for any river, including the uMngeni. This Management Class is also supposed to inform the Catchment Management Strategy, a task which is clearly not done.

Table 1
Summary of Management Classes
(Source: Dollar et al., 2009)

Management Class	Description
Class 1	**Minimally used** The configuration of water resources within a catchment results in an overall water resource condition that is minimally altered from its pre-development condition.
Class 11	**Moderately used** The configuration of water resources within a catchment results in an overall water resource condition that is moderately altered from its pre-development condition.
Class 111	**Heavily used** The configuration of water resources within a catchment results in an overall water resource condition that is significantly altered from its pre-development condition.

Table 2
Summary of the Ecological Categories used in determination of the ecological Reserve (modified from Kleynhans and Louw, 2007)

Ecological category	Description
A	Unmodified, natural
B	Largely natural with few modifications
C	Moderately modified – changes have taken place but the ecosystem functions are largely unchanged
D	Largely modified – large changes have occurred and the resource base reserve has been reduced.
E	Seriously modified – seriously reduced resource base reserve
F	Critically modified – where changes may be irreversible

- While many ecological Reserves have been determined, these are all preliminary, as they do not have the context of the Classification System to set the target. For the test case of the uMngeni River, no Reserve has been determined (besides the Desktop determination which was not intended for guidance in water allocations or dam operations).
- There is presently also no procedure for the determination of Resource Quality Objectives and thus objectives for the protection of rivers have not been set.

The Management Classes that are the output of the Classification System categorize 3 classes of acceptable water resource condition which would form the basis for setting the objectives for the management of a water resource. These are summarised in Table 1.

For various reasons, the above Class divisions were not considered to be appropriate for the assessment of the Ecological Category i.e. the scale on which the ecosystem is measured. The accepted scale is illustrated in Table 2.

The uMngeni River

The uMngeni River supplies water for the heartland of KwaZulu-Natal, which includes the cities of Durban and

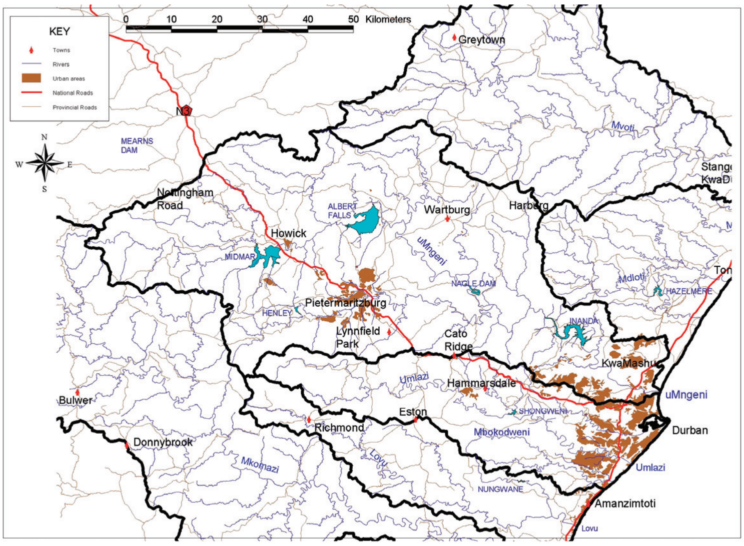

Figure 1
The uMngeni Catchment with the major impoundments and urban areas served (Source: Umgeni Water)

Pietermaritzburg, which currently have a combined population of 4.5 million (Fig. 1). Development and urbanisation have been rapid and, whereas until the 1960s water supply was from 2 small dams (Henley above Pietermaritzburg and Nagle above Durban), since then 3 large dams have been built (Midmar, Albert Falls and Inanda). These 3 dams together store 765 million m^3, exceeding the virgin mean annual runoff (MAR), which is estimated to be 740 million m^3 per year. The most stressed parts of the catchment, from a river health point of view, are the uMsunduze from above Pietermaritzburg to Inanda Dam, and the lower reaches above the estuary (Umgeni Water, 2008; Dickens et al., 2007; WRC, 2002).

The DWA management philosophy is to keep as much water as possible in Midmar, the highest dam with the best water quality, to use Albert Falls, via Nagle, to keep Durban supplied, and to limit the abstractions from Inanda only to that which cannot reliably be supplied from higher up. In practice all of Pietermaritzburg and its hinterland's water supply is derived from Midmar, while Durban's water is supplied from Midmar, Albert Falls and Nagle. Typically only 30% of Durban's water supply is supplied from Inanda, and the dam is usually above 90% full. The dam will be used more as the city's demands grow, and in times of drought, but it is not the first choice for supply due to the high pumping costs entailed in using this source. Inanda Dam's main value is to provide a safeguard against drought.

The present policy of the dam management is to release into the river a constant flow of 0.7 m^3/s from Midmar Dam, 5 m^3/s from Albert Falls Dam and 0.5 m^3/s from Inanda Dam, although in practise the volumes may differ depending on operational issues (real-time flow data can be found on the site: http://www.dwaf.gov.za/Hydrology/rtmain.aspx). The higher flow from Albert Falls is to provide for Durban's requirements, and is abstracted at the Nagle Dam, and the lower flows from the other 2 dams are the 'concession' that is made for environmental needs (slightly more is released from Midmar to allow for downstream users, including Durban). These flows were in the past determined by looking at the historic flow record and selecting a flow equivalent to the average low flow during the dry months in a drier than average year – this was called the 'base flow' and was thought sufficient to maintain the downstream river. However, this release policy clearly does not accord with the intentions of the ecological Reserve, which requires that flow patterns should vary and thus mimic natural flow as far as is reasonable, even when flow volumes are reduced.

In the case of Inanda Dam, there has been a defacto supplementary release policy in place, since the dam was built to cater for the needs of the KwaZulu Natal Canoe Union (KNCU), which every summer hosts a number of canoe races on the uMngeni River. In this paper we examine how the de facto policy has been working, how much water has been involved, how it relates to the ecological Reserve, and the economic benefits of these releases. Although the principles we elaborate are applicable across the catchment this discussion is limited to the Inanda Dam releases only, because currently there are no releases from Midmar Dam for recreation; at Albert Falls Dam releases for canoeing are effected by manipulating the standard 5 m^3/s and there is no additional allocation of water; and at Nagle Dam occasional releases are made but that water is captured and then released again on the following day from Inanda Dam, so it does not constitute additional water. Perhaps another way of making the point would be to say: releases from Inanda Dam cannot be re-impounded and therefore flow out to sea through the estuary. It is the 'loss' of this water that affects assurance of domestic and industrial supply for the greater Durban area, and which therefore requires justification.

The effect of the Inanda Dam on uMngeni River flows

The traditional and continuing approach to water releases from dams is to allow a base flow roughly equal to the average low flow in the dry months of the drier years; for Inanda Dam that flow is 0.5 m^3/s which equates to 15.8 million m^3/a or 2.1% of the virgin MAR. It is instructive to compare river flow data before and after the dam was built (Fig. 2 and Table 3). The lowest flow on record prior to the dam's construction was between the 1981 and 1983 hydrological years, when the flow measured at the present site of Inanda Dam dropped below 10% of the mean annual runoff. The naturalised flow record shows that the flow in the river at this time, at this site, would have been approximately one third of the normal MAR. The next lowest flow measured at the Inanda site was in 1964, but as the naturalised flow that year was not especially low, the probable explanation for the low flow measured was that this would have been the year when Midmar Dam (completed in 1965) first began to impound water.

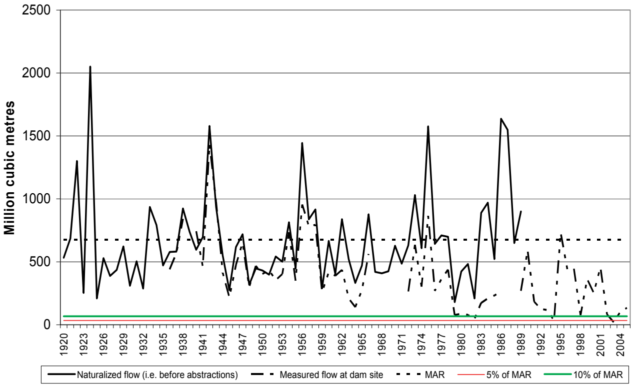

Figure 2
The measured and naturalised flows in the uMngeni River at the Inanda Dam site since 1920. Impoundment began in 1989 (Source: DWAF, 1999)

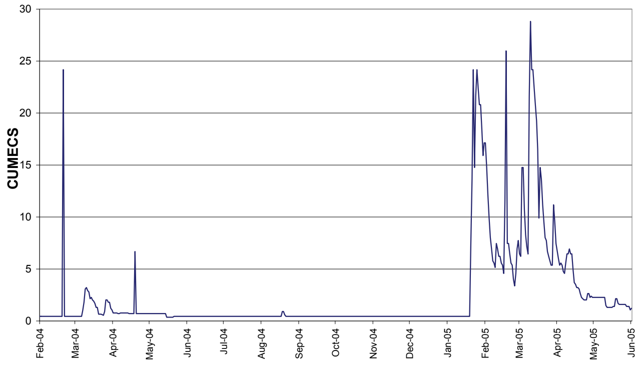

Figure 3
February 2004 to June 2005 flow below the Inanda Dam. Water was released from the dam in February 2004 for 1 day for a canoe race, and the dam spilled briefly in March 2004 and again from mid-January 2005. Apart from these occasions, the only flow in the river observed is the standard 0.5m³/s 'base flow' (Source: DWAF, 2009)

Table 3
A comparison of uMngeni River flow data at the Inanda site for 2 dry years. 1994 is one of three very dry years on the record since the construction of the dam (refer to Fig. 2). 1964 was the driest year on record (excepting the very severe drought of 1981 to 1983) prior to the dam's construction (Source: DWAF, 2009)

Attribute	Pre-Dam (1964)	Post-Dam (1994)
Lowest Flow (m^3/s)	0.633	0.363
Highest Flow (m^3/s)	23.995	9.602
No. of days with flow above 15 m^3/s	16	0
No. of days with flow above 10 m^3/s	38	0
No. of days with flow below 5 m^3/s	266	361
No. of days with flow below 2 m^3/s	181	361
No. of days with flow below 1 m^3/s	9	157

Table 3 illustrates the present water release practice, i.e. when the dam is not spilling, the only water release to the downstream river is the base flow. The one high flow of 9.6 m^3/s was a concession allowed for the 3rd stage of the Dusi Canoe Marathon, which is discussed in more detail below. In contrast in the very dry 1964 year, flow exceeded 10 m^3/s on no less than 54 d.

Another particularly dry period in the flow record since the dam was built was that from February 2004 to January 2005. During this period the dam was nearly full – it was spilling as late as April 2004 and it was spilling again by mid-January 2005. Despite this, due to a perceived drought risk, no environmental releases above the standard 0.5 m^3/s base flow were allowed during this period. This is clearly a contravention of the spirit of the 1998 Water Act and the only reason that it is not illegal is that the river has not yet been classified, and the Reserve has not yet been determined.

What would the ecological Reserve for the lower uMngeni River probably look like?

The ecological Reserve is intended to sustain the health of the resource so that it can continue to supply services to society. Assuming ideal conditions, the freshwater requirements for the uMngeni Estuary were historically estimated to be 1.9 million m^3/a and 154.3 million m^3/a for evaporative and flooding requirements, respectively (DWAF, 1986). The combined freshwater requirement of the estuary is therefore 156.2 million m^3/a, which is 21% of the virgin MAR of 740 million m^3/a. Approximately 5% of the catchment is located below the dam wall, and so an average of 37 million m^3/a of the flooding requirement can be considered to be contributed from this area. This means that, if the cological Reserve could be met without having to concede to other demands, the annual release requirement at Inanda might be in the order of 129 million m^3/a, or 15% of virgin MAR.

The uMngeni River below Inanda, however, is not by any means a pristine river. It is what is called a 'hard-working' river which, if a Reserve assessment were to be done today, is likely to have a Present Ecological Category of E, i.e. 'Seriously modified – seriously reduced resource base reserve' (see Table 2 above). It will also be argued by some that as much as 6% of the MAR is returned to the river via four of Durban's wastewater treatment works and that this accounts for a significant portion of the missing ecological Reserve flow (although it is conceded that these returns are made in the lower reaches of the river and thus do not provide their benefits to the intermediate river).

When it is finally determined, the ecological Reserve for the uMngeni, even if elevated to a Recommended Category of D, is likely to owe more to compromise than science. Ecological Reserve determinations are seldom found to require less than 5% of MAR (Hughes, 2005) and indeed this flow is considerably less than the 27.5% average estimate for the entire province (DWAF, 2007), but if one works with the 5% of virgin MAR as a conservative guideline for the environmental releases from Inanda Dam, and apportions this over the rain season, it can be seen from Table 4 that it is still possible to accommodate 25 spates above the base flow.

Figure 4 shows 3 hydrographs: the upper hydrograph represents an appropriate distribution of 10% of the virgin MAR, the middle hydrograph represents 5% of the virgin MAR, and the lower hydrograph shows 3% of the virgin MAR.

Table 4 shows the breakdown of the flows that would result in the middle or 5% hydrograph. The hydrograph approximately mimics natural flows, given that the rain falls mainly between October and March each year. Included are some 'maximum' flows limited to 40 m^3/s, as this is the largest flow that can be accommodated by the valves which have been built

Available on website http://www.wrc.org.za
ISSN 0378-4738 (Print) = Water SA Vol. 36 No. 3 April 2010
ISSN 1816-7950 (On-line) = Water SA Vol. 36 No. 3 April 2010

into the Inanda Dam wall. Some 21 million m^3/a is released on top of the 0.5 m^3/s base flow, with the 25 spates ranging from as little as 1 m^3/s to as much as 40 m^3/s, and with durations ranging from as little as 8 h to as much as 24 h.

The higher (10% of MAR) Reserve hydrograph allows for 99 spates spread through the year, with some 62.5 million m^3 being released on top of the 15 million m^3/a base flow. The lower (3%) hydrograph allows for just 4 spates to be released on top of the base flow. The significance of this hydrograph is discussed below.

Table 4
An illustrative set of flows that would result in an annual hydrograph with a total flow of 37 million m³ or 5% of the virgin MAR for Inanda Dam. The hydrograph is shown in the middle scenario in Fig. 4.

Month	Base flow (million m³)	Number of spates	Spate flow (m³/s)	Spate duration (hours)	Spate volume (million m³)	Monthly totals (including base flow)
Oct	1.31	1	3	24	0.26	1.83
		1	6	12	0.26	
Nov	1.31	1	5	24	0.43	2.17
		1	10	12	0.43	
Dec	1.31	1	35	16	2.02	5.34
		2	35	8	2.02	
Jan	1.31	2	35	18	4.54	8.15
		2	40	8	2.30	
Feb	1.31	1	35	20	2.52	4.84
		1	35	8	1.01	
Mar	1.31	1	15	12	0.65	3.97
		2	35	8	2.02	
Apr	1.31	1	10	12	0.43	2.89
		1	8	40	1.15	
May	1.31	1	2	24	0.17	1.66
		1	4	12	0.17	
Jun	1.31	1	2	24	0.17	1.48
		0	4	12	0.00	
Jul	1.31	1	1	24	0.09	1.40
		0	2	12	0.00	
Aug	1.31	1	1	24	0.09	1.40
		0	2	12	0.00	
Sep	1.31	1	3	24	0.26	1.83
		1	6	12	0.26	
Totals		**25**			**21.24**	**36.96**

The de facto release policy – accommodating a high-value recreation user

South Africa's oldest and most prestigious canoe marathon, known as the *Dusi Canoe Marathon*, has been staged annually on the uMsunduzi and uMngeni Rivers since 1951. While a number of other rivers in the country are also part of the annual marathon calendar, no other race captures the public imagination in the same way and to the same degree as the challenging, 3-day 'Dusi'. The event has become part of the culture of the region, and has been a crucible for South Africa's top paddlers, several of whom have over the years gone on to win world canoe marathon championship events.

Since 1990 the Dusi Canoe Marathon cannot be staged without a guaranteed water release from Inanda Dam for the 3rd day's paddling (in some cases the dam is spilling at the time, but this cannot be relied upon). There are 3 lesser, but related, canoeing events, in December, January and February, which also require water releases from Inanda Dam. Accordingly, each year since the dam was built the KwaZulu Natal Canoe Union (KNCU) has submitted a schedule of the desired water releases to the responsible authorities (the regional water utility Umgeni Water and the Department of Water Affairs and Forestry) (Trodd, 2008). To date the release for the Dusi Canoe Marathon has never been denied, although in some years a flow as low as 10 m^3/s has been released. The other 3 events are seen as less important and are not assured of releases.

The KNCU gives an upper and lower limit for the releases requested. The upper limit is the desired flow, while the lower limit is the flow below which paddling is difficult without damaging the participants' fibreglass boats on the many rocks in the river bed. The combined volume of the flows requested at the upper limit is 8.7 million m^3, while that for the lower limit is 3.8 million m^3. These volumes equate to 1.2% and 0.5% of the virgin MAR. Taking the 4 upper-limit releases and adding them to the 0.5 m^3/s base flow results in the lower scenario hydrograph in Fig. 4 above. The resulting hydrograph follows the more ideal 5% and 10% of MAR hydrographs in shape, and is identical in terms of seasonal timing. In average to good years the KNCU's requests for these 4 releases are granted at the upper level. In drier than average years some of the release

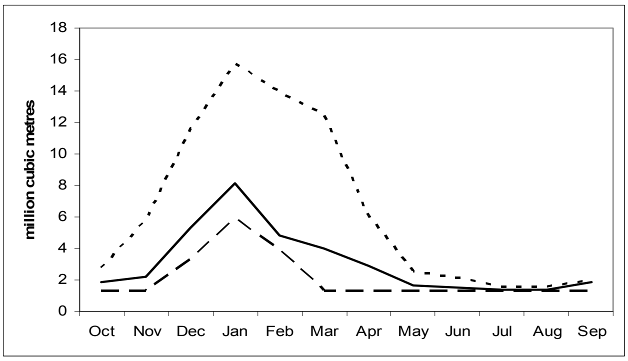

Figure 4
Three environmental release hydrogaph scenarios for Inanda Dam. The upper scenario allows for 10% of the virgin MAR to be released, the middle for 5% and the lower for 3% of the MAR. The base flow is the 1.3 million m³ per month released from the dam at a steady rate of 0.5 m³/s. The balance of flow in all 3 scenarios is made up of spates of between 1 and 40 m³/s for various durations from 8 to 24 h. The lower scenario is the de facto average to wet year release policy which is in place to allow for 4 major canoeing events. This policy is, however, not official and releases are liable to be cut by up to 80% in years where risk of drought is perceived to be higher than average.

Table 5 Value of water for different water use groups, according to different scenarios (Source: Mander, 2008)									
	Unit value of water (ZAR/m³)			Proportion of use			Weighed value of water (ZAR/m³)		
	Conventional water use	Winter use only: low value	Winter use only: high value	Conventional water use	Winter use only: low value	Winter use only: high value	Conventional water use	Winter use only: low value	Winter use only: high value
Agriculture	0.50	1.70	10.00	0.5	0.2	0.2	1.40	3.29	6.90
Industry	3.00	4.50	6.00	0.2	0.3	0.3			
Domestic	2.50	5.00	10.00	0.2	0.3	0.3			
Ecological Reserve	0.50	0.50	0.50	0.1	0.2	0.2			

requests are declined, and others are reduced to the lower limit. This means that in a good year as much as 1.2% of MAR will be allowed to be released from the Inanda Dam as spates on top of the 0.5 m^3/s base flow. In a not-so-good year as little as 0.5% of the MAR is released. A difficulty that the KNCU experiences in its dealings with the authorities is that there seems to be little understanding that the releases requested for canoe races are nothing more than a modest fraction of what would be required if the National Water Act of 1998 had been implemented. The authorities do not see the releases as the meeting of an obligation that they have in law, but as a favour for the KNCU. Moreover this release policy is not written down and it therefore has to be re-negotiated from time to time, especially when there are changes in the water authority staff.

In order to stage the Dusi Canoe Marathon and the 3 related events the KNCU requires an assurance that the required flows will be granted. The combined value to the regional economy of the 4 races which depend upon the releases from the Inanda Dam is estimated by the KwaZulu Canoe Union at ZAR41.4 million/a (Trodd, 2008). Furthermore, local and national tourism bodies estimate the marketing value of the Dusi Canoe Marathon to the region and to the country at R120 million (De Vries, 2008).

The releases on which these races depend amount to 8.7 million m^3/a in average to wet years. On this basis the value of the water works out to ZAR4.76 per cubic metre of release (above the base flow). In contrast, the economic output per cubic metre of water used in other sectors is outlined in Table 5.

Based on the above, under normal conditions, the ZAR4.76/m^3 value for these canoeing events is some 3.4 times greater than general water use (ZAR1.40/m^3). During a drier than average year the volume of water used for the canoeing races drops to less than half of the normal, and so the value of the water will more than double, still making this the highest value water use.

It is a debatable point whether the above valuation of water for canoeing use is reasonable. It is based on the ZAR41 million, which is the value to the regional economy which is assigned to the events which the releases make possible. It is not the value that participants in those events would be prepared or able to pay if they were required to 'buy' the water. However, what must not be forgotten is that these releases simultaneously partially fulfil the requirements of the National Water Act in sustaining the natural ecosystem below the dam. The value of the releases for canoeing purposes is the greater, in that no other ecological releases are currently allowed. If it were not for these releases, the natural ecosystem would have been neglected since the dam began to impound water. Almost accidentally, a high-value recreational use has been accommodated and this has to some extent mitigated the potentially damaging effects of the dam on the downstream river ecosystem.

If it one day becomes possible to implement an ecological Reserve at Inanda Dam which requires as much as 5% of the virgin MAR to be released, then there will be many more days on which canoeing and other forms of aquatic recreation such as white-water rafting will be possible. This can only be good for the local tourism industry.

Since the inception of the Dusi Canoe Marathon in 1951, paddlers have by no means been passive beneficiaries of the river's services. The instigator of the race, Dr Ian Player, went on to become a leading conservationist. His example inspired many others to dedicate their lives to conservation, and for these men the race became a kind of rite of passage. In the 1980s, when political tensions in South Africa were at their highest, paddlers set up the Valley Assistance Fund, raising money for community development projects and building relationships with the valley leaders and communities. This in time lapsed, as the post apartheid South African Government invested increasingly significant resources in schools, roads, water supply, electrification and sanitation in the uMngeni Valley. A more recent phenomenon is the establishment in February 2006 of the Duzi-uMngeni Conservation Trust (DUCT), an environmental NGO dedicated to championing the health of the uMsunduzi and uMngeni Rivers. While its membership is not limited to paddlers, much of the inspiration and support for this NGO has come from the paddling community. In the last 4 years DUCT has raised over ZAR2 million, and has moreover successfully lobbied various organs of government to spend many more millions on issues such as sewer maintenance, solid waste management, erosion control and invasive vegetation removal, all of which have a direct bearing on river health.

Discussion and conclusions

Although the value to society of allocating water to sustain ecological processes is widely acknowledged, the environment remains the 'Cinderella' when such allocations are considered. While it is over 10 years since the National Water Act was passed, the ecological Reserve has yet to be fully implemented on a single South African river. We argue that this is because the risks associated with domestic and industrial water shortages have been internalised over many years, whereas the risks to the economy and ecology from inadequate allocations for environmental and recreational use have not. Two ways of influencing this paradigm are to make the link between environmental flows and the economy more direct and apparent, and to use flows that are specifically intended to support the economy to also serve the intent of environmental flows.

We have demonstrated this principle using the case of the uMngeni River in KwaZulu-Natal where, since the construction of the Inanda Dam nearly 20 years ago, there has been

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ISSN 0378-4738 (Print) = Water SA Vol. 36 No. 3 April 2010
ISSN 1816-7950 (On-line) = Water SA Vol. 36 No. 3 April 2010

an unofficial policy to allow spates of flows on between 1 and 4 days per year, to make possible the continuation of the prestigious Dusi Canoe Marathon and 3 related lesser events. The total amount of water involved is just over 1.2% of the river's virgin MAR, although in years perceived to be dry the releases may be cut to as little as 0.3% of the virgin MAR. While these releases have been tolerated for the continuation of a high-value recreational industry, they are in fact aligned with the requirement of the National Water Act to provide for the requirements of all water users as well as environmental flows, albeit with a fraction of the necessary volume that would be required if the ecological Reserve had been determined. The releases for these events therefore have a dual or conjunctive value, serving both environmental and recreational purposes at the same time. When one day the Reserve is implemented in this river it is likely that there will be more environmental releases which can help to support a local eco-tourism industry.

South Africa shares 6 river basins with neighbouring countries and the storage capacity of its major impoundments is estimated to 73.7% of total annual run off (Basson et al., 1997). Not surprisingly, this situation causes tensions within and among neighbours and reinforces risk-averse behaviours and concern for deterioration of aquatic ecosystems (Nel et al., 2007; Ashton et al., 2008; Mohammed, 2003; Turton, 2003). Ashton et al. (2008) concluded that 'As the presently very high level of run-off exploitation is exacerbated, it will become increasingly difficult to meet environmental water requirements with direct consequences for both ecosystem and social resilience'. Conjunctive use, as we have illustrated in the lower uMngeni River, offers good prospects for managing multiple demands for scarce water. However, whether we can achieve this depends on the attributes of the water storage system and our willingness to accept that it can be done within the constraints of acceptable assurance of supply. It also requires acceptance that, although environmental flows will be suboptimal, the long-term prospects will be enhanced.

South Africa has a complex water transfer and storage system (Ashton et al., 2008). Inherent in this complexity is opportunity for conjunctive use. This suggests that whether or not we adopt conjunctive use has more to do with our philosophy for water resource management than with the properties of the storage system. The realities of water demands and availability dictate the urgency for a new understanding that realises the potential of conjunctive use in our social-ecological economy.

Acknowledgements

The contribution of Stephen Mallory to this paper is gratefully acknowledged.

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Available on website http://www.wrc.org.za
ISSN 0378-4738 (Print) = Water SA Vol. 36 No. 3 April 2010
ISSN 1816-7950 (On-line) = Water SA Vol. 36 No. 3 April 2010