Contributing Paper

Hume and Dartmouth Dams, Murray Darling Basin, Australia

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Operation, Monitoring and Decommissioning of Dams

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MURRAY-DARLING BASIN, AUSTRALIA

CHANGES IN DAM OPERATIONS TO MEET EMERGING ISSUES AND NEEDS

CASE STUDY 2 - HUME and DARTMOUTH DAMS

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Context – the Murray-Darling Basin

Australia is an ancient island continent. It is dominated by arid and semi-arid landscapes, but also has narrow tropical bands on its eastern and northern coasts. For tens of thousands of years its population was relatively small, comprising indigenous groups of hunter-gatherers living in harmony with the landscape. In the late 1700's European settlement began, and today it is an industrialised nation of some 19 million people, strongly urbanised, and concentrated on the coastal areas. Its economy was initially built on an agricultural base, but today agriculture generates only some 4 percent of gross domestic product. Gross value of farm production is A$27 billion, of which around 80 percent or A$22 billion represents the value of farm exports.

Around 40 percent of this farm production originates from the Murray-Darling Basin in the eastern half of Australia. The Basin is 1,057,000 square kilometres (sq km) in extent, and takes its name from two dominant rivers, the Murray and the Darling, with a combined length of 3,780 kilometres. See Figure 1 for a map of the basin. The Basin covers parts of four States. Its rivers are characterised by very flat gradients (most of the Basin is less than 200 metres above sea level), highly variable flows, and limited run-off.

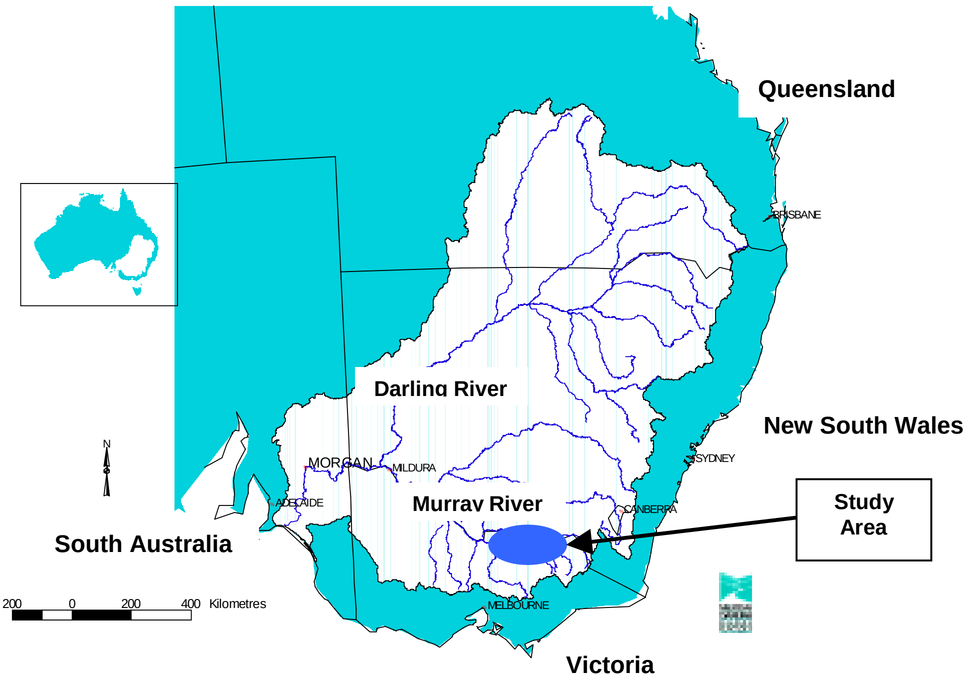

Figure 1 The Murray-Darling Basin

The Basin's rivers are fed mainly by run-off from the inland slopes of the Great Dividing Range and the water resources are now highly developed. Annual run-off is some 24,000 million cubic metres (MCM) of which around half is lost to natural processes. Total diversions are around 10,600 MCM of which 85% goes to irrigation. Storage dams in the Basin total 30,000 MCM (about 136% of mean yearly flow) and support some 1,470,000 hectares of irrigation, representing 70% of the Australian total.

The Basin is now home to 2 million people and boasts a gross product of over A$20 billion.

The River Murray and its Institutions

The River Murray rises in that part of the Great Dividing Range known as the Australian Alps, which are normally snow-covered for five or six months each year, and are the most reliable source of water on the Australian inland. Near its headwaters, the Murray is augmented by waters diverted by the Snowy Mountains Scheme. The length of the Murray until it discharges into the Southern Ocean near Goolwa in South Australia, is about 2530 kilometres, of which the first 1880 kilometres forms the boundary between the States of New South Wales and Victoria.

Originally independent Colonies of England, the States retained their sovereignty, including the sovereignty over natural resources, when the Commonwealth of Australia was created and a Federation brought about under the Constitution of 1901. The River Murray is thus a transboundary river with all the water sharing issues that this status brings with it.

Commercial navigation of the Murray began in 1853. The period of prosperous river trade that followed played an important part in opening up the settlement of large inland areas. However, when diversions for irrigation began in Victoria in the 1870s, the stage was set was for conflict. Continued disagreement over water sharing, in fact threatened Federation for a time.

Eventually however agreement was reached, and in 1915 a treaty between the governments of New South Wales, Victoria, South Australia and the Commonwealth provided for agreed shares of the water resources of the Murray, and for the construction of storage dams for water conservation and a series of locks and weirs for navigation. The River Murray Waters Agreement was ratified by legislation in each parliament and administered by the River Murray Commission comprising a senior official from each jurisdiction.

Many years later the River Murray Commission was subsumed by the Murray-Darling Basin Initiative of the 1980's, which has been described as the world's biggest experiment in integrated catchment management. A new executive body, the Murray-Darling Basin Commission (MDBC), was created, together with a Ministerial Council to oversight broad strategic policy. The role of these institutions is to go beyond transboundary water sharing and to oversight inter-State cooperation and coordination of the whole of natural resource management. The Basin ethic is about achieving objectives together that could not be achieved by working alone.

Direction of the management and operation of the inter-State works River Murray is now undertaken by River Murray Water, a Business Unit of MDBC which operates as an internal utility business delivering services to the States of the Basin partnership. The asset portfolio has increased over the years and now includes barrages at the mouth of the Murray and a number of salt interception schemes.

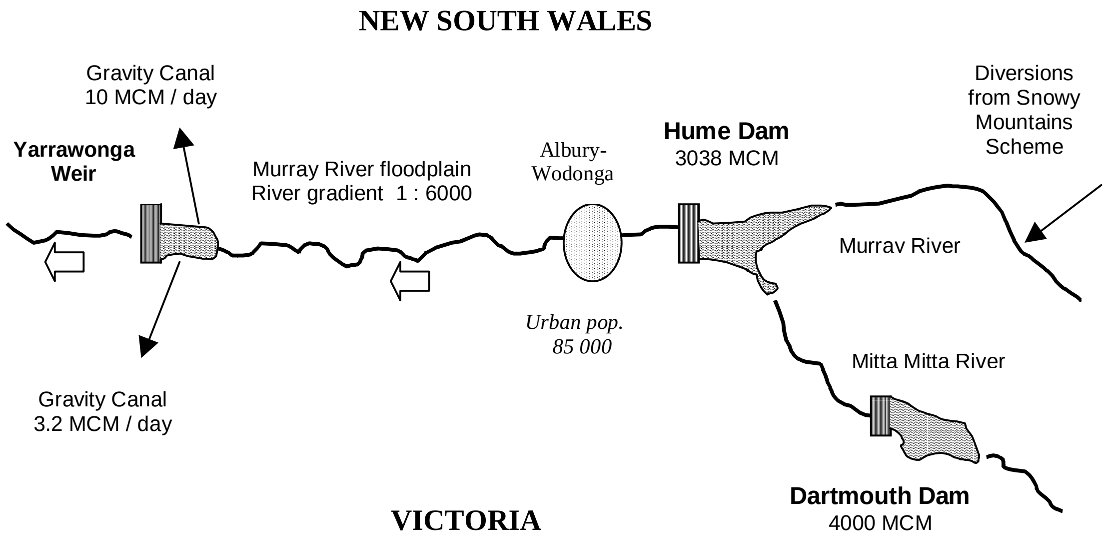

Figure 2 Study Area - the Upper Murray

The Case Study Area and the Role of Hume and Dartmouth Dams

This case study is essentially about operations of the dams of the Upper Murray. See Figure 2.

Apart from the Snowy Scheme, the two major storages regulating the Upper Murray are Hume Dam at 3038 million cubic metres (MCM) capacity and Dartmouth Dam within the Hume catchment and of 4000 MCM capacity. Hume Dam and the nearby city of Albury-Wodonga are sited on the western edge of the South West Slopes of the Great Dividing Range and the start of the vast Riverina Plains. The major diversions of water for irrigation in both New South Wales and Victoria come from the Yarrawonga Weir (capacity 118 MCM), situated some 90 kilometres below Hume Dam and designed to raise the river level to feed two major gravity canals. These two canals serve an area of well over 800 000 hectares, of which over one-third is irrigated.

Hume Dam has a reservoir volume of about 70% of the average annual flow at the dam site, whilst Dartmouth has a volume more than 4 times that of the average annual flow. The major role of these structures is for water supply for the three riparian States. All other roles (hydro-electricity, recreation, flood mitigation etc) are subsidiary, and are undertaken in a way that places no undue risks on water supply. Hume Dam is the key operating storage of the Upper Murray and is drawn down annually, whilst Dartmouth Dam acts as a reserve for dry climatic sequences.

Historical Overview of the Case Study Project

Regulation of the Murray by the construction of large storages has guaranteed a reliable supply of water, which has contributed greatly to the development and prosperity of the region. Since the completion of Hume Dam in 1936, a flow has been maintained along the river despite several severe droughts. The natural Murray would almost certainly have ceased to flow in 1939, 1945, 1968 and 1983.

The largest benefit in economic terms has been the secure supply of water for irrigation and other purposes, but there have been other benefits. The continuous flow has also greatly reduced the extremes in salinity levels that occurred under natural conditions. There have also been large flood mitigation benefits to human activities on the floodplain, and recreational opportunities have been enhanced by storages and by increased summer flows.

However regulation has not been without cost. Valuable land and even a town was flooded to provide storages. The raising and stabilising of water levels by weirs and storages drowned many trees and salinised some land. Some wetlands are now too wet and others too dry, release of cold water has reduced diversity of in-stream biota, and the reduction of spring flooding has adversely affected red gum trees in the extensive Barmah-Millewa Forests and wetlands downstream of Yarrawonga Weir. High regulated flows contribute to erosion in some reaches of the river system.

Overall, the community has generally considered that the benefits of regulation greatly outweigh the costs. However community values change, and we now have more knowledge about the impact of our actions on the health of the riverine system. There is now significant community pressure to improve the health of inland rivers. This was given national expression when, in 1994, the Council of Australian Governments (a forum comprising the Prime Minister plus Premiers of each State) developed a national policy for the efficient and sustainable reform of Australia's rural and urban water industries. Among the institutional, financial and water trading reforms was a requirement to recognise the environment as a legitimate user of water.

In addition, the floodplain communities below Hume and Dartmouth Dams have long been advocates for increasing flood mitigation. This was highlighted and aggravated during major natural floods in spring 1996 which were prolonged by a managed release of 900 MCM from Hume Dam associated with dam safety and a remedial works program for this aging structure.

Clearly, public opinion was saying it was time to change.

The Hume and Dartmouth Dams Operations Review

Against the above background, the Murray-Darling Basin Ministerial Council decided in December 1996 to carry out a thorough review of the operating rules for the two large upper Murray storages which the Commission operates – Hume and Dartmouth. The terms of reference can be summarised as:

> *"To review operating procedures for Hume and Dartmouth Dams and recommend how they might be amended to address competing objectives including water supply, environmental enhancement and flood mitigation"*

The Commission appointed a project manager to manage the process, and particularly the technical inputs, but the review was driven, shaped, and effectively 'owned' by a community-based Reference Panel. The Panel of 16 members was fully independent and was not influenced or directed by the Commission. It had an independent chair and a representative from each of the 3 state operating authorities, with the remaining 12 members drawn from the community of stakeholders, including external environmental interests. Meetings were also attended by an observer from each state's principal environmental or natural resources agency, and who could assist with technical advice.

The methodology was built around comprehensive inclusion and consultation of the stakeholders and valley community, plus a determined effort at creating an information-rich environment aimed at enhanced decision-making.

Consultation Arrangements

The breadth of the terms of reference implied a need to consult with a wide range of people who have an interest in one or more of the several management objectives. The following arrangements were made to achieve community inputs:

- The most direct and continuing consultation was through the Reference Panel of community representatives. This group was fully involved in all aspects of the Review. Members were responsible for communications to and from their interest groups. A number of members also hosted field visits to their area of the valley and arranged inspections and presentations for the Panel, which were selected and arranged entirely by the local interests. The final product of the Review was a report from this independent Panel directly to the Commission.
- At the start of the Review, the Australian Research Centre for Water in Society was engaged to carry out a scoping study to identify the issues that people along the River saw as important. This was done by a series of phone interviews with some 128 interviewees selected from a broad range of interest groups. The scoping study identified a wide range of issues that stakeholders saw as important, and made a number of recommendations aimed at improving community involvement in the Review.
- A series of seven "backgrounder" papers was produced, each describing an aspect of the Review or of present operation. A register of interested stakeholders was compiled and this grew to in excess of 850. Background papers and other information about the Review were distributed to everyone on the register.
- When the Panel's views on the issues and possible enhanced operating strategies began to emerge, an Options Paper was developed, widely distributed, and public comment sought. The paper was also discussed at a series of public/community workshops with comment and feedback being used to finalise the Panel's views. When the Final Report and recommendations to the Commission was produced in May 1999, to keep faith with the community every response to the Options paper was identified and summarised.

- The project team and the Reference Panel chair also made themselves available to meet with key groups requiring in-depth understanding of the substantial volume of sometimes complex material as it emerged from the Panel's work.

Issues

The fundamental issue, not surprisingly, was the tensions between the objectives of providing regular and secure water for irrigation, domestic and industrial consumption, mitigating floods below the storages, and making releases in an environmentally friendly way. Each of these three objectives, if maximised, would adversely affect the other two.

The Panel, in fact, ultimately identified over 60 issues important to stakeholders, which were classified in a regularly updated issues register under headings of water supply, flood mitigation, environment, water quality, channel stability, hydro power generation, recreation, communications, and (of course) 'other'.

To enable meaningful analysis, the issues were then categorised into two groups:

- Issues that do not involve balancing competing claims for water; and
- Issues that involve balancing competing claims for water.

Finally, to give some priorities to the Panel's work, the issues were sorted into river reaches and further classified on a simple high/medium/low rating for:

- Relevance of each issue to the review terms of reference
- Relevance of issue to each reach of river
- Priority for computer modelling or other assessment by the review.

Issues Without Competing Claims for Water

These issues were largely equity-based - they could be remedied by compensation, engineering works, etc. Examples are the adverse effect of high regulated flow between Hume and Yarrawonga on agricultural land, and the adverse effects of low-temperature releases from Dartmouth Dam on river ecology and productivity.

The Panel's approach to resolving these was through generation of solutions from its own experience, supplemented by ideas from the community consultations. The Panel formed preliminary views, which it then tested by publishing the options and listening to the community feedback.

Issues Involving Competing Claims for Water

These issues are largely contained in the main triangle of tensions – environment, water supply, and flooding. An example is the provision of 'air space' in reservoirs to provide flood mitigation. This 'air space' may decrease reliability of supply to irrigators and remove environmentally desirable flooding over the broader floodplain. There are also effects on hydro electric generation, on reservoir-based recreation, recreational fishing and on ecotourism operators.

Many aspects of these competing interests can be quantified, or at least clarified, by simulation modelling. Consequently the Reference Panel put considerable effort into having suitable computer models developed to support decision-making.

Scenario Modelling and Evaluation

The Hydrology Model

Computer modelling of water supply systems simulates (as closely as possible) the operation of the water supply system under any scenario or given set of conditions, through the historic sequence of climate for which information is available.

In this case:

- The system is the River Murray and its storages (Dartmouth, Hume, weirs along the Murray, Lake Victoria, and Menindee lakes). It is necessary to include the whole system because it is operated in an integrated way.
- The conditions that can be specified include:
    - level of irrigation demand;
    - size of storages;
    - detailed operating rules for the storages; and
    - any changes in inputs to the system (for example, returning water to the Snowy River, which would decrease flows into the system).
- Each scenario (or simulated option) operates the system under a fully described set of conditions to see what would have happened through the historic sequence. The results are available in whatever format and degree of detail is required, allowing different scenarios to be compared.
- The historic sequence for which information is available is the period for which the necessary data (inflows, temperature, evaporation, and rainfall) are available.

Two existing Commission models were linked to produce the model used in this review:

- The Monthly Simulation Model (MSM) — a well-developed and robust model that operates in monthly time-steps. This model is satisfactory for resource management purposes, but does not provide the level of detail needed to look at possible changes to flood operation.
- BIGMOD — a daily model that provides detail for the part of the water supply system upstream of Yarrawonga. Essentially, BIGMOD takes MSM output and reprocesses it in daily time-steps to produce daily output for that part of the system. The daily output is used to estimate costs to floodplain landholders of flooding below the storages. It is also useful for looking at in-stream variation from the environmental viewpoint.

Economic Evaluation

Fortunately, the MDBC hydrology models already had economic modules that put dollar values on irrigation along the whole length of the Murray, hydro-electric generation at both Hume and Dartmouth, Hume-based recreation, and effects of river salinity – including urban water use effects.

The salinity module had been recently reviewed and upgraded and was considered reliable. The irrigation module at the start was rather more primitive, based on a single farm gate value of water. This was updated using current 'regional gross margins' economic modelling from the states to distinguish between high and low security water (which not only have different values, but also are unequally subject to restrictions in times of water shortage.)

At the time of the dam safety release of water from Hume, the Commission agreed to an ex gratia payment to those who had been affected by the consequent flood prolongation – principally a matter of pasture loss. Evaluation of these losses was done in some detail by agricultural consultants and verified through consultation with affected groups. The review engaged consultants to use this base data to create a floodplain economic model which, when linked to the hydrology model, could evaluate various flood mitigation scenarios.

To allow interest groups to extract further meaning from the modelled scenarios, physical parameters were tabulated along with the dollar impacts. Figure 3 gives an abbreviated example of outputs for evaluating flooding.

FLOODING (Modelled 1934 – 1997)	**Natural Conditions**	**Current Operations**	**Scenario A** (Translucency only if dams over 60% full)	**Scenario C** (Translucency at all storage levels)
Mitta Mitta below Dartmouth				
Floods / year	1.21	0.37	0.42	0.47
Average days flooded / year	19	12	12	12
Average flood costs / year ($000)	506	244	220	230
Murray below Hume Dam				
Floods / year	1.38	0.70	0.65	0.67
Average days flooded / year	48	26	24	22
Average flood costs / year ($000)	2 394	1 133	991	913
Murray below Yarrawonga Weir				
Floods / year	1.02	0.54	0.54	0.52
Average days flooded / year	23	13	12	12
Average flood costs / year ($000)	1 358	654	566	561

Figure 3 Typical Modelling Output for Flood Mitigation

Environmental Evaluation

Whilst the models generated comprehensive hydrologic and dollar value outputs for irrigation, hydro-electricity, salinity, flooding, and recreation, there was no methodology available for generating environmental outcomes. Fundamental research is still in its early days, and there are no known reliable algorithms that describe quantified aquatic ecosystem responses to specific flow interventions.

It was therefore necessary to develop an agreed and comprehensive set of flow parameters that could be viewed as surrogates for environmental outcomes. This was a complex and time-consuming process, but was needed to overcome environmentalist's concerns that any generalised river health indices would mask important details.

The selection of flow parameters was assisted by the previous work of an 'expert panel'. This technique has been used on other rivers where a quick picture was needed of environmental health without the time and resources that full scientific investigations would require. It consists of assembling a small team of perhaps 5 or 6 the best available scientists covering disciplines such as geomorphology, limnology, wetlands ecology, hydrology, fish biology and so forth. The team then travels together making joint observations and drawing conclusions based on these plus accumulated experience and knowledge. In a matter of weeks the resource managers have an overall view of the key river health issues of the particular river.

New South Wales' own water reform process involved among other things, selecting river flow objectives for all its rivers. This process had used cumulative flow-duration curves to measure the degree of return to natural conditions. However, on the Murray these were found to be too insensitive and did not describe well the critical element of flow variability.

With several reaches of river being considered, including the Barmah-Millewa Forests, each with its own environmental characteristics, up to 250 elements of flow data for environmental flow evaluation were generated for each operational scenario being modelled. The data included seasonal temporal elements, for example stage height-duration bar graphs for natural, current operations, and modelled scenario, for spring months. Figure 4 gives an abbreviated example of modelling output for environmental evaluation.

ENVIRONMENTAL INDICATORS (Modelled 1891 – 1997)	**Natural Conditions**	**Current Operations**	**Scenario A** (Translucency only if dams over 60% full)	**Scenario C** (Translucency at all storage levels)
DARTMOUTH TO HUME REACH				
Floodplain inundation (>1 day Jun-Dec)				
No. years with an event > 13 000 ML/day	43	18	60	21
No. years with an event > 19 000 ML/day	36	9	35	12
Channel Stability				
Mean annual flow within river banks (MCM)	1 153	1 244	3 540	1 242
HUME TO YARRAWONGA REACH				
Floodplain inundation (>1 day Jun-Dec)				
No. years with an event > 25 000 ML/day	57	42	43	42
No. years with an event > 31 500 ML/day	52	27	26	28
Channel Stability				
Mean annual flow within river banks (MCM)	4 016	5 070	5 124	5 146
BELOW YARRAWONGA				
Floodplain inundation (>7 day Aug-Jan)				
No. years with an event > 14 000 ML/day	61	57	60	61
No. years with an event > 25 000 ML/day	53	36	35	38
Channel Stability				
Mean annual flow within river banks (MCM)	3 378	3 475	3 540	3 566
Bird & fish breeding indicators				
No. 'excellent' years	45	9	37	33
No. 'good' years	24	20	4	6
Barmah Forest watering indicators				
Years with 1 month or more > 550 MCM	98	55	61	65
Years with 1 month or more > 912 MCM	73	37	34	37
Years with 1 month or more > 1039 MCM	68	29	32	33
Hattah Lakes watering indicators				
Years with 1 month or more > 1116 MCM	93	45	46	47
Years with 1 month or more > 1487 MCM	72	38	34	36

Figure 4 Typical Modelling Output for Environmental Indicators

A significant by-product of this painstaking detail and discussion was that water users and irrigators in particular became aware of the scope and nature of change that regulated flows had produced. As a group of people whose livelihood derived from the river, their natural instincts to want a healthy river now became well informed, and they could understand and debate both the ecological changes and the practicalities and limits to improved flow management.

Trade-offs Between Economic Impact and Environmental Benefits

As an example of the trade-offs that the stakeholders were willing to negotiate, Figure 5 gives a broad set of results for the two scenarios that represented generally the limits of acceptability.

	Scenario A (Translucency only if dams over 60% full)		**Scenario C** (Translucency at all storage levels)	
SUMMARY of DOLLAR IMPACTS ($000/year)				
Irrigation - New South Wales	- 3341	*(- 1.5%)*	- 9415	*(- 4.2%)*
- Victoria	- 276	*(- 0.1%)*	- 1121	*(- 0.3%)*
Hydro-electricity	+ 91	*(+ 1.1%)*	- 136	*(- 1.6%)*
Salinity	+ 202	*(+ 0.3%)*	+ 486	*(+ 0.7%)*
Flooding	+ 254	*(12.5%)*	+ 328	*(+16.1%)*
Lake Hume recreation	- 90	*(- 4.1%)*	- 193	*(- 8.8%)*
TOTAL dollar benefit ($000/year)	- 3160	*(- 0.6%)*	- 10052	*(- 0.2%)*
SUMMARY of NON-DOLLAR IMPACTS				
Dartmouth – Hume reach	Little change		Little change	
Hume – Yarrawonga reach	Slightly better		Slightly better	
Below Yarrawonga :-				
Bird breeding (excellent + good years)	+ 12		+ 10	
% shift towards natural	*+ 30%*		*+ 25%*	
Forest watering (sum of low + high level)	+ 8		+ 13	
% shift towards natural	*+ 10%*		*+ 16%*	
Hattah Lakes watering (low + high level)	+ 2		+ 5	
% shift towards natural	*+ 2%*		*+ 6%*	

Figure 5 Trade-off between economic impact and environmental benefit

Overall Review Outcomes

The Panel achieved consensus on how to best manage what many people believed at the outset were irreconcilable objectives for the management of this precious resource. This was made possible by a consistent and meaningful depth of understanding, patiently acquired by all Panel members. In turn, this created an atmosphere of mutual respect for each party's views and opinions.

Debate remained vigorous throughout, but well informed. Rhetoric (a natural tendency for community leaders) was responded to by requests from the rest of the Panel for facts and evidence. No difference of opinion was allowed to remain unresolved, and the technical people were frequently called upon to do more work to facilitate this resolution.

As a result, the Panel's findings were non-trivial. A few examples are:

- For Hume Dam, a managed form of translucency of around 30% was supported, compared to a scientific panel's judgement that 10% was about as much as could be realistically hoped for;
- Irrigators were amenable to contributing to the cost of acquisition of easements to flood (estimated at A$1 million) where high regulated flows close to river channel capacity had impacted on private riparian lands;
- Floodplain land-holders relinquished their long-held desire for flood mitigation through provision of 'air-space' in the reservoirs set aside for flood storage, in favour of environmental flow rules that gave them marginally lesser benefits, but significantly reduced what was otherwise a major impact on water supply; and
- A proposal was agreed to in principle that further riparian flood easements above existing river channel capacity should be considered, in order to permit an increase in allowable environmental and pre-release rates from Hume Dam for instream, forest watering, or flood mitigation benefits, whilst minimising impacts on water supply.

The final package of recommendations to the Commission was contained in the May 1999 Hume and Dartmouth Dams Operations Review Final Report. It is a tribute to the thoroughness of the work of the review and the strong consensus which this made possible, that the Commission in June 1999 adopted all the recommendations either in principle, or for immediate implementation. For those recommendations adopted in principle, funding was provided for further investigations to enable an ultimate decision.

The final package included the following key elements.

Dartmouth to Hume reach of the Mitta Mitta River

- The possibility of operating the power station during floods to decrease flood duration should be investigated in detail.
- Geomorphic studies and an integrated program of waterway and floodplain management should be supported.
- Detailed investigations into the cost and benefits of a multi-level outlet on Dartmouth Dam should be undertaken.
- Strategies to increase the variability of instream flows should start immediately.

Hume to Yarrawonga reach of River Murray

- Adverse effects of flooding or waterlogging of private land at peak regulated flow should be remedied, principally by negotiating flood easements - costs to be met generally by beneficiaries of regulated flows.
- A 'no-borders' integrated River Management Plan addressing waterway and floodplain management requires funding and immediate initiation – led in the first instance by MDBC.
- A proposal to increase allowable environmental and pre-release rates from Hume through acquisition of flood easements (as a means of limiting impacts on water users) should be developed in more detail.
- Strategies to increase the variability of instream flows should start immediately.

Flow Policy Development

- The Panel's broad, but exhaustive, conclusions from modelling should form the basis of the Murray River Flow Management Plan. In brief, these showed that managed translucent flow scenarios in the order of 30% show considerable promise in balancing the 3 main competing objectives.
- Flow policy development that involves 'trade-offs' requires a community-based steering/reference committee, and requires an environment of well-defined property rights for successful implementation.

Conclusions – Factors for Success

The following are observations of the author, made during 25 years of water resources management in the Murray-Darling Basin and elsewhere. They are not official views of any specific agency, nor even particularly unique, but reflect the strong total catchment management (TCM) ethic that has grown in Australia during the past two decades. It is captured succinctly in the New South Wales TCM slogan of "…*Governments and Communities Working Together*".

- Any process of natural resource management that involves trade-offs will never succeed properly unless governments and bureaucrats recognise and support the need for community ownership of the process.
- 'Support' in this context includes adequate technical resources for data gathering, scientific investigations, simulation modelling, and socio-economic analysis.
- 'Support' also includes allowing the community to proceed at the pace that it feels comfortable with. Any attempt to push the process too hard to meet purely political timeframes will result in the community losing faith in the process, or even abandoning it.
- 'Community' in this context means the broad community, not just the community of a particular valley or catchment, although they are obviously the key group.
- Broad consultation is vital. This works best, and has most credibility, when it is seen to be led by informed community people, rather than by bureaucrats or experts. These latter are needed of course, but experts should generally be on tap, not on top. The community will however always respect and value the views of genuinely independent experts.
- The process of implementation of a flow management plan is just as important as the process of plan development. All observations about community ownership apply equally to this phase.
- The community will best accept a flow management plan that is built around pragmatic notions of adaptive management. This requires experts to admit that their knowledge is limited. It also requires highly public auditing and monitoring, and a commitment to research.
- Finally, experience in the Murray-Darling Basin shows that when all of these principles are in action, communities will do tougher things to themselves in order to ensure sustainability of the natural resources of their neighbourhood than they would ever permit governments and bureaucrats to do to them.

Put another way, these observations centre about a point of considerable agreement amongst water resource managers that,

'…water management is as much about psychology, as it is about hydrology or ecology.'