Weather, Climate, Water and Sustainable Development

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Introduction

When Bill Downey asked me in late January or early February to give an address for World Meteorological Day, I thought I was one of a number of speakers. With the arrival of the information on previous addresses, I discovered that not only was I the only speaker, but that I was also following a series of previous speakers of rather exceptionally high calibre.

In my background reading for this talk on weather, climate, water and sustainable development, I noted that Dr John Zillman in his World Meteorological Day 2003 lecture, said "It is sometimes said that climate is what you expect and weather is what you get."

In recent times, I think we have probably got a fair dose of weather that we didn't really expect.

We seem to be experiencing a period of highly variable weather for example, successive years of extraordinary dryness in parts of Australia, frequent violent storms, catastrophic bushfires and dramatic temperature changes. These extremes all have an impact on our economic and social activity and the environment, imposing greater challenges to our attempts to foster sustainable development in Australia.

Sustainable development was defined by the 1987 World Commission on Environment and Development as:

> "Meeting the needs of the present without compromising the ability of future generations to meet their own needs."

Today I would like to focus on the challenges that weather and climate, and particularly extremes of these, present to the management of water and sustainable development within the Murray-Darling Basin, and how we are trying to meet those challenges.

The Murray-Darling Basin

Background and History

The Murray-Darling Basin in south-east Australia covers an area of 1.06 million square kilometres, an area equivalent to the size of South Africa. It makes up approximately 15% of Australia and has a population of over 2 million people.

In the north of Australia, monsoons and tropical cyclones are dominant climatic weather influences. Mid-latitude storm systems are the major influence across the south.

The geographical coverage of the Basin means that its climate is varied with cool humid eastern uplands, temperate southeast mallee, inland subtropical northern areas and hot, dry arid and semiarid country in the far west.

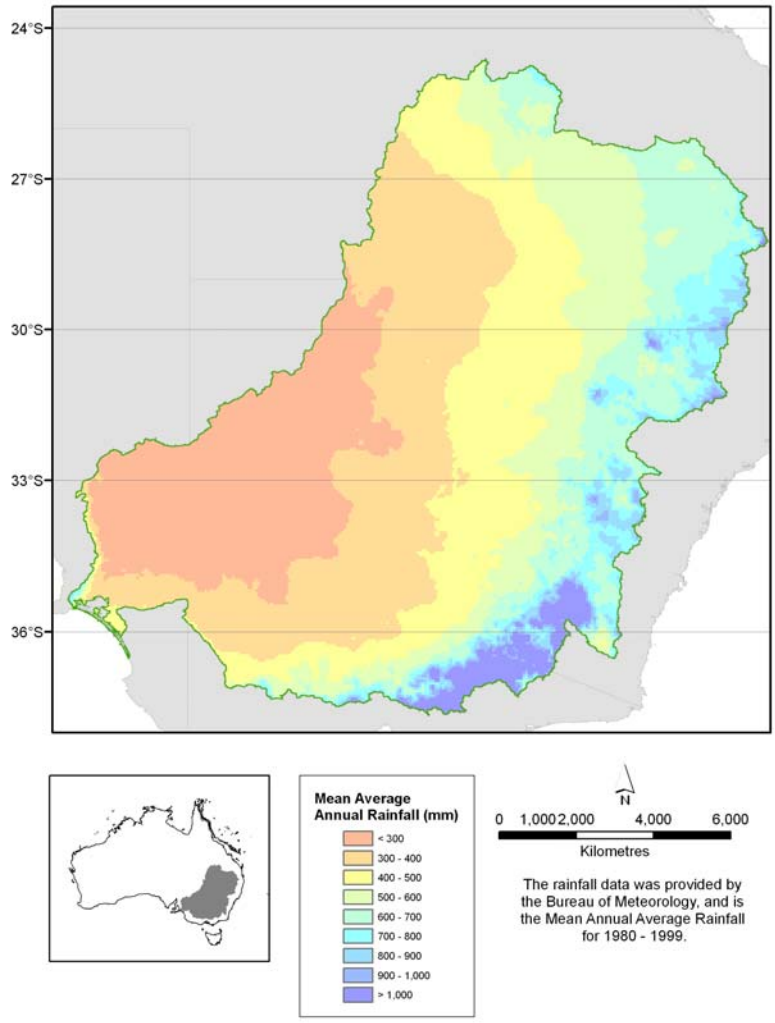

Figure 1: Rainfall and latitudes of the Murray-Darling Basin

Temperature, precipitation and evaporation are highly variable from one year to the next, with consequent impacts on availability of water resources in the Basin. The Basin has been subject to both extreme floods and extreme droughts.

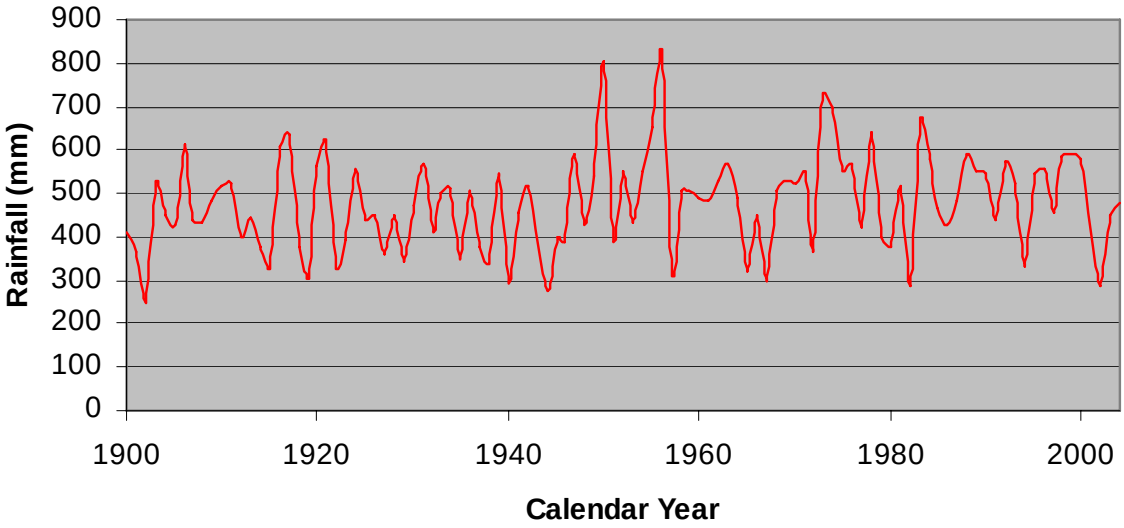

Figure 2: Rainfall variability of the Murray-Darling Basin

El nino events are a major interdecadal influence. Longer term climate change is of increasing concern.

The Murray-Darling Basin contains two major river systems by world standards. These are the Darling River - 2,740km in length and the Murray River - 2,530km in length. Despite their length, however, the flows in these rivers are small and extremely variable.

Average annual runoff in the Basin is around 24,000 GL/yr of which under natural conditions about 11,000 GL/yr is consumed by wetlands and/or floodplains and about 13,000GL /yr flows to the sea. The average annual flow of the Amazon, by contrast, is about 5.5 million GL and 1 million GL for the Yangtze. Annual flow variability is however, an even more telling comparison. The ratio between the maximum and minimum flows for the Amazon is 1.3 and Yangtze 2.0, compared with the Murray at 15.5 and the Darling at 4705.2!

Major catchment yields are in the south-east and feed into the Snowy system, Hume and Dartmouth Dams, as well as Burrinjuck Dam on the Murrumbidgee in NSW, and Eildon Dam on the Goulburn in Victoria. Significant tributaries feeding the Murray are the Murrumbidgee and Darling from NSW, and a series of rivers in northern Victoria including the Mitta Mitta, Kiewa, Ovens, Goulburn and Loddon.

However there is also periodically significant water flow in the Darling System resulting in an average 12% input into the Murray flows. Major tributaries of the Darling include the Barwon, Border Rivers, Namoi, Gwydir, Macquarie and Lachlan.

The Murray-Darling Basin is important in the economic, social and environmental fabric of Australia. The Murray was initially important as a navigation route and increasingly as a supplier of water for agriculture and local communities (including Adelaide). Now, the major commercial activity in the Basin is agriculture, which produces some 41% of Australia's gross value of production and some 70% the gross value of irrigated agricultural production. Agricultural processing and manufacturing, mining and tourism are also significant.

Prior to 1900, the self-governing colonies in the Basin were unable to reach an agreement on water management issues — specifically navigation and irrigation. From the late 1890s to about 1905, these tensions were exacerbated by the drought and this was reflected in robust debate in the conventions leading up to the adoption of the Constitution in 1901. Sections 51, 98 and 100 provide the framework which defines responsibilities of the Commonwealth and the States with respect to water. Although land and water management is primarily a State responsibility, the Commonwealth powers over trade, commerce (S 51) and also over navigation (S98) are limited by Section 100 which states:

> *The Commonwealth shall not, by any law or regulation of trade or commerce, abridge the right of a State or of the residents therein to the reasonable use of the waters of rivers for conservation or irrigation.*

In 1902, a conference in Corowa called on both the Commonwealth and state governments "to cooperate in preparing and carrying out a comprehensive scheme for the utilisation of the

waters of the River Murray", which would cater both for navigation and potential consumptive uses. As a result, the states appointed an Interstate Royal Commission on the River Murray in 1902.

The *River Murray Waters Agreement*, signed in 1914, by New South Wales, Victoria, South Australia and the Commonwealth, did three things. First, it set out a series of "joint" structures - storages, locks and weirs - to be built by a Constructing Authority nominated by the state in which the work was located. They were to be funded almost equally by the four governments. Later, the principle of sharing capital works equally between the parties was formally adopted. Since then, ongoing operation and maintenance costs have been shared between the three states.

From 1914, through to the 1970s, there was a major focus on increasing water diversions for irrigation. As a result of high variability, naturally low flows and high evaporation rates in storages and open channels, there was considerable development of infrastructure. Hume Dam (now 3,000 GL) was completed in 1936, the barrages between the lower lakes and the mouth of the Murray were completed in the 1940s to reduce salt water intrusion, stabilise the river level, concentrate releases in times of low flow and maintain a pool of water, and Dartmouth Dam (3,500GL) in 1979 — the last major storage to be built. Interestingly, Australia's large dams are about six times larger than those of European dams for the same mean annual streamflow. By 1980 the Murray River was a highly regulated river with what is now almost $2 billion of infrastructure and a complex series of rules for its operation to serve both the extensive irrigation development in each State and provide water for communities.

By the late 1970's, however there was a growing awareness of water quality problems especially salinity and water logging. This led to a recognition that the entire Basin, not just the Murray River, needed to be managed. Again, it took until 1992 to finally negotiate the Murray-Darling Basin Agreement, which Queensland, and the ACT subsequently joined.

Structure and charter of MDBC

The new Agreement maintains the water sharing rules, joint works and funding arrangements of the original River Murray Agreement. It however establishes a much broader purpose, a Ministerial Council, a revamped Commission and a community advisory council.

The Murray-Darling Basin Ministerial Council (Ministerial Council) is the primary body responsible for providing the policy and direction needed to implement the Murray-Darling Basin Initiative. The Council's main functions are to consider and determine major policy issues concerning the use of the Basin's land, water and other environmental resources; and to develop, consider and authorise (as appropriate) measures to achieve the purpose of the Murray-Darling Basin Agreement. The current framework is based on the philosophy of catchment management and not solely river management.

The Ministerial Council is made up of the ministers holding land, water and environment portfolios within the Australian, New South Wales, Victorian, South Australian and Queensland governments. As many as three ministers from each government may sit on the Council. The ACT may participate in but not vote on matters affecting the Murray-Darling Basin Initiative.

The Murray Darling Basin Commission (MDBC) is the executive arm of the Ministerial Council and is responsible for managing the River Murray, the Menindee Lakes system of the lower Darling River and for advising the Ministerial Council on matters relating to the use of the water, land and other environmental resources of the Basin. Paralleling the charter of the Ministerial Council, the MDBCs charter is to promote and co-ordinate

> "effective planning and management for the equitable efficient and sustainable use of the water, land and other environmental resources of the Murray-Darling Basin."

The Commission is not a statutory authority, nor is it subject to corporations law and it is not a government department. It is a unique creature requiring unanimous agreement for significant decisions. While this might seem a cumbersome arrangement, it is hard to think of a more effective model for decision making which significantly affects communities in a large part of Australia.

As a result, achieving an outcome of equitable, efficient and sustainable use of the Basin's environmental resources requires coordinated effort by the six partner governments and close cooperation with the Basin community. The MDBC actively supports a government-community partnership and relies on it to implement effective natural resources planning and management in the Basin. This cooperative approach brings to participants and end-users the benefit of shared concerns and expertise and jointly developed and integrated solutions as well as avoiding duplication of effort. The durability of the arrangement in its various forms is testament to its success.

Surface water diversions

The history of management actions in the Basin reflects a growing concern for sustainable catchment development. In relation to surface water diversions, water sharing principles initially developed under the River Murray Waters Agreement are a key ongoing focus. These principles take into account the variable flow, storage capacity and demand:

- upper States equally share flow at Albury
- upper States retain rights to develop downstream tributaries (capped at 1993-94 levels of diversion)
- South Australia ensured a nominated set of monthly and annual flows (effectively first commitment on available resources)
- continuous water accounts maintained; upper States have flexibility in annual use subject to priority of commitment to South Australia

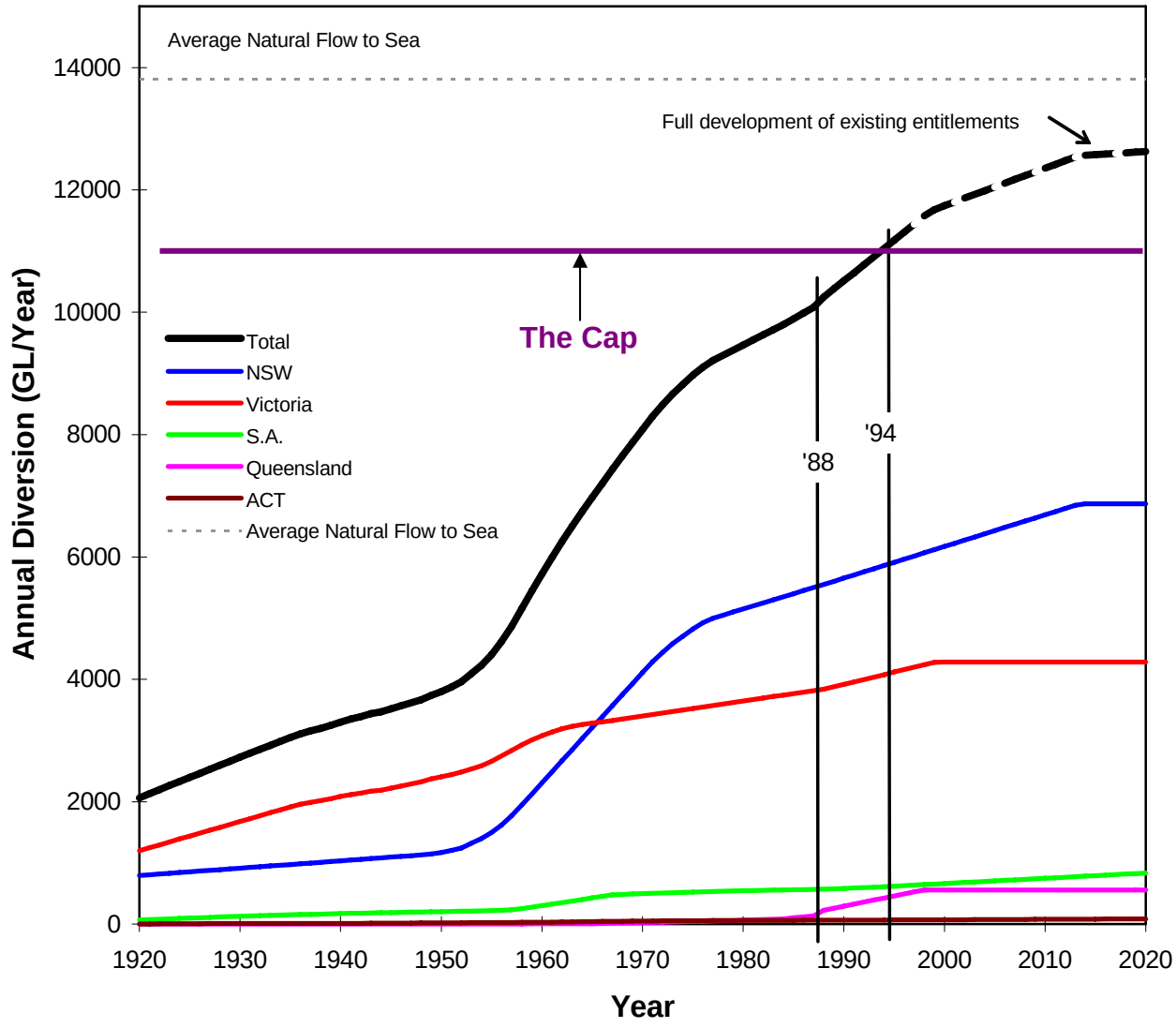

Figure 3: Water diversion, by States.

Surface water extraction is now about 12,000 GL. In the Murray, for example, this now means that while average natural annual flow to the sea is around 13,000 GL, current annual average flows to the sea are down to about 5,000 GL.

In 1995, recognising the importance of a more holistic approach to basin management, the MDBC Ministerial Council considered an audit of water use in the Basin. The audit confirmed increasing levels of diversions. In the six years prior to the audit, water consumption in the Basin had increased by 8% overall.

In 1995, the Council agreed to a Cap on further diversions of water, based on 1993-94 levels of development.

The Cap is adjusted for the climate experienced in any given year and is applied on a valley by valley basis across NSW, SA, and Victoria. Queensland and the ACT are yet to determine their caps. Compliance with the cap is independently audited each year.

The Cap serves the dual purpose of preventing further erosion of water access reliability for existing water users, and protecting river systems from further reductions in flow.

Salinity

Not only was there concern about the level of surface water extractions and reduced river flow, but there was increasing concern about salinity in the Basin and in the River Murray itself. Salinity is more than a threat to water quality - it impacts on the economic, cultural, social and environmental values of the Murray-Darling Basin.

The Salinity Audit of the Murray-Darling Basin in 1999, indicated that salinity levels in the River Murray and its key tributary rivers would rise significantly within 20 to 50 years, compromising their use for irrigation and urban purposes.

To ensure that the favourable salinity levels we enjoy today are maintained into the future and the Salinity Audit predictions are not realised, “doing nothing” is not an option. The objectives of the Basin Salinity Management Strategy (BSMS) are to “hold the line” at Morgan in South Australia - the key Basin target site for salinity, live with some salt in some tributaries, protecting key values and assets in catchments, and take a robust cost benefit approach to determine the best outcome from investments in reducing salinity impacts.

Two major strategies are being employed in the Basin to “hold the line” on salinity. Salt interception schemes are large-scale groundwater pumping and drainage projects that intercept saline flows and dispose of them, generally by evaporation. A program of salt interception schemes is currently being implemented to reduce salinity at Morgan by 61 EC’s.

This will simply "hold the line" in the short term until landscape change comes into effect. Landscape change is occurring through catchment planning processes and is vital towards meeting the strategy's objectives in the long term. Landscape change, however, takes significantly longer to achieve results for salinity in the river itself.

The Basin Salinity Management Strategy provides a long-term framework to coordinate and support salinity management efforts across the Murray-Darling Basin by providing context, setting targets and directing investment. The strength of the BSMS is that it recognises the diversity of salinity issues and approaches to salinity management by jurisdictions within the Basin, while providing a common purpose.

While there is no doubt that the "without intervention" scenario would have resulted in higher river salinity, there is concern that in the event of significant rain leading to flooding, salt currently locked in floodplains will be mobilised into the river.

Water reform

At about the same time that the Murray-Darling Basin Commission agreed to the Cap on surface water diversions in the Murray-Darling Basin, the Council of Australian Governments (COAG) agreed that there was a need to reform Australia's water arrangements. The key objectives were to put Australia's rural and urban water industries onto an economically and environmentally sustainable base.

Institutional reforms were to make the water industry more commercially focused, accountable, appropriately regulated and with effective engagement at the local level and from water users. Water entitlements would be tradeable, to establish the most economically productive use of water, stressed rivers were to be identified and a better balance achieved between consumptive use and environmental requirements for those rivers. In 1995, this reform agenda was linked to national competition policy.

The Murray-Darling Basin Commission has focussed over the last decade on implementing key reforms requiring cooperation across jurisdictions. These have included institutional

reforms through the establishment of River Murray Water as a separate ring fenced business arm providing the key services of water storage and river operations; the commencement of interstate water trade; investigations into the environmental water requirements of the River Murray and more recently, The Living Murray Initiative.

One of the reforms has been the establishment of water trading. Clearly, with the level of diversions from irrigation and the implementation of the Cap, any water for new developments has to be found from existing uses.

The irrigation industries in the Basin are in a process of continuous change, moving water from one activity to another, both on a short-term basis and permanently. Commodity markets are competitive, fluctuating and global. The speed of change in supply, demand, technology and the evolution of substitute goods are increasing. Water is just one of a range of input costs which are highly variable from one season to the next. Irrigation dependant industries need maximum flexibility to compete and adjust.

There are two possible ways to move water from one use to another – reallocation by government, or trading between water users. In establishing water trade, Governments recognise that rights to access and use water are valuable assets and that the users of those assets are best placed to decide their most productive use.

Water markets provide the opportunity for new investment in high value added agriculture despite resource constraints. Trade stimulates movement of water to higher value, more sustainable use. In addition, trade can provide the opportunity to make the most of water availability with the very high seasonal and inter-annual variability common to Australia. Trade helps individual irrigators to adjust to changing circumstances and to manage financial and climatic risks.

Unofficial local water trades have occurred in the Basin since the 1940s but it was not until the late 1980s and early 1990s that governments began to allow trade officially. In 1995 Murray-Darling Basin Ministerial Council agreed to establish permanent interstate trade. Arrangements under the Murray-Darling Basin Agreement were agreed in 1997 and a pilot

scheme began in 1998. With complex differences between State water management systems and the importance of meeting environmental requirements – the scheme was restricted to a region with similar geography and water entitlements – the lower Murray below about Swan Hill. About 26 GL of water has traded permanently interstate, probably resulting in development of in the order of 5,000 hectares. The water has traded into high tech and high value uses – viticulture and horticulture and away from irrigating pasture. Two reviews have shown its environmental impacts have been positive. At the same time trade has increased dramatically within States. Most trade occurs within any given valley. Total permanent and temporary water trade across the Basin is now about 1,000 GL per year. Permanent trade particularly has seen the growth of new industry in Sunraysia and in South Australia's Riverland. Temporary trade has been very important to industry adjustment during dry periods, particularly during the current drought.

In 2003, Ministerial Council decided to expand permanent interstate trade where it is hydrologically practicable - across the Murray, Goulburn and Murrumbidgee systems. Expansion requires the development of systems to transfer between the different entitlement types from one state to another, the establishment of trading zones and rules to manage hydrological constraints and environmental and salinity clearances and the management of issues arising from net trade out of particular districts. Ministerial Council also recognised that expanded trading arrangements would be important to achieving the outcomes of the Living Murray most efficiently and with least impact on industry. The Commission is close to finalising the technical requirements to expand trade.

The Living Murray

River regulation clearly changes flow regimes, for example, periods of constant and high flows or low flows, the absence or reduction of flooding or unseasonal (for ecosystems) flows, as well as water quality changes and habitat changes. In response to substantial evidence that the health of the River Murray System was declining, in the late 1990s, the Murray-Darling Basin Ministerial Council established its Living Murray initiative. Concerns were expressed about algal blooms, death of trees, the drowning of trees, salinity and the blockage of the Murray Mouth.

The Murray-Darling Basin Commission undertook significant work throughout 2002 and 2003 to investigate the options for contributing to the improvement of the health of the Murray through the provision of additional water for the environment. This work included scientific, economic and social analysis together with consultation with communities.

In November 2003, the Murray Darling Basin Ministerial Council, ratified by the Council of Australian Governments in 2004, agreed to invest $500 million to recover 500 GL over 5 years to achieve specific environmental objectives at six significant ecological sites: Barmah-Millewa Forest, Gunbower, Koondrook-Perricoota Forests, Hattah Lakes, Chowilla Floodplain (including Lindsay-Wallpolla), Murray Mouth and Coorong and Lower Lakes and the River Murray Channel.

Examples of the objectives for several of these sites are:

1. Barmah- Millewa Forest : Enhance forest fish and wildlife values, Successful breeding of thousands of colonial waterbirds in at least three years in ten, healthy vegetation in at least 55% of the area of the forest (including virtually all of the Giant Rush, Moira Grass, River red gum forest, and some River red gum woodland).
2. Murray Mouth and Coorong and Lower Lakes: Open Murray mouth, have more frequent estuarine fish spawning and an enhanced migratory wader bird habitat in the Lower Lakes.
3. River Murray Channel: To increase the frequency of higher flows in spring that are ecologically significant, overcome barriers to migration of native fish species between the sea and Hume Dam, and maintain current levels of channel stability

In November 2004, the Ministerial Council approved an initial four water recovery proposals to recover 240 GL at a cost of $179 million. The recovery projects involve decommissioning a dam, improved irrigation infrastructure, creation of a new separate tradeable water product of higher reliability in northern Victoria, piping and channelling open systems and temporary purchase of water in wet seasons.

In addition, under a $150 million Environmental Works and Measures Program, 38 projects are currently progressing and are already delivering results. These funds are applied to projects (construction, modelling etc) which will improve environmental outcomes. Projects include construction of regulators at wetlands to control flooding and drying, hydrological modelling, construction of fishways so that fish can swim unimpeded from the Murray mouth to the Hume Dam, watering stressed red gums for example at Chowilla floodplain. Arrangements for watering stressed River red gums on the Chowilla floodplain and operation of the new fish passages on the River Murray are well underway. The dredging program at the Murray Mouth has provided sufficient tidal surge to replenish the water at the Coorong.

To encourage non-governmental ideas for water recovery, the MDBC is funding four feasibility studies examining water recovery proposals, which, if they deliver on their promise, will provide an additional 60 GL. The Commission is also reviewing a further round of submissions for feasibility studies.

Climate in the last decade

Our lengthy historical record shows a cyclic variability in climate, as reflected in southern flows in the Murray, since 1890.

With only three wet years out of the last nine in the Basin, the drought, which has affected most of Australia at some time in the last decade, has been pronounced in south-eastern Australia. Nationally, the impact of the drought in its most severe year (2002-03) is reported by Treasury to have reduced the rate of economic growth in Australia by around 1.0 percentage point or $6.6 billion from what would otherwise have been achieved.

With low rainfall affecting water inflow in to the Murray and Darling Rivers and into storages along the rivers, irrigators, communities and ecosystems have been living with the consequences of low flows. In comparison with the historical record, the inflow sequence over the last eight years has been exceptionally dry. It is worse than the drought in the mid 1960s and the last 6-7 years are comparable with the 1940s. It is most comparable with the

prolonged drought of 1895 to 1902. However to February 2005, we have had the driest four year period on record.

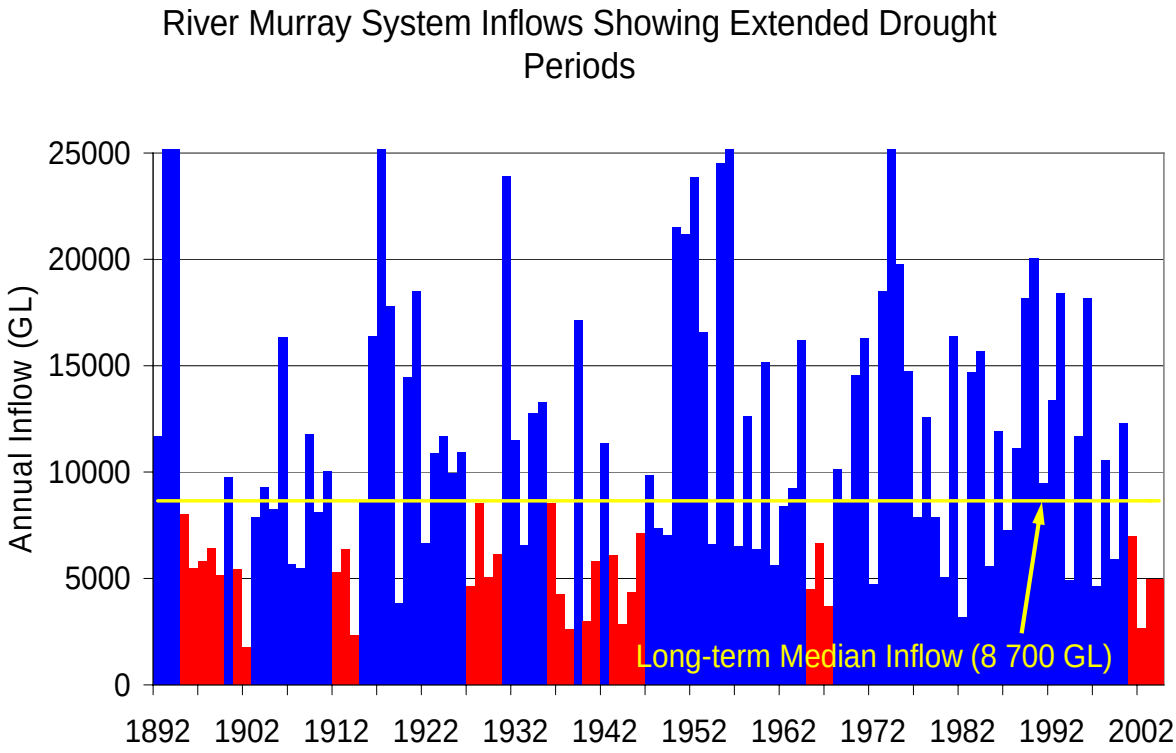

Figure 4: River Murray system inflows showing extended drought periods

Diversions of water were not significant at the turn of the century or in the 1940s and the dry period at the end of the 1960s was a rapidly expanding time for irrigation. Historically in the midst of drought there have been flushes of water down the Rivers.

The current combined impacts of drought and diversions results in extremely low flows in the Lower Murray. Any short-term water flushes are now often, though not always, captured by headwater storages.

In 1981, the Murray Mouth closed and it came close to closing again in 2002-03. Since mid 2003, we have had two dredges operating around the clock at a cost of about $7 m per year to

keep the Murray mouth open. With the current level of development, we expect to have the dredge for up to 50% of the time, in the future.

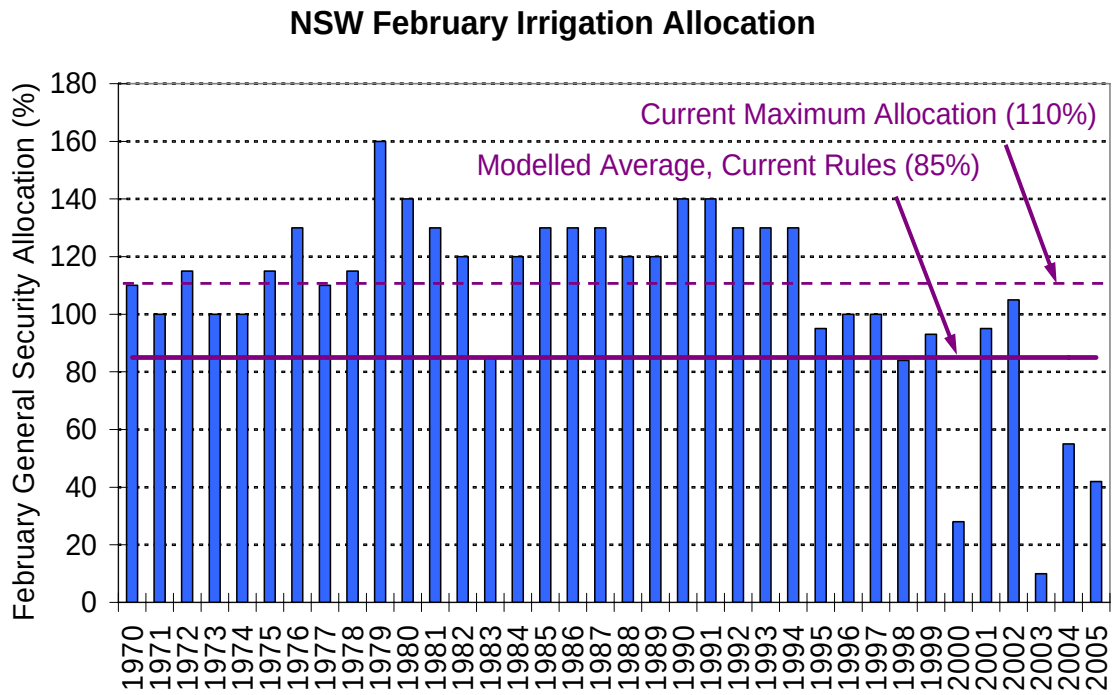

Figure 5: NSW February irrigation allocation

The bulk of irrigation development in the Basin took place during a relatively wet period. The current severe and prolonged drought is the first drought to occur at the current levels of development. This results in critical stresses to communities and to ecosystems.

The impacts of these stresses can be seen both directly and indirectly in both ecosystems and communities. In ecosystems, the stress on red gum populations in many parts of the river is evident. In communities, the stress is being seen in reduced levels of agricultural production with consequent flow ons to the entire community.

In the recent dry period we have seen the lowest water allocations to irrigators on record. For example, water allocations to New South Wales irrigators have been well below the modelled average of the last 35 years for four years out of the last six. Prior to 2000 the allocation has

never before been this low. The effect of this can be seen clearly in rice production. In the last decade, as efficiency and productivity had increased, rice production is closely related to water allocations for Murray irrigators, who produce a substantial part of the rice crop. This is particularly pronounced in the last six years, when allocations have been exceptionally low.

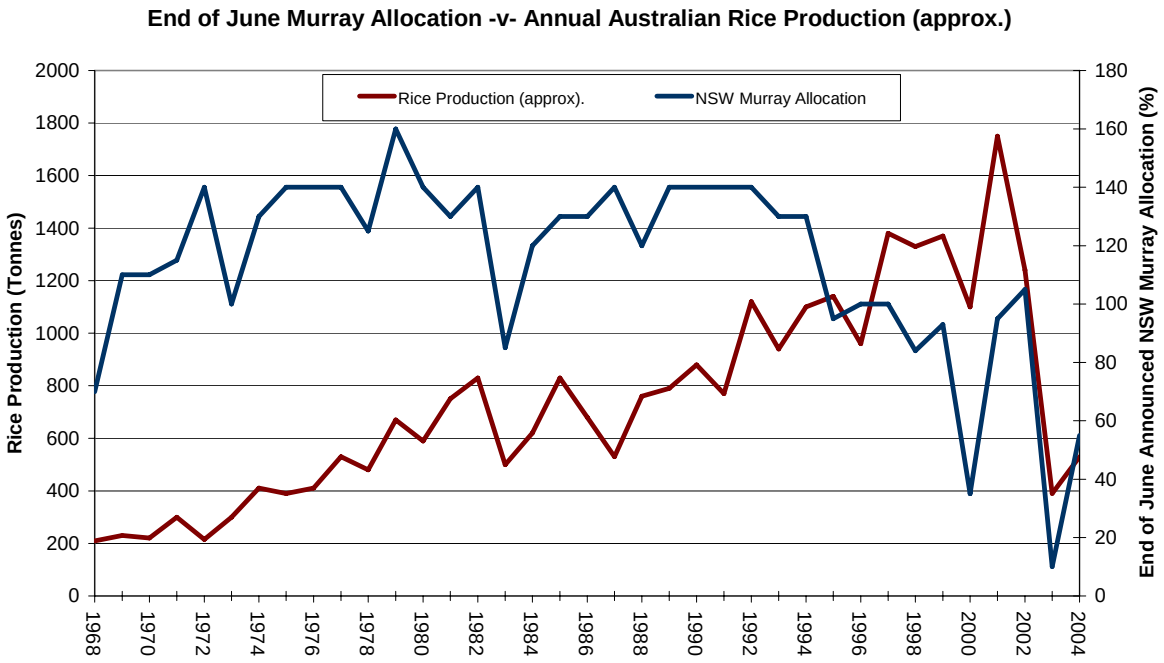

Figure 6: Murray water allocations and rice production in NSW

Flow on effects to local communities can be considerable. Anecdotal evidence from a freight company, 80% of whose business involved rice, indicated that between 2000–01 and 2003–04 turnover and number of employees almost halved.

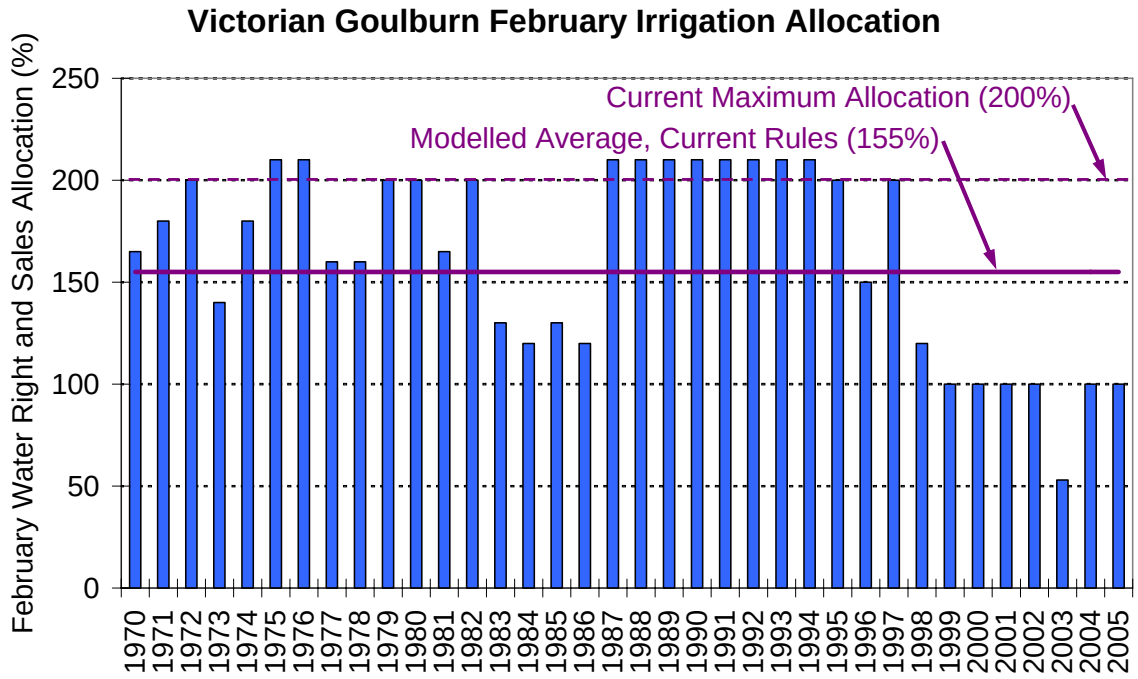

Figure 7: Victorian Goulburn February irrigation allocation

Similar stresses affect parts of the Victorian dairy industry with its historical reliance on full allocation of water rights and the allocations of sales water. Since 1998, allocations have been well below average. As Victoria has over half Australia's dairy herd, the impact will be large.

Government response the National Water Initiative

In 2004, Governments responded at the highest level across Australia to the problems of water scarcity, irrigation industry concerns and the environmental stress of rivers. The Council of Australian Governments agreed a National Water Initiative. This initiative continues the program of reform under the 1995 national competition policy agenda and focuses on establishing securely defined water access entitlements, sustainable water planning, environmental water entitlements, managing risks to water allocations, expanding water trade, improved water accounting, pricing reforms and urban water reforms. The initiative also establishes an inter-governmental agreement for delivery of the Living Murray, which I have described earlier.

The Prime Minister has recently announced the establishment and membership of the National Water Commission to oversee this reform initiative.

The MDBC role is focussed in two main areas. In implementing the overarching reforms the Commission plays a technical and support role for implementation in the Basin, focussing on those areas which require a cross-jurisdictional approach, such as interstate water trade. The Murray-Darling Basin Ministerial Council and Commission have implementation roles for The Living Murray.

Private enterprise responses

In response to changing climate and many other factors affecting rural communities, private enterprise is responding by seeking investment opportunities and in pursuing more sustainable development.

Increasing demand for water, combined with limited supply has resulted in increased water prices and a significant rise in the value of the asset held by irrigators in water access entitlements.

Many in the irrigation industry are looking forward to greater opportunities to manage risks presented by climate by each creating a portfolio of water entitlements with different reliabilities of supply into the future. More open water markets will facilitate the irrigation industry achieving this.

Private enterprise is also actively exploring opportunities to reduce losses in irrigation supply networks, for example through the $1.2 m Water Recovery Program managed by the Commission. Irrigators are also looking directly for greater on farm efficiencies for example, a Victorian irrigator producing tomatoes using underground drip irrigation, has reduced water use by 30% for 30% greater productivity.

Pratt Water have made a significant investment in analysing water issues in the Murrumbidgee Valley, and have recently released a report titled "The Business of Saving Water". While the Commission has yet to fully examine the ideas and challenges presented by this work, it is clear that the private sector are looking for greater investment opportunities in water. The Pratt Water work raises the profile of public/private partnership opportunities for investment.

Australia's largest private irrigation company (Murray Irrigation Limited) has been implementing Land and Water Management Plans now for a decade. These plans take an important step towards sustainable development. The plans are developed by the community with the support of government and are focussed on protecting the environmental, social and economic values of the NSW mid-Murray region of the Murray-Darling Basin. The region covers 950,000 ha, with over 3,000 farms (primarily irrigation farms) and is home to 25,000 people. A 15 year implementation phase commenced in 1995. Total investment in the plans is already more than $219 million.

Emerging risks and challenges

In 2004, the Murray-Darling Basin Ministerial Council considered six risk factors which, if not addressed, could cause the water quality and quantity in the Murray-Darling Basin to decrease. The six identified factors are increased groundwater use, bushfire impacts, climate change, reforestation, farm dams and reduced return flows from irrigation. Assessing and addressing these risks is very challenging, particularly given the large scale of some risks, the high levels of uncertainties of some, and the significant interactions likely to occur between risk factors and with irrigation demand.

Ministerial Council endorsed a work program to better assess the potential impact of these risk factors and to develop management options. In some cases for example, climate change and bushfire impacts, the capacity to directly reduce the impacts on the Basin's surface waters is very limited, but building the capacity to adapt is critical. In other cases, governments may have the opportunity to identify and implement management strategies to reduce the impacts.

Where groundwater and surface systems are connected, groundwater use can significantly reduce stream flow. Impacts of water extractions can thus be cumulative in dry cycles. Groundwater use in the Basin has increased between 1995-2000 and this increase is projected to continue. Although the understanding of connectivity between surface water and groundwater needs further work and the capacity to measure groundwater use is, in some cases, limited, Ministerial Council has recognised this issue as an immediate priority.

I have discussed earlier the impacts of the current exceptionally dry cycle. Staff in the Commission office run a little internal competition on whether Hume Dam will spill, if not, how high will it go and also how low will it go. Those who have predicted spills in the last few years have been the eternal optimists, and their numbers are very diminished. They've not won the prizes. Work done by CSIRO, your own Bureau of Meteorology (BOM) and the Western Australian government has focussed attention on declining rainfall and the significance of changing climate in the West. More recently we have been working with governments, CSIRO and BOM to develop a multi year investigation program on recent climatic influences on hydrology in the Basin and to assess the impact of greenhouse scenarios on water resource availability in the Basin.

In the bushfires of January 2003, over 1 million hectares across the key catchment areas of the south-east Murray-Darling Basin were burnt. In the first few years after these fires, when forest regeneration is just beginning, runoff will increase. In our case, however, these increases have, so far, been masked by drought. Over the subsequent 30 to 50 years, depending on the forest type, regenerating forests in these areas will reduce surface run-off. As the areas burnt covered most of the higher rainfall catchments of the southern Basin assessing this risk is of immediate priority. The Commission is investing in work under the Victorian Bushfire Recovery Program, which is assessing impacts across all the Victorian Murray-Darling Basin high rainfall catchments and the upper Murray in New South Wales. The initial estimates from this work are expected to be available for the Commission to consider in the near future.

The reforestation of cleared agricultural land can also have an impact on surface run-off, due to the higher water use of trees compared to pastures and crops. The impact is more acute in

higher rainfall areas where most run-off occurs. The higher rainfall areas in the southern Murray-Darling Basin are frequently those most viable for commercial forestry. In the mid to lower rainfall zones, revegetation can, however, have a very positive effect on saline groundwater levels and hence on both stream salinity and reducing the impacts of saline discharge on land. Information to identify spatial and temporal trade-offs is important. Extensive work under the National Action Plan on Salinity and Water quality is underway to identify target areas for revegetation to enhance salinity outcomes, but avoid reduction in streamflows.

Hillside farm dams in mid to higher rainfall regions of the Basin can have an effect on local streamflows, with some of these effects significant on larger scales. The number, capacity and surface area of these dams is increasing. Work is nearing completion assessing recent changes in number, volume and surface area. This work will support further hydrological assessment of impacts on streamflow.

Improved irrigation water use efficiency is an important objective, and the subject of investment by both governments and the private sector. It results in better use of irrigation water and reduced environmental impacts on farms, reduced leaching to salty groundwater tables, reduction in saline impacts on both streams and surrounding land, and a reduction in contaminated drainage water reaching streams. As irrigators and water companies invest in saving water, that water is then available for development and trade. Less water is however, returned to streams. The loss of volume is not always compensated by improvements in water quality.

Conclusion

Advances in irrigation technology, the implementation of land and water management plans, private sector investments and major initiatives of governments provide the framework for enhancing sustainability in the Murray-Darling Basin. The Murray-Darling Basin Commission provides a Basin wide perspective, with governments and communities working together to implement initiatives to enhance Basin sustainability.

The Commission's ninety-year history and lengthy hydrological records provide us with a good base for management of shared water resources in the Basin. However, climate and weather drive the Basin's hydrology in complex ways. High annual and multi year variability are very important influences on both industry and ecology in the Basin. The extremes, more than the averages, often drive the major changes to both environment and water use.

The significance of variability and of extremes continually challenges our decision making. Sustainability, both for industry and environment, is clearly dependant upon resilience and the capacity to weather extremes. Our challenge, as managers, is to manage in a way that recognises and supports the building and maintenance of that resilience.