MURRAY-DARLING BASIN

MINISTERIAL COUNCIL

An Audit of Water Use in the Murray-Darling Basin

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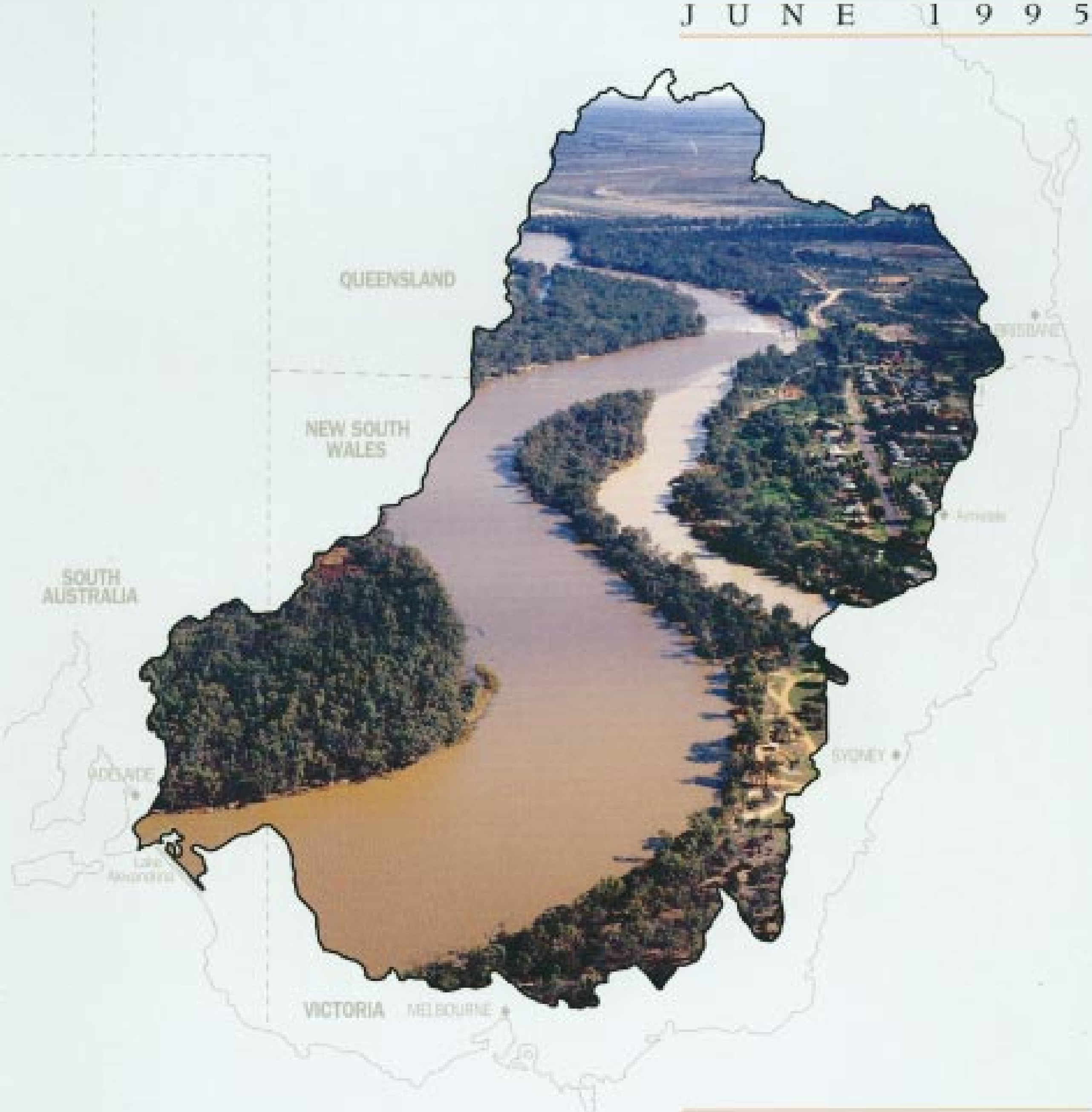
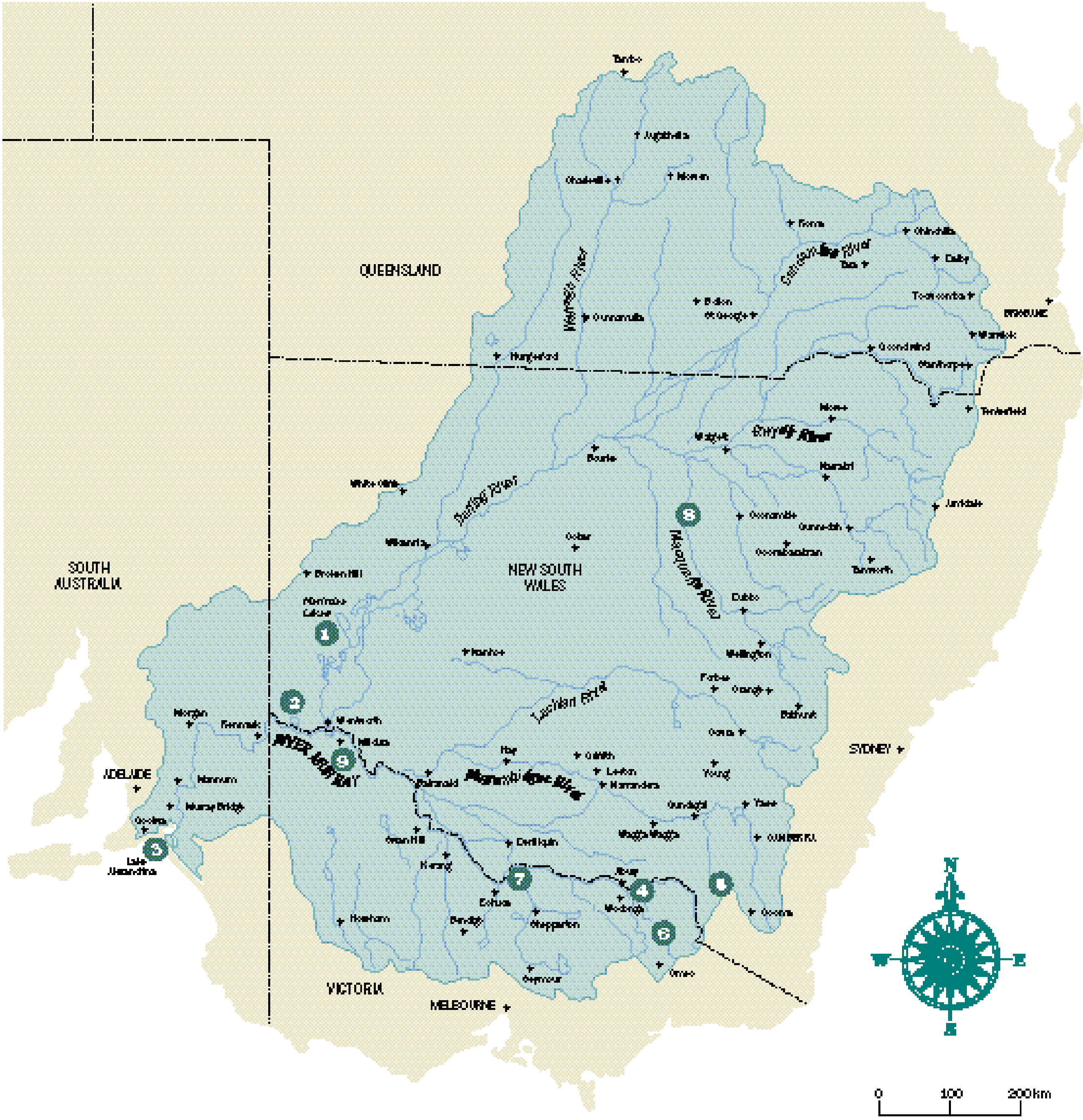


Water Use and Healthy Rivers – Working towards a Balance

The Murray-Darling Basin



1 Menindee Lakes

2 Lake Victoria

3 Barrages and Coorong

4 Hume Reservoir

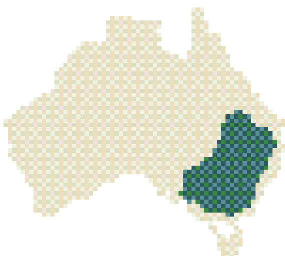
5 Snowy Mountains Scheme

6 Dartmouth Reservoir

7 Barmah / Millewa Forests

8 Macquarie Marshes

9 Hattah Lakes



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THE WATER AUDIT

This paper describes the water audit which has been carried out in the Murray-Darling Basin. It highlights that diversions have increased significantly since 1988 and will continue to increase unless water management arrangements are amended. This increase in diversion will have an adverse impact on river health. It concludes that the most urgent priority is to define the appropriate balance between water for consumptive uses (ie irrigation, domestic and industrial) and that required to be left in rivers (environmental flows) to ensure that the consumptive uses are sustainable and that the rivers remain in a healthy state. This water audit does not attempt to strike the balance between consumptive and instream water use. Rather it provides a sound body of knowledge on which to base the necessary community discussions which will lead to decisions about an appropriate balance between consumptive and instream uses.

THE ISSUE

The Murray-Darling Basin covers most of inland south-eastern Australia. It includes much of the country's best farm land and nearly two million people. Outside the Basin another million people are heavily dependent on its water. Utilisation of the Basin's water resources has made possible the expansion of agricultural development into the huge inland areas of Australia, away from the upland regions of the south-east Basin and the wetter coastal fringe.
The value of the Basin's agricultural produce exceeds $10 billion. Of this, $3 billion is derived from irrigation, the economic importance of which is even greater than this figure suggests. Irrigated crops support large numbers of jobs in urban areas and are a significant export income earner. Food processing is the largest secondary industry sector in Australia and it depends heavily on irrigation to provide the steady supply of high quality produce that it needs.

Between 1988/89 and 1992/93 the average total diversion from the Basin was 10 680 GL/year. Of this amount, over 95 per cent was diverted for irrigation. The benefits of irrigation are substantial. However, continuing expansion of the industry and increasing demands for water is coming at a heavy cost.

Although the Murray-Darling system has been modified fundamentally by the introduction of dams, river regulation structures and the diversion of water for existing irrigation activity, it still supports a wide range of natural eco-systems and other activities. With its mix of agriculture, wetlands, forests and traditional flora and fauna, the region remains an attractive place to visit and live. However, the present situation will undergo continual decline as diversions for consumptive uses of water continue to grow.

In response to increasing evidence of deterioration of the Basin's river system, and growing community concern, the Murray-Darling Basin Ministerial Council directed that a water audit be prepared to investigate the rate at which water use is increasing across the Basin, comment on the effects of this increase, and assess the likelihood and potential impact of further increases in the future.

CURRENT WATER USE — PREDICTING THE FUTURE

To provide a sound knowledge base the Murray-Darling Basin Commission has coordinated the collection of data on water diversion throughout the Basin and organised the computer modelling of a number of water management options. To enable the Commission to predict the impact of future water management options, computer models of all the main river systems have been developed. These models are based on the large scale, field tested computer systems which are used for water resource planning throughout the Basin. Use of these models has made it possible to quantify the changes in the river flow regime and to evaluate the likely impacts on river health.

The main scenarios which have been modelled for the water audit are:

- the level of diversions in 1988 and in 1994;
- the maximum level of diversions possible if all existing water entitlements are utilised to the limit defined by current management practices and the physical capacity of the system (Full Development);
- the level of diversions which would be reached if a range of management options that have been canvassed for limiting growth in diversions were implemented (Limited Intervention Scenario);
- Natural conditions (before diversions began in the 1880s); and
- the 1988 Salinity and Drainage Strategy benchmark.

The results of this modelling process have shown that across the Basin water diversions grew by about 8 per cent between 1988 and 1994, an increase of 790 gigalitres which is more than four times Adelaide's annual water usage from all sources and 1.6 times the capacity of Sydney Harbour. This increase is continuing at a rate of more than 1 per cent a year. (A gigalitre is equal to 1000 megalitres.

A megalitre is equal to 1000 000 litres or roughly the size of an Olympic swimming pool.)

The assessments have shown that the existing water allocation system rations water during periods of shortages, but is not effective for controlling the volume of water diversions under normal non-drought conditions. During the past five years only 63 per cent of the water that was permitted to be used, was used. The announced availability on each river system assumed that not all the water would be used because of differences in the level of development of individual irrigators. This system evolved at a time when water managers had the task of encouraging development and the utilisation of water resources. Modification to annual allocation policies will be necessary if diversions are to be managed on a sustainable basis.

In practice diversions have been restricted, not by the water allocation system, but rather by the limitations imposed by irrigation infrastructure, limited river channel capacity, the number of on-farm storages, forms of irrigated agriculture in the southern part of the Basin which are unsuitable for opportunistic watering, low financial returns from many irrigation activities and the undeveloped market for trading water entitlements. Unless there is modification to existing water management arrangements, as these constraints are progressively removed substantial expansion in the volume of water diverted for consumptive use will occur. This would have major consequences for the health of the Basin's rivers.

FUTURE SCENARIOS

The Full Development Scenario is designed to test how much of the water available under existing entitlements would be taken up, given the existing physical constraints of the delivery system and current water management practices. It indicates that there is a potential for a further 14.5 per cent increase above current levels of water usage.

The Limited Intervention Scenario examines the impact of a range of management procedures for limiting the growth in diversions that have been canvassed. It indicates that despite these management changes, diversions across the Basin would increase by 7.3 per cent. This estimate was developed to assess the impact of a range of management options currently being considered. It is not an agreed position of Governments or the Commission, but rather an option that provides perspective on what management changes need to be put in place if growth in diversions is to be maintained below the Full Development Scenario.

SECURITY OF SUPPLY TO EXISTING USERS

The increase in diversion which would result under both the Full Development and Limited Intervention scenarios will reduce security of supply for existing irrigators. Increased diversions will mean that the level of reserves held in the storages will be lower than is currently the case. This will reduce the capacity of the storages to be a reliable source of supply during long periods of drought. Water supplies for existing irrigators will therefore become less secure.

In addition, as competition for allocated water grows, water managers will have to decrease the allowance they make for under-usage when announcing allocations. Announced allocations will therefore be lower than in the past and those irrigators who currently use all of their allocations will be forced either to reduce their diversions or to purchase water on the open market.

ENVIRONMENTAL IMPACT AND RIVER HEALTH

The current and increasing consumptive use of water in the Basin is having a significant impact on river health and the environment. Rivers have been altered by significant changes in the annual flow, the distribution of flow through the year and the length of low flow periods. It is not possible to quantify all of the environmental and river health impacts resulting from changed river flows as they vary from location to location across the Basin. However, to put the issue into perspective, it is useful to review the changes that have occurred to the outflow of the whole Basin as reflected in the flow of the River Murray measured near where it enters the sea.

Flow at this point has been reduced very substantially. Severe droughts have occurred on the Murray in 5 of the last 100 years. Under natural conditions with no large scale diversions for irrigation, flows in these years would have been low and the bottom end of the river would have experienced drought. However, under 1994 development conditions, these drought-like flows will be experienced in 61 per cent of years. (In other words the drought that would have occurred in one in twenty years under natural conditions, is now happening in six out of ten years.) Under Limited Intervention conditions this frequency goes up to 66 per cent of years and under the Full Development Scenario it would rise to 74 per cent of years (ie. the river near the Murray Mouth would experience a severe drought in 3 out of 4 years).

In addition to reducing the size of river flows, regulation and water diversions have also reduced the variability and changed the seasonality of flows in some parts of the Basin. Flows now tend to occur in summer and autumn when the water is required for irrigation rather than in the spring and early summer as they did before.

These changes to flow volume and flow pattern have resulted in:

- an increase in the salinity of the River Murray at Morgan of 10.5 EC since 1988;
- a reduction in the frequency of flooding of the floodplain wetlands which are important to the environmental health of rivers because they play a major role in absorbing and breaking down nutrients and are essential breeding areas and refuges for native flora and fauna. For example the Macquarie wetlands has declined by 50 per cent and Victorian wetlands in the Basin have declined by 70 per cent;
- river conditions which are more suitable for the growth of blue-green algae; and
- a significant decline in native fish populations. In South Australia, the commercial catch of native fish has dropped to under 20 per cent of what it was in the 1950s, largely as a result of river regulation.

The Commission has commenced action, with national agencies, on a research program and decision support system (the Sustainable Rivers Project) to enable better quantification of the environmental impacts of changed flow management. This will take some time to complete and in the meantime each State is now addressing, using available information, the issue of environmental flows.

OPTIONS TO MANAGE DEMAND

If it is decided to cap diversions below the maximum possible then some of the options that will need to be discussed include:

- lowering annual allocations;
- changes to off-allocation policies on both regulated and unregulated streams;
- restrictions on the construction of off-river storages;
- reduction of entitlement by administrative deed or “buy-back” on rivers under stress;
- arrangements for interstate trade; and
- better monitoring/recording and reporting of usage and compliance.

In each catchment a mix of these measures is the most likely outcome.

COMMUNITY PARTICIPATION

The Murray-Darling Basin Ministerial Council is distributing this water audit in order to provide the basis for an informed public debate about the appropriate level of diversions in the Basin.

1. Introduction

The water audit highlights the extent to which diversions have increased since 1988 and shows they will continue to increase unless water management arrangements are amended. It concludes that the most urgent priority is to define the appropriate balance between water for consumptive uses (ie irrigation, domestic and industrial) and that required to be left in rivers (environmental flows) to ensure that the consumptive uses are sustainable and that the rivers remain in a healthy state. This water audit does not attempt to strike the balance between consumptive and instream water use. Rather it provides a sound body of knowledge on which to base the necessary community discussions about an appropriate balance between consumptive and instream uses.

At Ministerial Council Meeting 12, held 25 June 1993, Council directed the Murray-Darling Basin Commission to prepare a water audit on the continuing increase in water diversions from the rivers of the Murray-Darling Basin. The water audit was to establish the facts relating to water use in the Basin, describe the current level of development, document recent trends, project those trends into the future and assess the impacts of these developments.

Council was concerned that river health was continuing to decline as a result of the increasing demand for water from the system. Particular issues included increasing water salinity, the growing frequency of algal blooms, declining biodiversity in the riverine corridor throughout the Basin and the decreasing frequency of beneficial flooding of the floodplain and ephemeral streams.

In view of these issues Council noted a number of features of the existing water allocation system. Of particular significance was the existence of a large number of ‘sleeper’ licences, allocated but not yet activated, and ‘dozer’ licences which were under-utilised. It was felt that the development of the emerging water transfer market could provide a stimulus for these licences to be taken up. This would produce a substantial increase in the volume of water diverted from the river system, independent of the impact of granting of any new entitlements. At its June 1994 meeting the Ministerial Council also agreed upon a flow policy:

> ***To maintain and, where appropriate, improve existing flow regimes in the waterways of the Murray-Darling Basin to protect and enhance the riverine environment.***

This policy received wide community support during consultation phase of the Algal Management Strategy.

At the same meeting Council agreed to the Commission’s proposal that the ambit of the audit report be expanded to include:

- a review of the Salinity and Drainage Strategy;
- an assessment of the impact of current diversion levels on river health including algal pollution and water quality; and
- computer modelling, for all rivers in the Basin, of the following four scenarios:
  - — 1988 level of development;
  - — current development (1994);
  - — full development of existing water entitlements;
  - — a Limited Intervention scenario which would allow some growth but less than full development.

(Subsequently it was also decided to model the Salinity and Drainage benchmark and the natural conditions as the fifth and sixth scenarios for use in this report.)

The Murray-Darling Basin has a population of nearly two million people. More than one million people outside the Basin depend on the water it supplies. The value of its agricultural production exceeds $10 billion, constituting about one third of the national output from rural industries. In addition many of the Basin’s natural resources — its rivers, wetlands, vegetation and fauna — are of high environmental value. Together, with its varied landscapes and scenic beauty, these attributes make the Murray-Darling Basin one of Australia’s most important regions for economic activity, biodiversity and human habitation.

The benefits of irrigation in the Basin are substantial but the expansion of the industry, with its increasing demands for water, is coming at a heavy cost. Although the Murray-Darling system has been modified fundamentally by the introduction of dams, river regulation structures and the diversion of water for existing irrigation activity, it still supports a wide range of natural eco-systems and other activities. With its mix of agriculture, wetlands, forests and traditional flora and fauna, the region remains an attractive place to visit and live. However, the present situation will undergo decline as diversions for consumptive uses of water continue to grow.

Defining the balance between the amount of water to be allocated to irrigation and the amount to be allocated to alternative uses such as non-irrigated agriculture, the environment, tourism, and human consumption is technically complex and will require difficult choices to be made between the interests of various sectors of the community.

Whatever form the decision about the desirable balance between the competing demands for water ultimately takes, the interests of important sections of the community will be substantially affected. Consequently, a thorough process of community discussion will be required before any long term decision can be made and accepted.

2 Water Audit

The Division of Water Between the States

The legal entitlements to the water in the River Murray are established by the Murray-Darling Basin Agreement. Under this agreement, inflow to the River Murray upstream of Albury and the flow in the Darling River that reaches Menindee Lakes, are allocated half each to New South Wales and Victoria. Inflows downstream of Albury, with the exception of the Darling, are allocated to the State from which they flow.

From the water allocated to them, New South Wales and Victoria are each required to supply half of South Australia's entitlement. This entitlement, which is specified as 12 minimum monthly flows, totals 1 850 GL/year. There is, however, provision in the agreement for this quantity to be reduced in drought years.

The Agreement entitles the States to the full use of all the water in their tributaries that join the River Murray downstream of Albury. However New South Wales' right to the water in the Darling upstream of Menindee Lakes is qualified by the Border Rivers Agreement which establishes a framework for the sharing of water in streams that are adjacent to the New South Wales/Queensland border.

Water Use in the Murray-Darling Basin

As a first step, a detailed audit of water use in the Murray-Darling Basin was carried out. Water use data were collected for all the rivers in the Basin and are presented in **Table 1**. Between 1988/89 and 1992/93 the average total diversion from the Basin was 10 680 GL/year. Of this amount, over 95 per cent was diverted for irrigation. The diversions were shared amongst the States in the following proportions:

New South Wales	57.4%
Victoria	34.3%
South Australia	5.4%
Queensland	2.3%
ACT	0.6%

Water Entitlements & Their Utilisation

In addition to examining water use data, the water audit also collated information on water entitlements and their utilisation. There are four major types of water entitlement used in the Murray-Darling Basin and these are described in **Appendix A**. These water entitlements define the entitlement holder's access to water under the varying conditions that prevail from year to year.

Records of announced allocations, declarations of periods of off-allocation, the use of water both on and off allocation and the areas irrigated on the unregulated streams were collated for the five years from 1988/89 to 1992/93. This information was used to calculate the upper limits to diversion imposed on irrigators by the current allocation systems. A comparison between these limits and the volumes actually diverted is presented in **Table 2**. The Table shows that the total diversion from the Basin was only 63 per cent of the diversion permitted by the allocation system.

A small part of this large difference between the allocated water and the actual use can be attributed to 'sleepers', who are entitlement holders that never use their allocation, and to 'dozers', who are entitlement holders who use only a small part of their allocation. However, the most significant reasons for the unused allocations are:

- the off-allocation policy which allows many irrigators to get a significant proportion of the water they need during periods which have been proclaimed 'off allocation'; and
- the practice of allocating more water than is actually available in the knowledge that not all entitlement holders will use their full allocation. (This is a device to encourage the usage of all the available water by those irrigators who have the capacity to use it.)

In practice, in many parts of the Basin, it would not have been possible to supply the quantities of water that were theoretically made available by the seasonal allocations. The limits in **Table 2** can not therefore be used as estimates of the diversion possible if all existing entitlements were fully developed. However, what the data in **Table 2** does reveal is that over the past five years, the seasonal water allocation policies have not been a significant factor in limiting diversions. In practice diversions have been constrained by other factors such as:

- irrigation infrastructure;
- limited river channel capacity;
- forms of irrigated agriculture in the south of the Basin which require even watering year to year and do not allow irrigators to take advantage of extra water if it becomes available at relatively short notice;
- low financial returns for many irrigation activities;
- the undeveloped market for trading water entitlements; and
- the capacity of on-farm storages.

The data in **Table 2** is also important in its implications for the operation of the water market. The difference between the diversion limits and actual diversions is allocated water that is available for sale on the temporary transfer market. This large volume of unused allocation available for resale makes it unlikely that water will be retired from low value uses because of the returns that are available on the transfer market. It is much more likely that the water that is sold would not otherwise have been used. Under these conditions, any increase in sales will result in increased water use. (For other information collected in the water audit, describing the growth in the trading of water entitlements and the growth in on-farm storage see **Appendix B.**)

TABLE 1. Audit of Surface Water Use in the Murray-Darling Basin

(Figures are the Average Actual Diversions for 1988/89 to 1992/93)

River System	*Diversion for Irrigation (GL)*	*Domestic, Industrial, Stock and Town Use (GL)*	*Total Water Diversion (GL)*	*Diversion as a % of Total Basin Diversion*
NSW				
Border Rivers	221	1	222	2.1
Gwydir	299	1	300	2.8
Namoi	244	4	248	2.3
Macquarie/Castlereagh/Bogan	465	6	471	4.4
Upper Darling	188	1	189	1.8
Lower Darling	128	85	213	2.0
Murrumbidgee	2424	19	2443	22.9
Murray	2024	29	2053	19.2
Total NSW	5993	146	6139	57.4
Victoria				
Upper Murray/Ovens/Kiewa	1531	36	1567	14.7
Lower Murray	264	20	284	2.7
Goulburn/Broken/Loddon	1656	54	1710	16.0
Campaspe	79	22	101	0.9
Total Victoria	3530	132	3662	34.3
South Australia				
Private Pumped Diversion	235	4	239	2.2
Government Pumped Diversion	129	100	229	2.1
Reclaimed Swamps	106	0	106	1.0
Total South Australia	470	104	574	5.4
Queensland				
Border Rivers	72	2	74	0.7
Macintyre Brook	10	0	10	0.1
Condamine/Balonne*	157	5	162	1.5
Total Queensland*	239	7	246	2.3
ACT	0	63	63	0.6
Total for Basin	**10232**	**452**	**10684**	**100.0**

* Excludes water harvesting diversions

Key Points to Note from this Table

- Annual Diversion averaged 10676 GL/year.
- Over 95% of diversions were for irrigation.

TABLE 2. Limits to Diversion Imposed by the Allocation System

(Figures are the Average Actual Figures for 1988/89 to 1992/93)

River System	*Limits* to Diversion Imposed by the Allocation System (GL)*	*Actual Water Diverted (GL)*	*Water Diverted as a % of Diversion Limit (%)*
NSW			
Border Rivers	292	222	76
Gwydir	316	300	95
Namoi	387	248	64
Macquarie/Castlereagh/Bogan	823	471	57
Upper Darling	549	189	34
Lower Darling	255	213	84
Murrumbidgee	4268	2443	57
Murray	3362	2053	61
Total NSW	10252	6139	60
Victoria			
Upper Murray/Ovens/Kiewa	2365	1567	66
Lower Murray	460	284	62
Goulburn/Broken/Loddon	2630	1710	65
Campaspe	134	101	75
Total Victoria	5589	3662	66
South Australia			
Private Pumped Diversion	301	239	79
Government Pumped Diversion	295	229	78
Reclaimed Swamps	106	106	100
Total South Australia	702	574	82
Queensland			
Border Rivers	100	74	74
Macintyre Brook	19	10	53
Condamine/Balonne	177	162	92
Total Queensland	296	246	83
ACT	63	63	
Total for Basin	**16902**	**10684**	**63**

* **Note**: For regulated streams, the diversion limit has been calculated by adding the actual diversion to the difference between the announced allocation and the on-allocation use. For unregulated streams, the diversion limit is the licensed area converted to a volume of water.

Key Points to Note from this Table

- The difference between announced allocation and on-allocation use is large.
- Over the last five years, diversions from most systems have been constrained by factors other than the announced allocations.

3 Growth in Diversion between 1988 and 1994

An audit of historical data provides a reasonable picture of what has happened in recent years. However, because of climatic variability, it is difficult to determine accurately the size of any diversion trend on the basis of just a few years data. Between 1988 and 1993 for example, the northern half of the Murray-Darling Basin was subjected to a severe drought while the southern half of the Basin had higher than average levels of water available. Both of these conditions will affect diversions. In order to obtain a better indication of the long term significance of the changes in diversions that have occurred, it is necessary to carry out a detailed modelling exercise. Computer models have been used to test the 1988 and 1994 development conditions against the recorded climatic conditions of the last hundred years. By using the same climatic data for each scenario, uncertainty caused by climatic variability is reduced. The use of models also enables assessments to be made not only of the quantity of water diverted but also of the effect that those diversions have on the flow regime and on the salinity of the rivers.

The average diversion figures from the modelled 1988 and 1994 development scenarios are listed in **Table 3**. The difference between these scenarios gives a reliable indication of the growth in diversions over the last six years. In summary, the growth in diversion between 1988 and 1994 was:

	Increase in GL/year	% Increase
New South Wales	311	5.6%
Victoria	240	6.7%
South Australia	38	6.6%
Queensland	201	89.3%
ACT	2	4.1%
Total Basin	**792**	**7.9%**

(Note that Queensland's large percentage increase is based on a small level of previous activity.)

The growth in demand has been greatest in Queensland and northern New South Wales where the returns from the irrigation of cotton have encouraged development. However, steady growth has occurred in most other areas. This growth has occurred as a result of increased use within the existing water allocation system. With a few minor exceptions, there were no new water entitlements granted in this period.

TABLE 3. Growth in Diversions Between 1988 and 1994 (Figures are the Average Modelled Values)

River System	*1988 Development Diversion (GL)*	*1994 Development Diversion (GL)*	*Change in Diversion (GL)*	*Percentage change in Diversion (%)*
NSW				
Border Rivers	165	228	63	38.2
Gwydir	378	393	15	4.0
Namoi	274	288	14	5.1
Macquarie/Castlereagh/Bogan	375	400	25	6.7
Upper Darling	103	136	33	32.0
Lower Darling	128	139	11	8.6
Murrumbidgee	2220	2300	80	3.6
Murray	1907	1977	70	3.7
Total NSW	5550	5861	311	5.6
Victoria				
Murray	1640	1725	85	5.2
Goulburn/Broken/Campaspe/Loddon	1939	2094	155	8.0
Total Victoria	3579	3819	240	6.7
South Australia				
Pumped Diversions	468	506	38	8.1
Reclaimed Swamps	104	104	0	0.0
Total South Australia	572	610	38	6.6
Queensland				
Border Rivers	47	135	88	187.2
Condamine/Balonne	178	291	113	63.5
Total Queensland	225	426	201	89.3
ACT	63	65	2	4.1
Total for Basin	**9989**	**10781**	**792**	**7.9**

Key Points to Note from this Table

- Basinwide growth in diversions was 7.9% over six years.
- Highest growth occurred in the north of the Basin where cotton growing is profitable.
- Diversions increased in all regions.

4 Future Growth in Diversions

Two different scenarios have been modelled to examine the prospects for future diversion growth in the Basin.

Full Development of Existing Water Entitlements

In this scenario it is assumed that there are no changes to existing management rules and that all existing water entitlements are developed to their limit. In theory this scenario models the maximum diversions possible with the current entitlements. In practice some judgement has been used in limiting on-farm storage capacity, the extent of developed irrigation area and off-allocation use, as none of these key factors are limited by the current rules. In modelling this scenario it has been assumed that diversions will be limited by river channel and irrigation infrastructure constraints. In some systems, notably the Murrumbidgee and in Victoria, these constraints have limited diversions to a level considerably below the allocations that have been made in recent years. In these systems, it is apparent that this scenario will no longer be valid if further work is done to increase channel capacities or if irrigators are able to find new ways, either through on-farm storages or intervalley and interstate trading, to overcome these constraints.

The way that this scenario has been interpreted differs somewhat between the States. The key assumptions made by each State are summarised in **Appendix C**.

The growth in diversion from 1994 levels to the Full Development Scenario are listed in **Table 4**. In summary, the possible growth in diversion is:

	Increase in GL/year	% Increase
New South Wales	1007	17.2%
Victoria	191	5.0%
South Australia	225	36.9%
Queensland	130	30.5%
ACT	10	15.0%
Total Basin	**1563**	**14.5%**

This study shows that there is still scope for significant growth in diversion under the current water entitlements and management rules.

TABLE 4. Full Development of Existing Water Entitlements
(Figures are the Average Modelled Values)

River System	*1994 Development Diversion (GL)*	*Full Development of Existing Entitlements Diversion (GL)*	*Change in Diversion (GL)*	*Percentage Change in Diversion (%)*
NSW				
Darling and tributaries u/s Menindee	1445	1976	531	36.7
Lower Darling	139	183	44	31.7
Murrumbidgee	2300	2670	370	16.1
Murray	1977	2039	62	3.1
Total NSW	5861	6868	1007	17.2
Victoria				
Murray	1725	1910	185	10.7
Goulburn/Broken/Campaspe/Loddon	2094	2100	6	0.3
Total Victoria	3819	4010	191	5.0
South Australia				
Pumped Diversions	506	731	225	44.5
Reclaimed Swamps	104	104	0	0.0
Total South Australia	610	835	225	36.9
Queensland				
Border Rivers	135	156	21	15.6
Condamine/Balonne	291	400	109	37.5
Total Queensland	426	556	130	30.5
ACT	65	75	10	15.0
Total for Basin	**10781**	**12344**	**1563**	**14.5**

Key Points to Note from this Table

- Basinwide growth in diversions of 14.5% is possible under existing entitlements.
- New South Wales will supply model results for the individual regions in the Darling Catchment in a Barwon/Darling Water Audit planned for completion in October 1995.

Limited Intervention Scenario

The Limited Intervention Scenario includes changes to management rules that have been canvassed as possible options if a decision was made to allow limited expansion short of Full Development. It is not an agreed position of Governments or the Commission but rather an option that provides perspective on the effectiveness of various measures in restricting growth in diversions.

The major policy differences between the Limited Intervention Scenario and the Full Development Scenario are:

New South Wales

- **Border Rivers**
  It is assumed that a cap will be placed on unregulated flow diversions. The Border Rivers is shared by New South Wales and Queensland and the combined cap for both States is set at 170 GL/year. It is also assumed that there will be an increase in the Boggabilla flow, which triggers announcements of periods of unregulated flow, from 1 300 ML/d to 3 000 ML/d. Like the Full Development Scenario, the Limited Intervention Scenario includes the increases in diversion associated with the recent enlargement of Pindari Dam.
  The 'best management' rules for the Border Rivers are still being developed. It is likely that the final rules will involve a combination of cap, unregulated flow trigger and end-of-system target flow.

- **Barwon-Darling**
  The threshold flows at which pumping can commence are assumed to be raised by 500 ML/d for each location for B Class licences and by 1 000 ML/d for C Class licences. A cap of 280 GL/year is assumed to be placed on total diversion for these licences. This cap is significantly less than the volume obtained by applying the current factors used to convert from area licences to volumetric entitlements (ie. 482 GL).

- **Macquarie**
  The water use in the Macquarie will be held to the 1994 level. This is assumed to be achieved by changes to the overdraw, carry over and transfer rules.

- **Gwydir**
  The outflows from the Gwydir system will be held at 1994 levels. New unregulated flow access rules relating to the Gwydir Wetlands are assumed to reduce diversions to irrigators but outflows from the system are not likely to increase since additional water will be consumed by the wetlands.

- **Namoi**
  Irrigation diversions (and therefore Namoi River outflows) will be held at 1994 levels. This is assumed to be achieved by new rules preventing the transfer of entitlements to parts of the river where there is additional irrigable land.

- **Murrumbidgee**
  It is assumed that channel capacity problems in the Tumut will be managed by a reduction of 5 per cent in the maximum regulated flow permitted downstream of Blowering Dam (to 9000 ML/day). It is assumed that growth in use will be controlled by a cap of 400 GL/year on unregulated flow diversion, by changes to access rules for unregulated flow and by an increase in the end of system target flow at Balranald from 125 ML/d to 300 ML/d. Note that the Lowbidgee District is the major user of unregulated flow in this system.

- **Murray**
  It was assumed in modelling this scenario that no additional controls would be placed on Murray irrigators. However, NSW has subsequently advised that controls will be put in place to hold NSW Murray diversions at 1994 levels.
  These controls are likely to include:
  - a cap on off-allocation diversions
  - changes to off-allocation rules
  - amendments to maximum announced allocations; and
  - other regulated flow controls.

Victoria

- Caps are to be placed on diversion as part of the bulk water entitlements which the Victorian Government is issuing to regional water authorities. These caps are expressed as a maximum ten year rolling average diversion and are set at the maximum ten year diversion in a sequence modelled using 1990/91 levels of development. If demand does not rise above 1990/91 levels then the cap will not come into play. However, as diversion increases above that level, the cap will restrict allocations more and more frequently. Like the Full Development Scenario, the Limited Intervention Scenario includes the use of about 50 GL/year from Lake Mokoan which is outside the bulk entitlement caps.

Queensland

- **Border Rivers**
  As already noted, this system is shared by New South Wales and Queensland. In the modelling, which was done by New South Wales, it is assumed that there will be a combined cap for both States on unregulated flow diversions of 170 GL/year as well as changes to the trigger flows for declaring periods of off-allocation. This is not necessarily the management strategy that will be adopted by Queensland.

- **Condamine/Balonne**
  For this system, the Limited Intervention Scenario is the same as Full Development.

South Australia

- The arbitrary off-allocation usage of up to 250 GL/year is assumed to be replaced by "B Class" licences with a capacity of up to 100 GL/year. Under these licences, allocations would only be made in years when the flow exceeded 20 000 ML/day. However, unlike existing off-allocation periods, the allocated water would be available until the end of the season regardless of the subsequent flow conditions.

- Town water demand is set to meet "most likely" growth in population to 2026.

TABLE 5. Change in Diversions After Limited Intervention

(Figures are the Average Modelled Values)

River System	*1994 Development Diversion (GL)*	*Limited Intervention Scenario Diversion (GL)*	*Change in Diversion (GL)*	*Percentage Change in Diversion (%)*
NSW				
Darling and tributaries u/s Menindee	1445	1605	160	11.1
Lower Darling	139	188	49	35.3
Murrumbidgee	2300	2370	70	3.0
Murray	1977	2110	133	6.7
Total NSW	5861	6273	412	7.0
Victoria				
Murray	1725	1865	140	8.1
Goulburn/Broken/Campaspe/Loddon	2094	2041	–53	–2.5
Total Victoria	3819	3906	87	2.3
South Australia				
Pumped Diversions	506	673	167	33.0
Reclaimed Swamps	104	104	0	0.0
Total South Australia	610	777	167	27.4
Queensland				
Border Rivers	135	133	–2	–1.5
Condamine/Balonne	291	400	109	37.5
Total Queensland	426	533	107	25.1
ACT	65	75	10	15.0
Total for Basin	**10781**	**11564**	**783**	**7.3**

Key Points to Note from this Table

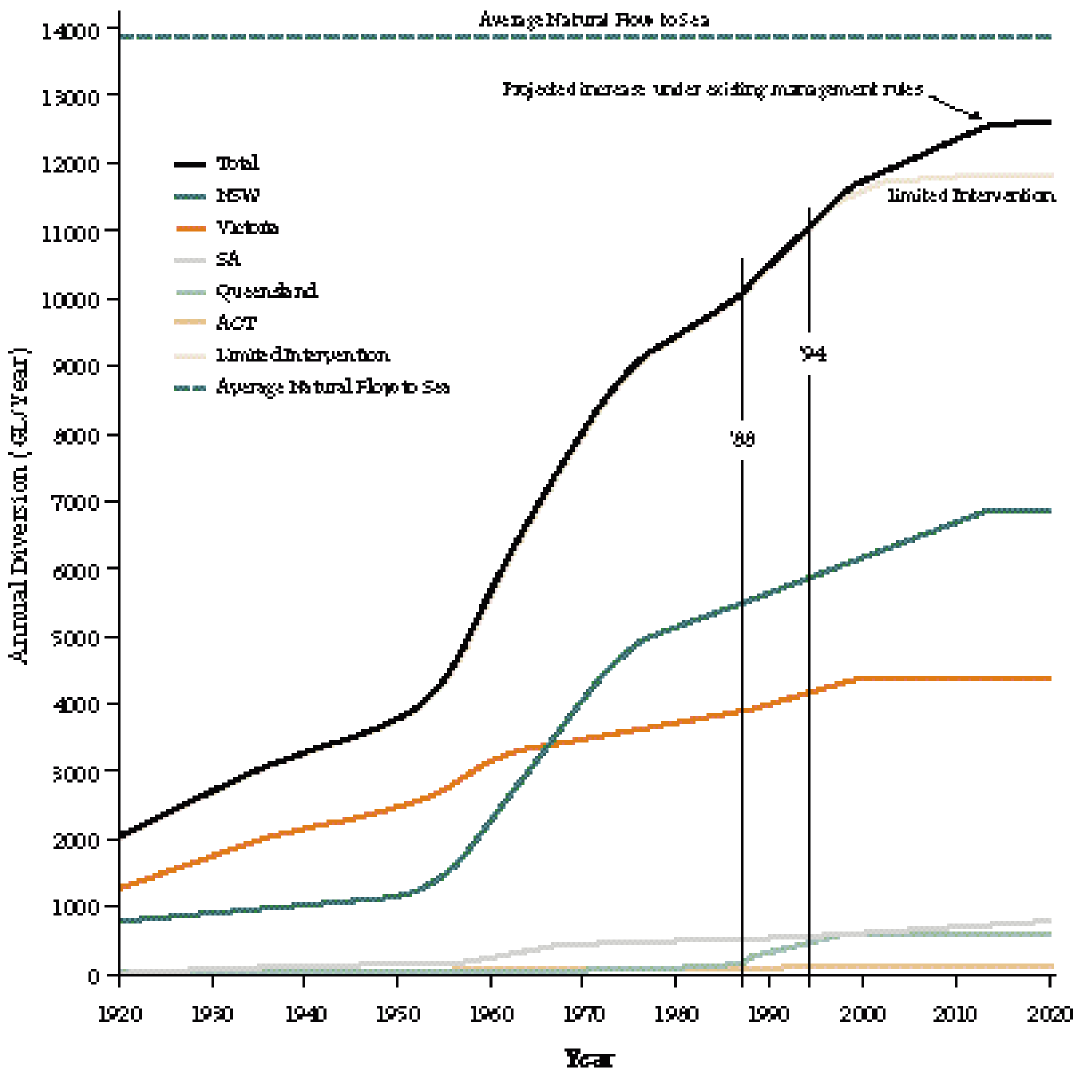
- Basinwide growth in diversions of 7.3% would result despite this level of intervention.
- Goulburn system diversions decline as a result of transfers of entitlement for use in the Murray.
- Because no intervention was assumed for the Murray, the increased tributary flows from the Goulburn and Murrumbidgee enable NSW Murray irrigators to divert more than in the Full Development Scenario. NSW is proposing changes to the management of NSW Murray diversions which would prevent this. (See comments on page 11.)

The expected growth in diversions under the Limited Intervention Scenario above current levels is summarised in **Table 5**.

	Increase in GL/year	% Increase
New South Wales	412	7.0%
Victoria	87	2.3%
South Australia	167	27.4%
Queensland	107	25.1%
ACT	10	15.0%
Total Basin	**783**	**7.3%**

Figure 1 reveals how diversions in the Basin have grown over the last 75 years. To this plot has been added the possible future growth in diversions. In adding future growth it has been assumed that the growth rates of the last six years are maintained until the ultimate levels of diversions are reached. This graph highlights the rapid growth that has occurred in recent years and suggests that diversion will continue to rise quickly unless changes are made to water allocation or river management policies.

FIGURE 1. Growth in Water Use in Murray-Darling Basin



Key Points to Note from this Figure

- Water diversions between 1988 and 1994 grew by 7.9%.
- Under the Limited Intervention Scenario there would be an 7.3% increase on 1994 levels.
- Under the Full Development Scenario the addition to 1994 levels would be 14.5%.

5 Changes to the Flow Regime

The computer models used for diversion can also model river flow. Using historical data for the 100 years from 1892 to 1992, these models can predict flows for a range of scenarios at sites across the Murray-Darling Basin. By comparing modelled flows from different scenarios, it is possible to quantify changes to both the pattern and the volume of flow. These changes affect a range of natural processes and are especially important for the 7000 floodplain wetlands along the mainstream of the River Murray from Hume Dam to the Murray Mouth; and the many thousands of smaller floodplain wetlands throughout the Basin.

In order to provide some indication of the impact of increased diversions on the flow regime of the rivers of the Basin, this chapter discusses a number of examples chosen from a range of locations. (The impact of the changes to the flow regime are discussed in greater detail in Chapter 7.)

River Murray

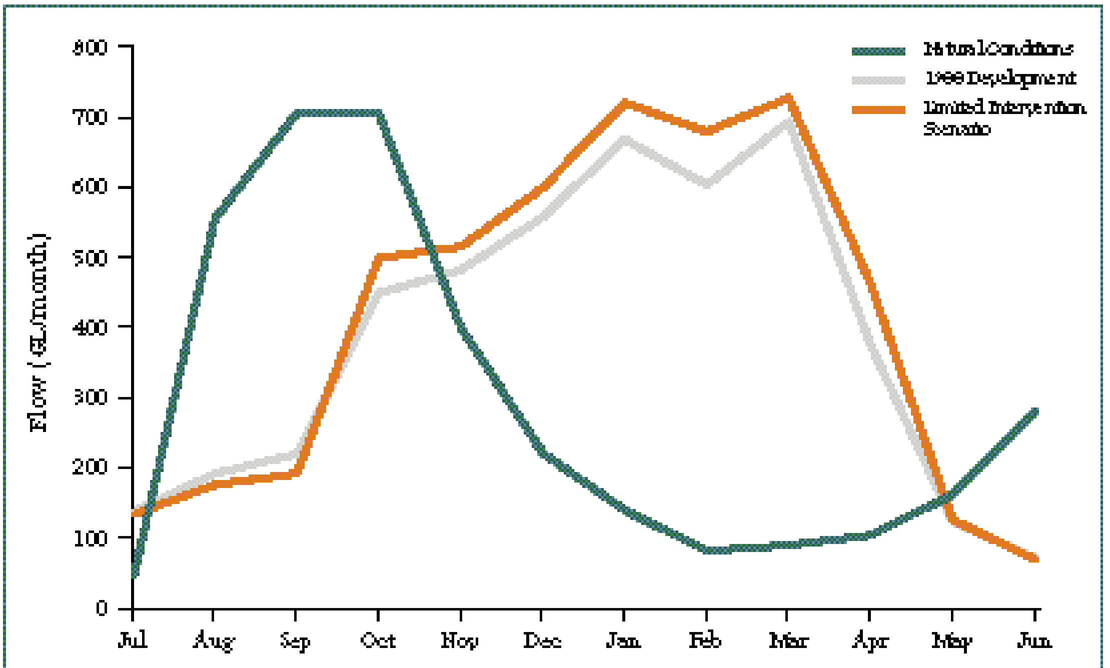
Albury

The flow regime has been changed in different ways in the different parts of the Basin. At Albury, which is downstream of Hume Dam and upstream of the major irrigation off-takes, the average annual flow in the River Murray is 10 per cent higher than natural conditions because of inflows from the Snowy Mountains Scheme. However, as can be seen from **Figure 2**, the pattern of flows has completely changed. Whereas the natural flows peaked in September and October and were lowest in February and March, current flows are now high in March. It can also be seen that this change is more pronounced for the Limited Intervention Scenario conditions than it is for 1988 development. Under the Limited Intervention Scenario, the river at Albury would be flowing at channel capacity (750 GL/month) in March in most years.

These changes to the flow pattern:

- reduce the flooding of wetlands in spring which affects fish breeding, bird nesting and the health of riparian vegetation;
- hinder the drying out of wetlands in autumn which affects the recycling of nutrients; and
- cause the river to run at channel capacity for longer periods which affects river bank stability, increases groundwater problems and causes effluents to develop which hamper landholder's access to the floodplain.

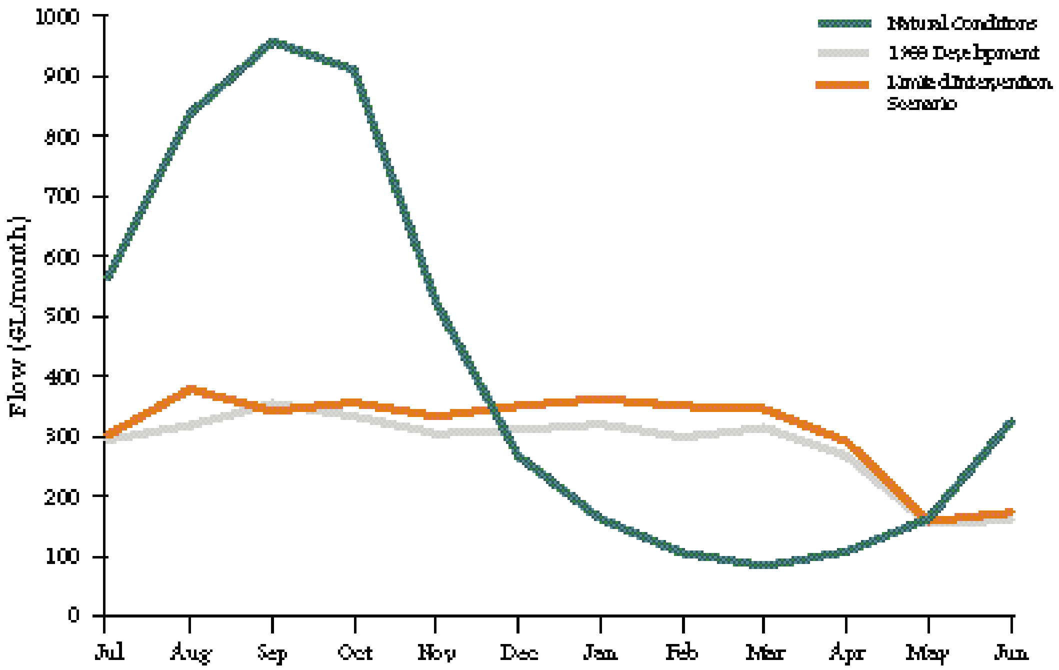
FIGURE 2. Median Monthly Flow at Albury (GL/month)



Key Points to Note from this Figure

- Under natural conditions, flows were highest in spring and lowest in autumn.
- Under current conditions, flows are usually highest in autumn and lowest in winter.
- These changes become more pronounced as diversions increase.
- The river frequently runs at channel capacity (750 GL/month) in March, which was previously one of the lowest flow months.

FIGURE 3. Median Monthly Flow Downstream of Yarrawonga Weir (GL/month)



Key Points to Note from this Figure

- The natural flow pattern has been smoothed and the extent of annual variation in flow reduced.
- Under current conditions, the river at Yarrawonga is running at channel capacity (330-350 GL/month) for much of the year.
- The Barmah-Millewa forest, which is just downstream of Yarrawonga, is flooded less in spring and dries out less in autumn.

Yarrawonga

Yarrawonga is downstream of two major irrigation offtakes in the Mulwala Canal and the Yarrawonga Channel. For this reason the average flow at the site is now less than the natural flow. However, as Yarrawonga is upstream of the off-takes of the Wakool Canal and the National Channel, regulated releases still constitute a large proportion of the flow. Yarrawonga is downstream of the junction with the largely unregulated Ovens River so there are more frequent periods of unregulated flow than at Albury. The annual flow pattern, which is presented in **Figure 3**, does not exhibit the complete reversal between spring and autumn flows that was observed at Albury but has a more uniform distribution between the seasons. A comparison of the 1988 Development and Limited Intervention Scenarios in **Figure 3** indicates that the median flows are higher under the Limited Intervention Scenario for every month. This indicates that the river at Yarrawonga will be running at channel capacity (330-350 GL/month) more frequently in the future if diversions continue to grow.

The flow at Yarrawonga determines whether the Barmah-Millewa Forests is flooded. In their management report on the Forests, Maunsell and Partners selected flows of 550 and 912 GL/month as the critical flows that were required to water the key parts of the forest. The modelled flows at Yarrawonga were analysed to determine the number of years that flows of this magnitude were received for each scenario.

Watering of Barmah-Millewa Forests

	Percentage of Years with Flow Greater than 550 GL/month	Percentage of Years with Flow Greater than 912 GL/month
Natural Conditions	94	69
1988 Development	50	35
1994 Development	48	26
Full Development	45	20
Limited Intervention	46	21

These results show that the growth in diversion that has occurred over the last six years has reduced the expected frequency of forest flooding by a significant amount. The growth that is expected in the future will further reduce the frequency of forest watering.

Euston

At Euston, which is well downstream of the major diversions and of all the tributaries other than the Darling, flows from rivers without storages largely maintain the seasonal pattern of flow but at a much reduced volume compared with natural conditions (see **Figure 4**). At this site, future development is expected to reduce further the spring floods but to increase regulated flows at other times of the year. The Hattah Lakes are just downstream of Euston and high river flows are required before water can flow into them. The number of years with flows sufficient to cause water to flow into the Lakes is expected to decline in the future as is the frequency of the even higher flows that are required to fully water the Lakes.

Watering of Hattah Lakes

	Percentage of Years Hattah Lakes partially watered	Percentage of Years Hattah Lakes fully watered
Natural Conditions	85	67
1988 Development	40	31
1994 Development	38	26
Full Development	32	20
Limited Intervention	35	21

River Murray at the Barrages

At the barrages which separate Lake Alexandrina from the Coorong, the outflow from the Murray system to the sea is now very much less than it was under natural conditions.

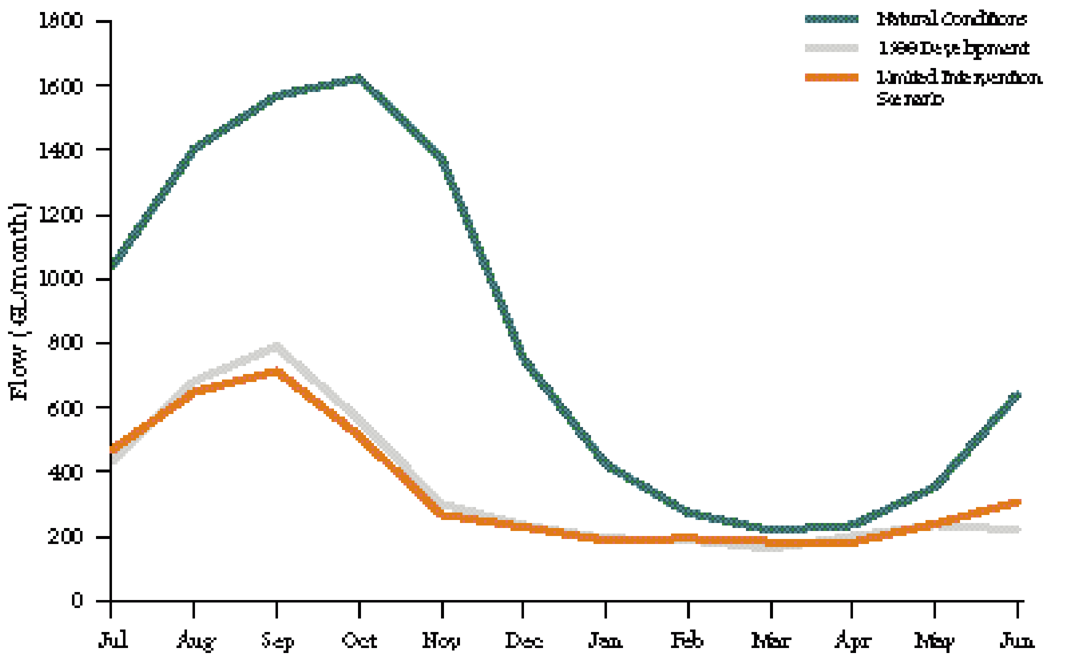
Flow to Sea

	Median Annual Outflow (GL/year)	Median Outflow as a % of Natural Outflow
Natural Conditions	11 880	100
1988 Development	2 880	24
1994 Development	2 540	21
Full Development	2 000	17
Limited Intervention	2 180	18

The 7.9 per cent increase in diversions in the Murray-Darling Basin between 1988 & 1994 caused the median annual outflows to decline by 12 per cent from 2880 to 2540 GL/year. Under the Limited Intervention Scenario, system outflow would decline to 2180 GL/year which is 14 per cent less than current flows.

The patterns of flow that would have occurred under both natural and 1994 conditions during the

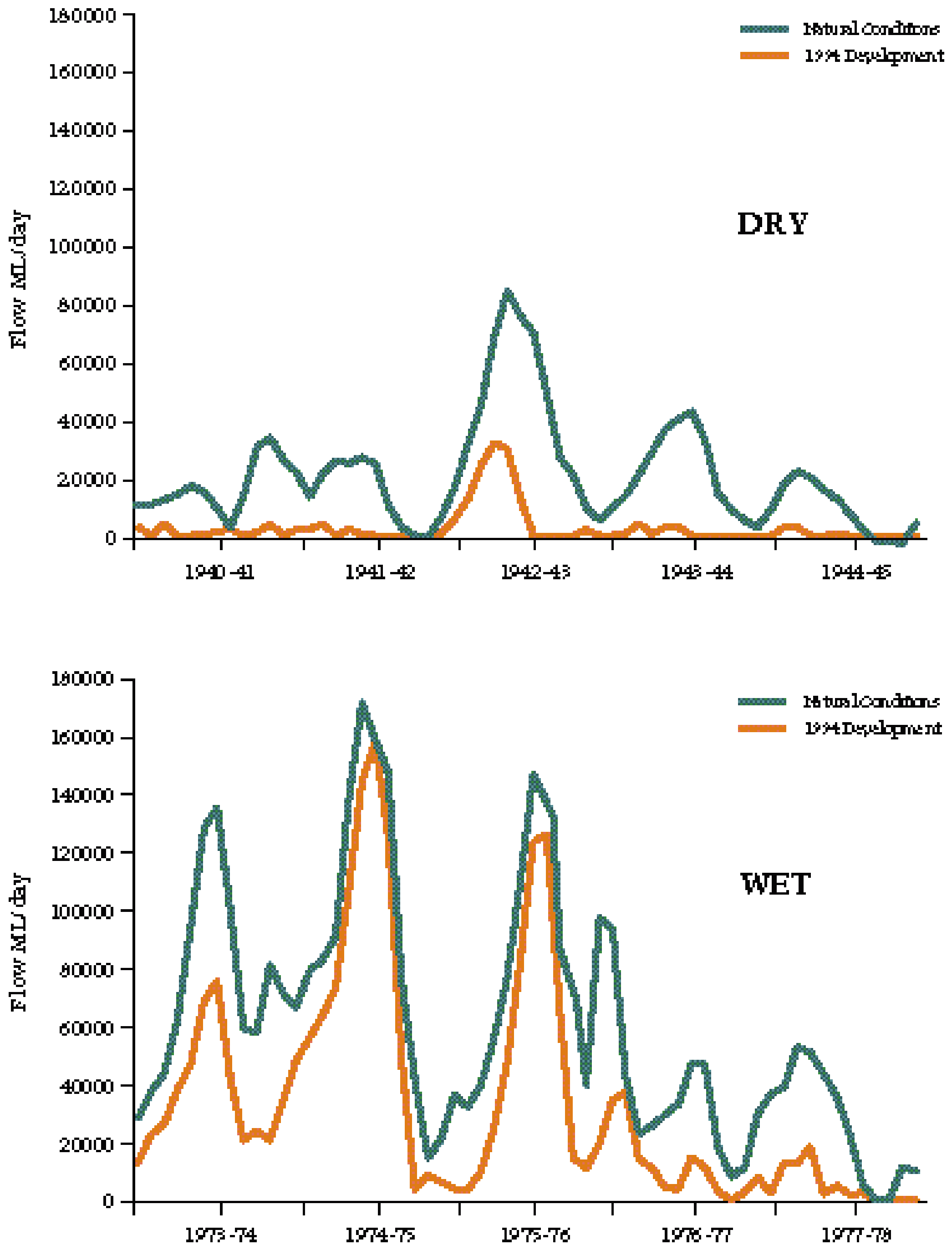
FIGURE 4. Median Monthly Flow at Euston (GL/month)



Key Points to Note from this Figure

- The seasonal flow pattern at Euston is similar to the natural pattern.
- The size of the flow has been much reduced.
- Increasing development will further reduce spring flooding and increase regulated flows in March.

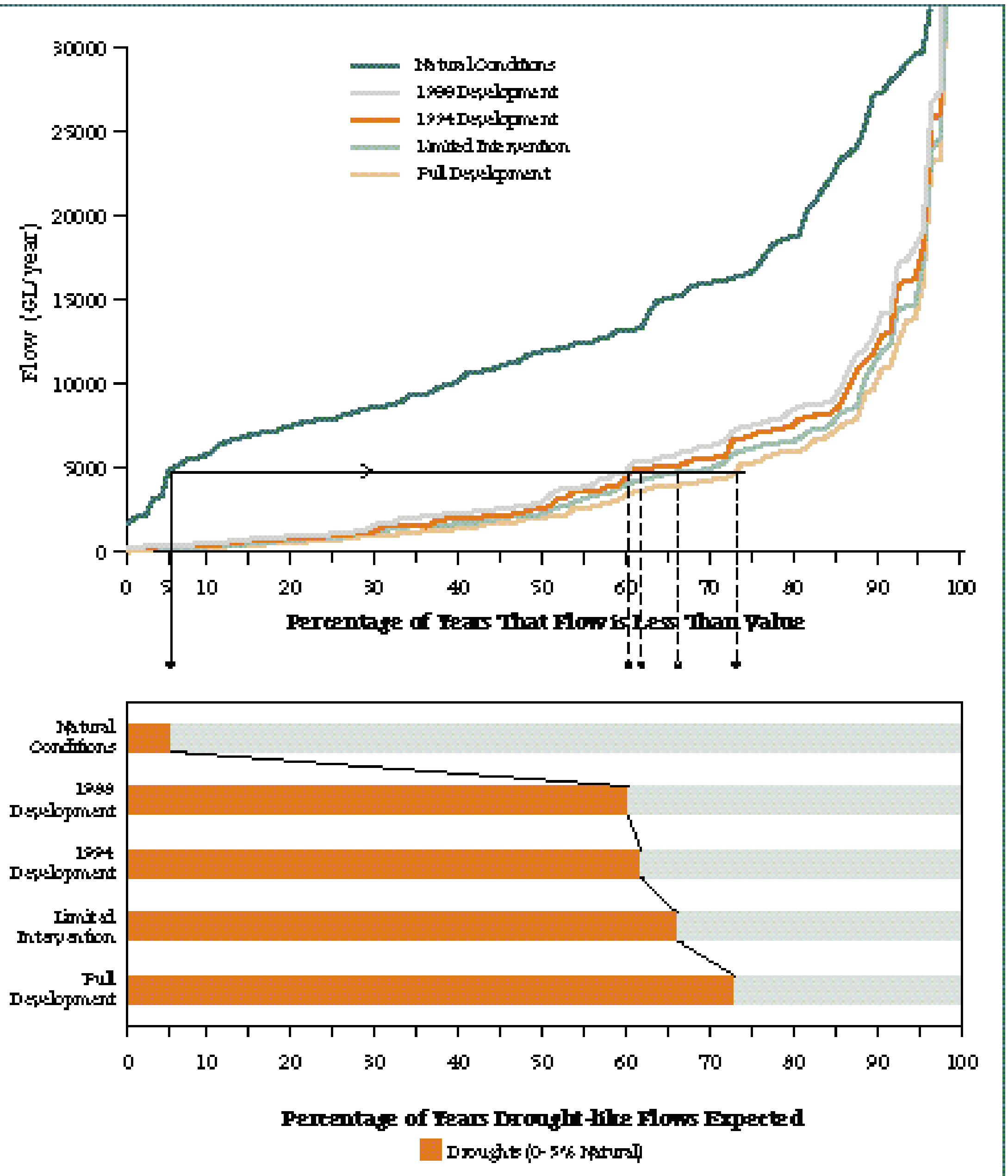
FIGURE 5. River Murray Flow over the Barrages During Dry and Wet Sequences



Key Points to Note from this Figure

- Flow in the biggest floods has not changed very much.
- Flow in average years has been significantly reduced.
- The river now stops flowing in the driest years.

FIGURE 6. Distribution of Annual River Murray Flow over Barrages



Key Points to Note from this Figure

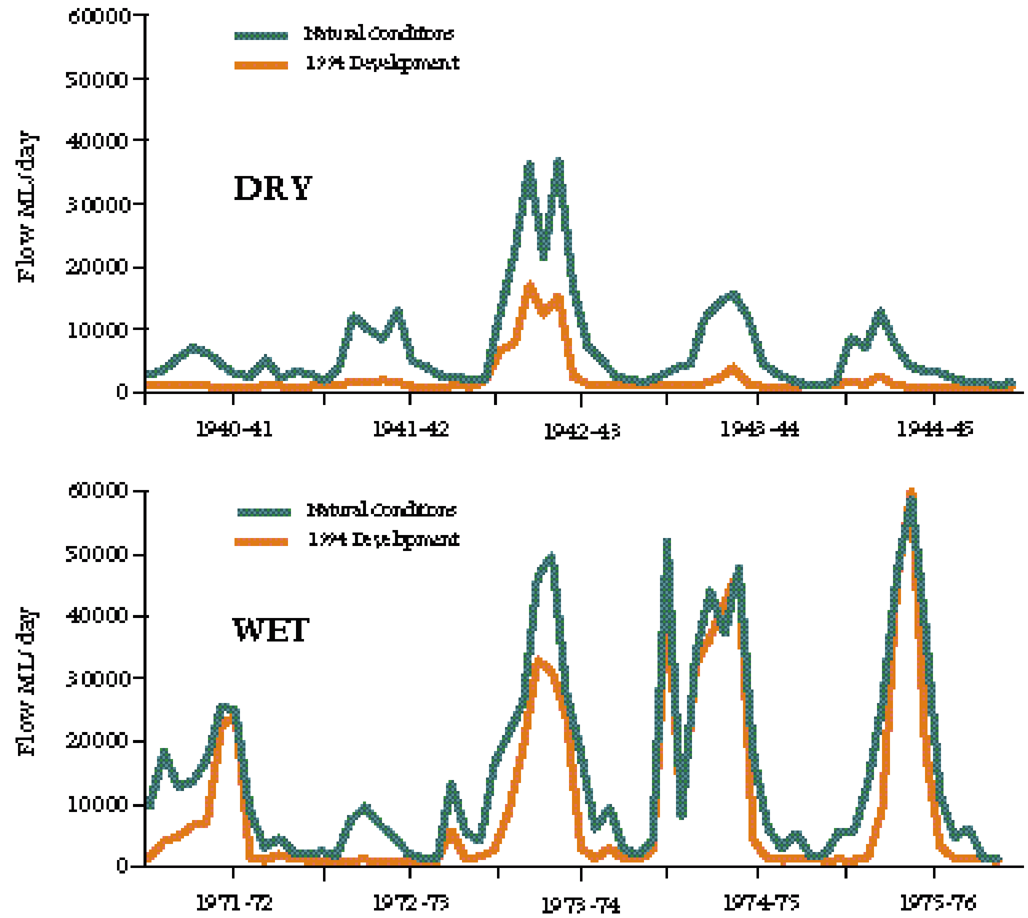
- Under natural conditions, the flow over the barrages would be less than 4600 GL/year in only 5% of years. (This corresponds with the five severe droughts observed in the last 100 years). To get an indication of how often this flow would occur under 1988, 1994, Limited Intervention and Full Development conditions, the horizontal line at 4600 GL/year should be traced to the right to where it intersects the curves for the four scenarios. Immediately below each point of intersection is the percentage of years in which the flow will occur under that particular scenario.
- The probability of the bottom end of the Murray experiencing drought like flows has increased from 5% of years to over 60% of years.
- This probability is expected to increase further in the future.
- The median annual outflow is currently less than one quarter of its natural value and is expected to decline further.

droughts of the 1940s and the floods of the 1970s are plotted in **Figure 5**. From this figure it can be seen that flows have been reduced by a similar quantity in each year. This quantity is small relative to the large floods so they have not been changed very much. However flows in average years have been significantly reduced and there is now no flow at all in the driest years.

A more detailed representation of the change in Murray outflows is provided in **Figure 6**. To produce this figure, the modelled outflows for each of the 100 years were ranked and plotted with the lowest outflow on the left and the highest on the right. This process neatly summarises the flow regime. It can be seen from this graph that, compared to natural conditions, there has been a significant reduction in the flow in every year. The frequency of floods, especially in the small to medium range, has been greatly reduced. Further development up to either the Limited Intervention or Full Development Scenarios will incrementally increase the changes that have already occurred.

The data on the flow distribution graph have been used to examine the changes to the frequency of drought flows. Severe droughts occurred naturally in 5 per cent of years. From the graph, the 5 per cent natural flow is 4 600 GL/year. By moving towards the right, the frequency with which that flow is experienced under the other scenarios can be determined. The results, which are plotted in the bottom half of the figure, reveal that flows that were naturally received only in the worst droughts are now expected in over 61 per cent of years. They also show that, unless management policies are changed, this percentage could increase to 74 per cent. The consequences of much more frequent drought-like flows may be

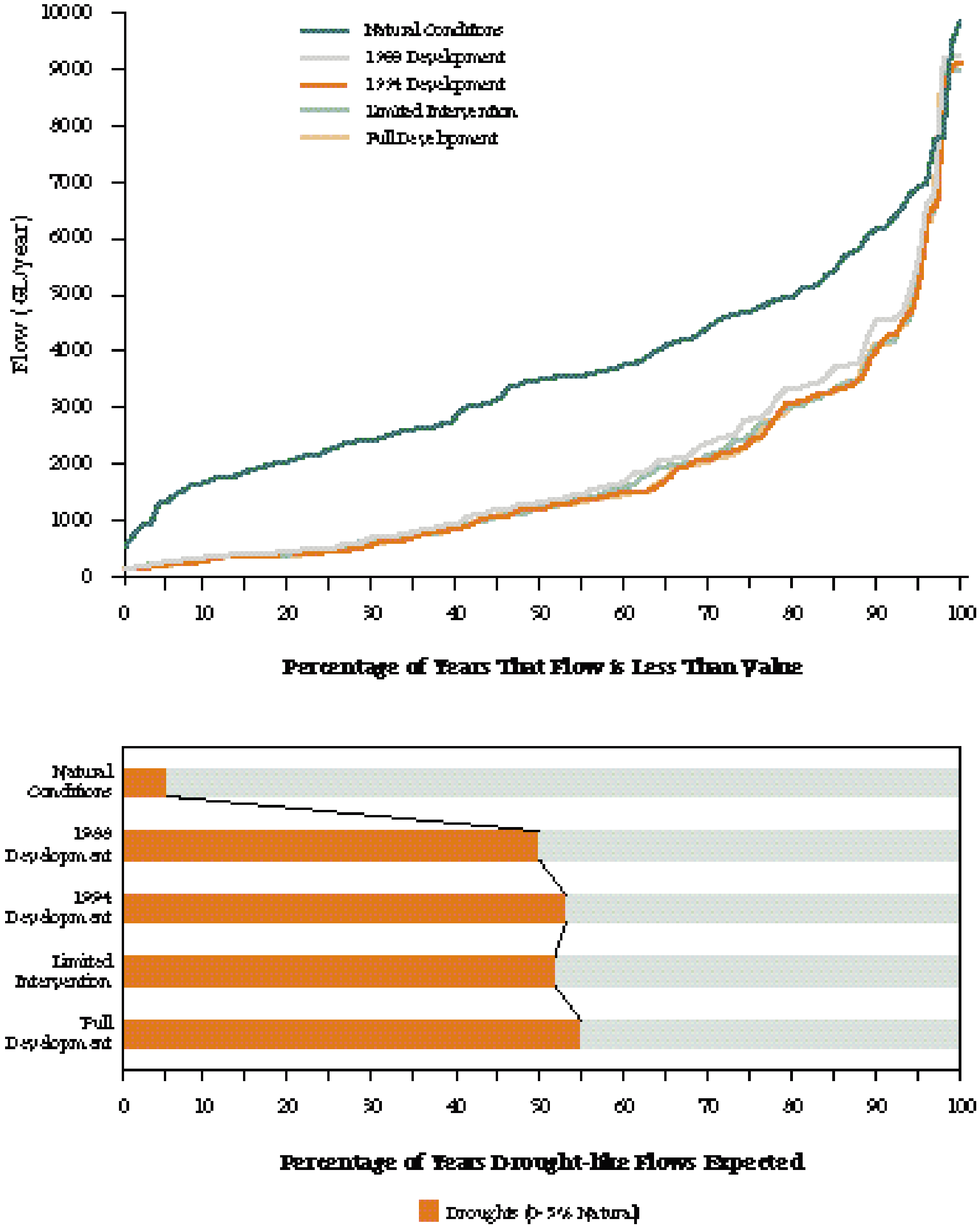
FIGURE 7. Outflows from the Goulburn, Broken & Campaspe Rivers During Wet & Dry Sequences



Key Points to Note from this Figure

- Flow in the biggest floods has not changed very much.
- Flow in average years has been significantly reduced
- Only minimal outflows are now expected in the driest years.

FIGURE 8. Distribution of Annual Outflow from Goulburn, Broken and Campaspe Rivers



Key Points to Note from this Figure

- The outflows from the Goulburn/Broken/Campaspe system have been significantly reduced from natural conditions in every year.
- Because it has been assumed in the Limited Intervention Scenario that entitlements will be transferred from the Goulburn to the Murray, outflows from the Goulburn are greater for this scenario than for the 1994 outflows.
- The frequency of drought-like flows at the end of this system has increased from 5% to more than 50% of years.

significant for the environment in the Coorong and the lower reaches of the Murray and for the probability of closure of the Murray Mouth.

Goulburn River

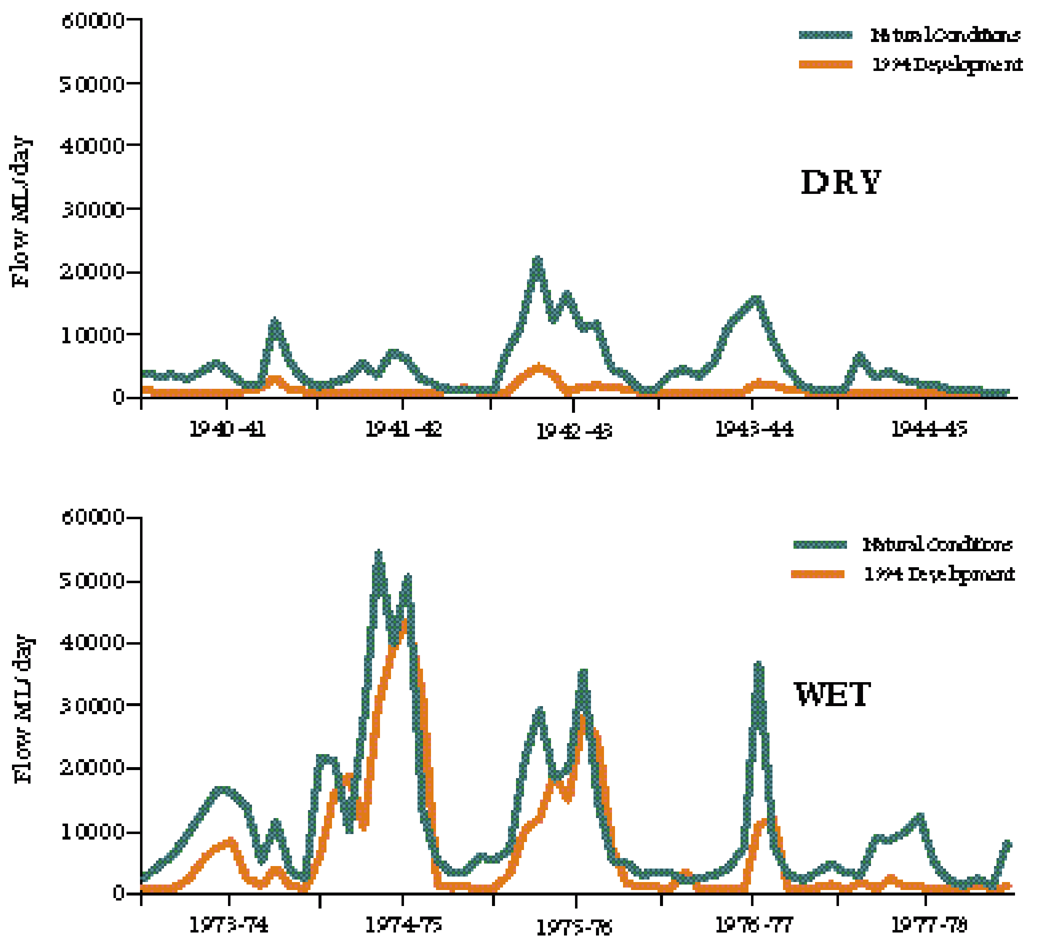
The pattern of the outflow from the Goulburn, Broken and Campaspe Rivers that would have occurred during droughts and floods is plotted in **Figure 7** and the distribution of annual outflows from these rivers is plotted in **Figure 8**. Outflows from this system have been reduced considerably with the median annual outflow currently 35 per cent of the natural outflow. Flows that were only experienced in the worst droughts under natural conditions are now expected in 54 per cent of years.

However, Victoria expects that as a result of capping entitlements, outflows will not decline in the future. In fact, under the Limited Intervention Scenario, outflows are expected to increase slightly as a result of the transfer of some Goulburn entitlement to the Murray and the possibility of development of new irrigation on the Murray using water from Lake Mokoan.

Murrumbidgee River

The pattern of flows in the Murrumbidgee River at Balranald during droughts and floods is plotted in **Figure 9** and the distribution of annual flow is presented in **Figure 10**. Median annual outflows from the Murrumbidgee are currently only 25 per

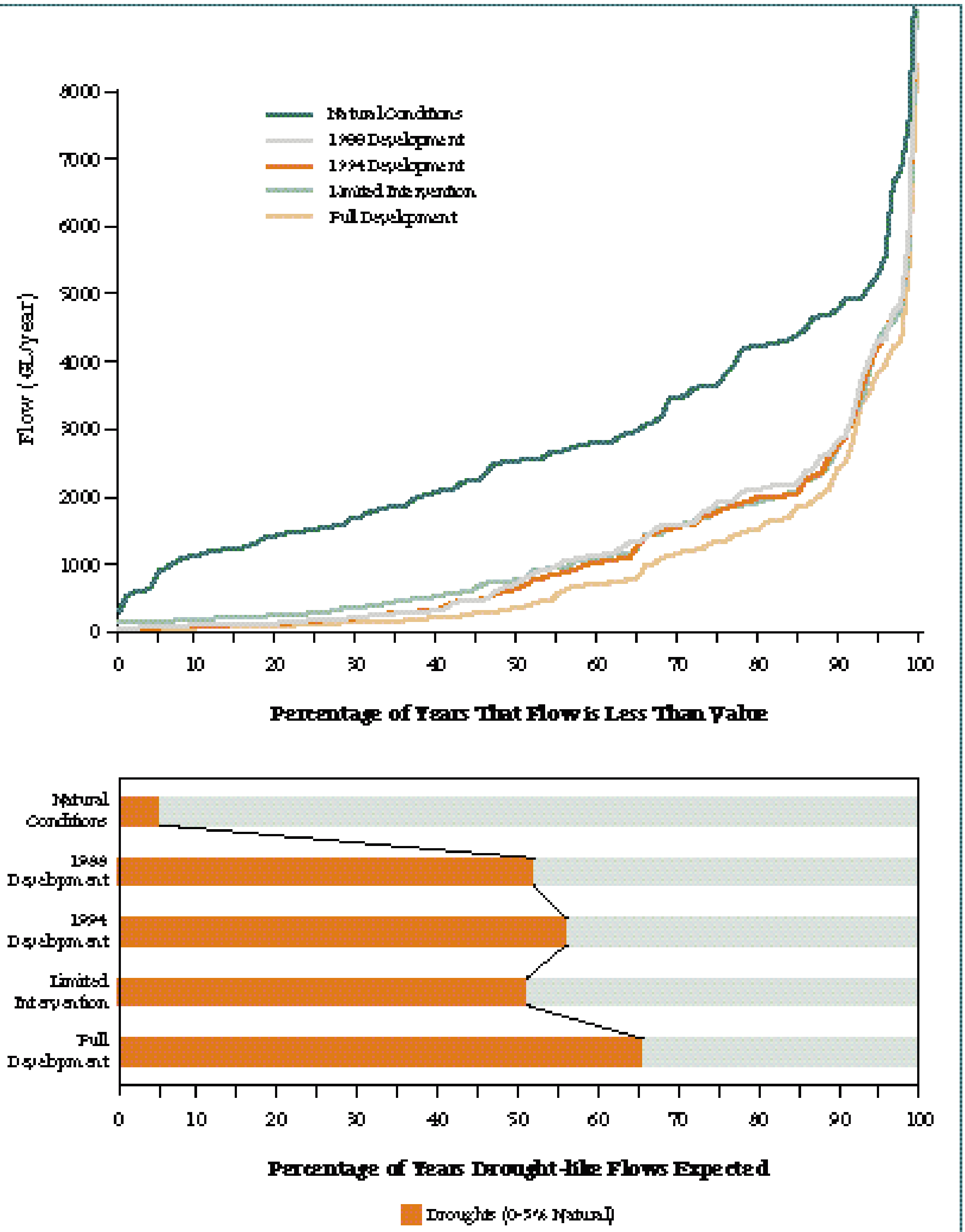
FIGURE 9. Flow in the Murrumbidgee at Balranald During Wet and Dry Sequences



Key Points to Note from this Figure

- Flow in the biggest floods has not changed very much.
- Flow in average years has been significantly reduced
- Only minimal flow is now expected in the drier years.

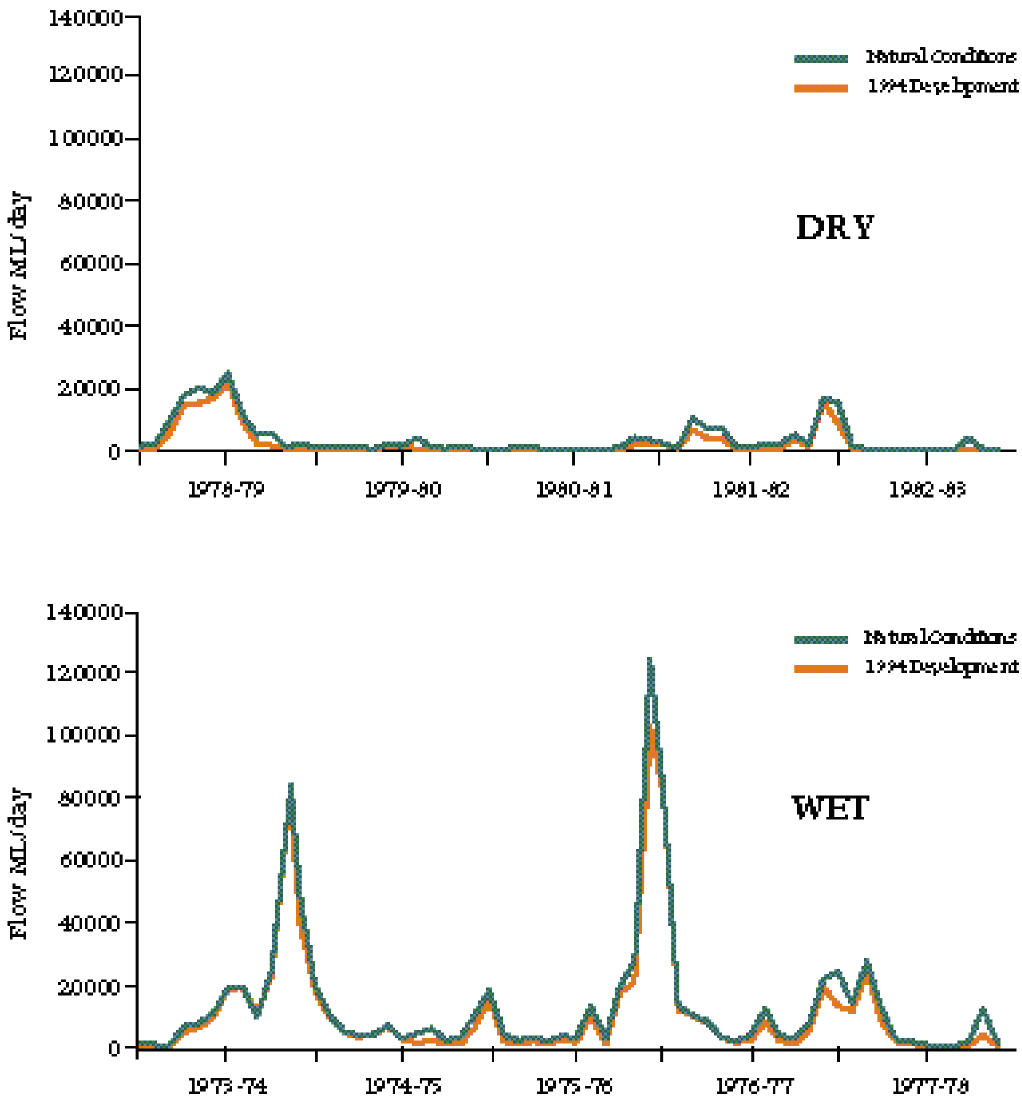
FIGURE 10. Distribution of Annual Murrumbidgee River Flow into River Murray



Key Points to Note from this Figure

- Drought like outflows are expected in over 50% of years.
- The flow regime has been significantly modified with large reductions in every year.
- Full Development of existing entitlements would lead to further significant reductions.
- The increase in minimum outflow targets in the Limited Intervention Scenario (from 125 to 300ML/day) increases the expected outflows in many years.

FIGURE 11. Darling River Flow into the Menindee Lakes During Wet and Dry Sequences



Key Points to Note from this Figure

- Flow in the biggest floods has not changed very much.
- Flow in small to medium floods has been reduced, but the relative change is less than that which has occurred for the southern streams (see Figures 5, 7 and 9).
- Under natural conditions, there were extended periods with very little flow. The frequency of occurrence of these low flow periods has increased.

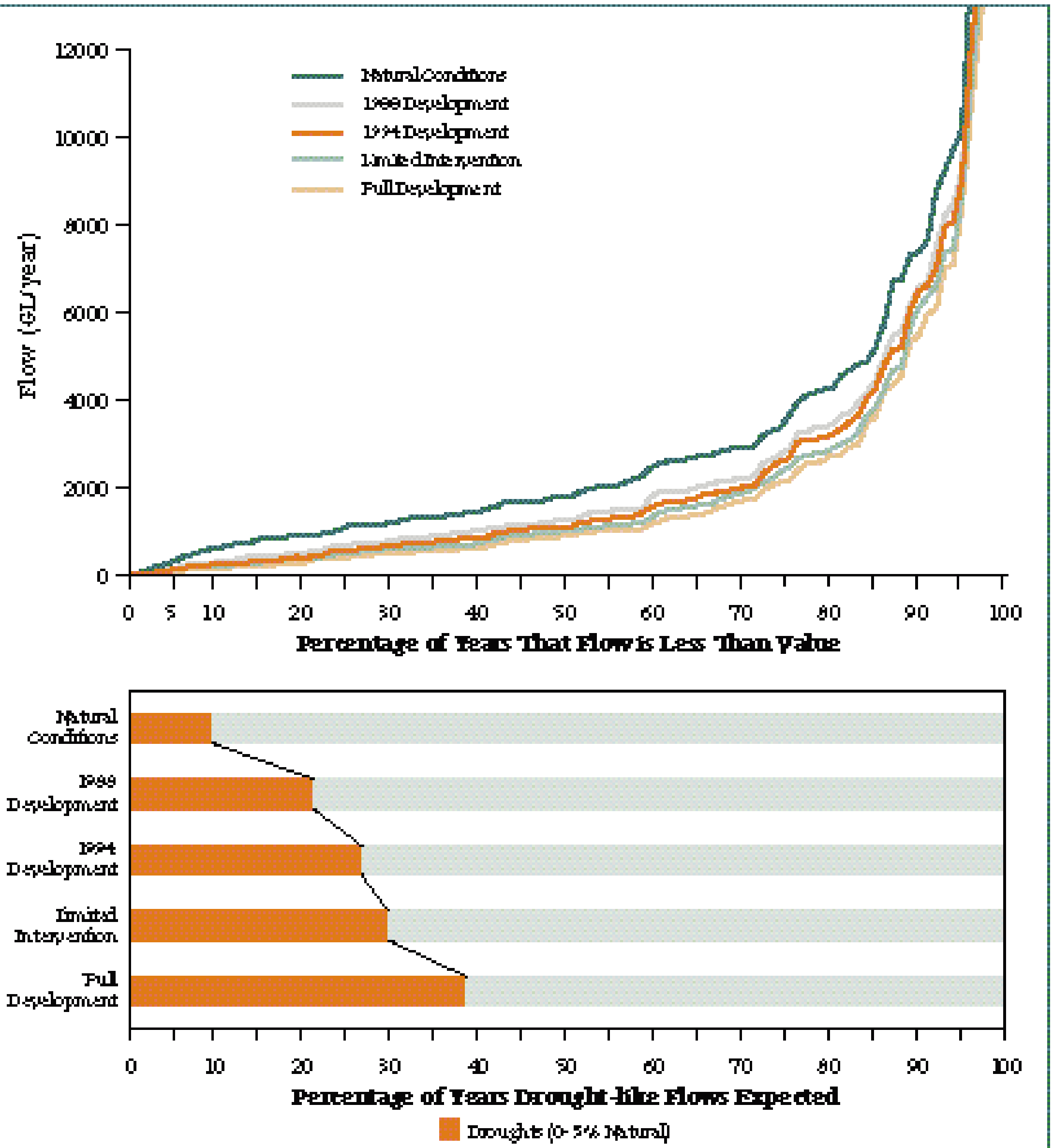
cent of the natural outflow despite the extra supplies from the Snowy Mountains Scheme. Flows that were only experienced in the worst droughts under natural conditions are now expected in 57 per cent of years.

If there is no change to the allocation and management rules, median outflows would fall by 46 per cent compared with the 1994 level of development. The Limited Intervention Scenario would produce a 2 per cent increase in median outflow, compared to 1994, largely as a result of an increase in the minimum target flow at Balranald from 125 ML/day to 300 ML/day. There is some evidence however, that the control of flows at the end of the system is not as good as assumed in the model. The minimum flows achieved in recent years appear to be closer to those in the Limited Intervention Scenario than either the modelled 1988 or 1994 conditions.

Darling River Just Upstream of Menindee Lakes

The pattern of flows in the Darling River upstream of Menindee Lakes during droughts and floods is plotted in **Figure 11** and the distribution of annual flow is presented in **Figure 12**. It can be seen from **Figure 12** that the natural flow in the Darling River was much more variable than the southern rivers. Compared with the Goulburn system, natural flow in the wetter years was comparatively much greater than the flow

FIGURE 12. Distribution of Annual Darling River Flows into Menindee Lakes



Key Points to Note from this Figure

- The natural flow in the Darling River has a more extreme variation than the southern rivers (i.e. compared with the Goulburn system in Figure 8, wetter years on the Darling have comparatively more flow than the drier years)
- Development reduces the flow by a fairly constant amount in each year.
- Full Development of existing entitlements would lead to a significant reduction in flow.
- There are relatively more extreme droughts on the Darling. (This is the reason why droughts have been defined as the lowest 10% of natural flows rather than the lowest 5% that was used on Figures 6, 8 and 10).

TABLE 6. Changes to the Flow Regime Across the Basin (Modelled Median Annual Flows)

River System	*Median Natural Flow (GL/year)*	*1994 Development Median Flow As a % of Natural Flow (%)*	*Limited Intervention Median Flow As a % of Natural Flow (%)*	*Limited Intervention Median Flow As a % of 1994 Flow (%)*
NSW Tributaries				
Border Rivers Outflow (a)	750	57	49	87
Gwydir System Outflow (b)	11	500	500	100
Namoi System Outflow	570	31	31	100
Macquarie System Outflows (c)	410	90	90	100
Darling River u/s Menindee	1746	60	55	91
Murrumbidgee System Outflows	2571	30	35	116
Victorian Tributaries				
Ovens at Wangaratta	1413	99	99	100
Goulburn/Broken/Campaspe	3510	35	35	102
Loddon at Loddon Weir	202	18	24	130
Queensland Tributaries				
Condamine/Balonne Outflow (d)	348	54	52	96
River Murray Flows				
At Albury (e)	4324	112	111	99
At Yarrawonga	5590	67	68	103
At Euston	11064	37	39	105
At SA Border	12648	32	32	99
At Barrages	11883	21	18	86

(a) Modelled outflows for 1966-92 only.
(b) Gwydir River end of system flows are greater under 1994 conditions than under natural conditions because of the large amount of re-regulation and channelisation that has occurred. Under natural conditions, the majority of the flow went down the Gwydir River and Gingham Watercourse to the wetlands. Flow only went down the Mehi, Moomin and Carole channels under high flows. With development, flows are being regulated down the Mehi, Moomin and Carole channels which join up with the Barwon River.
(c) Modelled outflows for 1966-92 only. Like the Gwydir, the Macquarie end of system flows have been affected by changes to the watering of wetlands.
(d) No intervention has been assumed for Queensland. These figures are for Full Development of existing entitlements.
(e) Albury flows have increased as a result of transfers from the Snowy Scheme.

Key Points to Note from this Table

- Outflows from the major systems are significantly reduced from natural conditions.
- As a result of proposed management changes and entitlement transfers, flows in some locations are expected to increase under the Limited Intervention Scenario.
- Under the Limited Intervention Scenario the flow to the sea is only 18% of the natural flow.

in the drier years. This greater variability has made it more difficult to exploit the resources of the Darling to the same extent as the southern rivers as much larger storages are required to store water from the flood years for use in the drier years. However, the flows in the drier years have been significantly modified.

Median annual outflows from the Darling are currently 60 per cent of the natural outflow. Flows that were only naturally experienced in the driest 10 per cent of years are now expected in 27 per cent of years. If there is no change to the allocation and management rules, the Full Development Scenario, median outflows would fall by another 20 per cent compared with the 1994 level of diversions. The assumptions incorporated into the Limited Intervention Scenario would limit this change to 9 per cent less than 1994 median outflows.

Summary of Changes to the Flow Regime in Other Parts of the Basin

The changes to the flow regime in other parts of the Basin are summarised in **Table 6**. This table lists the median annual flow under natural conditions, the 1994 Development and Limited Intervention median flows as a percentage of the natural flow and the Limited Intervention median flow as a percentage of 1994 conditions. These figures give some indication of the relative change to the flow regime in individual parts of the Basin.

6 Environmental Impacts on River Health

The Murray-Darling Basin supplies water for intensive agriculture and a wide variety of domestic, industrial and environmental purposes. Many cities, including Adelaide and Canberra as well as numerous other urban centres, both within and outside the region, rely on the Basin for their water supply. The importance of the Basin as a source of urban water is highlighted by the fact that the River Murray supplies on average 42 per cent of metropolitan Adelaide's water consumption. In dry years, this rises to 90 per cent of Adelaide's annual consumption.

The quality and quantity of water flowing through the Basin's water courses determines the health of the riverine eco-systems throughout most of inland south east Australia. These eco-systems include 30 000 wetlands which perform hydrological, biological and chemical functions that are essential for the productivity of rivers throughout the region.

The study has revealed that:

- there have been substantial changes to the flow regime of the rivers of the Basin;
- these changes are continuing; and
- unless these are major changes to current management policies, these changes will continue into the future.

Changes to the flow regime can affect the potential uses of the water and increase the stress on the natural eco-systems of the river system. This chapter describes some of the impacts resulting from the changes in flow regime and discusses their importance.

Water Quality

Algae

The progressive reduction in river flow is encouraging the preconditions which cause blue-green algae blooms to develop and making it harder for river managers to combat them after they occur. The progressive reduction in the amount of water being left in the system is producing shallower streams and rivers, greater concentration of nutrients, reduced oxygen levels and increased stagnation. These are ideal conditions for the development of algal blooms. Once they have developed the only effective method to dissipate blooms on a large scale is by dilution flushes from the storages. For rivers such as the Darling which are unregulated, the options available for the management of blue-green algae are becoming severely limited.

Impacts of Increased Salinity

The reduced flows are also leading to increased salinity problems for water users. Salinity affects the quality of domestic water in a number of ways:

Palatability —
As salinity of the water rises its taste becomes detectable.

Hardness —
The amount of soap required for washing increases in proportion to the concentration of magnesium and calcium ions in solution.

Corrosion —
Saline water increases the rate at which pipes and fittings corrode. Hot water systems for example, have an average life of 9 years in Adelaide compared with 15 years in Melbourne where the salinity is much lower.

Salinity also affects the use of water by industry. Many industrial processes require low salinity, softened or even demineralised water. The cost of producing this water increases with the increasing salinity of the raw water. In processes such as steam generation, feed water with high salinity needs to be replaced frequently in order to maintain salinities in the boilers at acceptable levels. Replacing water more frequently results in the loss of energy, chemicals and water.

The River Murray is the major source of domestic water for towns along the river and also for those places in South Australia, including Adelaide, which are supplied with River Murray water via pipelines. Consequently increasing salinity will bring substantial costs for the many water users dependent or partially dependent on the Basin. (See Chapter 8 for a more detailed discussion of the salinity impacts of increased diversions.)

Wetlands

Contribution of Floodplain Wetland Systems

The changes in the volume and seasonal pattern of flow have dramatically reduced the volume and effectiveness of water reaching the estimated 7 000 floodplain wetlands which are distributed along the Murray system. A growing body of evidence, generated by research and observation over the past ten years, is showing that healthy floodplain wetlands are vital for the protection of healthy, sustainable rivers. Healthy wetlands have many important qualities which can sustain a wide range of economic activities including recreational and commercial fishing, forestry, irrigation, cropping, grazing, waterfowl hunting and tourism, as well as many cultural, social and environmental values.

Floodplain wetlands perform many important biological functions such as the filtering of nutrients, enhancing water quality and mitigating floodwaters. Recent blue-green algal blooms in water storages and in rivers have focused a great deal of public attention on the role of wetlands in filtering nutrients and have raised the question of whether remaining wetlands can perform this function adequately. The importance of nutrient filtration is demonstrated by wetlands being constructed, at significant cost, to improve water quality from sewage treatment plants, industrial effluents and nutrient-rich catchment run-off.

As an example of the value now being placed on floodplain wetland systems, the Albury City Council is proposing to spend $3 million on the upgrading of a natural wetland south-west of Nursery Valley as part of its planned upgrading of the city's waste water treatment system.

Likely Impact of Future Diversions on Floodplain Wetlands

The best indication of the likely impact of increased diversions on floodplain wetlands in the future can be gained from an analysis of the impact of diversions to date. Over the last hundred years the number and extent of wetlands in the Basin has declined significantly. In Victoria the shallow and deepwater marshland, most of it in the Murray-Darling Basin, has been reduced by 70 per cent. In New South Wales the Macquarie Marshes have been reduced by 50 per cent and the Lower Gwydir water couch wetlands by 90 per cent. In other areas the changes resulting from river regulation have caused wetlands to be changed permanently by continual inundation. On the River Murray 35 per cent of ephemeral wetlands have been lost in this way.

Some indication of the additional impact on wetlands which is likely to result from the increased rate of diversions that would result from implementation of the Limited Intervention Scenario is provided in Chapter 5 *Changes to the Flow Regime*. For the Barmah Millewa wetlands the frequency of smaller floods will reduce from 48 per cent of years to 45 per cent of years and the frequency of complete watering of the forest will reduce from 26 per cent of years to 21 per cent of years. A similar change is indicated for the Hattah Lakes. At the Murray Mouth a decline of 14 per cent in outflows to the sea, compared with 1994 flows, indicates that there will be a substantial reduction in the volume of fresh water entering the Coorong system.

Changes in the Seasonal Pattern of Flows

An important impact on wetlands, resulting from increased diversions for irrigation, has been the change in the seasonal pattern of low and high flows in the southern part of the Basin. Normally the process of decomposition of vegetable matter is assisted by the watering/drying cycle which can be disrupted by even minor flooding or drought during the wrong period. Running the rivers high to get water to irrigators at the peak of the growing season in late summer/autumn has meant unseasonal flooding of many wetlands areas. This, combined with the lower level of traditional winter and spring flooding, at a time when the water is now held back in the storages, has reduced the volume and range of biological diversity and the productivity of floodplain wetlands.

Native Animals, Birds and Fish

The decline in wetlands productivity and the reduction in the duration of medium sized floods, has caused wetland areas to become less effective as breeding grounds for native fish species, which traditionally followed the winter/spring flood waters out of the rivers and on to the floodplains to spawn and feed. In turn the birds which used to support their springtime breeding colonies by feeding on the fish, frogs and insects breeding in the shallow warm water, have been forced to go elsewhere.

The decline of the wetlands has had a dramatic impact on the biodiversity of the Murray-Darling Basin. There has been a serious reduction in the numbers of many species of birds, fish, amphibians, insects and plants and many of these species have become locally extinct in areas where they were once common. Many traditional egret breeding areas are now unused while the Murray Cray is extinct in the lower Murray.

Other species, including Murray cod and freshwater catfish, are drastically reduced in numbers. In South Australia the commercial catch of Murray Cod has dropped from around 100 000 kg/year through the 1950s to under 10 000 kg through the 1980s. Over the same period golden perch catches in South Australia have declined from regular catches over 300 000 kg/year to around 60-70 000 kg/year. It is thought that these declining catches are caused largely by river regulation and the reduced volume of water left in the rivers as a result of increased diversions, and reflect changes which have occurred throughout the Basin.

On tributaries such as the Darling the reduction in the levels of flows caused by increased diversions has meant that the levels of water needed for fish to cross weirs and natural barriers and move upstream to breed are achieved less regularly.

Native fish have also been severely affected by other changes to their flow requirements. In contrast to previous flow patterns, the new river environment favours introduced species such as European carp which do not need to go out onto the floodplains to breed. They flourish in the main channel and in many areas now constitute up to 85 per cent of the local fish stock. Carp root into the stream beds, destroy aquatic plants, release nutrients into the water where they can more easily be taken up by blue-green algae, and contribute to the undermining of the sides of the water courses causing the riparian vegetation to fall into the water leaving the banks eroded and bare. This decline in the riparian zone also promotes the movement of nutrients held in eroded soils, that would previously have been trapped by vegetation on the river banks, into the river system where it promotes the growth of blue-green algae.

These changes are occurring in a complex dynamic eco-system. To be effective and relevant in this rapidly changing situation, policy decisions about its future will need to be made using currently available information. For the longer term a strategic approach will be needed. In order to ensure that there is an effective bridge between decision makers and managers, the community and the research providers, the Murray-Darling Basin Commission has approved the development of the Sustainable Rivers Project. It is proposed that this will be the cornerstone of the strategic long term approach to the Basin's rivers.

The Sustainable Rivers Project aims to develop a decision support system for use by planners and managers. The project will make it possible to predict the likely impact of changes to flow conditions through variations to irrigation allocations, the revision of water release policies, the construction of new structures such as dams, and the likely benefits of returning water to the environment.

The Sustainable Rivers Project will contain data on stream flow rate, depth and width, riparian vegetation, adjacent wetlands, water quality, areas of inundation floodplain flora and fauna for a wide range of different sections of the Murray-Darling river system. It will provide a basis for informed discussions about trade offs relating to water allocations and changes to river flows, and give managers and communities an indication of the likely effects on the riverine environment of the implementation of different flow scenarios.

7 Impact on Existing Irrigators

Security of Supply

An important factor in any irrigation enterprise is the security of the water supply. Security of supply refers to the frequency and severity of shortfalls between the quantity of water desired and the quantity of water that can be supplied. In a very secure system, all the demand would be met every year. In a less secure supply, irrigators might have their full demands met in very few years and might receive no water at all in some years. For a given river system, security is a function of inflow, storage and demand. For a given inflow and storage there will be a level of demand that can be supplied with high reliability (say 99 years out of 100). This is referred to as the safe yield. As supply increases above the safe yield, storages are drawn down more quickly and the reserves carried over into the drought years are reduced. This increases the frequency and severity of restrictions.

The level of risk that can be tolerated by an irrigation enterprise depends upon the irrigation activity being undertaken. Horticultural crops require very secure supplies. A year with no water supply might affect a horticulturalist’s production and marketing for many years thereafter. Similarly dairy farmers may have to reduce the size of their herd as a result of reduced supplies and this could affect production in subsequent years. In contrast other crops such as cotton and rice will suffer in the year of low supply but their production is unlikely to be affected in subsequent years.

The level of risk that can be tolerated by any enterprise will also be affected by the profitability of that enterprise. For highly profitable crops it may be appropriate to irrigate large areas in years when water is available even though this might increase the probability of low supplies in subsequent years. In enterprises with low profitability, even one restricted year may be sufficient to cause bankruptcy.

The different irrigation crops in the various States are reflected in the States’ policies on security. In South Australia, where horticultural crops predominate, entitlements are effectively 100 per cent secure. In Victoria, irrigators’ entitlements are divided into water rights which are very secure (99 years in 100) and additional sales water which is allocated as a percentage (up to 120 per cent) of water right and which is less secure. Victoria has a policy of not allocating sales water until it can guarantee 100 per cent of water right in the following year. New South Wales has a general policy of achieving 70 per cent reliability of supply for all the regulated rivers in the State. This means that they aim to supply irrigators with their full allocation in 70 per cent of years. However, the reliabilities of the New South Wales systems vary considerably. In Queensland there is no general security policy. However, in their regulated systems, full allocations are available between 75 and 99 per cent of years. (See appendix A for further discussion about the differences between regulated and unregulated streams.)

Because the Murray-Darling Basin incorporates such a wide variety of systems, there is no single measure of reliability that applies across the Basin. However, it is possible to examine the relationship between growth in demand and reliability by examining the variability of the total modelled diversions for the Basin. For each scenario, the modelled annual diversions were divided by the peak annual usage and the results were ranked and plotted on **Figure 13**.

If it is assumed that the peak annual diversion is a measure of the area developed for irrigation, then **Figure 13** becomes a measure of the average reliability of the Basin water supply. It can be seen that the water supply reliability decreases as the demand increases. By expressing the mean diversion as a percentage of the peak usage and comparing the scenarios, it can also be estimated that the water supply for the land developed in 1994 will decline by an average of 3.0 per cent under Limited Intervention Scenario conditions and 4.9 per cent under the Full Development Scenario.

Announced Allocations

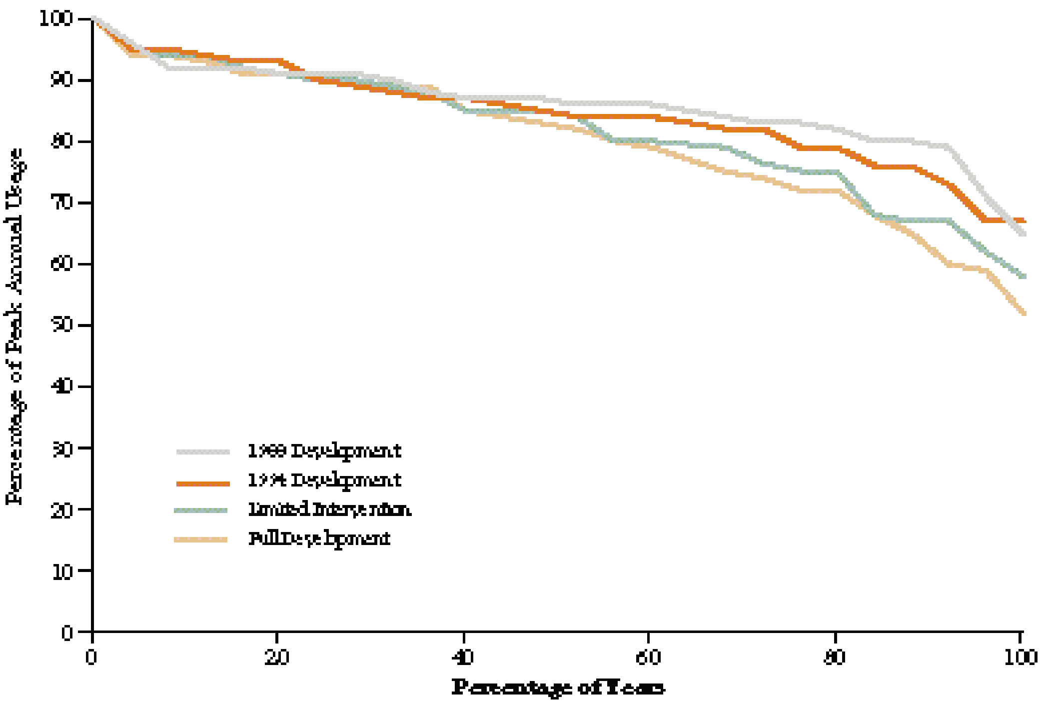
The water audit confirmed that water managers on the Murrumbidgee, Murray and Goulburn regulated systems have been making large allowances for under-usage when announcing allocations. On many occasions the nominal volume of water that has been allocated has been greater than the quantity that could be delivered through the distribution network or supplied from the storages. However, because only a minority of irrigators on these systems use their full allocation, few problems have arisen.

It is expected that as demand rises and the water market develops, the level of under-usage will fall and lower announcements will have to be made. The modelling studies also revealed other reasons why announced allocations may have to be lower in the future. On the Murrumbidgee, Murray and Goulburn systems, peak diversions never equalled the nominal maximum allocation even under Full Development. On the Murrumbidgee, the outlet capacity of Blowering Dam limited diversions. On the Murray it was the river channel downstream of Albury, while in the Goulburn-Murray Districts, diversion was limited by the capacities of the irrigation channels. As demand increases, water managers will be forced to decide whether it is better to develop a parallel system for sharing the capacity of the rivers and channels, or whether it is better to limit diversions using the existing allocation system by making lower announcements.

In Victoria, bulk entitlements which specify a ten year rolling cap are going to be issued to the regional water authorities. This cap will occasionally restrict allocations, sometimes even in years when storages are full. For the districts to keep within their caps they will need to limit the water they allocate to irrigators and this will result in generally lower allocations.

As an example of the likely changes to announced allocations, the modelled allocations to the Victorian Murray Districts have been analysed and the results are plotted on **Figure 14**. Between 1988 and 1994, there has been a decline in the expected allocations as a result of the increased demand. Under the Full Development Scenario the level of allocation will drop significantly, compared to 1994, as a result of the impact of the water market in reducing unused allocations. For the Full Development Scenario, no allowance was made for

FIGURE 13. Variability of Annual Diversions from the Murray-Darling Basin



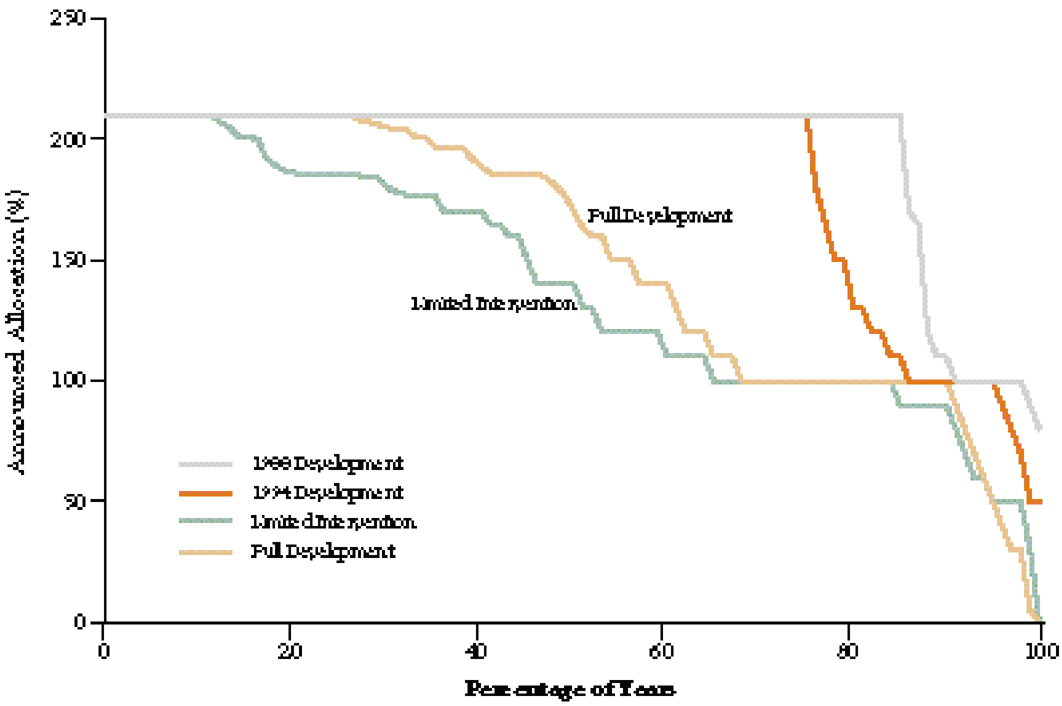
Plotted using modelled diversion data for 1966–1992

Mean Annual Diversion as a% Peak Division		*% of 1994*
1988 Development	86.3	101.6
1994 Development	85.0	100.0
Limited Intervention	82.4	97.0
Full Development	80.8	95.1

Key Points to Note from this Figure

- This figure gives a measure of the average reliability of the Basin water supply.
- Increased demand results in increased restrictions in 50% of years.
- In the worst year modelled, supply is restricted to 53% of peak use under Full Development compared with 67% of peak use under 1994 conditions.
- Under the Limited Intervention Scenario, the average water supply for land already developed is expected to decline by 3%.

FIGURE 14 Change in Announced Allocations for Victorian Murray Irrigation Districts



	Average Allocation %	*% of 1994*
1988 Development	195	106
1994 Development	185	100
Limited Intervention	139	75
Full Development	152	82

Key Points to Note from this Figure

- The growth in diversions that occurred between 1988 and 1994 reduced the likelihood of announcements of 210% of water right from 85% to 75% of years.
- Under the Full Development Scenario the number of years in which 210% would be announced would fall to 26%.
- Under the Limited Intervention Scenario this would decline to 11%. (because of the restrictions imposed by the 10 year rolling cap.)

under-usage and the nominal allocation was set to the water available. Finally, by comparing the Limited Intervention Scenario with Full Development, the effect of the rolling cap can be seen.

In all, the impacts of these changes are substantial. Announced allocations under the Limited Intervention Scenario would be on average 25 per cent less than 1994 levels. This change will have considerable impact upon the minority of irrigators that currently rely on using all the water allocated to them. Those irrigators will be forced either to scale down their operations or to purchase water on the transfer market.

8 Changes to River Salinity and Implications for the Salinity and Drainage Strategy

Changes to Salinity Caused by Reduced Flow

A relatively steady flow of saline groundwater enters the River Murray downstream of Euston. This groundwater flow is largely a natural phenomenon but it has been increased by the clearing of vegetation in the Basin and by irrigation. The inflowing salt causes the salinity of the River Murray to rise between Euston and the Murray Mouth. The amount that the salinity rises depends upon how much river flow there is to dilute the groundwater. The higher the flow the more dilution there is and the lower the salinity that results. Any decrease in River Murray flow will therefore cause salinity to increase.

corrosion, soap and maintenance costs for domestic water users and reduced yields for horticultural crops.

Changes to Salinity Caused by Increased Salt Accessions from Groundwater

In calculating the salinity increases and the salinity costs presented in **Tables 7** and **8**, only increases caused by reduced flow have been considered. However, in the past, irrigation development has invariably resulted in higher groundwater levels. In

areas with high salinity groundwater, these higher levels can result in increased salt flows to the rivers. In the Nyah to South Australian Border Region in Victoria, it has been estimated that every additional

Table 7:
Impact of Diversion on River Murray Salinity (EC) (Increase in Average Modelled Salinity)

		Increase from 1988 Development Scenario		
Site	*1988 Development Salinity*	*1994 Development*	*Full Development*	*Limited Intervention*
Euston	255	5.3	15.2	6.8
Merbein	346	5.0	18.4	5.5
Lock 9	359	1.0	9.5	1.4
Renmark	393	3.3	15.2	5.3
Berri	424	4.6	19.9	7.7
Morgan	537	10.5	41.2	22.1
Murray Bridge	578	13.2	48.3	29.3

The impact of the different development scenarios on river salinity were determined by the Murray-Darling Basin Commission's salinity models. The results are presented in **Table 7**.

These results show that development between 1988 and 1994 has increased the average salinity at Morgan (which is the most commonly used reference point for salinity in the River Murray) by 10.5 EC. Morgan salinity is expected to rise by an additional 11.6 EC under the Limited Intervention Scenario and by 30.7 EC under Full Development. To put these salinity changes in perspective, the Murray-Darling Basin Commission has spent $50 million since 1988 installing salt interception schemes to reduce Morgan salinity by 67 EC. (An EC is a measure of the conductivity of electricity through water. As the salinity of water increases the conductivity also increases. The conductivity can be measured and gives a good indication of the salt content of the water.)

An indication of the additional costs incurred by water users as a result of the increased salinity is given in **Table 8**. These costs comprise increased energy and treatment costs for industries, additional

megalitre used for irrigation in areas adjacent to the River Murray causes between one quarter and one tonne of additional salt to enter the river.

Using the conservative figure of one quarter of a tonne of salt for every additional megalitre of water mentioned above, it has also been estimated that the additional salt accessions from an extra GL/year of water diverted in the low impact zone in the Nyah to the Border region would increase salinity at Morgan by 0.2 EC. One GL/year is sufficient to irrigate about 120 hectares of vines in the Sunraysia Region.

Table 8:
Additional Costs to Water Users from Increased Salinity (Increase above the 1988 Development scenario)

1994 Development	$1.5 million/year
Limited Intervention	$3.0 million/year
Full Development	$4.6 million/year

The modelled diversions from the Murray below Euston and the Darling below Menindee are listed for each scenario in **Table 9** as are the salinity increases that could result from the increased salt accessions. (Calculated using the Nyah to the Border relationship of 0.2 EC/GL.)

All States have processes in place to prevent future salt accessions from reaching this potential. These generally take the form of conditions placed upon transfers of water entitlements.

The conditions can include:

- a requirement to carry out a whole farm plan to make existing irrigation more efficient and thus reduce overall groundwater accessions;
- a commitment to install groundwater interception works in the future if groundwater levels rise; and
- the purchase of salinity credits.

Continuing management will be required to ensure that these measures are successful and new policies may be required to prevent the growth in salt accessions from those properties where diversions can grow without entitlement transfers.

Implications for the Salinity and Drainage Strategy

The Salinity and Drainage Strategy was developed by the Murray-Darling Basin Commission in 1989 to reduce river salinity while at the same time enabling States to construct surface and subsurface drainage or to undertake other actions that increase river salinity. The Strategy establishes a system of salinity credits. States earn credits by funding the construction of salt interception schemes or by undertaking measures that reduce river salinity. States use credits by constructing drains or by initiating other measures that increase river salinity.

A key component of the Strategy is the benchmark. The benchmark is defined as the conditions applying on 1 January 1988. Activities included in the benchmark do not attract either salinity debits or credits while activities undertaken after that date are accountable. Prior to the adoption of the Strategy in 1989, the question of accountability for the development of unused water entitlements was raised and the Commission agreed that the benchmark for diversions should be the level of commitment on 1 January 1988. Under this ruling, the decision by a sleeper to activate his entitlement in 1990 would not attract salinity debits because that decision was covered by the commitment the State had made to the entitlement holder at the time when the entitlement was granted.

Table 9:
Growth in irrigation downstream of Euston since 1988 and the potential salinity impacts from increased salt accessions

Scenario	*Diversion Downstream of Euston and Menindee (GL/year)*	*Potential Increase in Salinity at Morgan from Extra Salt Accessions (EC)*
1994 Development	54	10.8
Full Development	222	44.4
Limited intervention	225	45.0

(**Note**: These diversion figures do not include South Australian off-allocation use or Class B licences.)

Since 1989 there has been much discussion regarding the interpretation of commitment. There have, for example, been a number of management changes made since 1988, such as transferable entitlements and intervalley transfers, which, although they do not increase the commitment, make it more likely that entitlements will be used. Other contentious areas include the development of land and the construction of on-farm storages for the utilisation of off-allocation supplies. There were no controls on these developments in 1988 but was there a commitment to them? Although a report which describes the commitment was prepared by the Commission at the time (MDBC Technical Report 89/2), that report does not contain comprehensive details and was not intended as a policing document.

As a first attempt at more tightly defining the Salinity and Drainage Strategy benchmark, each State was asked to propose the way that the 1988 commitment level should be interpreted for its rivers. The differences between the commitment level proposed by each State and the 1988 Development Scenario are described in more detail in **Appendix D**.

Table 10 lists the difference in salinity between the Trial Salinity and Drainage Benchmark and 1988 conditions. This difference is due only to the reduction in dilution flow and does not allow for any increase in salt accessions.

Additional model runs were conducted to determine the contributions of the individual States to the difference between the benchmark and 1988 Development. The results are listed in **Table 11**.

This is the first time that an attempt has been made to model the 1988 commitment level that constitutes the diversion conditions for the Salinity and Drainage Benchmark. Although there may still be some discussion about the assumptions that have been

Table 10.
Difference in River Murray Salinity Between Trial Salinity and Drainage Benchmark and 1988 Development Scenario (Average Salinity in EC)

Site	*1988 Development Salinity*	*Trial Salinity and Drainage Benchmark*	*Difference Benchmark Less 1988 Development*
Euston	255.5	266.0	10.6
Merbein	346.4	358.1	11.7
Lock 9	358.7	361.0	2.3
Renmark	392.9	397.9	5.0
Berri	424.1	431.6	7.5
Morgan	536.7	557.1	20.4
Murray Bridge	577.7	605.7	28.1
Cost of Salinity ($m/year)			**2.82**

used in this trial, the results indicate that there will be a substantial difference between the final benchmark and the 1988 conditions. The size of this difference may not have been expected by all parties when the decision was made on the benchmark in 1989.

Significance of Salinity and Drainage Strategy Benchmark

The importance of the Salinity and Drainage Strategy diversion benchmark is that it fixes the level at which a State becomes accountable for the salinity impacts of further diversion growth. It may also be used in the future to determine the credits assigned to a State that adopts policies that prevent development from reaching the benchmark level. The benchmark does not, however, establish an upper limit on diversion in a State. If the State is prepared to allocate the appropriate salinity credits, it is quite entitled to exceed the benchmark.

The Salinity and Drainage Strategy Benchmark is the only environmentally based constraint in the Murray-Darling Basin Agreement that affects a State's rights to make full use of the water resources in its tributaries. It has been argued that, as such, the Salinity and Drainage Strategy benchmark should be used as a starting point for any future policies that limit diversions to achieve objectives related to river health. Before the merits of this argument are discussed, some additional work may be required to refine the details of the benchmark.

Salinity Increases Caused by Development in Queensland

Since Queensland is not yet a party to the Salinity and Drainage Strategy, its development was not included in the trial benchmark and the consequences of development in that State were not included in **Table 11**. To assess the impact of development in Queensland on Murray salinity, a separate modelling study was carried out. For this study, Queensland diversions were increased to their Full Development levels while development in all other systems was kept at the 1988 level. The results of this study are presented in **Table 12**.

Compared with 1988 conditions, the growth in diversions in Queensland results in reduced diversions by the other States in the Barwon/Darling and in the Murray. The reduction in diversion in the Murray, combined with the necessity to transfer more water from Hume Dam to compensate for reduced Darling flows, causes the modelled salinity in the Murray upstream of the Darling junction to be reduced. Downstream of the junction, salinities tend to increase as a result of reduced dilution.

Table 11.
Contributions of Individual States to Difference Between 1988 Development and the Trial Benchmark

	NSW	*Victoria*	*South Australia*	*Total*
Merbein Salinity	3.1	8.6	0.0	11.7
Morgan Salinity	7.0	8.7	4.7	20.4
Murray Bridge Salinity	10.6	9.8	7.6	28.1
Cost of Salinity ($m/yr)	**0.94**	**1.06**	**0.82**	**2.82**

9 Achieving the Balance

Defining the balance between the amount of water to be allocated to irrigation and the amount to be allocated to alternative uses such as non-irrigated agriculture, the environment, tourism, and human consumption is technically complex and will require difficult choices to be made between the interests of various sectors of the community.

Problems with the Current Allocation System

Across the Basin over the last five years, 48 per cent of the announced allocation on regulated streams remained unused at the end of the season and 61 per cent of the licensed irrigation area on unregulated streams was not irrigated. The introduction of water trading, now well underway, and other changes such as technical developments in the irrigation industry, new management procedures for the distribution of water and the development of new crops and marketing opportunities, are generating considerable pressure for the slack in the allocation system to be taken up.

Most water diversions from the rivers of the Murray-Darling Basin are made under licence. The licensing of water diversions currently serves two main functions:

- to establish a basis for sharing water during periods of restriction; and
- to recover the cost of water regulation and distribution activities.

In most areas of the Basin the current licensing and allocation system only limits diversions during drought periods. In droughts there is a limited quantity of water available and the allocation system shares it out between licence-holders. During wetter periods, practices such as off-allocation declarations, the allowance for under-usage in the allocation process, the announcement of unlimited allocations, the provision of over-draws and the low level of rigour in monitoring and enforcement, all encourage rather than restrict diversions.

In non-drought years, factors other than the licensing system have been limiting diversions. These factors include:

- activities in the south of the Basin that are not suitable for opportunistic watering;
- low levels of on-farm storage in the south of the Basin;
- irrigation system infrastructure limits;
- river channel capacity;
- an undeveloped market for water entitlements; and
- low returns from irrigation.

The licensing and allocation practices in the Basin evolved during the period when the water resources of the Basin were being developed. The primary responsibility of water managers then was to encourage the economic use of the water resource and to achieve the greatest economic return from the considerable public investment in irrigation infrastructure. Until recent years, little consideration was given to limiting diversions to ensure that the quality of the water and the river environment was maintained.

If it is decided to cap growth in diversions then the options that will need to be discussed include:

- lowering annual allocations;
- changes to off allocation policies on both regulated and unregulated streams;
- restrictions on the construction of off-river storages;
- reduction of entitlement by administrative deed or "buy-back" as appropriate on rivers under stress;
- arrangements for interstate trade; and
- better monitoring/recording and reporting of usage and compliance.

Table 12.
Impact of Development in Queensland on River Murray Salinity (Average Salinity in EC)

Site	1988 Development Salinity	Full Development of Queensland Entitlements	Difference
Euston	255.5	254.4	-1.1
Merbein	346.4	343.7	-2.7
Lock 9	358.7	357.3	-1.4
Morgan	536.7	538.0	1.3
Murray Bridge	577.7	579.5	1.8
Cost of Salinity ($/yr)			**35 000**

Options for the Future

Whatever form the decision about the desirable balance between the competing demands for water ultimately takes, the interests of important sections of the community will be substantially affected. Consequently, a thorough process of community consultation and participation will be required before any long term decision can be made and accepted.

Some of the key questions which need to be discussed are:

(1) The Murray-Darling Basin Ministerial Council has the policy "to maintain and, where appropriate, improve existing flow regimes in the waterways of the Murray-Darling Basin to protect and enhance the riverine environment." How well do the results of the Water Audit, especially the estimates of future growth, reflect this policy?

(2) What are the key components of river flow regimes that can be adopted to ensure a sustainable riverine environment and what management strategies can be implemented to affect these changes?

(3) What are the costs associated with the implementation of these management strategies?

(4) How is the environment to be represented in the sharing of the water resource and how should the environment's share be managed?

(5) Where there is to be an adjustment in water allocation and/or supply patterns, what will be the impacts on communities in the Basin and who pays for the adjustment?

Appendix A

The Major Types of Water Entitlement in the Murray-Darling Basin

High security entitlements on regulated streams.

A regulated stream is one to which water can be supplied by releases from a storage. High security entitlements do not vary from year to year and are expected to be available in all but the worst droughts.

Normal security entitlements on regulated streams.

A normal security entitlement establishes the entitlement holder's share to the water resources in a regulated system. Each year the system managers announce the volume of water allocated to water users. This allocation is expressed as a percentage of the base entitlement. Maximum announced allocations differ markedly in the different river systems, varying from 60 per cent in the Border Rivers to 200+ per cent in Victoria. The quantity of water that each entitlement holder can divert is also affected by the announcement of periods of off-allocation at times when the flow in the river is uncontrolled. Diversions made during these periods do not count against the allocation.

Unregulated stream entitlements

Entitlements on unregulated streams are generally expressed as an entitlement to irrigate a certain area. There are usually conditions on the licence specifying the minimum flow in the river before pumping can commence and the maximum rate of pumping. Because the stream is unregulated, water is not always available when it is required.

Water harvesting entitlements

Water harvesting entitlements are similar to unregulated stream licences with the exception that there is no limit placed on the total quantity of water that can be diverted nor the area that can be irrigated. However, the flow at which pumping can be commenced is set at relatively high levels and the maximum rate at which water can be diverted is also specified.

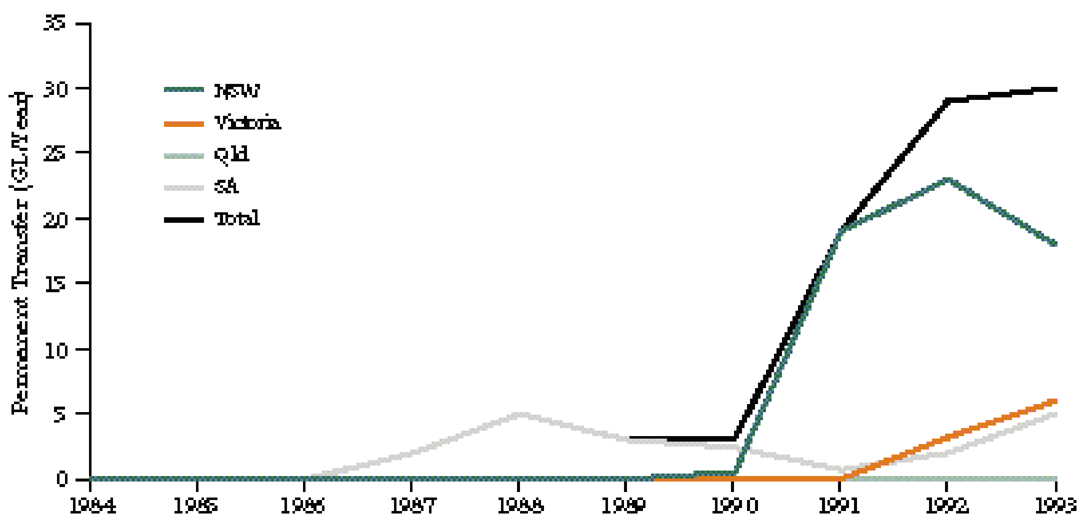
Appendix B

Details of Water Trading

Permanent Transfers

The right to make permanent transfers of base water entitlement was introduced in South Australia in 1982, in New South Wales and Queensland in 1989 and in Victoria in 1991. Prior to that date, some de facto transfers had occurred involving the sale of land with an entitlement to an existing irrigator and the subsequent amalgamation of the two water

FIGURE B1. Permanent Water Entitlement Transfers



Key Points to Note from this Figure

- Permanent transfers only commenced relatively recently.
- Rate of transfers increasing.
- Total permanent transfer to date is about 1% of total water entitlement.
- Trading in water entitlement is likely to lead to activation of sleeper entitlements.

entitlements. The traffic in permanent transfers is plotted in **Figure B1**. Since 1982, permanent transfers equal to 1 per cent of the base water entitlement have been made.

Temporary Transfers

Temporary transfers have been possible in South Australia since 1982, in New South Wales since 1983, in Victoria since 1987 and in Queensland since 1988. Trends in the volume of transfers are plotted in **Figure B2**. This graph indicates that the temporary transfer market has been growing in recent years. Between 1988 and 1993 the transfers ranged between 1 and 3 per cent of the total water allocation.

Growth in On-farm Storage

The capacity of on-farm storage on irrigation properties is the key factor determining how much use an irrigator can make of unregulated and off-allocation flows. In the north of the Basin the capacity of on-farm storages has more than doubled over the last five years to a value of 1150 GL. The growth in on-farm storage over the last six years is plotted in **Figure B3**.

Appendix C

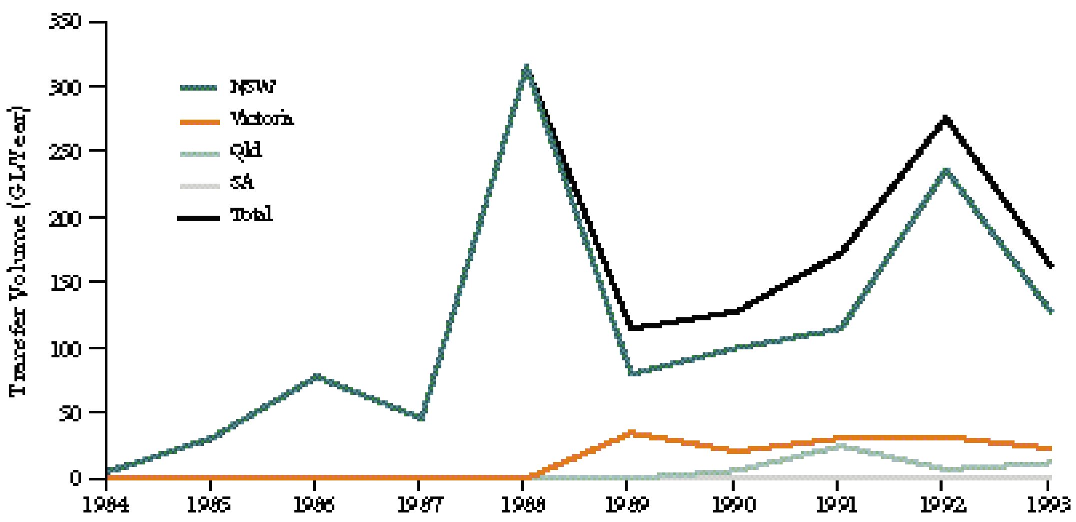
States' Key Assumptions for Full Development Scenario

Differences between Full Development Scenario and 1994 Development

New South Wales

- Darling River and tributaries:
  - — Maximum area irrigated increased by 25 per cent;
  - — On-farm storage capacity increased by 32 per cent; and
  - — Pindari Dam enlarged.
- Diversion by Lowbidgee system increased by 40 per cent.
- No development of on-farm storage on Murray or Murrumbidgee.
- Lower Darling irrigation increased to use full entitlement.
- Murray Irrigation increased to use the full allocation at the time that planting decisions are made.

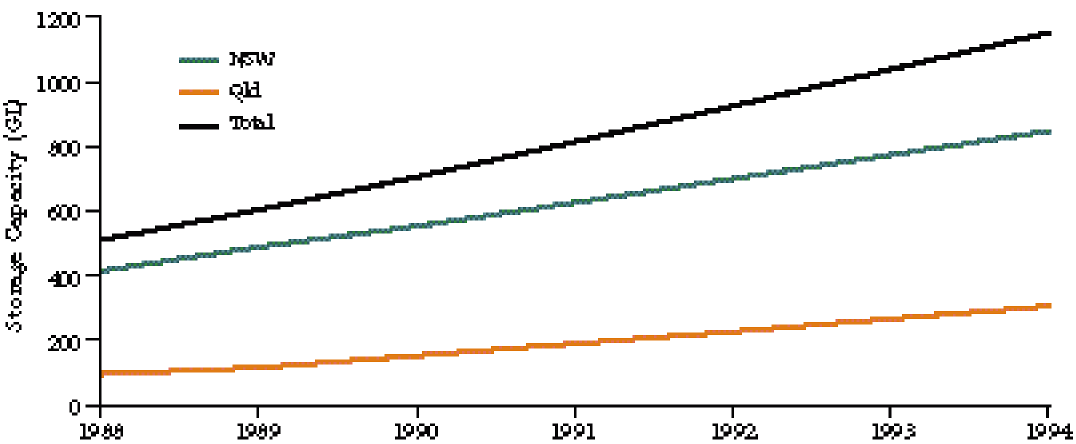
FIGURE B2. Temporary Water Entitlement Transfers (GL/year)



Key Points to Note from this Figure

- Trade in temporary entitlements is affected by the seasons.
- The rate of transfers increasing.
- Temporary transfers currently range between 1 and 3% of total water entitlement.
- Trading in water entitlements is likely to lead to greater utilisation of allocations.

FIGURE B3. On-Farm Storage in Murray-Darling Basin (GL)



Key Points to Note from this Figure

- Total on-farm storage capacity more than doubled between 1988 and 1994.
- On-farm storage development is concentrated in the north of the Basin where water supplies are less reliable and cotton growing is profitable.
- On-farm storage enables irrigators to harvest unregulated flows.

Victoria

- Goulburn system diversions increased by 5 per cent.
- Murray system diversions increased by 5 per cent.
- 40 GL of Goulburn entitlement transferred to the Murray between Torrumbarry & Wakool Junction.
- New Murray demand between Torrumbarry and Wakool Junction of 50 GL supplied from Lake Mokoan.
- All offtake channel capacities increased by 5 per cent.
- Environmental flows increased downstream of Eildon Reservoir.
- No development of on-farm storage or off-allocation use.

Queensland

- On-farm storage capacity increased by 83 per cent.
- Condamine/Balonne system demands increased by 37 per cent.

South Australia

- Irrigation demand increased so that the average use by pumped irrigation is 90 per cent of the entitlement. This results in 100 per cent of entitlement being used in the drier years.
- Opportunistic use of up to 250 GL/year assumed during periods of off-allocation.
- Town water supply demands set to meet high estimates of population growth to the year 2026.

Australian Capital Territory

- Population growth expected to be 15 per cent over next ten years.
- Water use growth expected to be 10 per cent over similar period.
- Growth projected to 2010 to give 15 per cent increase.

Appendix D

Key Differences Between the Salinity and Drainage Strategy Benchmark Scenario and 1988 Development

New South Wales

- Darling River and Tributaries
  - — Maximum area irrigated increased by 13 percent.
  - — On farm storage capacity increased by 30 per cent.
  - — Base entitlements higher by 13 per cent.
  - — Barwon Darling licensed area higher by 21 per cent.

- Murrumbidgee
  - Maximum announced allocation 140 per cent rather than 120 per cent
  - High security entitlements 275 GL rather than 260 GL.
- Lower Darling
  - Full usage of entitlement rather than 38 per cent (54.3 GL used on Lower Darling plus 15.58 GL entitlement for Tandou).
  - Higher demands by Tandou Lakes (80 GL/year compared with 40 GL/year).
- Murray
  - Maximum announced allocation 160 per cent rather than 140 per cent.
  - Utilisation by river pumpers increased so that the peak diversion equalled the base entitlement multiplied by the maximum allocation (160 per cent*500 GL +170 GL). This corresponds to an increase in demand by river pumpers of 138 per cent over 1988 levels.

Victoria

- Goulburn
  - All demands increased by 26.5 per cent over 1988 levels (5 per cent over 1994 levels).
- Murray
  - Yarrawonga and Torrumbarry demands up 13.8 per cent (5 per cent over 1994), Sunraysia demands up 5 per cent, other demands up 22.6 per cent (15 per cent over 1994 levels).

Queensland

- Condamine/Balonne — No change from 1988 conditions
- Border Rivers
  - on-farm storage decreased by 5 per cent.
  - maximum area irrigated increased by 74 per cent.

South Australia

- Pumped irrigation increased to average 90 per cent of the 496 GL pumped entitlement. (This figure includes a 29 GL allowance for delivery and metering losses in the Government pumped districts.)
- Peak demand from Murray for domestic, town and stock supplies of 315 GL/year (based upon a figure quoted in a 1987 Department of Engineering and Water Supply document). This figure corresponds to an average South Australian demand of 352 GL/year from all sources, and an average demand for supply from the Murray of 189 GL/year.

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