Australian Government

MURRAY–DARLING BASIN AUTHORITY

Guide to the proposed Basin Plan

Volume 1

Overview

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Disclaimer

Volume 1 (*Guide to the proposed Basin Plan: Overview*) has been prepared by the Murray–Darling Basin Authority for public consultation purposes, using the best efforts to ensure that the material it presents is current and accurate. The opinions, comments and analysis (including those of third parties) expressed in this document are for consultation purposes only. There are a further 20 volumes that are being prepared by the Chief Executive of the Murray–Darling Basin Authority to further inform public discussion about the proposed Basin Plan. To the extent that there is a material inconsistency between this document and other volumes of the *Guide to the proposed Basin Plan*, then the policy intent in this document prevails.

This document does not indicate the Murray–Darling Basin Authority's commitment to undertake or implement a particular course of action, and should not be relied on in relation to any particular action or decision taken in respect of the proposed Basin Plan. Users should note that developments in Commonwealth policy, input from consultation and other circumstances may result in changes to the approaches set out in this document.

Descriptive information about the Basin, regions within it, and their history and development has been collated primarily from previously published sources. The Murray–Darling Basin Authority makes no warranty as to the accuracy or completeness of this information. Material in this volume is based on the latest information available at the time of writing.

Cover image:

Irrigation farming with River Murray in foreground near Mildura, Victoria

Foreword

The release of the *Guide to the proposed Basin Plan* represents a significant step towards the historic adoption of the first Basin Plan in 2011.

While the Murray–Darling Basin Authority (the Authority) is charged with developing a Basin Plan for the Minister's consideration, this occurs within the framework of the *Water Act 2007* (Cwlth). The Commonwealth Parliament in 2007 and 2008 clearly laid out the general objectives of the Water Act, and prescribed how the Basin Plan was to be developed. The Water Act requires the Authority to determine the volume of water required to maintain and restore environmental assets, using best available science and the principles of ecologically sustainable development. Subsequently the Authority addressed the optimisation of environmental, social and economic outcomes.

This volume of the Guide provides an overview to assist people to understand the basis of the proposed Basin Plan, and the rationale behind the proposals presented by the Authority for discussion. Supporting volumes of the Guide are technical documents that are being developed by the Chief Executive and staff of the Authority to assist in informing public discussion on the proposed Basin Plan.

The Guide is the result of considerable work over the past 18 months to shape the decisions underpinning the proposals described. This includes extensive scientific analysis of the Basin's ecology, identification of the key environmental assets and key ecosystem functions and their water requirements, detailed hydrologic modelling using models developed by Basin states and the Authority, and detailed social and economic analyses to assess the potential impacts of meeting the environmental water requirements of the Basin. While the best available information and analysis underpin this work, the Authority recognises the limitations of the available data and the capacity of any modelling exercise.

The Guide sets out discussions on environmental water requirements, volumes of water that can be taken for consumptive use — known as long-term average sustainable diversion limits (SDLs) — for surface water and groundwater, and transitional arrangements to support implementation of the SDLs. The Guide also outlines how the Authority proposes to put the Basin Plan into effect.

In developing proposals for surface-water SDLs, the Authority explored a number of scenarios to understand the trade-offs between risk to the environment and social and economic effects. While all the scenarios considered meet the objectives of the Water Act, the Authority is aware that they also have significant social and economic implications. With this in mind the Authority is seeking the views of the community and stakeholders on a range of possible SDLs.

The proposals in this Guide are put forward for consultation, discussion and debate and the Authority wants to receive community and stakeholder views. While the Authority has taken care to ensure it has used the best available information and knowledge, there will still be issues where new information or fresh eyes will make a useful contribution.

We invite this input.

Chair	Michael Taylor, AO
Members	Dianne Davidson
	Dr Diana Day
	Rob Freeman (MDBA Chief Executive)
	David Green
	Professor Barry Hart

Volumes of the Guide to the proposed Basin Plan

The *Guide to the proposed Basin Plan* comprises a series of publications that are being prepared to inform consideration and discussion of the proposed Murray–Darling Basin Plan.

While the Basin Plan itself will be a legislative instrument, the *Guide to the proposed Basin Plan* provides information on the background and process of developing all the different parts of the plan. This information includes:

- a summary of the history and current state of Basin water resources
- the factors driving change in use and management of water resources
- the new arrangements under the Basin Plan and their impacts
- implementation of the Basin Plan.

The volumes of the *Guide to the proposed Basin Plan* are:

1 Overview
2 Technical background
3 Barwon–Darling region
4 Border Rivers region
5 Campaspe region
6 Condamine–Balonne region
7 Eastern Mount Lofty Ranges region
8 Goulburn–Broken region
9 Gwydir region
10 Lachlan region
11 Loddon region
12 Lower Darling region
13 Macquarie–Castlereagh region
14 Moonie region
15 Murray region
16 Murrumbidgee region
17 Namoi region
18 Ovens region
19 Paroo region
20 Warrego region
21 Wimmera–Avoca region

Acknowledgement

In preparing this overview of the *Guide to the proposed Basin Plan* the Murray–Darling Basin Authority has drawn on the knowledge and support of many individuals, organisations and communities. Some of these have been involved in developing underpinning information and knowledge, assisting with the development of policy positions, or technical scrutiny of early drafts. The Authority and staff would like to thank everyone for their assistance, including the community members who participated in workshops and forums and provided feedback and comments (See Appendix A).

Contents

Executive summary

Information on how to provide feedback as well as additional details on the technical details and work that supports the proposals outlined in this document can be found on the MDBA website at www.mdba.gov.au, by phoning 1800 230 067, or via email to engagement@mdba.gov.au

Introduction — the purpose of the Guide

The Murray–Darling Basin Authority (the Authority) is preparing the *Guide to the proposed Basin Plan* to present proposals to the community for discussion. These proposals are about the key decisions the Authority is required to make under the *Water Act 2007* (Cwlth), in particular the new limits on water that can be taken from the Basin, known as long-term average sustainable diversion limits (SDLs), which will apply to both surface water and groundwater. The proposed Basin Plan (a legislative instrument) will be released later this year or early next year.

This document sets out proposals on the main issues in the plan. The Authority is endorsing the issuing of the overview, noting that it represents a set of proposals based on the information provided to the Authority by its staff, state and federal governments, stakeholders, consultants and others. A technical background to the Guide (volume 2) provides greater scientific detail, with 19 regional guides dealing with the specifics of each region and the proposals as they affect each region. Volume 2 and the regional guides are being approved for release by the chief executive.

The Authority is interested in the views of the community and stakeholders on the proposals in the Guide and on the quality of data and evidence used and the analysis that has been undertaken. The Authority will consider any feedback in finalising the Basin Plan.

How volume 1 is structured

The Guide, through its overview and accompanying volumes, reflects the mandatory content of the Basin Plan. This executive summary to the overview is lengthy; however, it summarises the detail in the overview and presents the logic and analysis that underpin the proposals, which are presented for consultation, discussion and feedback.

The overview is structured around three broad areas:

Chapters 1 to 5 — Background and context

These chapters provide important context for the proposals. They cover:

- Chapter 1: The purpose of the overview, the consultation process, the roles and responsibilities of key institutions such as the Authority, the Commonwealth Water Minister, and the Basin states, and the outcomes that the Authority expects from the plan.
- Chapter 2: A description of the Basin and its importance to Australia in economic, social and environmental terms.
- Chapters 3–5: A description of the imperatives for change including the history of reform, the key challenges and risks facing the Basin and its communities, and the methodology used to prepare the proposed Basin Plan.

Chapters 6 to 11 — Proposals on decisions required by the Water Act 2007 (Cwlth)

These chapters are the critical part of the Guide overview. They need to be read together as each is interrelated. They outline:

- Chapter 6: Proposals on the amount of water needed to achieve the environmental water requirements of the Water Act.
- Chapter 7: Analysis of the potential social and economic effects of reductions to current diversion limits to meet the environmental water requirements.
- Chapters 8–9: Consideration of scenarios for long-term average sustainable diversion limits (SDLs) for surface water and groundwater, drawing on the social and economic analysis in conjunction with the environmental water requirements.
- Chapter 10: Proposals for meeting critical human water needs.
- Chapter 11: Proposals on transitional arrangements to implement SDLs.

Chapters 12 to 15 — Basin Plan implementation, monitoring and compliance

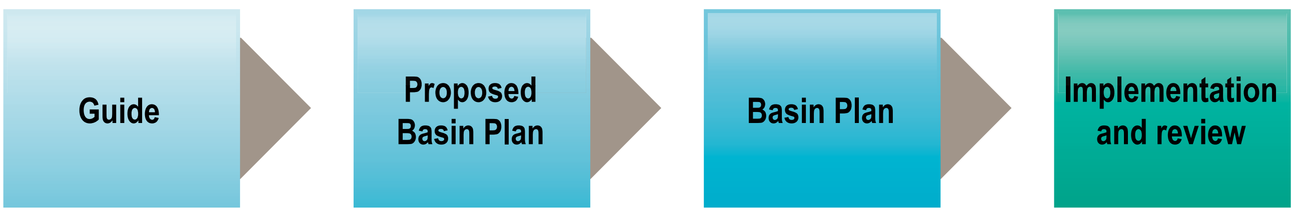
These chapters cover the key implementation requirements of the Water Act regarding how the plan will be put into effect through an Environmental Watering Plan, a Water Quality and Salinity Management Plan, water trading rules and the requirements for Basin state water resource plans. These chapters also cover how the plan will be monitored and reviewed.

The Guide overview also covers an assessment of the intended outcomes of the Basin Plan (Chapter 13) if the SDL proposals are adopted, before providing commentary on additional issues the Authority considers important, but are outside the scope of the Authority in the development of the proposed Basin Plan (Chapter 15).

Chapter 16 outlines the next steps in the process.

The consultation process

The Guide provides an additional step in the process of developing the Basin Plan. The Guide will be followed by the release of the proposed Basin Plan (the legislative instrument) by late 2010 to early 2011 for detailed and extensive consultation, then the Basin Plan (late 2011) and the state water resource plans (2012–19).



The Guide is a plain language explanation of the proposed Basin Plan, written in a clear and explanatory style. The Guide enables the Authority to present ideas for discussion and expose the data and the thinking behind those ideas to public scrutiny, and also prepare people for the proposed Basin Plan. The Guide has been prepared for discussion purposes, but this should not preclude feedback on any proposals that meet the requirements of the *Water Act 2007* (Cwlth).

This additional step recognises the complexity of the task of developing the Basin Plan — a task that has not been undertaken to this scale anywhere else in the world and which has required not only the collection and analysis of large amounts of existing information, but also the need to commission additional work.

The Authority is seeking to generate discussion and feedback on the proposals in the Guide. The Authority will also continue to undertake discussions with Basin states as well as peak representative organisations. The Authority will seek ongoing expert advice and input into Basin Plan development. Importantly, the Authority will continue to consult with Basin communities about the proposals contained in the Guide.

The Authority will incorporate feedback on the Guide into the finalisation of the Basin Plan. This means the community and key stakeholders will have the opportunity for maximum input into the development of the Basin Plan.

Background and context to the development of the proposed Basin Plan and the Guide

The history of reform

The history of Australian water reform, the requirements of the legislation and the challenges facing the Basin and its communities form a critical backdrop to the proposed positions developed by the Authority. This background provides important context for the Guide and the proposed Basin Plan that will follow.

The *Water Act 2007* (Cwlth) is very specific in respect of its requirements of the Authority and the content of the Basin Plan. As such, the Guide steps through the legislative requirements and the relative priorities for certain decisions such as setting environmental watering requirements for the Basin.

The Water Act and the proposed Basin Plan build on a long history of water reform in Australia. Much of this reform has centred on the future environmental, social and economic health of the Murray–Darling Basin. For more than a decade, the Australian Government and Basin states have been working together to restore the environmental health of the Basin and redress past decisions.

In 2007, supported by both sides of Federal Parliament, the Water Act was passed to deal with the management of water resources in the Basin in the national interest. The Water Act established the Murray–Darling Basin Authority and tasked it with preparing a Basin Plan. In 2008, again supported by both sides of Federal Parliament, amendments to the Water Act were passed to enhance the arrangements.

The development of the Basin Plan is supported by other significant water reforms. These include:

- The National Water Initiative, which, among other things, establishes the principle of risk and cost-sharing for the recovery of additional water for the environment between the Australian Government, Basin states and individual entitlement holders. These principles are a critical consideration for the Authority's proposals on transitional arrangements and risk allocation.

- The Australian Government's Water for the Future program, which allocates $12.6 billion over 10 years to restore the health of the Basin. Two critical elements of this program are important for the development of the Basin Plan:
  - The first of these is establishment of the Commonwealth Environmental Water Holder to manage water purchased in the market. The purchasing of water for the environment from willing sellers will reduce the potential impact on individual water entitlement holders from potential reductions to entitlements. The Authority has factored this into its assessment of the potential impacts of reductions in current diversion limits.
  - The $5.8 billion investment (part of the $12.6 billion program) in water efficiency projects, which will also generate additional environmental water.

The requirements of the Water Act

The objects of the Water Act

The Water Act establishes the Authority as the body responsible for developing and overseeing a framework for the management of the Basin's water resources in the national interest.

The objects of the Water Act give the Authority clear guidance about the management of the water resources of the Murray–Darling Basin. The Authority is required to:

- give effect to relevant international agreements
- protect, restore and provide for the ecological values and ecosystems services of the Basin
- promote the use and management of Basin water resources in a way that optimises economic, social and environmental outcomes
- ensure the return to environmentally sustainable levels of extraction for water resources that are overallocated or overused
- maximise net economic returns to the Australian community from the use and management of Basin water resources while protecting, restoring and providing for the ecological values and ecosystems services of the Basin.

The mandatory decisions required by the Water Act

Under the Water Act the Authority has three broad areas for mandatory decision making. These require the Authority to:

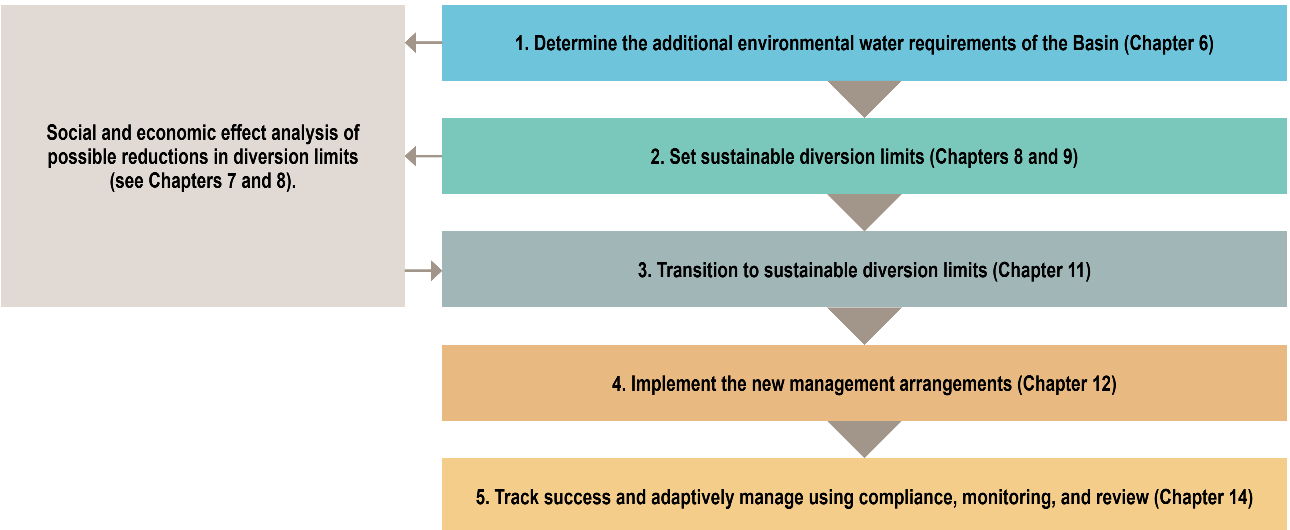
- determine the amount of water needed for the environment, known as the environmental water requirement, to protect, restore and provide for the ecological values and ecosystem services of the Basin
- establish long-term average sustainable diversion limits (SDLs), which must not compromise key environmental assets (including water-dependent ecosystems, ecosystem services and sites with ecological significance), key ecosystem functions, the productive base and key environmental outcomes for the water resource
- provide advice on appropriate transitional arrangements to SDLs and in particular advise on the Australian Government's share of meeting the costs of returning water to the environment as part of the risk allocation provisions of the Water Act.

The process the Authority has used to develop proposals

In accordance with the Water Act, the Authority has followed the process outlined below to develop the proposals in the Guide. It has:

- established a range for the amount of water needed for the environment based on the best available science. Additional water that falls within that range will meet the environmental water requirements of the *Water Act 2007* (Cwlth)
- considered the social and economic effects of providing additional water to the environment within that range, to meet its statutory requirement to optimise economic, social and environmental outcomes
- considered scenarios for establishing surface-water and groundwater long-term average sustainable diversion limits (SDLs) and how they will balance the environmental water requirements with the potential social and economic impacts
- presented SDL proposals for surface water and groundwater that meet these requirements
- examined the social and economic effects of the SDL proposals
- in response to the social and economic assessment, developed proposals for transitional arrangements to support communities, individuals, industries and businesses to make the transition to the SDLs, when finalised.

The decision-making process is also described in the following diagram.



The imperative for change

The Authority is acutely aware of the urgency and importance of restoring the ecological health of the Basin.

The water reform process being undertaken by the Australian Government and Basin states recognises the vital role the Basin plays in the environmental, social and economic wellbeing of Australia. The Basin and its communities, however, are facing significant challenges and risks.

Many of these challenges and risks are the direct result of the actions of successive governments over the history of the Basin. In retrospect many of these decisions failed to strike a long-term balance between meeting the needs of the environment and those of a growing economy and population.

The Authority recognises that the impacts of the necessary adjustments fall on the current generation of farmers and irrigators, industries and communities. This is why it is essential that effective transitional arrangements be put in place to help businesses and individual water entitlement holders adjust to change, and why action must continue to be taken to maintain strong and prosperous regional communities.

Irrigation used on a pecan orchard near Moree, New South Wales

The Authority also recognises that the environment has not had sufficient water for decades. This has led to serious environmental decline in many parts of the Basin. The real possibility of environmental failure now threatens the long-term economic and social viability of many industries and the economic, social and cultural strength of many communities.

Over the past few decades the focus has swung primarily to looking at the economics of the Basin and what it can produce, such that the role of the environment in underpinning that economic development has been somewhat overlooked. If the focus does not swing back towards considering water required for the environment, then the nation risks irretrievably damaging the attributes of the Basin that enable it to be so productive.

The Australian Government and the Basin states, in passing the *Water Act 2007* (Cwlth) and agreeing to a referral of certain powers, recognised the need for urgent action. Unless action is taken now to redress the imbalance between water taken for the environment and water used for consumptive purposes, there is a risk that the Basin will face an irreversible environmental, economic and social decline.

The following 'snapshot' highlights the critical environmental, economic and social challenges that must be addressed in developing the proposed Basin Plan.

Snapshot of the Basin and its challenges

The Basin is a highly significant factor in Australia's ecological health, containing some of the country's most diverse and rich natural environments.

It is home to one world heritage site and 30,000 wetlands, of which 16 are Ramsar listed, providing critical habitat for 95 Basin state and Commonwealth-listed threatened inundation-dependent fauna species.

The Basin is also a critical part of Australia's economy and its food security. It contributes 39% of national agricultural production and provides for the critical water supplies of more than three million people.

The Basin is home to some two million people and is a critical cultural asset to the many Aboriginal nations who live in the Basin.

However, the Basin is under enormous stress as a result of past water management decisions and a severe and prolonged drought. Both of these factors risk being compounded by natural climate variability and climate change.

Twenty out of 23 catchments in the Basin are in 'poor' to 'very poor' ecosystem health. The past decade has seen increasing water quality problems and more frequent outbreaks of blue-green algae blooms.

The amount of surface water diverted for consumptive use such as towns, industry and irrigation has increased from about 2,000 GL/y in 1920 to entitlements of approximately 11,000 GL/y in the 1990s. However, the impact of drought over the past decade has seen actual diversions drop significantly.

The combination of drought and historic diversions means that there have been no significant flows through the Murray Mouth since 2002.

Against this backdrop of the requirements of the Water Act and the imperative for change, the Authority has established a set of objectives and a set of outcomes expected as a result of meeting those objectives. These outcomes cover improvements in ecological health, water quality and water management arrangements.

Achieving the objectives and outcomes will require a robust partnership between Basin states, the Australian Government, the Authority and Basin communities.

The method used to prepare the Guide and the proposed Basin Plan

The Guide and the proposed Basin Plan build on a comprehensive process of research, data analysis, stakeholder consultation and hydrological modelling, undertaken over an 18-month period. Some of the key elements of the process undertaken so far include:

- In June 2009, a concept statement was released for the development of the Basin Plan (www.mdba.gov.au/basin_plan/concept-statement).
- In November 2009, the Authority developed an issues paper on the development of long-term average sustainable diversion limits (SDLs) for general community consultation. The community responses to that SDL paper have been carefully considered in the development of the Guide and can be found on the Authority's website (www.mdba.gov.au/basin_plan/sdl-submissions).
- The Authority has released a number of technical reports over the past 12 months including a Social and Economic Context for the Murray–Darling Basin report released in September 2009.
- The Authority released a stakeholder engagement strategy in November 2009. This strategy sets out how the Authority will consult and work with states, the Basin Officials Committee, peak bodies, the Basin Community Committee and the Basin community.
- Three Basin-wide stakeholder engagement forums have been held; two in December 2009 and one in April 2010. The purpose was to build stakeholders' understanding of the Basin planning process by providing an opportunity for interaction with the Authority and for the Authority to receive feedback from stakeholders on a range of issues related to the development of the Basin Plan. Indigenous forums have also been held, including two with the Murray and Lower Darling River Indigenous Nations group and two with the Northern Murray–Darling Basin Aboriginal Nations group.
- The Authority has also conducted individual meetings with key stakeholder groups, peak bodies and communities, including presentations and discussions. The Authority has directly consulted with and received advice from the Basin Community Committee. It has also provided information stands at regional meetings of the Basin Community Committee.

The Authority has also undertaken extensive hydrologic modelling (using the hydrologic models developed by the Basin states), data analysis and social and economic modelling.

The hydrologic modelling and data analysis has been the subject of extensive expert and peer review. That peer review has confirmed that the analysis and approaches represent the best available science.

The Authority acknowledges, however, that there are inherent limitations with data analysis and hydrologic modelling of this scale and complexity. Therefore, the Authority has exercised its judgement on matters such as proposals for SDLs.

In respect of the requirements of the *Water Act 2007* (Cwlth) for the Authority to consider and balance social and economic impacts, considerable analysis has been undertaken. This has sought to test potential effects at an individual, community, industry and business level. It has attempted to examine both direct and indirect effects.

The Authority recognises the critical nature of economic and social effects. It has therefore commissioned additional work to inform the finalisation of the Basin Plan. This includes further analysis of the wider economic effects of reductions in current diversion limits on communities and, in particular, small and medium enterprises, which operate in many of the regions that will be most affected.

A detailed cost-benefit analysis has also been commissioned on the range the Authority is considering for surface-water SDLs. This analysis is intended to sharpen the Authority's decision making on the trade-offs between generating additional water for the environment and minimising social and economic effects on communities, and will be considered in developing the proposed Basin Plan.

The proposals on mandatory decisions

Environmental water requirements

Requirements of the Water Act

The *Water Act 2007* (Cwlth) requires the Basin Plan to include long-term average sustainable diversion limits (SDLs). In simple terms, this means the amount of water used for consumptive purposes (drinking water, industry, irrigated agriculture, etc) after environmental needs have been met in accordance with the environmental water requirements of the Water Act. This is described in the Water Act as the 'environmentally sustainable level of take'.

The Water Act is quite specific in respect of the environmental water requirements. It says that the environmentally sustainable level of take or amount of water used for consumption must not compromise:

- key ecosystem functions
- key environmental assets (including water-dependant ecosystems, ecosystem services and sites with ecological significance)
- the productive base of the water resource
- the key environmental outcomes for the water resource.

The method used to determine environmental water requirements

Establishing a baseline

The first step in determining the environmental water requirements was to establish a baseline about how water is used now and in particular how water is currently shared between the environment and consumptive uses.

This analysis shows that:

- the long-term average rainfall for the Basin is about 500,000 GL/y
- the amount of rainfall that ends up in the river system, which is referred to as inflow, is about 32,800 GL/y and for groundwater recharge is about 26,500 GL/y
- the average amount of that inflow that is used for consumption is 15,400 GL/y. This is made up of 13,700 GL/y surface water and 1,700 GL/y groundwater

- surface-water use is made up of 10,940 GL/y taken from watercourses and floodplains (watercourse diversions) and 2,740 GL/y is taken by farm dams and plantation forestry. This second category is generally referred to as interceptions and these are generally not as closely regulated
- the long-term average amount of water that would flow through the Murray Mouth if there was no development is about 12,500 GL/y. Although this is highly variable, on average, 83% of this would come from the Murray system and 17% would come from the Darling system
- at present, with current levels of development, the long-term modelled average amount of water flowing out of the Murray Mouth is about 5,100 GL/y.

Determining the environmental water requirements

Determining the amount of water needed for the environment is a complex task. It has never been done before in the Murray–Darling Basin at a whole-of-Basin scale.

To determine the amount of additional water needed for the environment the Authority has undertaken three tasks. It has:

- established the hydrologic characteristics of an environmentally healthy Basin on the basis that a healthy Basin requires the maintenance of the key ecosystem functions, key environmental assets, a productive base and key environmental outcomes for the water resource
- created a robust methodology for determining the amount of water required for an environmentally healthy Basin, in particular for key ecosystem functions and key environmental assets
- used this methodology to determine the Basin's environmental water requirements.

A healthy Basin environment is driven by the health of its key ecosystem functions (e.g. flow regimes within rivers and the ecological benefits these flows bring for connectivity such as fish habitat) and its key environmental assets (e.g. Macquarie Marshes, Narran Lakes and Barmah–Millewa Forest). The interplay between assets and functions drives the hydrology and ecological health of the Basin and underpins the modelling used by the Authority.

For surface water, the main determining factors of a healthy system are the key ecosystem functions and key environmental assets.

For groundwater, the main determining factors are key ecosystem functions, the productive base of water resources and key environmental outcomes.

The Authority has assessed the Basin's riverine, wetland systems and groundwater. Four ecosystem functions that were relevant for all parts of the Basin were identified and also 2,442 key environmental assets spread across the Basin.

To represent the complex and interconnected hydrology of the key ecosystem functions and key environmental assets, the Authority identified 106 'hydrological indicator sites', which were used to model the hydrologic flows for a healthy Basin environment. These 106 sites are made up of 88 sites to assess water requirements for key ecosystem functions and 18 sites to assess the water requirements of key environmental assets.

The Authority has set objectives and targets for the required environmental outcomes. The outcomes relate to particular catchments as well as outcomes to improve the Basin ecosystem as a whole. The Authority then determined the volume of water needed on a long-term basis that would deliver the type of flow regime that would ensure the health of rivers, wetlands, floodplain forests etc, as well as meeting the key ecosystem functions to ensure a healthy system as a whole. The variable nature of the Basin's climate means that a healthy ecosystem requires that the Basin's rivers receive frequent but irregular and variable water flows.

Amount of water needed for the environment

The analysis undertaken indicates that the amount of additional surface water needed for the environment is between 3,000 GL/y and 7,600 GL/y (long-term average).

Considering the current average volume of water provided to the environment of about 19,100 GL/y, this range of additional water would mean that the long-term average volume of water provided to the environment would be between 22,100 GL/y and 26,700 GL/y.

Onions growing on a farm near Coleambally, New South Wales

It is important to stress that notwithstanding the extensive research and modelling, it is not possible to set an exact figure for the amount of additional water needed for the environment as there are significant variables and uncertainties. The Authority is therefore using a range of water needed for the environment in determining its proposals.

With respect to groundwater, the Authority has identified that the total amount of additional water needed for the protection of groundwater bodies across the Basin ranges from 99 GL/y to 227 GL/y (long-term average). As individual aquifers are generally quite discrete, this range is the sum of the individual requirements to meet environmental water requirements of the Water Act.

The Authority is confident that for surface and groundwater systems, additional water within these ranges will achieve the environmental water requirements of the Basin. This judgement is obviously influenced by the bounds of certainty that the data and science allows. Nonetheless, the Authority also judges that providing water at the higher end of the range would on the whole deliver better environmental outcomes.

The Authority has had this approach peer reviewed by both national and international peer reviewers. They confirm that the approach is robust and represents the application of the best available science as required by the Water Act.

Social and economic effects considered in developing proposed sustainable diversion limits

The task of the Authority is to balance social and economic effects of reduced consumptive water with the requirement to determine the amount of water needed for the environment. This is not a simple task.

The Authority is conscious that the past management of water use in the Basin has resulted in overdevelopment and overallocation in some catchments. The Authority acknowledges that these decisions were made by successive governments, not by the individuals, communities and industries who make up the Basin. However, the requirement of the Water Act to return water to the environment to achieve an environmentally sustainable level of take will by definition, mean substantial reductions in current diversion limits.

The effects of reductions in water diversions will not be felt evenly by communities, businesses, industries and individuals throughout the Basin.

The Water Act requires the Authority to optimise economic, social and environmental outcomes and to maximise the net economic return for the Australian community from the use of the Basin's water resources.

The Authority has commissioned extensive social and economic analysis to advise it in key areas, such as proposing long-term average sustainable diversion limits (SDLs) for surface and groundwater (within the range of environmental water needed) and practical and sensitive transitional arrangements that will better assist communities, industries, individuals and businesses to adjust to reductions in current diversion limits.

These transitional arrangements in themselves may not be sufficient and action may be needed by all levels of government to maintain prosperous, resilient regional communities.

The Authority examined the potential impacts on individuals, industries and particular communities of the range of environmental water required. It tested a range of scenarios to understand the social and economic effects and implications for setting SDLs.

The Authority found that:

- The reduction in irrigated agricultural activity is modelled to be in the order of $0.8 billion/y gross, to meet the minimal reduction of 3,000 GL/y without offsets, although the Authority recognises that modelling of the effects can be difficult given the data limitations and the difficulty in predicting likely responses. The effect in the short term may be greater than this due to the flow-on effects on other parts of the Basin economy. The Authority has commissioned additional work to better understand the likely size of these flow-on effects.
- Depending on the actual size of the reduction in current diversion limits, this could have serious effects on some communities. Any reduction in water availability will affect communities.
- Industries with high water usage but lower or more volatile value products such as broadacre cereals, rice and cotton will be more severely impacted than other industries with higher value products such as grapes, nuts and fruit.

- Those regions with a relatively high dependence on irrigated agriculture would be expected to experience a larger reduction in economic activity compared to regions with more diverse economic activities. The regions expected to experience the greatest reduction in economic activity are Murrumbidgee, Moonie, Goulburn–Broken and, to a lesser extent, Condamine–Balonne, Murray (in all three states), Macquarie, Campaspe and Loddon.
- Smaller towns with heavy dependence on irrigated agriculture could experience greater social and economic implications due to their dependence and the lack of alternate industries.
- Severe and prolonged drought across the Basin (from 2000 to 2009) has resulted in a sustained period of substantially reduced water available for economic purposes. This has adversely affected the cash flows and capital and increased the debt levels of farms, households and businesses in the agriculture, forestry and fishing industry and related sectors.
- A significant proportion of Basin communities appear to have sufficient diversity of economic activity and social capital that they will be relatively resilient to the proposed reductions in diversions. However, several regions appear to be at a relatively higher risk of substantial social impacts, including in the north-east of the Basin, the Border Rivers, Gwydir, Namoi and Macquarie–Castlereagh regions and, in the southern Basin, the Lachlan, Loddon, Murrumbidgee and Murray regions.

Based on this analysis the Authority has made a number of critical judgements in developing these proposals.

First, the Authority decided only to examine scenarios for setting surface-water SDLs at the lower end of the range of additional water needed for the environment (that is the lower end of the 3,000 GL/y to 7,600 GL/y range).

The Authority believes reductions that exceed 4,000 GL/y will not meet the requirements of the Water Act. Indeed, reductions of this size would not represent an optimisation of the economic, social and environmental outcomes under the Water Act. The Authority therefore determined that it would only examine scenarios with reductions of between 3,000 GL/y and 4,000 GL/y.

Setting sustainable diversion limits for surface water

What is a long-term average sustainable diversion limit?

Long-term average sustainable diversion limits (SDLs) represent the amount of water which can be used for consumption after the environmental requirements have been met. As covered previously, the *Water Act 2007* (Cwlth) refers to this as an 'environmentally sustainable level of take'. The setting of SDLs will result in additional water being made available to the environment and in turn will result in a reduction in the amount of water that can be used for consumption.

Based on the different characteristics of surface water and groundwater the Authority has taken a slightly different approach for surface water compared to groundwater in setting these SDLs.

SDLs represent the long-term average volume of water that can be used for consumption. They will be applied to all forms of extraction from the Basin's water resources.

The SDLs will be applied to:

- Watercourse diversions — including diversions from watercourses to provide water for towns, community water supplies and irrigators and industries. These are normally provided by a system of entitlements administered by Basin states through water resource plans. Watercourse diversions also include floodplain harvesting which is normally included in water resource plans
- Interception activities — including uses such as farm dams and forestry plantations.

The combination of current levels of watercourse diversions and interception activities are referred to as current diversion limits, or CDLs.

How SDLs will operate

As stated, SDLs represent the long-term average volume of water that can be taken for consumption. The Authority presents proposals for discussion for the 29 surface-water SDL areas that have been established for the Basin Plan.

The actual local application of SDLs will be determined by Basin states through the development of water resource plans, which must be consistent with the Basin Plan.

The actual water allocations made to entitlement holders will, as is the case now, be dependent on water availability. That is, in some years the actual allocation will be lower than the SDL and some years it will be higher.

Factors influencing the setting of surface-water SDLs

Three factors drive the setting of surface-water SDLs:

- The amount of water needed for the environment which the Authority has determined is between 3,000 GL/y and 7,600 GL/y.
- The requirement to optimise the economic, social and environmental outcomes and to maximise the net economic return to the Australian community from the use of the Basin's water resources. Based on the available social and economic information, the Authority has made a judgement to only examine scenarios for increasing the amount of water available for the environment to between 3,000 GL/y and 4,000 GL/y.
- The physical constraints of the Basin, which limit where water can be physically sourced.

The scenarios considered

The Authority has examined three scenarios in the range 3,000–4,000 GL/y (long-term average):

- scenario 1 — target an additional 3,000 GL/y for the environment
- scenario 2 — target an additional 3,500 GL/y for the environment
- scenario 3 — target an additional 4,000 GL/y for the environment.

These scenarios were assessed based on their capacity to deliver:

- the environmental water requirements of the overall Basin (all scenarios meet this requirement)
- the environmental water requirements in each individual catchment
- minimal social and economic impacts (within the bounds of water needed for the environment).

Grapevines with solar-powered moisture monitors near Lake Boga, Victoria

SDL proposal

The Authority is proposing that the range 3,000–4,000 GL/y as the additional water required by the environment be considered. This range:

- meets the environmental water requirements of the Water Act.
- provides a range of improved environmental outcomes (particularly end-of-system flow)
- provides a range of social and economic impacts.

The SDL proposal for surface water

The current diversion limit is about 13,700 GL/y. Based on a proposal to consider an additional 3,000–4,000 GL/y to the environment, the surface-water SDL for the Basin as a whole would be 9,700–10,700 GL/y. This represents the long-term 'environmentally sustainable level of take'.

This SDL range will produce an estimated long-term average flow of 7,100–7,700 GL/y through the Murray Mouth. This means that the amount of water available to the environment would be 22,100–23,100 GL/y or 67–70% of all inflows, compared with 58% or 19,100 GL/y as is currently the case.

An additional 3,000–4,000 GL/y represents a Basin-scale average 22–29% reduction in current diversions for consumptive purposes (from all diversions; i.e. watercourse diversions, floodplain harvesting and interceptions such as farm dams and forestry), or an average 27–37% reduction if the reduction is sourced only from watercourse diversions.

The regional reductions in current surface-water diversions under this proposal are provided below. The fourth column is the percentage if the reduction was to be taken only from watercourse diversions.

Region	SDL area	Range of reductions in current diversion limit (%)	Reduction in current diversion limit if taken only from watercourse diversions (%)
Barwon–Darling	Barwon–Darling Watercourse	14–18	22–29
	Intersecting Streams	14–18	25–33
Border Rivers	NSW Border Rivers	14–18	21–27
	Queensland Border Rivers	14–18	19–25
Campaspe	Campaspe	26–33	35–45
Condamine–Balonne	Condamine–Balonne	21–28	29–39
Eastern Mount Lofty Ranges	Eastern Mount Lofty Ranges	26–35	–
	Marne Saunders	0	–
Goulburn–Broken	Broken	10–11	40–45
	Goulburn	26–35	28–37
Gwydir	Gwydir	20–27	27–37
Lachlan	Lachlan	7–11	15–23
Loddon	Loddon	21–23	40–45
Lower Darling	Lower Darling	26–35	29–38
Macquarie–Castlereagh	Macquarie–Castlereagh	14–18	24–32
Moonie	Moonie	14–17	37–45
Murray	Kiewa	18–20	40–45
	NSW Murray	26–35	28–37
	SA Murray	26–35	26–35
	SA Non-Prescribed Areas	0	–
	Victorian Murray	26–35	27–36
Murrumbidgee	Australian Capital Territory (Surface Water)	26–34	34–45
	Murrumbidgee	26–35	32–43
Namoi	Namoi	14–18	21–27
Ovens	Ovens	12–13	40–45
Paroo	Paroo	0	0
Warrego	Nebine	8–9	40–45
	Warrego	14–16	40–45
Wimmera–Avoca	Wimmera–Mallee (Surface Water)	0	0
	Australian Capital Territory	26–34	34–45
	New South Wales	21–28	27–37
	Queensland	18–24	27–36
	South Australia	26–35	26–35
	Victoria	24–32	27–36
	Basin total	**22–29**	**27–37**

Groundwater SDLs

The method used for applying the concept of environmentally sustainable level of take is somewhat different for groundwater compared with surface water. For example, the Authority proposes that extraction levels should be set such that groundwater systems are not subject to continued drawdown.

The best available science indicates that an aggregate reduction in groundwater extraction across the Basin of between 99 GL/y and 227 GL/y is required to achieve an environmentally sustainable level of take for groundwater.

Consistent with the approach taken for surface water, the Authority proposes that the optimisation of social, economic and environmental outcomes as required in the Water Act will be achieved with reductions in groundwater current diversion limits of an aggregate of 186 GL/y in overdeveloped groundwater systems at Basin scale.

These proposals are variable relative to current diversion limits. Most groundwater SDLs are set on the basis that they be limited at current use.

To summarise, the regions where proposed groundwater SDLs require reductions from current diversion limits are:

Region	SDL area	Proposed reduction to current diversion limit (%)
Lachlan, Murrumbidgee, Barwon–Darling, Lower Darling	Lower Lachlan Alluvium	40
Namoi, Gwydir, Barwon–Darling	Lower Namoi Alluvium	13
Eastern Mount Lofty Ranges	Angas Bremer	38
Condamine–Balonne	Upper Condamine Alluvium	34
Condamine–Balonne	Upper Condamine Basalts	20
Lachlan	Upper Lachlan Alluvium	18
Murrumbidgee	Lake George Alluvium	32
Namoi	Upper Namoi Alluvium	22
Macquarie–Castlereagh	Lower Macquarie Alluvium	40
Namoi	Peel Valley Alluvium	22
Murrumbidgee	Australian Capital Territory (Groundwater)	39

Not all groundwater systems are fully developed. Some systems contain 'unassigned' groundwater, and have the potential for further sustainable groundwater extraction, although much of this water may be saline or accessible only via low-yielding bores.

Making an allowance for the impacts of climate change

While there is uncertainty associated with different predictions of the magnitude of climate change effects by 2030, there is general agreement that surface-water availability across the entire Basin is more likely to decline, with Basin-wide change of 10% less water predicted. For groundwater, modelling of the predicted impact of the 2030 median climate change scenario shows no strong impact, as the impact of less water availability is first felt in surface water.

Given the Basin Plan is comparing climate scenarios from 1990 to 2030, the first half of the percentage change due to climate change is already embedded in existing modelling. Further, as water resource planning or successive 10-year periods will commence between 2012 and 2019, and the Basin Plan must be reviewed by about 2021, it is only appropriate to incorporate a percentage of the remaining change not already in the modelling.

Therefore the Authority has determined that the percentage of the remaining change due to climate change not already in the modelling is 3% of the entire water resource, and so a 3% reduction in the current diversion limit is an appropriate allowance for the effect of climate change. Given the modelling relating to the impact of climate change on groundwater, no climate change allowance for groundwater is provided for in the proposals.

Potential impacts and policy implications of SDLs

The Authority has examined the potential impacts of setting the SDLs. This has informed the proposed transitional arrangements and temporary diversion provisions, which are set out at Chapter 11.

Environmental benefits

Some significant environmental benefits will be achieved from adopting surface water and groundwater SDL proposals. These benefits include:

- improvements to the overall health of the Basin as a result of improving its key ecosystem functions and the health of its key environmental assets
- most river valleys will no longer be rated as 'poor' for end-of-system flows
- assistance in the recovery of many of the Basin's threatened species of birds, fish, invertebrates mammals and reptiles
- stabilising or significantly reducing the rate of decline in the populations of water birds
- improvements in the environmental health of the river red gum communities and increased numbers of native fish including Murray cod.

Importantly, it is anticipated that this additional water will significantly improve the resilience of water-dependent ecosystems and allow them to withstand short- and long-term changes in watering regimes, particularly in light of the increasing variability in climate conditions.

Finally, in the long term the additional water for the environment should see the Murray Mouth open between 90% and 92% of the time (for a 3,000 GL/y reduction on current diversion limits and a 4,000 GL/y reduction, respectively), compared to 64% of the time as modelled under the current arrangements. This long-term change, combined with short-term management actions and works and measures being undertaken by the South Australian Government, should see a significant improvement in the health of the Coorong and Lower Lakes.

Social and economic effects

The Authority has examined the potential social and economic implications of adopting the SDLs within the above range. Effects will commence from adoption of the Basin Plan; however, the total effects of SDLs will not be felt until the Basin Plan has been fully implemented, which will occur in 2019.

These effects occur at a regional scale and will affect communities, industries, businesses and individuals.

If SDLs in the range being discussed were adopted they may reduce the Basin's gross value of irrigated agriculture production by approximately $805 million/y (if 3,000 GL/y is adopted), which is around 13% of current gross value of irrigated agriculture production (although the Authority recognises the limitations of this estimate given data difficulties). Taking into account flow-on effects to regional economies (e.g. water-dependent businesses and related small- and medium-sized enterprises), this would be expected to translate into a long-term, permanent reduction in the Basin's gross regional product in the order of 1.1%. A fall in Basin-wide employment of around 800 full-time jobs (if 3,000 GL/y is adopted) would be expected. The Authority notes that other studies have indicated a higher reduction in employment. It is important to note that these figures represent a gross impact and do not take any offsetting benefits into account.

The Authority is particularly concerned about the potential flow-on effects to communities, industries and individuals in key areas. Given the dependence on water availability and the diversity of regional economies, some industries, businesses and communities would be more severely affected than others.

In the short and long term, sectors most adversely affected are likely to be irrigated broadacre agriculture (e.g. rice, cereals) where reductions in gross value of irrigated agriculture production may be greater than 30%. Cotton is likely to incur a reduction in gross value of irrigated agriculture production of around 25%, dairy around 10%, and horticulture less than 5%.

All catchments would be likely to experience reductions in economic activity at least in the short to medium term, with the greatest percentage reductions estimated to occur in the Moonie, Gwydir and Barwon–Darling regions in the northern Basin, and the Murrumbidgee, Loddon and Murray (NSW Murray) regions in the southern Basin. Depending on the local communities' capacity to adapt, these regions would also be likely to be the most at risk in terms of adverse social impacts.

However, the Authority is concerned that the short-term social and economic impacts on some communities and regions could be severe without structural adjustment.

The Authority has commissioned further analysis on the potential impacts for small and medium enterprises.

Policy implications

There are significant policy implications for the Authority, Basin states and the Australian Government arising from adopting SDLs within the range being proposed.

It is clear that assistance will be needed at a community and an industry and small business level, and potentially at an individual water entitlement holder level; while a number of government programs providing assistance and considerable expenditure are already in place, more and specific targeted assistance could be considered by governments.

The Authority proposes that transitional arrangements will need to be staged in a way that provides for practical and sensible adjustment, particularly given that many communities and individuals are still suffering the effects of drought and the broader economic downturn.

Individual entitlement holders

For individual entitlement holders, the potential impacts will be highly dependent on decisions made by Basin states through the development of water resource plans. These will vary considerably and, in some cases, there may be no impact.

There will be some assistance for water entitlement holders from water buybacks and potential payment in certain circumstances. For example, the Australian Government has indicated it will bridge any gap between what has been returned to the environment and what is required to be returned under the final Basin Plan for surface water. The Guide and the proposed Basin Plan will provide indicative direction for any new purchases of water entitlements.

Should there be any remaining gap when water resource plans are implemented — for example, from insufficient willing sellers — the proposed risk allocation provisions will be triggered.

The Authority notes that revenue from water entitlement purchases and/or risk allocation payments may not circulate through communities as it may be used to discharge debt.

Importantly, even though the effects on individual water entitlement holders may be offset, significant volumes of water will still leave some communities. This means that some regions and towns that are highly dependent on water diversions may experience significant impacts.

Communities, industries and business (small, medium and large)

The Authority believes the most significant concerns are those associated with communities, industries and businesses dealing with any reductions.

The Authority believes there is an urgent need to undertake a comprehensive assessment of social and economic impacts at a community and industry level.

The Authority also believes that governments should consider examining existing community assistance packages to help potentially create new industries and employment opportunities, and examine existing industry packages to assist industries to improve water efficiency, to exit, or to shift to higher-value forms of production.

The Authority welcomes the formation of an Australian Government cross-agency group to consider the implications of the proposed Basin Plan and to coordinate the government's response.

Proposed transitional arrangements

Effective transitional arrangements that allow for water entitlement holders and communities to adjust to potentially less water will be essential. Transitional arrangements will minimise the social and economic impacts from the reduction in current diversions.

Two mechanisms are available to Basin states and the Australian Government to drive a smooth transition to the SDLs. These are:

- The role of the Australian Government as part of the Water for the Future program, in particular through the purchasing of entitlements both historically and in the future. This will act to limit the impact on individual water entitlement holders, given the Australian Government has indicated it will purchase the gap between the final sustainable diversion limits and the current diversion limits for surface water.
- The implementation of temporary diversion provisions, which allow for a phasing in of SDLs.

Water for the Future

Under Water for the Future initiatives, the Australian Government is taking action to purchase water entitlements for the environment and implement irrigation efficiency programs that return water to the environment. Water recovered under Water for the Future is helping to substantially reduce the amount of water for the environment that would be needed to be sourced through a reduction in entitlements.

As at 30 June 2010, the Australian water purchase program had acquired the equivalent of 655 GL/y of water. In addition, around $4 billion has been committed in principle to irrigation infrastructure efficiency projects. It is conservatively estimated that under the existing program the combination of water purchasing and the investment in water efficiency infrastructure will recover a long-term average volume of surface water of approximately 2,000 GL/y by 2014.

In addition, the Australian Government has indicated it will buy the gap between the final SDLs and the current diversion limits for surface water.

Risk allocation

The Water Act outlines risk allocation provisions that are to apply to the residual difference between the current diversion limit and the sustainable diversion limit, when the relevant water resource plan is implemented.

In accordance with the methods outlined in the Water Act, the Authority proposes that the climate change component, for which the water entitlement holder is responsible, is 3% of the reduction in current diversion limits for surface water, and 0% for groundwater.

Once that has been taken into consideration, the Authority proposes that the Australian Government should carry the full (100%) responsibility for the residual. How this will be implemented will be managed by the Australian Government.

The net result of this provision is that if the government were to buy back the entire gap between the current diversions and the SDLs, there would be no residual to which the proposed risk allocation provisions would apply.

Temporary diversion provisions

The risk allocation provisions of the Water Act focus on the impact of reductions in current diversion limits on individual entitlement holders. The Authority is also concerned about the flow-on effects within communities.

Temporary diversion provisions are a mechanism available under the Water Act to provide a phase-in period for SDLs of up to five years. This will reduce the social and economic impacts of SDLs, giving water access entitlement holders and communities more time to adjust to the reduction.

The Authority proposes that temporary diversion provisions should be available to all transitional or interim water resource plans that cease less than five years after the date of the Basin Plan taking effect, where there are residual SDL reductions (i.e. the effective reduction once the impact of government water recovery efforts and the 3% reduction attributed to climate change have been taken into account). Further, the Authority proposes that these measures should be phased in evenly over five years.

Putting the proposed Basin Plan into effect

The Authority is aware of the extent of interest within the community regarding implementation arrangements, particularly how additional environmental water will be used and how the Basin state water resource planning arrangements will align with the Basin Plan. Existing environmental watering arrangements will inform environmental watering plans.

The Authority recognises the scale of the challenge to implement the Basin Plan. This will require making decisions that for the first time implement the integrated management of water resources across the whole Basin, which take into account both the needs of Basin communities and the environment.

The Basin Plan will be put into effect through the following mechanisms:

- an environmental watering plan, which will set out how water will be applied to the environment to maximise environmental outcomes
- a water quality and salinity management plan, which will set new water quality and salinity objectives
- new water trading rules, which are required under the *Water Act 2007* (Cwlth) and will establish the way water will be traded across the Basin
- the accreditation of state water resource plans which will ensure that Basin states implement SDLs and other water resource management arrangements in accordance with the Basin Plan.

Environmental Watering Plan

The Environmental Watering Plan is the primary mechanism to ensure that the best use is made of water available to the environment. The proposed watering plan uses a principles-based approach supported by a planning and reporting framework and an Environmental Watering Advisory Committee.

The Environmental Watering Plan will set out how additional water will be used to achieve the three environmental watering requirements of the Water Act to:

- protect and restore the water-dependent ecosystems of the Basin
- protect and restore the ecosystem functions of water-dependent ecosystems
- improve the resilience of water-dependent ecosystems to risks and threats.

The Environmental Watering Plan will build on an adaptive management framework to manage watering activities rather than prescribing a strict watering or flow regime. This adaptive approach means that the environmental watering arrangements will make allowances for improvements in knowledge and will provide a way to manage variations in climate conditions from year to year.

Water Quality and Salinity Management Plan

The Water Quality and Salinity Management Plan will introduce new water quality and salinity objectives for the Basin, for aquatic ecosystems, drinking water, recreational water and irrigation water. It will build on established water quality management protocols both nationally and in the Basin. These objectives will be implemented at the Basin level through operational requirements on authorities and infrastructure operators, and at the regional level through water quality management plans, incorporated at appropriate scales in water resource plans.

Water quality and salinity targets set under the plan will not impose direct mandatory compliance obligations on governments, instrumentalities or individuals; instead, operational and management planning and action must be taken, leading to targets being achieved.

Water trading rules

The aim of the proposed Basin Plan water trading rules is to develop an efficient water-trading regime by reducing barriers to trade and creating greater transparency for users of the water market. The water trading provisions of the proposed Basin Plan are based upon the advice of the Australian Competition and Consumer Commission, with a number of minor additions.

The Basin Plan water trading rules will address general matters regarding the trade and tradability of water access rights, including removal of volumetric limits.

Accreditation of Basin state water resource plans

While many of the existing unique and regionally specific characteristics in current water resource plans will be built upon in developing new water resource plans, the existing plans will ultimately need to be replaced with new plans that comply with the Basin Plan. These new water resource plans will:

- ensure complete coverage of the Basin, using a consistent set of water resource and planning boundaries
- encompass a greater range of matters than the current state water planning instruments
- provide the mechanism for implementing SDLs for the Basin's water resources.

The proposed Basin Plan will set out distinct requirements that must be met prior to Basin state water resource plans being accredited.

The Authority and the Commonwealth Water Minister are required to assess whether water resource plans are consistent with the Basin Plan. This process needs to clearly articulate accreditation requirements, a transparent evaluation framework and robust accreditation process. New Basin state water resource plans will be accredited over the period 2012–2019.

The Authority is concerned about the possible inequities that may arise from the different commencement dates of the water resource plans.

The outcomes of the proposed Basin Plan

The proposals outlined in this Guide, if implemented, would result in a significant improvement in the environmental health of the Basin and provide a more predictable base for continued economic production, creating a foundation for stronger, more resilient communities.

The proposed Basin Plan constitutes a long-term transformation for the whole Basin and its communities. The Authority recognises that there will be impacts felt by many communities and those impacts should not be underestimated. This is why community assistance is a vital part of the implementation task.

The success of the proposed Basin Plan will be largely dependent on the effectiveness of transitional arrangements, rigour of the implementation process, and cooperation between the Australian Government and Basin states.

The Authority has developed four outcomes, upon which the success of the Basin Plan will be measured and monitored. The Authority is planning for the following outcomes:

Water-dependent ecosystems in the Basin would be more able to withstand short- and long-term changes in watering regimes resulting from a more variable and changing climate

Signposts of success:

- in the short term, decline in the ecological condition of river valleys addressed, and improvement achieved in the long term
- maintained or improved health of the Basin's key environmental assets
- maintained or improved ecological character of declared Ramsar wetlands that depend on Basin water resources
- protected and restored ecosystems that depend on Basin water resources to support life cycles, for example those of migratory birds, to such a condition that they continue to support the species
- the Murray mouth remaining open at frequencies and for durations to enable tidal exchanges to maintain the Coorong's water quality, in particular salinity levels, within the tolerance of the ecosystem's resilience
- minimised barriers to the natural passage of native fish throughout the Basin
- reinstigated or maintained streamflows and floodplain inundations that are consistent with ecological requirements such as migration, germination and breeding
- increased maintenance through drought of refuges to enable the long-term survival and resilience of the populations that depend on them, such as native fish
- minimised habitat fragmentation and the threat it causes to the survival of species and their resilience to climate variability and climate change
- coordinated, consistent and adaptive management of environmental water across the Basin.

Use of Basin water resources would not be adversely affected by water quality, including salinity levels

Signposts of success:

- acceptable levels of salinity in the Basin catchments and the Basin as a whole, achieved through flows that are sufficient to export salt
- increased protection and enhancement of water quality in the Basin facilitated through the Water Quality and Salinity Management Plan setting specific, measurable, appropriate, realistic and time-bound water quality targets across the Basin
- improved water quality outcomes achieved through water and land planners creating strategic water-quality-related operating rules, investing in infrastructural change to achieve water quality outcomes, and integrating operational decision making with catchment management and pollution control considerations
- avoid projected increases in median salinity levels in South Australia beyond Australian Drinking Water Guidelines within 100 years
- water quality of key tributary rivers remains suitable for irrigation and urban use.

There would be improved clarity in water management arrangements in the Basin, providing improved certainty of access to the available resource

Signposts of success:

- management of the Basin as a whole in the national interest through a Basin-wide integrated approach to the management of the water
- accreditation of Basin state-developed water resource plans to ensure that states can optimise water planning and management while ensuring that decisions regarding the level of water use and provision of water to environmental assets are made with regard to the national interest and Basin objectives
- reduced procedural uncertainty in the development of water planning arrangements and a higher level of Basin-wide consistency
- facilitation of a properly functioning and enhanced water market, through Basin-wide water market rules and water charge rules, and improved access to information, so assisting water entitlement holders to manage their assets more effectively
- a solid foundation upon which the water market can mature to a market in which buyers and sellers can operate with confidence and minimal administrative delay and red tape
- an improved water market to allow water to reach its highest value use, thereby helping to optimise economic, social and environmental outcomes within the Murray–Darling Basin
- greater consistency in processes and terminology surrounding water transfers across the Basin
- easy access to the information required to make investment and portfolio management decisions.

Basin entitlement holders and communities would be better adapted to reduced available water

Signposts of success:

- meeting critical human water needs, thus safeguarding the needs of the communities that rely on the Basin's water resources, wherever they are in the Basin
- creating improved long-term security of surface-water entitlements by limiting the growth in non-entitlement use of water, limiting the growth in highly connected groundwater systems, sustaining or improving water quality and salinity levels, preparing for the impacts of climate change, and improving certainty and flexibility within the water market system
- driving improvements in water-use efficiency through reductions in water use under the SDLs, which will assist in making agricultural production more resilient to shocks and prepared for climate change impacts in the future
- improved security of groundwater entitlements to stabilise groundwater levels and reduce the potential for the mining of fossil groundwater aquifers
- development of a framework that can contribute to other positive outcomes, including sustainable industries demonstrating leadership in water-use efficiency, cutting-edge technologies, new crops and innovative land and water management
- treating management of water take consistently, so that all users of water are treated consistently and fairly.

Next steps

The release of the Guide presents a number of proposals for the purposes of discussion. A key part of the consultation process will be listening to and discussing input from stakeholders, states, peak bodies and members of the community on the proposals outlined in this Guide.

In addition to this important engagement phase the Authority will continue to refine key inputs to the proposed Basin Plan. Key actions include:

- Ensuring that the compliance method for the SDLs is robust and transparent. The primary and default method for determining SDL compliance will be a volumetric annual limit that varies according to climatic conditions and relevant triggers in water resource plan rules. The Authority will conduct compliance audits to ensure Basin states are correctly applying the compliance method.
- Developing a comprehensive and detailed monitoring and assessment program to evaluate whether the Basin Plan has been effective in meeting its objectives and reporting these outcomes publicly. This program will form a critical component of the adaptive management framework which will, where necessary, see amendments to the Basin Plan. The adaptive management framework will establish the cause and effect relationships between activities, expected outcomes, and policy objectives. During 2010–11 the Authority will further refine its approach to monitoring and evaluation.
- Continuing to examine the social and economic effects and the cost benefits from the proposed scenarios for SDLs in order to reach a single proposed position on SDLs.
- Working with Basin states to quickly resolve policy matters identified but outside the scope of the Basin Plan.

The proposed Basin Plan will be released later in 2010 or early 2011. Upon release the official 16-week public consultation period on the Basin Plan will commence. During this time the Authority will continue to inform, explain and listen. The community will be invited to make submissions on the proposed Basin Plan. Submissions received will be published on the Authority website, and when the public comment period has finished, a summary of the submissions received will be produced, together with information on any resulting amendments to the plan.

Once the Authority has taken comments and feedback into account and finalised the proposed Basin Plan, the Murray–Darling Basin Ministerial Council will consider it, together with the Authority's assessment of the socioeconomic implications of any reductions to current diversion limits. The Authority will then present the proposed Basin Plan to the Commonwealth Water Minister for review. The Basin Plan will become law when the Minister adopts it, which is expected to occur in 2011.

Importantly, between the Basin Plan taking effect and the implementation of accredited Basin state water resource plans, the existing Cap process will continue under the authority of the Murray–Darling Basin Agreement.

The Authority welcomes feedback and comments on the Guide, and will be consulting further with stakeholders, communities, Basin states, and peak representative organisations. That feedback and input will be used to finalise the Basin Plan.

Information on how to provide feedback as well as additional details on the technical details and work that supports the proposals outlined in this document can be found on the MDBA website at www.mdba.gov.au, by phoning 1800 230 067, or by email to engagement@mdba.gov.au.

1. Introduction

Key points

- This overview document provides the Murray–Darling Basin Authority's current position on the key decisions the Authority is required to make under the *Water Act 2007* (Cwlth). It will assist stakeholders to better prepare for and understand the proposed Basin Plan when it is released.
- The purpose of the Basin Plan is to provide for the integrated management of the Basin's water resources in a way that promotes the objects of the Water Act. The Act includes a statement of mandatory items that the Basin Plan must contain in the national interest.
- Responsibility for developing the proposed Basin Plan resides with the Authority, with the final responsibility for the adoption of the Basin Plan residing with the Commonwealth Water Minister.
- The Authority has developed a comprehensive consultation and engagement process for consideration of both the *Guide to the proposed Basin Plan* and the proposed Basin Plan. This process is detailed in Appendix B.
- While the Authority plays a significant strategic role across the Basin, each Basin state has the authority and responsibility to manage the use of its water resources within the framework set by the Basin Plan. As a result, the Basin governments — New South Wales, Victoria, Queensland, South Australia and the Australian Capital Territory — will play a major role in implementing the Basin Plan.
- Many issues with which individuals, stakeholders and the community are vitally concerned are only addressed in a broad sense in the Guide. These issues will be addressed through specific theme plans, such as the Environmental Watering Plan and the Water Quality and Salinity Management Plan, or detailed water resource plans that will be developed by Basin states within the framework of the Basin Plan.

1.1 About this Guide

This document is Volume 1 of the *Guide to the proposed Basin Plan*.

The proposed Basin Plan will be released for comment later this year or early next year by the Murray–Darling Basin Authority (the Authority).

In this document the Authority is putting forward proposals on all the key issues. The Authority is committed to hearing individual, stakeholder and community views on these proposals to support a transparent process. Consequently, the Authority is seeking feedback on the proposals presented in this volume, and when the proposed Basin Plan is released will also be seeking submissions on that document. This gives people more opportunity to contribute to the development of the plan. The Authority is committed to ensuring individual, stakeholder and community views are taken into consideration in the finalisation of the Basin Plan.

The Authority recognises that the proposed Basin Plan is a legal document and, by its nature, will be written in a way that it is not easily accessible to all parts of the community. Consequently, the Authority has decided to publish the Guide, which is intended to provide some early indication of proposals on

River Murray at Wallpolla Island State Forest, Victoria the key decisions it is required to be made under the *Water Act 2007* (Cwlth). It will also assist individuals, stakeholders and communities to better prepare for and understand the proposed Basin Plan when it is released.

The Authority is mindful of the impact and importance of the outcomes of the Basin Plan for the environment, regional communities, agriculture, the economy and for present and future generations of Australians. The Authority wants the Guide to build community understanding of how it has arrived at its current position, the potential impact of its decisions, and how it has provided for transitional arrangements.

The *Guide to the proposed Basin Plan* will form a suite of documents, illustrated in Figure 1.1, which comprise:

- Volume 1: *Guide to the proposed Basin Plan* — overview (this document)
- Volume 2: a technical background document that provides detail on each element of the proposed Basin Plan
- Volumes 3–21: 19 volumes that describe the provisions of the proposed Basin Plan for each of the 19 regions of the Basin.

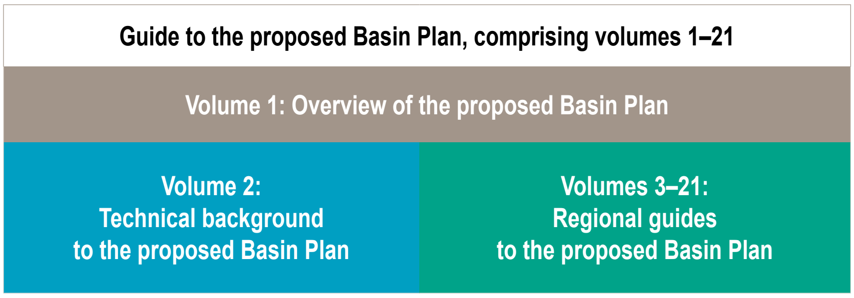


Figure 1.1 ***Guide to the proposed Basin Plan*: suite of documents**

Structure of this document

This document outlines the key positions required to be developed for the Basin Plan. It does this by first providing the context and a discussion of the background and evidence that has been used. This includes information on the roles of the key participants, a description of the Basin — its waters, its environment and its people, a brief history on what brought all of the participants to this point, and information concerning the data and information that has been used to develop the positions. This includes the scientific data sets and other sources of information as well as the baseline data and the methodologies used (Chapters 2, 3, 4 and 5).

Next the environmental water requirements of the Basin are described and how they were determined (Chapter 6). Subsequent chapters examine how this will affect the water available for consumptive use, the social and economic implications and the setting of the long-term average sustainable diversion limits (SDLs) for both surface water and groundwater, and how water for critical human water needs is incorporated (Chapters 7, 8, 9 and 10).

The document then describes how water users will be supported to transition to the new arrangements in the Basin Plan; when new management arrangements will begin to impact upon users; risk allocation; and temporary diversion provisions (Chapter 11). The following chapter (12) covers how the water for the environment will be planned for and managed; how water quality and salinity is to be managed under the plan; and how implementation of the new arrangements will occur through water resource plans and water trading.

Finally the document explains how the Authority will deliver the outcomes, including setting out what they will mean for the Basin and the importance of tracking success through compliance activities. It clarifies monitoring and evaluating whether the plan is achieving its objectives (Chapters 13 and 14). Information about the next steps, contacting the Authority and how to obtain more information completes the document.

1.2 The Murray–Darling Basin reform process

From the late 19th century, the waters of the River Murray and its tributaries were recognised by governments and the community as critical for the social and economic development of the country. The first diversions of water from the Murray for irrigation commenced in the 1880s and river flows and the need to provide water for irrigation became political issues. The reduction in River Murray flows was raised in the South Australian Parliament — and debate and argument on the management and sharing of the Basin's water continues today.

In 1885, the colonies of New South Wales and Victoria signed an agreement to share the waters of the River Murray evenly, without provision for the downstream use or needs of South Australia. By 1887, concerns were raised in South Australia that extraction for irrigation would cause intrusion of salt from the ocean into the lower River Murray because river flows could no longer hold back the sea

River Murray near Paringa, South Australia

The River Murray Commission was established in 1917 as a part of the multi-jurisdictional River Murray Waters Agreement signed in 1915. Various amendments were made to the agreement over the following decades, reflecting shifts in community values and changes in economic conditions. Initially water quantity was the prime concern but by the late 1960s water quality was also part of the discussion.

By the 1980s the condition of much of the Basin's water resources was affected by a number of distinct and critical water quality and quantity issues, particularly rising salinity levels and declining water availability. In 1981–83, the Murray Mouth closed for the first time since regulation of the river system, leading to an increased awareness of environmental water requirements, especially during droughts. It became increasingly evident that these issues extended across state boundaries, and that reaching a resolution would require a coordinated approach by the Australian Government and all the Basin states.

In 1987, a new agreement was signed between the Commonwealth, New South Wales, Victorian and South Australian governments. This new agreement (renamed the Murray–Darling Basin Agreement in 1992) promoted a joint coordinated approach to dealing with some of the developing natural resource management problems in the Basin, in particular salinity and water quality. The expanded scope of the agreement saw Queensland and the Australian Capital Territory sign on in 1996 and 1998 respectively.

The Murray–Darling Basin Agreement is Schedule 1 of the *Water Act 2007* (Cwlth). The purpose of the Murray–Darling Basin Agreement is to

> ...promote and co-ordinate effective planning and management for the equitable, efficient and sustainable use of the water and other natural resources of the Murray–Darling Basin, including by implementing arrangements agreed between the contracting governments to give effect to the Basin Plan, the Water Act and state water entitlements.

Despite the new agreement, from 1988 to 1994, Basin governments allowed water diversions from the Basin to increase significantly — by nearly 8%. Combined with changed river flow regimes, the rise in water diversions reduced the number of healthy wetlands and affected native flora and fauna, with a commensurate increase in salinity levels and blue-green algal blooms. These negative effects were confirmed in a Murray–Darling Basin Ministerial Council report, *An audit of water use in the Murray–Darling Basin* (1995), which outlined the decline in Basin river health and pointed to significant future problems if the Basin's health issues were not addressed effectively.

In 1994, the Council of Australian Governments adopted a strategic water reform framework, which was incorporated into the National Competition Policy agreements. The main objectives of the strategic framework were to establish an efficient and sustainable water industry, and to arrest widespread natural resource degradation partly caused by consumptive water use.

In 1995, the Murray–Darling Basin Ministerial Council introduced an interim Cap on surface water diversions from the Basin; this Cap became permanent from 1 July 1997. The Council of Australian Governments reinforced and extended these strategic water reforms in 2004 through the Intergovernmental Agreement on a National Water Initiative.

In 2007, the *Water Act 2007* (Cwlth) was enacted to deal specifically with the management of the water resources of the Murray–Darling Basin. The Water Act established the Murray–Darling Basin Authority and its powers and functions, and specified that the Authority must prepare a Basin Plan for the integrated management of Basin water resources.

In 2008, the Prime Minister, premiers of New South Wales, Victoria, Queensland, South Australia and the Chief Minister of the Australian Capital Territory, reached agreement on a referral of certain powers to the Commonwealth under the Agreement on Murray–Darling Basin Reform (the Intergovernmental Agreement). The Water Act and the Murray–Darling Basin Agreement were amended and the Murray–Darling Basin Authority took over the responsibilities of the former Murray–Darling Basin Commission.

Agreement on water reform of the Basin was reached in the context of this history of over 90 years of collaborative management by the Commonwealth and the Basin states. Past Basin arrangements have informed the new approach which is also required to deal with the pressures of climate change, economic development and accelerating environmental degradation in the Basin. The central principle of the Basin reforms is to improve planning and management by addressing the Basin's water and other natural resources as a whole, in the context of a federal-state partnership. The plan will not, however, regulate land management issues, as these are outside the scope of the Water Act.

Swimmers near Bright, 2010, Victoria

Under the 2008 Intergovernmental Agreement, governments gave an undertaking to implement the reforms necessary to meet the current needs of the Basin and in the long term protect and enhance its social, environmental and economic values. This undertaking includes commitment to Basin-wide management and planning, through new structures and partnerships. The preparation of a whole-of-Basin Plan and new long-term average sustainable diversion limits on water use in the Basin are central elements to ensure the long-term future health and prosperity of the Murray–Darling Basin and to safeguard the water needs of the communities that rely on its water resources.

Responsibility for preparing the proposed Basin Plan resides with the Authority and final responsibility for the adoption of the Basin Plan resides with the Commonwealth Water Minister. The Basin states have a clear and important advisory role in the preparation of the Basin Plan and in implementing the Basin Plan through state water resource plans.

1.3 The role of the Authority

The Authority is an independent statutory agency established under the *Water Act 2007* (Cwlth). Consistent with the requirements of the Act, the Authority is developing a Basin Plan that will provide for the long-term management of the Basin's water resources in a way that gives effect to relevant international agreements by redressing the degraded ecological health of the Basin while optimising the social, economic, and environmental outcomes for the Basin. The creation of the Authority means that, for the first time, a single agency is responsible for planning the integrated management of water resources across the Murray–Darling Basin. This is significant as the Basin Plan seeks to address the imbalance between water for the environment and water for consumptive uses.

On 15 December 2008, the Authority absorbed the functions of the former Murray–Darling Basin Commission and began work on the Basin Plan. The Authority has six members appointed by the Minister for Climate Change, Energy Efficiency and Water.

The Authority's functions under the Murray–Darling Basin Agreement include giving effect to decisions of the Ministerial Council and the Basin Officials Committee in relation to natural resource management programs and River Murray operations, advising these bodies and providing them with administrative support. The Authority delivers its functions under the Agreement in conjunction with and on behalf of contracting governments.

Timing

The Authority is working to a timetable that will produce the first Basin Plan in 2011. The phases for plan development are outlined in Figure 1.2.

During the proposed Basin Plan's development, the Authority has engaged with non-government stakeholders, including the individuals, stakeholders and communities of the Basin, both by visiting the regions and through a Basin Community Committee and its specialist subcommittees, such as an Irrigation Subcommittee, Environmental Water Subcommittee and Indigenous Water Subcommittee. The Authority has also worked with all Basin governments and their agencies, the Basin Officials Committee, and key conservation, Aboriginal and industry bodies.

During the first phase of planned development ('Getting started'), the Authority worked with key agencies to start drawing together the environmental, social, cultural and economic information required to describe the Basin's water resources and how they are used (including how they are used by all communities). This description is a mandatory part of the plan. It is also important in shaping the monitoring and evaluation strategy.

The second phase of development ('Understanding and preparation') began in mid-2009. During this phase, the Authority drew together the information on water resources, the environment and socioeconomic issues required to make the key decisions mandated under the Water Act about the environmentally sustainable level of water take. Extensive scientific and evidence-based input was sought and scenario modelling undertaken. The release of the *Guide to the proposed Basin Plan* and consultation on the Guide completes this phase.

The third phase of the Basin Plan's development ('Consultation and refinement') starts with the release of the proposed Basin Plan. Later this year or early next year, the Authority will release the proposed Basin Plan to begin the formal consultation as required by the Water Act. At the end of this third phase, the proposed Basin Plan will be sent to the Commonwealth Water Minister for consideration and adoption.

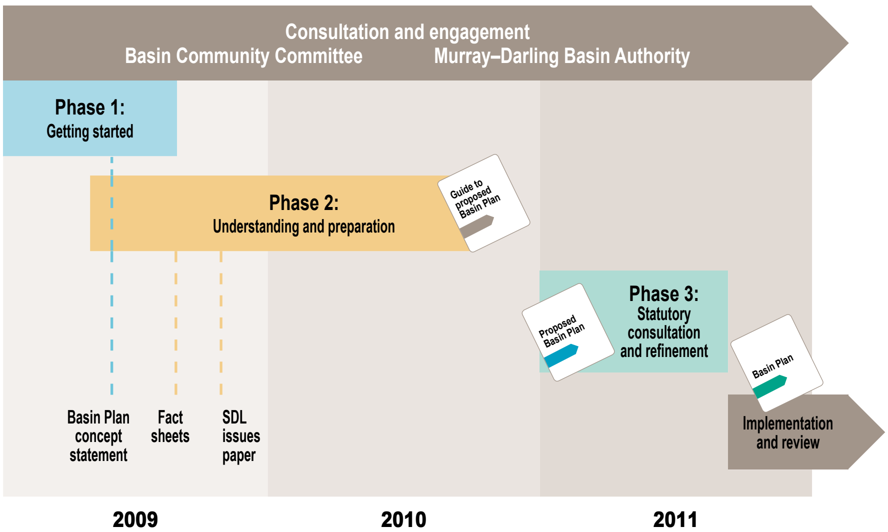


Figure 1.2 The phases of Basin Plan development

1.4 Objectives and outcomes for the proposed Basin Plan

The *Water Act 2007* (Cwlth) has a set of objects that clearly outline what is intended to be achieved by the Act.

The Water Act requires the development of a Basin Plan and describes the purpose of the Basin Plan as providing for the integrated management of the Basin's water resources in a way that promotes the objects of the Act (s. 20) in the national interest. The Water Act also includes a table of mandatory items that the Basin Plan must contain (s. 22). One of these is the management objectives and outcomes to be achieved by the Basin Plan. The objectives and outcomes must address:

- environmental outcomes
- water quality and salinity
- long-term average sustainable diversion limits and temporary diversion limits trading in water access rights

As a result of this requirement the Authority has developed a number of strategic objectives for the proposed Basin Plan, which are to:

- maintain and improve the ecological health of the Basin, and in doing so optimise the social, cultural, and economic wellbeing of Basin communities
- establish limits on the quantity of surface water and groundwater that can be taken from the Basin's resources for consumptive use, based upon a determination of what is environmentally sustainable at a catchment and a whole-of-Basin level
- improve the resilience of key environmental assets, water-dependent ecosystems and biodiversity in the face of threats and risks that may arise in a changing environment
- maintain appropriate water quality, including salinity levels, for environmental, social, cultural and economic activity in the Basin
- improve the transparency and efficiency of water marksets within the Basin
- provide a clear transition path for entitlement holders and communities through the period from plan adoption to implementation at local level.

Meeting these objectives is anticipated to result in the following outcomes:

- water-dependent ecosystems in the Basin would be more able to withstand short and long-term changes in watering regimes resulting from a more variable and changing climate
- use of Basin water resources would not be adversely affected by water quality, including salinity levels
- there would be improved clarity in water management arrangements in the Basin, providing improved certainty of access to the available resource
- Basin entitlement holders and communities would be better adapted to less water.

Achieving these objectives and outcomes will require a robust partnership between state, territory and Commonwealth governments and the Basin community.

River red gum on the bank of the River Murray in the Barmah–Millewa Forest, Victoria

1.5 The consultation process

In 2009, the Authority prepared a stakeholder engagement strategy to guide its engagement activities in the lead-up and during, the public consultation period on the proposed Basin Plan. The strategy is available on the Murray–Darling Basin Authority (MDBA) website at www.mdba.gov.au and outlines principles and objectives for engagement.

Ahead of the release of the proposed Basin Plan, the Authority has been engaging widely with stakeholders, including through:

- the Basin Officials Committee
- the Basin Community Committee
- community meetings held in conjunction with regional Authority and Basin Community Committee meetings
- delivery of national forums on the Murray–Darling Basin planning process
- attendance at peak body and local government meetings, conferences and workshops
- one-on-one meetings with key stakeholders
- consultation with Aboriginal communities in addition to a study on effects of changes in water availability on Indigenous people of the Murray–Darling Basin
- participation in the community information sessions held by the Commonwealth Department of Sustainability, Environment, Water, Population and Communities.

The Authority has listened to and taken into consideration the issues and concerns of stakeholders, and where possible built them into the proposed positions and has considered the advice of the Australian Competition and Consumer Commission in relation to water trading rules.

With the release of the Guide, the Authority is providing an early opportunity for individuals, stakeholders and the community to examine the thinking of the Authority and provide feedback. This feedback will be taken into consideration in finalising the proposed Basin Plan.

The Authority has developed comprehensive consultation and engagement processes for both the consideration of the Guide and for the subsequent detailed consideration of the proposed Basin Plan (see Appendix B).

The steps the Authority must follow once the proposed Basin Plan has been released are outlined in the *Water Act 2007* (Cwlth). These include a minimum 16 weeks of public consultation providing individuals, stakeholders and the community an opportunity to comment on the proposed Basin Plan. The proposed Basin Plan will be released together with a plain English summary to assist this stage of consultation.

After considering the comments received during the formal public consultation period the Authority must provide the proposed Basin Plan and a report on the likely socioeconomic implications of any reductions in water availability as a result of the proposed long-term average sustainable diversion limits (SDLs), to members of the Murray–Darling Basin Ministerial Council for their comments. After considering the Ministerial Council's comments, the Authority will submit a final proposed Basin Plan to the Commonwealth Water Minister for consideration and adoption.

Surveying recent flows on the Tarcutta Creek, New South Wales

Should the proposed Basin Plan be adopted the Authority would consult with holders and managers of environmental water towards implementation of the Environmental Watering Plan (see Chapter 12). The Authority would also work with state and territory governments and stakeholders to support the plan's implementation. The Act sets out requirements for consultation should the Basin Plan be amended (once adopted), and for the review of its impacts at the end of its first five years.

1.6 Role of the Minister

The Commonwealth Water Minister is responsible for the final decision on adopting the Basin Plan and tabling it in Parliament. This process causes the Basin Plan to become a legislative instrument.

After the plan commences, the Commonwealth Water Minister has a key role in implementing it. This role includes determining, on consideration of the Authority's recommendations, whether or not to 'accredit' a Basin state or territory water resource plan as being consistent with the Basin Plan (accreditation of water resource plans is dealt with in Chapter 12).

1.7 Role of the Commonwealth

The office of Commonwealth Environmental Water Holder has been established under the *Water Act 2007* (Cwlth) to manage the Australian Government's environmental water holdings. This position is not a part of the Authority, but comes within the Commonwealth Department of Sustainability, Environment, Water, Population and Communities. The Commonwealth Environmental Water Holder has an important role to protect and restore the environmental water assets of the Murray–Darling Basin as well as assets outside the Basin where water is held for that area.

Environmental water held by the Commonwealth Environmental Water Holder must be managed in accordance with the Environmental Watering Plan that is to be prepared by the Authority as a key component of the Basin Plan (see Chapter 12). The water will be used to protect and restore wetlands of international importance as well as rivers and wetlands which support listed migratory and threatened species.

Functions of the Commonwealth Environmental Water Holder

The functions of the Commonwealth Environmental Water Holder are set out in Part 6 of the Water Act. They are:

- to manage the Commonwealth environmental water holdings (the holdings) on behalf of the Commonwealth
- to administer the Environmental Water Holdings Special Account (the Special Account) on behalf of the Commonwealth.

In meeting these objectives in 2009–10, the Commonwealth Environmental Water Holder will:

- use robust and transparent decision-making processes to determine the most effective use of the Commonwealth environmental water holdings
- continue to implement cooperative arrangements to use water from the holdings
- shepherd water through watercourses
- apply environmental water to environmental assets
- improve available information on the environmental assets that are in scope for environmental watering
- further evaluate the outcomes of using Commonwealth water in the environment
- administer effectively the Commonwealth environmental water holdings
- build and maintain productive relationships with stakeholders.

1.8 Role of Basin states

While the Authority plays a significant strategic role across the Basin, each Basin state has the authority and responsibility to manage the use of its water resources within the framework set by the Basin Plan. As a result the Basin states — New South Wales, Victoria, Queensland, South Australia, and the Australian Capital Territory — will play a major role in implementing the Basin Plan.

As current Basin state water resource plans expire they will be replaced by new ones that implement key provisions of the Basin Plan by incorporating long-term average sustainable diversion limits (SDLs), planning for environmental watering, achieving water quality and salinity objectives and water trading (see Figure 1.3). These water resource plans will be developed by Basin governments and accredited by the Commonwealth Water Minister as being consistent with the Basin Plan. Until these new water resource plans are accredited, existing water plans will continue to apply to the administration of local water entitlement and allocation arrangements. New Basin state water resource plans will be accredited over the period 2012–19 with major plans in New South Wales, Queensland, South Australia and the Australian Capital Territory due for accreditation in 2014. In Victoria new plans are due to be accredited in 2019.

Gulgong, New South Wales

In order to be accredited, water resource plans must cover:

- identification of the water resource plan area
- incorporation of the SDL for the water resource plan area
- sustainable use and management of the water resources within the SDL
- regulation and management of significant interception activities
- planning for environmental watering
- water quality and salinity objectives for the water resource plan area
- arrangements for trading of water rights for the water resource plan area
- how risks to the water resources will be addressed
- metering and monitoring of the water resource plan area
- models and scientific information on which the water resource plan is based
- arrangements for the review and amendment of the water resource plan.

The Commonwealth and Basin states have agreed that critical human water needs are the highest priority water use for communities who are dependent on Basin water resources. The Basin Plan will set out the quantities of water that are required for these critical human water needs, and for carrying that water through the river system ('conveyance water') (*Water Act 2007* (Cwlth) s. 86B), but it is the responsibility of each state to meet those needs, including by deciding how water from its share is used, and what uses will be provided for as 'critical' for specific communities.

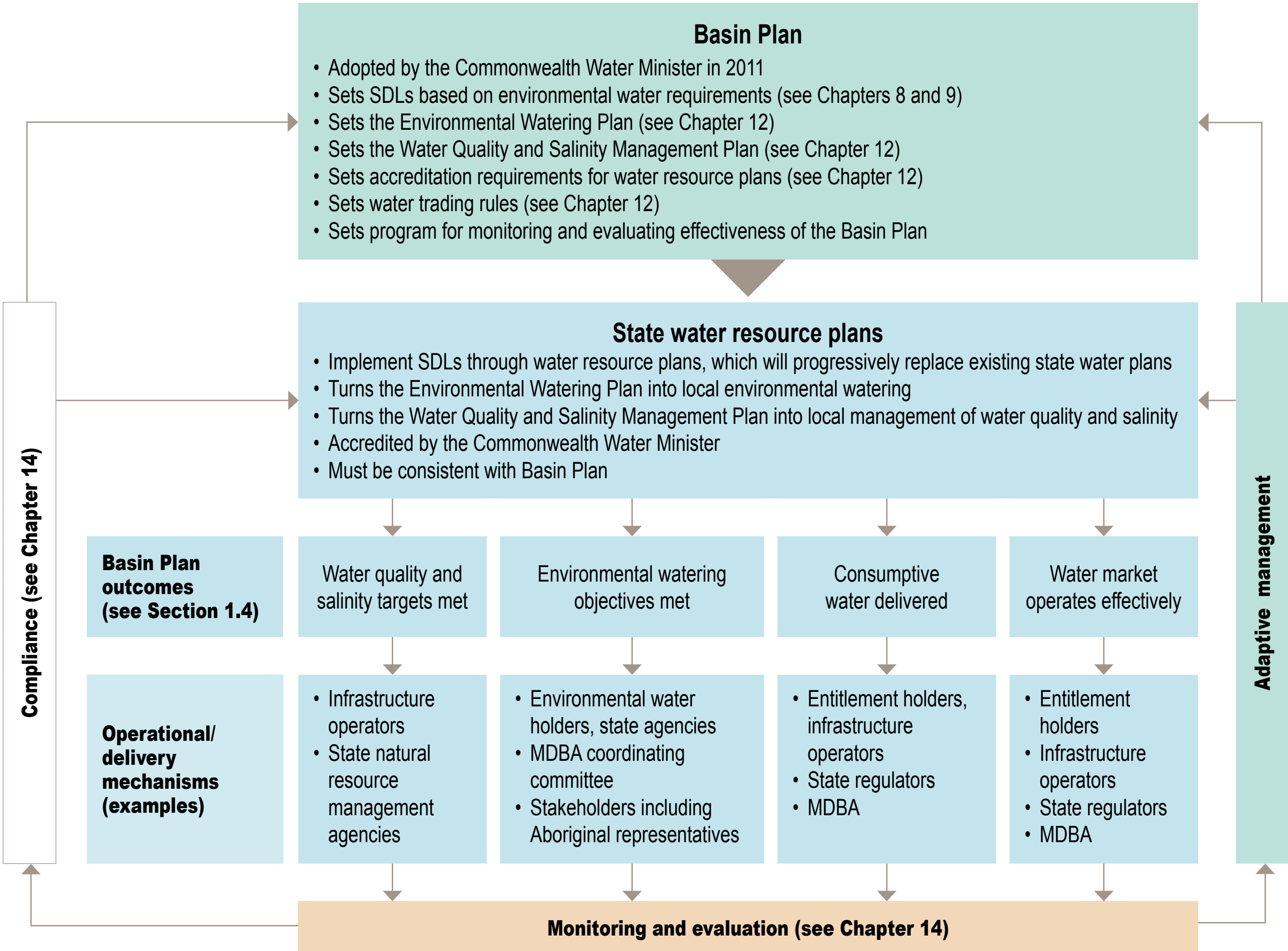


Figure 1.3 How the provisions of the Basin Plan and local implementation are intended to work together

2. The Basin and its importance to Australia

Key points

- The Murray–Darling Basin consists of 23 major river valleys and covers one million km^2 across four states and the ACT.
- It is one of the largest and driest catchments in the world, and includes 16 Ramsar wetlands.
- It is highly significant to Australia, to Aboriginal Australians, to the Australian economy and is an iconic part of the Australian environment. Over two million people live there.
- The Basin's agriculture produces $15 billion worth of produce annually, 39% of Australia's total agricultural production. It contains around 65% of Australia's irrigated land area and around 40% of Australia's farms.
- Twenty of the 23 major river valleys of the Basin are in poor to very poor ecological condition.

2.1 A description of the Basin

The Murray–Darling Basin is Australia's most iconic river system, defined by the catchment areas of the Murray and Darling rivers and their many tributaries. Comprising 23 river valleys, the Basin extends over one million km^2 of south-eastern Australia — covering three-quarters of New South Wales, more than half of Victoria, significant portions of Queensland and South Australia, and all of the Australian Capital Territory (see Figure 2.1).

The Basin presents a varied landscape, from semi-arid ephemeral river systems in the north to highly regulated river systems in the south fed from the Australian Alps. To the east and south, the highlands of the Great Dividing Range form the limit of the Basin, while in the north, west, and south-west the boundaries are much less distinct. By far the greater proportion of the Basin is made up of extensive plains and low undulating areas, mostly no more than 200 m above sea level. A consequence of the extent of the Basin is the great range of climatic and natural environments: from the rainforests of the cool eastern uplands, the temperate mallee country of the south-east, the inland sub-tropical areas of the north, to the hot, dry semi-arid and arid lands of the western plains.

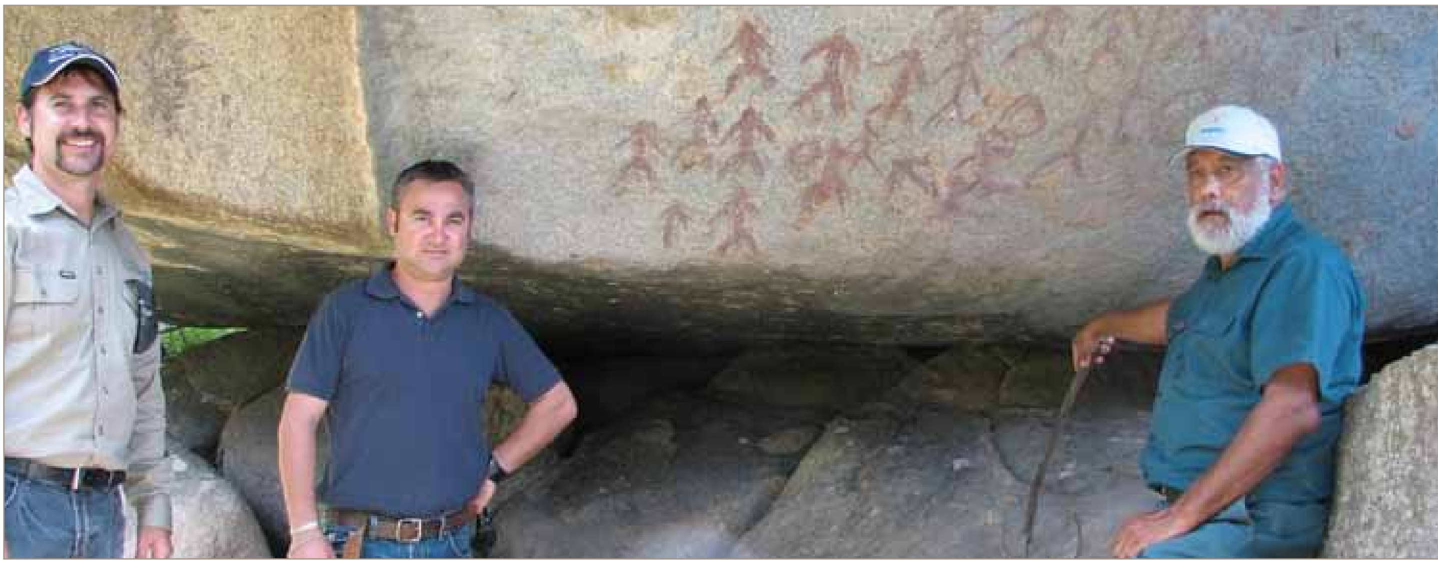
This landscape has been home to Aboriginal people for at least 50,000 years; sustaining cultural, social, economic and spiritual life. Trade routes, major gathering places and sacred sites exist across the length and breadth of the Basin. Aboriginal people all along the Murray and Darling rivers and throughout the Basin talk of their deep relationship to the rivers. Still today, 34 major Aboriginal nations maintain their traditional lands within the Basin, and the Basin's waters, waterways and wetlands remain significant places.

Murrumbidgee River at Jugiong, New South Wales

Area	1,042,730 km² (14% of mainland Australia)
Average annual rainfall (1990–2006)	469 mm
Average annual evapotranspiration (1990–2006)	461 mm
Average annual rainfall (1895–2006)	457 mm
Population within the Basin	2,100,000 (10% of the Australian population)
Gross value of agricultural production	$14,991 million (39% of the national value)
Average annual inflows (includes inter-Basin transfers)	32,800 GL
Major water storage capacity	22,663 GL
Average annual outflows (modelled)	5,105 GL

- Basin Plan regions
- ■ capital city
- ● main town
- main rivers
- state border

Figure 2.1 The regions of the Murray–Darling Basin with fast facts



Aboriginal rock drawings at Daruka near Tamworth, New South Wales

The Basin covers a large area, yet run-off in the Basin is very low compared with other major river systems around the world. Inflows to the rivers of the Basin have ranged from 117,907 GL in 1956 to less than 6,740 GL in 2006. Accordingly, the Authority estimates that under without-development conditions (i.e. conditions prior to significant human development) about 31,800 GL/y (gigalitres per year) (or 6% of average rainfall) would occur as run-off and flow into rivers and streams. On average, approximately an additional 1,000 GL/y is transferred into the Basin from external sources, comprising transfers into the Murray and Murrumbidgee rivers from the Snowy Mountain Scheme, and transfers into the Wimmera region from the Glenelg River. Therefore, the Basin experiences average annual inflows of 32,800 GL/y. This is low when compared with major international rivers. For example, the average annual flow of the River Murray is only about 16% of the Nile, 3% of the Mississippi and just over 0.25% of the Amazon River.

However, the Basin is most understood at a community level — for most people what happens in the Queensland area of the Basin is a world away if they live in Victoria. Therefore, to enable the proposed Basin Plan to be more relevant to regional communities, the Authority has divided the Basin into 19 regions. The regional boundaries were developed to be consistent with those used in the CSIRO Sustainable Yields Project, but with some amendments to better match the state water resource plan areas. Volumes 3–21 of this Guide, based on those 19 regions, will provide a regional perspective of the proposed Basin Plan, including important base information and the relevant proposed SDLs. Figure 2.1 shows the 19 regions.

2.2 The Basin community

Drawing from the most recent census there were 2.1 million people living within the Basin and dependent on its water resources in 2006. Outside the Basin a further 1.3 million people are dependent on its water resources. This number includes Adelaide, the largest population base reliant on Basin water.

The Basin population grew by 3% between 2001 and 2006 (see Figure 2.2), a period which saw relatively strong growth in the Australian economy amid a continuing drought. This compares to a 6% growth in population nationally. Within the Basin, the total rural population (in rural localities and rural living) declined by 1.7% between 2001 and 2006, while populations in large and medium-sized urban centres (with more than 5,000 people) grew by 8%. Overall, the number of Basin residents living in very remote areas fell by 32%.

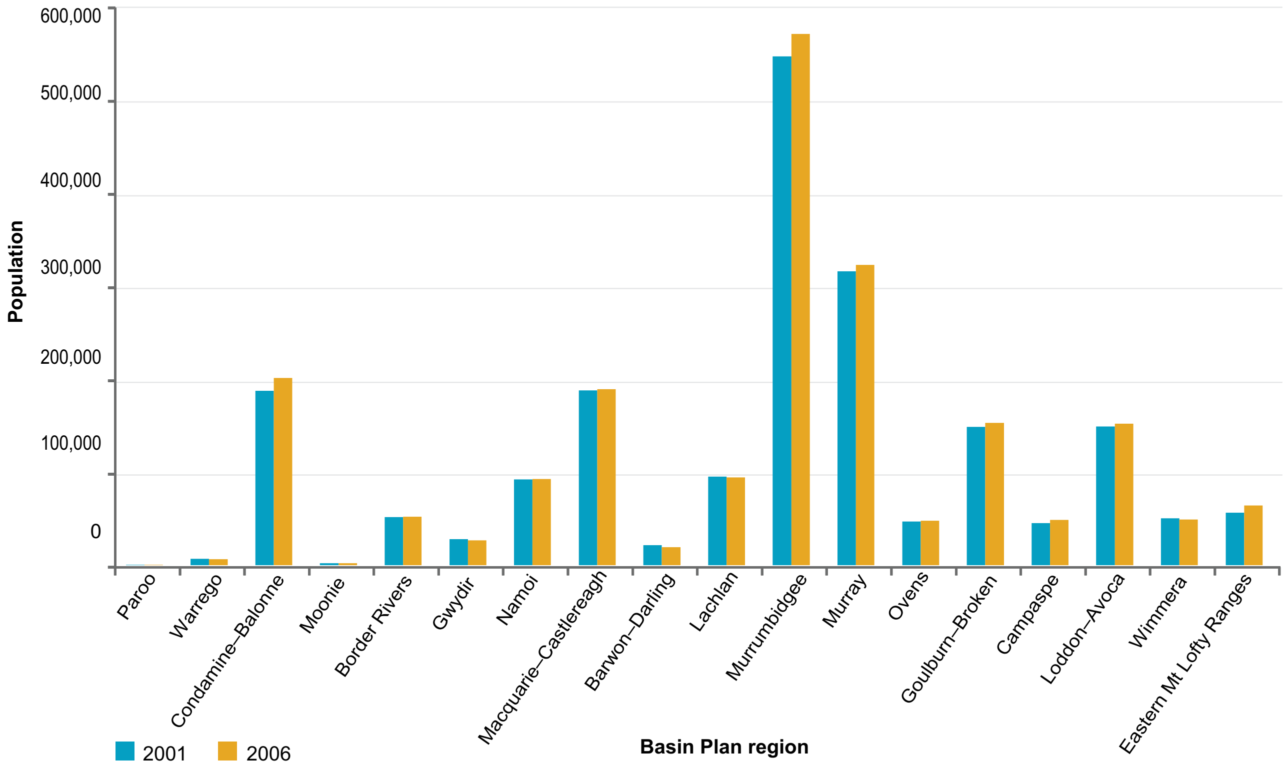


Figure 2.2 Population and population change 2001–06 in the Basin

Note: Statistics for Lower Darling region included in Murray region

The population of Australia is ageing, and this trend is slightly more pronounced for the Murray–Darling Basin. In 2001, 13.1% of the Basin population was aged over 65, and this increased to 14.5% in 2006. In 2006, there were 1.3 million people aged between 15 and 64, representing 64.5% of the Basin population. There is also a smaller proportion of younger people in the Murray–Darling Basin compared with the rest of Australia, particularly those aged 25 to 34. In 2006, about 69,500 Aboriginal people lived in the Murray–Darling Basin, some 3.3% of the Basin's population. This number had increased by 17% from 2001. During 2001–06, the number of Aboriginal people living in very remote areas decreased by 34%.

Urbanisation is a continuing trend with 19 large rural towns across the Basin. The population of each town is greater than 10,000. Some of the fastest growing urban centres are directly on or near the Murray River — Mildura, Murray Bridge, Albury–Wodonga, Echuca and Shepparton — and, in the case of Dubbo, on the Macquarie River. Together with Canberra, these centres accommodate almost one million people and account for almost half of the Basin's population.

In the 10 years to February 2009, employment across Australia's agriculture, fisheries and forestry industry fell by 14.9%, equating with a decline of 1.6% per annum. Agriculture experienced the largest declines in employment compared with any other industry. The agriculture industry has the highest proportion of workers aged over 45 (56.8%) and over 65 (15.2%). In 2006, 66.8% of Australian farmers were aged over 45 and 18.1% were over 65. The age profile of farmers in the Basin was very similar to the Australian profile, with 67.6% aged over 45 and 18.6% over 65.

2.3 The environment of the Basin

The Murray–Darling Basin covers one-seventh of Australia. It is one of the larger catchments in the world and one of the driest. The Basin is ecologically diverse and supports a variety of ecosystems that are significant at international, national, state and regional levels. It covers a broad climate range from the alpine regions to the western lowlands.

The Basin can be divided by climate into northern rivers (Darling system) and southern rivers (Murray system). In the north rainfall is less seasonal but greater in summer, more influenced by tropical weather systems and produces higher peak flows. The northern Basin is also hotter, with higher evaporation and less predictable flow, and more frequent and longer periods of very low flow.

Of the Basin's wetlands, 16 are internationally important Ramsar wetlands, which cover more than 6,300 km^2 (Table 2.1). These wetlands and other water-dependent ecosystems are sites for waterbird foraging and breeding, for important vegetation communities, and for habitat for a range of fish and other aquatic and terrestrial animals.

Table 2.1 Australia's Ramsar-listed wetlands in the Murray–Darling Basin

Ramsar site	Basin region
Riverland	Murray
Banrock Station Wetland Complex	Murray
Barmah Forest	Murray
Gunbower Forest	Murray
Hattah–Kulkyne Lakes	Murray
Kerang Wetlands	Murray
New South Wales Central Murray State Forests	Murray
The Coorong and lakes Alexandrina and Albert wetlands	Murray
Currawinya Lakes (Currawinya National Park)	Paroo
Paroo River Wetlands	Paroo
Fivebough and Tuckerbil Swamps	Murrumbidgee
Ginini Flats Wetland Complex	Murrumbidgee
Gwydir Wetlands: Gingham and Lower Gwydir (Big Leather) Watercourses	Gwydir
Lake Albacutya	Wimmera–Avoca
Narran Lake Nature Reserve	Condamine–Balonne
Macquarie Marshes	Macquarie–Castlereagh

The Basin supports a great number of plants, animals and ecosystems that are nationally and internationally significant, including 95 Basin state and Commonwealth-listed threatened inundation-dependent fauna species. More than half its native fish species are considered threatened or of conservation significance. Many species of waterbirds breed in large numbers only during flooding of wetlands and lakes. The large wetlands on the lower reaches of the Condamine–Balonne, Gwydir, Macquarie, Lachlan and Murrumbidgee rivers are among the most important sites of their type in Australia for species of waterbirds that breed in large colonies.

Many of the Basin's wetlands, including the Coorong, are critical habitat for migratory waterbirds. They form part of the east Asian–Australasian flyway, the migratory path for waterbird species such as plovers, sandpipers, stints, curlews and snipes. The flyway extends from the Arctic Circle, through east and south-east Asia, to Australia and New Zealand. The Australian

Government is a signatory to a number of international agreements to ensure the protection of migratory birds, including the Ramsar Convention, the Convention on Migratory Species and bilateral agreements with Japan, China and the Republic of Korea.

Much of this ecological diversity is under stress and in poor health. The very small organic carbon supply to the River Murray is seen to be pivotal in the decline of fish and waterbirds. This is due to isolation of the river from its floodplains and removal of riparian vegetation over extensive stretches of the river.

The National Land and Water Resources Audit 2000 Assessment of River Condition provided base data for assessing the condition of the Murray–Darling Basin's rivers. The assessment, while limited in its ability to report on trends or compare across different areas of the Basin, indicated clearly and unequivocally that the ecological health of Basin rivers was poorer than that required for ecological sustainability.

Since this assessment of river condition, the Sustainable Rivers Audit has been implemented, providing a comprehensive assessment of the ecosystem health of river valleys in the Basin. On the basis of this assessment the Paroo Valley in the north-west of the Basin was the only one to achieve a health rating of 'good'. The Condamine and Border Rivers valleys were rated as being in 'moderate health' and all other valleys were rated 'poor' or 'very poor', with the lowest ranked being the Murrumbidgee and Goulburn valleys. Table 2.2 shows the assessment of ecosystem health of river valleys in the Basin, and Table 2.3 shows the hydrologic health.

Table 2.2 Sustainable Rivers Audit ecosystem health assessments by valley, 2004–07: Murray–Darling Basin

Health rating	Valley
Good	Paroo
Moderate	Border Rivers, Condamine
Poor	Namoi, Ovens, Warrego
	Gwydir
	Darling, Murray Lower, Murray Central
Very poor	Murray Upper, Wimmera
	Avoca, Broken, Macquarie
	Campaspe, Castlereagh, Kiewa, Lachlan, Loddon, Mitta Mitta
	Murrumbidgee, Goulburn

Source: Davies, PE, Harris, JH, Hillman, TJ & Walker, KF 2008, *A report on the ecological health of rivers in the Murray–Darling Basin 2004–2007*, report by the Independent Sustainable Rivers Audit Group for the Murray–Darling Basin Commission, Canberra.

Table 2.3 Sustainable Rivers Audit hydrologic health assessments by valley, 2004–07: Murray–Darling Basin

Health rating	Valley
Good	Castlereagh, Kiewa, Mitta Mitta, Namoi, Ovens, Paroo, Warrego
Moderate to good	Avoca, Border Rivers, Broken, Condamine, Gwydir, Lachlan, Macquarie, Upper Murray
Moderate	Campaspe, Loddon, Central Murray
Poor to moderate	Murrumbidgee
Poor	Darling, Goulburn, Lower Murray, Wimmera
Very poor	–

Note: 'Hydrologic health' measures ecologically significant aspects of the flow regime including volume, variability, extreme flow events and seasonality.

Paroo River, 2007 New South Wales

The Sustainable Rivers Audit also reported that the condition of the native fish population in the Basin was at best moderate, and most macroinvertebrate populations showed a lower diversity than expected, especially in the Campaspe, Castlereagh, Wimmera and Avoca rivers. In hydrological terms, sites that were rated as being in poor hydrological health were located in the lowland reaches of the major river systems, namely the Darling, Goulburn, lower Murray and Murrumbidgee valleys, or in reaches affected by river regulation and extraction for irrigation.

During the past 50 years, populations of native fish species in the Basin, such as silver perch and golden perch, have declined seriously in both distribution and abundance, reflecting the poor state of the river system and the impacts of human use. A group of expert fisheries and riverine ecologists estimate current fish populations in the Basin to be about 10% of their levels before European settlement, and predict that, without intervention, levels could fall to near 5% in the coming 40–50 years.

Along the floodplains of the Murray, Murrumbidgee and lower Lachlan rivers, river red gums are dying. In the Booligal Wetlands on the Lachlan River, the decline in river red gums has coincided with increasing impacts of river regulation and diversions, which have increased the duration of low flows and reduced the frequency of large floods to the region by 50% compared with natural conditions.

2.4 The economy of the Basin

In 2006, more than 920,000 people were employed across the Basin. Over the previous five years, the Basin experienced employment growth of 8.3%, with wholesale and retail trade being the largest employment sector. Employment growth was primarily concentrated in government administration and defence, construction and service-based industries, including health and community services and education.

The agriculture, forestry and fishing sector also makes a large and direct contribution to the Basin economy. In 2005–06, agriculture, forestry and fishing was the second-largest sector in terms of employment, although the sector suffered a decline in employment in this period.

In 2005–06, the Murray–Darling Basin accounted for approximately 20% of Australia's total agricultural land area, approximately 40% of Australian farms and gross value of agricultural production, and 65% of total irrigated land area. The Basin also accounts for 50% of the nation's irrigated agricultural water consumption (2007–08). In the north broadacre crops, chiefly cotton, predominate in terms of irrigation, while in the south livestock and dairy farming, rice, and horticulture predominate. Figure 2.3 provides a breakdown of the water use of the key sectors in the Basin. Figure 2.4 shows the current share of water between diversions, interceptions and outflows from the Murray Mouth and environment.

Wholesale and retail trade was the largest employment sector within the Murray–Darling Basin in 2006, employing 161,100 people. The agriculture sector was also a very large Basin employer with 98,100 people employed within the broader agriculture, forestry and fishing sector. Other important industry sectors in terms of employment include government administration and defence (94,500), education and training services (71,600), manufacturing (83,900) and healthcare and social assistance (97,600). The unemployment rate in the Basin in 2006 was 5%, close to the Australian total of 5.2%.

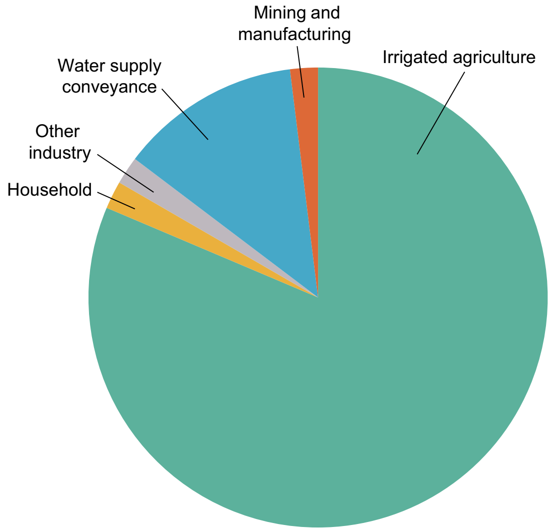


Figure 2.3 Consumptive water use by sector in the Murray–Darling Basin

(Australian Bureau of Statistics 2010, feature article – Murray–Darling Basin, *Year Book Australia 2009–10*, ABS 1301.0)

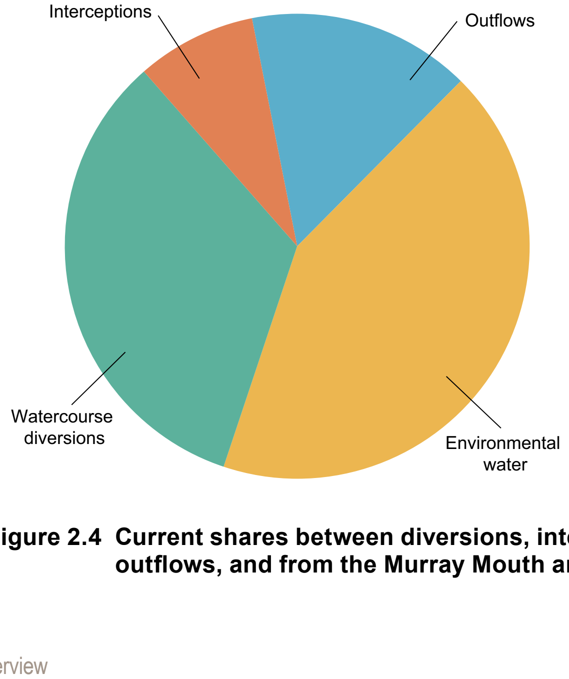


Figure 2.4 Current shares between diversions, interceptions and outflows, and from the Murray Mouth and the environment

While there are various competing demands for water within the Murray–Darling Basin, the consumptive use of water is dominated by the irrigated agriculture sector. In 2004–05, agriculture accounted for 7,204 GL (83%) of water use in the Basin, while the mining and manufacturing sectors together used around 73 GL of water (less than 1%). Households in the Basin consumed approximately 189 GL of water (about 2%) in 2004–05. The facts and figures quoted in this chapter have come from the Australian Bureau of Agricultural and Resource Economics (ABARE) and ABS 2007 and 2009 publications. Full and more specific references can be found in volume 2, *Guide to the proposed Basin Plan: Technical background*.

Food and fibre

The agricultural industry in the Murray–Darling Basin provides an annual average of $15 billion worth of produce to the national economy.

In dollar terms, the most significant commodities produced in the Basin during 2005–06 were grain ($3.4 billion), meat cattle ($2.8 billion) and sheep and other livestock ($1.7 billion). However, the recent prolonged drought significantly curtailed both cotton and rice production. The Basin was responsible for 45% ($5.5 billion) of Australia's total 2005–06 irrigated production ($12.2 billion). The Basin is home to a number of significant irrigated agricultural areas. For example, most of Australia's rice is produced in the Murrumbidgee and New South Wales Murray irrigation regions and 90% of the nation's cotton comes from the northern Basin. The Basin also provides 56% of Australia's total grape crop, 42% of Australia's total fruit and nut production, and 32% of Australia's total dairy production.

Orange trees at Curlwaa near Wentworth, New South Wales

Indirectly, agricultural activity is also a key economic driver of local industries and regional activities that support small and medium enterprises and employment across the Basin. For example, around one-third of people employed in manufacturing are employed in food products industries, representing a further 30,000 employees.

A variety of crops and pasture are grown in the Basin for food, fibre and, more recently, bio-fuel for domestic consumption and export. These include:

- cereals (e.g. wheat, barley, rice, sorghum)
- cotton
- legumes (e.g. field peas)
- fruit and nuts (e.g. apples, oranges, almonds)
- grapes
- vegetables (e.g. tomatoes, onions)
- canola
- livestock fodder (e.g. pasture for grazing or hay/silage).

Growing crops and pasture through irrigation is more common in the Basin than elsewhere in Australia. Irrigated agricultural land is a relatively small

Flooded irrigation channel on a farm near Moree, New South Wales

proportion of total agricultural land throughout Australia (0.6%) — however, in the Basin, 2% of agricultural land is irrigated.

In 2005–06, the Basin accounted for 58% of all orchard trees in Australia, and 47% of the total area of fruit grown. Oranges were the most significant fruit crop in the Basin and Australia in terms of production weight (507,000 tonnes in Australia). The vast majority (95%) of Australian oranges were produced in the Basin, with 92% of all trees of bearing age located in the region. More than half (53%) of all apple trees of bearing age were located in the Basin and the area produced 54% of Australia's apples. The Basin also produced the majority of Australia's almonds (93% by weight and 90% by area).

In Australia in 2005–06, around one-quarter (26%) of land dedicated to growing vegetables for human consumption was located in the Basin. In this period, potatoes were by far the largest Australian vegetable crop with 1.2 million tonnes produced, and around one-third (32%) of this production was in the Basin. The region accounted for more than two-thirds (68%) of total tomato production and 56% of Australian tomato growing land area, indicating higher yields, potentially as a result of irrigation. Almost half (48%) of the land area dedicated to growing rockmelons and cantaloupes was situated in the Basin and 38% of land dedicated to growing onions (brown and white varieties) was in the Basin.

Annual horticulture in the Basin includes a diverse range of fruit and vegetables: potatoes, lettuces, melons, sweet corn, fresh and processing tomatoes, onions, pumpkins, carrots and asparagus. Production is distributed across the Murray and Murrumbidgee valleys, Border Rivers region and the Goulburn–Murray Irrigation District.

Annual horticultural activity tends to differ from other Basin agricultural activities in that it tends to be high risk with high value, perishable products; it is labour intensive and responsive to expected market returns and contracts. There are a few large-scale producers along with a large number of smaller producers.

Mining

Mining in the Basin displays considerable variety in terms of the minerals mined, the nature of the mining operations, the value of their operations, and locations. The mining industry consumed less than 1% of the total water (around 20 GL) used for consumptive purposes in the Murray–Darling Basin in 2004–05. Most water (80%) used for mining is sourced from groundwater, while only 15% comes from surface water and 5% from mains infrastructure. Within the mining industry, the highest consumers of water were the metal ore mines and coalmines, with 56% and 29% of total mining water consumption respectively. While overall use of water by mining in the Basin is modest, some mining operations can pose a risk to the integrity of water resources, for example, through aquifer interference or water quality impacts.

Coal seam gas extraction is an emerging industry in and outside the Basin, and is a potential user of water in some regions of the Basin. While direct consumptive use of water is relatively small, mining activities can have large, localised incidental water use and quality impacts associated with ore production or oil and gas extraction, although precise quantities are difficult to determine.

The Basin Plan will incorporate a Water Quality and Salinity Management Plan to provide a framework for the maintenance of appropriate water quality, including salinity levels, for environmental, cultural and economic activity in the Basin. The framework (see chapter 12 of this volume) will encompass any water quality impacts of mining activities.

> Water Act 2007 (Cwlth) Section 255A
>
> Prior to licences being granted for subsidence mining operations on floodplains that have underlying groundwater systems forming part of the Murray–Darling system inflows, an independent expert study must be undertaken to determine the impacts of the proposed mining operation on the connectivity of groundwater systems, surface and groundwater flows, and water quality.

The Authority is aware of the growing concern in relation to the potential impact of mining on water resources in particular regions of the Basin. Section 255A of the Water Act provides a mechanism to ensure that the water impact of any future mining activity is considered prior to approval.

Manufacturing

Manufacturing industries consumed around the same volume of water as the mining industry in 2004–05; that is, less than 1% of total water consumed in the Basin. In the manufacturing sector, the food, beverage and tobacco industries used the highest volume of water, accounting for over a third of total manufacturing water consumption. The next highest users of water were the metal products sector (24%), and then the wood and paper products industry (16%).

The manufacturing sector employed 83,900 people in 2006, representing 9% of the Basin's total workforce. The industry is widely distributed across the Basin although it is concentrated around major cities.

Almost one third of people employed in the manufacturing sector in the Basin are engaged in the food products industry, so water is important for this part of the sector. Employment patterns across the food product industry tend to closely reflect the agricultural profile of individual regions.

Tourism

Tourism has few direct water consumption needs. However, its ongoing viability is closely related to the ecological health of rivers, lakes and other

Basin environmental assets including world heritage sites and Ramsar wetlands. These sites represent significant tourist destinations for visitors and Basin residents.

It is difficult to accurately determine the economic size and employment base of the tourism sector. There are a range of tourism-related service-based industries across the Basin that employ a large part of the Basin workforce, including:

- cultural and recreational services – 1.8%
- wholesale and retail trade – 17.5%
- accommodation, cafes and restaurants – 4.8%.

In total this accounted for approximately 221,000 employees in 2006.

3. The context for decisions

Key points

The Authority is conscious that proposals contained in the Basin Plan must take account of a number of critical factors that affect the environmental, social and economic health of the Murray–Darling Basin. These include recognising:

- that the Basin has been developed over the past 100 years, supported and encouraged by governments, to harness water for agriculture and other benefits
- that the recent drought has had a devastating impact on the environment and Basin communities
- the decade or more of reforms undertaken by the Commonwealth and Basin states
- that, unless action is taken now, the Basin and its communities do not have a long-term future and consequently face irreversible decline in the environmental health and, in turn, the economic strength of the Basin
- the contribution that many individuals, stakeholders and communities have made to date in restoring the health of the Basin
- that it is vital to change the balance between water for the environment and water for economic benefit in order to restore the environmental health of the Basin and preserve and enhance its long-term productivity
- the wide hydrologic, ecological and socioeconomic variability of the Basin must be a significant factor in shaping the future arrangements
- that the potential impact of climate change must be taken into consideration.

The development of the Basin Plan did not start with a blank page. There is a significant history of the development of water resources in the Basin, supported and encouraged by governments. Recognition of the need to take action has occurred primarily during a decade of significant drought, which has had considerable impacts on water availability and the agricultural productivity of the region. There is also a significant history of attempts to address some of the issues that have become apparent over time, in particular the impacts of current levels of use on the long-term economic and environmental sustainability of the Basin.

The future management of the Basin must take into account the range of risks that are evident, including extreme climatic variability of the region and climate change.

Definitions

Water access entitlement — a water entitlement is a perpetual or ongoing entitlement, issued under a law of a Basin state, to exclusive access to a share or volume of the water resources of a water resource plan area.

Water allocation — a water allocation is the specific volume of water allocated to a water access entitlement by the relevant Basin state in a given water accounting period. Depending on the rules established in the relevant water plan, in a given year the allocation may only be a small proportion of the full water entitlement.

1850	First pumping schemes for River Murray
1887	First large-volume pumping plant at Mildura
1891	Goulburn Weir completed on Goulburn River, first major diversion structure built for irrigation in Australia
1902	Interstate Royal Commission examined conservation and distribution of waters of River Murray
1906	Burrinjuck Dam approved
1915	NSW, Victoria and South Australia sign River Murray Waters Agreement
1922	Lock 1 completed near Blanchetown
1926	Lake Victoria reservoir completed
1928	Burrinjuck Dam on Murrumbidgee completed
1936	Hume Dam completed
1937	Lock 15 at Euston completed
1939	Lake Mulwala reservoir completed
1949	Construction of Snowy Mountains Scheme commenced
1960	Tantangara Reservoir completed
	Keepit Dam built on the Namoi River
1961	Kiewa Hydro-electric Scheme completed
1967	Burrendong Dam built on the Macquarie River
1968	Wyangala Dam built on the Lachlan River
1973	Copeton Dam built on the Gwydir River
1974	Construction of Snowy Mountains Scheme completed
1979	Dartmouth Dam completed
1987	Murray–Darling Basin Agreement signed, initially as an amendment to the River Murray Waters Agreement
1992	New Murray–Darling Basin Agreement replaces River Murray Waters Agreement
1993	Murray–Darling Basin Act passed by all contracting governments
1994	Water Reform Framework agreed by Council of Australian Governments
1995	National Competition Policy Package for water reform agreed by Council of Australian Governments
2004	National Water Initiative
2007	Water Act
2008	New Murray–Darling Basin Agreement, Intergovernmental Agreement on MDB reform, referral of constitutional powers
2010–2011	Proposed Murray–Darling Basin Plan released
2011	Murray–Darling Basin Plan adopted
2012	First water resource plan aligned
2014	Major plans aligned in NSW, Queensland, SA and ACT
2017	All major NSW groundwater resources aligned
2019	Victoria water resource plans aligned

3.1 History of development

Economic success in the Basin is a direct result of historical efforts by Basin states, supported by the Commonwealth, to harness the water resources of the Murray–Darling Basin for agriculture. For many this effort is most visible in the physical infrastructure across the Basin, both public and private water storages and irrigation channels. However, the physical harnessing of the water resources of the Basin has been complemented and sustained by other national reforms such as the introduction of legal entitlements over water and a water market to allow the trade of water to its highest value use.

The first major water storages were constructed in the southeast of the Basin, where the Great Dividing Range receives the highest rainfall and produces the most run-off. The alpine areas in southern New South Wales and north-east Victoria form the headwaters of the three major river systems in the Murray system — the Goulburn, Murrumbidgee and Murray rivers — and early irrigation development focused on construction of storages on these rivers, namely Burrinjuck (completed 1928), Eildon (Sugarloaf Reservoir, completed 1929) and Hume (completed 1936), respectively. As more storage capacity was needed to support further growth in development, numerous dams were built in the mountainous areas. Significant construction from the 1950s to the 1970s included the Snowy-Mountains Hydro-electric Scheme (completed 1974) and Dartmouth Dam (completed 1979). Figure 3.1 shows this period of rapid expansion.

Harvesting cotton near Dalby, Queensland

Development has occurred differently and later in the Darling system, where river flows are more variable. Rapid development did not occur until the 1980s and 1990s, as large storages were constructed on farms to hold water captured from rivers and floodplains.

Since the 1920s there has been a significant increase in the volume of surface water extracted from the Murray–Darling Basin (from about 3,000 GL in the 1930s to about 11,000 GL in the 1990s). Increases during the 1970s and 1980s were particularly rapid, corresponding to the construction of major water infrastructure. While this increase underpinned the Basin's agricultural and socioeconomic development, in combination with climate variability it has contributed to a significant decline in the health of the Basin.

With the impact of drought over the past decade, surface-water use in the Basin has dropped substantially, as seen in Figure 3.2.

3.2 History of drought

Different parts of the Basin experience wet and dry cycles at different times. Annual rainfall in the southern Murray–Darling Basin was significantly lower than the long-term average for the 10-year period 1997 to 2006. Similar low-rainfall periods occurred in the mid 1890s to early 1900s (the 'Federation drought') and around 1940 (the 'World War II drought'). However, the recent drought has seen significantly lower inflows than in previous periods of very low rainfall.

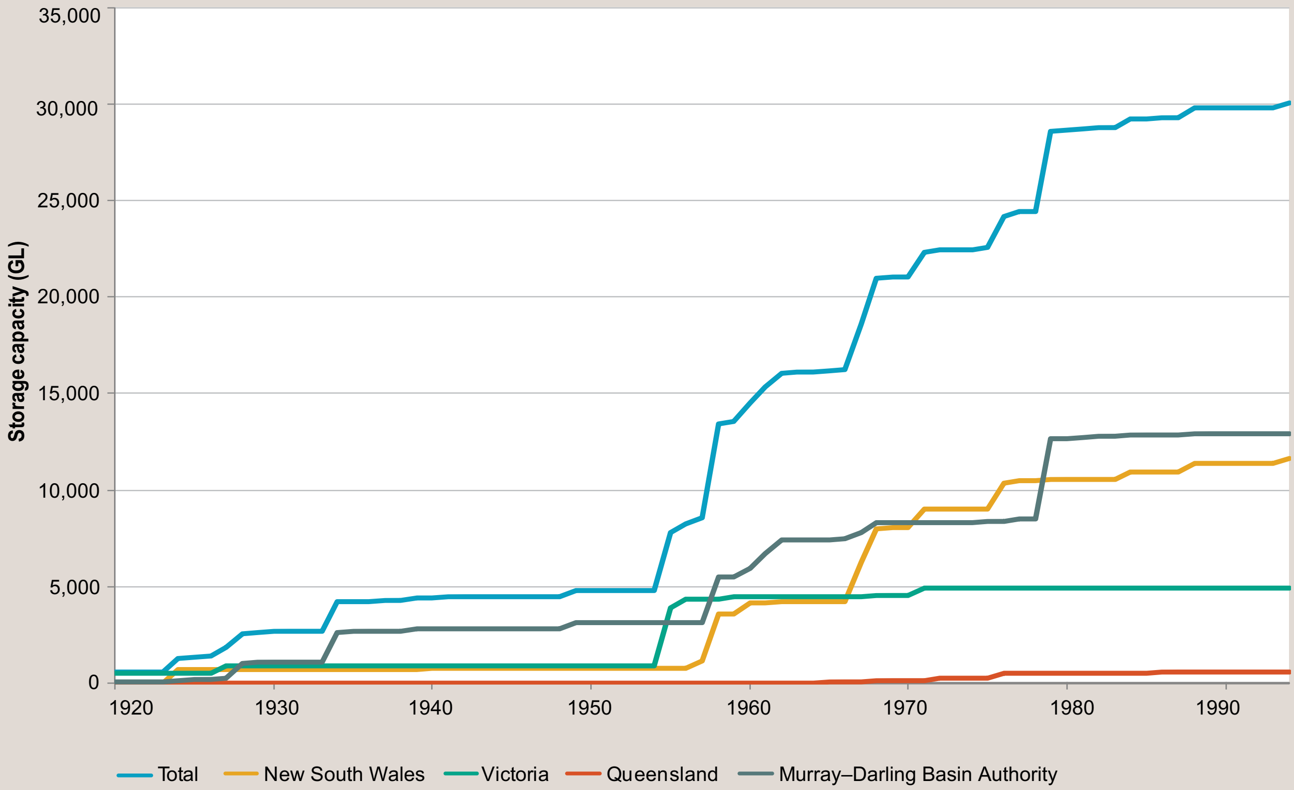


Figure 3.1 Growth in public surface-water storage capacity across the Murray–Darling Basin

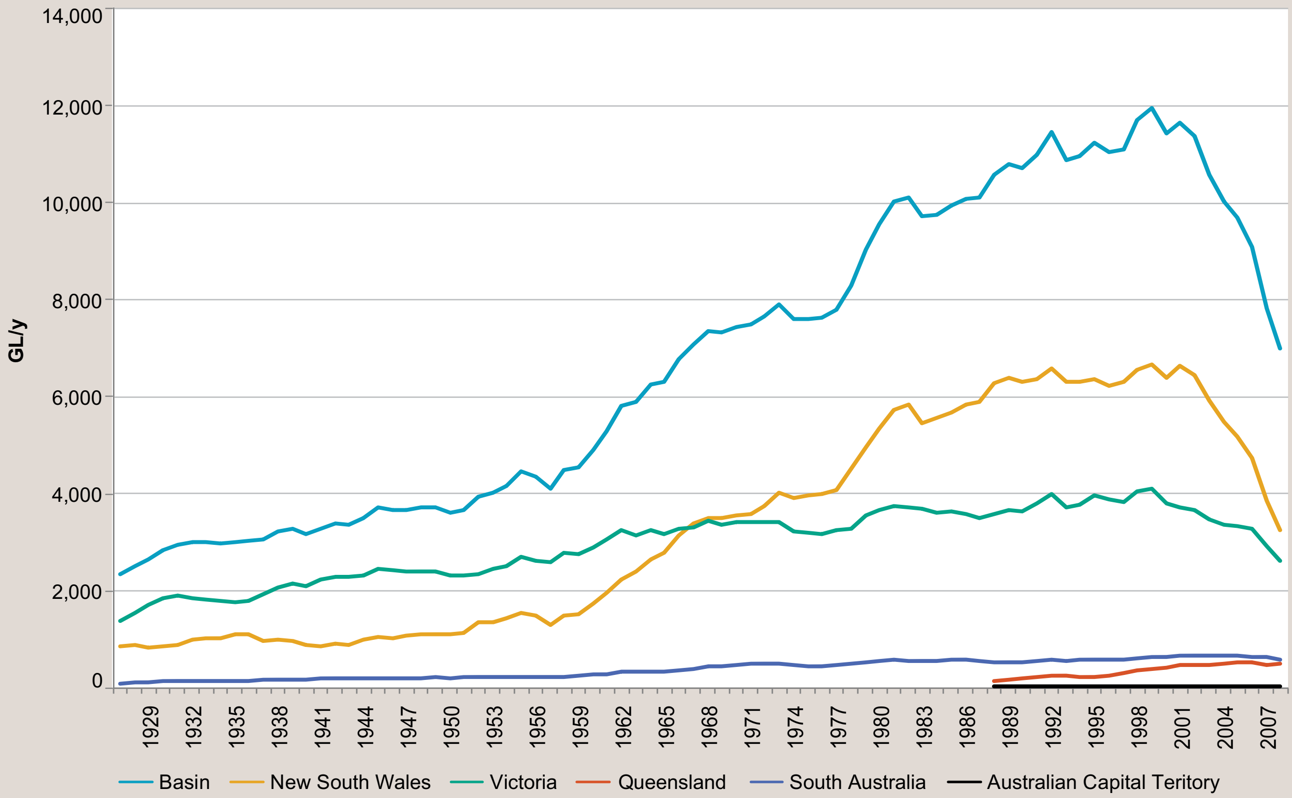


Figure 3.2 Basin surface-water use: five-year rolling average

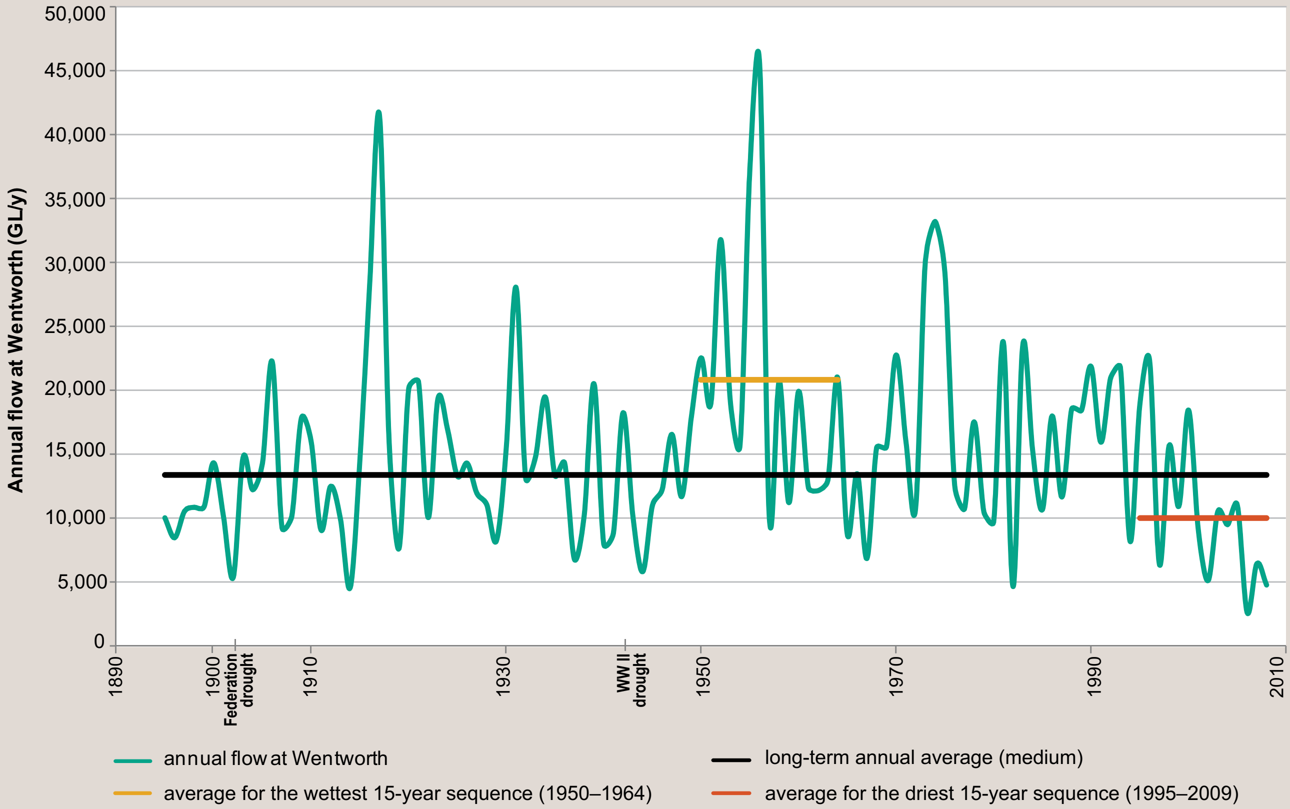


Figure 3.3 Modelled without-development streamflow at Wentworth on the River Murray: 1895–2009

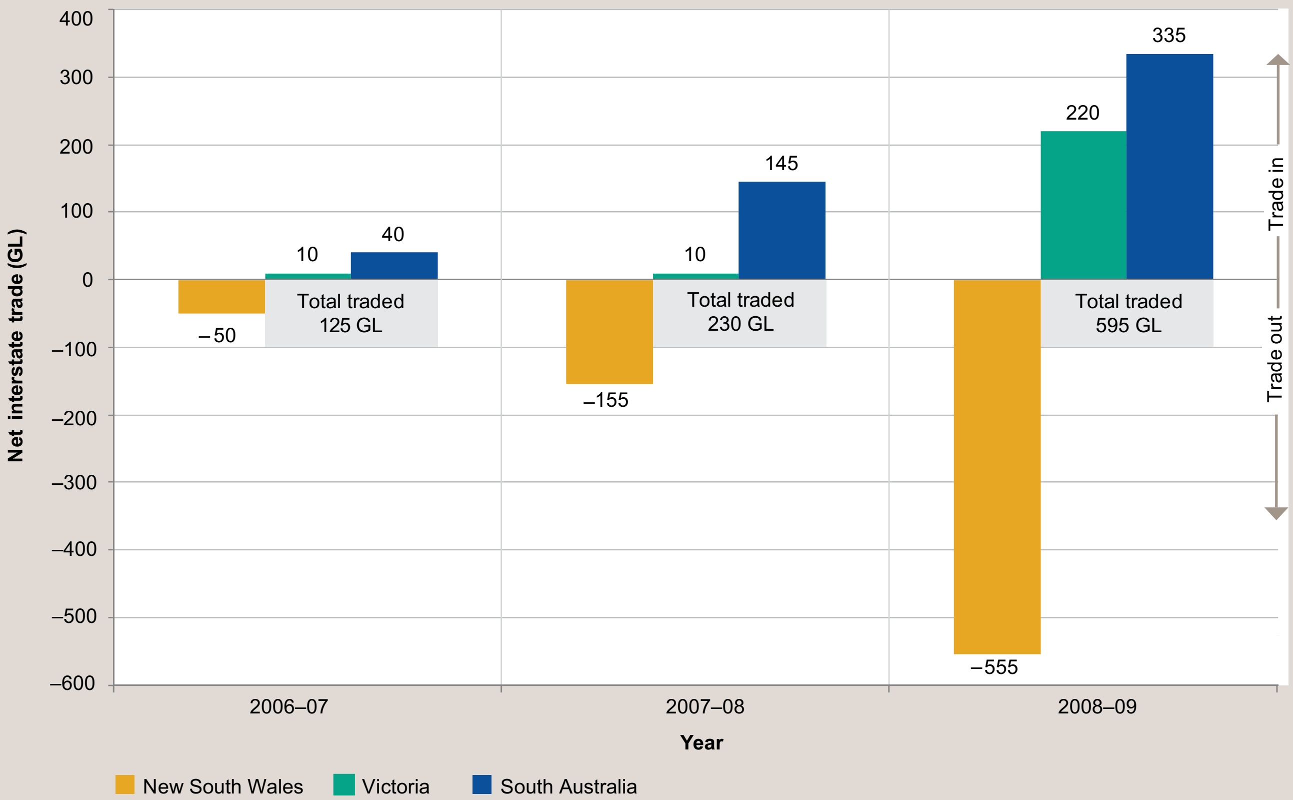


Figure 3.4 Net interstate trade of allocations, 2006–07 to 2008–09

River flows have reduced across the entire Basin but the impact of the recent drought has been most pronounced in the southern Basin, where it is the most extreme on record. Over the past decade, the volume of available water in the southern Basin has been around 40% less than the long-term average, compared with a reduction of around 20% in the northern parts of the Basin. Inflows into Lake Hume at the headwaters of the River Murray have been about 40% less than the long-term average and in 2006–07 were the lowest ever recorded.

Figure 3.3 shows the average annual flows past Wentworth at the confluence of the Murray and Darling rivers. This location gives an indication of overall flows in the Basin and illustrates how they vary over time. The figure shows that inflows over the past decade have been declining and are well below the long-term average.

Several years in the last decade have seen unprecedented low water allocations in many parts of the Basin. In some cases, this forced Basin states to modify the local water sharing rules. In early 2007, some of the lowest inflows on record prompted Basin states to agree on special arrangements for sharing water in the River Murray to ensure water could be delivered to towns along the Murray.

Severe and prolonged drought has resulted in critical stresses to communities and ecosystems. In ecosystems, the stress on river red gum populations in many parts of the river is evident — such as in the Narran Lakes, where many of the river red gums are now dead. In human communities, the stress is evinced by reduced levels of agricultural production with consequent flow-on effects on entire communities.

Reduced water availability over the past decade has severely affected irrigated agriculture across the Basin. The decline has included the following impacts:

- From 2000–01 to 2006–07 the gross value of irrigated agricultural production in the Basin dropped from $5.1 billion to $4.9 billion per year.
- Annual planting of crops such as rice and cotton has been particularly affected by reduced water allocations, with the gross value of irrigated agricultural production of rice dropping from $349 million in 2000–01 to $274 million in 2005–06 and cotton from $1,184 million to $861 million.
- Permanent plantings such as wine grapes and fruit trees have been affected to a lesser degree, as irrigators have striven to maintain plantings that are not easily replaced.
- From 2005–06 to 2007–08, irrigated land use in the Basin fell from 1,654,000 ha to 958,000 ha, a decline of 42%.
- Flood events can mobilise salt from floodplains to the rivers. A reduction of flood events coupled with reduced saline drainage from irrigation districts and catchments (which has left salt accumulating rather than draining to rivers), has masked underlying salinity risks as this salt may again be mobilised under wetter conditions.

Irrigators have used a number of strategies to limit the effects of lower and more variable water supplies on farm business, such as buying and selling water on the temporary water market and accessing alternative sources of water such as groundwater. They have also introduced more extensive and long-term techniques such as upgrading irrigation infrastructure and technology. Figure 3.4 shows the net interstate allocation trade (temporary trade) for the years 2006–07 to 2008–09, with a clear trend towards increasing trade overall and a net sale of water downstream towards South Australia. Also, there is extensive trade within states.

3.3 Management of the Basin

In 1994, the Council of Australian Governments adopted a strategic water reform framework, which was incorporated into the National Competition Policy agreements. The main objectives of the strategic framework were to establish an efficient and sustainable water industry, and to arrest widespread natural resource degradation partly caused by consumptive water use. The strategic framework covered pricing, the appraisal of investment in rural water schemes, the specification of, and trading in, water entitlements, resource management (including recognising the environment as a user of water through formal allocations), institutional reform, and improved public consultation. The Council of Australian Governments reinforced and extended these strategic water reforms in 2004 through the Intergovernmental Agreement on a National Water Initiative.

In particular the initiative includes specific commitments to:

- return overallocated and overused systems to environmentally sustainable levels of extraction
- the creation of perpetual share-based water access entitlements
- a risk assignment framework that provides for a sharing of the responsibility for reduced water allocations once overallocation and overuse are dealt with
- removal of barriers to trade
- improved water accounting.

As the reforms have been implemented by individual Basin states, a growing body of evidence has accumulated indicating that the water resources of the Basin are being overextended, while the ecological health of the Basin is under increasing stress and degrading. This includes the decline of wetlands with associated loss of semi-arid vegetation and collapse of waterbird breeding. Initial steps were taken to rein in increasing demand for water in 1995 with the Commonwealth and Basin states agreeing to cap the bulk of surface-water diversions in the Basin at 1993–94 levels.

In response to extreme drought, exacerbated environmental stress across the Basin, frustration over the pace of implementing water reform measures, and the implications of climate change, the Australian Parliament passed the *Water Act 2007* (Cwlth). The Water Act established the Murray–Darling Basin Authority with the powers necessary to develop and implement new Basin-wide water planning and management arrangements, including legally enforceable limits on the extraction of water.

Northern Macquarie Marshes, near Coonamble, New South Wales

3.4 The long-term impact of current management arrangements

In 2008, modelling for the CSIRO Murray–Darling Basin Sustainable Yields Project found that harnessing the waters of the Basin now results in the River Murray ceasing to flow through the mouth 40% of the time, compared with 1% of the time under without-development conditions. The report also found that between 1999 and 2009, water availability in the Basin has been about 40% less than the long-term average. In the same year the Sustainable Rivers Audit highlighted the declining ecological health of the Basin, with a single catchment — the Paroo — considered to be in good health.

For communities, dying river red gums, declining native fish populations, shrinkage of wetlands, reduced floodplain flood events and fewer bird breeding events are more localised signals of this broader ecological decline.

The past decade has also seen increasing water quality issues, particularly more frequent blue-green algal blooms. However, with the drought, regional groundwater levels have fallen, resulting in reduced saline groundwater discharge from dryland catchments. As less land has been irrigated there has been less saline drainage from irrigation, although these trends may reverse again in the future, with salt being mobilised again.

Regulation of rivers in the Basin has caused long-term changes in geomorphological and ecological processes downstream of dams, including erosion, depressed water temperature, removal of fish breeding habitat, reduced supply of organic material and nutrients to the rivers, declining water quality, loss or degradation of wetlands in lakes Alexandrina and Albert, and more recently the exposure of acid sulfate soils. In 1991, the Darling River suffered a bloom of blue-green algae that extended for more than 1,000 km caused largely by river regulation.

Wheat crop stunted by drought near Urana, New South Wales

River regulation and extraction of water have also had damaging effects on waterbird populations. For example, they have reduced nesting waterbird breeding in the Barmah–Millewa Forest, the number of waterbirds and waterbird nests, and the frequency of waterbird breeding in the Macquarie Marshes. Changes to the seasonal flow regimes have affected fish breeding, and constant low flows reduce ecosystem productivity by removing the high- and low-flow cues to trigger and sustain historical breeding cycles.

The health of riparian and wetland vegetation, which plays a key part in riverine ecology, has declined. Many areas remain under significant pressure due to the combined effects of human activity and the drought. For example, in 2003, 80% of remaining river red gums on the River Murray floodplain in South Australia were stressed to some degree, and 20–30% of them were severely stressed. In the Macquarie Marshes nearly half the river red gum forest and woodland has between 40 and 80% dead canopy. A more recent study conducted in 2009 by Cunningham et al. showed that only 30% of river red gum stands across the study area were in good condition and that there has been a downstream decline in the stand condition of river red gum forests and woodlands along the Victorian Murray River Floodplain.

In addition, at least 90% of the Gwydir Wetlands, 75% of the wetlands of the Lower Murrumbidgee floodplain, and 40–50% of the Macquarie Marshes have been lost.

The National Land and Water Resources Audit 2000 Assessment of River Condition, Sustainable Rivers Audit 2008, and CSIRO Murray–Darling Sustainable Yields Project 2008 present a stark picture of the ecological health of the Basin and its water-dependent ecosystems. In 2010, the Productivity Commission stated: '… the [Productivity] Commission is not arguing against the case for allocating more water for the environment. This is patently necessary to improve the health of the Basin's environment'.

3.5 Looking to the future

The consequences of not taking action to restore balance in the Murray–Darling Basin are severe. Australia is at a critical point in how it manages the resources of the Basin. Unless steps are taken immediately to correct the level of diversions and restore water to the environment there is a risk of irreversible decline in the health of the Basin. Consequently the communities that depend on the Basin for vital drinking water supplies and its productive base will also face decline in their way and quality of life.

In 2004, the Murray–Darling Basin Ministerial Council identified six factors that pose a risk to the shared water resources of the Basin:

- climate change
- increases in farm dams
- increased groundwater extraction
- afforestation
- bushfires
- decreasing irrigation return flows.

These six factors vary in size, impact and consequence across the Basin and have the potential to significantly affect water availability. The Authority has undertaken further work to identify other risks to the Basin water resources. This work identifies an additional three broad risks:

- insufficient water available for the environment
- water of a quality unsuitable for use
- poor health of water-dependent ecosystems.

The factors identified as contributing to these risks have been used to identify a series of risk management strategies for implementation in the first 10 years of the Basin Plan. The Authority also identified a fourth risk: policy with unintended adverse impacts. Due to the complex and qualitative nature of this latter risk, the Authority has identified a need for further work to inform its future assessment and management.

3.6 Climate variability and climate change

The climate of the Basin is highly variable from year to year, which means that flows in the rivers of the Basin are highly variable and unpredictable, although mitigated to some extent by water storages. Consequently it is critical that new planning and management regimes, in particular the way in which any new diversion limitations are assessed, take this variability into account. The planning for environmental water will also need to incorporate strategies to deal with drought, flood and climatic variability in general.

Climate change science applicable to the Murray–Darling Basin indicates that climate variability is likely to increase in the future. This means that more extreme weather events, including droughts and floods, are likely to happen more often. In addition, storms are likely to be larger and stronger, and droughts longer and drier, than in the past.

While climate variability and change are a significant future risk to the availability of the Basin's water resources, the specific hydrologic effects of climate change in the Murray–Darling Basin are difficult to predict with certainty. The Authority has focused on climate predictions based on trends in atmospheric condition using 1990 and 2030 as reference points.

The Authority has considered the possible impacts on water availability by 2030 for a wide range of modelled climate scenarios, namely median, wet extreme and dry extreme. It is clear that, while the evidence suggests that it is more likely that the climate will be drier in the future, there is a wide range of possible impacts. At the Basin scale the change in water availability could range from an increase of 9% under the wet extreme scenario to a decrease of 27% under dry extreme. Also, while the southern Basin is more likely to be drier than the northern Basin, the range of possible change is even greater at a regional scale.

While there is uncertainty associated with different predictions of the magnitude of climate change effects by 2030, there is general agreement that surface-water availability across the entire Basin is much more likely to decline than to increase. Recent updates suggest the Basin-wide change in surface-water availability for the period from 1990 to 2030 will be about 10%. This means the latest climate change modelling suggests that, under a median 2030 prediction, conditions are likely to be around 10% drier than past experience.

Scientific work commissioned by the Authority has examined the recent drought and concluded that, while there is an increasing likelihood that climate change is part of the reason for the recent drought, it is not yet possible to distinguish this component from the naturally high climatic variability experienced in the Basin.

Loddon River, Wombat State Forest south of Glenlyon, Victoria, 2009

For groundwater, the situation is somewhat different. Groundwater modelling of the predicted impact of the 2030 median climate change scenario on groundwater recharge shows no strong deviation from historical median recharge.

The Authority is conscious that the risks and impacts of climate change and climate variability will adversely affect Basin communities and potentially reduce the ecological resilience of the Basin. It is therefore essential that the proposed Basin Plan appropriately addresses the impacts of climate change.

3.7 Approach to including climate change

As it is not yet possible to separate the effects of climate change from overall variability in water availability in the Basin, the Authority has adopted the full historical record (1895 to 2009) as the assessment baseline. Historical data has been used to describe the current hydrologic character of the Basin (see Chapter 5), in considering environmental water requirements (see Chapter 6) and in establishing SDLs (see Chapters 8 and 9).

Given the Basin Plan will apply to water resource planning in the Basin for successive 10-year periods commencing between 2012 and 2019, and the plan must be reviewed by around 2021 if not before, the Authority considers that incorporation in the first Basin Plan of the full effect of the 10% predicted decline in average annual water availability under median 2030 conditions is unwarranted.

In light of the various issues associated with climate change, the Authority has determined that 3% is an appropriate allowance to account for the effect of climate change in the proposed Basin Plan. That is, the reduction being considered as necessary to achieve an environmentally sustainable level of take is inclusive of a 3% reduction in the current surface-water diversion limit in the Basin.

As the issues around uncertainty in the climate predictions also extend to the distribution of impacts across the Basin, the 3% allowance is to be applied across the Basin, without attempting to incorporate possible local variations.

The 3% allowance in the reduction in current diversion limits will also apply for the purposes of risk allocation for climate change (see Chapter 11).

Given the lower sensitivity of groundwater resources to climate change noted above, the Authority has adopted the historical recharge sequence as being representative of the climate for the Basin Plan planning period for groundwater planning purposes. Accordingly, no allowance is provided for in groundwater planning to account for climate change in the proposed Basin Plan.

Flooded Ovens River at Wangaratta, Victoria, 2010

As well as incorporating climate change consideration into the determination of surface water long-term average sustainable diversion limits, the Authority has also included accreditation requirements for surface-water water resource plans that ensure that these plans are responsive to climate change and are robust under a wide range of possible future climate conditions. For example, a principle of equitable sharing of any reductions in water availability between consumptive and environmental uses has been adopted by the Authority to address the current situation, in which most water resource plans are biased significantly towards allocation for consumption under drier future climates. This approach will need to be applied in a manner that does not put at risk water requirements for meeting critical human water needs. As a further requirement, surface-water water resource plans will also be required to show how they would manage conditions that include a repeat of extremely dry periods such as the 2000–10 drought.

4. *Developing the proposed Basin Plan*

Key points

- The national datasets used to develop the proposed Basin Plan were supplemented by extensive data collections typically from water, environment and primary industry departments in each Basin state. The Authority has used existing water resource planning and management models from New South Wales, Victoria, Queensland, South Australia and the Australian Capital Territory. This includes models of each major river system and groundwater system in each Basin state.
- The Authority has sought technical peer-review within Australia of individual elements of the proposed Basin Plan and has invited international scrutiny of the approaches used to develop the Basin Plan. The independent reviews confirm that the approaches being taken in developing the proposed Basin Plan represent best available science.
- Most of the available evidence base falls into the medium confidence category, that is, it consists of knowledge and data available from a range of sources, but may not have been subject to formal peer-review.
- The integrated modelling framework being used was first tested by the CSIRO Murray–Darling Basin Sustainable Yields Project, which was independently reviewed by an expert panel. Since updating this framework for Basin Plan application, the modelling systems design and modelling methods have been subjected to two additional independent scientific reviews.
- The methods used to develop climate change scenarios for the Basin Plan have also been independently peer-reviewed and published in international scientific journals.
- While these comprehensive review processes have confirmed that the modelling platforms are the best available, it is important to recognise that there are inherent uncertainties in any mathematical modelling. The Authority has made allowance for these uncertainties in its decision making.

The Authority is mindful that the community will want to understand how key decisions have been proposed and the logic supporting the proposed positions. It is critical to emphasise that the role of the Authority is one of considering the best available science in respect of the water needed for the environment and the social and economic impacts on regions and communities, and exercising a significant degree of expert judgement to recommend measures that implement the requirements of the *Water Act 2007* (Cwlth) to manage Basin water resources.

The Authority has collated the best available information, sophisticated hydrologic modelling, and knowledge to ensure that there is a robust evidence base to underpin the proposed Basin Plan. In addition, the Authority commissioned a comprehensive peer review of its approach to confirm that it represents best available science. In particular, Australian and international peer reviewers confirm that the approach taken by the Authority to determine environmental water requirements is at the leading edge of current scientific thinking.

Onion crop near St George, Queensland

Against the backdrop of the extensive work that has been undertaken, the Authority recognises that fundamentally its role is one of informed policy judgement and striking a balance to restoring the health of the Basin. To this end the Authority has brought together extensive analysis and adopted an iterative approach to determining its positions. That is, it is recognised that scientific analysis alone cannot make the necessary decisions and the Authority has taken other factors into account, including impact on communities and the level of confidence in data and modelling that support the outcomes.

The development of the proposed Basin Plan can be divided into six distinct components (see Figure 4.1). These are:

- determining the environmental water requirements — Chapter 6 sets out the approach to assessing the additional environmental water needs of the Basin
- understanding socioeconomic impacts (Chapter 7)
- setting long-term average sustainable diversion limits (SDLs) — Chapter 8 analyses scenarios within a range for surface-water SDLs, Chapter 9 presents proposals for groundwater SDLs
- supporting transition to SDLs — Chapter 11 sets out proposals that will assist with transition to the SDLs
- putting the Basin Plan into effect — Chapter 12 sets out new management arrangements and how they will be implemented, including the Environmental Watering Plan and the Water Quality and Salinity Management Plan
- delivering the outcomes — Chapter 13 sets out what achieving the outcomes will mean for the Basin, while Chapter 14 sets out how the Authority will use monitoring, evaluation and reporting to adaptively manage the Basin.

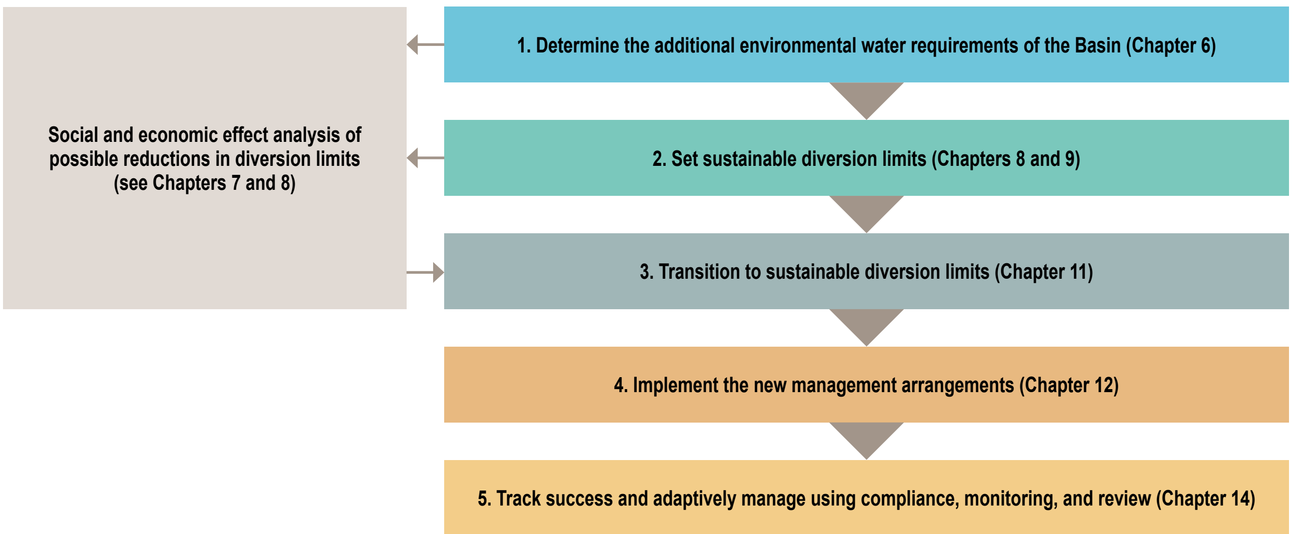


Figure 4.1 The components of the development of the proposed Basin Plan

Kings Billabong near Mildura, Victoria

4.1 The scientific evidence base

Planning of this scale and complexity has never been undertaken anywhere in the world. As a result it was important that the Authority brought together the best available data, modelling and scientific knowledge to support decision making. However, recognising the importance of confidence in the underlying evidence base, the Authority has also sought technical peer-review within Australia of individual elements of the proposed Basin Plan. In addition to this, the Authority has invited international scrutiny of the approaches used to develop the proposed Basin Plan.

The independent reviews confirm that the approaches being taken in developing the proposed Basin Plan represent best available (biophysical and social) science and knowledge, albeit they also reinforce the Authority's view that there is much scope for further work and additional data capture into the future. However, they do represent the best available data on which to develop the plan at this point in time.

The Authority has drawn on data from a range of reputable and internationally recognised national sources, most notably:

- Commonwealth Scientific and Industrial Research Organisation
- Australian Bureau of Statistics
- Bureau of Meteorology
- Geoscience Australia
- Australian Bureau of Agricultural and Resource Economics – Bureau of Rural Sciences
- Department of the Environment, Water, Heritage and the Arts (now Department of Sustainability, Environment, Water, Population and Communities).

These national datasets were supplemented by extensive data collections typically from water, environment, and primary industry departments in each Basin state. The Authority supplemented this data further with new work to gain insight into the social and economic situation within specific irrigation districts. In developing the positions in this document, the Authority has been informed by the data, sources and analyses assembled and undertaken by its staff. This data and information has been collated and is available on the Authority's website at www.mdba.gov.au.

Collectively this represents a significant body of data upon which to develop the proposed Basin Plan. However, early analysis found that there were compatibility issues with these various datasets, significant duplication between them, and there is usually no single authoritative source. Furthermore, data quality and consistency were variable, and there were significant gaps in the data record over time and space.

To supplement data collections, the Authority used a suite of modelling tools, most significantly in hydrology, to understand the complex water management arrangements that exist in the Basin. These models use hydrologic observations to describe the full range of behaviour of the water resource system from 1895 to 2009. In ecology, much of the modelling effort to date focuses on the response of an ecosystem to watering events, while economic modelling tends to focus on predicting future economic behaviour based on past experience.

Measuring instream water quality on the Darling River, New South Wales

The final piece of the evidence base is available scientific knowledge. The Authority has drawn on extensive scientific literature as it relates to specific locations in the Basin or to methods and approaches that have been used in similar fields of endeavour in Australia and internationally. This literature includes peer reviewed publications in scientific journals, published books, and published and unpublished reports from governments.

Of the three broad categories of evidence that the Authority has drawn on to develop the proposed Basin Plan the hydrology evidence is considered the 'best' in terms of level of detail, historical record, completeness, availability and suitability. By comparison, there tends to be different ecological evidence collected in each Basin state, invariably for different purposes and to different standards. Similarly, with social and economic evidence there is usually a choice between macro-scale data or purpose specific collections, with little relating to the micro-scale social and economic fabric of the Basin.

However, a simple compilation of data, models, and scientific knowledge does not provide insight into how much confidence might be ascribed to the evidence base. The quality of every dataset and publication used to develop the proposed Basin Plan has been categorised as either:

- high — broadly incontestable knowledge, formally peer reviewed, published and repeatable. High confidence
- medium — knowledge and data available from a range of sources, but may not have been subject to formal peer review. A relatively lower level of confidence for this category
- low — scientific knowledge and data is limited or emerging. Requires research investment.

Most of the evidence base available falls into the medium confidence category, primarily as a result of being datasets or publications of government which have not undergone any significant peer-review scrutiny. The Authority remains concerned that much of this evidence is difficult to find, is often subject to restrictions on access, and is not easy to integrate. To address this issue the Authority has committed to making the evidence base available for public scrutiny.

4.2 Social and economic assessments

The *Water Act 2007* (Cwlth) requires that, in meeting the additional environmental water needs of the Murray–Darling Basin, the Authority must optimise social, economic and environmental outcomes, and at a minimum, the impacts need to be well understood. The Authority considered many existing reports into the socioeconomic effects of changes in water management arrangements, particularly at a regional level. However, the existing social and economic evidence base for the Basin was not considered adequate to undertake the required assessment at a fine degree of resolution.

To overcome the weakness in the available information, the Authority sought advice from industry, community and government stakeholders as part of its regional program of visits, as well as from the Basin Community Committee. It also commissioned a wide range of studies to assess the likely socioeconomic implications of any reductions to current diversion limits. These projects include work undertaken by the Australian Bureau of Statistics (ABS) in conjunction with the Australian Bureau of Agricultural and Resource Economics (ABARE) and the Bureau of Rural Sciences (BRS) to look at baseline social and economic information on the circumstances of Basin communities. The issues that were covered included population trends, analyses of water use by industry and community, and indicators of economic and community wellbeing.

Work to develop regional community profiles was also undertaken and a comprehensive data store of available social and economic information was compiled to enable ongoing monitoring and review work. A synthesis of current knowledge of the concepts of community resilience was also undertaken, by BRS and the University of New England's Institute for Rural Futures, with an emphasis on understanding the drivers of change in regional and rural communities, especially regarding reductions in water availability. The study identified indicators of community sensitivity, adaptive capacity and vulnerability and mapped these across the Basin. This work evaluated one perspective of how a potential reduction in diversion limits might affect the social sphere.

The BDA Group, in conjunction with the Australian National University, undertook a review and synthesis of the results of previous socioeconomic studies conducted in the Murray–Darling Basin, particularly relating to changes in water availability and policy.

In addition, economic modelling was undertaken in separate studies by ABARE and the University of Queensland's Risk and Sustainable Management Group to estimate the direct impacts on agricultural industries of various scenarios of reductions in water availability. The ABARE modelling identified changes in the value of irrigated agricultural production, land use and water use as well as estimating the flow-on economic and employment impacts at a regional, Basin, state and national level. The work also identified regions and towns that may be particularly vulnerable to a reduction in irrigation activity.

Work to understand the effects of changes in water availability on Aboriginal communities of the Murray–Darling Basin was undertaken by CSIRO. This highlighted water planning requirements that need to be met to ensure Aboriginal interests are duly considered when finalising the proposed Basin Plan, and in the accreditation of water resource plans.

Structural adjustment pressures on irrigated agriculture in the Basin were examined by Frontier Economics. This provided a review of the range of structural adjustment pressures facing irrigated agriculture and its dependent communities, so that the likely impact of the proposed Basin Plan could be understood in the broader context of ongoing structural change in the Basin.

Charles Sturt University and CSIRO undertook an economic valuation of environmental benefits in the Basin, in particular of non-market values likely to be associated with long-term average sustainable diversion limits (SDLs) in the Basin.

Many Basin residents participated in a study undertaken for the Authority by Marsden Jacob Associates. This delivered information at local and regional scale (including 12 irrigation district case studies) to enhance the Authority's understanding of the social and economic circumstances of Basin communities. It assessed the likely impacts of reduced water availability, especially in terms of community vulnerability and adaptive capacity. The project gathered information about regional community opportunities, risks, constraints and aspirations as well as an appreciation of how communities can transform and adapt in response to changed water availability in the context of developing the proposed Basin Plan.

Effects of changes to water allocation policy on financing the agricultural sector, small business and individuals in the Murray–Darling Basin were also analysed in a study by an independent consultant. In this analysis the factors affecting the availability and cost of debt and equity capital in agricultural and tertiary industries in the Basin as a result of potential reductions in water availability for consumptive use were considered. The Nous Group undertook an analysis that integrated three of the socioeconomic assessments and synthesised the key findings. Further assessments have been commissioned by the Authority to better understand the likely implications of introducing SDLs. The Centre of Policy Studies (Monash University) is carrying out modelling to assess the short-, medium- and long-term economic implications, as well as the downstream flow-on effects, of the introduction of SDLs across a range of water availability and adjustment scenarios.

Alpine peatlands near Falls Creek, Victoria

The Authority has also commissioned the Centre for International Economics to carry out a series of social cost-benefit analyses of the effects of scenarios for introducing SDLs on each of the 19 regions in the Murray–Darling Basin and for the Basin as a whole.

The various reports prepared for the Authority use widely different methodologies. Both ABARE and the Marsden Jacob Associates report, for example, have addressed the socioeconomic impacts of possible SDLs but differ significantly in their techniques and underlying assumptions. Other reports took a more general look at how the finance sector might be expected to respond to the Basin Plan itself, and provided an integrated analysis and evaluation of the findings.

ABARE has analysed the socioeconomic implications of the Basin Plan through its water trade model (used to estimate the direct effects of changes in the SDLs on the value of irrigated agriculture) and AusRegion, a computable general equilibrium model, to estimate economy-wide effects of change at the industry and regional levels. Similarly, the University of Queensland used its Risk and Sustainable Management Group model to simulate water allocation for irrigated agriculture in the Basin, and the Centre of Policy Studies (Monash University) used a computable general equilibrium model (TERM-H2O) in its study to analyse flow-on effects to regional economies. Marsden Jacob Associates, on the other hand, conducted face-to-face interviews with community representatives and a phone survey of households across the Basin to establish a social profile of regional communities.

Marsden Jacob Associates' work taps into community understanding and knowledge of Basin agriculture and water resource management, but is limited in the insight it can provide to understand the dynamic responses of industry and communities to increased water scarcity and changes in relative prices of water and other inputs. However, the work by ABARE and the Centre of Policy Studies is very useful in this regard and when considered together, the reports provide a solid foundation for consideration of the socioeconomic issues relevant to considering an SDL regime.

The recently commissioned work will complement these existing studies to provide a further level of understanding of the social and economic impacts of the Basin Plan.

4.3 Hydrologic modelling

The Authority has used existing water resource planning and management models from New South Wales, Victoria, Queensland, South Australia and the Australian Capital Territory. This includes models of each major river system and groundwater system within their jurisdiction.

The CSIRO Murray–Darling Basin Sustainable Yields Project linked 24 of these models to represent Basin-wide hydrology and water sharing arrangements. However, to adapt for the specific needs of the Basin Plan, the methods and tools underpinning the CSIRO Sustainable Yields Project have been updated by the Authority. As a result this integrated model provides the best available model to underpin the hydrologic modelling for the Basin Plan. The Authority is aware that the CSIRO Sustainable Yields Project attracted some community concern especially about interpretation of modelling results. The Authority has addressed these concerns by developing the water balance reporting in each valley from the models in discussions and collaboration with the state agencies that have developed these models. This water balance reporting includes modelled long-term average inflows, diversions, outflows and losses for each valley.

Using this integrated model, a reference baseline has been developed which represents a reference point from which changes to water management strategies can be assessed. The reference baseline includes a range of conditions — including infrastructure such as dams, entitlements and water sharing rules, operating rules, environmental flow rules, etc — that affect water hydrology and water management. This baseline is discussed in more detail in Chapter 5.

In addition, the Authority has compiled 'without-development' models which have been used to understand how the Basin river systems may have operated under natural conditions. These 'without-development' models have stripped out water development conditions such as dams, water sharing rules and diversions from the reference baseline models.

Groundwater modelling is not as well developed in the Murray–Darling Basin as river system modelling, however extensive use has also been made of those groundwater models that exist. In total 11 groundwater models have been developed to help analyse possible SDLs for groundwater use across the Basin.

The surface-water hydrologic models are based on observed data for rainfall, temperature, evaporation, streamflow, crop type, planted areas and metered diversions from 1895 to 2009. However, these data are not observed everywhere, and there are gaps in the data records over time. To overcome these shortcomings in the observed data record, a variety of well established techniques such as interpolation are used to fill in the gaps in both space and time. This ensures that the extended datasets describe the full range of behaviour of the water resource system over the full period 1895 to 2009 for a given set of water management conditions. Based upon this extended dataset the models can also provide estimates of flows and water use at locations where measurements have not been made.

Windmill on the Myroolia property near Bourke, New South Wales

This data is used to calibrate models in a step-wise manner, first by calibrating the hydrologic processes and then by calibrating water use. The period over which each model is calibrated depends on the availability of observed data as well as the history of water resource development. The calibration process attempts to use historical periods that are relatively stable in terms of development (no major changes in infrastructure, water sharing and irrigation demands) but also capture the full range of historical climate variability; this ensures a robust calibration.

The individual river system models provided by the states, and in the case of the Murray and Lower Darling, by the Authority, have been calibrated by the state agencies and, in most cases, detailed calibration reports have been produced although seldom previously published. The quality assurance around these models has been further enhanced through the independent audit and review process set up for compliance with the Cap on diversions. This process has led to significant revisions and improvements to the river models.

The integrated modelling framework being used to develop the Basin Plan was first tested by the CSIRO Murray–Darling Basin Sustainable Yields Project, which was independently reviewed by an expert panel headed by a National Water Commissioner. Since updating this framework for Basin Plan application, the modelling systems design and modelling methods have been documented and subjected to two additional independent scientific reviews. In addition the methods used to develop climate change scenarios for the Basin Plan have also been independently peer-reviewed and published in international scientific journals.

While these comprehensive review processes have confirmed that the modelling platforms are the best available, it is important to recognise that there are inherent uncertainties in any mathematical modelling. Some of this uncertainty is introduced through the methods used to fill the gaps in the data record, while others are introduced through the imperfect understanding of the complexity of the river system or aquifer.

5. Hydrologic character of the Basin

Key points

- The long-term (1895–2009) average rainfall across the Basin is in the order of 500,000 gigalitres per year (GL/y).
- Average surface-water inflow is 32,800 GL/y and groundwater recharge is 26,500 GL/y.
- An average of 15,400 GL/y is the total of current consumptive use in the Basin — 13,700 GL/y from surface water and 1,700 GL/y from groundwater.
- Surface-water use is made up of 10,940 GL/y taken from watercourses and floodplains, and 2,740 GL/y intercepted by farm dams and forestry plantations.
- The 26,500 GL estimated gross groundwater recharge includes groundwater that discharges to streams, contributing part of the 32,800 GL surface-water inflow. Of the net groundwater recharge, some recharge is saline groundwater.
- Under without-development conditions, an average of 12,500 GL/y would flow out of the Murray Mouth. Some 83% of these outflows would originate from the River Murray system and 17% from the Darling system.
- Under the current diversion baseline, the environment receives an average of 19,100 GL/y (58%) of surface water inflows. Of this, an average of 5,100 GL/y flows out of the Murray Mouth — some 41% of the average outflows under without-development conditions.

Rainfall records suggest that the long-term (1895–2009) average rainfall across the Basin is in the order of 500,000 GL/y. There is climate variability throughout the Basin and a strong east–west rainfall gradient with decreasing rains from east to west. The northern and southern parts of the Basin also display markedly different seasonal patterns. The northern Basin experiences intense and sporadic summer-dominated rainfall, with winter-dominated rainfall in the south. However, a small portion of the rainfall ends up as water in surface-water streams and underground aquifers. Most of the rainfall evaporates or transpires. Around 6% of rainfall — about 31,800 GL/y (long-term average) — becomes inflow (excluding inter-Basin transfers) to the Basin's surface water streams.

The Basin receives some 1,000 GL/y of additional surface water**,** mainly via the Snowy Mountains Hydro-electric Scheme, giving a long-term average Basin total of 32,800 GL/y of surface-water inflows. Figure 5.1 shows that of the total inflows, approximately 19,100 GL/y (about 58%) currently remains in the environment and includes losses such as evaporation, while about 13,700 GL/y (about 42%) is extracted for consumption; 10,940 GL/y is consumed by irrigation together with urban supplies from watercourse and floodplain diversions (collectively termed watercourse diversions), and 2,740 GL/y is accounted for by farm dams and forestry plantations that intercept run-off before it reaches watercourses (termed interception).

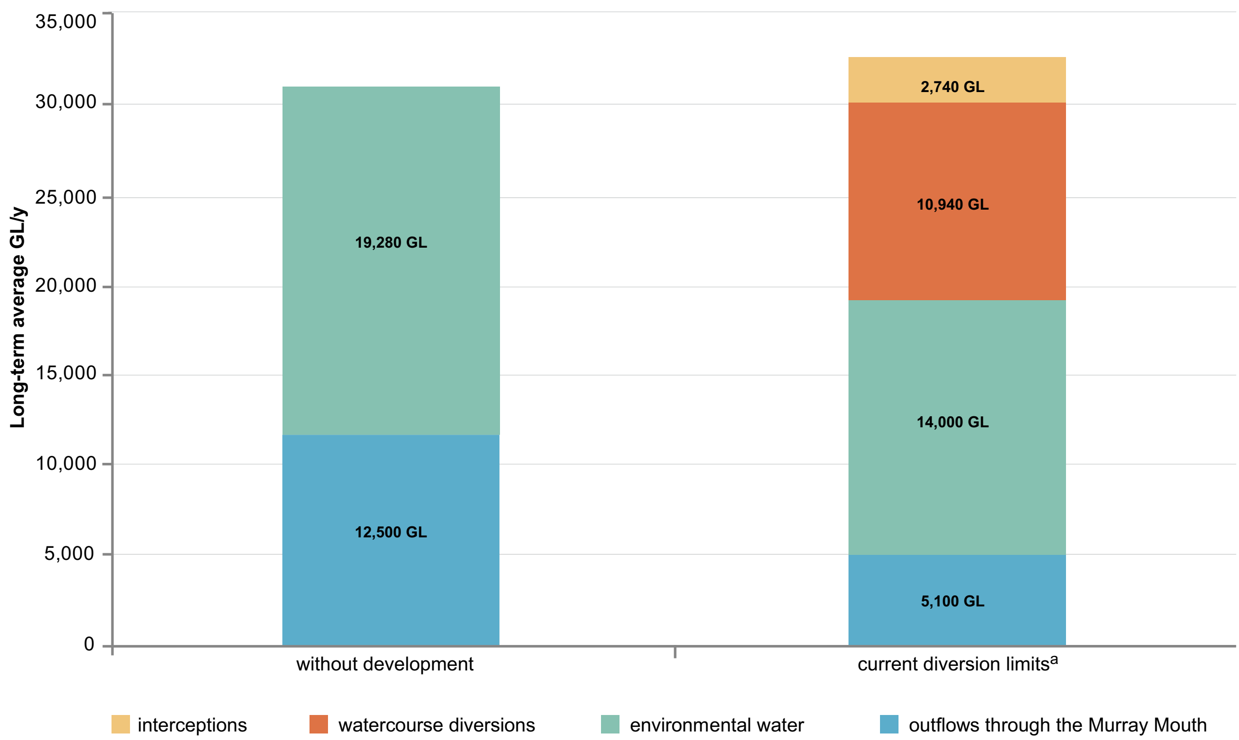
Similarly, a small proportion of rainfall (26,500 GL, or 5%) finds its way into the groundwater system as groundwater recharge. Since surface water and groundwater are connected in many parts of the Basin, some of this

Darling River at Wilcannia, New South Wales volume discharges to streams and forms part of the surface-water inflow. Connectivity between the two resources also means that groundwater extraction can reduce the amount of groundwater that discharges into streams or sometimes induce water from streams into the aquifer. The speed and amount of flow between the resources varies throughout the Basin and groundwater discharge can make up a large part of the flow in some streams during dry times.

Around 1,700 GL of groundwater is consumed each year from the Basin's water resources. This volume is much smaller than the amount of surface water consumed across the Basin, but some areas rely heavily on groundwater for supply. High salinity in some aquifers can mean the groundwater is unsuitable for many uses.

Currently average outflows from the Basin are 5,100 GL/y. This is 41% of the 12,500 GL/y that might be expected under without-development conditions.

A more detailed description of the reference baseline is provided later in this chapter. The numbers for flows, diversions and use given in the detailed tables are based on model results and data on water use or diversions. The number of significant figures has been retained for ease of reference to the source data. The overall accuracy of data, however, is reflected by the rounded numbers used in the text.



a Includes transfers of 527 GL from the Snowy River to the River Murray, 410 GL from the Snowy River to the Murrumbidgee River and 60 GL from the Glenelg River to the Wimmera River

Figure 5.1 Use of long-term average surface-water inflows in the Murray–Darling Basin

5.1 Surface water

The Basin is a complex, interconnected river system rather than a series of separate catchments. However, its naturally diverse climate and landscape and the presence of artificial structures mean that not all parts of the system are connected to the same extent. For example, rivers such as the Paroo, Lachlan and Wimmera only rarely, if ever, contribute flows further downstream. However, during very wet periods water spreads from the river channels out onto wide floodplains. These floodplains are typically very flat in their lower reaches, resulting in very slow travel times and high natural losses through seepage and evaporation, particularly over summer and in the northern parts of the Basin.

Infrastructure such as dams and weirs allows the manipulation of natural flows. Where large dams have been built, flows can be stored in wet months and released later for use in the catchments immediately — and sometimes up to hundreds of kilometres downstream. The dams in the three major southern rivers — the Murrumbidgee, Murray and Goulburn — are used to provide regulated flows downstream, as far as the lower lakes, even in summer. This includes regulated releases to the Murray from the Murrumbidgee and Goulburn. In the northern Basin it is not physically possible to regulate releases from dams to supply water down the Darling River, let alone to the Murray. However, additional flows in these northern rivers can contribute to these flows in downstream rivers, though not as regulated supply. Generally, water users in much of the northern Basin must rely on collecting water during floods and storing it on-farm for later use.

In a number of locations across the Basin, water is transferred into or out of the Basin as well as from one catchment to another within the Basin. The major transfers into the Basin are from the Snowy River catchment via the Snowy Mountains Hydro-electric Scheme and from the Glenelg catchment to the Wimmera system. Transfers out of the Basin include diversion of water from the South Australian River Murray to supply Adelaide and associated country areas.

Channels and pipelines in the river systems of the southern Basin also allow water to be moved and traded from one catchment to another. For example the Waranga Western Channel delivers water from the Goulburn River to the Campaspe, Loddon and Wimmera–Avoca catchments.

Wimmera Mallee Pipeline construction, Victoria

5.2 Without-development surface-water flow conditions

Without-development flow conditions are based on river system modelling with infrastructure such as dams and consumptive water use removed. Adjustments have not been made for the effects of diffuse land-use changes on run-off (i.e. other than interceptions). Therefore these flow conditions do not completely represent the flow conditions before development occurred. However, they provide a useful reference point for Basin flow conditions.

The surface-water inflow for the Basin is the amount of water that flows over its land surface and into its watercourses as a result of rainfall, as well as discharge from groundwater. Inflows can be determined in several ways.

The CSIRO Murray–Darling Basin Sustainable Yields Project adopted current surface water availability assessed as modelled flows without consumptive water use at the points of maximum flow. This method resulted in a long-term average total of 23,313 GL/y for the Basin (1895–2009). This method provides a robust and reliable measure of long-term average water availability.

Floodwaters on the Balonne River 2010, Queensland

However, this approach has the disadvantage of making it difficult to compare the water used between current conditions and possible future conditions. Interception activities also capture water resources not included in this measure of water availability.

The Authority has therefore adopted a best estimate of surface-water run-off generated across the Basin, based on modelled inflows adjusted where necessary to incorporate the effects of interception activities. This results in an estimate of the long-term average total Basin inflows of 31,800 GL/y (excluding inter-Basin transfers).

Table 5.1 shows long-term average inflows, outflows and water used by the environment for each major catchment in the Basin under without-development conditions. The water used by the environment is the difference between inflows and outflows.

Table 5.1 shows that, under without-development conditions, an average of 12,500 GL/y would flow out of the Basin through the Murray Mouth. Average inflows are 13,500 GL/y for the Darling and its tributaries, and 16,000 GL/y for the Murray and its tributaries upstream of Wentworth. However, due to the higher natural losses in the northern Basin, the outflow from the Darling at its junction with the Murray is only 2,400 GL/y (18% of inflows) compared with 11,800 GL/y (74% of inflows) from the Murray upstream of the junction

The Paroo, Lachlan and Wimmera–Avoca terminate in wetlands that rarely or never contribute flows further downstream.

5.3 Current diversion limits for surface water

The current surface-water diversion limits include all water pumped, diverted or intercepted for consumptive purposes, including irrigation, urban supplies, stock water, domestic supplies and industry. Water losses that occur in delivering supplies via irrigation channels are also included. Current diversions are limited by existing transitional and interim water resource plans where these are in place. These are existing plans, prepared by Basin states, and recognised under the *Water Act 2007* (Cwlth). Where transitional or interim water resource plans are not in place, or plans do not apply to certain types of take, the current diversion limit reflects the current level of take.

Table 5.1 Without-development conditions in the Murray–Darling Basin[a]

Catchments	Inflows (GL/y)	Water used by environment and losses (GL/y)	Outflows (GL/y)
Darling and tributaries			
Paroo	688	688	0
Warrego	702	632	69
Condamine–Balonne	2035	1466	569
Moonie	202	106	96
Border Rivers	2,195	1,397	797
Gwydir	1,131	701	429
Namoi	2,128	1,300	828
Macquarie–Castlereagh	3,214	2,454	760
Total for tributaries contributing to Darling	**12,295**	**8,745**	**3,550**
Barwon–Darling	1,247	1,524	3,273
Lower Darling	6	879	2,399
Total for Darling including tributaries	**13,547**	**11,148**	**2,399**
Murray and tributaries upstream of Wentworth (excluding Darling)			
Disconnected tributaries:			
Lachlan	1,755	1,755	0
Wimmera–Avoca	399	399	0
Total for disconnected tributaries	2,155	2155	0
Connected tributaries:			
Ovens	1,804	76	1,728
Goulburn–Broken	3,559	300	3,521
Loddon	347	202	145
Campaspe	333	52	281
Murrumbidgee	4,791	1,943	2,848
Kiewa	689	7	682
Total of tributary contribution to Murray (excluding Darling)	**11,523**	**2,580**	**8,943**
Murray upstream of Wentworth	4,436	1,628	11,751
Total for Murray (excluding Darling)	**15,959**	**4,208**	**11,751**
Murray downstream of Wentworth			
Murray downstream of Wentworth		1,720	12,430
Eastern Mount Lofty and Marne Saunders	120	47	73
Basin total	**31,781**	**19,278**	**12,503**

[a] Long-term (1895–2009) averages

Sections 20(b) and 22(3(d)) of the *Water Act 2007* (Cwlth) require the regulation of significant interception activities. Therefore, for surface water, the current diversion limit is made up of two main parts:

- watercourse diversions
- interception activities.

Watercourse diversions include diversions from watercourses and floodplain harvesting. Diversions from watercourses are reasonably well measured, with improvements continuing through ongoing meter installation. Most of these diversions are included explicitly in river system modelling and are limited by existing water resource plans or existing water management arrangements, including the 1995 Murray–Darling Basin Cap. Floodplain harvesting is less well measured, but is included in river system models where there are significant diversions (i.e. in most of the larger models in the northern Basin). Floodplain harvesting is also included in existing water resource plan limits.

In recent years there has been significant investment by governments in the provision of environmental entitlements such as The Living Murray and Water for Rivers initiatives (recovering water for the Murray and the Snowy). As these investments are complete or well known, the Authority has adopted a reference point that includes water recovered for the environment through The Living Murray and Water for Rivers initiatives, and the Wimmera Pipeline Project.

However, environmental entitlements purchased or made available by infrastructure savings under the Commonwealth Water for the Future program have not been included as this program is not complete.

All environmental water purchased or saved through the Commonwealth Water for the Future program will be available to offset reductions in diversion limits resulting from the Basin Plan.

Aerial view of Barmah Forest, 2007, Victoria

The reference baseline for watercourse and floodplain diversions under current diversion arrangements has been assessed using the modelling framework. Taking all of these elements into account, under 1895–2009 historical climate conditions, the long-term average watercourse diversions are 10,940 GL/y.

By comparison, there is limited reliable data on the level of interception by farm dams and forestry plantations. Further, the majority of these interceptions are not explicitly represented in models. Although floodplain harvesting could be considered a form of interception; because it is explicitly represented in models it has been included with diversions from watercourses as described above. Interception by farm dams and forestry plantations for reference baseline conditions has been based on the most recent available estimates of the impact of interception activities on run-off.

Outcomes from studies undertaken by SKM (Sinclair Knight Merz), CSIRO and the Bureau of Rural Sciences (2010) and SKM (2007) have been used for these estimates. However, these studies acknowledge the limitations to the accuracy of their results, and the Authority recognises that their application in the Basin Plan needs to keep these limitations in mind. The reference baseline for interceptions is estimated at 2,740 GL/y on average, giving a total of surface-water current diversion limits of about 13,700 GL/y. Further information on interceptions by farm dams and forestry plantations is included in this chapter.

Table 5.2 shows long-term average inflows, outflows, interceptions, diversions and water used by the environment for each major catchment in the Basin under current diversion limits. The current diversion limit is divided into interceptions and watercourse diversions. The figures for watercourse

Darling River with no water at Tilpa, New South Wales

diversions include floodplain harvesting. Where catchments include more than one water planning area, current diversion limits are shown for each area. The Intersecting Streams water planning area comprises the New South Wales part of a number of catchments in the northern part of the Basin, and the current diversion limit is included in a separate row for this area. The Murray upstream and downstream of Wentworth comprises three water planning areas, and limits for these areas are shown at the bottom of the table.

The baseline conditions include inter-Basin transfers from the Snowy River catchment to the Murray and Murrumbidgee, and from the Glenelg River catchment to the Wimmera. The results in Table 5.2 are based on the river system modelling framework with existing infrastructure, water sharing and operating rules, using the 1895–2009 historical climate. Water leaving the Basin is considered as consumption within the catchment from which it is extracted. Outflows under current diversion limit conditions are compared with outflows under without-development conditions.

Water used by the environment and losses is the difference between inflows and outflows, after accounting for transfers into the Basin, watercourse diversions and interceptions. Under current diversion limit conditions, this is made up of water used by the local environment in the catchment, plus additional evaporation and losses resulting from water used for consumptive purposes.

Surface water and groundwater connectivity has been taken into account by determining the impact of past and current groundwater extractions on current and future (to 2030) streamflow. This has been accounted for by including the estimated impact, where this is significant, as a 'loss' component in surface water river system models. The volume of recharge from surface-water to groundwater was identified in numerical groundwater models as part of the water balance.

Going back to Table 5.1, the outflows under without-development conditions are of the order of 12,500 GL/y. Table 5.2 shows that the average flow out of the Basin at the Murray Mouth under current diversion limits reduces to 5,100 GL/y, which is around 41% of without-development outflows. Under current arrangements, some catchment outflows have been significantly affected. There are a number of catchments where the outflows are reduced to around 40% of the without-development conditions. They are the Condamine–Balonne, Gwydir, Lower Darling, and Loddon catchments, and the Murray downstream of Wentworth.

Table 5.2 Current diversion baseline conditions in the Murray–Darling Basin

Catchment	Inflows (GL/y)	Transfer into Basin (GL/y)	Current diversion limits			Water used by environment and losses (GL/y)	Outflows	
			Interceptions (GL/y)	Watercourse diversions (GL/y)	Total (GL/y)		Downstream (GL/y)	As % of without-development outflows
Darling and tributaries								
Paroo	688		9.7	0.2	9.9	678	0	
Warrego	702		83	45	128	510	58	84
Condamine–Balonne region	2,035		290	712	1,002	792	241	42
Condamine–Balonne			265	706	971	792	241	
Nebine			25	6	31			
Moonie	202		51	32	83	48	71	74
Intersecting Streams (diversions only)			2.4	3	5.4			
Border Rivers region	2,195		174	433	607	1,075	513	64
Queensland Border Rivers			78	223	301			
New South Wales Border Rivers			95	210	305			
Gwydir	1,131		125	326	451	507	173	40
Namoi	2,128		165	343	508	967	653	79
Macquarie–Castlereagh	3,214		310	425	735	1902	577	76
Total for tributaries contributing to Darling	**12,295**		**1,210**	**2,319**	**3,529**	**6,479**	**2,286**	**64**
Barwon–Darling	1,247		108	197	305	1,506	1,721	53
Lower Darling	6		6	55	61	645	1,021	43
Total for Darling including tributaries	13,547		1,324	2,571	3,895	8,631	1,021	43
Murray and tributaries upstream of Wentworth (excluding Darling)								
Disconnected tributaries								
Lachlan	1755		316	302	618	1,137	0	
Wimmera–Avoca	399	60	62	74	136	323	0	
Total for disconnected tributaries	**2,155**	**60**	**378**	**376**	**754**	**1,460**	**0**	
Connected tributaries								
Ovens	1,804		58	25	83	13	1,708	99
Goulburn–Broken region	3,559		152	1,607	1,759	200	1,600	49
Goulburn			109	1,593	1,702			
Broken			43	14	57			
Loddon	347		90	95	185	101	61	42
Campaspe	333		40	115	155	24	153	54
Murrumbidgee region	4,791	410	513	2,100	2,613	995	1,593	56
Murrumbidgee			501	2,061	2,562			
Australian Capital Territory			12	39	51			
Kiewa	689		14	11	25	7	657	96
Total for tributaries contributing to Murray (excluding Darling)	**11,523**	**410**	**868**	**3,953**	**4,821**	**1,341**	**5,772**	**65**
Murray upstream of Wentworth	4,436	527	149	3,338	3,487	1,000	6,248	53
Total for Murray including all tributaries except Darling	**15,959**	**937**	**1,017**	**7,291**	**8,308**	**2,341**	**6,248**	**53**

... continued

Table 5.2 Current diversion baseline conditions in the Murray–Darling Basin (continued)

Catchment	Inflows (GL/y)	Transfer into Basin (GL/y)	Current diversion limits			Water used by environment and losses (GL/y)	Outflows	
			Interceptions (GL/y)	Watercourse diversions (GL/y)	Total (GL/y)		Downstream (GL/y)	As % of without-development outflows
Murray downstream of Wentworth								
Murray downstream Wentworth				704	708	1,524	5,038	41
Eastern Mount Lofty Ranges region[a]	120		13	0	13	42	67	92
Eastern Mount Lofty Ranges[a]			11	0	11			
Marne Saunders[a]			1.8	0	1.8			
Basin total	**31,781**	**997**	**2,735**	**10,942**	**13,677**	**13,996**	**5,105**	**41**
Murray total (by SDL area)			149	4,042	4,191			
Murray New South Wales			104	1,721	1,825			
Murray Victoria			45	1,656	1,701			
Murray South Australia			0	665	665			

a Current diversion limits for Eastern Mount Lofty Ranges and Marne Saunders are not split by the South Australian Department for Water between interceptions and watercourse diversions

5.4 Interception activities

Best available estimates of interception activities that have significant impact on surface-water yield (run-off), including farm dams and forestry plantations, are presented in Table 5.3.

Farm dams vary in storage capacity and their use includes basic rights and irrigation, among other uses. Farm dams under basic rights are generally used for stock and domestic purposes. Because of the different regulation of farm dams under basic rights and for irrigation and other uses, their impact is shown separately. For the purposes of the Basin Plan, the impact on run-off is used as the basis for estimating interception by farm dams.

The impacts of forestry plantations are not modelled explicitly and their estimated take is the third component of the interception activities. The estimates of the impact on run-off of forestry plantations are based on the work done for the National Water Commission (SKM, CSIRO & BRS 2010).

While not tabulated here, it is noted by the Authority that interception through mining activities can have a locally significant impact on groundwater. While much of the current coal seam gas exploration focuses on gas contained in sedimentary deposits forming part of the Great Artesian Basin, there may be some hydrologic connection between the Great Artesian Basin and overlying aquifers that are considered to be Murray–Darling Basin resources. Hence, coal seam gas projects that involve very large pressure changes in the groundwaters of the Great Artesian Basin sediments may alter the rate at which water in the Murray–Darling Basin groundwater systems exchanges with those of the Great Artesian Basin. Therefore, this potentially comprises an interception activity for which the volumes must be accounted for within the management area for the relevant Murray–Darling Basin groundwater resource. Section 21(4) (viii) of the *Water Act 2007* (Cwlth) requires the Authority and the minister to consider '... the potential effect of the use and management of water resources that are not (Murray–Darling) Basin water resources on the use and management of Basin water resources'.

The Authority will work to improve estimates of interception impacts and develop arrangements to incorporate improved estimates over time.

Table 5.3 Initial estimates of surface-water interception activities in the Murray–Darling Basin

Code[a]	Catchment	Farm dams impact		Forestry plantations (GL/y)	Total (GL/y)	Proportion of current diversion limits (%)
		Basic rights[b] (GL/y)	Irrigation and other uses (GL/y)			
SS29	Paroo	9.7			9.7	98
SS28	Warrego	33	50		83	65
SS26	Condamine–Balonne	61	203	1.1	265	27
SS27	Nebine	25	0.3		25	81
SS25	Moonie	11	40		51	61
SS17	Intersecting Streams	2.4			2.4	44
SS24	Border Rivers (Queensland)	16	61	1.4	78	26
SS23	Border Rivers (New South Wales)	16	79	0.1	95	31
SS22	Gwydir	20	104	0.7	125	28
SS21	Namoi	21	139	5.3	165	33
SS20	Macquarie–Castlereagh	110	156	44	310	42
SS19	Barwon–Darling	3.3	105		108	35
SS18	Lower Darling	6			6	9
SS16	Lachlan	57	230	29	316	51
SS09	Wimmera–Avoca (surface water)	22	39	1.3	62	46
SS04	Ovens	17	9.4	32	58	70
SS06	Goulburn	39	47	23	109	6
SS05	Broken	11	19	13	43	75
SS08	Loddon	26	59	5.2	90	49
SS07	Campaspe	16	23	1.2	40	26
SS15	Murrumbidgee	41	344	116	501	20
SS01	Australian Capital Territory (surface water)	0.4	0.7	11	12	24
SS03	Kiewa	4.5	2.1	7.1	14	55
SS14	Murray (New South Wales)	10	70	24	104	6
SS02	Murray (Victoria)	10	13	22	45	3
SS11	Murray (South Australia)					0
SS12	Marne-Saunders[c]		1.8		1.8	100
SS13	Eastern Mount Lofty Ranges[c]		7.5	3.2	11	100
SS10	SA Non-Prescribed Areas	3.5			3.5	100
	Basin total	**591**	**1,803**	**341**	**2,735**	**20**

[a] A code has been assigned to each surface-water SDL area, as shown in Figure 8.5

[b] Generally used for stock & domestic

[c] Figure for farm dams impact includes basic rights. Provided by South Australian Department for Water

Note: The Authority will work to improve estimates of interception impacts and develop arrangements to incorporate improved estimates over time

Silverbeet crop irrigated with groundwater near Oakey, Queensland

5.5 Current diversion limits for groundwater

There are 78 proposed groundwater management areas in the Basin, reflecting the discrete character of groundwater systems. There are, however, only 13 transitional or interim water resource plans covering groundwater in the Australian Capital Territory and parts of New South Wales and South Australia. These include the water sharing plan for the Upper and Lower Namoi Groundwater Sources, which is generally recognised and managed as two distinct groundwater sources, and one draft plan in South Australia that is expected to be finalised as an interim plan in 2010.

These plans do not include a further five plans in Victoria that are expected to become transitional plans (although several of them cover only parts of the relevant groundwater systems).

Although the total area covered by existing plans represents about 10% of the Basin area, they cover over 49% of groundwater extracted from Basin resources.

In some plan areas in New South Wales, groundwater use is currently higher than the plan limit because this limit represents the level at the expiry of the plan, following planned reduction in groundwater entitlements over the course of the plan under a joint New South Wales and Australian Government program, Achieving Sustainable Groundwater Entitlements.

Groundwater extraction is metered in irrigation areas and other sites of intense extraction. Larger individual extractions (including for some irrigation, town water supply and industrial purposes) are also metered. The majority of groundwater use, by volume, is in areas covered by a plan and is metered. However, most bores located throughout the Basin are used for stock and domestic purposes and are not metered, and most are not included in an area covered by an interim or transitional plan.

In areas where groundwater use is metered, the baseline has been determined from average measured take over the previous five years (2003–04 to 2007–08) or, where that data is not available, from the measured take in 2007–08. Take from unmetered bores has been estimated by a variety of methods, taking advice from state and consultant groundwater experts.

The current diversion limit baseline comprises plan limits for those areas for which there are accredited plans, and entitlement, or current use, for the areas for which there are no accredited plans. Table 5.4 shows the current groundwater diversion baseline for the Basin regions which totals 1,786 GL/y for the whole Basin.

Table 5.4 Current diversion baseline for groundwater in the Murray–Darling Basin

Region	State	SDL area	Code[a]	Current diversion limit (GL/y)[b]
Barwon–Darling	NSW	Lachlan Fold Belt: Western	GS34	1.2
Border Rivers	NSW	Inverell Basalt	GS28	2.9
Border Rivers	NSW	New England Fold Belt: Border Rivers	GS50	3.4
Border Rivers	NSW	NSW Border Rivers Alluvium	GS47	6.6
Border Rivers	NSW	NSW Border Rivers Tributary Alluvium	GS48	0.5
Border Rivers	Qld	Queensland Border Rivers Alluvium	GS67	13.4
Border Rivers	Qld	Queensland Border Rivers Fractured Rock	GS68	6.8
Border Rivers	Qld	Sediments above the Great Artesian Basin: Border Rivers	GS69	0.1
Condamine–Balonne	Qld	Condamine Fractured Rock	GS66	2.1
Condamine–Balonne	Qld	Sediments above the Great Artesian Basin: Condamine–Balonne	GS70	0.3
Condamine–Balonne	Qld	St George Alluvium: Condamine–Balonne (deep)	GS73	7.5
Condamine–Balonne	Qld	St George Alluvium: Condamine–Balonne (shallow)	GS73	2.5
Condamine–Balonne	Qld	St George Alluvium: Warrego–Paroo–Nebine	GS75	0.3
Condamine–Balonne	Qld	Upper Condamine Alluvium	GS76	117.1
Condamine–Balonne	Qld	Upper Condamine Basalts	GS77	76.1
Eastern Mount Lofty Ranges	SA	Angas Bremer	GS1	6.5
Eastern Mount Lofty Ranges	SA	Eastern Mount Lofty Ranges	GS2	19.3
Eastern Mount Lofty Ranges	SA	Marne Saunders	GS5	4.7
Goulburn–Broken	Vic.	Goulburn–Broken Highlands	GS9	9.8
Goulburn–Broken	Vic.	Victorian Riverine Sedimentary Plains (deep; Renmark Group and Calivil Formation)	GS14	89.6
Goulburn–Broken	Vic.	Victorian Riverine Sedimentary Plains (shallow; Shepparton Formation)	GS14	83.3
Gwydir	NSW	Lower Gwydir Alluvium	GS38	32.3
Gwydir	NSW	New England Fold Belt: Gwydir	GS51	4.1
Gwydir	NSW	Upper Gwydir Alluvium	GS56	0.8
Lachlan	NSW	Belubula Alluvium	GS21	1.9
Lachlan	NSW	Lachlan Fold Belt: Lachlan	GS30	23.1
Lachlan	NSW	Lower Lachlan Alluvium	GS39	108
Lachlan	NSW	Orange Basalt	GS53	6.9
Lachlan	NSW	Upper Lachlan Alluvium	GS57	77.1
Lachlan	NSW	Young Granite	GS64	4.3
Loddon	Vic.	Loddon–Campaspe Highlands	GS10	9.4
Lower Darling	NSW	Adelaide Fold Belt	GS19	3
Lower Darling	NSW	Kanmantoo Fold Belt	GS29	8.2
Lower Darling	NSW	Lower Darling Alluvium	GS37	1.4
Lower Darling	NSW	Western Porous Rock	GS63	29.3
Macquarie–Castlereagh	NSW	Bell Valley Alluvium	GS20	2.2
Macquarie–Castlereagh	NSW	Castlereagh Alluvium	GS23	0.4
Macquarie–Castlereagh	NSW	Collaburragundry–Talbragar Alluvium	GS24	3.7
Macquarie–Castlereagh	NSW	Cudgegong Alluvium	GS25	1.6
Macquarie–Castlereagh	NSW	Eastern Porous Rock: Macquarie–Castlereagh	GS26	5.2
Macquarie–Castlereagh	NSW	Lachlan Fold Belt: Macquarie–Castlereagh	GS31	47.7
Macquarie–Castlereagh	NSW	Lower Macquarie Alluvium	GS40	69.3
Macquarie–Castlereagh	NSW	NSW Alluvium above the Great Artesian Basin	GS46	1.2
Macquarie–Castlereagh	NSW	Upper Macquarie Alluvium	GS58	13.7
Macquarie–Castlereagh	NSW	Warrumbungle Basalt	GS62	0.5

a A code has been assigned to each groundwater SDL area, shown in Figure 9.2

b Current diversion limit is based on plan limit, entitlement and current use. Current use is based on the 2007–08 level of use in most instances; however, where the 2003–04 to 2007–08 data was available, the average of these values was used

… continued

Table 5.4 Current diversion baseline for groundwater in the Murray–Darling Basin (continued)

Region	State	SDL area	Code[a]	Current diversion limit (GL/y)[b]
Moonie	Qld	Sediments above the Great Artesian Basin: Moonie	GS71	0.5
Moonie	Qld	St George Alluvium: Moonie	GS74	0.5
Murray	NSW	Lachlan Fold Belt: Murray	GS32	5.1
Murray	NSW	Lower Murray Alluvium (deep; Renmark Group and Calivil Formation)	GS41	83.7
Murray	NSW	Lower Murray Alluvium (shallow; Shepparton Formation)	GS41	39.5
Murray	NSW	Upper Murray Alluvium	GS59	11
Murray	SA	Mallee	GS3	41.2
Murray	SA	Mallee Border Zone	GS4	22.2
Murray	SA	Peake–Roby–Sherlock	GS6	5.2
Murray	SA	SA Murray (Groundwater)	GS7	1.8
Murray	SA	SA Murray Salt Interception Schemes	GS8	11.1
Murray	Vic.	Murray Highlands	GS11	4.4
Murray	Vic.	Wimmera–Mallee Border Zone (Loxton Parilla Sands)	GS17	0
Murray	Vic.	Wimmera–Mallee Border Zone (Murray Group Limestone)	GS17	8.8
Murray	Vic.	Wimmera–Mallee Border Zone (Tertiary Confined Sands Aquifer)	GS17	
Murrumbidgee	ACT	Australian Capital Territory (Groundwater)	GS65	7.25
Murrumbidgee	NSW	Billabong Creek Alluvium	GS22	2
Murrumbidgee	NSW	Lachlan Fold Belt: Murrumbidgee	GS33	30.9
Murrumbidgee	NSW	Lake George Alluvium	GS35	1.1
Murrumbidgee	NSW	Lower Murrumbidgee Alluvium	GS42	280
Murrumbidgee	NSW	Mid–Murrumbidgee Alluvium	GS45	44
Namoi	NSW	Eastern Porous Rock: Namoi–Gwydir	GS27	10.3
Namoi	NSW	Liverpool Ranges Basalt	GS36	2.7
Namoi	NSW	Lower Namoi Alluvium	GS43	86
Namoi	NSW	Manilla Alluvium	GS44	1.9
Namoi	NSW	New England Fold Belt: Namoi	GS52	15.6
Namoi	NSW	Peel Valley Alluvium	GS54	9.3
Namoi	NSW	Upper Namoi Alluvium	GS60	122.1
Namoi	NSW	Upper Namoi Tributary Alluvium	GS61	2
Ovens	Vic.	Ovens Highlands	GS12	3.2
Ovens	Vic.	Ovens–Kiewa Sedimentary Plain	GS13	14.7
Paroo	NSW	NSW Sediments above the Great Artesian Basin	GS49	1
Paroo	NSW	Upper Darling Alluvium	GS55	2.4
Warrego	Qld	Sediments above the Great Artesian Basin: Warrego–Paroo–Nebine	GS72	1.1
Warrego	Qld	Warrego Alluvium	GS78	0.7
Wimmera–Avoca	Vic.	West Wimmera (Loxton Parilla Sands)	GS15	0
Wimmera–Avoca	Vic.	West Wimmera (Murray Group Limestone)	GS15	1.9
Wimmera–Avoca	Vic.	West Wimmera (Tertiary Confined Sands Aquifer)	GS15	0.8
Wimmera–Avoca	Vic.	Wimmera–Avoca Highlands	GS16	0.2
Wimmera–Avoca	Vic.	Wimmera–Mallee Sedimentary Plain	GS18	0.6
		New South Wales		1,211
		Victoria		227
		South Australia		112
		Queensland		229
		Australian Capital Territory		7
		Basin total		**1,786**

a A code has been assigned to each groundwater SDL area, shown in Figure 9.2

b Current diversion limit is based on plan limit, entitlement and current use. Current use is based on the 2007–08 level of use in most instances; however, where the 2003–04 to 2007–08 data was available, the average of these values was used

6. *Determining the environmental water requirements of the Basin*

Key points

- The *Water Act 2007* (Cwlth) requires that long-term average sustainable diversion limits (SDLs) must reflect an 'environmentally sustainable level of take'. This means that the amount diverted for human use leaves sufficient water for the Basin's key environmental assets, key ecosystem functions, the productive base and key environmental outcomes — the Basin's environmental water requirements.
- The Basin covers an area of around 1 million km^2 with extensive riverine and groundwater systems, accompanying wetlands, billabongs, floodplains and their forests, and the Lower Lakes, the Coorong and Murray Mouth. This complex network of rivers and adjacent assets requires frequent, irregular and variable flows, and flooding in order to sustain its health.
- The Authority has systematically assessed the Basin's riverine, groundwater and wetland environment and identified four key ecosystem functions relevant to all parts of the Basin, and 2,442 key environmental assets spread across the Basin. The water requirements to support the productive base and the environmental outcomes of the resource will be met if the water requirements of key environmental assets and key ecosystem functions are met, along with the water quality targets contained in the Water Quality and Salinity Management Plan.
- To represent the complex and interconnected hydrology of the key ecosystem functions and key environmental assets, the Authority has also identified 106 hydrologic indicator sites spread across the Basin — 88 sites to assess the water requirements for key ecosystem functions and 18 sites to assess the water requirements for key environmental assets. These 18 hydrologic indicator sites for assets are a small subset of the 2,442 key environmental assets.
- The Authority has considered the environmental objectives of the Water Act and has used the best available information to determine the total environmental water requirements at 106 hydrologic indicator sites, and hence for the Basin as a whole.
- Detailed analysis showed that the range of surface water required to meet the environmental objects of the Water Act is between 22,100 gigalitres per year (GL/y) and 26,700 GL/y (long-term average), which is between 67% and 81% of the total available surface water under the historical climate scenario.
- To meet this range would require an additional volume of between 3,000 GL/y and 7,600 GL/y (long-term average) from the current diversion limits.

Cuttaburra Basin near Wanaaring, New South Wales

Key points (continued)

- For groundwater, the Authority has identified the maximum volume that can be taken without compromising the key ecosystem functions, productive base and key environmental outcomes of groundwater systems. To determine an environmentally sustainable level of take from groundwater, the Authority has updated groundwater recharge modelling for the entire Murray–Darling Basin, and undertaken detailed numerical modelling where possible.
- Detailed analysis showed that the aggregate of additional water required to meet the environmental objects of the Water Act is between 99 GL/y and 227 GL/y from the current groundwater diversion limits.
- The Authority is confident that this range of water volumes will meet the environmental water requirements of the Basin, within the bounds of certainty that the data and science allow.
- National and international peer reviewers confirm that this method for estimating the surface water environmental water requirements and the related approach for groundwater is robust.

Cherry trees at Myrtleford, Victoria

This chapter outlines the approach taken by the Authority to determine the environmental water requirements of the Basin for surface water and groundwater, to inform the calculation of long-term average sustainable diversion limits.

The *Water Act 2007* (Cwlth) requires the Basin Plan to establish long-term average sustainable diversion limits (SDLs) that reflect an environmentally sustainable level of take (ss. 22(1), 23(1)), which means that the level of take for consumptive purposes (human consumption, agriculture, industry, etc.) must not compromise key ecosystem functions; key environmental assets (including water-dependent ecosystems, ecosystem services, and sites of ecological significance); the productive base of the water resource; and key environmental outcomes for the water resource.

The task of assessing Basin-wide and catchment-specific environmental water requirements has never before been undertaken in the Murray–Darling Basin. The key environmental assets of the Basin have never been comprehensively identified or prioritised on a consistent basis at the Basin scale, and in many cases an assessment of their water needs has never been undertaken. Similarly, the water needs of key ecosystem functions have not been considered holistically with assets at Basin scale, although they are increasingly recognised locally. Finally, very little work has been done to define the productive base and identify key environmental outcomes at a Basin scale. In short, this is largely new territory for the Basin.

Providing additional environmental water will promote the sustainable use of the Basin's water resources to protect and restore the ecosystems, natural habitats and species reliant on them and conserve biodiversity (Water Act (s. 21(2)(b)).

In determining the Basin's environmental water requirements, the Authority has:

- established the hydrologic characteristics of an environmentally healthy Basin
- created a robust methodology to determine the water required for an environmentally healthy Basin
- used this methodology to determine the Basin's environmental water requirements.

Definitions

Key ecosystem functions — these are the fundamental physical, chemical and biological processes that support the Basin's environmental assets; for example, the transport of nutrients, organic matter and sediment in rivers, wetting and drying cycles, provision for migration and recolonisation by plants and animals along rivers and across floodplains.

Key environmental assets — these include the rivers, lakes, billabongs, wetlands, groundwater-systems floodplains and their flood-dependent forests and the estuary of the Basin. The term encompasses water-dependent ecosystems, ecosystem services and sites with ecological significance (for example, sites that are important refuges for wildlife during droughts).

The productive base — the support offered by ecosystems to human economic and social production.

Key environmental outcomes — are defined in the Water Act to include ecosystem functions, biodiversity, water quality and water resource health.

Ecosystem services — benefits people obtain from ecosystems. The rivers, floodplains and wetlands of the Murray–Darling Basin provide many important ecosystem services. These include clean water, food, timber, livestock production, flood control and mitigation, groundwater replenishment, sediment and nutrient retention and transport, reservoirs of biodiversity, cultural values, and recreation and tourism.

Hydrologic indicator sites — have been used to quantify the environmental water requirements across the Basin. These sites comprise 18 hydrologic indicator sites for assets, a subset of 2,442 key environmental assets across the Basin and 88 sites for key ecosystem functions.

6.1 The Basin environment — overview

As explained in Chapters 2 and 5, the Murray–Darling Basin represents a complex, interlinked hydrologic system. It is also a complex ecological system with a huge number and diversity of creeks, rivers, wetlands, billabongs, floodplains and groundwater systems; along with the Murray Mouth and estuary at the downstream end of the Basin system.

To appreciate the scale and diversity of the Murray–Darling system, it is important to note that the Basin constitutes:

- around 440,000 km of rivers, of which 60,000 km are major
- some 30,000 wetlands — most on private land — covering an area of around 25,000 km^2 with Ramsar-listed wetlands spanning 6,363 km^2
- a total floodplain area in the Basin of about 60,000 km^2, or about 6% of the Basin (see Figure 6.1)
- a total of 78 groundwater systems.

In terms of biodiversity, the Basin supports:

- more than 60 fish species, including 10 that are alien, and 7 marine or estuarine species
- some 124 families of macroinvertebrates, such as shrimps, snails, and insects
- around 98 species of waterbirds
- 4 water-dependent ecological communities listed as threatened or endangered under state or federal legislation
- key floodplains in the Murray–Darling Basin, such as the Murrumbidgee–Lachlan confluence, Chowilla, Macquarie Marshes and Lower Balonne, supporting 150–300 plant species.

6.2 Hydrologic characteristics of an environmentally healthy Basin

Freshwater ecosystems — rivers, lakes, floodplains, wetlands and estuaries — are essential to human health and wellbeing. Healthy freshwater ecosystems provide clean water, food, fibre, energy, and many other benefits supporting economies and livelihoods.

Lagoon on the Moonie River near Moonie, Queensland

A healthy Basin has rivers with a wide range of flows, from pools in dry times to those that fill and overflow banks, connecting floodplains, billabongs and lakes. It includes diverse, self-sustaining riverbank, floodplain and wetland vegetation harbouring many different species. It supports self-sustaining populations of native fish that can move freely between upstream and downstream habitats and between stream channels, floodplains and wetlands. It has abundant, secure populations of waterbirds, with habitats for breeding and feeding. In dry times it provides refuge, and in wet times opportunities for critical action such as breeding and migration.

Variable flows of fresh water are vital to support the health and resilience of the rivers of the Basin, to maintain important ecosystems and the services they provide. Environmental flow regimes are an essential part of planning for good water resources and management practices. A useful definition of environmental flows is 'the quality, quantity, and timing of water flows required to maintain the components, functions, processes, and resilience of aquatic ecosystems which provide goods and services to people'.

It is not correct to assume that water allocated to the environment is at the complete expense of human use and economic development, or being wasted by being allowed to flow to the sea. Environmental flows provide both direct and indirect benefits for community and society.

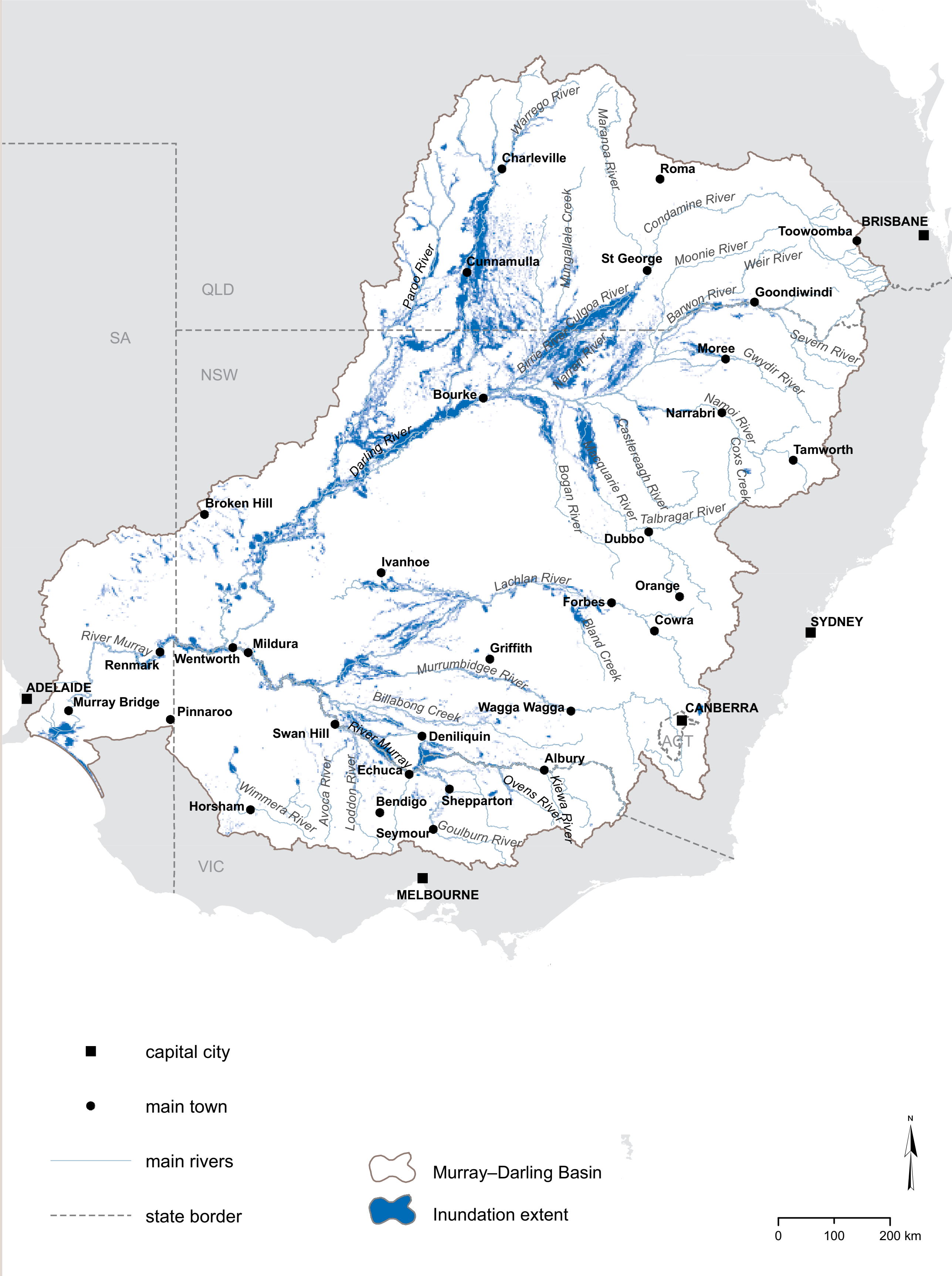


Figure 6.1 Murray–Darling Basin floodplain and wetlands map indicative of the extent of a 1 in 10-year flood event

Note: this is a composite map; not all rivers flood simultaneously

Source: Overton, IC, Colloff, MJ, Doody, TM, Henderson, B & Cuddy, SM (eds) 2009, *Ecological outcomes of flow regimes in the Murray–Darling Basin*, report prepared for the National Water Commission by CSIRO Water for a Healthy Country Flagship, CSIRO, Canberra. 422 pp.

Flooding at Bourke, New South Wales, 2009

Key ecosystem functions and key environmental assets

A healthy river system requires the maintenance of the full range of key ecosystem functions, key environmental assets (including water-dependent ecosystems and ecosystem services), a productive base of the water resource, and key environmental outcomes for the water resource.

Key ecosystem functions

The Authority has identified four key ecosystem functions considered critical to maintaining the ecological health of the Basin rivers:

- creation and maintenance of habitats for use by plants and animals
- transportation and dilution of nutrients, organic matter and sediment
- provision of connections along the river and downstream for migration and recolonisation by plants and animals
- provision of connections across floodplains, adjacent wetlands and billabongs for foraging, migration and recolonisation by plants and animals.

Key ecosystem functions do not occur in specific locations in the Basin; they are supported by flow regimes across all the Basin's rivers and creeks. Groundwater key ecosystem function is considered in terms of how it contributes to streamflow, thereby maintaining the four functions listed above. Across the Basin more than 60% of groundwater systems were assessed as being highly connected to surface-water systems.

Key environmental assets

The Basin's environmental assets include the rivers, billabongs, wetlands, aquifers, floodplains and their forests, and the Lower Lakes, estuary and mouth of the Murray. To identify the Basin's key environmental assets, the Authority examined over 20,000 records of potential assets and assessed them on five criteria, as listed below.

Criterion 1 The water-dependent ecosystem is formally recognised in, and/or is capable of supporting species listed in relevant international agreements.

Criterion 2 The water-dependent ecosystem is natural, near natural, rare or unique.

Criterion 3 The water-dependent ecosystem provides vital habitat.

Criterion 4 The water-dependent ecosystem supports Commonwealth-, state-, or territory-listed threatened species and/or ecological communities.

Criterion 5 The water-dependent ecosystem supports or is capable of supporting significant biodiversity.

Sites that met one or more of the five criteria were identified as the key environmental assets. Through this process, the Authority determined that there are 2,442 key environmental assets in the Basin. Table 6.1 outlines the distribution of the key environmental assets across the Basin's catchments. Groundwater systems have been assessed in terms of their contribution to the maintenance of these key environmental assets.

Table 6.1 Regional distribution of key environmental assets

Basin Plan region	Number of key environmental assets
Warrego	278
Condamine–Balonne	294
Paroo	251
Moonie	27
Border Rivers	166
Gwydir	47
Namoi	20
Macquarie–Castlereagh	20
Barwon–Darling	64
Lower Darling	73
Lachlan	58
Murray	477
Murrumbidgee	258
Eastern Mount Lofty Ranges	18
Wimmera–Avoca	82
Loddon	42
Ovens	101
Goulburn–Broken	153
Campaspe	13
Basin total	**2,442**

Examples of key environmental assets include Narran Lakes, Currawinya National Park (Currawinya Lakes Ramsar site), the Coorong Lower Lakes and Murray Mouth, and Barmah–Millewa Forest (see Figure 6.2).

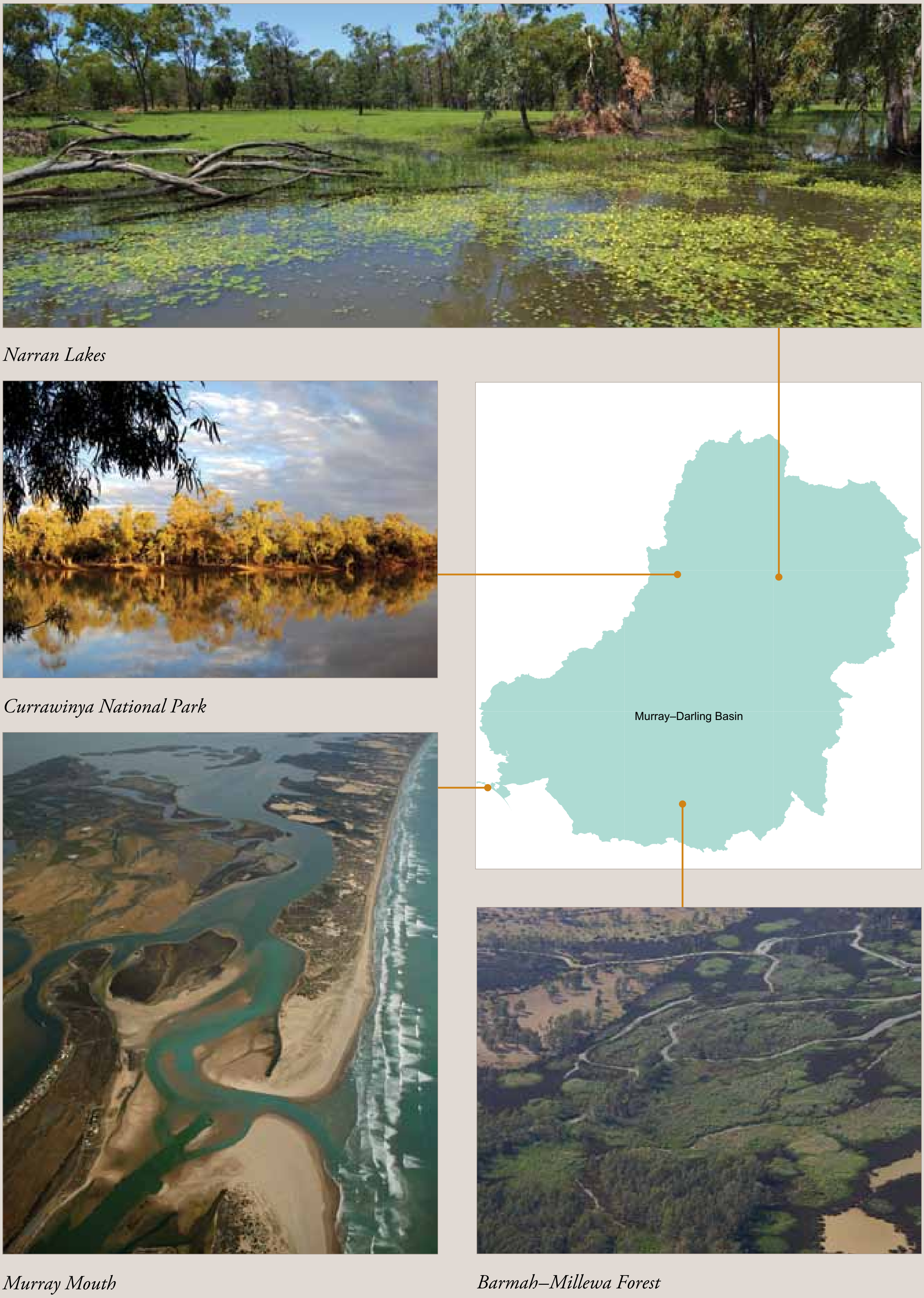


Figure 6.2 Some key environmental assets in the Murray–Darling Basin

Water required to sustain the Basin's key ecosystem functions and key environmental assets

The flow regime in the rivers, and the floods beyond the rivers across floodplains and wetlands, are critical to the sustainability of the Basin's key ecosystem functions and key environmental assets. The flow regime can be divided into three components as outlined in Figure 6.3:

- **Base flows** — which maintain aquatic habitats for fish, plants and macroinvertebrates. There are three aspects of base flow of interest: cease-to-flow, base flow during the low-flow season and base flow during the high-flow season, each of which produce specific ecological outcomes. Groundwater can often be a major contributor to base flow during periods of low flow.
- **Freshes** — which connect habitats along the river channel, allowing aquatic species to move through the river system and provide cues for aquatic animals to migrate and breed. There are high and low season freshes which provide greater and lesser degrees of connection.
- **Overbank/bankfull flows** — which provide opportunities for fish and invertebrates to move out of the river channel to forage and reproduce. Inundation of wetlands provides nutrients and sediments for forests and other habitats, food for bird breeding, and returns carbon to the rivers as flows dissipate.

Owing to the highly variable climate and rainfall in the Basin, ecosystem functions must have frequent, but irregular and variable water flows. Environmental assets require a flow regime that provides flooding, and with it highly variable volumes of water at a frequency relevant to the particular ecosystem's needs. The assets also require dry periods, reflecting the unpredictable and highly variable nature of the Basin climate over time.

Pied stilts on the Lower Lakes, South Australia, 2009

The Authority found that the flow regimes required to sustain key ecosystem functions are typically the base and freshes flow components, while the overbank flows typically sustain key environmental assets.

Figures 6.4 and 6.5 outline the typical flow pattern over a period of years in the southern and northern parts of the Basin respectively. In the southern part, Basin flow events tend to be longer, more extended in nature and more regular. In the northern Basin, rivers often experience low flows with brief but large flood events in response to rainfall events in upper catchments. The key environmental assets and key ecosystem functions occurring naturally across the Basin have evolved in response to these patterns of flow regime. Therefore, in order to protect, maintain and restore key environmental assets and key ecosystem functions, it is important to understand the typical shape of a flow regime that would have occurred without development.

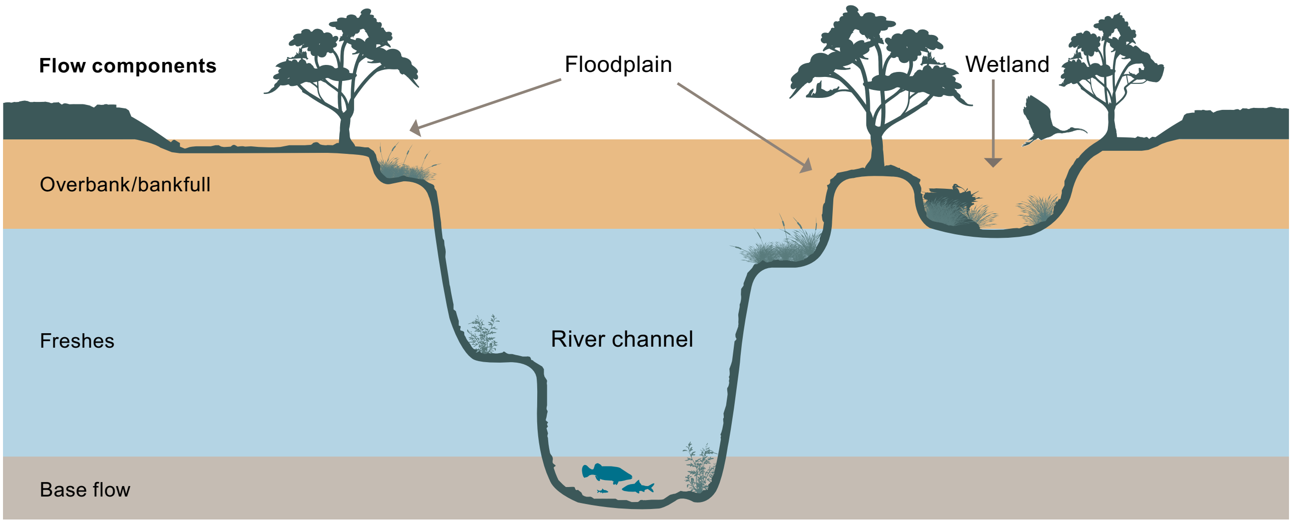


Figure 6.3 Illustration showing the variety of flow components and the connectivity of a river to its floodplain

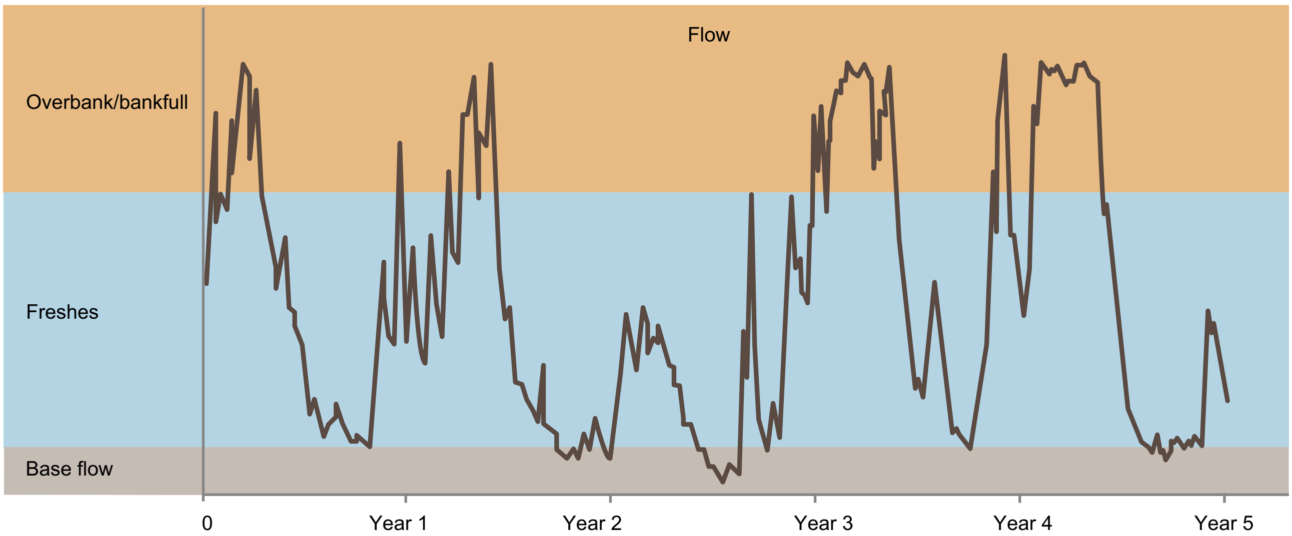


Figure 6.4 Typical flow hydrograph for a river in the southern Basin by water year (July–June)

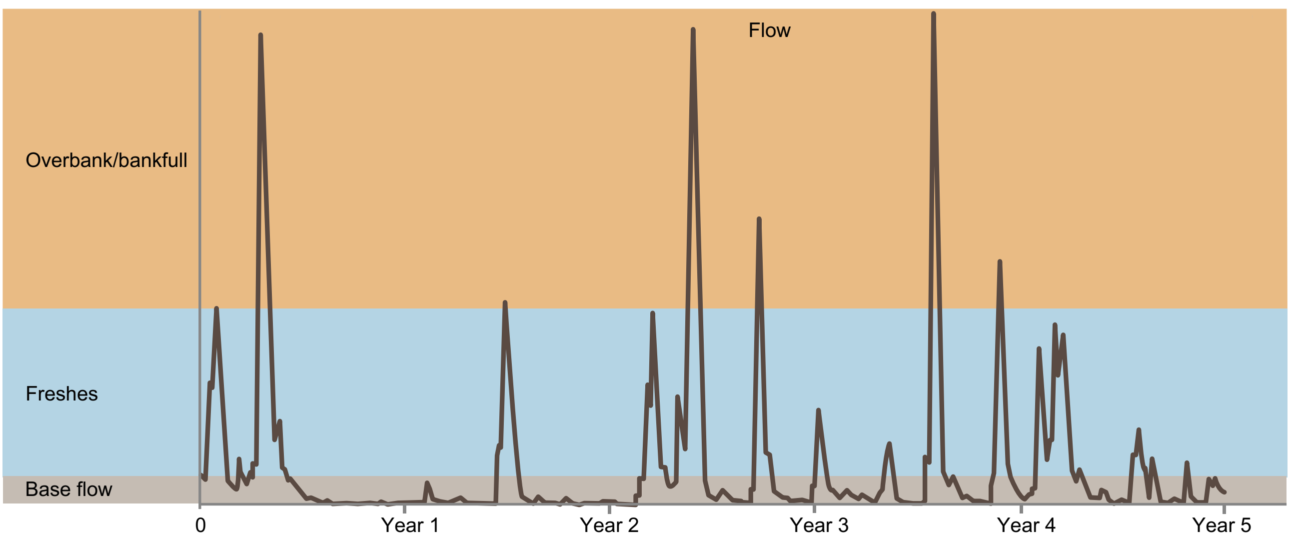


Figure 6.5 Typical flow hydrograph for a river in the northern Basin by water year (July–June)

6.3 Adequacy of current environmental flows, by region

End-of-system flows are broad-scale measures of flow that reach the end of a catchment or the end of the Basin. As an indicator of the hydrologic and environmental connectivity of the rivers of the Basin, end-of-system flows are used as a measure of the adequacy of the water available to meet the environmental needs of key ecosystem functions and key environmental assets in regions. Using this method, end-of-system flows under current arrangements are compared with modelled end-of-system flows for conditions in a without-development scenario. Current end-of-system flows are expressed as a percentage of a region's long-term, without-development flows. Where the value for current end-of-system flows for a region is <60% of without-development flows, the adequacy of environmental flows in that region is considered 'poor'. A value of 60%–80% is considered 'moderate', and a value of >80% is considered 'good'.

Figure 6.6 shows that, with the current distribution of water for end-of-system flows:

- four regions are currently ranked as 'good' with current end-of-system flow of >80% of without-development flows — these are the Paroo, Warrego, Ovens and Eastern Mount Lofty Ranges
- five regions are currently ranked as 'moderate' with an end-of-system flow of 60%–80% — Namoi, Moonie, Macquarie–Castlereagh, Lachlan and Border Rivers
- the remaining 10 regions are ranked as 'poor' for environmental flow outcomes — Barwon–Darling, Campaspe, Condamine–Balonne, Goulburn–Broken, Gwydir, Loddon, Lower Darling, Murray, Murrumbidgee and Wimmera–Avoca.

Assessing the surface environmental water requirements

To calculate the Basin's additional surface environmental water requirements, the Authority first determined the total volume of water (on a long-term average basis) that would deliver the variable flow regimes required to meet the environmental objects of the *Water Act 2007* (Cwlth).

It is a significant challenge of scale and complexity to determine the environmental water requirement for key ecosystem functions in all rivers and all 2,442 key environmental assets across the Basin. Individually testing the environmental water requirements for every kilometre of river and every asset would take years to complete.

From a surface-water flow perspective, many of the key ecosystem functions and key environmental assets are hydrologically connected and interdependent. This means that if sufficient water is provided for key ecosystem functions at one location it will be sufficient for those functions at many locations, both upstream and downstream. This same water will also provide for floodplain and wetland ecosystem functions associated with environmental assets, as well as contribute to the ecosystem functions associated with the rivers connecting the assets. This water will also provide for the broader environmental water requirements of ecosystem services, the productive base, and the key environmental outcomes for the water resource.

Lake Lockie, one of the Hattah Lakes, Victoria

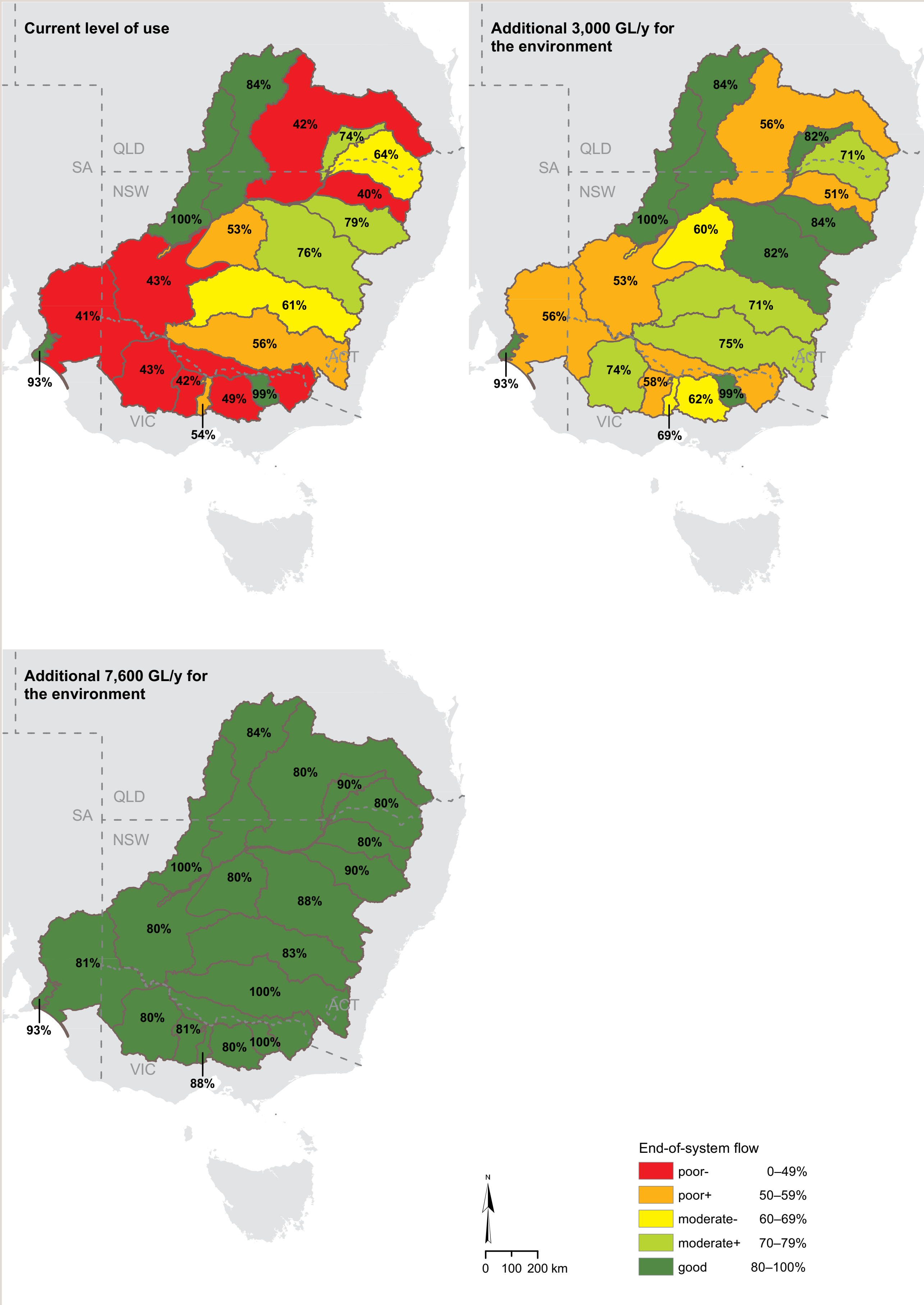


Figure 6.6 Environmental flow outcomes based on end-of-system flows under current diversion limits, with a 3,000 GL/y reduction and with a 7,600 GL/y reduction

This extensive interconnectivity led the Authority to develop a methodology to determine the environmental water requirements of both functions and assets, without double or triple counting those water requirements. By determining the environmental water requirement at a subset of locations in the Basin, selected either for functions or assets, this methodology ensured that functions in all parts of the Basin and all key environmental assets would receive adequate environmental water.

This subset of locations is called the Basin's hydrologic indicator sites. In total, the Authority identified 106 hydrologic indicator sites across the Basin — 88 sites for ensuring key ecosystem functions and 18 sites for key environmental assets.

The 88 hydrologic indicator sites for key ecosystem functions were selected because they:

- provided reliable water flow measurement over an extended period
- represented a broad geographic spread throughout the Basin
- included the variety of river types found in the Basin.

Most locations are similar to those reported in the Sustainable Rivers Audit, a long-term assessment of the condition and health of the river valleys in the Murray–Darling Basin.

The 18 hydrologic indicator sites for key environmental assets were chosen using the following criteria:

- the asset contained water-dependent ecosystems requiring flows at the high end of the flow regime
- the asset was located in a valley where the natural flow regime has been significantly affected by water resources development
- in a regional context the high-flow-dependent ecosystems present with the asset had large volumetric water requirements
- the assets provided a geographic spread across the Basin
- the assets avoided overlap and repetition in potential environmental water requirements.

Modelling, review, and analysis have established that the 106 hydrologic indicator sites provide a robust geographical base for the assessment of the overall environmental water requirements of the Basin.

National and international technical peer review has confirmed that selecting a representative set of hydrologic indicator sites and determining flow regimes required to sustain ecosystem function and key environmental assets (individually and together), represents a robust means of specifying the environmental water needs of the Basin.

The technical peer review recommended that the Authority specify a range of environmental water requirements for the Basin because its river systems are dynamic and the current level of understanding of ecological responses to environmental water is relatively poor.

Distribution of the 106 hydrologic indicator sites across the Basin is shown in Figure 6.7.

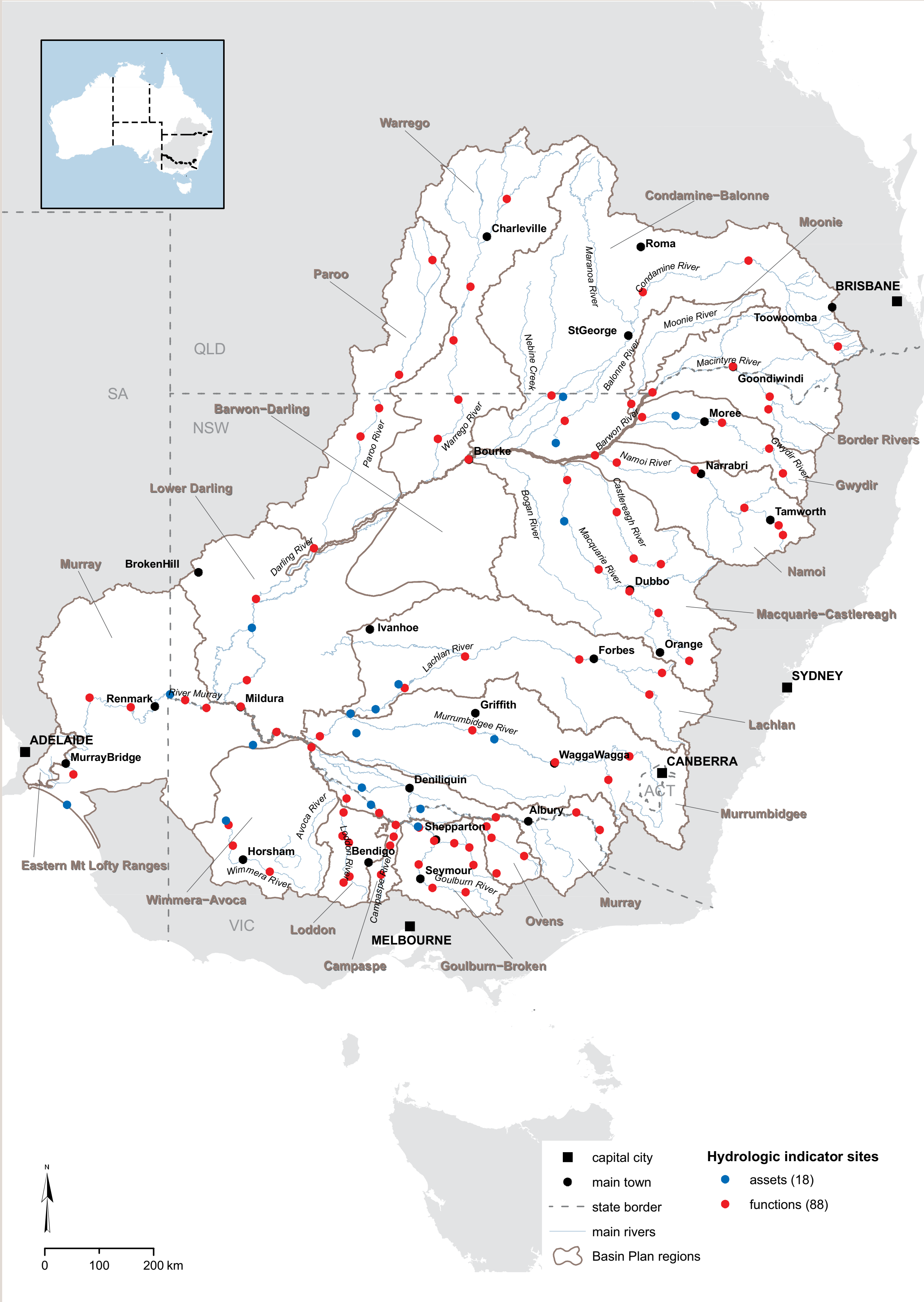


Figure 6.7 106 hydrologic indicator sites across the Basin

To establish the Basin's environmental water requirements, the Authority:

- identified a range of flow regimes required to support key ecosystem functions and key environmental assets at each of the 106 hydrologic indicator sites
- converted flow requirements into catchment-scale volumes of environmental water
- assessed the adequacy of the current distribution of water between consumptive and environmental use in each catchment and across the Basin (see Chapter 5 for detail on current water distribution).

This range of flow regimes required to support key ecosystem functions and environmental assets represents the minimum and maximum boundaries of additional environmental water needed to fulfil the environmental objects of the Water Act, including giving effect to relevant international agreements. Figures 6.8 and 6.9 give a general indication of the difference between the maximum and minimum reduction figures in relation to meeting base flow, instream and floodplain targets.

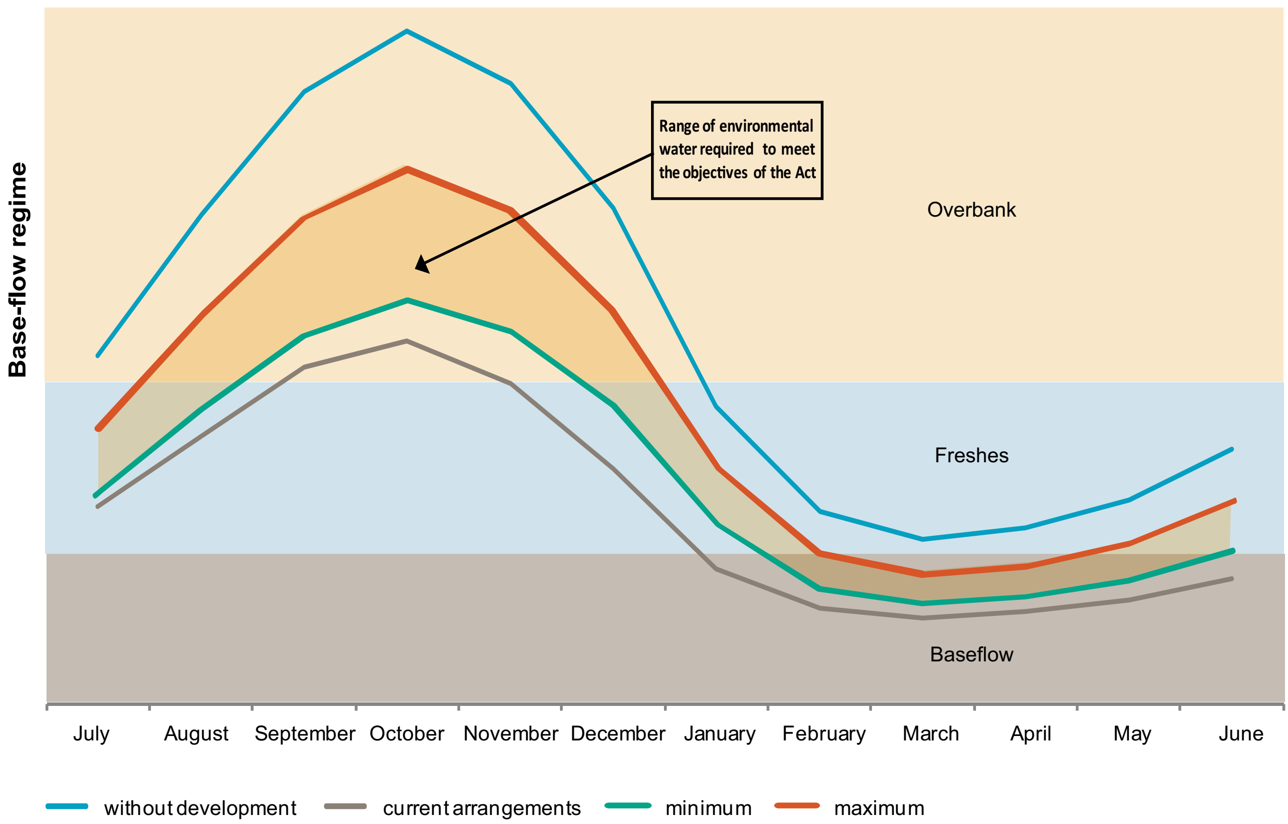


Figure 6.8 The base-flow regimes of rivers in the southern Basin, showing the current situation, the situation without development and the range of additional environmental water required to meet the objects of the Water Act

Note: stylised — actual flows may be more variable during both high and low periods

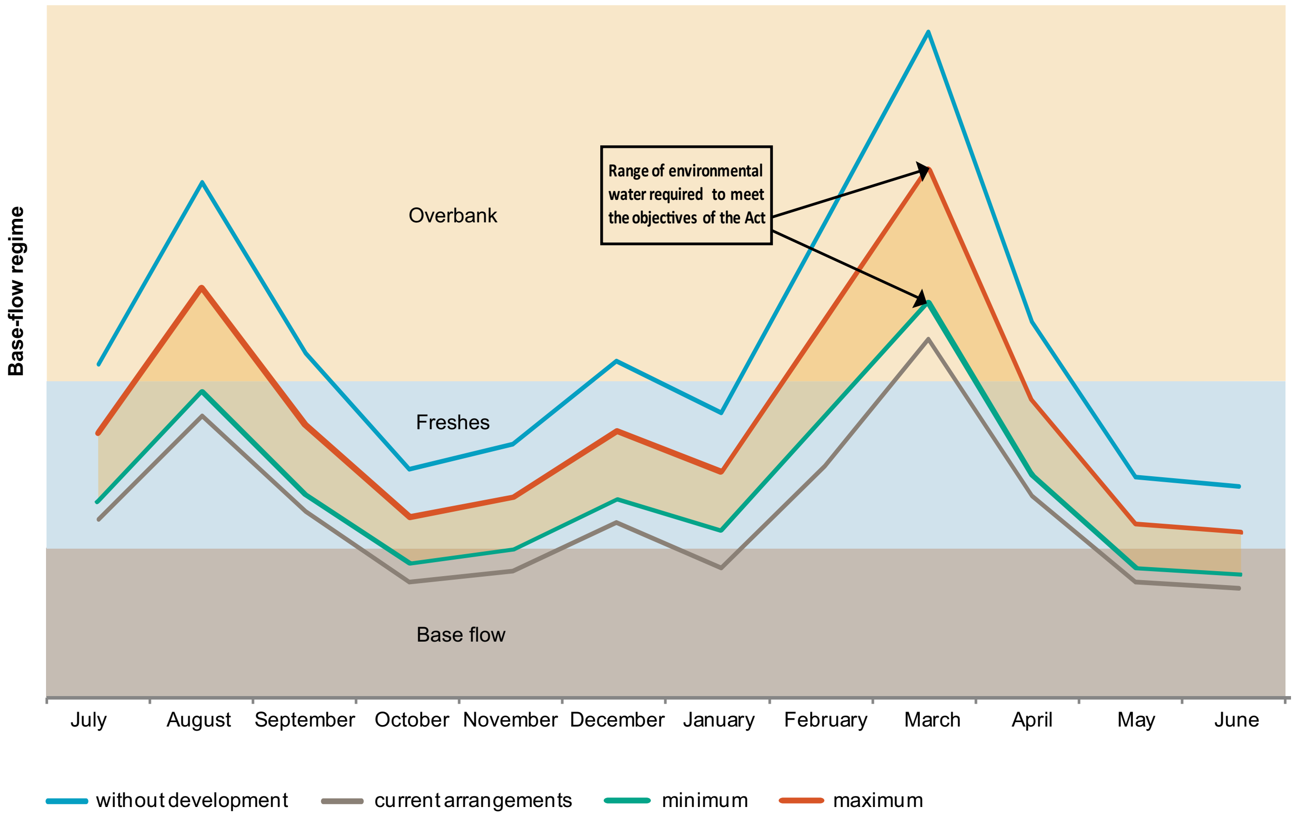


Figure 6.9 The base-flow regimes of rivers in the northern Basin, showing the current situation, the situation without development and the range of additional environmental water required to meet the objects of the Water Act

Note: stylised — actual flows may be more variable during both high and low periods

Flow regimes to support key ecosystem functions and key environmental assets

Key ecosystem functions

Flow targets for the 88 ecosystem function sites were set as a proportion of without-development flow conditions and are similar to those used in the Sustainable Rivers Audit. Each catchment was assigned a rating depending upon how different it was from the without-development (long-term average) flow regime used. The ratings (see also Section 6.4) are:

- 'good' — 80–100% of without-development flow
- 'moderate' — 60–80% of without-development flow
- 'poor'— less than 60% of without development flow.

Catchments with a 'poor' rating were judged to be in a state where the ecosystem functions were at significant risk of being compromised.

For catchments rated as 'poor' under current arrangements, hydrologic targets were set to achieve a long-term annual flow regime (encompassing typical variability) of 'moderate' rating at a whole-of-catchment level. No specific improvements were sought in regions with a 'moderate' or 'good' rating under current arrangements, although flow regimes and indicator values in those regions may be positively influenced by the need to supply environmental water to downstream regions or to key environmental assets.

Narran Lakes, New South Wales, 2004

Key environmental assets

For the 18 hydrologic indicator sites for environmental assets, ecological objectives and targets were set and flow regime targets were developed to achieve the ecological objectives. Detailed ecological targets are provided for each of the 18 hydrologic indicator sites in the environmental water requirements reports on the Murray–Darling Basin Authority website at www.mdba.gov.au/basin_plan/water-assessment-report.

The flow requirements for targets may be expressed as either a long-term average volume, or a specific flow threshold or volume for a specific period of time, and potentially at a specific time of year. This reflects the different requirements to achieve particular environmental outcomes. Meeting the targets will require a combination of flows, providing a range of depth and duration as part of a long-term flow regime. For example, achieving vegetation targets will require a certain sequence of flows. In some wetlands large-scale waterbird breeding occurs as a result of higher, less frequent flows, in addition to the flow regime that supports vegetation.

Determining the range of additional environmental water requirement in each catchment and across the Basin

Based on the approach described above the required range of total additional long-term average environmental water for the Basin is between 3,000 GL/y and 7,600 GL/y. This additional environmental water is sourced from, and provides for, all catchments in the Basin as shown in Table 6.2, which sets out:

- current volumes of water available to the environment in each region in the Basin
- a range of values for additional water required for the environment
- a range of values for the total water potentially available for the environment.

Table 6.2 Analysis of current, additional and total environmental water requirements for each Basin Plan region

Region	Current long-term average water available to environment (GL/y)	Range of additional environmental water requirements		Range of total environmental water requirements (GL/y)
		GL/y	Increase (%)	
Paroo	678	0	0	678
Warrego	510	5–13	1–3	515–523
Condamine–Balonne	792	203–520	26–66	995–1,312
Moonie	48	1–13	2–27	49–52
Border Rivers	1,075	54–225	5–21	1,129–1,300
Gwydir	507	89–234	18–46	596–741
Namoi	967	31–123	3–13	998–1,090
Macquarie–Castlereagh	1,902	20–189	1–10	1,922–2,091
Barwon–Darling	1,506	228–249	15–17	1,734–1,755
Lower Darling	645	19–43	3–7	664–688
Lachlan	1,137	44–158	4–14	1,181–1,295
Wimmera–Avoca	323	0	0	323
Ovens	13	0	0	13
Goulburn–Broken	200	352–1,072	176–536	552–1,272
Loddon	101	28–69	28–68	129–170
Campaspe	24	28–77	114–316	52–101
Murrumbidgee	995	483–1,422	49–143	1,478–2,417
Murray	2,531	1,414–3,191	56–126	3,945–5,722
Eastern Mount Lofty Ranges	40	0	0	40
Flows out of the Murray Mouth	5,100	1,960–5,080	38–100	7,060–10,180
Total of all regions including flow out of the Murray Mouth	**19,100**	**3,000–7,600**		**22,100–26,700**

Note: with this additional water, the total long-term average volume of water for the environment would be between 22,100 GL/y and 26,700 GL/y, some 67% to 81% of the total available surface water. This compares with the current long-term average share of the environment (including outflows) of 19,100 GL/y, 58% of the total available surface water.

Figure 6.6 shows an assessment of improvements in end-of-system environmental flow condition for each region for an additional 3,000 GL/y long-term average, and an assessment of end-of-system flows for an additional 7,600 GL/y.

An additional 3,000 GL/y long-term average of surface water for the environment (Figure 6.6), compared with the end of system flow for current arrangements, would result in:

- the Ovens, Paroo, Warrego and Eastern Mount Lofty Ranges regions retaining a 'good' rating for environmental flow outcomes
- the Namoi, Macquarie–Castlereagh and Moonie regions improving from 'moderate' to 'good'
- the Border Rivers and Lachlan regions remaining at a 'moderate' ranking, although they would be improved compared to current status
- the Murrumbidgee, Campaspe and Goulburn–Broken, Barwon–Darling and Wimmera–Avoca regions improving from 'poor' to 'moderate'
- the Condamine–Balonne, Gwydir, Loddon, Lower Darling and Murray regions remaining at a 'poor' ranking, although they would be improved compared with the current status.

Figure 6.6 shows that with a long-term average increase of 7,600 GL/y, the environmental targets are all met and all catchments improve from their existing status to good flow levels.

Figure 6.10 shows the current distribution of water between interception, watercourse diversions, environmental water and outflows through the Murray Mouth on a long-term annual basis. It shows the changes to this distribution under a 3,000 GL/y and a 7,600 GL/y long-term average reduction.

Under current arrangements, total water available to the environment is 19,100 GL/y, made up of 14,000 GL/y environmental water and 5,100 GL/y outflows through the Murray Mouth.

A reduction of 3,000 GL/y in diversions increases the total water available to the environment to 22,100 GL/y, made up of 15,040 GL/y environmental water and 7,060 GL/y outflows through the Murray Mouth. This volume of reduction in extractions and return of water to the environment represents the minimum the Authority considers is required to achieve the environmental objects of the Water Act. This level of reduction has a high dependence on a long-term return to wetter climatic conditions across the Basin.

A long-term average reduction of 7,600 GL/y in diversions would increase the total water available to the environment to 26,700 GL/y. This is made up of 16,520 GL/y environmental water and 10,180 GL/y long-term average outflows through the Murray Mouth. This volume of reduction in extractions and return of water to the environment is the maximum required to achieve the objects of the Water Act, including giving effect to relevant international agreements. This level of reduction has a lower dependence on a return to wetter climatic conditions across the Basin than smaller reductions, and will provide greater resilience to the Basin's water-dependent ecosystems — including a full range of forecasts of reductions in surface-water availability due to climate change.

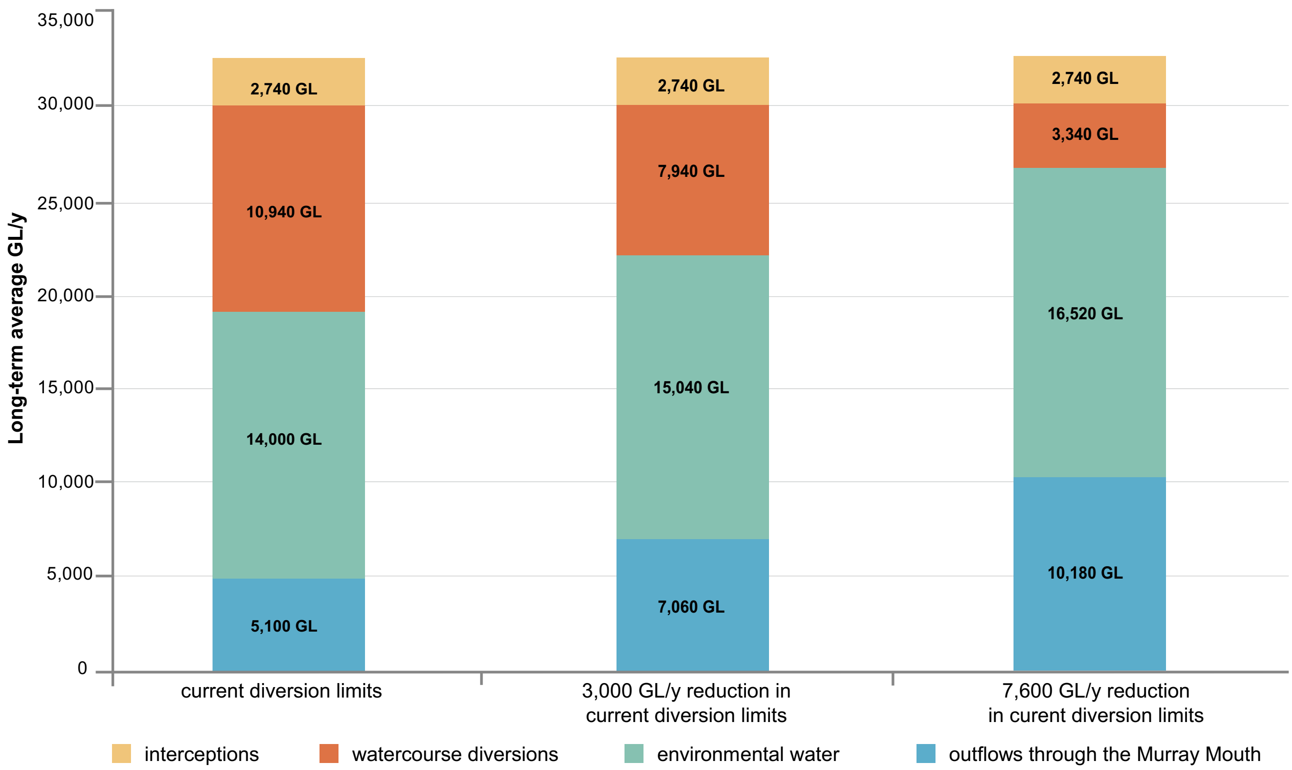


Figure 6.10 Comparison of current distribution of water between interception, watercourse diversions, environmental water and outflows through the Murray Mouth on a long-term annual basis under the range of environmental water requirements

6.4 Determining the Basin's environmental groundwater requirements

The Authority identified 78 groundwater aquifers for which it needed to identify environmental water requirements. Compared to surface-water hydrology, the behaviour of groundwater aquifers in the Basin is frequently more complex and less well understood, and the evidence on which to make decisions is less robust. To improve the evidence base, the Authority has updated groundwater recharge modelling for the entire Murray–Darling Basin, and undertaken detailed numerical modelling for 11 of the largest alluvial groundwater systems. These 11 groundwater models cover 73% of the 2007–08 Basin-wide groundwater extraction.

Unlike surface-water environmental requirements where the key ecosystem functions and key environmental assets are critical, to establish the environmental water requirements for groundwater, the productive base and key environmental outcomes are the more significant determinants. The productive base for groundwater relates to the maintenance of groundwater volume, level and quality within the aquifer. Key environmental outcomes are important for groundwater where they relate to the potential for groundwater contamination, and where the productive aquifer contains better quality groundwater than aquifers above, below or laterally.

Flooded waterhole on Paroo River, near Wanaaring, New South Wales

In those aquifers where groundwater makes a significant contribution to key ecosystem functions through stream base flow, this is also considered in determining the environmental water resources for those groundwater systems. Consideration has been given to the impact that groundwater take will have on groundwater-dependent key environmental assets, particularly at a local scale.

Considerations in identifying groundwater environmental water requirements

Given the complexity of groundwater systems, the Authority has taken a number of considerations and practical constraints into account in setting a range for groundwater environmental water requirements:

- There is significant uncertainty inherently associated with modelling of groundwater systems that show strong declining trends in groundwater levels. Models calibrated over periods during which rapid water level decline has occurred need to be applied with caution in developing extraction limits designed to achieve stabilised groundwater levels over the long term.
- Similarly, groundwater planning is not as well developed as surface-water planning in terms of the area covered. Around 80% of the area of the Basin is 'unincorporated' in terms of groundwater planning, i.e. there is no recognised transitional or interim water resource plan over this area.

Groundwater monitoring station near Dalby, Queensland

- There is also significant uncertainty associated with a lack of monitoring data and a lack of numerical groundwater models in most of the unincorporated area. Consequently, a risk management approach has been developed to analyse possible long-term average sustainable diversion limits (SDLs) for groundwater based on a proportion of recharge in these areas.
- There are long time lags in the behaviour of many groundwater systems. The full impact associated with past groundwater extraction can take many decades to be completely realised. Additionally, there is considerable uncertainty associated with very long-term projections using available models. For these reasons a time span of 50 years has been used as the basis of groundwater modelling.
- Extraction levels need to be set such that groundwater systems are not subject to continued drawdown and to establish a new equilibrium in each groundwater system. In effect, take must be less than recharge in an SDL area over the long term, though in any one year take may exceed recharge, provided the long-term take is less than recharge. To protect the productive base, an environmental water resources volume should be such that groundwater levels are stabilised within a 50-year period to a level that protects the integrity of the groundwater resource.
- For some aquifers, groundwater contributes significantly to base flow for rivers and streams, particularly in low-flow periods, and is therefore an important contributor to maintaining key ecosystem functions. Where groundwater and surface-water systems are known to be connected, appropriate adjustments have been made to ensure there is no double counting of water extractions.
- Much of the groundwater resource in the Murray–Darling Basin is highly saline. In areas containing both fresh and saline groundwater, overextraction of fresh groundwater can pose a threat to consumptive use and the environment, through contamination of fresh groundwater resources via vertical or lateral inflow of saline groundwater.
- Of the 78 groundwater areas defined by the Basin Plan, there are just 14 subject to an interim or transitional water resource plan. This includes one interim plan in South Australia expected to be finalised shortly. There are a further five plans in Victoria that will potentially be recognised as transitional water resource plans, although four of these cover only part of the relevant groundwater SDL area. Although only a minority of groundwater areas have a recognised plan, their plans cover most groundwater used.

Angellala Creek near Charleville, Queensland

- There is significant conjunctive use of groundwater and surface water at a regional scale. For example, many irrigators in the Murray, Murrumbidgee and Goulburn regions in the southern Basin, and the Condamine and Namoi regions in the northern Basin, have access to both surface water and groundwater entitlements. Some regions with overdeveloped surface water resources do not have overdeveloped groundwater resources, and vice versa.
- In areas of fossil groundwater such as in the Mallee of South Australia and western Victoria, any extraction is essentially mining the resource, and the concept of sustainability requires particular consideration in terms of the resource being available for future generations.

These considerations have been incorporated in the methodology that has been developed to identify the environmentally sustainable level of take for groundwater. In summary, the key factors for consideration in identifying environmental water requirements for groundwater are:

- **Maintaining base flow** — for some aquifers, groundwater contributes significantly to base flow for rivers and streams, particularly in low-flow periods, and is therefore an important contributor to maintain key ecosystem functions.
- **Accounting for groundwater induced recharge** — where groundwater and surface water systems are connected (including systems where time lags are significant), appropriate adjustments have been made so there is no double counting of water extractions to protect key ecosystem functions.
- **Protecting against continued drawdown of groundwater levels** — so that groundwater levels are stabilised within a 50-year period, to a level that protects the integrity of the groundwater resource and the productive base. The use:recharge ratio should be kept as low as possible and definitely <1.
- **Maintaining key environmental assets** — that depend on groundwater (for example the Lower Goulburn River Floodplain and the Great Cumbung Swamp).
- **Protecting against salinisation** — much of the groundwater resource is highly saline. In areas that contain both fresh and saline water, extraction of groundwater can pose a threat to the environment through vertical or lateral inflow of saline groundwater.

Determining the Basin's environmental groundwater requirements

The Basin's environmental groundwater requirements have been determined using a three-step process that incorporates the factors mentioned above, which are critical to determining the environmental water requirements of the groundwater systems:

- determine water resource plan areas and finer scale management areas for groundwater systems
- undertake updated groundwater recharge modelling for the entire Murray–Darling Basin and apply a risk assessment framework to identify the proportion of recharge that should be reserved for the environment to achieve the objectives of the Basin Plan
- undertake detailed numerical modelling for 11 of the largest alluvial groundwater systems (for which suitable models are available), which represent more than 70% of Basin groundwater resources.

Additional groundwater to meet environmental needs

Additional groundwater needed for the environment is estimated, at an aggregate level, to be between 99 GL/y and 227 GL/y from groundwater systems across the Basin. This reflects the uncertainty of groundwater model predictions and the risks associated with not achieving the environmental objectives of the Basin Plan, and therefore represents a minimum and maximum range. In summary:

- The current diversion limits of 67 groundwater systems have been assessed as reflecting an environmentally sustainable level of take. No reduction is proposed.
- Of the remaining groundwater systems the current diversion limits of the Upper Namoi Alluvium, Lower Macquarie Alluvium, Peel Valley Alluvium and the Australian Capital Territory do not reflect an environmentally sustainable level of take. Accordingly, a reduction in the diversion limit will be required in each case to meet the environmental water requirements. The level of use in these four systems is lower than the current diversion limits and the current use has been assessed as at or below an environmentally sustainable level of take. The total of the current diversion limits for these four systems is 208 GL/y and the use is 145 GL/y, indicating that the scope to reduce diversion limits without impacting on use is 63 GL/y. This is an upper level as it may be possible to make smaller reductions and still provide for an environmentally sustainable level of take. As these reductions do not affect use, they do not contribute to the additional groundwater that needs to be provided for the environment.
- The final seven groundwater systems (Lower Lachlan Alluvium, Lower Namoi Alluvium, Angas Bremer, Upper Condamine Alluvium, Upper Condamine Basalts, Upper Lachlan Alluvium and Lake George Alluvium) are considered to be overdeveloped, and the current diversion limits do not reflect an environmentally sustainable level of take. It is across these seven systems that the additional groundwater, at an aggregate level, that needs to be provided for the environment has been estimated to be between 99 GL/y and 227 GL/y, as shown in Table 6.3. The table indicates the range (from minimum to maximum) of additional environmental water requirements that have been identified using the methodology described in this chapter, and its associated potential range in reduction of current diversion limits.

Table 6.3 Overview of the environmental water requirements for the seven groundwater systems considered overdeveloped

Groundwater system	Current diversion limit (GL/y)	Additional groundwater required for environment Minimum (GL/y)	Additional groundwater required for environment Maximum (GL/y)	Potential reduction associated with requirement Minimum %	Potential reduction associated with requirement Maximum %
Lower Lachlan Alluvium	108.0	43.2	80.0	40	74
Lower Namoi Alluvium	86.0	0.0	24.0	0	28
Angas Bremer	6.5	0.0	2.5	0	38
Upper Condamine Alluvium	117.1	40.3	68.1	34	58
Upper Condamine Basalts	76.1	15.0	24.1	20	32
Upper Lachlan Alluvium	77.1	0.1	28.1	0	36
Lake George Alluvium	1.1	0.0	0.6	0	55
Total	**472**	**99**	**227**	**21**	**48**

7. Social and economic considerations of reductions in current diversion limits

Key points

- This chapter assesses the potential effects of reduced current Basin-wide diversion limits in the range of 3,000 to 7,600 GL/y on individuals, enterprises, communities and regions in the Basin. This assessment has informed the Authority's proposal for long-term average sustainable diversion limits (SDLs) (see Chapters 8 and 9) for surface water and groundwater, and the proposed transitional arrangements. This chapter does not include analysis of the potential contribution of mitigation measures. The impacts presented in this chapter are therefore likely to be larger than the final impacts. Potential mitigation arrangements are discussed in Chapters 8 and 11.
- Understanding the potential effects of reduced water for consumption on businesses and communities is a highly complex task. The Authority has commissioned an extensive range of economic, social and cultural analyses, and has drawn on independent work where available. The Authority has recognised that due to the inevitable limitations of social and economic data and the complexity of the issues, it will need to exercise its judgement in its use and interpretation of the analyses.
- The Authority has tested the likely effects of a Basin-wide reduction in current diversion limits in the range of 3,000–7,600 GL/y, based on the findings outlined in Chapter 6. Consumptive water reductions in this range would have significant negative implications on some Basin communities, industries, enterprises and individuals. The scale of this effect would vary with each catchment and community, depending on a complex array of factors.
- The direct percentage reduction in the gross value of irrigated agriculture production in the Basin is modelled to be in the order of 13% for a respective reduction in diversions of 3,000 GL/y. The flow-on effects to businesses that service or rely on irrigated agriculture are difficult to determine but will be additional to this reduction in gross value of irrigated agricultural production.
- Broadacre irrigated agricultural industries with relatively lower-value products are likely to experience larger reductions in activity than higher-value sectors such as horticulture. Enterprises that rely on irrigated agriculture as suppliers or customers, particularly small and medium-sized enterprises, would also be likely to be significantly affected.
- Regions with a relatively higher dependence on lower-value irrigated agriculture would experience a larger reduction in economic activity. The social fabric of some towns and communities may be significantly affected, particularly in the near term. The capacity of towns to adapt is likely to vary widely, and would be influenced by factors such as the size of the community, the diversity of its economic base, its demographic mix and its proximity to other large regional towns. Some communities may be permanently changed by the reduction in diversion limits.

… continued

Key points (continued)

- In light of the severity of this impact on specific sectors and communities, the Authority has judged that in order to optimise social, economic and environmental outcomes, as it is obliged to do under the Water Act 2007 (Cwlth), it can only consider Basin-wide reductions of between 3,000 and 4,000 GL/y for the Basin (reductions of 22–29% of current diversion limits). That is, reductions in current diversions above 4,000 GL/y have been judged to be beyond the range of acceptable reductions. A reduction in current water diversions of 3,000–4,000 GL/y (or greater than 29%) would represent a reduction in gross value of irrigated agricultural production of around 13–17%, or $0.8–1.1 billion per year.
- The Authority anticipates that in the long run, innovation in irrigated and dryland agricultural practices, which would improve yields, reduce water requirements and improve environmental sustainability, would go some way to offsetting the impact of water reductions.
- The severity and length of the drought is reported to have left many Basin enterprises financially weakened, with high levels of debt. Many of these enterprises are likely to be less able to adapt to a reduction in long-term average diversions.

The purpose of the social and economic analyses is to enable the Authority to understand the potential implications for individuals, enterprises, industries, communities and the Basin as a whole of providing additional water to the environment, thereby reducing the level of current diversions.

This chapter first sets out the approach adopted by the Authority to analyse and understand the potential social and economic implications of the range of water reductions under the Basin Plan. Drawing on a range of analyses, it then outlines the potential social and economic implications of a reduction in current diversion limits for irrigated agriculture, the Basin economy and the broader community.

7.1 Approach to the social and economic analysis of the Basin Plan

Water makes a critical contribution to the economic, social and cultural health of many parts of the Basin. Although there are many industrial and household users of water in the Basin, agriculture accounts for over 80% of consumptive use and is the sector most likely to be affected by any reduction in current diversion limits. This analysis therefore concentrates primarily on the impacts on irrigated agriculture and its flow-on effects for regional economies and communities.

Many towns in the Basin have grown throughout many years of government policy that encouraged water use and regional development. The dependence of many communities on the economic activity generated by irrigated agriculture means that the effects of reduced diversion limits would be felt well beyond the irrigated agriculture sector. The Authority recognises the relationship between water diversions, individual business decisions, economic prosperity, social wellbeing, and community cohesion is complex and multi-faceted.

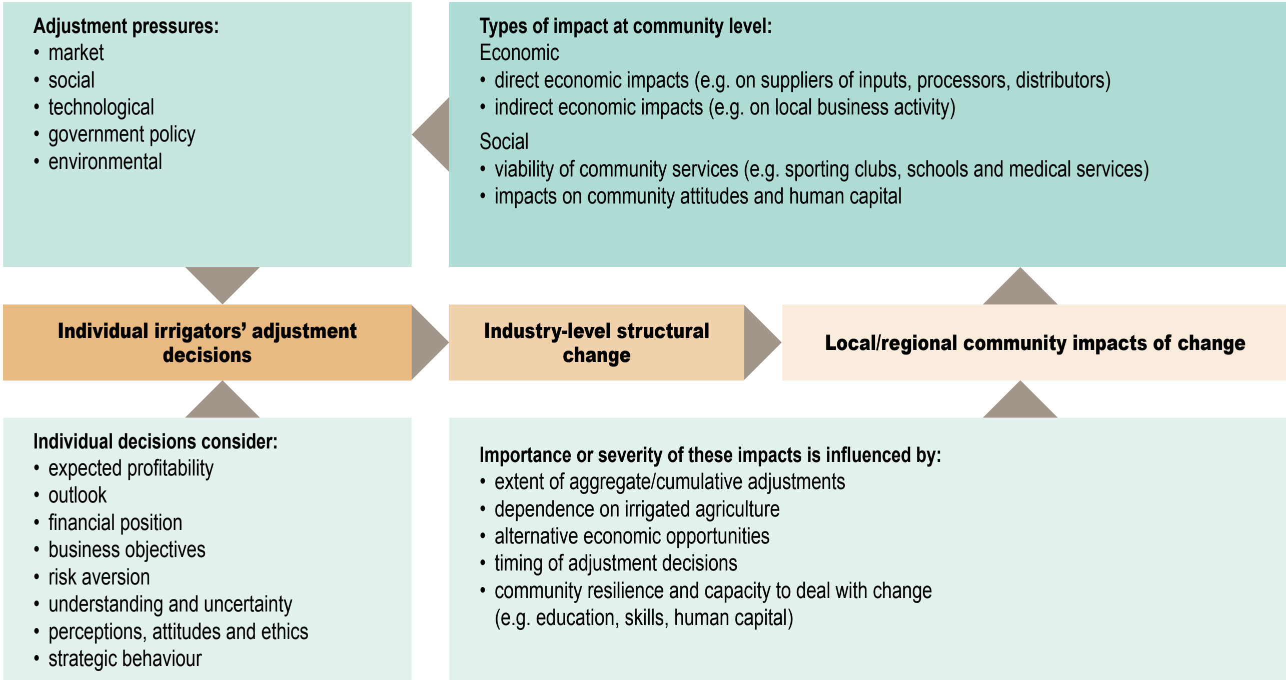


Figure 7.1 Irrigators' adjustment decisions and their economic and social impact

Source: adapted from Frontier Economics 2010, Structural adjustment pressures affecting irrigated agriculture in the Murray–Darling Basin, report for the Murray–Darling Basin Authority, Canberra.

As shown in Figure 7.1, economic and community change is driven by the adjustment decisions of individuals. In response to a reduction in diversions, it is irrigators' decisions that will drive change in communities where irrigated agriculture is a large part of the economy.

In consistency with this framework, the Authority has commissioned a range of studies to understand the complexity and interconnectedness of the Basin's economic and social system. The Authority's assessment of social and economic implications was assisted by meetings held during regional visits, by information provided by the Basin Community Committee and by a range of other reports and papers in the literature and provided to it by key stakeholders.

In particular, the Authority has sought analyses that enable a better understanding of the direct and indirect effects of reducing current diversion limits on irrigated agricultural production, related industries and wider community wellbeing.

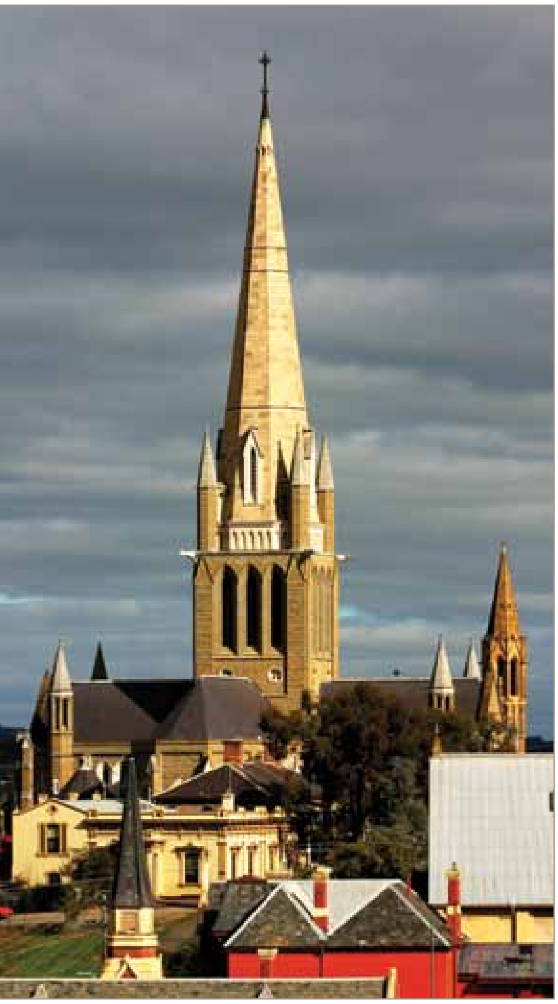
Six studies, as detailed in Section 4.2 of Chapter 4, formed the main basis of the analysis as follows:

- Economic modelling, to estimate the potential impact of a range of reductions in current diversions on the irrigated agriculture sector and its flow-on effects to the Basin's regional economies
- Consultation, to gain an understanding of the likely response of individual enterprises to the introduction of SDLs. This involved gathering stakeholder information about the likely impacts on and responses of individuals, industries and communities to reductions on current water diversions

- An assessment of community vulnerability, resilience and adaptive capacity in the face of reduced diversion limits across the Basin. The aim was to characterise communities and represent how well they might be able to respond to change based on their initial social characteristics
- Review of Aboriginal cultural, social, economic and environmental interests in the Basin's water resources, including consultations for three case studies to gain a descriptive characterisation of the potential impacts of the Basin Plan on Aboriginal groups and their interests
- An assessment of likely actions and responses of the financial services sector to the Basin Plan
- A review of economic valuation of potential environmental benefits in the Basin. This report synthesised information on the non-market values associated with Basin environmental assets and how these economic estimates of values may change as a result of diversion-limit changes.

These analyses and consultations represent the best available information on likely social and economic implications of a reduction in watercourse diversions. In isolation, none of these analyses provide perfect insight into the social and economic implications of providing additional water to the environment. However, when combined, the studies' findings provide an understanding of the social and economic capacities of communities, and improve information on the upper and lower bounds of likely effects.

In weighing the results of this analysis, the Authority recognised the range of complex and inter-related factors that will exert influence on the ultimate outcome, such as ongoing rural restructuring, technological change, commodity price fluctuation, short- and long-term climatic variation, long-term demographic changes in many rural towns, and remoteness from opportunities offered by major centres.



Sacred Heart Cathedral in Bendigo, Victoria

7.2 Dependence of irrigated agriculture on current water diversions

The main irrigation regions of the Basin are highly productive working communities, the source of essential food and fibre products for domestic and export markets. Figure 7.2 shows the gross value of irrigated agricultural product for 2005–06, a dry year with reduced water allocations, in 10 irrigation areas in the Murray–Darling Basin.

While there is no typical farm type or business, even in distinct sectors, the following provides an overview of the current status of the major irrigated agriculture industries of the Basin, and their dependence on watercourse diversions. These profiles are indicative of the past five years of agricultural activity in the Basin.

Cotton

Cotton is the dominant crop in the Queensland regions of Lower Balonne and Border Rivers, and in the northern New South Wales regions of Gwydir, Namoi and Lachlan. It is a highly adaptable annual crop. The area planted is readily adjusted in response to water availability and the crop is experiencing ongoing improvements in yields, quality and productivity.

In terms of differing regional sensitivity to reductions in current diversion limits, the cotton-based regions and communities that are further inland tend to be more sensitive to potential reductions. For example, the agriculture sector in Condamine–Balonne in Queensland directly employs approximately 36% of workers in the region — a greater percentage than any other region in the state. The small cotton-dependent communities of this region often face significant social issues: they have highly mobile workforces that follow job opportunities and if these workers leave because cotton-related activities have declined, the towns may lose critical mass for community services and face increased risk of welfare-dependency.

Rice

Rice is the predominant crop in the New South Wales Central Murray and Murrumbidgee irrigation regions. Like cotton, rice is an adaptable annual crop, although the level of rice production tends to decline at a greater rate than the respective decline in watercourse diversions. If crop profitability is high enough and water is affordable, rice-growers will buy water to supplement allocations; however, if the price of water is higher (often in response to low allocations) and/or crop profitability is lower, they will sell their water (often to horticulture or dairy farmers).

On average, rice farmers hold nearly 60% of their assets as water assets. Rice farmers are likely to be relatively highly sensitive to any reduction in long-term diversion limits that decreased the value of their water assets, because they have typically geared their operations around the value of their water entitlement. Of the Basin's two dominant rice regions, the relatively higher volumes of water held per irrigator in the Murrumbidgee suggests that irrigators in that region may be somewhat less sensitive to a reduction in current diversion limits than the Murray region, because they are more able to generate more revenue by selling water into the market. They may therefore be able to take greater advantage of water trading as business strategy.

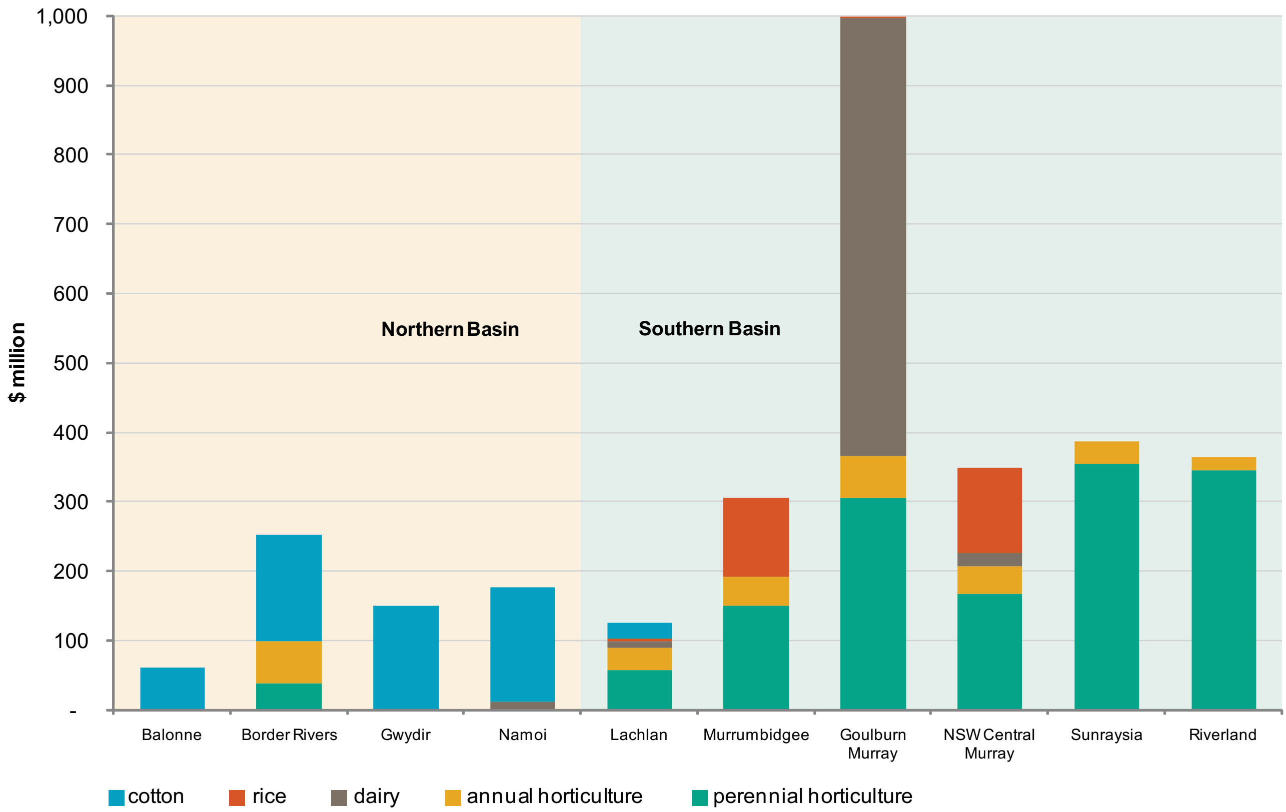


Figure 7.2 Irrigated agricultural production by sector and region, 2006

Source: Adapted from Marsden Jacob Associates, Rendell and McGuckian Consulting Group, EBC Consultants, DBM Consultants, The Australian National University, McLeod, G & Cummins, T 2010, Synthesis report: economic and social profiles and impact assessments in the Murray–Darling Basin, report for the Murray–Darling Basin Authority, Canberra. The regions shown are for some prominent irrigation districts and are indicative of the types of crops grown in different parts of the Basin. 2005–06 was a drier than average year; this would have affected the quantity of some crops grown such as cotton and rice.

Dairy cows on a farm near Elmore, Victoria

Dairy

The dairy industry of the Basin is focused in the Victorian Goulburn-Murray Irrigation District, but includes some farms in the New South Wales Central Murray and in South Australia. Dairy farmers irrigate more than 70% of their land and hold more high-reliability than low-reliability entitlements, reflecting the importance of a reliable supply, particularly to sustain herds in dry years.

The past 10 years have seen declining farm numbers, increasing average farm size, low milk prices and high water prices (in response to low allocations), both due to reductions in water allocations and government structural reforms. This has led to increased farmer debt, decreased milk production and rationalised processing capacity. However, irrigation efficiency and fodder productivity has increased, so farmers tend to balance the cost of growing feed themselves with the cost of buying it from mixed, dryland farmers.

Horticulture

Horticultural production is located throughout the Murray–Darling Basin, but is particularly important in southern Basin valleys. Horticultural farmers irrigate more than half their land and predominantly hold high reliability entitlements, reflecting the importance of a reliable water supply, particularly to maintain trees and vines in dry years.

For annual horticulture, water is a relatively small component of input costs and the response of annual horticulture to low allocations is usually to buy water.

Perennial horticulture has highly variable profitability across the different crops, related to international competition and the relative value of the Australian dollar, although water is a relatively small input cost for most crops. Low water allocations due to the recent drought have forced enterprises to choose between drying off plantings or buying in water.

The Murrumbidgee and New South Wales Sunraysia regions have had high levels of entitlements per hectare historically and so the New South Wales regions tend to be net sellers of water allocation. The Victorian Sunraysia and the South Australian Riverland tend to buy water in dry years, making them relatively more sensitive to reductions in diversions.

7.3 Potential direct economic implications for irrigated agriculture

Irrigated agriculture represents around 6% of the Basin's gross regional product (from Wittwer 2010, The regional economic impacts of Sustainable Diversion Limits, Centre of Policy Studies, Monash University, report prepared for MDBA). With reductions in watercourse diversions in the range of 3,000–7,600 gigalitres per year (GL/y), the direct reduction in the gross value of irrigated agricultural production is modelled to be in the order of 13–35% per year, although the Authority recognises that modelling of the effects can be difficult given data limitation.

The Authority has judged, based on the information presented in the remainder of this chapter, that while 3,000–7,600 GL/y is the range of additional water required to meet environmental water requirements, reductions in diversions over 4,000 GL/y would not enable it to meet its obligations under the Water Act 2007 (Cwlth) to optimise environmental, social and economic outcomes. Therefore, the Authority has judged that it can only consider reductions in current water diversions of between 3,000 and 4,000 GL/y. Reductions in water diversions in this range are likely to result in a reduction in gross value of irrigated agricultural production of 13 – 17%, or $0.8 – 1.1 billion per year.

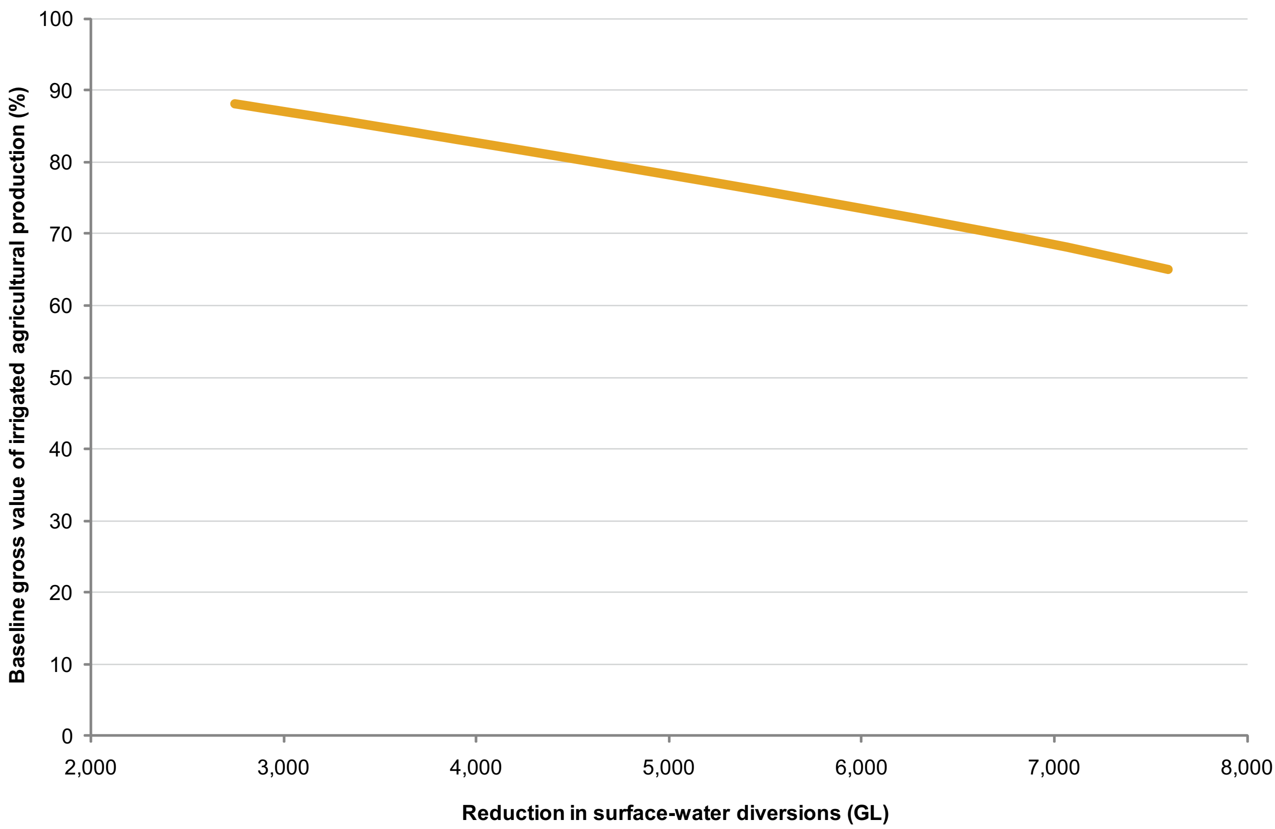


Figure 7.3 Projected changes in estimated gross value of irrigated agricultural production from the long-term historical average due to reductions in water use

Source: adapted from ABARE (Australian Bureau of Agricultural and Resource Economics) 2010, 'Environmentally sustainable diversion limits in the Murray–Darling Basin: socioeconomic analysis', unpublished report for MDBA, Canberra. Impacts are estimated with interregional trade

As Figure 7.3 shows, the economic impact of reduced water is likely to become progressively more pronounced as less water is available for irrigation.

A small reduction in current diversion limits would be most likely to affect lower-value crop sectors only, whereas greater reductions in water would also affect higher value agricultural production resulting in a larger economic impact.

Moreover, this analysis assumes current agriculture practices continue in each of the sectors. The Authority recognises that in response to a reduction in diversion limits, many farmers and whole sectors would, as in the past, innovate in order to increase yields while reducing water consumption. The effect of such innovation is not captured in this section and thus it might be argued that the reduction in gross value of irrigated agricultural production that would occur in each sector has been overstated.

The relative economic effect of a reduction in current diversion limits on individual irrigators and sectors would vary widely across the Basin, due to the diversity of its agriculture industries, communities and regions. There are a number of factors that will shape how each farmer and sector responds to a reduction in diversion limits. These factors include, but are not limited to, the relative value of water to an industry (e.g. water is a relatively higher cost for rice than for grapes), the size and financial capacity of different enterprises, debt levels, access to sources of off-farm income, the impact of global financial crisis on prices and access to credit, and the long-term consequences of severe and prolonged drought.

Farmers are far from a homogeneous group and would be unlikely to exhibit uniform sensitivity to change in watercourse diversions. The Authority has found some diversity in the types of farmers. These include those who are:

- concerned and uncertain about the future of irrigated and dryland agriculture in the Basin
- financially stable after many years of successful farming when times were better
- well prepared for lower water entitlements, having established or transformed their practices during the extended drought
- financially exposed due to the extended drought and surviving on exceptional circumstances and off-farm income
- optimistic and/or have strong connections to their farm and community
- reaching the end of their farming life and would like to exit.

The relative importance of water assets to overall farm assets has a direct bearing on sensitivity to reduced diversion limits and ability to restructure farm business to adapt in the longer term. For example, without purchase of water entitlements, reduction in water asset value, for example, could significantly reduce the value of farm assets and increase financial gearing. Reduced access to water and therefore the derived revenue could increase the risk of farmers breaching or default on debt agreements. This means that rather than adjusting to reduced water access, farmers may exit farming. In addition to the direct implications for irrigators, the Authority has identified that food production constitutes around one third of the Basin's manufacturing industry and is primarily responsible for processing agricultural commodities. A reduction in current diversion limits is likely to affect the food industries in direct and indirect ways. Food processing uses a large amount of water for production in comparison with other manufacturing activities. More importantly, a contraction in agricultural production will lower the quantities of agricultural produce available for processing.

Across the Basin, the fundamental effect of any reduced diversion limits is likely to be a lower intensity of economic activity in each region. However, the interaction between these many different, complex factors means that the Authority has exercised caution in considering and attempting to estimate economic impacts. The following assessments should be read with this in mind.

Potential impacts by sector

As Figure 7.4 illustrates, some irrigated agriculture sectors are likely to suffer larger declines than others in response to a reduction in watercourse diversions. Sectors that have relatively lower-value product, such as broadacre crops (including hay and cereals), rice and cotton, are likely to experience larger relative reductions in size than industries with higher-value products such as nuts and fruit, vegetables and grapes, and to a lesser extent dairy. These reductions do not include the potential impact on food processing businesses.

Figure 7.4 assumes that water will be traded from lower-value to higher-value sectors, within the current policy and physical limits to trade. However, the extent of this trade is not anticipated to be large enough to generate a net increase in the total production of any higher-value sector. The Authority recognises that irrigators may choose to change their mix of crops and activities in response to the change in watercourse diversions.

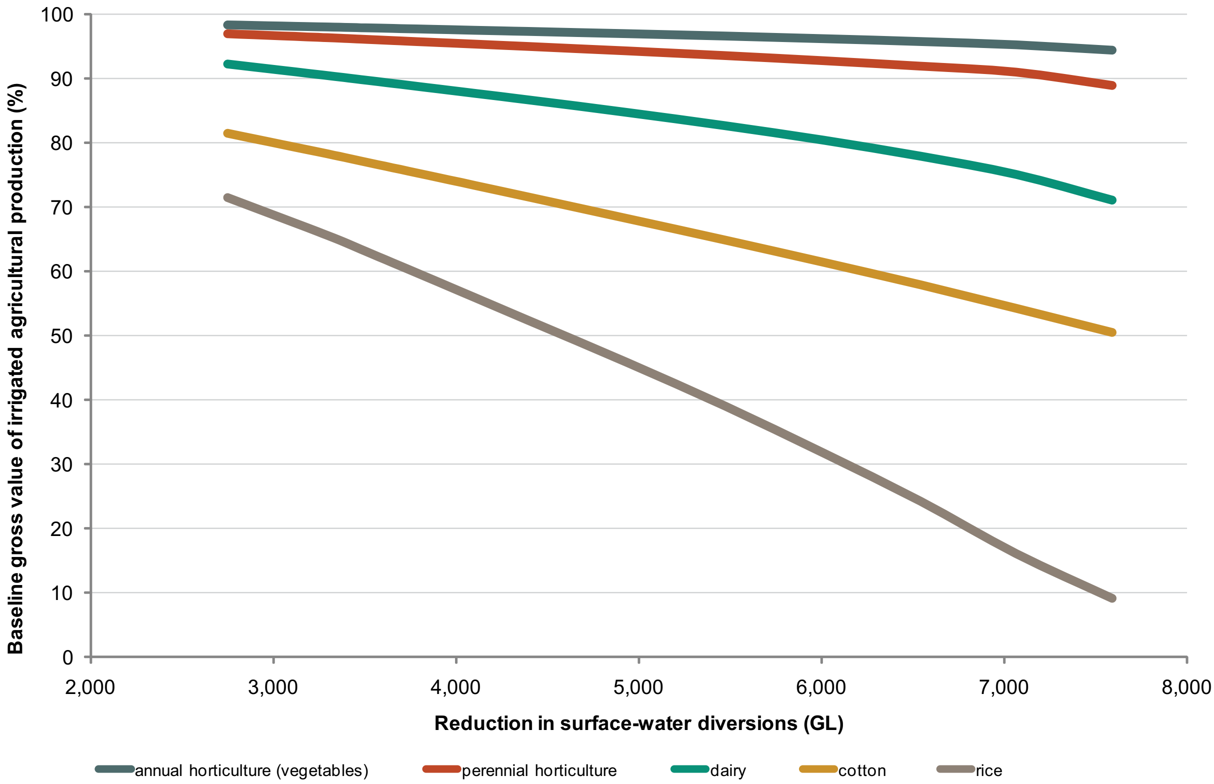


Figure 7.4 Reduction in baseline gross value of irrigated agricultural production due to reduction in surface-water diversions, by sector

Source: adapted from ABARE (2010) (see notes for Figure 7.3)

Rockmelon seedlings, St George, Queensland

Rice

Rice production tends to decline at a greater rate than the respective decline in watercourse diversions. While the rice farming system is a mixed farm, it is the rice crop, and winter cereal crops grown in rotation with rice, that underpin farm financial returns. Reduced diversion limits, even in the relatively lower end, would rapidly marginalise the viability of many irrigated rice system farms as farmers may choose to trade their water to higher value uses.

A decline in rice production is also likely to have widespread impacts for rice mills, storage and production facilities, as has been seen through the period of the drought.

Cotton

The extent of a decline in cotton production would be expected to be proportional to the extent of reduced diversion limits. Once cotton farmers have exploited water-use efficiency to the extent commercially feasible, their next response would be to diversify from permanent cotton crops to mixed cropping and other crops, including dryland cropping and/or pastoral farming. However, returns to dryland cropping are significantly lower than returns to irrigated cotton, in terms of both yields and employment.

A reduction in the production of cotton and other broadacre irrigated products is likely to result in significantly less processing activity in the northern Basin regions.

Dairy

Reductions in current diversion limits could be expected to continue to drive trends in dairy farming systems that developed during the drought, in particular:

- the change in feeding systems from perennial pasture to more flexible and complex feeding systems with an increased focus on annual crops
- farm numbers may continue to decline as average farm size increases
- a suite of water-use efficiency improvements could be implemented on-farm.

Reductions in current diversion limits at the 3,000–4,000 GL/y end of the range may result in dairy actually expanding from current levels of production compared with the recent drought.

Horticulture

Annual horticulture has a relatively low sensitivity to a reduction in diversion limits because water is a relatively low input cost. As diversion limits are reduced, annual horticulture enterprises would be likely to buy water on the market, although as water prices rise, annual horticulture could move to lower-cost regions outside the Basin. The industry may not experience significant closure; rather, those businesses with the capacity to do so could relocate to more water-reliable regions and, in the case of higher-value plantings, may purchase water from other broadacre agricultural industries.

Perennial horticulture also has a relatively low sensitivity to watercourse diversions, as water is a relatively low input cost. In the event of reduced diversion limits, the sector may buy water on the market. However, perennial horticulture cannot relocate easily, for climatic reasons and due to the long lead-time to maturity of plantings, and the high sunk costs.

7.4 Implications for regions

Any reductions in current diversion limits would have significant implications for the regions in which they occur. Nonetheless, the relative size of these implications would vary depending on the regional concentration of irrigated agriculture, and the dependence of local businesses and the community on irrigated agriculture. Figures 7.5 and 7.6 show the possible relative decline in gross value of irrigated agricultural production for each region for the range of reductions in watercourse diversions.

Northern Basin

Across the cotton regions of northern New South Wales and the Queensland Lower Balonne, reductions in watercourse diversions in the 3,000–4,000 GL/y range may lead to further investments in water-use efficiency and some sale of entitlements, where allowed. If reductions beyond 4,000 GL/y were imposed, cotton production could fall, and farmers may shift to alternative dryland farming (often of lower value) or may choose to exit. Some properties might consolidate and some cotton gins may close (as has occurred through the period of extended drought), with a consequent decline in employment opportunities and possible increased migration of people from the region.

The irrigation communities of the Gwydir, Namoi, and Border Rivers are highly dependent on cotton. Reductions in the 3,000–4,000 GL/y range may see significant loss of economic activity in these communities. Beyond 4,000 GL/y, there could be significant economic impacts on cotton growing regions with flow-on impacts to remote cotton-dependent towns that often lack other economic activities, or future economic opportunities.

While the Macquarie and Lachlan (further south) regions are also highly dependent on cotton, the larger urban centres in these regions have more diverse economies and may be relatively less affected by a reduction in current diversion limits than smaller towns.

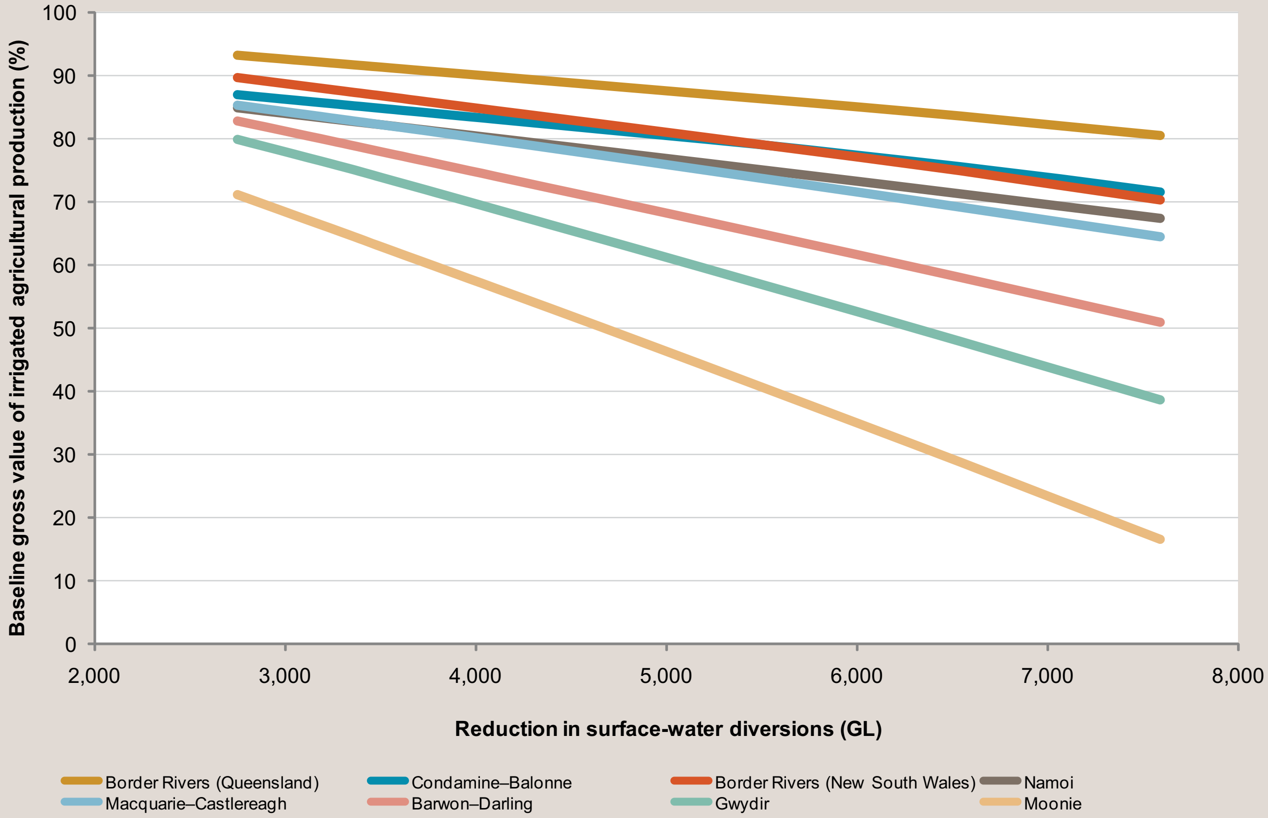


Figure 7.5 Reduction in baseline gross value of irrigated agricultural production due to reduction in surface water diversions, by northern Basin region

Source: adapted from ABARE (2010) (see notes for Figure 7.3)

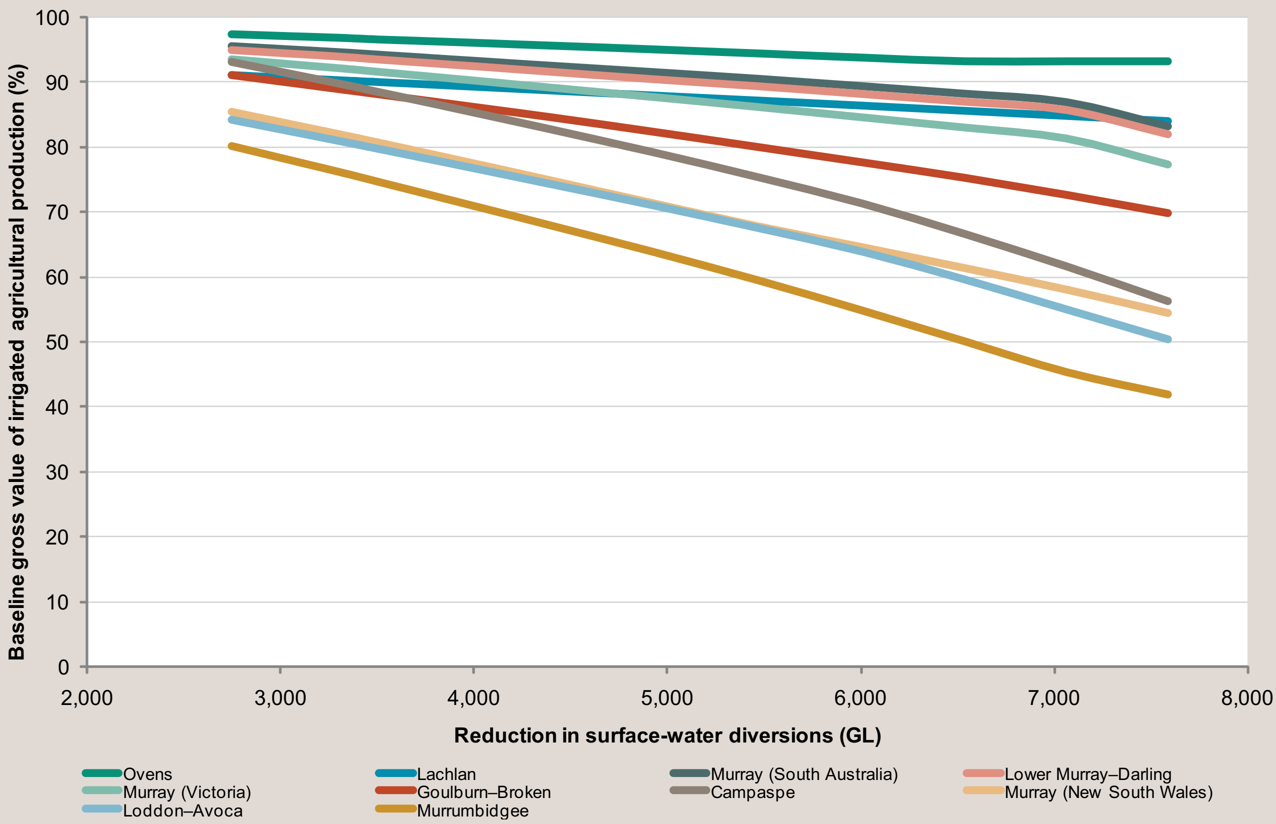


Figure 7.6 Reduction in baseline gross value of irrigated agricultural production due to reduction in surface-water diversions, by southern Basin region

Source: adapted from ABARE (2010) (see notes for Figure 7.3)

Southern Basin

The rice-growing regions of the Murrumbidgee and Central Murray in New South Wales are likely to be highly sensitive to economic decline caused by reductions in rice farming. However, the Murrumbidgee may be relatively less affected, because of the higher number of entitlements per hectare for Murrumbidgee farms. Across these two regions, smaller farms may become unviable if diversification was not possible. Larger enterprises that can leverage economies of scale typically might be expected to attempt to restructure, including purchasing water entitlements or annual allocated water to maintain productivity. Beyond 4,000 GL/y, some rice farms may become unviable.

Like the cotton towns, rice-growing towns might lose their skilled workers and their families with consequent impacts on critical community population mass, and may struggle to sustain businesses and provide community services. Flow-on effects would be seen in the smaller urban service centres, including reductions in post-farm processing. Some service centres may become more welfare-dependent.

For the northern Victorian regions of Goulburn, Murray, Campaspe and Loddon (the Goulburn-Murray Irrigation District), a reduction in current diversion limits of 3,000–4,000 GL/y could be absorbed in the medium to longer term through water trading. Beyond 4,000 GL/y, negligible water would be available for mixed and broadacre farming. The horticulture and dairy industries would experience some contraction. To offset reduced water allocations, some farms may be able to buy water from mixed farming and the New South Wales rice-growing regions.

The reductions in gross value of irrigated agricultural production in the Ovens region are low relative to the reductions in surface-water use, because this region uses a high proportion of groundwater that is not proposed to be reduced by the long-term average sustainable diversion limits (SDLs).

For the Nyah to SA border region (including the NSW and Victorian Sunraysia and the SA Riverland), horticulturists may cope with a reduction in current diversion limits of 3,000–4,000 GL/y through water trading and would dry off less viable plantings. Beyond 4,000 GL/y, drying off may expand and some industries may see negative flow-on impacts into the communities in the region which rely on horticulture and food processing for economic activity.

For the SA Murray below Lock 1, more reliable water levels in the river and the Lower Lakes as a result of reductions in current diversion limits across the Basin may include a number of important social and economic benefits to the region, including for boating, commercial fishing, experiential and eco-tourism, as well as the potential for greater wellbeing of the community.

However, a reduction in diversions of 3,000–4,000 GL/y might result in milk factory closures. With reductions beyond 4,000 GL/y, dairy on the reclaimed swamps may face further adjustment; however, dairy by the Lakes, which has already largely converted to dryland, may be less affected. Horticulture in the region would be significantly affected and may contract or leave the region, except for some boutique wineries with cellar-door sales.

7.5 Economic value of environmental benefits

The Authority commissioned work on the economic value of the likely environmental benefits of an increase in water for the environment — and by corollary, the economic effect of deteriorating ecosystems. Given that the environmental goods and services being considered are not traded in markets, these benefits are inherently difficult to quantify in monetary terms. Moreover, the environmental benefits accrue to a wide distribution of people, whereas the costs of a reduction in agricultural production are largely localised to individual irrigators and related businesses.

The Authority recognises that any conclusions in which values are put to ecosystem health should be treated with caution. It has commissioned this work to enable understanding of the potentially positive economic implications of an increase of water for the environment, as well as the adverse implications for irrigation sectors. The Authority sees this work as an important information source in understanding the benefits to the Basin of reducing water diversions, but it is only one informational input into this process.

The Authority has concluded that at this stage, additional work is required to have sufficient confidence in the economic value that might be put on environmental health.

7.6 Implications for the broader Basin community

The Authority recognises there would be broader economic effects in the Basin due to the flow-on effects through the agriculture supply chain, and to related businesses dependent on demand from irrigated agriculture.

The short-term economic effects on the Basin are even more difficult to determine, as they depend on the particular circumstances of the Basin's businesses and individuals and their capacities to adapt to reduced watercourse diversions. Moreover, they will respond in different ways to the transitional support that is provided to enable Basin communities to adjust.

Irrigated agriculture delivers greater production than dryland farming per unit area, as noted in Table 7.1, and therefore delivers flow-on employment and economic activity to its local communities.

This greater value per hectare flows on into demand in service industries such as retail and wholesale trade, transport, finance and machinery repairs, which are all affected by the spending patterns of irrigators. Employment opportunities for town residents and opportunities for off-farm employment for farmers are likely to be closely linked to expenditure by irrigators in many towns within or near the Basin.

Communities that rely directly on access to water for irrigation are likely to be most affected by reductions to current diversion limits. Other communities with agriculture sector-related industries (e.g. manufacturing) or those that lack other significant industries (e.g. communities in remote areas) would also be affected. In short, shops and clubs in country towns flourish when farmers earn a living, while the wealth and employment generated by irrigation also supports the provision of essential public-sector services such as education, social services and healthcare.

Table 7.1 Average non-irrigated gross value of agricultural production per hectare, and average gross value of irrigated agricultural production per hectare, by Basin region

Region	Average gross value of non-irrigated agricultural production ($/ha)	Average gross value of irrigated agricultural production ($/ha)
Condamine	106	4,028
Border Rivers (QLD)	145	6,348
Border Rivers (NSW)	145	4,049
Warrego	15	3,747
Paroo	80	6,602
Namoi	200	2,752
Macquarie	127	3,310
Moonie	109	3,627
Gwydir	165	3,285
Barwon Darling	25	2,487
Lachlan	147	2,934
Murrumbidgee	189	2,149
Ovens	488	7,025
Goulburn Broken	461	4,496
Campaspe	546	4,142
Wimmera	291	4,813
Loddon	366	2,236
Murray (NSW)	79	1,702
Murray (VIC)	79	4,261
Lower Murray Darling	79	7,024
SA Murray	79	9,176
Eastern Mount Lofty Ranges	411	8,241
Basin average	**184**	**3,295**

Source: adapted from ABARE (2010) (see notes for Figure 7.3)

Street scene, Wee Waa, New South Wales

7.7 Likely implications for small and medium enterprises and towns

There are more than 200,000 businesses in the Basin, comprising some 65,000 farms and around 135,000 other businesses. Many Basin-based small and medium enterprises are directly dependent on irrigated agriculture or on agricultural revenues and irrigator expenditure as a key source of income.

Small businesses are one of the largest employers in the Basin and, in some cases, small and medium enterprises can account for more than 90 per cent of all employment in regional towns. Small and medium enterprises are thus critical to regional towns and communities.

As Figure 7.7 shows, across all farm types, 50–70% of farm expenditure is in nearby towns, with a further 20–30% in regional centres where the population is greater than 10,000. In total, in all sectors, more than 75% of total farm expenditure is in the regional economy.

Analysis also revealed that irrigators' expenditure made a larger contribution to the economy of smaller towns on a per-capita basis. Total annual expenditure by irrigation farmers ranged from $4,700 per resident in towns with fewer than 1,000 people to $1,000 in towns of over 10,000. As Figure 7.8 shows, smaller towns are more reliant than larger towns on irrigation expenditure and would tend to be more adversely affected by any reduction in irrigated production. Larger towns tend to have more diversified economies, resulting in lower overall dependence on expenditure by irrigators.

As Table 7.2 shows, 80% of the towns identified by irrigators as a place of expenditure have fewer than 5,000 residents.

Table 7.2 Town size categories in the Murray–Darling Basin

Town population	Number of towns[a]	Share of all towns (%)
1,000 or less	110	50
1,000 to 5,000	65	30
5,000 to 10,000	24	11
More than 10,000	20	9
Total	219	100

a Towns identified by irrigators as places of expenditure, 2007–08.

Source: Australian Bureau of Agricultural and Research Economics (ABARE) 2007–08 irrigation industry survey

Towns with approximately $2,000 or more per resident in terms of irrigation expenditure per resident in the Basin are considered to be highly reliant on irrigator expenditure. Many such towns are in the southern part of the Murray–Darling Basin, with the majority in the Murrumbidgee and in the New South Wales and Victorian divisions of the Murray region. Highly reliant towns are also in the northern Basin, particularly in the Condamine–Balonne and Namoi regions.

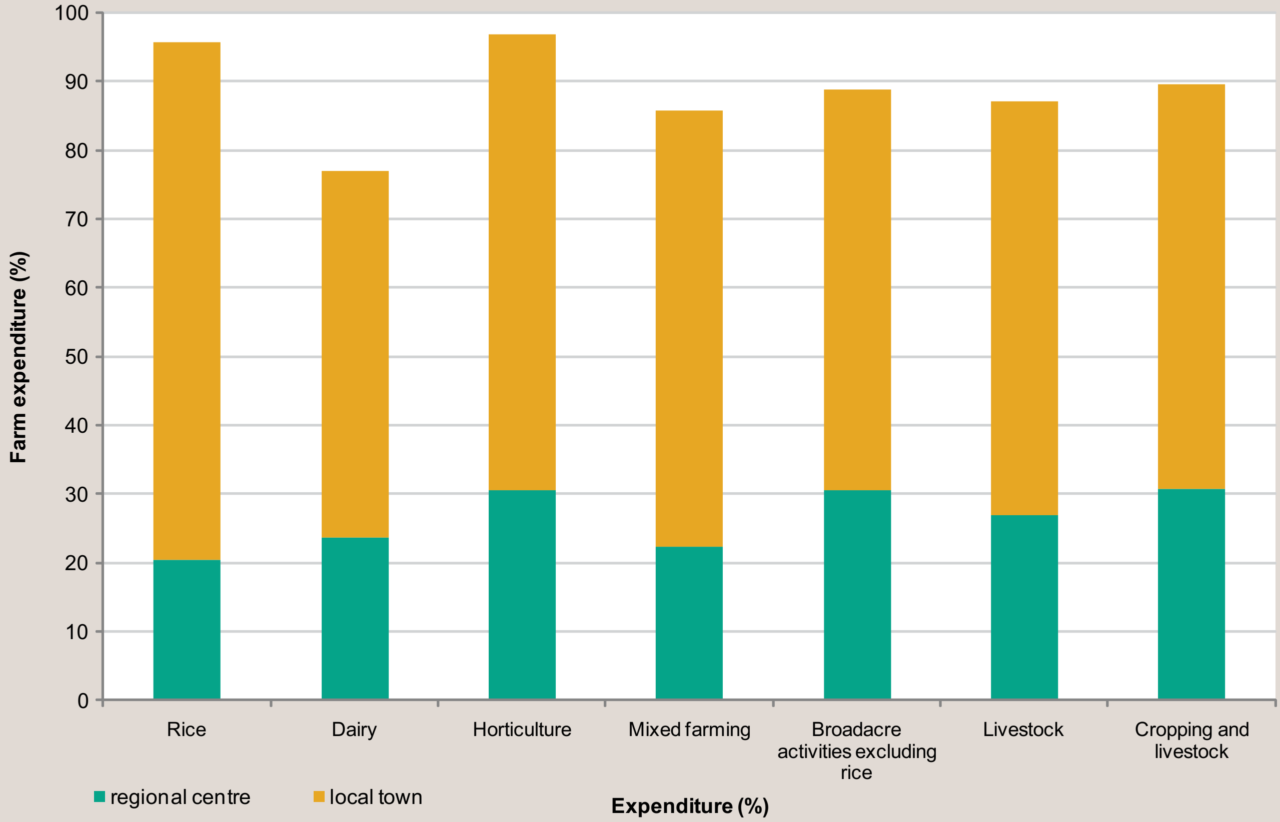


Figure 7.7 Farm expenditure in the Basin by sector

Source: Marsden Jacob Associates et al. (2010) (see notes for Figure 7.2)

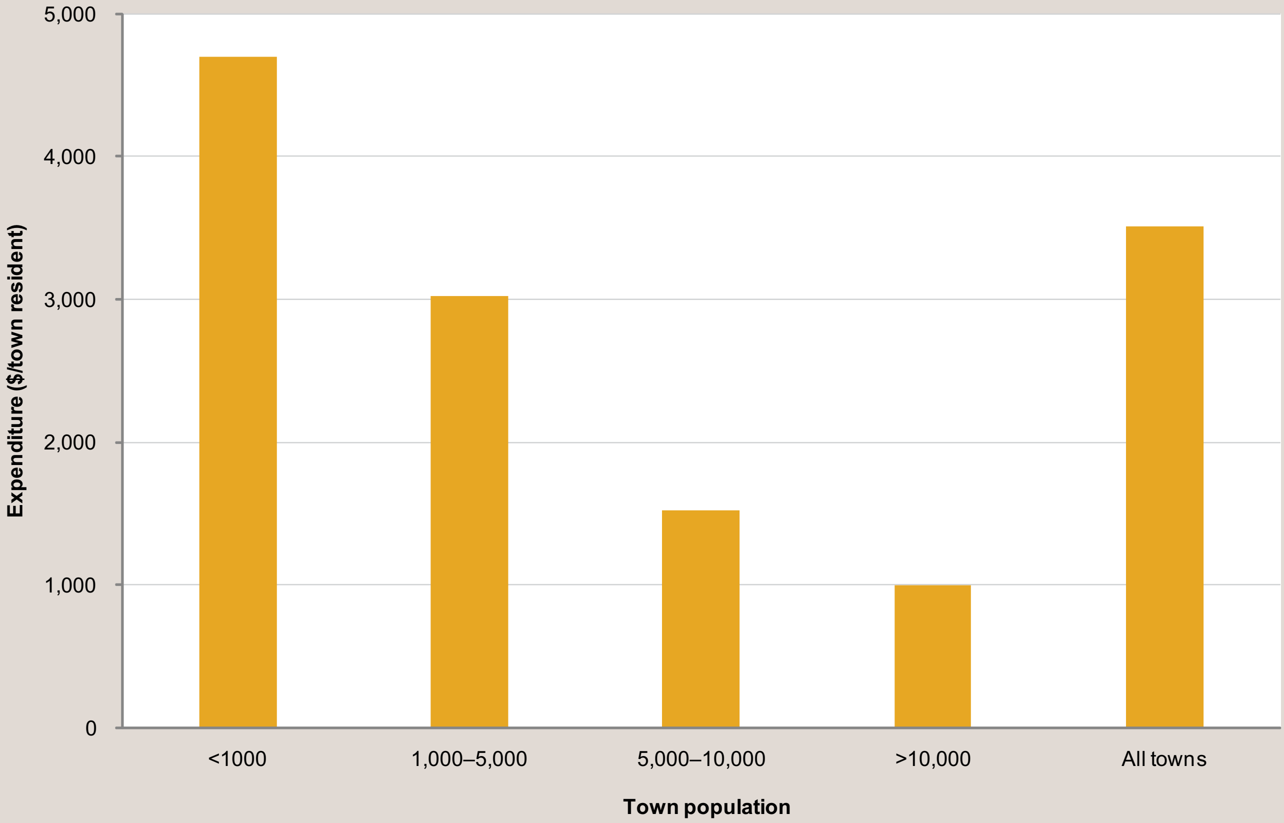


Figure 7.8 Total irrigation farm expenditure per resident in Murray–Darling Basin towns

Source: ABARE 2007–08 irrigation industry survey

7.8 Long-term consequences for communities at risk

A decline in business activity across these at-risk regional and rural towns and communities may have long-term consequences. In particular, a decline in the rateable base for local government authorities and reduced levels of demand for major community services such as health and education may mean that the level of service provision is likely to decline over time. As a consequence, there is a greater likelihood that:

- access to health services and education will become more difficult
- there will be fewer funds available to local government authorities to invest in and maintain community infrastructure
- social and community networks will come under increasing pressure.

On the other hand, across the Basin, greater urbanisation means that increasingly more people continue to live in major towns and regional centres that are the primary sources of employment and economic activities, including construction, manufacturing, government administration and defence, health and community services and education. These larger centres are more resilient with their lower sensitivity to water-dependent industry and their more diverse business base.

7.9 Possible implications for the Basin's Aboriginal communities

The Murray–Darling Basin is home to numerous Aboriginal groups such as the Barkindji, Nari Nari, Muthi Muthi, Gamilaroi and Yorta Yorta. The Basin has a population of just over two million people, of whom approximately 70,000 are Aboriginal, constituting 15% of Australia's Aboriginal population.

Analysis undertaken for the Authority of the likely effects of a change in watercourse diversions on the Basin's Aboriginal peoples concluded that the Basin's river systems are critical to the social, cultural and economic life of these peoples. Aboriginal people have multiple interests in the waters of the Basin, some of which are consumptive and commercial in nature.

The relationship maintained by Aboriginal nations with their countries is a key motivation behind their interests in water. Many of these peoples have expressed the desire for restoration of environmental systems; improvement in the environmental condition of the Basin is therefore likely to be viewed positively by many Aboriginal people.

However, as with all residents of the Basin, reduced watercourse diversions could limit Aboriginal development options, most directly for those who hold formal entitlements to water and/or are employed in irrigated agricultural industries. There is some evidence to suggest that in the northern Basin, Aboriginal residents rely heavily on the cotton industry for employment. More broadly, many Aboriginal people are active in natural resource management.

Within this context, the Authority understands that there may be some potential for structural change to open up new opportunities for Aboriginal people in emerging natural resource-based industries. Such peoples have

Millet broom shed in Tumut, New South Wales

expressed a strong desire to exercise authority, responsibility and control in the determination of allocations to meet their water requirements.

Although the Authority welcomed the additional understanding provided by its commissioned work (Jackson, S, Moggridge, B & Robinson, CJ 2010, *Effects of changes in water availability on Indigenous people of the Murray–Darling Basin: a scoping study*, report for the Murray–Darling Basin Authority, Canberra), it also recognises that critical data gaps remain, such as:

- a severe lack of quantitative data on Aboriginal water uses and values
- a lack of data on Aboriginal interests in water at the level of the Basin regions
- a lack of data on Aboriginal commercial interests in water.

7.10 The economic impacts of long-term average sustainable diversion limits in context

It is necessary to consider the economic impact of SDLs within the broader context of the Australian Government's Water for the Future program, which includes two main components: a water entitlement buyback (Restoring the Balance in the Murray–Darling Basin program) and infrastructure investment (Sustainable Rural Water Use and Infrastructure program).

The buyback and infrastructure programs are currently in progress and are likely to secure significant amounts of water prior to the introduction of the SDLs. At this stage the total volume of water that will eventually be obtained via the buyback and infrastructure investment programs in each region of the Basin remains uncertain.

Effectively, water secured for the environment though the Water for the Future program will reduce the gap between existing (historical long-run average) usage and the lower SDLs.

Importantly, unless specifically noted otherwise, the estimates of the economic impacts presented in Chapter 8 relate to the full reduction in water availability relative to long-run historical levels imposed by the SDLs and not to the potential 'gap' referred to in the preceding paragraph.

7.11 Implications for the Authority's decision-making

To summarise, the Authority has drawn on the social and economic studies that it has commissioned, and others available, to exercise its judgement on how to meet its obligations under the *Water Act 2007* (Cwlth). These obligations are to protect, restore and maintain the ecological health of the Basin while optimising social, economic and environmental outcomes.

As outlined in Chapter 6, the environmental water requirements of the Basin have been found to be between 3,000–7,600 GL/y. This chapter has explored the potential social and economic implications for the Basin of this range of reductions in watercourse diversions.

From this analysis, the Authority has judged that only with reductions in current diversion limits in the range of 3,000–4,000 GL/y can it optimise social, economic and environmental outcomes, as it is required to do under the Water Act. The Authority is concerned that reductions in diversion limits of greater than 4,000 GL/y would have implications for the social and economic fabric of the Basin severe enough to prevent the Authority from complying with the Water Act.

8. Setting long-term average sustainable diversion limits for surface water

Key points

- Under the *Water Act 2007* (Cwlth) the Authority is required to establish new long-term average sustainable diversion limits (SDLs) for surface water and groundwater.
- SDLs represent the long-term average amounts of water which can be used for consumptive purposes after the environmental water requirements have been met.
- This chapter deals with the detailed examination of the surface-water SDL proposals.
- SDL proposals are effectively driven by the Authority's decision about the amount of water needed for the environment. This identifies any additional water required for the environment and places a limit on the amount of water available for consumption.
- SDL proposals will apply to all forms of water extraction and include watercourse diversions such as for town and community water supplies, irrigation and industries, floodplain harvesting and interception activities such as farm dams and forestry plantations. The current limits on the volumes of water for these uses are referred to as the current diversion limits.
- The Authority recognises that any reductions in current diversion limits will result in social and economic impacts on communities and industries. The larger the reduction, the more significant the impacts.
- In setting the SDLs the Authority is required to:
  - deliver additional water to the environment to meet the environmental water requirements associated with the objectives and outcomes determined by the Authority, consistent with the *Water Act 2007* (Cwlth), using best available science. As indicated in Chapter 6, the range of additional water needed for the environment is between 3,000 GL/y and 7,600 GL/y
  - optimise economic, social and environmental outcomes from these changes.
- The Authority has set three objectives to achieve this optimisation. These are:
  - to meet key environmental outcomes and address the issues regarding the ecological health of the Basin
  - to ensure each catchment can satisfy its own environmental requirements such that key water-dependent ecosystems in each catchment can be returned to good health
  - to minimise social and economic impacts on Basin communities and industries, recognising that significant reductions will occur in some catchments given previous overallocation by governments.

... continued

Gum trees reflected in low water levels at Loxton, South Australia

Key points (continued)

- The Authority has examined three scenarios for providing additional water to the environment at the lower end of the range that would provide for an environmentally sustainable level of take. These scenarios are for an increase in water available to the environment of 3,000 GL/y, 3,500 GL/y and 4,000 GL/y. This represents proposed average reductions of between 22% and 29% in current diversion limits for surface water at the Basin scale.
- The water that would be made available to the environment by any of these scenarios would meet the environmental water requirements for the Basin, but with different levels of confidence, and align with the objectives and outcomes determined by the Authority consistent with the Water Act, but with different levels of confidence.
- SDLs will be used by Basin states to underpin revised water resource plans; these plans will determine the distribution of water available for use under the SDLs among various water entitlement holders in each area.
- The Authority is mindful that the reductions proposed to current diversion limits for the purpose of consultation could have significant social and economic impacts across the Basin. It understands that these impacts would not be evenly spread across communities and industries due to the need to satisfy environmental water requirements within each catchment and across the Basin.
- The Australian Government Water for the Future program will act to mitigate some of these impacts (see Chapter 11).

This chapter describes the scenarios considered by the Authority for the proposed SDLs for surface water. The Authority is required to establish SDLs for surface-water and groundwater systems. Given the differences in the approach to surface water and groundwater, groundwater is the subject of Chapter 9.

The determination of SDLs is one of the most important judgements the Authority must make. It is also a judgement which, when finalised, will have very significant impacts on the communities of the Basin. For this reason, this chapter describes in detail:

- the process for developing SDL proposals, particularly the importance of considering the social and economic impacts of any potential reduction in current diversion limits
- the various scenarios which the Authority considered to fulfil the obligations of the Water Act and to balance the requirement to return water to the environment in a way that optimises economic, social and environmental outcomes
- the environmental flow outcomes and the social and economic implications associated with these scenarios
- the analysis of the scenarios considered and the amount of additional water to be returned to the environment.

The Authority has not settled on a preferred position for surface-water SDLs. Due to the significance of the reductions required in current diversion limits, the Authority has decided to present the analysis of scenarios across the range of total reductions within which the Authority considers that the preferred level of reductions lies. This will provide a basis for meaningful discussion with stakeholders. The Authority will then decide the surface-water SDLs to be included in the proposed Basin Plan released for formal consultation.

8.1 What is meant by SDLs

Long-term average annual sustainable diversion limits (SDLs) represent the volume of water that is available for consumptive use (irrigation, town water supplies, industry, etc) after the environment has received what it requires. The Water Act refers to this as the 'environmentally sustainable level of take' and it requires that this level of take must be established using the best available science. The setting of SDLs will result in additional water being made available to the environment and in turn a reduction in the amount of water currently used for consumption.

SDLs, therefore, represent the long-term average annual quantity of water that can be used for consumptive purposes. They are applicable to all forms of extraction from the Basin's water resources including:

- watercourse diversions
- interception activities.

Watercourse diversions include diversions from watercourses for town and community water supplies, irrigation and industries (including major irrigation schemes through public infrastructure and irrigation channels and also water diverted from rivers by individuals) and floodplain harvesting. Most watercourse diversions are generally provided for under a system of entitlements, explicitly included in river system modelling and limited by existing water resource plans or existing water management arrangements, including the 1995 Murray–Darling Basin Cap. Floodplain harvesting is less well measured, but is included in river system models where there are significant diversions (i.e. in most of the larger models in the northern Basin). Floodplain harvesting is also generally included in existing water resource plan limits.

Interception activities include the run-off that is captured by farm dams and forestry plantations before it reaches watercourses.

As described in earlier chapters, the current limits on these uses are the current diversion limits. Also, 'without-development' conditions refer to the estimated river flows if the major infrastructure such as dams and consumptive water use are removed, using the 1895–2009 historical climate scenario.

Plantation timber near Cobram, Victoria

8.2 The requirements of the Water Act

The *Water Act 2007* (Cwlth) sets two broad requirements for the Authority in identifying SDLs. These are:

- To establish SDLs that reflect an environmentally sustainable level of take (Water Act s. 23(1)) which is a level of extraction that will not compromise the environmental water requirements of key environmental assets including water-dependent ecosystems; ecosystem services and sites with ecological significance; key ecosystem functions; the productive base; and key environmental outcomes for the water resource.
- That, in doing so, the economic, social and environmental outcomes are optimised and the net economic returns maximised.

The Authority needs to balance these broad requirements and, by necessity, the decision to identify SDL proposals is a judgement about how best to balance these requirements. The Authority has therefore undertaken a stepped approach to developing SDL proposals by bringing together environmental requirements and a consideration of social and economic impacts.

8.3 The process for setting SDLs

The process the Authority has followed for developing the proposed SDLs is outlined in Figure 8.1.

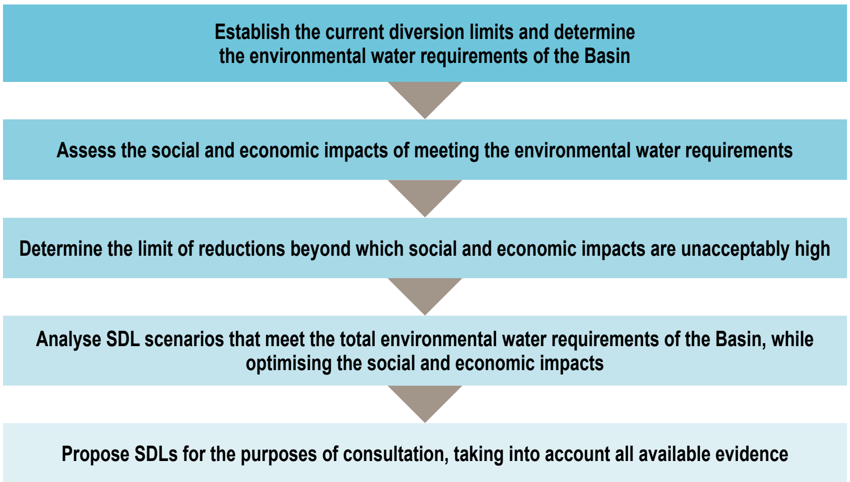


Figure 8.1 Process for establishing surface-water SDL proposals

8.4 How the SDLs will operate

As stated, the long-term average sustainable diversion limits (SDLs) represent the long-term average quantity of water that can be taken for consumption in any one year, i.e. the long-term average annual limit.

Across the Basin, 19 regions have been identified for the purposes of the Basin Plan. A larger number of surface-water SDL areas (29 in total) have been identified to cater for the state borders (e.g. Border Rivers and Murray regions) and the hydrologic units used by Basin states for their existing and proposed water resource plans.

An SDL will be set for all diversions in each of the 29 surface-water SDL areas that have been established for the Basin Plan. See Figure 8.2 for surface-water SDL areas.

Basin states will then develop water resource plans consistent with the requirements of the Basin Plan. Those plans will determine the distribution of water available for use under the SDLs among various water entitlement holders in that area. That is, the impact on particular water entitlements which will result from the establishment of SDLs is a matter for the new state water resource plans. It is possible that, depending on the decisions of the relevant state, some water entitlement holders in a particular area may not be affected at all as a result of the Basin Plan while others in the same area may experience significant impacts.

Allocations reflecting variable annual water availability will be determined under the arrangements in these water resource plans. That is, there will be some years where the actual allocation is lower than the SDL and some years where it will be higher. These arrangements, when tested under the relevant 114-year climate scenario, will need to limit long-term average diversions to no more than the SDL in order for the state plan to be accredited by the Commonwealth Water Minister, after receiving advice from the Authority. It is important to note that if an accredited water resource plan operates during a wetter-than-average decade, the actual average annual take for the 10 years is likely to be more than the SDL and such levels of use would be

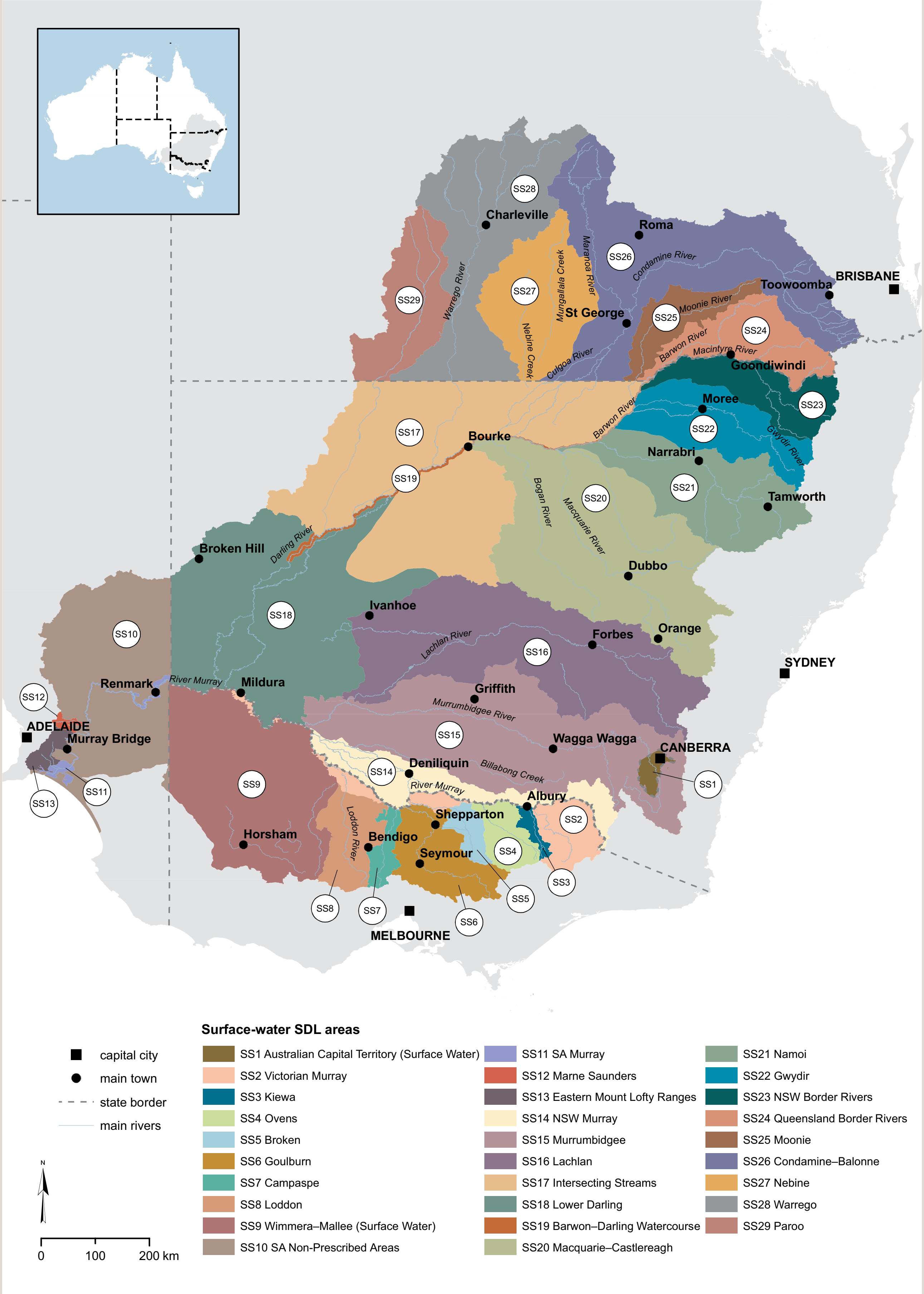


Figure 8.2 Surface-water SDL areas: Murray–Darling Basin

consistent with the Basin Plan. The converse would also be the case for a drier-than-average decade.

As well as incorporating climate change consideration into the development of surface-water SDL proposals (see Chapter 3), the Authority has also included accreditation requirements for surface-water water resource plans that ensure that these plans are responsive to climate change and are robust under a wide range of possible future climate conditions. A principle of equitable sharing of any reductions in water availability between consumptive and environmental uses has been adopted by the Authority to address the current situation in which most water resource plans are biased significantly towards allocation for consumption under drier future climates. This approach will need to be applied in a manner that does not put at risk water requirements for meeting critical human water needs. As a further requirement, surface-water water resource plans will also be required to show how they would manage conditions which include a repeat of extremely dry periods such as the 2000–10 drought.

8.5 Key issues the Authority is required to consider

In developing the SDL proposals, the Authority has considered three critical matters:

- the fundamental obligation of the Water Act to determine an environmentally sustainable level of take based on the best available science
- the need to optimise economic, environmental and social outcomes and to make a judgement about how best to achieve the optimisation requirements
- the need to take account of the physical constraints of the Basin, which limit from where water can be sourced. This includes taking account of the hydrologic characteristics and interdependencies of each catchment and the need to deliver on individual catchment- and Basin-level environmental outcomes.

These three considerations have assisted the Authority to develop a set of parameters on which the SDL proposals can be identified to deliver the requirements of the Water Act. Two of these are discussed below. In respect of the environmental water requirements, this has been described in Chapter 6.

8.6 Defining optimisation

The Authority believes that an important step in developing SDL proposals is to spell out its interpretation of the requirement of the Water Act to optimise economic, environmental and social outcomes. This interpretation has guided the Authority's judgement about developing SDL proposals for the purpose of discussion.

The Authority believes that three objectives must be achieved for the optimisation requirement of the Water Act to be properly met. These are as follows:

Achieving key environmental outcomes

The Authority is proposing to deliver an additional volume of water for the environment that will meet the outcomes and objectives it has set consistent with the requirements of the Water Act (Chapter 1) and in doing so meet specific environmental outcomes (Chapter 6). The outcomes which have been set by the Authority seek to address the key issues in the ecological health of the Basin (see Chapter 13).

The Authority is developing the Basin Plan to deliver the following outcomes:

- Water-dependent ecosystems in the Basin would be more able to withstand short- and long-term changes in watering regimes resulting from a more variable and changing climate.
- Use of Basin water resources would not be adversely affected by reduced water quality, including salinity levels.
- There would be improved clarity in water management arrangements in the Basin, providing improved certainty of access to the available resource.
- Basin entitlement holders and communities would be better adapted to less water.

Achieving water-dependent ecosystem health in each catchment

As part of providing for the overall environmental water requirements for the Basin, the Authority believes that SDLs must deliver appropriate environmental water requirements in each catchment. That is, the Authority believes that SDLs must ensure there is adequate water for the health of the water-dependent ecosystems (rivers, wetlands, etc.) in each catchment.

Social and economic implications

The Authority is mindful that some catchments have been previously overallocated by governments. This will mean that reductions to consumptive use to generate the necessary additional water for the environment will impact more severely on communities in these areas.

Against that backdrop, the Authority has set a third objective for optimisation to maximise the net economic returns to communities and key industries from the use and management of Basin water resources. The Authority recognises that there is no formula for determining the optimal result and will do this by applying its judgement in seeking to maximise the benefit to the environment while minimising the economic and social impacts.

Accordingly, the Authority is investing in comprehensive social and economic studies to inform its deliberations in this area (see Chapter 7).

8.7 Constraints on setting surface-water SDLs

The Authority recognises that a number of practical constraints affect the development of SDL proposals, particularly the interdependency between catchments and the need to have regard to the hydrologic function of the Basin. These include:

- Upstream catchments must provide their own internal environmental water requirements.
- Catchments that are hydrologically disconnected, or only connected during rare flood events, cannot contribute additional environmental water downstream. This applies to the Paroo, Lachlan, Wimmera–Avoca and Marne–Saunders catchments.
- All hydrologically connected catchments can contribute additional environmental water downstream to the Darling or the Murray. This applies to Warrego, Condamine–Balonne, Nebine, Moonie, Border Rivers, Gwydir, Namoi, Macquarie–Castlereagh, Goulburn, Broken, Loddon, Campaspe, Murrumbidgee, Kiewa, Ovens and Eastern Mount Lofty Ranges catchments.

Kulcurna area on the Chowilla flood plain before environmental watering, South Australia, 2010

- There are practical limitations or difficulties in reducing the interception component of the current diversion limits. For example, significantly reducing the farm dam interception component may only be achieved by major adjustments to, or the decommissioning of, large numbers of small farm dams.
- Larger, more highly developed rivers can make bigger volumetric contributions to additional environmental water requirements, although there are some physical and operational constraints to delivering additional environmental water in some areas, for example past the Barmah Choke on the Murray.
- On a long-term average annual basis without development, the northern Basin (Darling and tributaries) naturally contributes only 17% of the flow through the Murray Mouth, compared with the southern Basin (Murray and tributaries, excluding the Darling) which naturally contributes 83% of the flow.
- Catchment contributions to additional water to meet environmental water requirements cannot be made at the expense of the critical human water needs for the catchment.

8.8 The parameters for developing SDL proposals

The Authority is aware that, in developing the SDL proposals, transparent choices have to be made as to how additional environmental water is sourced from upstream catchments, for example additional environmental water for the Chowilla floodplain could be sourced from the Murrumbidgee, Goulburn or the upper River Murray systems. While the choice must be within hydrologic constraints, it has implications for the distribution of social and economic effects. The Authority adopted a principle whereby each upstream catchment should first meet its own environmental requirements and then all connected tributaries should provide for the respective downstream systems (Barwon–Darling or the Murray) through increasing reductions in tributaries in proportion to current diversion limits up to the necessary level.

Taking into account the best available science, the Authority's objectives for optimisation and the physical constraints of the Basin, the Authority has identified parameters for developing SDL proposals. The following parameters have been used to generate a number of scenarios for evaluation:

- Best available science indicates that supplying additional water to the environment of between 3,000 GL/y and 7,600 GL/y will achieve an environmentally sustainable level of take and meet the environmental outcomes set by the Authority (see Chapter 6). Therefore, any additional water within this range will meet the environmental watering requirement identified by the Authority consistent with the Water Act, but with different certainty that the objectives will be met.
- The social and economic considerations outlined in Chapter 7 suggest that any reductions in current diversion limits will result in social and economic impacts being felt by communities and industries. The larger the reduction, the more significant the impact.
- Because of the practical difficulties in implementing reductions in the interception component of the current diversion limits, Basin state governments are likely to consider first reducing watercourse diversions only. Therefore, the Authority has placed an upper bound on the reduction in any catchment as a percentage of the watercourse diversion component (see Chapter 5) of the current diversion limit.

New plantings with drip irrigation on a nectarine orchard near Lake Boga, Victoria

8.9 Implications of improved interception estimates

The approach to determining current diversion limits has involved quantifying each component of take separately, then adding these up to give the total current diversion limits. As described in Chapter 5, there is significant variation in the accuracy and extent to which the different components are measured or estimated. For example, diversions from regulated watercourses and transfers into the Basin are traditionally well estimated and included in river system models, while take via interception is not. This approach combines elements of varying accuracy and as the accuracy of this information inevitably improves, it is important that the policy positions in the Basin Plan accommodate this without perverse impacts.

This issue is particularly important with interception activities. The best available estimates of interception have been used in the development of the current diversion limits and SDL proposals. However, if better data and information lead to an improved estimate of the existing level of interception, it will be necessary to incorporate this new information into amendments of the Basin Plan. The compliance method and the states' statutory reporting obligations are therefore important in ensuring states implement SDLs effectively.

The proposed approach to implementing SDLs is through separate components (i.e., watercourse diversions and interceptions). For those components that are based on estimates of the current level of diversions or take, water resource plan requirements will ensure that take is limited to no more than the levels under current arrangements. This will prevent the inaccuracy of the estimates for an SDL component from being used to allow a level of diversions higher than was intended when developing the SDL.

States will have the flexibility to vary this initial breakup of the SDL across components when developing their water resource plan, but only if they can demonstrate that any change to an SDL component can be estimated accurately enough to allow offsetting of the change against another component of the SDL.

8.10 Potential scenarios for SDL proposals

On the basis of the parameters identified above, the Authority has examined three Basin-wide scenarios for providing additional water to the environment at the lower end of the range that will provide for an environmentally sustainable level of take. These scenarios are for an increase in water available to the environment of 3,000 GL/y, 3,500 GL/y or 4,000 GL/y. This represents proposed reductions of between 22% and 29% in current diversion limits for surface water.

In summary the three scenarios presented by the Authority for detailed scrutiny are:

- **scenario 1** — target an additional volume of 3,000 GL/y for the environment
- **scenario 2** — target an additional volume of 3,500 GL/y for the environment
- **scenario 3** — target an additional volume of 4,000 GL/y for the environment

It is important to stress that all these scenarios are in the range of the overall environmental water requirements. Each scenario has been considered in light of the Authority's objectives for optimisation. Scenarios for more water for the environment beyond an additional 4,000 GL/y have not been explored because the Authority feels that the escalating social and economic effects are likely to outweigh the additional environmental benefits. The range of 3,000 to 4,000 GL/y additional water for the environment provides adequate scope for determining the scenario that best meets the Authority's objectives.

The constraints described above will result in a range of current diversion limit reductions to ensure that the Basin's environmental water requirements are satisfied. The analysis below considers the environmental benefits and the social and economic implications of each scenario. Because of the practical limitations of significantly reducing interception by farm dams and forestry plantations, the implications of applying the entire reduction only to watercourse diversions are also considered.

The Authority has used its judgement for scenarios 1 and 2 and placed an upper bound on the reduction in any catchment as 40% of the watercourse diversion component of the current diversion limit. For scenario 3, a slightly higher limit (45%) has been used reflecting the greater volume of water required to be recovered for the environment under this scenario. Appendix C provides details of current diversion limits, SDL proposals and the associated changes in diversions and flows for each of the scenarios.

8.11 Overview of environmental flow outcomes

Each of the three scenarios will provide substantial environmental benefits, and at the Basin scale all scenarios would provide substantial improvements to the health of the Basin's rivers, wetlands and floodplains, and the associated flora and fauna. At the aggregate, Basin scale, the Authority believes each of the scenarios meets the requirements of the objectives and outcomes the Authority has established consistent with the Water Act, in terms of protecting and restoring the Basin's key environmental assets and

Vineyard east of Morgan in South Australia during the 2007 drought

key ecosystem functions. However, there are clear differences between the scenarios when they are explored at a finer level of detail.

The discussion of the three scenarios provided below is cognisant of these benefits and aggregate outcomes, but is aimed at explaining the differences between the scenarios, and therefore is focussed on points of differentiation (e.g. risks, potential trade-offs), rather than total benefits. First, outcomes for the Murray Mouth, waterbirds, native fish, river red gums and salinity are discussed and then each scenario is analysed.

The discussion of environmental outcomes below is informed by modelling and other analysis undertaken to date. The Authority is continuing its hydrologic modelling to further define potential environmental outcomes and to inform future decisions.

End-of-system flows

Figure 8.3 illustrates the end-of-system flows at the catchment scale across the Basin under current diversion limits and for each of the three scenarios. End-of-system flows do not represent a particular environmental outcome or ecosystem function, but nevertheless provide a broad measure of environmental flow provision for each region, (the ranges shown in Figure 8.3 are the ratio of the long-term average end-of-system flow under each scenario expressed as a percentage of the without-development long-term average end-of-system flow).

End-of-system flow data tabulated in Appendix C has been used for the purposes of preparing Figure 8.3; in the case of the disconnected systems (e.g. Paroo, Lachlan, Wimmera), an appropriate location near the end-of-system has been used. Under a without-development scenario, all catchments would be rated 'good' with respect to end-of-system flow.

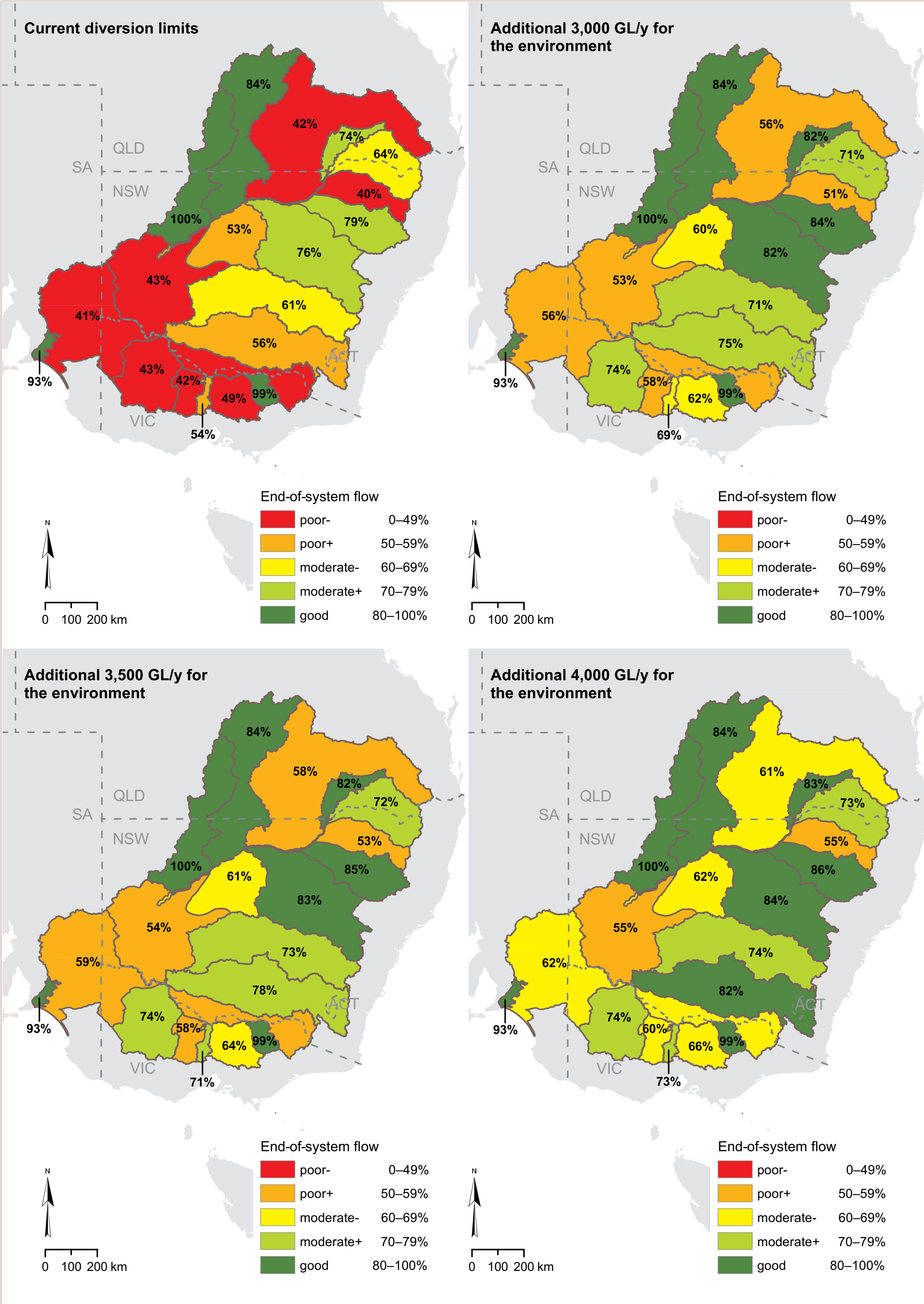


Figure 8.3 Environmental flow outcomes

Outcomes for the Murray Mouth

While the Murray Mouth is an iconic feature of the Murray–Darling Basin, it performs a far more important function in that an open mouth is essential to the environmental health of the Basin for a range of reasons including:

- export of salt and nutrients from the Basin — without salt export land will salinise and water quality will deteriorate with negative effects on both the environment and consumptive use for all irrigation and human water needs throughout the Basin
- a healthy Coorong — tidal exchange between the Southern Ocean and the Coorong is important in maintaining water quality in the Coorong (particularly the southern Coorong) and in maintaining water levels that inundate mudflats, which are important habitat for a range of plant and animal species
- assist with maintaining a range of healthy estuarine, marine and hypersaline conditions in the Coorong, including healthy populations of 'keystone' species such as tuberous tassel in the South Lagoon and widgeon grass in the North Lagoon
- migration of diadromous fish species (fish that require access to both fresh and saline water to complete their life cycle) — seven such species, including common galaxias and estuary perch, require this connectivity.

Figure 8.4 shows the proportion of years when the Murray Mouth is expected to be open, under without development, current arrangements and potential scenarios. Hydrodynamic modelling has shown that flows of approximately 2,000 GL/y are required to maintain an open Murray Mouth, to the extent currently being achieved by dredging. Under without-development conditions, models show that flows greater than 2,000 GL/y occurred about 97% of years, indicating that the mouth would have remained open nearly all of the time. Under current arrangements, the models show that this has reduced to 64% of years. The provision of an additional 3,000 GL/y for the environment will increase the proportion to about 90% of years. An additional 3,500 GL/y will increase this to about 91% of years, and 4,000 GL/y will increase this to about 92% of years.

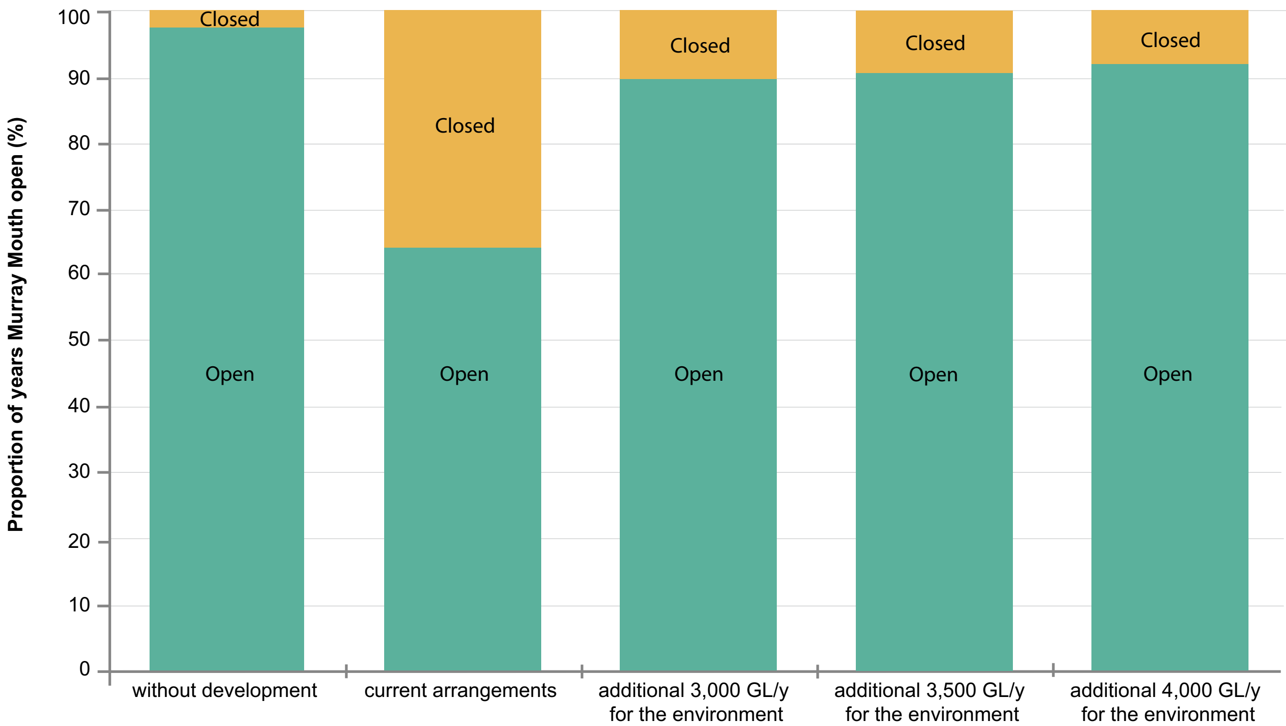


Figure 8.4 Proportion of years the Murray Mouth could be expected to be open under without-development conditions, under current arrangements, and with potential Basin Plan scenarios

Outcomes for waterbirds

The wetlands of the Murray–Darling Basin are among the most important areas for waterbird breeding in Australia. Important breeding sites include many of the Basin's most significant key environmental assets such as the Coorong and Lower Lakes, Barmah–Millewa Forest, the Lowbidgee floodplain, Booligal Swamp, Great Cumbung Swamp, the Macquarie Marshes, Narran Lakes, the Gwydir Wetlands, and the wetlands of the Warrego and Paroo rivers. When conditions are suitable, hundreds of thousands of birds can breed at these sites.

However, since 1983, waterbird abundance in the Basin has declined by about 80% (see Figure 8.5). This downward trend in numbers and species evident in wetlands across the Basin is due primarily to breeding events being insufficient in frequency and scale. Experts anticipate this downward trend to continue under the current water management arrangements in place across the Basin. The Basin Plan is seeking to address the decline in waterbird populations by providing sufficient water to improve the condition of key waterbird habitats, and provide conditions suitable for more frequent and successful breeding events.

Potential impacts on waterbird breeding and populations provide one measure to further describe the environmental outcomes and differences between the three scenarios. The Authority has assessed potential outcomes for waterbirds using some simple modelling of how waterbird breeding and populations may respond to improvements in environmental watering.

Figure 8.5 shows the future forecasts in waterbird populations under a continuation of current arrangements, and for Scenarios 1 and 3.

The Authority's analysis of waterbird populations indicates that Scenario 1 (additional 3,000 GL/y of water for the environment) is most likely to slow the decline in waterbird numbers and maintenance of current abundance. There is some uncertainty associated with the analysis (expressed by the shaded area associated with each scenario), and the range of outcomes for Scenario 1 is considered to be between a slow decline or slow increase in abundance.

Scenario 3 (additional 4,000 GL/y of water for the environment) is most likely to result in a steady increase in waterbird numbers. All outcomes associated with the likely range of uncertainty show an increase in waterbird numbers.

Scenario 2 (additional 3,500 GL/y of water for the environment) is deliberately not shown on the graph to avoid overlap, however it lies between Scenario 1 and Scenario 3. The most likely outcome is estimated to be a slow increase in waterbird numbers, with the range of outcomes considered to be from maintenance of current abundance (middle estimate for Scenario 1) to a more rapid rise in numbers (middle estimate for Scenario 3).

It should be noted that actual outcomes for waterbirds will be sensitive to future climate variability, potential climate change and water availability. These projections assume a return to long-term average climate conditions, combined with best estimates of climate change impacts at 2030. The projections are intended to show long term trends – actual numbers in each year will fluctuate around the long term trend lines in response to successful breeding events in wet periods, and decline in numbers during extended drought.

Outcomes for native fish

As with waterbirds, fish are near the top of the aquatic food chain, and are sensitive to both short- and long-term environmental change. Consequently, the health of native fish communities can serve as an indicator of the overall health of the Basin's water resources.

Currently, native fish populations are estimated to be about 10% of their pre-European levels. Additionally, the structure of the Basin's fish populations has changed, with 16 of the Basin's 35 native fish species now listed as threatened and 80–90% of the fish biomass in the Murray and Murrumbidgee rivers consisting of alien fish species. The Sustainable Rivers Audit found that the fish populations in 20 of the 23 river basins studied were in 'poor' to 'very poor' condition for the period 2004–07.

The Murray–Darling Basin Authority (MDBA) Native Fish Strategy outlined a number of factors that are thought to have contributed to this decline including flow regulation and extraction, barriers to migration and poor physical habitat.

The Basin Plan is aiming to restore important aspects of the natural flow regime, and this will provide more frequent conditions suitable for the migration and spawning of native fish, and conditions that should encourage increased survival of young fish.

The expected improvement in native fish populations is demonstrated using the lower reaches of the River Murray in South Australia as a specific example.

It is well known that the spawning success and larval survival of Murray cod, freshwater catfish, golden perch and silver perch are linked to flow conditions, and in particular that the timing of environmental flows should match the spawning season for these large-bodied native fish species. Delivery of peak flows during the spawning season will encourage spawning and enhance survival of larvae and juveniles. Research indicates the spawning period for the above species commences in mid-spring and generally extends to late summer (see Figure 8.6).

Within the Riverland–Chowilla stretch of the River Murray, flows of between 40 to 60 GL/d are required to overtop the river banks and commence floodplain inundation, with significant floodplain inundation occurring at the upper end of this range. This range is shown in Figure 8.6, which indicates the time of year and quantities of water required to provide conditions mostly likely to facilitate fish access to floodplain habitat.

The last successful Murray cod breeding event in the Lower Murray occurred in 2000 when flows were elevated at between 20 GL/d and 50 GL/d for nearly four months. Flows of above 20 GL/d are now considered important for Murray cod recruitment in the Lower Murray. Flows above 20 GL/d are also considered to be important triggers for fish migration.

Figure 8.6 shows important flow thresholds and the spawning season, together with potential outcomes from each of the three scenarios. The figure shows how river regulation has changed the natural flow regime in the lower sections of the River Murray. Current flows are now lower on average, with a less defined seasonal peak that is on average below the level required to provide fish with access to wetland and floodplain habitats.

Each of the three scenarios will deliver significant improvements to flows that will provide benefits to native fish. It is likely that the return of greater volumes of water to the environment, and the associated improvement in flows, will provide greater benefits. Therefore scenario 3 will provide greater benefits for fish than scenario 2, and scenario 2 will provide greater benefits for fish than scenario 1.

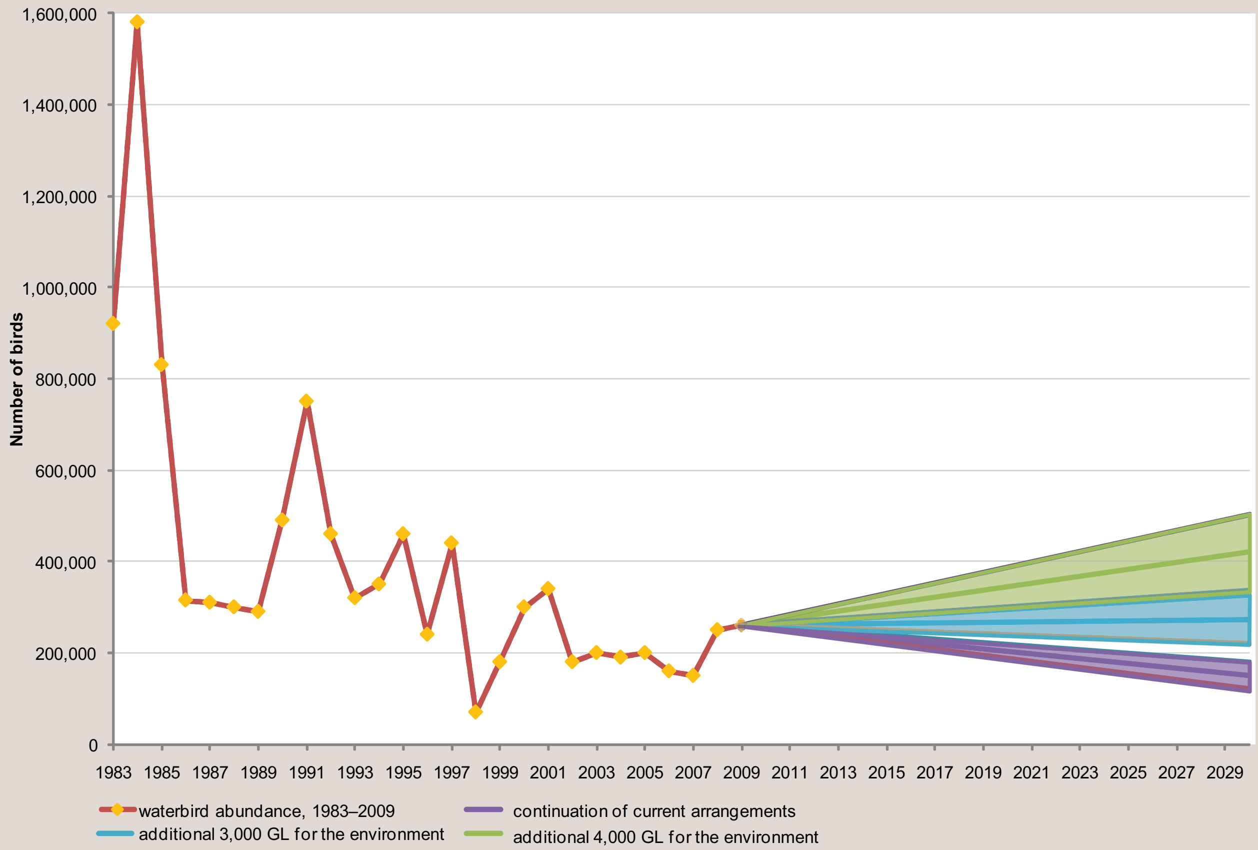


Figure 8.5 Change in total waterbird abundance (more than 50 taxa) across the Murray–Darling Basin from 1983 to 2009 (after Porter and Kingsford 2009). Projected abundance post 2009 is based on MDBA analysis under a continuation of current conditions, and with additional environmental water

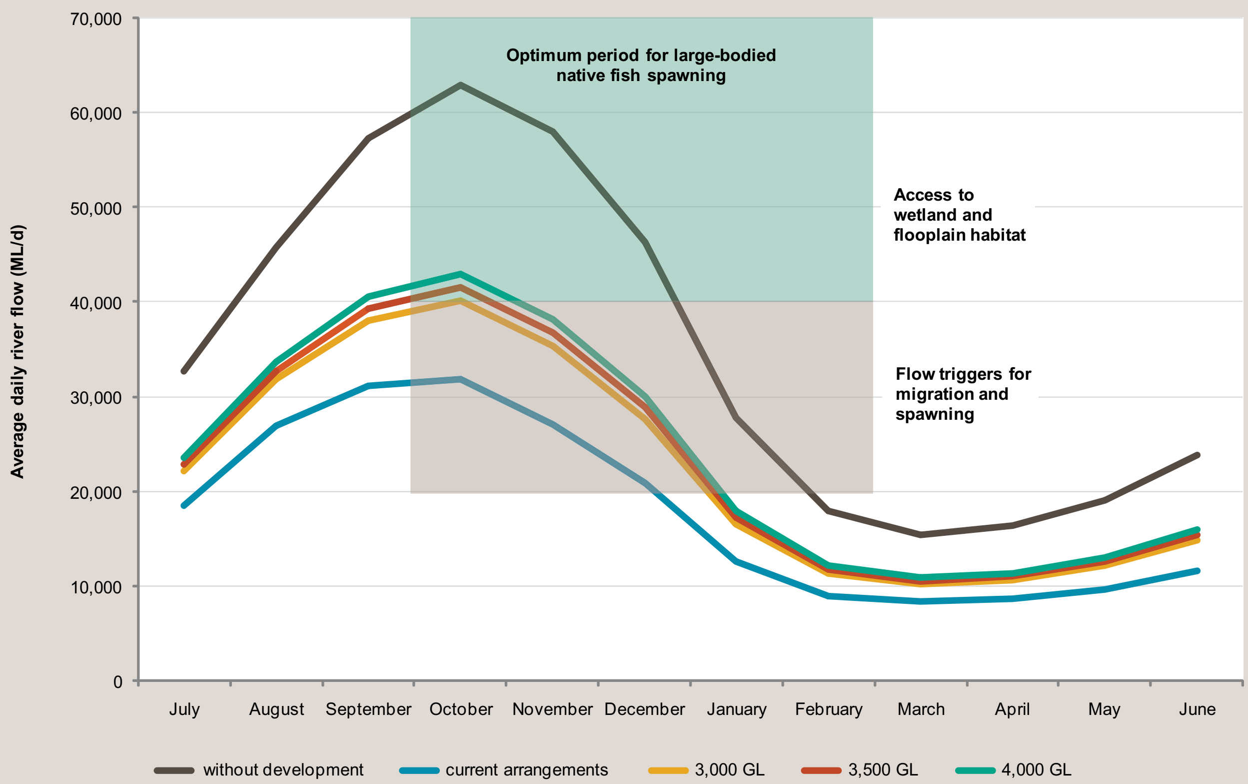


Figure 8.6 Modelled daily flows to South Australia under without-development, current and potential Basin Plan scenarios illustrating the relationship to native fish migration and spawning

It is difficult to quantify the differences between the three scenarios, although, in an average year, scenarios 2 and 3 will provide access to some floodplain and wetland habitat, whereas scenario 1 will fall just short of this threshold. A number of small-bodied fish need to breed each year to maintain their population.

Outcomes for river red gum

River red gums line the watercourses of the Murray–Darling Basin, as well as forming extensive forests and woodlands, principally within the Murray, Murrumbidgee, Lachlan and Macquarie river systems. A healthy river red gum forest has a dense canopy and usually a wetland understorey that includes reeds, rushes and sedges. River red gum woodland occurs in less frequently flooded areas, tends to be more open, and often has grass species in the understorey. Population structure is very important in these woodlands and forests. In many areas a predominance of one age class, especially if most trees are old, is cause for concern. River red gum forests and woodlands provide critical habitat for woodland birds in the Murray–Darling Basin, having a greater abundance and richness of woodland birds than other woodland types.

Throughout the Basin the health of river red gum forests and woodlands has been in decline for more than 20 years. In the late 1980s and 1990s the decline of red gum forest and woodland was recorded along the lower Murray and in the Macquarie Marshes. In 2003, approximately 80% of river red gums on the River Murray in South Australia showed signs of crown stress. A survey in 2006 showed a general decline along the River Murray progressing downstream from Hume Dam. Along the Victorian River Murray floodplain only 30% of river red gum stands were in good condition, and northern Victoria was the only area where the majority of stands were in good condition. By 2009, the area of river red gum forests and woodlands estimated to be in good condition in The Living Murray icon sites had fallen to 28%.

The decline of river red gum forest and woodland has continued in the Macquarie Marshes since it was first recorded in the 1990s. By 2004, up to 30% of trees identified as stressed in 1996 had died. By 2008, 40% of river red gum communities in the marshes were in poor condition, with more than 80% dead canopy. More than half the area of river red gum forest and woodland was identified as stressed and only 5% of the area was in good condition, having less than 10% loss of canopy. A similar pattern of decline has been recorded in the Murrumbidgee and Lachlan valleys.

The implementation of the Basin Plan aims to slow the current decline in condition and extent of river red gum forests and woodlands across the Basin by restoring flows that are critical to their survival and will, over time, improve their condition.

Approximately half of the total area of river red gum forests and woodlands in the Basin are located within the 18 indicator assets. On average, the Guide targets for the indicator assets seek to maintain or restore about 75% (about 230,000 ha) of the river red gum communities contained in those assets to good condition. Whilst it is difficult to quantify outcomes outside of the indicator assets, achievement of these targets is likely to have a similar scale of impact across the rest of the Basin's red gum communities.

Scenario 1 is unlikely to enable the achievement of all environmental targets in many regions. This means it is unlikely that this target of 75% of the red gum communities to be maintained or restored to good condition can be achieved with scenario 1. However further assessment would be required to better define the outcome.

Scenario 2 is likely to be on the threshold of achieving the 75% target; however further modelling is required to verify this outcome.

Scenario 3 is likely to provide sufficient water to achieve the 75% target.

Salinity outcomes

The Water Quality and Salinity Management Plan will ensure the protection and enhancement of water quality in the Basin by setting water quality targets across the Basin. This includes a Basin-wide target to export a long-term minimum of two million tonnes a year (10-year rolling average) of salt out of the Basin. Export of salt through the Murray Mouth to the ocean is necessary for the Basin to continue as a freshwater system. It also supports improved water quality for human consumption, irrigation and the environment.

Water quality is largely controlled by the volumes of water that flow down the river and the condition of the catchments. The Authority is confident that additional environmental water between 3,000 GL/y and 4,000 GL/y would result in the water quality targets in the Water Quality and Salinity Management Plan being met. These targets will lead to improved water quality outcomes as natural resource managers develop strategic water quality-related operating rules, invest in infrastructural change to achieve water quality outcomes, and integrate operational decision-making with catchment management and pollution control considerations.

Figure 8.7 shows the effect of water volumes on salt export through the Murray Mouth over the past 105 years (1904–2009). While this is modelled data, it estimates the amount of salt that would have been exported under current arrangements and the three scenarios. It also shows the minimum salt export target of two million tonnes per year. All data are shown as rolling 10-year averages.

For all three scenarios, Figure 8.7 shows that it is unlikely the salt export target will be achieved in all years. Achieving the target would be particularly difficult in a repeat of the Federation drought and the recent drought. The additional environmental water associated with Scenarios 2 and 3 reduce the length of time that export is below target, as well as the deficit in each drought. Failure to achieve the target is likely to result in salt accumulation in wetlands and on floodplains, resulting in a decline in condition of those systems, as well as elevated salinity across the Basin, which may impact on consumptive uses.

Perhaps the most significant differences between the three scenarios will be felt in the future under potential climate change. Declining flows associated with climate change will make it increasingly difficult to achieve the salt export target in the future. The scenarios with greater environmental water will provide increased capacity to achieve the target on an ongoing basis.

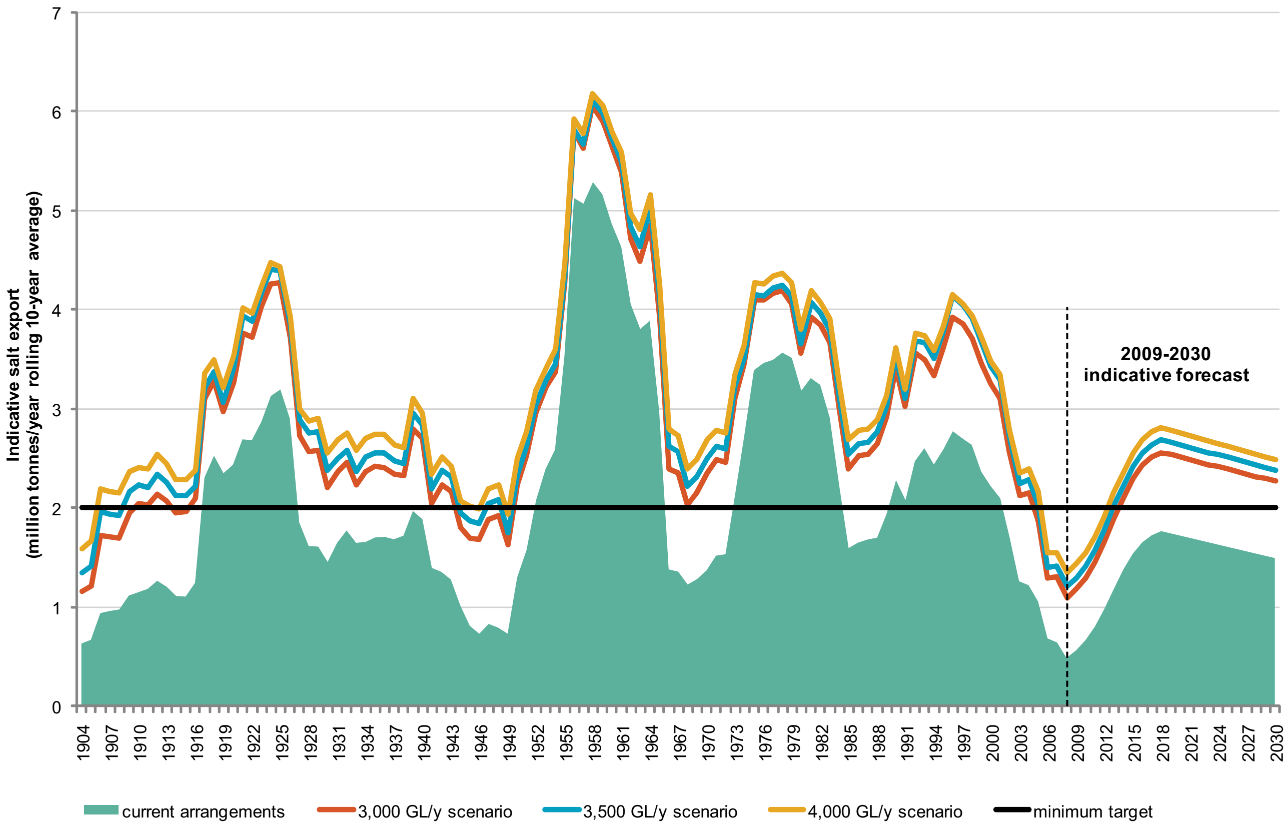


Figure 8.7 Indicative salt load exported through the Murray Mouth, 1904–2030 (rolling 10-year average). For the period 2009–2030, the forecast assumes a gradual return to long-term average conditions and then a decline due to the anticipated effects of climate change

8.12 Overview of social and economic implications

There are a range of social and economic impacts related to rebalancing water uses in the Basin that will unfold over time. The negative impacts relate primarily to reduced water availability for irrigated agriculture. As a first step in the chain of impacts, the related costs can be estimated in terms of the reduced agricultural output and reduced employment likely to follow reductions in diversions for irrigation. Because there is reasonably good aggregate information about what is produced, where it is produced, profitability and related water use, estimates of dollar value costs of change at a Basin scale for the long term can be reasonably estimated. Positive impacts, including environmental benefits, are not as easily estimated in dollar terms but are nonetheless real.

The implications provided here are generally on a gross basis and do not take account of the offsetting benefits of the Australian Government's Water for the Future program. Further discussion of this program and other transition mechanisms is provided in Chapter 11.

The Authority notes that estimates of economic activity provided below are limited by a number of factors but do, however, provide useful broadscale information. Further, the estimates of gross value of irrigated agricultural production do not take into account post farm gate impacts and represent a longer run steady state outcome.

8.13 Implications for irrigated agriculture

The estimates of economic impacts on irrigated agriculture of the three scenarios provided here are based on the modelling commissioned by the Authority. The starting point, or baseline for the modelling, in terms of water use, land use and gross value of irrigated agricultural production, is Australian Bureau of Statistics agricultural census data for the years 2001 and 2006. The modelling uses the overall level of water availability for irrigation in each region in 2001 as being representative of a typical or long-run average year. The models do not predict a future but rather inform the potential extent of change that may occur in a region or sector, and relativities of change across regions and sectors. All estimates should be read as indicative of the relativities of reductions across sectors rather than exact assessments.

Analysis undertaken for the Authority indicates that, as would be expected, the larger the reduction in water availability, the larger the economic impact. Impacts for irrigated agriculture across the Basin for the three scenarios are summarised in Table 8.1. All the estimated impacts provided here include the reductions to both surface-water diversions and groundwater (see Chapter 9). Furthermore, the estimates reflect reductions to the amounts of water used in irrigation that would follow from reductions to current diversion limits. Water used in irrigation differs from current diversion limits for a number of reasons including transmission losses through irrigation channels.

At Basin-scale, it is estimated that gross value of irrigated agricultural production would decline by around 13% under a 3,000 GL/y scenario to a new level of $5,415 million. Under a 3,500 GL/y scenario the decline in gross value of irrigated agricultural production would be 15%. Under the 4,000 GL/y scenario the decline in gross value of irrigated agricultural production would be 17%. These results assume efficient trade of water away from relatively lower value broadacre activities to relatively higher value horticultural activities.

Without interregional trade, the estimated gross value of irrigated agricultural production reductions would be 14%, 16% and 19% per cent under 3,000, 3,500 and 4,000 GL/y scenarios respectively. Without interregional water trade in the southern Basin, the loss is estimated to be greater because water would not be moving freely across regional borders to more profitable uses. It is likely that actual water trades would result in impacts between the two estimates for 'with' and 'without' trade.

Table 8.1 also shows the longer-term estimates for gross regional product and employment for the Basin as a whole that results from the flow through impact of reduced irrigated agricultural activity. Under the three scenarios, reductions in irrigated agricultural activity are estimated to result in permanent, long-term reductions in gross regional product of about 1.1 to 1.5%. However, these modelling results provide estimates of the economic impacts in the Basin in isolation from other relevant government water polices. Impacts will be less, depending on how effective other policies are in reducing the impacts. For example, recent Australian Bureau of Agricultural and Resource Economics – Bureau of Rural Sciences estimates for a reduction of 3,500 GL/y indicate that the Australian Government's $12.6 billion Water for the Future program would reduce the impact on the long-term Basin gross regional product by one half, to about 0.7%. This program includes the Restoring the Balance water entitlement purchase program and the Sustainable Rural Water Use and Infrastructure Program. The Water for the Future program is likely to affect the eventual impacts on regional communities by providing additional water savings which offset long-term average sustainable diversion limit reductions (through infrastructure investments) and by providing regional economic stimulus (through both entitlement sale proceeds and infrastructure investment expenditure.

In terms of employment impacts, in isolation from other government programs that may affect employment levels, the Australian Bureau of Agricultural and Resource Economics – Bureau of Rural Sciences estimates provided for the Authority indicate that the long-run, Basin-wide employment would fall by approximately 800 full-time jobs, or around 0.1% of current employment levels (see Table 8.1). At the national level, in the long term, the decline in current gross domestic product ($759 billion) is estimated to be in the order of 0.11 to 0.15% ($0.8 to $1.1 billion) with about 0.03% (approximately 3,000) fewer jobs in the future economy. The Authority notes that other studies have indicated likely higher reductions in employment.

Table 8.1 Summary of economic impacts of reduced diversion limits on irrigated agricultural activity[a]

	Baseline	Basin Plan	Change (%)	Value change
3,000 GL/y reduction in current diversion limits				
Water use (GL/y)[b]	10,403	7,736	-26	-2,666
GVIAP ($m/y)	6,220	5,415	-13	-805
Irrigated Agricultural Profit ($m/y)	1,956	1,833	-6	-123
Basin Gross Regional Product ($m/y)	59,033	58,359	-1.1	-674
Basin employment ('000)[c]	922	921	-0.09	-0.76
3,500 GL/y reduction in current diversion limits				
Water use (GL/y)[b]	10,403	7,311	-30	-3,091
GVIAP ($m/y)	6,220	5,280	-15	-940
Irrigated Agricultural Profit ($m/y)	1,956	1,804	-8	-152
Basin Gross Regional Product ($m/y)	59,033	58,240	-1.3	-793
Basin employment ('000)[c]	922	921	-0.10	-0.92
4,000 GL/y reduction in current diversion limits				
Water use (GL/y)[b]	10,403	6,895	-34	-3,507
GVIAP ($m/y)	6,220	5,145	-17	-1,075
Irrigated Agricultural Profit ($m/y)	1,956	1,773	-9	-183
Basin Gross Regional Product ($m/y)	59,033	58,122	-1.5	-911
Basin employment ('000)[c]	922	921	-0.12	-1.1

a Estimates are based on modelling that includes intra regional water trade and inter regional water trade in the southern Basin

b 'Water use' includes water used for irrigation that is sourced from both groundwater (Chapter 9) and surface water (Chapter 8). Water Use is based on estimates of water use in irrigation and therefore differs from long-term average diversion limits, which include addition volumes of water not used for irrigation such as volumes lost during transmission through irrigation channels

c Percentage impacts for employment differ across scenarios while employment levels reported here are the same. This reflects the effects of rounding.

Source: Australian Bureau of Agricultural and Resource Economics – Bureau of Rural Sciences 2010, *Environmentally sustainable diversion limits in the Murray–Darling Basin: socioeconomic analysis*, report to the Murray–Darling Basin Authority, Canberra.

Regional economic impacts will vary according to the size of the reductions in current diversion limits, the types and value of crops under irrigation, the ability to purchase water, the profitability of purchasing and selling water, the resultant net reduction in irrigated agriculture and the related reductions in the business of suppliers and customers. Key to this chain of impacts is the impact on irrigated agriculture in the regions.

Regional estimates of gross value of irrigated agricultural production under 3,000 GL/y, 3,500 GL/y and 4,000 GL/y reduction scenarios, assuming interregional trade in the connected southern Basin Basin have been prepared for the Authority and the Authority notes this work is based on the best modelling available. The Authority is committed to improving these estimates through further investigations to improve the quantification of the economic impact at the regional level. These investigations will be an ongoing aspect of the Authority's work as it develops the proposed and final Basin Plan during 2010 and 2011.

While all irrigated agriculture sectors would experience some reduction in activity, the economic impacts are likely to vary substantially mainly because reductions to current diversion limits vary across regions where certain crops are concentrated.

Broadacre irrigated agriculture is estimated to experience the largest impact whilst most perennial and annual horticultural crops are estimated to have the least impact. Figure 8.8 illustrates these relative declines in activity for the key Basin commodities. Fruits and nuts, grapes and vegetables are estimated to maintain capacities at more than 90% of baseline capacities with little decline over this range of diversion reductions. Declines for these relatively high profit commodities are moderated with irrigators buying in water in order to maintain production. Others sell water when it is more profitable to do so, rather than to produce crops.

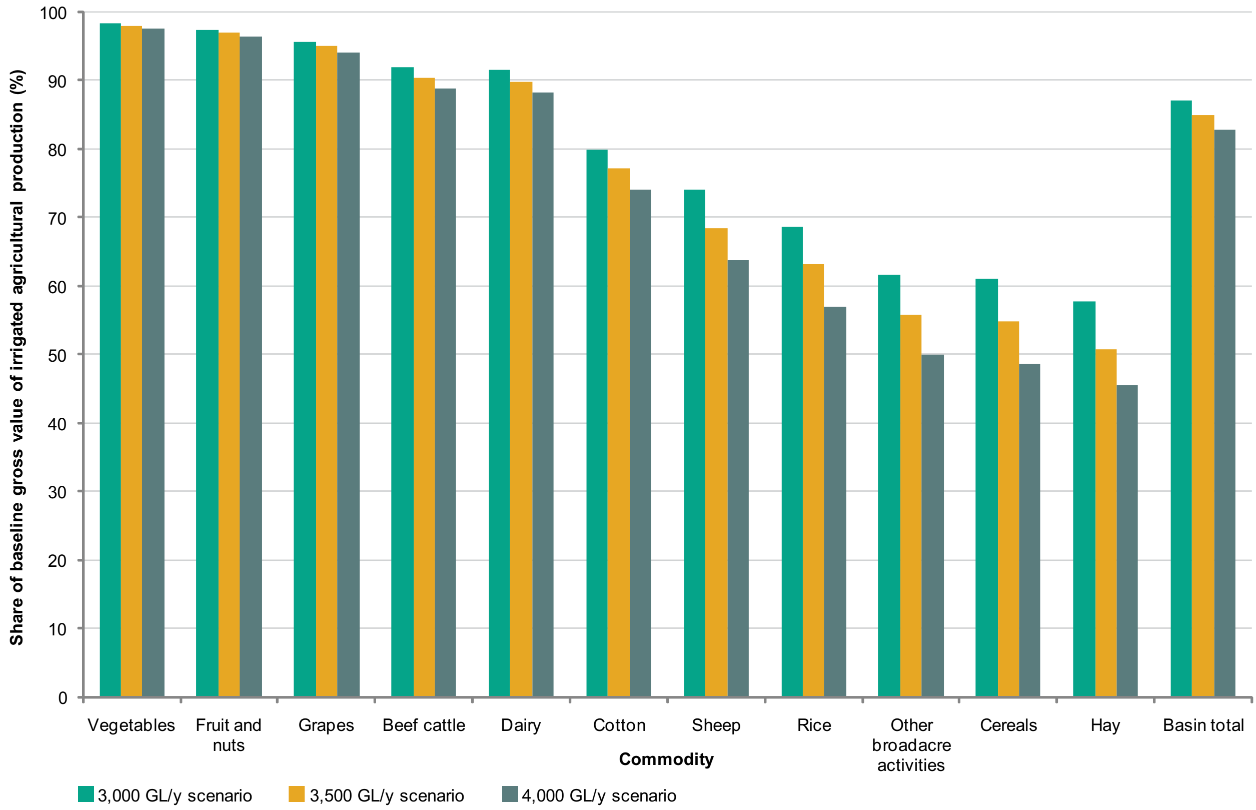


Figure 8.8 Estimated commodity implications: 3,000–4,000 GL/y reductions – share of baseline gross value of irrigated agricultural production (%)

Note: The baseline commodity gross value of irrigated agricultural production uses Australian Bureau of Statistics agricultural census data for the years 2001 and 2006 and 2001 water availability for irrigation. 2001 is taken as a typical or long-term average year for irrigation water availability.

Source: Australian Bureau of Agricultural and Resource Economics – Bureau of Rural Sciences 2010, *Environmentally sustainable diversion limits in the Murray–Darling Basin: socioeconomic analysis*, report to the Murray–Darling Basin Authority, Canberra.

8.14 Implications for the broader economy and communities

Specific irrigated agriculture sectors have substantial supply chains that could be adversely affected by a reduction in output. For example, the rice, cotton, horticulture, dairy and vegetable production industries all have extensive processing and packaging operations. All such operations are dependent on extensive supply chains and, further, support the regional economy and community activity.

The Authority notes that the potential effects described in Table 8.2, which do not assume any water purchases or government assistance, are independent of the current financial stress experienced by Basin businesses.

Table 8.2 Key points raised by stakeholders in relation to potential effects of reduced water availability

Region	Potential effects on suppliers and customers of irrigated agriculture
Gwydir and Moonie	Likely to experience significant reduction in processing activity mainly associated with reduced output from cotton and other broadacre irrigated agriculture.
Condamine–Balonne and Barwon–Darling	Likely to experience moderate losses in processing activity mainly associated with reduced output from cotton and other broadacre irrigated agriculture.
Murrumbidgee and Murray (NSW)	Likely to experience significant impacts on rice processing sector. Over twenty towns within these regions are considered to be highly reliant on irrigation expenditure.
Goulburn–Broken, Murray, Campaspe and Loddon (i.e. the Goulburn–Murray Irrigation District)	Likely to experience significant reductions in mixed farming, some further dairy contraction and a relatively static outlook for horticulture. There are numerous small and medium sized communities in the Goulburn-Murray that are highly reliant on irrigation expenditure. However, impact may be modest compared to dairy restructuring that has occurred in the last decade.
Nyah in Victoria to the SA border (including the NSW and Victorian Sunraysia) and the SA Riverland	Although horticultural food processing and food-based tourism industries have a high sensitivity to water availability, the high production value per megalitre of water means these regions are better placed to purchase water on the market and make up for any shortfalls.
Below Lock 1 on the Murray, such as the Lower Lakes and the Coorong	Important social and economic benefits can be expected from the reductions in consumptive water use that occur across the Basin, including for tourism, boating, recreation and fishing.

Source: Adapted from Marsden Jacob Associates, RMCG, EBC Consultants, DBM Consultants, Australian National University, McLeod, G & Cummins, T 2010, *Synthesis report: economic and social profiles and impact assessments in the Murray–Darling Basin*, a report to the Murray–Darling Basin Authority, Canberra.

Also, the Authority is aware that there are many communities, particularly smaller towns, likely to be disproportionately and negatively affected by the proposal for a reduction in current diversion limits. Work commissioned by the Authority has identified 'at risk' towns and communities from a financial and social wellbeing perspective[1].

The most at risk communities will be those that exhibit certain features including those areas that:

- have exhibited significant economic decline
- have a concentrated dependence on expenditure from irrigated agriculture
- have less economic diversity within the local region
- may be less able to respond and develop new businesses
- have lower levels of social capital to assist in the change process

1 Stenekes, N, Kancans, R, Randall, L, Lesslie, R, Stayner, R, Reeve, I & Coleman, M, 2010, Indicators of community vulnerability and adaptive capacity across the Murray–Darling Basin. Bureau of Rural Sciences and Institute for Rural Futures, UNE, Canberra; Rizza, 2010, Future Financial Investment in the Murray–Darling Basin: The potential effects of changes to water allocation policy on financing the agricultural sector, small business and individuals in the Murray–Darling Basin. Report to the Murray–Darling Basin Authority prepared by Adrian Rizza, Independent Banking Consultant, September 2010.

Social and economic benefits

While there is clear concern for adverse impacts, the Authority recognises that there will also be benefits that will flow through to communities because of improved environmental conditions resulting from the additional water for the environment. Although these benefits are difficult to fully identify, they are expected to increase as environmental conditions improve. Benefits such as better quality drinking water and improved recreational use values associated with activities such as fishing, boating and bird watching will be tangible results.

Further community values are held by Aboriginal peoples of the Basin who have maintained their interests in caring for country as part of their cultural responsibility. Many Aboriginal people have indicated to the Authority their desire for restoration of environmental systems. However, as for all residents of the Basin, there is also concern that reduced watercourse diversions could limit Aboriginal development options, most directly for those who hold formal entitlements to water and/or are employed in irrigated agricultural industries.

Given the difficulties associated with accurate quantification, it is not possible to fully appreciate the size of the benefits that are likely to be generated as more water is provided for the Basin environment. Furthermore, the specific actions of the holders of environmental water will determine the size and distribution of benefits generated. The Authority has commissioned a benefit-cost study to explore these issues further.

Goulburn River between Eildon and Alexandra, Victoria

Financial implications of the Basin Plan

Severe and prolonged drought across the Basin over the past decade has resulted in a sustained period of substantially reduced water available for economic purposes. This has adversely affected the cash flows of farms, households and businesses in the agricultural industry and related sectors.

Consequently, the debt levels for many businesses are high. In addition, the global financial crisis has reduced capital availability and increased its cost. Beyond the immediate challenges facing the agricultural sector some other small and medium enterprises may also be financially vulnerable. Many of these businesses have secured their debt using their family homes, and have experienced falls in house and land prices of up to 20%. This means that many small businesses have reduced equity with which to adapt and respond to changes in the wider regional economy.

The Authority understands that many farmers have sold permanent water rights as a means of reducing their debt exposure. Such responses may satisfy the short term requirements of financial institutions but may restrict agricultural options. This means that some properties and businesses may have a reduced capacity to generate cash flow and may have less capacity to restructure their business activities (such as shift to alternative crops, invest in new capital equipment to improve the efficiency of water usage or purchase new livestock). The Authority is concerned that financial institutions may be reluctant to increase levels of debt to allow farmers to restructure their businesses.

The Authority is also concerned that the Guide could constitute a material adverse event under normal loan agreements and therefore grounds under which financial institutions can act to reduce outstanding loans balances. The Authority is concerned that this could occur well before the final Basin Plan SDLs are determined and before Basin state governments determine changes in individual water entitlements and support is determined and announced. Discussions between the Authority and financial institutions have indicated this is not the preferred course of action.

The financial sector has expressed some confidence that the introduction of the (final) Basin Plan will provide greater certainty concerning water entitlements through the certainty provided from an overarching Basin-wide planning framework. This would enable cash flows to return to more sustainable levels across the Basin and for asset values to improve albeit at potentially a lower level for some farmers.

8.15 Analysis of potential scenarios

Having provided an overview of the implications in relation to environmental outcomes and social and economic impacts, each of the three scenarios identified by the Authority is now examined.

8.16 Scenario 1 — target an additional 3,000 GL/y for the environment

Scenario 1 targets an additional 3,000 GL/y for the environment, which would result in a Basin-wide total of surface-water SDLs of 10,700 GL/y or a 22% reduction from current diversion limits.

Achieving key environmental outcomes

This scenario is at the low end of the range of additional environmental water considered necessary to achieve the Authority's proposed environmental outcomes and objectives.

At the aggregate Basin scale the Authority believes scenario 1 meets the requirements of the objectives and outcomes the Authority has established consistent with the *Water Act 2007* (Cwlth).

Work to date to simulate the future water management arrangements associated with this volume of additional environmental water has identified that some localised environmental trade-offs will be required and these are described further below. The need for these trade-offs in the distribution of environmental water reflects the view of the Authority that this scenario is at the lower end of the additional amount of water that could be provided for the environment and still meet the objectives and outcomes the Authority has established consistent with the Water Act.

Under this scenario it should be possible to achieve most of the environmental water requirement targets established for key environmental assets and key ecosystem functions (see Chapter 6 for further detail). However, modelling and other analysis undertaken to date indicates that it will not be possible to achieve these targets for all key environmental assets and key ecosystem functions, and consequently there will need to be some trade-offs in many regions. This is the main point of differentiation with scenarios 2 and 3 and is the focus of the discussion below.

All three scenarios will require very careful and effective environmental water planning to provide the best environmental outcomes from the available environmental water. The long-term average volume of environmental water can be managed and applied in different ways, in respect to different spatial priorities (e.g. water one asset rather than another asset), and/or different temporal priorities (e.g. reduce the effects of drought rather than enhancing flood events). As the scenario with the lowest volume of environmental water, and with less water than is needed for all high uncertainty targets, scenario 1 will require additional consideration of priorities and potential trade-offs in the planning process.

The exact outcomes of this scenario will only be determined through implementation of the Environmental Watering Plan, and the associated prioritisation process that occurs in response to future climate conditions. However one potential example is described here, with reference to a number of indicator assets, to demonstrate the nature of potential trade-offs that may be required.

Most indicator assets (such as Barmah–Millewa Forest and the Riverland Ramsar site) include flood-dependent wetlands and floodplains. Floods required to water the indicator assets have reduced in frequency, magnitude and duration as a result of diversions and river regulation. Achieving the environmental water requirements of these indicator assets requires the provision of additional environmental water during median to wet years (to water red gums, promote successful waterbird breeding, etc).

On the other hand, the condition of the Coorong, Lower Lakes and Murray Mouth indicator asset is particularly sensitive to drought conditions. Diversions and river regulation has substantially reduced the volume of water that flows to the Coorong, Lower Lakes and Murray Mouth during dry periods (actual flows over the past three years have been reduced by up to 96% compared to estimated flows over the same period without development). Achieving the environmental water requirements of the Coorong, Lower Lakes and Murray Mouth indicator asset therefore requires the provision of additional environmental water during dry years (to avoid excessive salinity in the Coorong, and the associated loss of aquatic plants, animals and waterbirds).

The Authority is of the view that the long-term average volume of available environmental water under scenario 1 will be sufficient to meet the objectives and outcomes the Authority has established consistent with the Water Act. However, it will not be possible to always provide the flows during dry, median and wet years to the extent required to achieve targets for all indicator assets. If floodplain assets are chosen as a priority in this particular example, then insufficient water will be available in the very dry years to meet targets in the Coorong, Lower Lakes and Murray Mouth.

On the other hand, if the Coorong, Lower Lakes and Murray Mouth were chosen as a priority in this particular example, then insufficient water will be available in the median-to-wet years to meet targets at floodplain sites like Barmah–Millewa Forest, and the Riverland Ramsar site. Watering priorities within those sites would need to be determined. One option would be to reduce watering of some black box communities, in favour of wetlands and red gums.

This is just one example of the potential prioritisation and trade-offs that may be necessary. Other options would include some level of trade-off for all key environmental assets and key ecosystem functions, or prioritising the environmental watering of some regions over others.

The outcomes described above are reflected in Figure 8.3, where end-of-system flows improve substantially compared with current arrangements, but in some regions do not achieve a 'moderate' rating.

Scenario 1 would result in an overall Basin-wide reduction of 22% of current diversion limits. Flow through the Murray Mouth would, on average, increase from 5,100 GL/y to 7,100 GL/y — an increase of 2,000 GL/y. This increases average flows through the mouth from 56% to 62% of without-development flows.

Social and economic implications

A broader discussion on social and economic implications is provided earlier in this chapter; however, some key points relevant to this scenario are provided here.

If reductions are implemented by reducing watercourse diversions alone, then there would be a number of long-term average sustainable diversion limit (SDL) areas where watercourse diversions would reduce by the 40% limit identified by the Authority as the maximum acceptable impact from a social and economic perspective. These are the following SDL areas: Warrego, Nebine, Loddon, Broken, Kiewa and Ovens (see Table 8.3).

There are three regions likely to encounter significant reductions in gross value of irrigated agricultural production with the proposed reduction in diversions of 3,000 GL/y.

The regions facing the greatest economic impact under this scenario are:

- in the northern Basin: Moonie and Gwydir
- in the southern Basin: Murrumbidgee.

8.17 Scenario 2 — target an additional 3,500 GL/y for the environment

Scenario 2 targets an additional 3,500 GL/y for the environment, which would result in a Basin-wide total of surface-water SDLs of 10,200 GL/y or a 26% reduction from current diversion limits.

Achieving key environmental outcomes

As with scenario 1, at the Basin scale the Authority believes scenario 2 meets the requirements of the objectives and outcomes the Authority has established consistent with the Water Act. The main difference between scenario 1 and scenario 2 is that scenario 2 will require less localised environmental trade-offs.

Modelling undertaken to date suggests that it will be possible to meet most environmental water requirements targets in most regions, but trade-offs may still be required in some regions. Difficulties are likely to be encountered in achieving the environmental water requirements targets in the Condamine–Balonne and Murray regions. In the Condamine–Balonne region it may not be possible to achieve both the environmental water requirements of the Lower Balonne Floodplain and Narran Lakes at all times, and some trade-offs may be needed. In the Murray region, some trade-offs between floodplain assets and the Coorong, Lower Lakes and Murray Mouth may be required, although they will be less significant than under scenario 1.

The Authority is continuing hydrologic modelling to better quantify the environmental outcomes of each scenario. Alternative means of delivering the environmental water requirements are being considered in that modelling, and the Authority is hopeful that further efficiencies can be achieved that make it possible to achieve all environmental water requirements with scenario 2, but this is yet to be verified. Notwithstanding this, as with scenario 1, very careful and effective environmental water planning will be required to provide the best environmental outcomes from the available environmental water. There will be no contingency to achieve the environmental water requirements targets if environmental watering is inefficient and/or future climate change has severe impacts on flows.

The outcomes described above are reflected in Figure 8.3, where end-of-system flows improve substantially compared to current arrangements, but in some regions do not achieve a 'moderate' rating.

Scenario 2 would result in an overall Basin-wide reduction of 26% of current diversion limits. Flow through the mouth of the Murray would, on average, increase from 5,100 GL/y to 7,400 GL/y — an increase of 2,300 GL/y. This increases average flows through the mouth by 45% on current flows and from 41% to 59% of without-development flows.

Social and economic implications

A broader discussion on social and economic implications is provided earlier in this chapter; however, some key points relevant to this scenario are provided here.

If reductions are implemented by reducing watercourse diversions alone, then there would be a number of SDL areas where watercourse diversions would reduce by the 40% limit identified by the Authority as the maximum acceptable impact from a social and economic perspective. The SDL areas affected are Warrego, Nebine, Moonie, Loddon, Campaspe, Broken, Kiewa, Ovens and the Australian Capital Territory (see Table 8.4).

The regions facing the greatest economic impact under this scenario are:

- in the northern Basin: Moonie, Gwydir and Barwon–Darling
- in the southern Basin: Murrumbidgee and Loddon.

8.18 Scenario 3 — target an additional 4,000 GL/y for the environment

Scenario 3 targets an additional 4,000 GL/y for the environment, which would result in a Basin-wide total of surface-water SDLs of 9,700 GL/y or a 29% reduction from current diversion limits.

Achieving key environmental outcomes

Modelling and other assessments indicate that scenario 3 is likely to achieve all environmental water requirement targets in all regions. In some regions it may be possible to achieve the environmental water requirements with greater reliability.

Very careful and effective environmental water planning would still be required to maximise the environmental outcomes and achieve the targets; however, scenario 3 will provide some flexibility and capacity to respond to future challenges such as climate change.

The outcomes described above are reflected in Figure 8.3, where end-of-system flows improve substantially and nearly all regions achieve a 'moderate' rating.

Scenario 3 would result in an overall Basin-wide reduction of 29% of current diversion limits. The flow through the Murray Mouth would, on average, increase from 5,100 GL/y to 7,700 GL/y — an increase of 2,600 GL/y. This increases average flows through the Murray Mouth from 41 to 62% of without-development flows.

Social and economic implications

A broader discussion on social and economic implications is provided earlier in this chapter; however, some key points relevant to this scenario are provided here.

If reductions are implemented by reducing watercourse diversions only, then there would be a number of SDL areas where watercourse diversions reduce by greater than 40%. This scenario includes a limit of 45% on the reduction if it was implemented entirely by reducing watercourse diversions (it was not possible to achieve the proposed reduction of 4,000 GL/y within a 40% constraint watercourse diversion reduction). The following SDL areas would have watercourse diversion reduction equal to or greater than 40%: Loddon, Campaspe, Broken, Kiewa, Ovens, Murrumbidgee, Australian Capital Territory, Moonie, Warrego and Nebine (see Table 8.5).

The regions facing the greatest economic impact under this scenario are:

- in the northern Basin: Moonie, Gwydir, Barwon–Darling and Macquarie
- in the southern Basin: Murrumbidgee, Murray NSW and Loddon.

8.19 What this would mean at the Basin scale

Figure 8.9 provides a visual comparison of the three long-term average sustainable diversion limit (SDL) scenarios and the current diversion limits. These scenarios would reflect an environmentally sustainable level of take of between 10,700 and 9,700 GL/y (compared with the current diversion limit of 13,700 GL/y).

The range of SDL scenarios would produce an estimated long-term average flow of between 7,100 and 7,700 GL/y through the Murray Mouth. This would mean that the amount of water available for the environment will increase from a long-term average of 19,100 GL/y (58% of inflows) to between 22,100 and 23,100 GL/y (67 to 70% of inflows).

With the range of SDL scenarios, the volumes of water available for consumption are expected (on average at the Basin scale) to be just above the average actual use in the period 2002–03 to 2008–09 as shown in Figure 8.10. This figure shows the watercourse diversions and how these compare with this component of current diversion limits and the range of SDL scenarios. Currently, interception activities are estimated to use around 2,740 GL/y and are not included in Figure 8.10 due to the lack of data availability on an annual timescale.

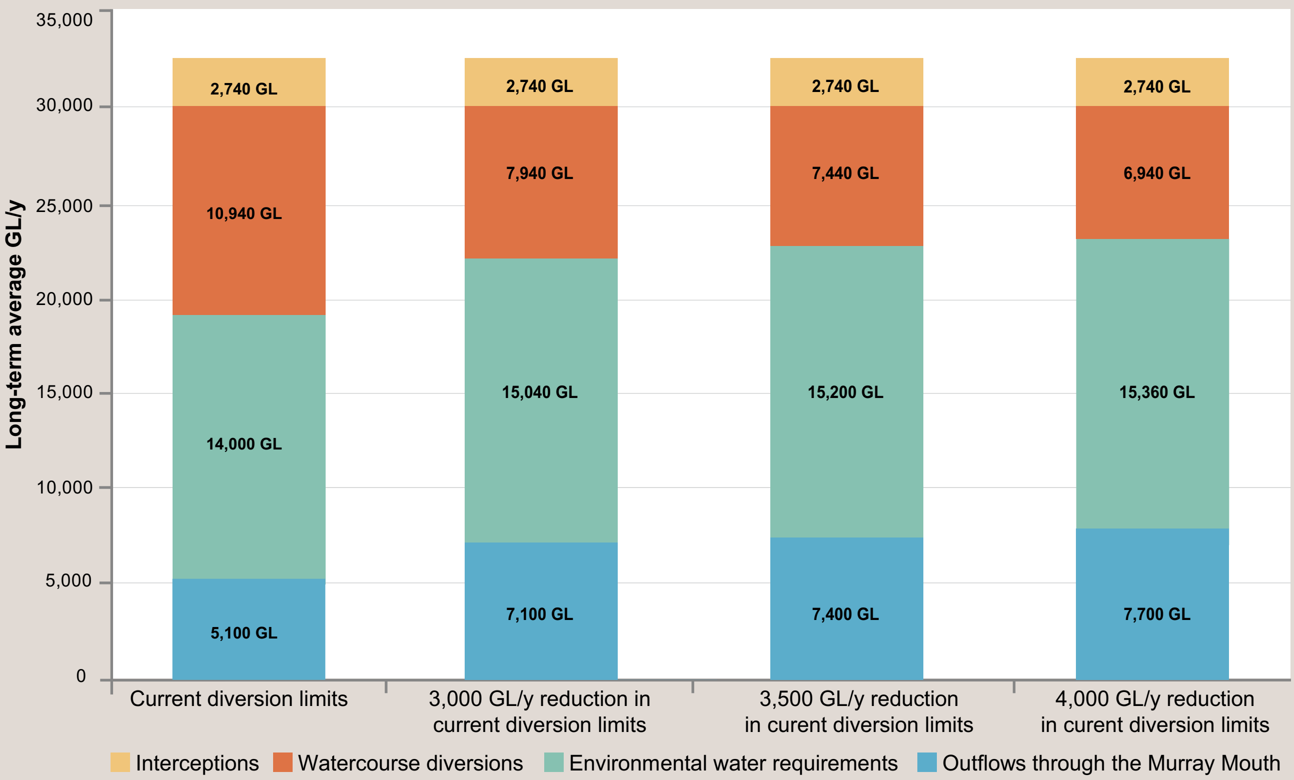


Figure 8.9 Water use in the Basin under three scenarios

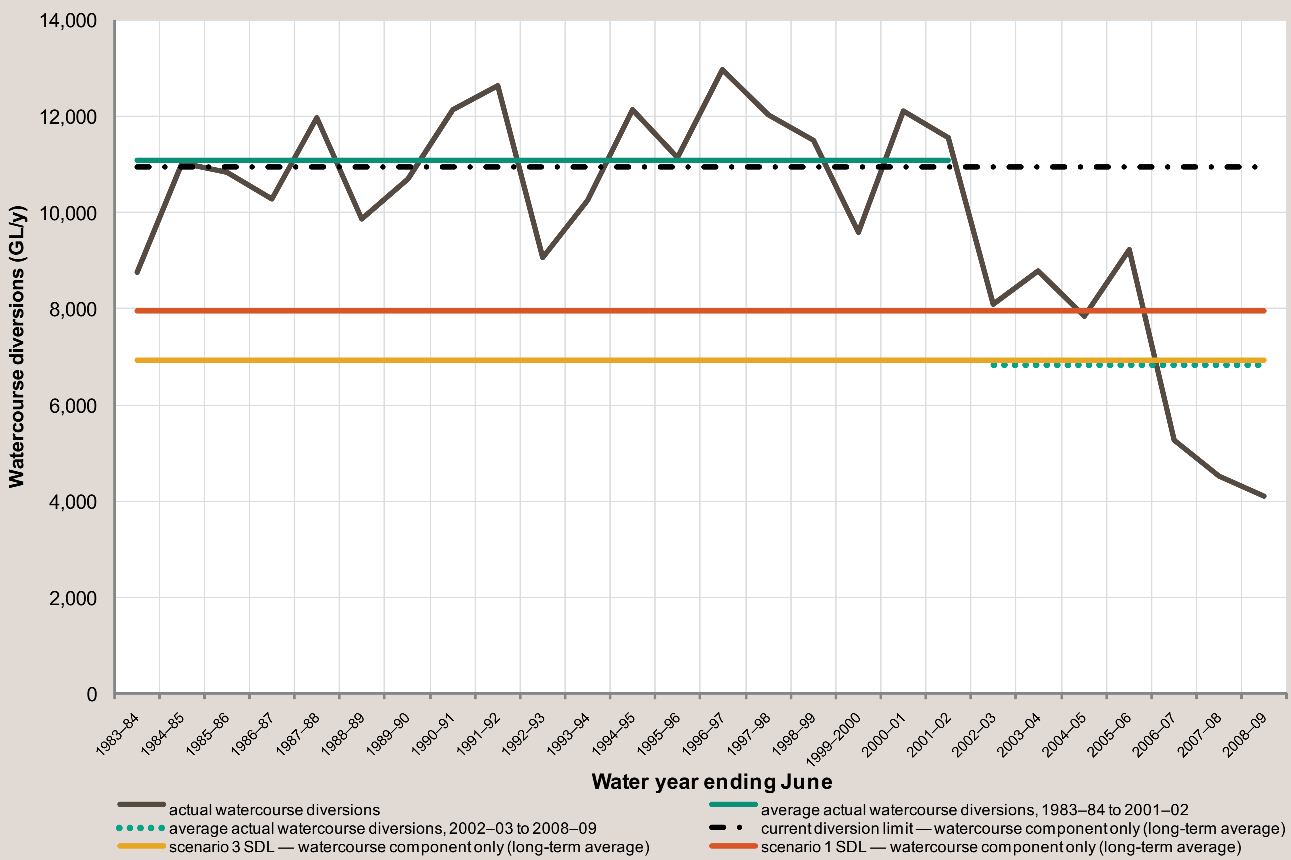


Figure 8.10 Watercourse diversions in the Murray–Darling Basin from 1983–84 to 2008–09

8.20 What this would mean at a catchment scale

Tables 8.3, 8.4 and 8.5 provide summaries of the current diversion limits and proposed long-term average sustainable diversion limits (SDLs) for each of the three scenarios (see also Appendix C). These tables show the break-up of both current diversion limits and scenarios for SDL proposals into the two main components and generally assumes the reduction is only applied to the watercourse diversion component.

The tables present results from the analyses undertaken by the Authority to the nearest gigalitre consistent with the more detailed presentation in Appendix C. The Authority is aware of the limitations in the accuracy of the data but has not rounded the figures at this stage, to allow clear reference to the source analysis.

Under each of the scenarios, each catchment in the Basin will have adequate environmental water for the health of its own key environmental assets and key ecosystem functions, but with different levels of confidence. Further, some of this water will also contribute to the health of downstream assets and functions as it flows through the Basin, ultimately improving the health of the Lower Lakes and Coorong.

SDL proposals shown in Tables 8.3, 8.4 and 8.5 are based on each upstream catchment meeting its own requirements and all connected tributaries providing for the Barwon–Darling or the Murray as relevant. In detail:

Barwon–Darling/northern Basin

The SDL proposals in the northern Basin were based on first satisfying the internal environmental water requirements of individual catchments.

Then, Barwon–Darling environmental water requirements were satisfied by distributing the proposed reductions across the connected tributaries by an equal percentage based on current diversion limits (unless a greater reduction was needed to meet internal catchment needs).

Due to the more ephemeral nature of the rivers in the northern Basin (Darling River system) and the high levels of losses due to floodplain inundation and evaporation, there is limited ability to provide meaningful contributions to the additional environmental water requirements below Wentworth (the location of the junction of the Darling River with the River Murray).

Table 8.3 Overview of SDLs for surface water (scenario 1 — additional 3,000 GL/y for the environment)

			Surface water[e]								
			Current diversion limit components (GL/y)[b]			SDL components (GL/y)[b]			Reductions in current diversion limits		Proposed reduction in water-course diversion[d]
Region	Code[a]	SDL area	Inter-ception[c]	Water-course diversions	Total	Inter-ception[c]	Water-course diversions	Total	GL/y	%	%
Paroo	SS29	Paroo	9.7	0.2	9.9	9.7	0.2	9.9	0	0	0
Warrego	SS28	Warrego	83	45	128	83	27	110	18	14	40
Condamine-Balonne	SS26	Condamine-Balonne	265	706	971	265	503	768	203	21	29
	SS27	Nebine	25	6	31.3	25	3.6	28.9	2.4	8	40
Moonie	SS25	Moonie	51	32	83	51	20	71	12	14	37
Border Rivers	SS24	Queensland Border Rivers	78	223	301	78	180	259	43	14	19
	SS23	NSW Border Rivers	95	210	305	95	167	262	43	14	21
Gwydir	SS22	Gwydir	125	326	451	125	237	361	89	20	27
Namoi	SS21	Namoi	165	343	508	165	271	437	72	14	21
Macquarie-Castlereagh	SS20	Macquarie-Castlereagh	310	425	735	310	321	631	104	14	24
Barwon-Darling	SS19	Barwon-Darling	108	197	305	108	154	262	43	14	22
	SS17	Intersecting Streams	2.4	3	5.4	2.4	2.2	4.6	0.8	14	25
Lower Darling	SS18	Lower Darling	6	55	61	6	39	45	16	26	29
Lachlan	SS16	Lachlan	316	302	618	316	258	574	44	7	15
Wimmera-Avoca	SS09	Wimmera-Mallee (surface water)	62	74	136	62	74	136	0	0	0
Ovens	SS04	Ovens	58	25	83	58	15	73	10	12	40
Goulburn-Broken	SS06	Goulburn	109	1,593	1,702	109	1,151	1,260	442	26	28
	SS05	Broken	43	14	57	43	8	51.4	5.6	10	40
Loddon	SS08	Loddon	90	95	185	90	57	147	38	21	40
Campaspe	SS07	Campaspe	40	115	155	40	75	115	40	26	35
Murrumbidgee	SS15	Murrumbidgee (NSW)	501	2,061	2,562	501	1,396	1,897	665	26	32
	SS01	Australian Capital Territory (surface water)	12	39	51	12	26	38	13	26	34
Murray	SS14	Murray NSW	104	1,721	1,825	104	1,247	1,351	474	26	28
	SS02	Murray VIC	45	1,656	1,701	45	1,214	1,259	442	26	27
	SS03	Kiewa	14	11	24.7	14	7	20.3	4.4	18	40
	SS11	Murray SA	0	665	665	0	492	492	173	26	26
	SS10	SA Non Prescribed Areas	3.5	0	3.5	3.5	0	3.5	0	0	-
Eastern Mount Lofty Ranges	SS13	Eastern Mount Lofty Ranges	10.7	included in interception	10.7	7.9	included in interception	7.9	2.8	26	-
	SS12	Marne Saunders	1.8	included in interception	1.8	1.8	included in interception	1.8	0	0	-
		New South Wales	1,732	5,643	7,375	1,732	4,092	5,824	1,551	21	27
		Victoria	462	3,583	4,045	462	2,601	3,063	982	24	27
		South Australia	16	665	681	13	492	506	175	26	26
		Queensland	513	1,012	1,525	513	734	1,247	278	18	27
		Australian Capital Territory	12	39	51	12	26	38	13	26	34
		Total Basin	**2,735**	**10,942**	**13,677**	**2,732**	**7,945**	**10,677**	**3,000**	**22**	**27**

a This code relates to each SDL area in Figure 8.2

b SDL represents long-term average sustainable diversion limits

c Interception includes impact of farm dams and forestry plantations

d Percentage reduction if only applied to watercourse diversion component

e The Authority is aware of the limitations in the accuracy of the data in this table but has not rounded at this stage to allow clear reference to the source analysis

Table 8.4 Overview of SDLs for surface water (scenario 2 — additional 3,500 GL/y for the environment)

			Surface water[e]								
			Current diversion limit components (GL/y)[b]			SDL components (GL/y)[b]			Reductions in current diversion limits		Proposed reduction in water-course diversion[d]
Region	Code[a]	SDL area	Inter-ception[c]	Water-course diversions	Total	Inter-ception[c]	Water-course diversions	Total	GL/y	%	%
Paroo	SS29	Paroo	9.7	0.2	9.9	9.7	0.2	9.9	0	0	0
Warrego	SS28	Warrego	83	45	128	83	27	110	18	14	40
Condamine-Balonne	SS26	Condamine–Balonne	265	706	971	265	468	734	238	24	34
	SS27	Nebine	25	6.0	31.3	25	3.6	28.9	2.4	8	40
Moonie	SS25	Moonie	51	32	83	51	19	70	12.8	15	40
Border Rivers	SS24	Queensland Border Rivers	78	223	301	78	174	252	49	16	22
	SS23	NSW Border Rivers	95	210	305	95	160	255	50	16	24
Gwydir	SS22	Gwydir	125	326	451	125	221	346	105	23	32
Namoi	SS21	Namoi	165	343	508	165	260	426	83	16	24
Macquarie–Castlereagh	SS20	Macquarie–Castlereagh	310	425	735	310	305	615	120	16	28
Barwon–Darling	SS19	Barwon–Darling	108	197	305	108	147	256	50	16	25
	SS17	Intersecting Streams	2.4	3.0	5.4	2.4	2.1	4.5	0.9	16	29
Lower Darling	SS18	Lower Darling	6	55	61	6	37	42	18	30	33
Lachlan	SS16	Lachlan	316	302	618	316	245	561	57	9	19
Wimmera–Avoca (surface water)	SS09	Wimmera–Mallee	62	74	136	62	74	136	0	0	0
Ovens	SS04	Ovens	58	25	83	58	15	73	10	12	40
Goulburn–Broken	SS06	Goulburn	109	1,593	1,702	109	1,075	1,184	518	30	33
	SS05	Broken	43	14	57	43	8	51	5.6	10	40
Loddon	SS08	Loddon	90	95	185	90	57	147	38	21	40
Campaspe	SS07	Campaspe	40	115	155	40	69	109	46	30	40
Murrumbidgee	SS15	Murrumbidgee (NSW)	501	2,061	2,562	501	1,281	1,782	780	30	38
	SS01	Australian Capital Territory (surface water)	12	39	51	12	23	36	16	30	40
Murray	SS14	Murray NSW	104	1,721	1,825	104	1,165	1,269	556	30	32
	SS02	Murray VIC	45	1,656	1,701	45	1,138	1,183	518	30	31
	SS03	Kiewa	14	11	25	14	6.6	20	4.4	18	40
	SS11	Murray SA	0	665	665	0	462	462	203	30	30
	SS10	SA Non Prescribed Areas	3.5	0	3.5	3.5	0	3.5	0	0	–
Eastern Mount Lofty Ranges	SS13	Eastern Mount Lofty Ranges	11	included in interception	11	7.4	included in interception	7.4	3.3	30	–
	SS12	Marne Saunders	1.8	included in interception	1.8	1.8	included in interception	1.8	0	0	–
		New South Wales	1,732	5,643	7,375	1,732	3,824	5,557	1,819	25	32
		Victoria	462	3,583	4,045	462	2,443	2,904	1,140	28	32
		South Australia	16	665	681	13	462	475	206	30	31
		Queensland	513	1,012	1,525	513	692	1205	320	21	32
		Australian Capital Territory	12	39	51	12	23	36	16	30	40
		Basin total	**2,735**	**10,942**	**13,677**	**2,731**	**7,445**	**10,177**	**3,500**	**26**	**32**

a This code relates to each SDL area in Figure 8.2

b SDL represents long-term average sustainable diversion limits

c Interception includes impact of farm dams and forestry plantations

d Percentage reduction if only applied to watercourse diversion component

e The Authority is aware of the limitations in the accuracy of the data in this table but has not rounded at this stage to allow clear reference to the source analysis

Table 8.5 Overview of SDLs for surface water (scenario 3 — additional 4,000 GL/y for the environment)

Region	Code[a]	SDL area	Surface water[e]								
			Current diversion limit components (GL/y)[b]			SDL components (GL/y)[b]			Reductions in current diversion limits		Proposed reduction in water-course diversion[d]
			Inter-ception[c]	Water-course diversions	Total	Inter-ception[c]	Water-course diversions	Total	GL/y	%	%
Paroo	SS29	Paroo	9.7	0.2	9.9	9.7	0.2	9.9	0	0	0
Warrego	SS28	Warrego	83	45	128	83	25	108	20	16	45
Condamine-Balonne	SS26	Condamine-Balonne	265	706	971	265	434	699	272	28	39
	SS27	Nebine	25	6	31.3	25	3.3	28.6	2.7	9	45
Moonie	SS25	Moonie	51	32	83	51	18	69	14	17	45
Border Rivers	SS24	Queensland Border Rivers	78	223	301	78	168	246	55	18	25
	SS23	NSW Border Rivers	95	210	305	95	154	249	56	18	27
Gwydir	SS22	Gwydir	125	326	451	125	205	330	121	27	37
Namoi	SS21	Namoi	165	343	508	165	249	415	94	18	27
Macquarie-Castlereagh	SS20	Macquarie-Castlereagh	310	425	735	310	290	600	135	18	32
Barwon-Darling	SS19	Barwon-Darling	108	197	305	108	141	249	56	18	29
	SS17	Intersecting Streams	2.4	3	5.4	2.4	2	4.4	1	18	33
Lower Darling	SS18	Lower Darling	6	55	61	6	34	39	21	35	38
Lachlan	SS16	Lachlan	316	302	618	316	233	549	69	11	23
Wimmera-Avoca	SS09	Wimmera-Mallee (surface water)	62	74	136	62	74	136	0	0	0
Ovens	SS04	Ovens	58	25	83	58	14	72	11	13	45
Goulburn-Broken	SS06	Goulburn	109	1,593	1,702	109	1,000	1,109	593	35	37
	SS05	Broken	43	14	57	43	8	50.7	6.3	11	45
Loddon	SS08	Loddon	90	95	185	90	52	142	43	23	45
Campaspe	SS07	Campaspe	40	115	155	40	63	103	52	33	45
Murrumbidgee	SS15	Murrumbidgee (NSW)	501	2,061	2,562	501	1,169	1,670	892	35	43
	SS01	Australian Capital Territory (surface water)	12	39	51	12	21	34	18	34	45
Murray	SS14	Murray NSW	104	1,721	1,825	104	1,086	1,190	635	35	37
	SS02	Murray VIC	45	1,656	1,701	45	1,064	1,109	592	35	36
	SS03	Kiewa	14	11	24.7	14	6.1	19.8	4.9	20	45
	SS11	Murray SA	0	665	665	0	433	433	232	35	35
	SS10	SA Non Prescribed Areas	3.5	0	3.5	3.5	0	3.5	0	0	-
Eastern Mount Lofty Ranges	SS13	Eastern Mount Lofty Ranges	10.7	included in interception	10.7	7	included in interception	7	3.7	35	-
	SS12	Marne Saunders	1.8	included in interception	1.8	1.8	included in interception	1.8	0	0	-
		New South Wales	1,732	5,643	7,375	1,732	3,562	5,295	2,081	28	37
		Victoria	462	3,583	4,045	462	2,281	2,743	1,302	32	36
		South Australia	16	665	681	12	433	446	235	35	35
		Queensland	513	1,012	1,525	513	647	1,160	365	24	36
		Australian Capital Territory	12	39	51	12	21	34	18	34	45
		Total Basin	2,735	10,942	13,677	2,731	6,946	9,677	4,000	29	37

a This code relates to each SDL area in Figure 8.2

b SDL represents long-term average sustainable diversion limits

c Interception includes impact of farm dams and forestry plantations

d Percentage reduction if only applied to watercourse diversion component

e The Authority is aware of the limitations in the accuracy of the data in this table but has not rounded at this stage to allow clear reference to the source analysis

Murray/southern Basin

The SDL proposals in the southern Basin were based on first satisfying the internal environmental water requirements of individual catchments.

For the Murray, similarly to the approach taken in the northern Basin for the Barwon–Darling, in that all connected tributaries in the southern system were reduced by an equal percentage based on current diversion limits, unless a greater reduction was needed to meet internal catchment needs. The Darling catchment above the Menindee Lakes was not included in the southern system, though additional water that would flow to the Murray as a result of reductions in the Darling catchment was accounted for in this analysis.

As might be expected, the most substantial volumetric increases in water for the environment come from the large rivers contributing large flows to the system, and in particular those that are subject to higher levels of current diversion. In the northern Basin, the Condamine–Balonne, the Border Rivers, the Gwydir and the Macquarie–Castlereagh will contribute around 80% of the total additional environmental water in the northern Basin. In the southern Basin, the Goulburn, Murrumbidgee, and Murray will contribute over 90% of the total additional environmental water.

However, while these large-volume, more heavily developed rivers would contribute most of the additional environmental water, the analysis found that much of it is required for the internal key environmental assets and key ecosystem functions of the river valleys themselves. These rivers, which contribute a larger volume of environmental water, are generally meeting their internal environmental needs rather than contributing to a downstream region.

Those rivers that contribute water to meet downstream requirements would themselves experience benefits to local key environmental assets and ecosystem functions as the water flows through.

Further details are provided in Appendix C to inform discussion and consultation showing the impact of the SDL proposals on flows and water used by the environment throughout the Basin.

9. Setting long-term average sustainable diversion limits for groundwater

Key points

- There are 78 groundwater long-term average sustainable diversion limit (SDL) areas in the Basin, reflecting the diverse range and management requirements of the groundwater systems throughout the Basin.
- The groundwater SDL proposals have been determined by first considering the contribution of each groundwater system to maintaining environmental water requirements at local and regional scales, then determining the level of take that can be sustained.
- Of the 78 groundwater SDL areas identified in the Basin, 67 are proposed to be set at current diversion limits.
- The Authority proposes that at the Basin scale, the requirements of the *Water Act 2007* (Cwlth) will be achieved with aggregate reductions in current groundwater diversion limits of 186 gigalitres per year (GL/y), comprised of:
  - an aggregate of 126 GL/y from seven groundwater systems requiring a reduction in current diversion limits and use: the SDL areas of the Upper Condamine Alluvium, Upper Condamine Basalts, Angas Bremer, Lower Lachlan Alluvium, Upper Lachlan Alluvium, Lake George Alluvium and Lower Namoi Alluvium. These reductions, based on the long-term average, range from 13% to 40%
  - an aggregate of 60 GL/y from four groundwater systems requiring a reduction in current diversion limits but not current use: the SDL areas of the Lower Macquarie Alluvium, Upper Namoi Alluvium and Peel Valley Alluvium and the Australian Capital Territory.
- Not all groundwater systems are overdeveloped. Some contain 'unassigned' water and have the potential for further sustainable groundwater extraction, although much of this water is either of low quality, or is difficult to extract economically.
- Limited amounts of fossil water occur in some aquifers in the Basin, such as in the Mallee of South Australia and western Victoria. These are groundwater systems where recharge rates are so low as to be effectively zero, and the concept of sustainability requires consideration of the availability of the water resource for future generations. For these SDL areas, the rate of decline contained in existing state agreements has been assessed as sustainable.
- Assessment of potential groundwater recharge response to a range of modelled climate scenarios to 2030 indicates that there is no need to specifically adjust groundwater SDLs to account for climate-change effects. This will be monitored and adjusted if necessary in the future.

Flooding flag indicates the water table level, 2005, near Lyrup, South Australia

9.1 Requirements of the Water Act

The *Water Act 2007* (Cwlth) requirements are outlined in Chapter 8 (8.2). The process for setting long-term average sustainable diversion limit (SDL) proposals, which is broadly the same for surface water and groundwater, is also described in Chapter 8 (8.3).

Chapter 8 (8.8) includes the parameters for setting SDLs.

9.2 Key issues the Authority is required to consider

Chapter 8 (8.5) broadly describes the key issues the Authority is required to consider.

The conceptual approach for groundwater reflects the physical features of groundwater systems. Water recharges to groundwater systems in a number of ways, including from rainfall, irrigation leakage and from flowing streams. Water also discharges from groundwater systems to the surface, including through springs, and there are often significant ecosystems that rely on such groundwater discharge for their health (i.e. groundwater-dependent ecosystems).

Bore water used for cattle on Old Dromana Station near Moree, New South Wales

There are also significant quantities of water in storage in groundwater systems; changes to this storage, over time, reflect relative recharge versus discharge from those systems and also the water that is extracted for use from those systems. In determining groundwater SDLs, the volume of recharge provides an 'envelope' within which sustainable levels of take can be developed. Accordingly, significant effort has gone into estimating the volume of recharge for each groundwater system in the Basin as a starting point for analysing SDL scenarios.

9.3 Groundwater SDLs for the Basin

Groundwater SDLs are determined on the basis of meeting environmental water requirements, as described in Chapter 6. The estimated additional groundwater for the environment requires an aggregate reduction in current diversion limits of between 99 GL and 227 GL. This range reflects the uncertainty of groundwater model predictions and the risks associated with not achieving the environmental objectives of the Basin Plan. In summary:

- no changes are proposed to the current diversion limits for 67 groundwater systems
- reductions in current diversion limits, but not in use, are proposed for the following four groundwater systems: Upper Namoi Alluvium, Lower Macquarie Alluvium, Peel Valley Alluvium and the Australian Capital Territory

- reductions in current diversion limits and use are proposed for the following seven groundwater systems: Lower Lachlan Alluvium, Lower Namoi Alluvium, Angas Bremer, Upper Condamine Alluvium, Upper Condamine Basalts, Upper Lachlan Alluvium and Lake George Alluvium.

There are a number of groundwater systems that are highly connected to surface water and that are considered to be fully developed. Groundwater SDL proposals for these systems have been 'capped' at current use, and induced recharge from surface-water streams has been included in the surface-water baseline.

Some groundwater systems are highly connected to surface-water systems, but may be capable of sustaining further take. In these SDL areas, further take could be feasible provided that there is a corresponding reduction in surface-water take to offset the resultant impact on streamflow. Tagged trade has been identified as a means to offset streamflow impacts in these systems (this is referred to as 'trade offset').

Table 9.1 outlines the current diversion limits, current use, the SDL proposals and reductions in current diversions and use for the 78 groundwater SDL areas. The current diversion limits are defined as:

- the current plan limit where a plan exists or
- use if there is no plan.

The groundwater SDL areas can be placed in seven broad groupings, reflecting the variety of changes to current diversion limits across the Basin.

1. Seven SDL areas where the SDL proposal is a reduction in current diversion limits and use:
   - The SDL proposal for three SDL areas with interim or transitional plans is a reduction in current diversion limit and use to achieve an environmentally sustainable level of take. These are the Lower Lachlan Alluvium and the Lower Namoi Alluvium in New South Wales, and the Angas Bremer in South Australia.
   - The SDL proposal for four SDL areas that do not have interim or transitional plans is a reduction in use. These are the Upper Condamine Alluvium and the Upper Condamine Basalts in Queensland, and the Upper Lachlan Alluvium and Lake George Alluvium in New South Wales.
   - In aggregate, these seven SDL areas require additional water for the environment for groundwater take to be sustainable. In limiting the reduction in any one area to a maximum of 40% of the current diversion limit, an aggregate reduction of 126 GL/y is proposed for these aquifers. The reduction in take varies between 13% and 40% for the seven SDL areas.
2. Four SDL areas where the SDL proposals represent a reduction in current diversion limits, but not in use:
   - In these areas, the plan limit was considered to exceed the environmentally sustainable level of take. However, it was determined that recent historical use was able to meet an environmentally sustainable level of take, provided that additional surface water losses are accounted for. These SDL areas are the Lower Macquarie Alluvium, Upper Namoi Alluvium and Peel Valley Alluvium in New South Wales and the Australian Capital Territory. The aggregate reduction in plan limit proposed for these four SDL areas is 60 GL/y.

3. The SDL proposals for seven SDL areas where environmental water requirements can be met by setting the SDL at the existing plan limit:
   – Existing water-plan limits in seven SDL areas provide sufficient water to meet the environmental water requirements and therefore are considered an environmentally sustainable level of take. These are the Lower Gwydir Alluvium, Lower Murray Alluvium (deep aquifer), and Lower Murrumbidgee Alluvium in New South Wales; and the Marne Saunders, Peake–Roby–Sherlock, Mallee, and Mallee Border Zone in South Australia.
4. The SDL proposal for 18 SDL areas where the environmental water requirements are consistent with limiting the SDL to current use:
   – These areas are considered to be highly connected to surface water. While the impact of current groundwater take on streamflow has been accounted for in the determination of the surface-water SDL proposals, further groundwater take would further reduce surface-water streamflow. It is proposed that the groundwater SDLs for all of these areas are capped at current levels of use, with no reduction.
5. The SDL proposals for 16 SDL areas where the environmental water requirements are consistent with limiting SDLs to current use with a trade offset:
   – These areas are also highly connected to surface water. However, it is recognised that further development of groundwater resources is possible, provided the Basin states undertake an assessment to identify the maximum sustainable volume that could be taken from groundwater systems and provided that impacts on surface water flows are accounted for. One mechanism to achieve this is by tagged trade from surface water to groundwater. Water resource plans will be required to implement management rules that reflect the connected nature (such as by creating appropriate linkages between groundwater management rules and those for surface water).
6. The SDL proposals for 26 groundwater SDL areas where the environmental water requirements allow the SDLs to be set higher than current use, but water quality and accessibility may restrict use:
   – None of these areas has an existing plan and, further, they may be capable of sustaining an increase in groundwater use. Some 'unassigned water' has been identified in these groundwater systems. Development of these additional resources is subject to appropriate monitoring and reporting arrangements. Although much of this groundwater is saline and/or inaccessible for agricultural consumptive use, it may be suitable for industrial uses including mining.
7. Areas of fossil groundwater:
   – There are some areas of fossil groundwater in the Basin, such as in the Mallee in South Australia (for which there are interim and transitional plans) and in western Victoria (for parts of which some state plans exist that have not yet been recognised as transitional plans). In these areas the current diversion limits have been assessed as sustainable in the context of the timeframe involved (15% depletion in 200 years) and SDL proposals have been set to reflect the rate of decline contained in existing state agreements. This rate of decline has also been adopted as the basis of the environmental water requirements for fossil groundwater resources in these aquifers in adjoining SDL areas.

Bore on the Myroolia property near Bourke, New South Wales

Figure 9.1 identifies the SDL areas.

Table 9.1 Overview of long-term average sustainable diversion limit proposals for groundwater

Main region	Code[a]	SDL area	Groundwater						
			Current diversion limit [b] (GL/y)	Current use [c] (GL/y)	SDL [d] (GL/y)	Reduction in current diversion limit		Reduction from current use (GL/y)	
						GL/y	%	GL/y	%
Reduction in current diversion limit and use required (7 SDL areas)									
Lachlan	GS39	Lower Lachlan Alluvium	108	117.9	64.8	43.2	40	**53.1**	**45**
Namoi	GS43	Lower Namoi Alluvium	86	99.4	75	11	13	**24.4**	**25**
Eastern Mount Lofty Ranges	GS1	Angas Bremer	6.5	6.7	4	2.5	38	**2.7**	**40**
Condamine–Balonne	GS76	Upper Condamine Alluvium	117.1	117.1	76.8	40.3	34	**40.3**	**34**
Condamine–Balonne	GS77	Upper Condamine Basalts	76.1	76.1	61.1	15	20	**15**	**20**
Lachlan	GS57	Upper Lachlan Alluvium	77.1	77.1	63	14.1	18	**14.1**	**18**
Murrumbidgee	GS35	Lake George Alluvium	1.1	1.1	0.75	0.35	32	**0.35**	**32**
Reductions in current diversion limit but not in use (4 SDL areas)									
Namoi	GS60	Upper Namoi Alluvium	122.1	95	95	27.1	22	–	–
Macquarie–Castlereagh	GS40	Lower Macquarie Alluvium	69.3	41.9	41.9	27.4	40	–	–
Namoi	GS54	Peel Valley Alluvium	9.3	7.3	7.3	2	22	–	–
Murrumbidgee	GS65	Australian Capital Territory (Groundwater)	7.25	0.5	4.4	2.85	39	–	–
Cap at current diversion limit (7 SDL areas)									
Murrumbidgee	GS42	Lower Murrumbidgee Alluvium	280	303.7	280	–	–	**23.7**	**8**
Murray	GS41	Lower Murray Alluvium (deep; Renmark Group and Calivil Formation)	83.7	86.3	83.7	–	–	–	–
		Lower Murray Alluvium (shallow; Shepparton Formation)	40	40	40	–	–	–	–
Murray	GS3	Mallee	41.2	24.4	41.2	–	–	–	–
Gwydir	GS38	Lower Gwydir Alluvium	32.3	32.3	32.3	–	–	–	–
Murray	GS4	Mallee Border Zone	22.2	16.4	22.2	–	–	–	–
Murray	GS6	Peake–Roby–Sherlock	5.2	1.7	5.2	–	–	–	–
Eastern Mount Lofty Ranges	GS5	Marne Saunders	4.7	2.5	4.7	–	–	–	–
Cap at current use (18 SDL areas)									
Murrumbidgee	GS45	Mid–Murrumbidgee Alluvium	44	44	44	–	–	–	–
Ovens	GS13	Ovens–Kiewa Sedimentary Plain	14.7	14.7	14.7	–	–	–	–
Macquarie–Castlereagh	GS58	Upper Macquarie Alluvium	13.7	13.7	13.7	–	–	–	–
Border Rivers	GS67	Queensland Border Rivers Alluvium	13.4	13.4	13.4	–	–	–	–
Murray	GS59	Upper Murray Alluvium	11	11	11	–	–	–	–
Namoi	GS27	Eastern Porous Rock: Namoi–Gwydir	10.3	10.3	10.3	–	–	–	–
Loddon	GS10	Loddon–Campaspe Highlands	9.4	9.4	9.4	–	–	–	–
Border Rivers	GS47	NSW Border Rivers Alluvium	6.6	6.6	6.6	–	–	–	–
Lachlan	GS64	Young Granite	4.3	4.3	4.3	–	–	–	–
Macquarie–Castlereagh	GS24	Collaburragundry–Talbragar Alluvium	3.7	3.7	3.7	–	–	–	–
Macquarie–Castlereagh	GS20	Bell Valley Alluvium	2.2	2.2	2.2	–	–	–	–
Namoi	GS61	Upper Namoi Tributary Alluvium	2	2	2	–	–	–	–
Lachlan	GS21	Belubula Alluvium	1.9	1.9	1.9	–	–	–	–

a A code has been assigned to each groundwater SDL area; these are shown on the map in Figure 9.1

b Current diversion limit is based on plan limit or current use if there is no plan

c Current use is based on the 2007–08 level of use in most instances; however, where the 2003–04 to 2007–08 data was available, the average of these values were used

d Groundwater SDL figures exclude unassigned groundwater

e Totals are provided to allow assessment at the state and whole-of-Basin levels but this does not suggest that discrete SDL areas can be aggregated

Table 9.1 Overview of long-term average sustainable diversion limit proposals for groundwater

Main region	Code[a]	SDL area	Groundwater						
			Current diversion limit[b] (GL/y)	Current use[c] (GL/y)	SDL[d] (GL/y)	Reduction in current diversion limit		Reduction from current use (GL/y)	
						GL/y	%	GL/y	%
Namoi	GS44	Manilla Alluvium	1.9	1.9	1.9	–	–	–	–
Macquarie–Castlereagh	GS25	Cudgegong Alluvium	1.6	1.6	1.6	–	–	–	–
Gwydir	GS56	Upper Gwydir Alluvium	0.8	0.8	0.8	–	–	–	–
Border Rivers	GS48	NSW Border Rivers Tributary Alluvium	0.5	0.5	0.5	–	–	–	–
Macquarie–Castlereagh	GS23	Castlereagh Alluvium	0.4	0.4	0.4	–	–	–	–
Cap at current use with trade offset (16 SDL areas)									
Macquarie–Castlereagh	GS31	Lachlan Fold Belt: Macquarie–Castlereagh	47.7	47.7	47.7	–	–	–	–
Murrumbidgee	GS33	Lachlan Fold Belt: Murrumbidgee	30.9	30.9	30.9	–	–	–	–
Lachlan	GS30	Lachlan Fold Belt: Lachlan	23.1	23.1	23.1	–	–	–	–
Namoi	GS52	New England Fold Belt: Namoi	15.6	15.6	15.6	–	–	–	–
Goulburn–Broken	GS9	Goulburn–Broken Highlands	9.8	9.8	9.8	–	–	–	–
Border Rivers	GS68	Queensland Border Rivers Fractured Rock	6.8	6.8	6.8	–	–	–	–
Macquarie–Castlereagh	GS26	Eastern Porous Rock: Macquarie–Castlereagh	5.2	5.2	5.2	–	–	–	–
Murray	GS32	Lachlan Fold Belt: Murray	5.1	5.1	5.1	–	–	–	–
Murray	GS11	Murray Highlands	4.4	4.4	4.4	–	–	–	–
Gwydir	GS51	New England Fold Belt: Gwydir	4.1	4.1	4.1	–	–	–	–
Border Rivers	GS50	New England Fold Belt: Border Rivers	3.4	3.4	3.4	–	–	–	–
Ovens	GS12	Ovens Highlands	3.2	3.2	3.2	–	–	–	–
Border Rivers	GS28	Inverell Basalt	2.9	2.9	2.9	–	–	–	–
Namoi	GS36	Liverpool Ranges Basalt	2.7	2.7	2.7	–	–	–	–
Condamine–Balonne	GS66	Condamine Fractured Rock	2.1	2.1	2.1	–	–	–	–
Wimmera–Avoca	GS16	Wimmera–Avoca Highlands	0.2	0.2	0.2	–	–	–	–
Unassigned Water (26 SDL areas)[d]									
Goulburn–Broken	GS14	Victorian Riverine Sedimentary Plain (deep; Renmark Group and Calivil Formation)	89.6	89.6	89.6	–	–	–	–
		Victorian Riverine Sedimentary Plain (shallow; Shepparton Formation)	83.3	83.3	83.3	–	–	–	–
Lower Darling	GS63	Western Porous Rock	29.3	29.3	29.3	–	–	–	–
Eastern Mount Lofty Ranges	GS2	Eastern Mount Lofty Ranges	19.3	19.3	19.3	–	–	–	–
Murray	GS8	SA Murray Salt Interception Schemes	11.1	11.1	11.1	–	–	–	–
Condamine–Balonne	GS73	St George Alluvium: Condamine–Balonne (deep)	7.5	7.5	7.5	–	–	–	–
Condamine–Balonne		St George Alluvium: Condamine–Balonne (shallow)	2.5	2.5	2.5	–	–		–
Murray	GS17	Wimmera–Mallee Border Zone (Loxton Parilla Sands)	0	0	0	–	–	–	–
		Wimmera–Mallee Border Zone (Murray Group Limestone)	8.8	8.8	8.8	–	–	–	–
		Wimmera–Mallee Border Zone (Tertiary Confined Sand Aquifer)				–	–	–	

a A code has been assigned to each groundwater SDL area; these are shown on the map in Figure 9.1

b Current diversion limit is based on plan limit or current use if there is no plan

c Current use is based on the 2007–08 level of use in most instances; however, where the 2003–04 to 2007–08 data was available, the average of these values were used

d Groundwater SDL figures exclude unassigned groundwater

e Totals are provided to allow assessment at the state and whole-of-Basin levels but this does not suggest that discrete SDL areas can be aggregated

Table 9.1 Overview of long-term average sustainable diversion limit proposals for groundwater

			Groundwater						
			Current diversion limit [b] (GL/y)	Current use [c] (GL/y)	SDL [d] (GL/y)	Reduction in current diversion limit		Reduction from current use (GL/y)	
Main region	Code[a]	SDL area				GL/y	%	GL/y	%
Lower Darling	GS29	Kanmantoo Fold Belt	8.2	8.2	8.2	–	–	–	–
Lachlan	GS53	Orange Basalt	6.9	6.9	6.9	–	–	–	–
Wimmera–Avoca	GS15	West Wimmera (Loxton Parilla Sands)	0	0	0	–	–	–	–
		West Wimmera (Murray Group Limestone)	1.9	1.9	1.9	–	–	–	–
		West Wimmera (Tertiary Confined Sand Aquifer)	0.8	0.8	0.8	–	–	–	–
Paroo	GS55	Upper Darling Alluvium	2.4	2.4	2.4	–	–	–	–
Murrumbidgee	GS22	Billabong Creek Alluvium	2	2	2	–	–	–	–
Murray	GS7	SA Murray (Groundwater)	1.8	1.8	1.8	–	–	–	–
Lower Darling	GS19	Adelaide Fold Belt	3	3	3	–	–	–	–
Lower Darling	GS37	Lower Darling Alluvium	1.4	1.4	1.4	–	–	–	–
Macquarie–Castlereagh	GS46	NSW Alluvium above the Great Artesian Basin	1.2	1.2	1.2	–	–	–	–
Barwon–Darling	GS34	Lachlan Fold Belt: Western	1.2	1.2	1.2	–	–	–	–
Warrego	GS72	Sediments above the Great Artesian Basin: Warrego–Paroo–Nebine	1.1	1.1	1.1	–	–	–	–
Paroo	GS49	NSW Sediments above the Great Artesian Basin	1	1	1	–	–	–	–
Warrego	GS78	Warrego Alluvium	0.7	0.7	0.7	–	–	–	–
Wimmera–Avoca	GS18	Wimmera–Mallee Sedimentary Plain	0.6	0.6	0.6	–	–	–	–
Moonie	GS71	Sediments above the Great Artesian Basin: Moonie	0.5	0.5	0.5	–	–	–	–
Moonie	GS74	St George Alluvium: Moonie	0.5	0.5	0.5	–	–	–	–
Macquarie–Castlereagh	GS62	Warrumbungle Basalt	0.5	0.5	0.5	–	–	–	–
Condamine–Balonne	GS75	St George Alluvium: Warrego–Paroo–Nebine	0.3	0.3	0.3	–	–	–	–
Condamine–Balonne	GS70	Sediments above the Great Artesian Basin: Condamine–Balonne	0.3	0.3	0.3	–	–	–	–
Border Rivers	GS69	Sediments above the Great Artesian Basin: Border Rivers	0.1	0.1	0.1	–	–	–	–
		Queensland[e]	229	229	174	55.3	24	55.3	24
		New South Wales	1,211	1,204	1,086	125.15	10	115.65	10
		Australian Capital Territory	7	0.5	4	2.85	39	0	0
		Victoria	227	226.7	227	–	–	0	0
		South Australia	112	83.9	110	2.5	2	2.7	3
		Basin total[e]	**1,786**	**1,744**	**1,601**	**185.65**	**10**	**174**	**10**

a A code has been assigned to each groundwater SDL area; these are shown on the map in Figure 9.1

b Current diversion limit is based on plan limit or current use if there is no plan

c Current use is based on the 2007–08 level of use in most instances; however, where the 2003–04 to 2007–08 data was available, the average of these values were used

d Groundwater SDL figures exclude unassigned groundwater

e Totals are provided to allow assessment at the state and whole-of-Basin levels but this does not suggest that discrete SDL areas can be aggregated

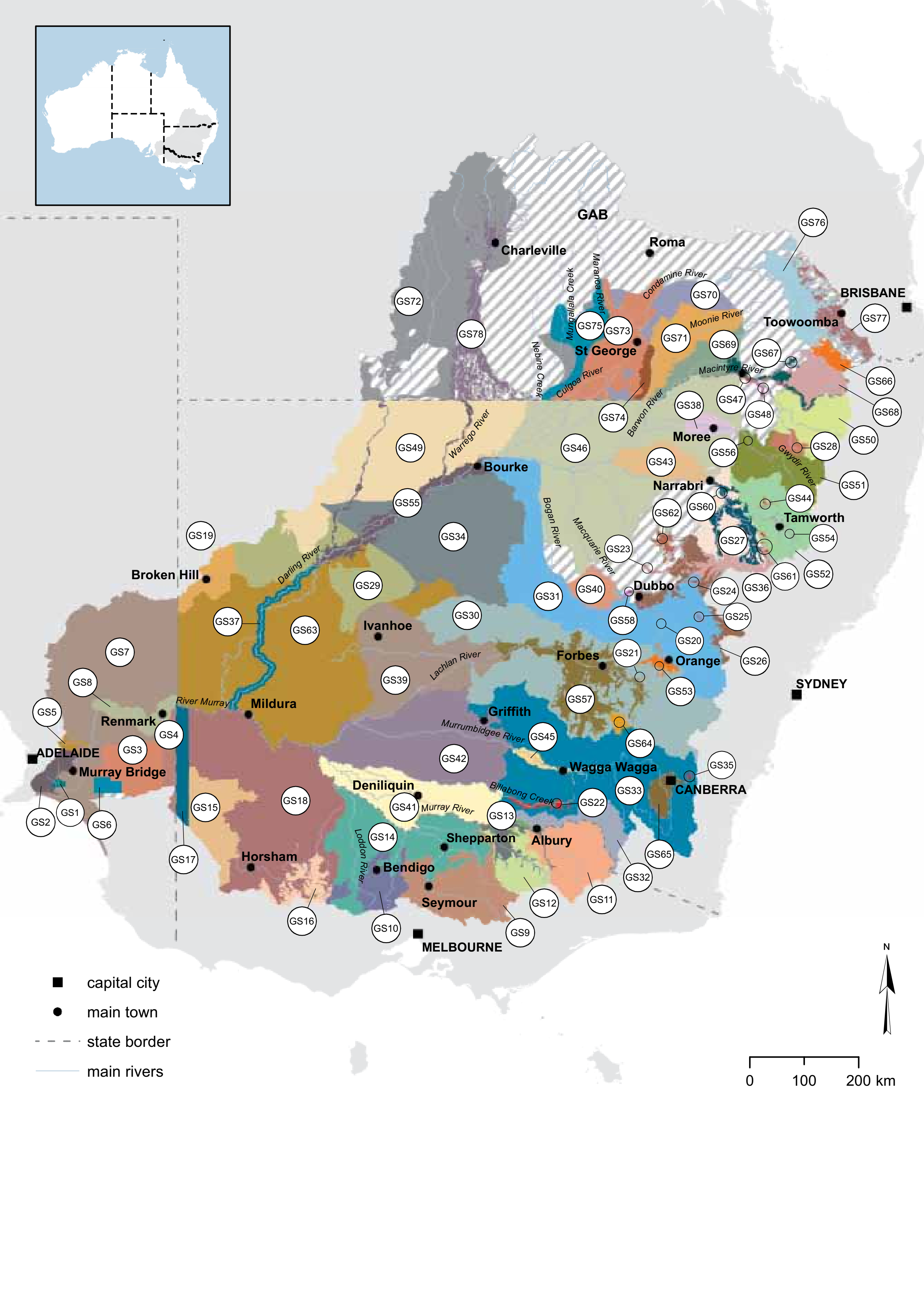


Figure 9.1 Groundwater SDL areas: Murray–Darling Basin

Groundwater SDL areas

- Not Basin water resources
- GS1 Angas Bremer
- GS2 Eastern Mount Lofty Ranges
- GS3 Mallee
- GS4 Mallee Border Zone
- GS5 Marne Saunders
- GS6 Peake–Roby–Sherlock
- GS7 SA Murray
- GS8 SA Murray Salt Interception Schemes
- GS9 Goulburn–Broken Highlands
- GS10 Loddon–Campaspe Highlands
- GS11 Murray Highlands
- GS12 Ovens Highlands
- GS13 Ovens–Kiewa Sedimentary Plain
- GS14 Victorian Riverine Sedimentary Plain
- GS15 West Wimmera
- GS16 Wimmera–Avoca Highlands
- GS17 Wimmera–Mallee Border Zone
- GS18 Wimmera–Mallee Sedimentary Plain
- GS19 Adelaide Fold Belt
- GS20 Bell Valley Alluvium
- GS21 Belubula Alluvium
- GS22 Billabong Creek Alluvium
- GS23 Castlereagh Alluvium
- GS24 Collaburragundry–Talbragar Alluvium
- GS25 Cudgegong Alluvium
- GS26 Eastern Porous Rock: Macquarie–Castlereagh
- GS27 Eastern Porous Rock: Namoi–Gwydir
- GS28 Inverell Basalt
- GS29 Kanmantoo Fold Belt
- GS30 Lachlan Fold Belt: Lachlan
- GS31 Lachlan Fold Belt: Macquarie–Castlereagh
- GS32 Lachlan Fold Belt: Murray
- GS33 Lachlan Fold Belt: Murrumbidgee
- GS34 Lachlan Fold Belt: Western
- GS35 Lake George Alluvium
- GS36 Liverpool Ranges Basalt
- GS37 Lower Darling Alluvium
- GS38 Lower Gwydir Alluvium
- GS39 Lower Lachlan Alluvium
- GS40 Lower Macquarie Alluvium
- GS41 Lower Murray Alluvium
- GS42 Lower Murrumbidgee Alluvium
- GS43 Lower Namoi Alluvium
- GS44 Manilla Alluvium
- GS45 Mid–Murrumbidgee Alluvium
- GS46 NSW Alluvium above the Great Artesian Basin
- GS47 NSW Border Rivers Alluvium
- GS48 NSW Border Rivers Tributary Alluvium
- GS49 NSW Sediments above the Great Artesian Basin
- GS50 New England Fold Belt: Border Rivers
- GS51 New England Fold Belt: Gwydir
- GS52 New England Fold Belt: Namoi
- GS53 Orange Basalt
- GS54 Peel Valley Alluvium
- GS55 Upper Darling Alluvium
- GS56 Upper Gwydir Alluvium
- GS57 Upper Lachlan Alluvium
- GS58 Upper Macquarie Alluvium
- GS59 Upper Murray Alluvium
- GS60 Upper Namoi Alluvium
- GS61 Upper Namoi Tributary Alluvium
- GS62 Warrumbungle Basalt
- GS63 Western Porous Rock
- GS64 Young Granite
- GS65 Australian Capital Territory (Groundwater)
- GS66 Condamine Fractured Rock
- GS67 Queensland Border Rivers Alluvium
- GS68 Queensland Border Rivers Fractured Rock
- GS69 Sediments above the Great Artesian Basin: Border Rivers
- GS70 Sediments above the Great Artesian Basin: Condamine–Balonne
- GS71 Sediments above the Great Artesian Basin: Moonie
- GS72 Sediments above the Great Artesian Basin: Warrego–Paroo–Nebine
- GS73 St George Alluvium: Condamine–Balonne
- GS74 St George Alluvium: Moonie
- GS75 St George Alluvium: Warrego-Paroo-Nebine
- GS76 Upper Condamine Alluvium
- GS77 Upper Condamine Basalts
- GS78 Warrego Alluvium

9.4 Mining interception of groundwater

There is currently relatively little direct consumptive water used for mining, but mining activities can cause large, localised incidental water-use and water-quality impacts, as well as aquifer interference associated with ore production or oil and gas extraction. The Authority is aware of growing concern over the potential impact of mining on water resources in particular regions of the Basin. Section 255A of the *Water Act 2007* (Cwlth) provides a mechanism to ensure that the impacts of any future mining activity on water resources are considered. The take of water for mining is subject to the long-term average sustainable diversion limit (SDL), and to this extent the volume able to be used specifically for mining will be regulated by the Basin Plan.

However, the Basin Plan does not constrain the purpose for which the take will be used as long as the total take complies with the SDL. Any take of water, including for mining, will be required to comply with water resource plans, which will contain detailed arrangements. The Basin Plan will also incorporate a Water Quality and Salinity Management Plan, which will provide a framework for the maintenance of appropriate water quality, including salinity levels, for environmental, cultural and economic activity in the Basin. The framework provided by the Water Quality and Salinity Management Plan (see Chapter 12) will encompass any water-quality impacts of mining activities.

10. Critical human water needs

Key points

- Water set aside and used for critical human water needs will be included in the long-term average sustainable diversion limits (SDLs) for each region. Water resource plans will have to provide for critical human water needs as the highest priority.
- The proposed volumes of water required from the River Murray system to meet the critical human water needs of the communities in the relevant states dependent on that system are:
  - 61 gigalitres per year (GL/y) for New South Wales
  - 77 GL/y for Victoria
  - 204 GL/y for South Australia.
- Based on losses in recent times of very low water availability, the conveyance water volume has been estimated at 1,596 GL/y. This comprises 150 GL/y for losses from the major storages, 750 GL/y for losses upstream of the South Australian border, and 696 GL/y for dilution and losses in South Australia between the border and Wellington.
- A salinity trigger point is proposed at 840 mg/L; above this, water is unsuitable for critical human needs and an emergency response is required.
- A water quality trigger point is proposed when the Authority receives notification that a water quality characteristic has been measured at a level significantly outside the manageable range for any parameter. For example, had the recent occurrence of acid sulfate soils led to a part of the system becoming highly acidic, this trigger would have been met, prompting an emergency response.
- The Basin Salinity Management Strategy and the Water Quality and Salinity Management Plan, combined with raw water treatment that is consistent with the Australian Drinking Water Guidelines, are considered to adequately address the risks associated with any other public health issues and impacts concerning drinking water sourced from the River Murray system.

Checking water quality in the fish ponds at the Narrandera fish hatchery, New South Wales

10.1 The requirements of the Water Act

The *Water Act 2007* (Cwlth) requires that critical human water needs be taken into account in the preparation of the Basin Plan (s. 86A) and the Commonwealth and the Basin states have agreed that these needs are the highest priority water use for the communities dependent on Basin water resources (s. 86A(1)). Critical human water needs are defined in the Water Act (s. 86A(2)) as the minimum amount of water required to meet core human needs in urban and rural areas, and non-human consumption needs which, if unmet, would cause prohibitively high social, economic or national security costs. Water set aside and used for critical human needs is the first priority of the long-term average sustainable diversion limit (SDL) for each area.

The recent drought has highlighted the challenge of ensuring ongoing supply to meet the basic human water needs of individuals and communities reliant on the rivers of the Basin. While this is a state government responsibility, recent experience in the southern connected Basin has emphasised the need for cooperative arrangements between the states to ensure adequate supplies, as the water sharing rules in the Murray–Darling Basin Agreement (Schedule 1 to the Water Act) did not contemplate such low water availability.

Circumstances in which enough water is available to meet only critical human needs are expected to be rare, having occurred only once in about 100 years, but thorough preparation for such a scenario is still vital.

The Water Act requires the Basin Plan to include a statement of the minimum amount of water required from the River Murray system, in New South Wales, Victoria and South Australia, to meet the critical human water needs of communities dependent on the system. The plan must also include a statement of the amount of conveyance water required to deliver the amounts needed to meet the critical human water needs of those communities, and specify the quality and salinity trigger points at which water in the River Murray system becomes unsuitable for meeting critical human water needs.

Water pipes from the Cotter River to supply Canberra, Australian Capital Territory

Under the Water Act, the Basin Plan does not have to determine critical human water needs beyond the River Murray system, but to ensure that it takes into account the agreed priority of critical human water needs, the Authority has undertaken a basic comparison of estimated critical human water needs with SDL proposals to ensure that the SDLs allow for such needs to be met across the whole Basin.

10.2 Volumes for critical human water needs

The Basin Plan will set out a minimum volume of water for critical human needs in the River Murray system for New South Wales, Victoria and South Australia. These volumes have been calculated to allow for basic individual requirements such as drinking, food preparation and hygiene; water to cover community essentials such as keeping hospitals, schools, emergency services and other key services operating; water for essential commercial and industrial users; and water to maintain, as far as possible, the social fabric of the community.

While the Basin Plan will set out the quantities of water that are required for these critical human needs, and for delivering that water through the river system (conveyance water) (*Water Act 2007* (Cwlth) s. 86B), it will be the responsibility of each state to meet those needs. This should include deciding how water from each state's share is used; which water uses will be treated as 'critical' for specific communities; and how risks associated with the provision of critical human water needs are managed. It is expected that states will use carryover or reserve arrangements to set aside water for critical human needs to ensure sufficient water is available at the start of each year.

The amount of water required for critical human needs has been determined in consideration of how communities function during periods of very low water availability. It has not, therefore, been set at a level that would sustain 'normal' function. How communities function with very little water will also be affected by how the states limit water use, and how each state manages the distribution of the water.

The approach used to determine a bulk volume for critical human water needs from the River Murray system at a state level has been based on:

- assumed average daily community use of 340 L per person in urban areas and 398 L per person in rural areas; these numbers include community services, commercial and industrial use, and are based on an analysis of recent water use in Australian communities (including in the Basin) under high-level water restrictions
- an allowance for each state for extraordinary circumstances
- consideration of alternative water supplies that may supplement Basin water resources
- an allowance for distribution losses from the River Murray system to the point of supply.

Using this approach, the Authority considers that the volumes of water required to meet the critical human needs of the Basin communities dependent on the River Murray system are as set out in Table 10.1. The volumes of water for critical human water needs used at present have been determined by each state using its own methodology. The volumes proposed for each state have been determined using a consistent methodology and have taken into account experience from the most recent drought.

Table 10.1 Volumes required to meet critical human water needs of Basin communities dependent on the River Murray system

State	Current (GL/y)	Proposed (GL/y)
New South Wales	75	61
Victoria	75	77
South Australia	201	204

10.3 Conveyance water

Conveyance water is the amount required to ensure there is sufficient flow in a river to physically deliver water for critical human needs without it evaporating or seeping into the riverbed. Without allowing for conveyance water, much of the water required to meet critical human needs would not reach the communities who rely on it. The conveyance water volume in the River Murray system has been estimated at 1,596 GL/y in periods of low availability (i.e. when delivery of water for critical human water needs is at its most difficult). This comprises three volumes:

- 150 GL/y for losses by evaporation and seepage from the major storages. This volume is estimated based on observations during periods of below-average storage levels.
- 750 GL/y for losses by seepage and evaporation in the River Murray system, between the major storages and the South Australian border. This volume is estimated based on observations during dry conditions.
- 696 GL/y for dilution and losses in the River Murray between the South Australian border and Wellington. This is a fixed volume, which is a requirement set out in clause 88(b) of the Murray–Darling Basin Agreement.

Currently there is no specific provision for a reserve to ensure sufficient conveyance water is available at the start of each year to deliver water for critical human needs. The *Water Act 2007* (Cwlth) (s. 86D) requires the Basin Plan to include a reserves policy. The Authority proposes that conveyance reserve provisions will give protection for a potential worst-case scenario of extremely low inflows at a time when there is also very little water in storage. Depending on prior conditions, this is expected to be sufficient to provide for a sequence of at least two exceptionally dry years.

10.4 Other issues

In terms of the water quality and salinity triggers, the Authority considers that water sourced from the River Murray system will be unsuitable for meeting critical human water needs when the salinity level equals or exceeds 840 mg/L of total dissolved solids, or when a water quality characteristic has been measured at a level significantly outside the typical range for any parameter. The water quality trigger is most likely to be met when a state notifies the Authority that water from the River Murray system cannot be treated to an acceptable quality using existing processes, and that a system-level emergency response is required.

The Authority considers that the Basin Salinity Management Strategy and the Water Quality and Salinity Management Plan (see Chapter 12), combined with raw water treatment that is consistent with the Australian Drinking Water Guidelines, will adequately address the risks associated with any other public health issues and impacts associated with drinking water sourced from the River Murray system.

Water testing at Bathurst Water Treatment Plant, New South Wales

The Basin Plan will include monitoring, assessment and risk management provisions that will enable the Authority on behalf of, and in conjunction with, the Commonwealth, New South Wales, Victorian and South Australian governments to assess and mitigate risks to critical human water needs associated with inflow predictions.

The *Water Act 2007* (Cwlth) and Murray–Darling Basin Agreement also cover issues relating to water sharing arrangements. The Schedule for Water Sharing is a new schedule to the Agreement (Part XII (Division 4)) that is being developed in parallel with the proposed Basin Plan provisions for critical human water needs. This schedule will provide some of the key mechanisms to set aside, deliver and account for the critical human water needs and conveyance reserves.

The approval arrangements for the Basin Plan provisions and the Schedule for Water Sharing are quite different. The Basin Plan provisions are to be adopted by the Commonwealth Water Minister and the schedule is to be approved by the Murray–Darling Basin Ministerial Council. If the Basin Plan provisions relating to critical human water needs affect state or Border Rivers water sharing arrangements, the application of those provisions will be limited unless the Ministerial Council has agreed that they will be given full application, or the Schedule for Water Sharing has not yet been made (Water Act ss. 86G(2) and 86H(4)). In addition, there are areas of overlap between the Basin Plan and the Schedule for Water Sharing that will require endorsement by the Authority and the Ministerial Council.

11. Supporting transition to sustainable diversion limits

Key points

- There are a number of ways in which the social and economic impacts of the long-term average sustainable diversion limits (SDLs) will be reduced, including through water recovery efforts under programs such as the Australian Government's 'Water for the Future', risk allocation provisions and temporary diversion provisions.
- Under the existing Water for the Future program the Australian Government expects to recover in the order of 2,000 GL for the environment across the Basin, either through water purchasing or investments in more efficient irrigation infrastructure. The purchasing of water in this way will assist in offsetting impacts of SDLs on water entitlement holders.
- The Australian Government has indicated its intention to bridge any remaining gap between what has been returned and what is required to be returned under the Basin Plan by continuing to buy back surface water entitlements. In light of this commitment, the risk allocation provisions of the Basin Plan will only be activated for groundwater. As required under the Water Act, the Authority proposes that the Australian Government share under the risk allocation provisions will be 100%, after consideration of 3% attributable to climate change in regard to surface water (0% for groundwater).
- For transitional or interim water resource plans that cease less than five years after the date of the Basin Plan being adopted, temporary diversion provisions will apply in all areas where there are residual reductions (i.e. the effective reduction remaining once the impact of government water recovery efforts and the 3% reduction attributable to climate change have been taken into account – 0% for groundwater). In these areas, the Authority proposes that SDLs will be phased in over a period of five years, allowing water users and communities more time to adjust to the new arrangements.
- SDLs take effect when new Basin state water resource plans are accredited. These new plans will be accredited over the period 2012–19, with major plans in New South Wales, Queensland, South Australia and the Australian Capital Territory due for accreditation in 2014. In Victoria new plans are due to be accredited in 2019. The Authority is concerned about the inequity of such a long time period between accreditations, and therefore when the various entitlement holders using the same river systems will be affected differentially by the SDLs.

Groundwater monitoring bore on the Toowoomba–Cecil Plains Road, Queensland

The Basin Plan will have an impact on individuals, stakeholders and Basin communities. These impacts will vary depending on a wide range of factors including location, business exposure to changes in diversion limits, alternative industries in the area, and other general size and resilience factors in the community.

The *Water Act 2007* (Cwlth) outlines some transitional support mechanisms; in particular risk allocation and temporary diversion provisions. In addition the Australian Government has in place programs that support the transition to a future with sustainable diversion limits (SDLs).

11.1 Bridging the gap

Under the Water for the Future program, the Australian Government has been purchasing water entitlements for environmental benefit, and returning water saved through irrigation efficiency programs to the environment. This water will assist in bridging the gap between current diversions limits and SDLs.

Further, the Government has indicated its intention to bridge any remaining gap between what has been returned and what is required to be returned under the Basin Plan.

As at 30 June 2010, the Australian Government water buyback and state water recovery programs had secured some 705 gigalitres (GL) of surface water (long-term Cap equivalent) in the Basin. While the actual entitlement volumes purchased may be higher, these purchased entitlements have been converted to long term Cap equivalent volumes to permit direct comparison with long-term average SDLs and other Basin Plan volumes. The Authority considers the purchasing of water in this way to be the most effective way of ensuring environmental flows are increased. In addition to the water buyback program, close to $3.7 billion has been committed in principle to irrigation infrastructure efficiency improvement projects in the Basin, subject to due diligence of those projects. It is conservatively estimated that Commonwealth and state water purchases and savings under the infrastructure improvement program, will recover around 2,000 GL (long-term Cap equivalent) for the environment.

These water purchases will assist in mitigating the impact of any reductions that will be required to meet the SDLs adopted under the Basin Plan. This offset will vary from region to region depending on the quantity of water access entitlements purchased by the Australian Government. However, at an aggregate level the residual amount of water (the gap) to be returned to the environment taking into account the existing and potential purchases under the current Water for the Future program could be in the range 1,000–2,000 GL if SDLs of between 9,700 gigalitres per year (GL/y) and 10,700 GL/y were adopted.

In addition to the Australian Government water purchasing and infrastructure investment programs under Water for the Future, other relevant government programs that could help to offset the impact of reductions in current diversions limits include:

- NSW Riverbank program
- state government investments in the irrigation efficiency programs such as the Northern Victoria Irrigation Recovery Program
- Water for Rivers program (although some of the water recovered is for the Snowy River)

- Strengthening Basin Communities program (Australian Government)
- the Exceptional Circumstances Exit Package (Australian Government)
- the Climate Change Adjustment program (Australian Government).

Table 11.1 presents the volumes of Australian Government- and state-held environmental water in each catchment that are able to offset reductions to current diversion limits. It also shows the range of remaining difference that has not yet been met (the gap at 30 June 2010). The greater the proportion of the required reductions purchased by an environmental water holder, the less an individual entitlement holder's entitlement will be impacted by the SDL. If the gap is fully bridged, the impact on remaining consumptive users will be nil. However, some of the economic impact on the community in the area would remain, due to the flow-on impact of less water being available for production.

In other catchments, there is still a significant gap and the Authority believes that the Australian Government should target its purchasing in those areas most affected.

Table 11.1 Environmental water available for offset

Region	Held environmental water to offset reductions[a] at 30 June 2010 (GL/y)	Range of gap after water recovery[b, c] at 30 June 2010 (GL/y)
Paroo	0	0–0
Warrego	8	10–12
Condamine–Balonne	1	204–274
Moonie	1	11–14
Border Rivers	4	82–108
Gwydir	64	26–57
Namoi	6	66–88
Macquarie–Castlereagh	57	47–78
Barwon–Darling	32	12–25
Lower Darling	0	16–20
Lachlan	45	-1–24
Wimmera–Avoca	0	0–0
Ovens	0	10–11
Goulburn–Broken	107	341–492
Loddon	3	35–40
Campaspe	5	35–47
Murrumbidgee region	64	615–846
Murray	309	784–1,155
Eastern Mount Lofty Ranges	0	3–4
Murray–Darling Basin total	**705**	**2,295–3,295**

a Includes water held by Basin states and the Australian Government as at 30 June 2010 but does not include water held for The Living Murray Initiative

b The gap is the difference between the current diversion limit and the proposed SDL range for that region, less the held environmental water (previous column) as at 30 June 2010. It is possible that in some regions more water has been purchased since 30 June 2010

c Totals may not be the sum of the figures provided due to rounding

Note: The held environmental water is the long-term Cap equivalent converted from purchased water entitlements to allow direct comparison with SDLs

11.2 Risk allocation

Risk allocation is a complex mechanism for sharing the risks of any changes to the volume and reliability of entitlement holders' allocations of water between individual entitlement holders and governments, according to a formula that recognises changes attributable to new knowledge and policy changes as well as to the effects of seasonal or long-term changes in climate and periodic natural events such as bushfires and drought.

The risk allocation provisions that must be included in the Basin Plan stem from two intergovernmental agreements between the Commonwealth and states: the Intergovernmental Agreement on a National Water Initiative 2004, and the Intergovernmental Agreement on Murray–Darling Basin Reform 2008. They resulted in the Australian Government and the Basin states undertaking to share the risks associated with implementing sustainable diversion limits. Further, through the 2004 initiative, Basin states undertook to address overallocation and overuse of water resources.

Through the Basin Plan the Authority is responsible for identifying that part of the reduction that is the Australian Government's share. The Act requires the Australian Government to manage the impacts on entitlement holders of:

- all the reduction that results from changes in Australian Government policy
- some of the reduction that results from improvements in knowledge about the environmentally sustainable level of take.

Under the Water Act, the Australian Government is not responsible for any reduction in water availability that results from seasonal or long-term changes in climate or periodic natural events such as bushfire and drought. The Authority proposes the climate change component to be 3% of current diversion limits for individual surface water SDL areas (0% for groundwater). This portion of the change will be borne by water entitlement holders.

While the Authority is responsible for determining the Australian Government's share of any reduction in the proposed Basin Plan, it is the Commonwealth Water Minister, who is responsible for managing the impact of the Australian Government's share of the reduction. This will occur in two ways:

- water recovery programs such as those mentioned above will contribute to managing the Australian Government's share. The water recovered under these programs will effectively offset impacts on many water entitlement holders
- in the event that water recovery efforts do not fully offset the Australian Government's share of the reduction, the Water Act provides for payments to be made to affected entitlement holders. Payments for any such residual share would relate to any reduction in market value of eligible water entitlements.

Blowering Dam near Tumut, New South Wales

Changes in government policy

In calculating the Australian Government's share in relation to new policy there are two competing issues to take into account:

- the National Water Initiative (2004) requires that Basin states are to address existing overallocation and overuse before the risk assignment framework agreed under the Initiative applies
- there is an argument that the Water Act is a change in Australian Government policy in that the Australian Government now has the statutory policy role to set SDLs across the whole Basin and enforce state compliance, when previously the government relied on the states to determine their own diversion limits. The Water Act specifies that the Commonwealth, in determining environmental sustainability, among other issues, should give effect to relevant international agreements, which goes beyond considerations under the National Water Initiative.

In addition to the latter point, it can be argued that the Water Act provides for Basin-wide benefits beyond the Basin states commitments to address overallocation under the Initiative, such as improving water quality and salinity conditions in the Basin.

The Authority accepts that, notwithstanding the Basin states' requirements to meet their obligations under the Initiative to address overallocation and overuse, the Australian Government's role under the Water Act is a change in Australian Government policy while pursuing the general overall goal of the Initiative.

Therefore it is reasonable to attribute 100% of any reduction in current diversion limits to changes in Australian Government policy.

Improvements in knowledge

In order to quantify the effect of a change in knowledge about the environmentally sustainable level of take for a particular water resource, upon implementing an SDL, and hence calculate the improvements in knowledge component, it is necessary to identify the baseline knowledge upon which Basin state water resource plans were prepared and to compare this with the information used for preparing the Basin Plan. The Authority has examined the information on current Basin state plans that is available to it, and found it is not possible to make a valid comparison.

Consequently, the Authority has concluded that none of the overall reduction can be attributed to the use of new knowledge.

Australian Government's share of reductions due to long-term average sustainable diversion limits

In summary, the Authority is proposing that the Australian Government's share of reductions in current diversion limits necessary to implement SDLs for the Basin Plan (Water Act s. 75(1)(d) and 75(2)) is:

100% of the reduction, being:

- all of the change due to the changes in Australian Government policy component
- no change due to the new knowledge component.

This share applies after taking out the effects of seasonal or long-term changes in climate and periodic natural events such as bushfires and drought. The Authority has determined that this amount is 3% of the current diversion limit for surface water and 0% for groundwater.

This would mean that the Australian Government's share of the proposed surface-water reduction is in the range 3,000 GL to 4,000 GL is estimated to be 2,590 GL to 3,590 GL (i.e. the total after a reduction of 3% of the current diversion limit for climate change for each SDL area though the exact amount will depend on the way the reduction is implemented by Basin states) subject to a transitional or interim plan being in place according to the terms of the Water Act.

Should the groundwater SDL proposals be adopted, the Australian Government's share of the total groundwater reduction of 186 GL is 186 GL (i.e. the total reduction given there was no adjustment to groundwater SDLs in respect of climate change effects), subject to a transitional or interim plan being in place according to the terms of the Water Act.

In the event that future reviews of the Basin Plan require a decrease in the SDLs, the Authority will calculate the Australian Government's share on the basis of considering any subsequent changes to Australian Government policy and the application of new knowledge, using the initial Basin Plan as the baseline for comparison (after taking out the effects of seasonal or long-term changes in climate and periodic natural events such as bushfires and drought). This point is made not on the basis that further change is envisaged, but to establish certainty for the future.

Risks arising from other changes to the Basin Plan

Subdivision B of Division 4 of Part 2 of the Water Act (ss. 80–86) applies when a change in the Basin Plan, apart from the implementation of SDL, results in a change in reliability of water allocations in a water resource plan area. Changes to the reliability of water allocations may be caused by various elements of the Basin Plan, in particular the specific requirements against which new Basin state water resource plans will be accredited. However, it will not be possible to specify the magnitude of any changes in reliability caused by the Basin Plan until after the development of Basin Plan-compliant state water resource plans.

The Authority will therefore make any assessments as to the Australian Government share of any impacts arising from a change in reliability on water allocations (if any) as part of the accreditation process for state water resource plans.

11.3 Temporary diversion provisions

The risk allocation provisions of the *Water Act 2007* (Cwlth), as described in the previous section, target the impact of reductions in current diversion limits on individual entitlement holders. However, the Authority is also very concerned about the flow-on impacts within local businesses and communities.

Temporary diversion provisions are a mechanism available under the Water Act to provide a phase-in period for SDLs of up to five years. This will reduce the impact of SDLs, giving water access entitlement holders and communities more time to adjust to the reduction.

Temporary diversion provisions must be set for all SDL areas, but can be set at zero. Where a ‘non-zero’ temporary diversion limit is set, it must reduce to zero by the end of five years and the rate at which it reduces must be specified.

Factors that could be taken into account when considering any temporary diversion provisions for the proposed Basin Plan are:

- the social and economic impacts of the reduction arising from the SDLs
- the potential adverse impact in delaying water for key environmental assets and key ecosystem functions
- the length of time available until the SDL first takes effect
- the size of the residual adjustment needed to comply with SDLs.

The time already available for entitlement holders to adjust to an SDL will vary for different water resource plan areas depending on when the relevant interim or transitional plan expires. For example, the surface-water resources of the Murray region shared by New South Wales, Victoria and South Australia are currently covered by water resource plans that expire by 2014 (New South Wales and South Australia) and 2019 in Victoria. Across the Basin, new Basin state water resource plans will be accredited over the period 2012–19 with major plans in New South Wales, Queensland, South Australia and the Australian Capital Territory due for accreditation in 2014. In Victoria, new plans are due to be accredited in 2019.

The Authority is concerned that the different implementation dates for Basin state water resource plans will create inequity between the various entitlement holders using the same river.

The Commonwealth Environmental Water Holder holds a growing portfolio of water entitlements which must be used for environmental benefit. As indicated above, these entitlements will effectively reduce the gap between current diversion limits and the SDLs. The difference between the current diversion

Campaspe River near Echuca, where it flows into the River Murray, Victoria, 2007

limit reduction, after disregarding the reduction of 3% attributable to climate change (0% for groundwater), and any offsetting water entitlements held by the government can be considered to be the 'residual adjustment' component for which a temporary diversion provision will be considered.

Because the Australian Government water recovery efforts are still underway, it is not possible for the Basin Plan to set precise temporary diversion provisions at this point. Instead, a formula based on the size of the 'residual adjustment' has been developed. While water users are able to use this formula to estimate the likely impact of the temporary diversion provisions in their area, the precise impact can only be calculated once state water resource plans are accredited as consistent with the Basin Plan.

The Authority proposes that temporary diversion provisions should be available to all transitional or interim water resource plans that cease less than five years after the date of the Basin Plan being adopted, where there are residual reductions required to comply with the SDL (i.e. the effective reduction once the impact of government water recovery efforts and the 3% reduction attributable to climate change have been taken into account — 0% for groundwater). Further, they should be phased in, allowing water users and communities more time to adjust to the new arrangements.

Taking the above issues into account, the Authority has developed the following method for applying temporary diversion provisions:

1. If a transitional water resource plan ceases more than five years after the date of the Basin Plan being adopted, the temporary diversion provision for the relevant SDL area will be set at zero.
2. Subject to (1) if the residual adjustment component for an SDL area is greater than 0% of the current diversion limit at the date of the water resource plan taking effect then the temporary diversion provision will initially equal the residual amount and reduce to zero in five equal steps by the end of the fifth year (see Table 11.2).

It should be noted that where there is a residual SDL reduction, and the risk allocation provisions apply such that payments to water entitlement holders are made, the temporary diversion provisions will still apply. In effect, this means that although entitlement holders may have received payments for the residual, the five-year staged introduction of the SDL will still apply.

Table 11.2 Example of the application of the temporary diversion provision to surface water

	Current diversion limit	SDL	Reduction of 3% attributable to climate change	Commonwealth Environmental Water Holder	Residual adjustment	Year					
						1	2	3	4	5	6
Diversion (GL/y)	500	300	15	85	100	400	380	360	340	320	300
Temporary diversion provision (GL/y)						100	80	60	40	20	0

11.4 Policy implications of transitional arrangements

The Authority recognises that the above initiatives will help in easing the transition from current diversion limits to long-term average sustainable diversion limits (SDLs) for some groups more than others, and notes that assistance will need to be targeted to ensure that all groups affected are adequately supported through the process.

The success with which communities transition will be shaped by the continued provision of community services such as health, education, aged care, and the ongoing activities of community clubs, sporting clubs and other community connections. Sustaining the social fabric of communities will be in part determined by the economic adjustments to the reduction in diversions, and the strength of communities social capital will in turn also shape communities' ongoing economic success.

Analysis commissioned by the Authority suggests that if the Basin is able to adjust smoothly to the reduction in water availability, then the long-term effect on the Basin economy would be in the order of a reduction of 1.3% in gross regional product. Such an amount could be more than offset by a solid breaking of the drought of the past decade or a permanent uplift in commodity prices.

If on the other hand, the adjustment of Basin enterprises and communities does not occur smoothly, then the long term impact on the Basin might be more dislocating and create longer term hardship in communities. The Authority recognises that substantial effort should be made to avoid such an outcome. For these reasons, the Authority has put significant weight on the policy settings of Basin governments as a critical determinant of the long-term future of Basin communities.

Supporting water entitlement holders

Given the volumes of water that may have to be bought back by the Australian Government to bridge the gap between current diversion limits and SDLs, it will be important the process does not distort the market and the efficient allocation of water in the Basin, if the long-term objectives of the Basin Plan are to be met. This will require careful consideration of a range of complex but important issues:

- the price paid for water
- the potential viability of irrigation areas where significant buybacks occur
- the relationship with Basin states' resource strategies
- timing of implementation and consideration of possible future water trading outcomes.

Given the scale of the transformation required to implement the Basin Plan the Authority would welcome views on the adequacy of the current adjustment support under the Australian Government Water for the Future program.

12. *Putting the Basin Plan into effect*

Key points

- Effective implementation of the Basin Plan will require a strong partnership between the Authority, Commonwealth agencies and the Basin states.
- The Basin Plan will contain an Environmental Watering Plan, a Water Quality and Salinity Management Plan, water trading rules and water resource plan requirements.
- The Environmental Watering Plan provides for the management of environmental water to protect and restore environmental assets and achieve other environmental outcomes for the Basin. It is the primary mechanism to ensure that the best use is made of the water that is being made available to the environment. The proposed plan uses a principles-based approach supported by a planning and reporting framework and an Environmental Watering Advisory Committee.
- The Water Quality and Salinity Management Plan will introduce new water quality and salinity objectives and targets for the Basin, for aquatic ecosystems, drinking water, recreational water and irrigation water. These will be implemented at the Basin Plan level and at the regional level. That is, the Basin Plan will require operating authorities and infrastructure operators to comply with certain principles when making flow management decisions. At the regional level, water resource plans will be required to include water quality management plans that contain measures to achieve these objectives and targets.
- Water quality and salinity targets set under the plan will not impose direct mandatory compliance obligations on government, instrumentalities or individuals. Instead, at the regional level, water quality management plans will need to be prepared as a part of the water resource plans and will include management actions that, when implemented, will ensure that water quality target values are achieved.
- The water trading provisions of the proposed Basin Plan are based on the advice of the Australian Competition and Consumer Commission, with a number of minor changes. The Basin Plan water trading rules will address general matters regarding the trade and tradability of water access rights.
- The proposed Basin Plan will set out distinct requirements that must be met prior to accreditation of a water resource plan prepared by a Basin state.

Reedy Swamp after an environmental water allocation near Shepparton, Victoria

Although the Basin Plan will identify new long-term average annual sustainable diversion limits (SDLs), a range of new arrangements will be required to apply the SDLs to SDL areas. Arrangements will also be needed to incorporate SDLs in water management decisions and optimise the outcomes from the water available to the environment.

The *Water Act 2007* (Cwlth) requires the Basin Plan to include a number of specific items to help implement the necessary changes to water management to deliver the objects of the Water Act, and these are reflected in the objectives that the Authority has developed for the Basin Plan, in particular to:

- improve the resilience of key environmental assets, water-dependent ecosystems and biodiversity in the face of threats and risks that may arise in a changing environment
- maintain appropriate water quality, including salinity levels, for environmental, social, cultural and economic activity in the Basin
- improve the transparency and efficiency of water markets in the Basin.

The first of these objectives relates to the implementation of an Environmental Watering Plan, which will determine how water will be applied to the environment to achieve maximum benefit. The second relates to the implementation of the Water Quality and Salinity Management Plan. The third relates to the implementation of water trading rules, which will establish the basis on which water rights will be traded in the Basin.

One of the main ways in which the Basin Plan will be given effect will be through the water resource plans prepared by Basin states, and the accreditation of these plans by the Commonwealth Water Minister.

This chapter explains how these plans, rules and accreditation will operate in the Basin.

12.1 Environmental Watering Plan: how the water will be used

The Environmental Watering Plan is the primary mechanism to make the best use of water available to the environment. It builds on experience gained through:

- The Living Murray initiative
- the Commonwealth Environmental Water Holder
- other environmental watering initiatives over recent years.

The purposes of the Environmental Watering Plan are to:

- safeguard existing environmental water
- plan for the recovery of additional environmental water
- coordinate the effective management of this environmental water.

The Environmental Watering Plan does this to protect and restore the ecosystem functions, wetlands and other environmental assets of the Basin, to protect biodiversity dependent on the Basin water resources, and to achieve other environmental outcomes for the Basin (*Water Act 2007* (Cwlth) s. 28).

The Water Act requires the Environmental Watering Plan to specify overall environmental objectives for the Murray–Darling Basin's water-dependent ecosystems. As a result, the Authority has developed the following objectives:

- protect and restore the key water-dependent ecosystems of the Murray–Darling Basin
- protect and restore the ecosystem function of these key water-dependent ecosystems
- enhance the resilience of key water-dependent ecosystems to future risks and threats.

Murray River near Wangaratta, Victoria

The plan must also specify targets to measure progress against these objectives. The targets proposed can be summarised as:

- no loss or degradation of ecological response outcomes within five years of the Basin Plan being adopted
- improvements in ecological response outcomes within 5 to 20 years of the Basin Plan being adopted.

The Environmental Watering Plan must also specify an environmental management framework for planned and held environmental water; the methods to be used to identify the environmental assets and ecosystem functions that will require environmental watering; the principles and methods to determine the priorities for applying environmental water; and the principles to be applied in environmental watering.

It is proposed that the Environmental Watering Plan will provide a framework for adaptive management of watering activities, rather than prescribing a strict watering or flow regime. The adaptive management approach will allow for advances in knowledge, provide a way to deal with variations in climate from year to year and manage risks associated with environmental watering (e.g. flooding). In addition it will incorporate strategies to deal with drought and climate variability.

The key elements proposed for the environmental management framework are summarised in terms of the following five elements:

1. Basin states will be required to develop strategic environmental watering plans for each surface-water water resource plan area, showing how they will manage water to meet the requirements of the assets and functions in that area. In developing strategic environmental watering plans, Basin states will need to use the method outlined in the Environmental Watering Plan to identify environmental assets and ecosystem functions that need environmental watering. The application of this method in the Basin states' plans will allow for refinement to assets or functions over time. Once the Basin Plan is adopted, Basin states will be required to start long-term environmental water planning consistent with the Environmental Watering Plan. Under this framework the strategic environmental watering plans will need to be submitted to the Authority no later than 12 months after the Basin Plan is adopted.

2. The annual water planning will propose annual watering priorities for each of the water resource plan areas, to inform a Basin-scale prioritisation process. The environmental watering prioritisation process will coordinate Basin-scale priorities in accordance with principles outlined in the Environmental Watering Plan and on the advice of an Environmental Watering Advisory Committee (to be established and chaired by the Authority). The prioritisation method will actively consider the forecast water availability and the management outcomes being sought. The Authority will use this information to publish annually a statement of environmental watering priorities.
3. Managers of environmental water must make their decisions about how to use their water, having regard to the statement of environmental watering priorities published annually by the Authority and other such considerations, such as opportunities for piggybacking on river flow patterns and the avoidance of unintended flooding.
4. Environmental water delivery will remain the responsibility of the Basin states and/or current river operators at the request of the environmental water holders and/or managers.
5. Monitoring, evaluation, reporting and compliance will be used to evaluate whether Basin-scale outcomes are being achieved (see Chapter 14).

Implementation of the environmental management framework will start immediately when the Basin Plan is adopted, except where existing interim or transitional water resource plans maintain a current environmental watering arrangement.

The proposed principles for prioritising and managing environmental watering are as follows:

- maximise environmental outcomes consistent with the Environmental Watering Plan objectives
- develop and implement adaptive management arrangements
- consider the environmental asset's and ecosystem function's contribution to Basin Plan goals and objectives
- consider efficiency and effectiveness of the watering required
- assess and manage risks
- ensure robust and transparent decision-making
- apply the precautionary principle when relevant
- consider downstream ecological objectives and Basin-scale benefits.

The proposed method involves determining the management outcomes appropriate to the likely water availability scenario. For the various water availability scenarios and aligned management outcomes, it then involves determining priorities for environmental watering through application of the principles and applying ranking criteria (to be published by the Authority), then managing environmental watering to deliver these priorities consistent with the principles.

Each year the Authority will:

- call for advice on watering priorities and then publish a statement of environmental watering priorities for the Basin for that year
- publish a report of all watering events for the previous water year, to increase transparency in watering activities and to help inform the environmental watering needs of the next year.

In addition to the monitoring and evaluation set out in the monitoring and evaluation program (see Chapter 14), the Authority will report on progress towards meeting the environmental water requirements for the hydrologic indicator sites.

12.2 Water Quality and Salinity Management Plan

For many years Basin communities have been concerned about water quality and salinity and governments have developed policies and strategies to address the issues.

In 1990, the Murray–Darling Basin Ministerial Council adopted a policy position to improve water quality to meet the needs of all beneficial uses. Despite early measures, including the Integrated Catchment Management Strategy, insufficient work has been done to mitigate the significant risk that water quality will deteriorate in the Basin.

The National Water Quality Management Strategy, adopted in 1994, provided a useful framework for water quality management. However, implementation has been slow and although natural resource management plans addressing water quality in the Basin have been developed, variation across and in Basin states means they have been of limited strategic impact.

The *Water Act 2007* (Cwlth) requires the Basin Plan to include a Water Quality and Salinity Management Plan. That plan must identify the key causes of water quality degradation in the Murray–Darling Basin and include water quality and salinity objectives and targets for the Basin water resources. In doing this, the Authority must have regard to the National Water Quality Management Strategy.

To address the continuing challenges of water quality and salinity management, the Authority proposes a plan with the following features:

- the introduction of water quality and salinity objectives and targets for the Basin (see Table 12.1) for aquatic ecosystems, drinking water, recreational water and irrigation water
- objectives, targets, and associated management requirements that will provide a framework to meet society's expectation that its water supply is of adequate quality. These will be implemented at the Basin Plan level and at the regional level. That is, the Basin Plan will require operating authorities and infrastructure operators to comply with certain principles when making flow management decisions. And, at the regional level, water resource plans will be required to include water quality management plans that contain measures to achieve these objectives and targets
- implementation of the plan will contribute to maintaining the productive base of the water resource
- the plan will outline the key causes of water quality degradation in the Murray–Darling Basin — such as salinity, algal blooms, water temperature, dissolved oxygen, suspended matter, toxicants, nutrients, pH and the release of acid and metals from acid sulfate soils — and promote a collaborative and integrated approach to managing them
- water quality and salinity targets set under the plan will not impose direct mandatory compliance obligations on government, instrumentalities or individuals. Instead, water quality management plans prepared at the regional level as part of water resource plans will include management actions that will ensure the water quality targets are achieved. In

Bottle Bend, near Mildura, affected by salinity and acid sulfate soils addition, flow management decisions made by operating authorities or infrastructure operators must have regard to any adverse impact on water quality at the Basin level.

The Water Quality and Salinity Management Plan will build on the existing intergovernmental water quality and salinity frameworks: the National Water Quality Management Strategy and the Basin Salinity Management Strategy.

The overarching objective is to maintain appropriate water quality, including salinity levels, for environmental, social, cultural and economic activity in the Basin. Under this objective a series of five water quality environmental values have been defined, each with a set of specific objectives (see Table 12.1). Targets will be set against each of these objectives, which give effect to the policy intent of the plan and seek to manage water quality to protect the assets of the Basin. These targets build upon previous water quality and salinity management strategies and policy positions of the Murray–Darling Basin Ministerial Council. They will include for the first time a salt export target for the Basin as a measure of a healthy river system.

Table 12.1 Water quality and salinity management values and objectives

Water quality environmental value	Specific objectives
Aquatic ecosystems — high conservation sites	To ensure that the quality of water is sufficient to maintain the ecological character of declared Ramsar sites, consistent with their ecological character description as published by the Commonwealth Department of Sustainability, Environment, Water, Population and Communities.
Aquatic ecosystems — regional	To ensure catchment-wide water quality is sufficient to protect and restore viable populations and communities of endemic biota. To ensure catchment-wide water quality is sufficient to protect and restore critical ecosystem functions such as energy, carbon and nutrient dynamics including primary production and respiration, particularly during drought periods.
Raw drinking water	Health related: To ensure that the quality of water supplied for treatment for human consumption does not result in adverse human health effects. Aesthetic related: To maintain the palatability rating of water supplied for treatment for human consumption at 'good' (NHMRC and NRMMC 2004) and to ensure that the odour of drinking water is not offensive to consumers.
Irrigation water	To maintain water quality at current levels or better, suitable for a range of crops typically grown across the Basin.
Recreational water	To protect health of humans from water quality threats posed during recreational use of the water bodies of the Basin.

Salinity levels can be highly variable and, while much floodplain and instream life is adapted to this variability, the frequency and duration of high-salinity events can affect the resilience and sustainability of aquatic ecosystems. High salinity also reduces the suitability of water for drinking purposes, irrigation and industrial use; contributes to the loss of productive land; and adversely affects public and private infrastructure. The objectives and targets have been designed to take such variability into account.

Water quality and salinity issues will be managed at Basin, state and regional levels depending on the nature of the issues.

Water quality and salinity issues best managed at Basin level will usually have one or more of three attributes: Basin-wide impact, size is of such magnitude that coordinated action of an operational nature will be required, and management responsibilities will already be shared (as in the case of salinity). At this level, river managers will need to plan, coordinate and implement river operational actions relevant to achieving Basin-wide water quality targets. Generally, management actions will relate to flow management and infrastructure construction and operation.

Some water quality issues will be managed through state water resource plans, with their details identified in the water resource plan accreditation requirements. To fulfil the Water Quality and Salinity Management Plan's objectives and targets, water quality management plans will be incorporated at appropriate scales in water resource plans.

For water quality and salinity issues best managed at a regional level:

- achieving water quality and salinity objectives and targets will be managed through water resource plans prepared by Basin states, with the detailed content identified in the water resource plan accreditation requirements
- it will be necessary for state agencies to develop water quality management plans at an appropriate scale (their specific nature will vary depending on the particular legislation, policies, strategies, programs and plans of individual states)
- specific water quality targets for aquatic ecosystems, relevant to water quality management plans, will apply.

As the plan is prepared within the context of the Water Act it cannot directly regulate land use or land use planning, the management of natural resources (other than water) or the control of pollution. However, the Authority recognises that water and salinity can be significantly affected by activities in the catchment. Therefore, to maximise the effectiveness of state and regional water quality and salinity management plans, these plans will need to align with existing and evolving land use planning and catchment management plans and actions.

12.3 Water trading rules

Water markets

One of the management objectives proposed for the Basin Plan is to improve the transparency and efficiency of water markets within the Basin. The *Water Act 2007* (Cwlth) (s. 22) requires that rules for the trading or transfer of tradeable water rights in relation to Basin water resources must be included in the Basin Plan. These trading rules will complement the water market and water charge rules also required under the Water Act, which are set by the Commonwealth Water Minister (see explanations box).

A central tenet of water reform in Australia over recent years has been the use of water markets to facilitate the movement of water to its most productive use. Water trade allows users improved flexibility and provides another option for them to better manage risks and better align their water portfolios with their business/water use needs. Because of this, the water market has become an increasingly important tool for water users.

The water market is set up to allow trade of water access entitlements ('entitlement trade') and trade of water allocations ('allocation trade'). Entitlement trade means that the actual ownership of the underlying right changes hands, whereas allocation trade is a one-off transaction that moves a defined volume of water from one account to another and is generally only available for that year.

Water users may engage in allocation trade and entitlement trade based on a range of business decisions. There is increasing evidence of farmers using the market as a business risk management tool.

Such trade is regulated by state legislation, which in the future will need to be consistent with the framework of the Basin Plan and its trading rules.

Weir on the Culgoa River, Queensland

There are a number of constraints on the efficient operation of the water market in the Basin including physical, environmental and hydrologic constraints, market maturity, the experience of market participants and structural and governance arrangements.

Physical constraints may include an irrigation channel, a pipeline or a river channel with limited carrying capacity, meaning that at times of high water demand it may not be physically possible to supply traded water to some areas. A specific example of a physical constraint is the Barmah Choke, which is located on the river Murray. The narrow and shallow nature of the river at the Barmah Choke limits the volume of water that can pass through the choke in any one day, without increasing losses as a result of water spilling into and passing through the Barmah–Millewa Forest.

Environmental constraints are the maximum or minimum flow limit that does not compromise environmental assets. An example of an environmental constraint is the timing and volume of an environmental water requirement of a specific asset within the Murray–Darling Basin.

Flood irrigated pasture in the Goulburn Valley region, Victoria

Hydrological constraints are related to the ability to deliver water from one regulated system (or trading zone within a system) to another depending on its hydrologic connectivity. If two water sources are connected water can be diverted between them. However, the water needs to be delivered without unacceptable incremental losses or adverse third-party impacts.

Water trade can clearly play an important role in mitigating the impact of reduced diversions for irrigators. However, to achieve the full benefits of water trade will require the development of more sophisticated markets over time. While the Authority believes the trading rule provisions are appropriate given the current level of maturity in the Basin water market, there is significant scope to reconsider the current design of the water market in the future, using the example of other markets such as the energy and property markets. Further research on this issue will be undertaken by the Authority.

However, even with sophisticated markets, water trade is only one part of the solution to efficient and effective water use in the future.

The Australian water markets report 2008–09 (National Water Commission 2009) estimated the value of water transactions Australia-wide at approximately $2.8 billion per year in 2008–09. Current water markets are limited by barriers to trade and a lack of market information exchange, the inevitable result of differing arrangements between Basin states.

Trading rules and information access

The aim of the Basin Plan water trading rules is to develop an efficient water-trading regime by removing barriers to trade, such as inconsistent interstate rules or inefficient processes and lack of easily accessible information for users. This will facilitate the movement of water to its most productive use.

The differences between water trading rules, water market rules and water charge rules

Water trading rules

Trading rules will be included in the Basin Plan and deal with the trade or transfer of tradeable water rights (i.e. water access rights, water delivery rights and irrigation rights) in relation to Basin surface-water and groundwater resources. The rules will govern the terms for trade and processes by which rights will be traded, while also imposing or removing barriers to trade and ensuring the availability of information to increase the efficiency and transparency of Murray–Darling Basin water markets.

Water market rules

Market rules relate to the actions of irrigation infrastructure operators that prevent or unreasonably delay transformation arrangements, or the subsequent trade of any transformed water access entitlement. 'Transformation' is the process that allows a person to convert their entitlement to water held under an irrigation right against an irrigation infrastructure operator's entitlement into a separately held, tradeable water access entitlement (Water Act s. 97(1)).

The water market rules do not require operators to transform the irrigation rights of all their customers. Transformation can only be triggered by a request from an irrigation right holder and, once requested, the operator is generally required to facilitate transformation.

Water charge rules

Charge rules impose various requirements in relation to regulated water charges. Water charges that can be regulated are set out in the Water Act (s. 91) and include:

- fees and charges payable to an irrigation infrastructure operator (e.g. for access or changing access to an irrigation network, for terminating access, and for related services)
- charges levied by infrastructure operators and water authorities for providing water storage and delivering water to downstream users
- charges for water planning and water management activities
- other fees or charges prescribed by regulation.

The water trading rules set out in the proposed Basin Plan are based on the advice of the Australian Competition and Consumer Commission, with a number of minor changes. They will:

- apply to all Basin water resources from when the Basin Plan is adopted. Under the Water Act (s. 4), these are defined as all water within or beneath the Murray–Darling Basin, except for groundwater that forms part of the Great Artesian Basin, or other water resources excluded by regulations
- affect all entities wishing to buy or sell water within the Basin. All buyers, sellers and administrators of water (including Basin states and irrigation infrastructure operators) will be required to comply with the water trading rules as set out in the Basin Plan from the time that the plan commences (subject to the operation of transitional and interim water resource plans). This will ensure consistency and transparency within the water market

- address the terms and processes for trading water, the manner in which trade is conducted, and the provision of information to enable trading to take place
- contribute to achieving the Basin water market and trading objectives and principles in Schedule 3 of the Water Act
- apply to different types of tradeable water rights within the Murray–Darling Basin, including water access rights (such as entitlements and allocations), irrigation rights and water delivery rights
- address general matters regarding the trade and tradability of water access rights, approval mechanisms, changes in location of extraction and other issues including:
  - reduce barriers to trade that are based on ownership restrictions
  - ensure that the trade of a water access right is separate from other approvals that may be required where water rights are unbundled
  - reduce barriers to trade based upon the intended use of water
  - reduce barriers to trade that may be imposed on trades into and out of the Basin
  - ensure trade is not used as a method to address overallocation and overuse issues
  - ensure trade restrictions are not placed on water carried over
  - reduce barriers to trade by removal of volumetric trade limits
- require approval authorities to disclose their other trade activities in order to improve market confidence by addressing potential or perceived conflicts of interest
- provide the conditions that need to be met in order for trade to occur within a groundwater resource
- provide the conditions that need to be met in order for trade to occur between groundwater and surface-water resources
- reduce transaction costs by providing for the specification and separation of water delivery rights
- reduce barriers to the trade of water delivery rights
- require irrigation infrastructure operators to specify the volume/unit share of irrigation rights and water delivery rights.

However, to ensure that the environmental water requirements of the Basin are met, water trade in the Basin will inevitably require the existence of some barriers to trade to take account of the physical and hydrologic configuration of the Basin's water resources. Environmental requirements for water will also limit the capacity for increased volumes of trade in some catchments.

Rice in the Riverina, Victoria

Access to timely and accurate information (such as characteristics of tradeable water rights, trading volumes and prices, allocation and policy announcements) is critical to a well-functioning water market. The provision of market information allows market participants to make timely and informed decisions about managing their water access

Brolga in Kinnairds Swamp near Numurkah, Victoria

and delivery needs. Good information flows can also contribute to lowering transaction costs.

Under the Water Act (s. 26), water trading rules may deal with the availability of information to enable the trading or transfer of tradeable water rights, and the reporting of trades and transfers. The proposed water trading rules will basically set out the minimum information requirements for the operation of markets within the Basin.

Processes are already under way to improve the reporting and availability of information for market participants. The Commonwealth Department of Sustainability, Environment, Water, Population and Communities is developing a National Water Market System in conjunction with the Basin states.

To address reporting and the availability of information in the water market, the proposed Basin Plan water trading rules will provide for:

- a standardised form and common location for information regarding tradeable water right characteristics
- a standardised form and common location for information about trading rules and processes
- reporting of trading prices
- standards for allocation and policy announcements.

12.4 Accreditation of water resource plans

Accreditation arrangements

Under the process of water reform that commenced with the National Competition Policy reforms in the 1990s and continues today with the National Water Initiative, Basin states have been working towards the development of regulatory and planning-based systems of managing surface-water and groundwater resources. There has been significant progress in the development of water resource plans, the provision of water for the environment, the creation of legally enforceable water access entitlements and water markets. The Basin Plan builds on this work by creating a Basin-wide framework within which these plans, entitlements and markets can operate.

While the Authority will play a significant strategic role across the Basin, each Basin state maintains the authority and responsibility to manage the use of its water resources, but within the framework set by the Basin Plan. To this end, the *Water Act 2007* (Cwlth) requires each water resource area in the Basin to be managed under a water resource plan that is consistent with the Basin Plan. Basin states may prepare plans for accreditation by the Commonwealth Water Minister.

The Commonwealth Water Minister, with advice from the Authority, will accredit water resource plans prepared by states. Figure 12.1 illustrates the current situation regarding the timing of the accreditation of water resource plans.

Accredited water resource plans will enable water users to undertake their business planning and water management in much the same way as they do now, but with the adjustments needed to be consistent with a Basin-wide planning framework.

A water resource plan consists of one or more documents that specify the principles, processes, rules, regulations, provisions and linkages of water management that the state intends to apply in the water resource plan area.

The accreditation of state-developed water resource plans will ensure that those plans remain the primary tool for implementing water resource management in the Murray–Darling Basin, and that state decisions regarding the level of water use and provision of water to environmental assets are made consistently with the Basin Plan.

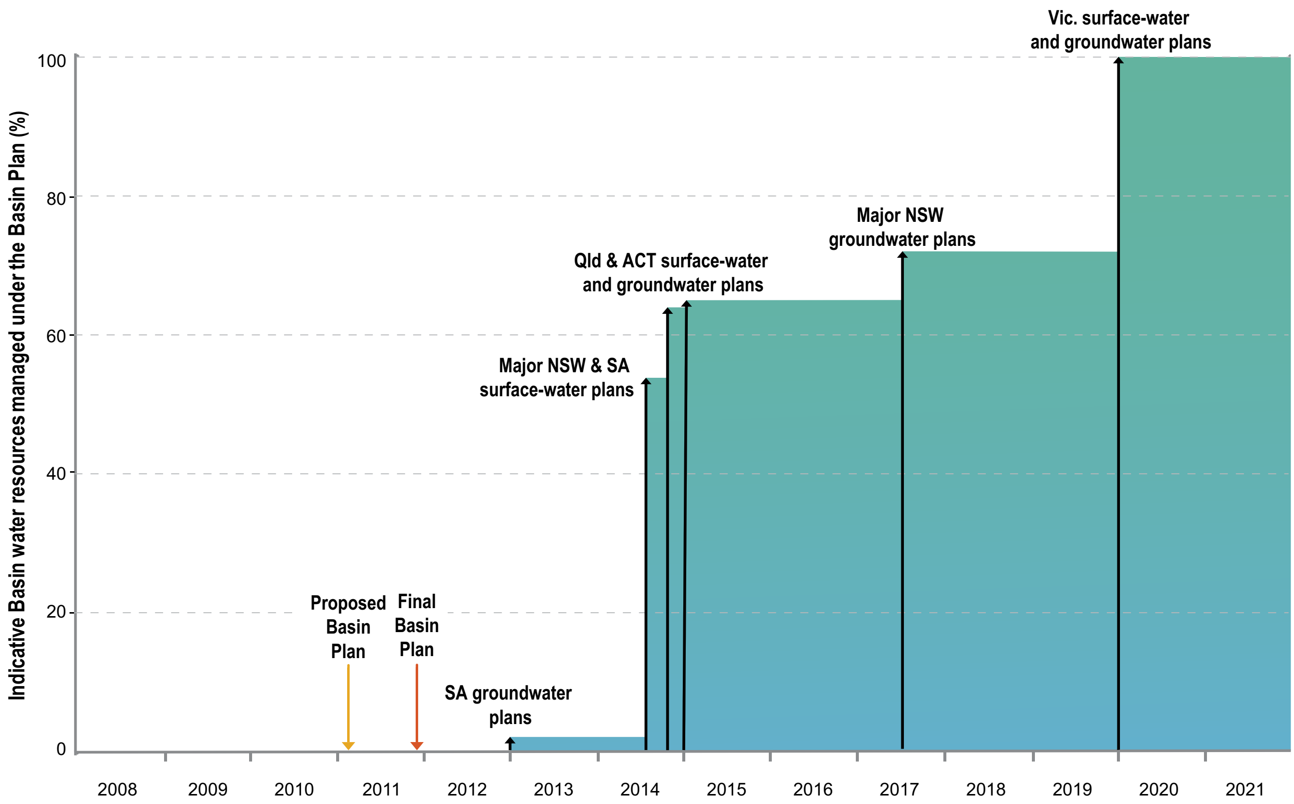


Figure 12.1 Indicative timing and percentage of Basin water resources managed by the Basin Plan: Murray–Darling Basin

The Authority will have the role of assessing proposed water resource plans prepared by Basin states for consistency with the Basin Plan (including the accreditation requirements) and providing advice about accreditation to the Commonwealth Water Minister.

To assist Basin states in preparing water resource plans, the Authority will prepare accreditation criteria that it will apply in assessing proposed water resource plans.

The sequence of events in achieving accreditation of water resource plans for water resource plan areas is outlined in the flowchart in Figure 12.2.

Once accredited or adopted, a water resource plan will be in effect for 10 years unless the plan ceases to operate at an earlier time.

Individuals, organisations and governments will be required to comply with the obligations imposed by the Basin Plan and by the relevant water resource plan.

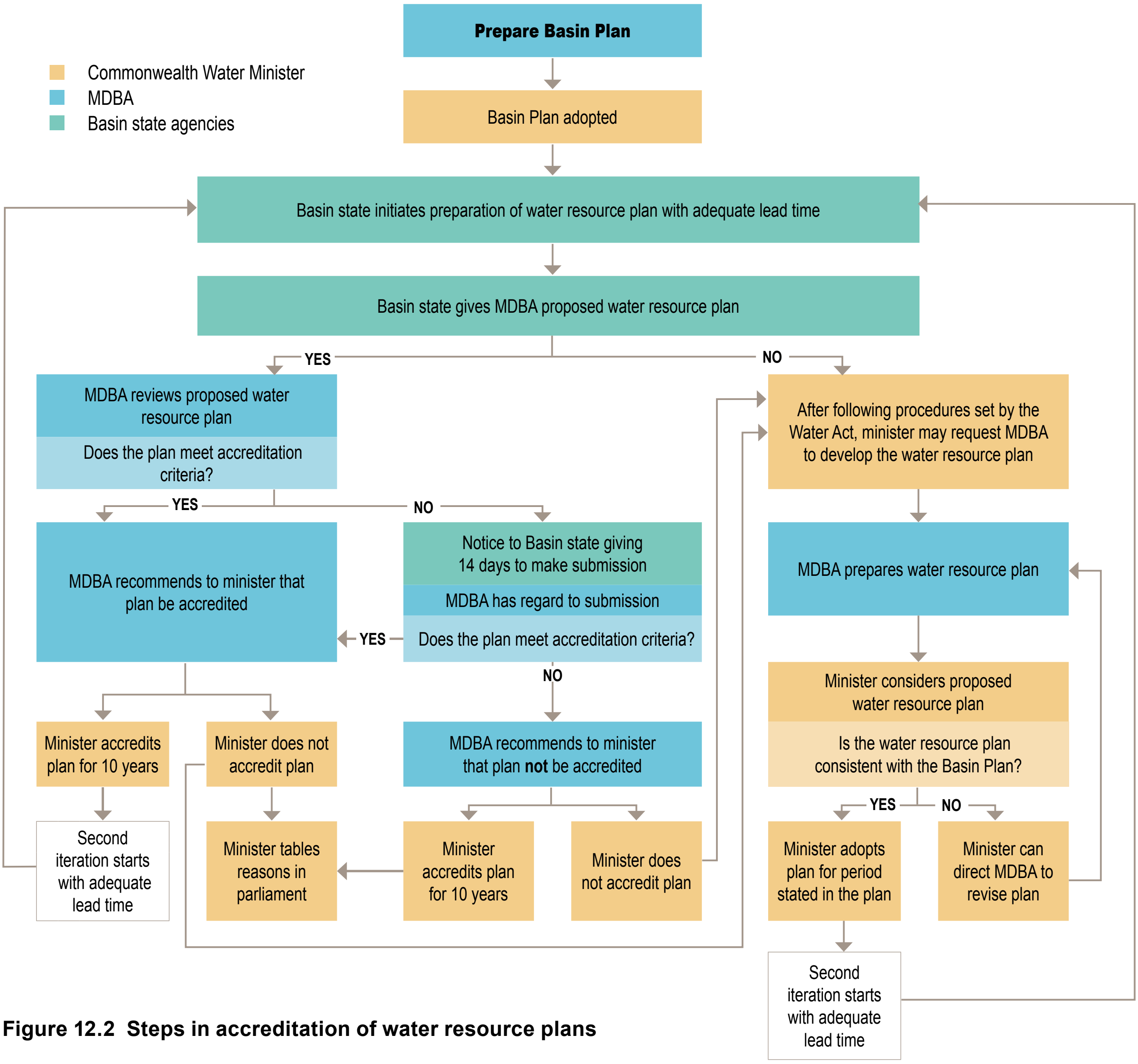


Figure 12.2 Steps in accreditation of water resource plans

Water resource plan requirements

Water resource planning instruments set out in Schedule 4 of the Water Act are transitional water resource plans. Instruments made on or after 25 January 2007 and before the Basin Plan comes into effect are interim water resource plans. These transitional and interim water resource plans are deemed to have been accredited by the Commonwealth Water Minister under the Water Act (ss. 63–67).

Transitional and interim water resource plans cease to have effect at various dates (between 2012 and 2019) and will be replaced by accredited water resource plans.

New accredited water resource plans will:

- ensure complete coverage of the Basin, using a consistent set of water source and planning boundaries
- encompass a greater range of matters than the current state water planning instruments
- provide the mechanism for implementing new long-term average sustainable diversion limits for the Basin's water resources.

The Authority and the Commonwealth Water Minister are required to assess whether proposed water resource plans are consistent with the Basin Plan. This process needs clearly articulated accreditation requirements, a transparent evaluation framework and robust accreditation process.

The Basin Plan will define a set of requirements that must be met prior to a plan being accredited. These include the mandatory requirements of the Water Act (s. 22(3)), which will require a water resource plan to include matters relating to:

- identification of the water resource plan area
- how the long-term annual diversion limit will be applied in the water resource plan area
- how the water resources of the area will be sustainably used and managed within the sustainable diversion limit
- how significant interception activities will be regulated or managed and possibly changed
- planning arrangements for environmental watering
- the water quality and salinity objectives for the plan area
- the water trade arrangements
- how risks to the water resources will be addressed
- metering and monitoring arrangements for the water resource
- reviews of the water resource plan and amendments arising from reviews
- the information and models upon which the water resource plan is based.

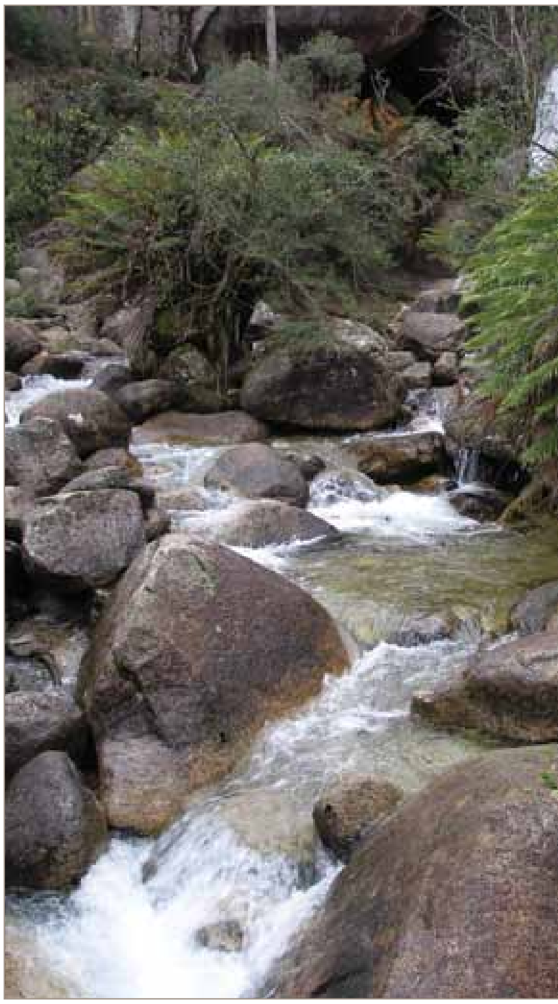
In addition to these mandatory requirements under the Water Act, the Authority also proposes that the Basin Plan will require water resource plans to:

- ensure that they are robust enough to continue to operate during extreme and unprecedented events
- specify the Aboriginal interests and values in the water resource
- specify the consultative arrangements upon which the water resource plan will be developed.

13. The outcomes of the proposed Basin Plan

Key points

- The Murray–Darling Basin Authority has developed six strategic objectives for the proposed Basin Plan. Meeting these objectives is anticipated to result in outcomes related to improving ecological health, improving water quality, improving water management arrangements, and enhancing the ability of communities to adapt to less water.
- The plan is likely to substantially improve the key ecosystem functions and key environmental assets of the Basin so that in the long term: the ecological functioning of most rivers is likely to improve to a 'good' rating; the health of the Basin's key environmental assets should be stabilised and then improved; the current poor condition of the Basin's river red gum, native fish and waterbird communities should improve; and the many species of birds, fish, invertebrates, mammals and reptiles currently threatened or endangered are likely to be less vulnerable.
- The plan should ensure that the use of the Basin's water resources will not be adversely affected by decreasing water quality by exporting salt from the Basin so that agricultural production can continue into the long term; halting the projected increase in median salinity levels in South Australia; and preventing the deterioration of the Basin's environmental assets.
- Implementation of the plan will improve clarity in water management arrangements, including a Basin-wide approach; improve certainty of access to the available resource; reduce the tension between Basin states and competing interests upstream and downstream; and allow the Basin to be managed as a whole system and in the national interest.
- The Authority recognises that many Basin entitlement holders and communities may experience short- to medium-term reductions in economic activity as a result of SDLs. However, effective management of the transition should help Basin communities manage their adjustment to reduced volumes of consumptive water.



Waterfall in Mount Buffalo National Park near Bright, Victoria

The *Water Act 2007* (Cwlth) has a set of objects that clearly outline what is intended to be achieved by the Act.

The Water Act requires the development of a Basin Plan and describes the purpose of the Basin Plan as providing for the integrated management of the Basin's water resources in a way that promotes the objects of the Act (s. 20) in the national interest. The Water Act also includes a table of mandatory items that the Basin Plan must contain (s. 22). One of these is the management objectives and outcomes to be achieved by the Basin Plan. The objectives and outcomes must address:

- environmental outcomes
- water quality and salinity
- long-term average sustainable diversion limits and temporary diversion limits trading in water access rights

Black ducks at Reedy Swamp near Shepparton, Victoria

As a result of this requirement the Authority has developed a number of strategic objectives for the proposed Basin Plan, which are to:

- maintain and improve the ecological health of the Basin, and in doing so optimise the social, cultural, and economic wellbeing of Basin communities
- establish limits on the quantity of surface water and groundwater that can be taken from the Basin's resources for consumptive use, based upon a determination of what is environmentally sustainable at a catchment and a whole-of-Basin level
- improve the resilience of key environmental assets, water-dependent ecosystems and biodiversity in the face of threats and risks that may arise in a changing environment
- maintain appropriate water quality, including salinity levels, for environmental, social, cultural and economic activity in the Basin
- improve the transparency and efficiency of water marksets within the Basin
- provide a clear transition path for entitlement holders and communities through the period from plan adoption to implementation at local level.

Meeting these objectives is anticipated to result in the following outcomes:

- water-dependent ecosystems in the Basin would be more able to withstand short and long-term changes in watering regimes resulting from a more variable and changing climate
- use of Basin water resources would not be adversely affected by water quality, including salinity levels
- there would be improved clarity in water management arrangements in the Basin, providing improved certainty of access to the available resource
- Basin entitlement holders and communities would be better adapted to less water.

Achieving these objectives and outcomes will require a robust partnership between state, territory and Commonwealth governments and the Basin community.

13.1 Outcome 1 — Ecological health

Chapter 2 describes the Murray–Darling Basin's environment and includes an assessment of the Basin's current condition provided by the Sustainable Rivers Audit. This audit assesses the health of the Basin's river systems every three years (see Chapter 2, tables 2.2 and 2.3) and it found that between 2004 and 2007, only one (the Paroo) of the 23 river valleys of the Basin was in a 'good' condition. A further two river systems — the Condamine and Border Rivers — were in 'moderate' condition, and all other river valleys across the Basin were in 'poor' or 'very poor' ecological health.

Improved connectivity along the Basin's rivers will enhance fish migration for foraging and spawning, resulting in more sustainable and resilient native fish populations. Transportation of organic matter, nutrients and sediment, as well as flushing of salt from the system, will be improved with increases in water available to the environment. Improved connectivity will also enable transport of aquatic invertebrates and aquatic plant seeds, enhancing the overall ecological condition of rivers and wetlands across the Basin.

This additional environmental water will also improve the connection between the rivers and their floodplains by increasing the frequency and duration of flooding and providing better watering of wetlands, aquatic vegetation and floodplain forests.

In many lowland rivers, the return flows from flooded wetlands and floodplains can supply organic matter and nutrients to the river. The timing and frequency of this important exchange of materials between rivers and their floodplains will be improved through the additional water for the environment, which is expected to result in a better balance of nutrients, improved diversity of aquatic communities within the river systems, a reduction in the frequency of algal blooms and improved water quality throughout the Basin.

The Basin Plan will allow water-dependent ecosystems to become more resilient by providing sufficient environmental water to enable them to withstand short- and long-term changes in watering regimes that will inevitably result from a more variable and changing climate.

In summary, the overall environmental benefits from the range of additional water for the environment would be to improve the ecological health and resilience of the Basin's key environmental assets and key ecosystem functions. This improvement would be measurable through increases in native fish abundance, increased numbers of waterbirds and improved condition of water-dependent vegetation communities such as river red gums. The Authority recognises that it will take time for some of these anticipated improvements to be measurable, but that it should be possible to stabilise the decline in most degraded systems within five years of the Basin Plan being implemented, while the signs of improved conditions should be obvious within 10 years.

If the return of an additional 186 GL of groundwater were to be adopted, the overall health of groundwater systems across the Basin, would also be improved and groundwater extractions would be sustainable.

The Environmental Watering Plan will provide a planning framework for delivering this water in the most effective and efficient way. Effective delivery will require detailed and well-managed environmental water planning to ensure water use is optimised in relation to climate variability and water availability.

13.2 Outcome 2 — Water quality

The Water Quality and Salinity Management Plan will ensure the protection and enhancement of water quality in the Murray–Darling Basin by setting water quality targets across the Basin. This includes a Basin-wide target to export a long-term minimum of two million tonnes a year (10-year rolling average) of salt out of the Basin. Export of Basin salt through the Murray Mouth to the ocean is necessary for the Basin to continue as a freshwater system. It also supports improved water quality for human consumption, irrigation and the environment.

Water quality is largely controlled by the volumes of water that flow down the river and the condition of the catchments. The Authority is confident that the water quality targets in the Water Quality and Salinity Management Plan can be met within the range of SDLs presented. These targets will lead to improved water quality outcomes as natural resource managers develop strategic water quality-related operating rules, invest in infrastructural change to achieve water quality outcomes, and integrate operational decision-making with catchment management and pollution control considerations.

13.3 Outcome 3 — Water management arrangements

The Basin Plan will clarify water management arrangements in the Murray–Darling Basin, providing improved certainty of access to the available resource for both consumptive and environmental purposes. This improved clarity starts with a Basin-wide approach to the management of the Basin, reducing the tension between states and competing interests upstream and downstream and instead managing the Basin's water resources as a whole and in the national interest and providing improved water security for all uses of the Basin water resources.

Water security

Improved water security for all uses of Basin water resources is an object of the *Water Act 2007* (Cwlth) and, similarly, a purpose of the Basin Plan. Improved water security is provided through the transparent, statutory, Basin-wide arrangements for water management. For example, these arrangements will reduce procedural uncertainty in the development of water planning arrangements through the several stages of consultation required in the development of the Basin Plan.

Improved water security is a significant positive outcome of the new arrangements. It will be achieved through the provision of greater certainty, and a higher level of Basin-wide consistency, in water planning arrangements. Water security is often interchangeably described as certainty, and a major benefit of its provision is the ability to invest in use of water access rights in the knowledge that their terms and conditions, and the management rules that affect these rights, will not alter over a defined period. Accordingly, the benefits of water security flow through to the individual entitlements and the holders of these entitlements, providing a secure property rights framework.

A key aspect where water security will be provided is in relation to the accreditation of water resource plans. Water resource plans will be developed by Basin states according to requirements specified in the Basin Plan and will be accredited by the Commonwealth Water Minister on the recommendation of the Authority. Accreditation of water resource plans will ensure that Basin states can optimise water planning and management while ensuring that

Basin state decisions regarding the level of water use and provision of water to environmental assets and ecosystem functions are made with regard to the national interest and Basin objectives. For the first time, the actions of Basin states across the Basin will meet their individual requirements and be aligned with the interests of the Basin as a whole.

These new water resource plans will be accredited for 10 years by the Commonwealth Water Minister, on the advice of the Authority, if they are assessed as being consistent with the Basin Plan. This accreditation for 10 years will apply throughout the Basin and replace the state-based variation in the lifetimes of existing plans or the review periods associated with the water planning arrangements. Once accredited, a water resource plan will provide certainty for a 10-year period, including in relation to the long-term average sustainable diversion limit (SDL), so that if the Basin Plan is amended during this period, the new Basin Plan requirements would not take effect until the expiry of the accreditation.

While the Basin Plan will provide for greatly enhanced water security through the provision of greater certainty in management arrangements, it is not possible to provide any specific guarantees about the volume and timing of water availability over the life of the Basin Plan and the Basin state water resource plans. That is, while water entitlements will have clearly defined features associated with the proprietary right, the actual water access they will support will depend, primarily, on rainfall. Through clear and transparent planning arrangements and 10-year accreditation processes, areas of uncertainty can be reduced to those external climatic factors, which can be expected to become more variable as the effects of climate change become more evident in south-eastern Australia, with the potential of decreased water availability and increased rainfall variability. Governments can, however, invest in better understanding of these climatic factors and the provision of information associated with this research. This will be a key aspect of the work of the Authority throughout the implementation of the Basin Plan, including drawing on the work of the Bureau of Meteorology and Basin states in this area.

Under current statutory arrangements, Basin states have the authority to suspend water management arrangements in some circumstances, such as in times of extreme drought. Requirements specified in the Basin Plan will include the need for water resource plans to be capable of operating under the full range of anticipated climatic conditions, as well as to contain provisions for dealing with unprecedented situations. This will also provide greater certainty in water management arrangements under the full range of possible future conditions.

Reliability

The impact of the Basin Plan on the reliability of existing water entitlements is harder to specify, and the exact extent of the changes will not be possible to determine until the relevant Basin Plan-compliant water resource plans have been accredited by the Commonwealth. Within a particular water resource plan area, the relevant Basin state will determine the way in which SDLs and other requirements of the Basin Plan are distributed locally, including between holders of different types of water entitlements. Changes to the reliability of water allocations may be caused by the implementation of various elements of the proposed Basin Plan, in particular SDLs and the specific requirements against which new water resource plans will be accredited. The intention of the Government to bridge any remaining gap between what has been returned to the environment under the Water for the Future program and what is required to be returned under the Basin Plan by continuing to buy back water from willing sellers substantially reduces, though does not eliminate, the potential for change in reliability associated with the implementation of the Basin Plan.

Water trading

Basin-wide water market rules and water charge rules, and improved access to information, will facilitate a properly functioning and enhanced water market, assisting water entitlement holders to manage their assets more effectively.

The Basin Plan water trading rules will provide a solid foundation upon which to base the water market. The water trading rules aim to create a more mature water market in which buyers and sellers can operate with confidence. They aim to minimise administrative delays, transaction costs and third-party impacts. They also aim to create a water market that will allow water to reach its highest-value use.

The Basin Plan water trading rules will provide for trade restrictions based on environmental constraints. This restriction on trade creates a link between the operational aspects of water trade with the Environmental Watering Plan provisions. Holders of environmental water will be required to adhere to the Basin Plan water trading rules, but as the Basin Plan water trading rules will expand the ability to trade throughout the Basin and reduce restrictions on trade, more opportunities to trade water for environmental purposes will be created in the future.

Positive environmental outcomes as a result of water trade are not limited to water traded for environmental purposes or even instream environmental improvements. An efficient and effective water market will move water to more efficient water uses. This can result in land-based environmental improvements at the point of application. An example of this is water use moving from a high-impact salinity zone to a low-impact salinity zone.

The Basin Plan will provide for greater consistency in processes and terminology surrounding water transfers across the Basin. As a result of the trade rules in the Basin Plan, the water market and associated administrative processes will operate in a more transparent manner with easy access to information required to make investment and portfolio management decisions. The trade rules and administrative processes should be better understood by those in the market and entail less duplication.

13.4 Outcome 4 — Basin entitlement holders and communities

The Authority recognises that the Basin Plan, will have a substantial economic effect on some Basin communities. Recognition of this impact has led the Authority to place a very strong emphasis on the transition plan for entitlement holders and communities. In the longer term, the Basin Plan should assist Basin entitlement holders and communities to adapt to reduced available water.

The arrangements under the Basin Plan and the Murray–Darling Basin Agreement ensure that critical human water needs are met, so safeguarding the needs of the communities that rely on the Basin's water resources.

The Basin Plan will improve the long-term certainty of surface-water entitlements by discouraging water interception activities, eliminating the potential for overextraction in highly connected groundwater systems, sustaining or improving water quality and salinity levels, preparing for the impacts of climate change, and improving certainty and flexibility within the water market system.

Reductions in water use under the SDLs will drive improvements in water use efficiency, which will make agricultural production more resilient to shocks and prepared for climate change impacts in the future. The Basin Plan will also improve the certainty of groundwater entitlements by stabilising groundwater levels.

The Basin Plan will also provide a framework that can contribute to other positive outcomes. These include sustainable industries demonstrating leadership in water use efficiency, cutting-edge technologies, new crops and innovative land and water management suited to the Australian environment. In parallel, vibrant river communities can demonstrate leadership in restoring their local environments, developing new opportunities, and responding to the challenges of water scarcity with imagination and enterprise.

Basin state water resource plans accredited under the Basin Plan will be consistent with the environmentally sustainable level of take, and long-term average sustainable diversion limits (SDLs) will apply to all forms of water take including watercourse take and interceptions of water due to activities such as forestry plantations and farm dams. For the first time, the management of water take will be treated consistently across all forms of take, so that all users of water are treated consistently and fairly. The inclusion of all forms of water use in the SDLs will provide increased certainty for the environment and all water users, including irrigators. For example, unmanaged growth in any aspect of water use (e.g. interception activities), which would impact on other users, will no longer be possible under the Basin Plan.

As a result of the SDLs set by the Basin Plan, the management of the various groundwater resources of the Basin will be on a sustainable footing. Systems that are currently overallocated will be brought back to a sustainable level of take and the risk of long-term damage to the aquifers minimised.

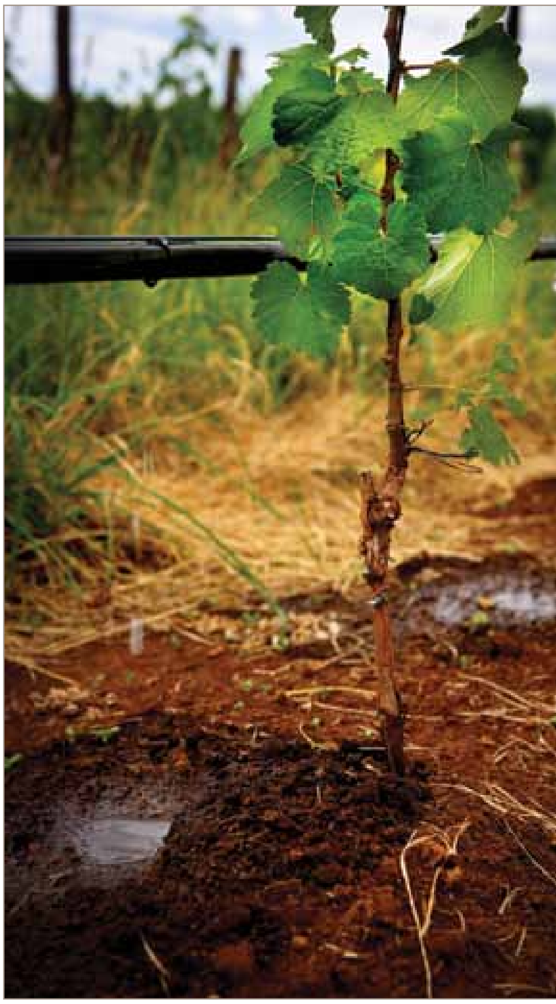
14. Delivering outcomes

Key points

- The *Water Act 2007* (Cwlth), through the Basin Plan, establishes a new paradigm in water resources management in the Basin: the environment will be a genuine stakeholder in water resources management. Success under this new paradigm requires a robust adaptive mechanism to ensure that the Basin Plan's management objectives and outcomes are delivered.
- It is proposed that the extensive compliance and enforcement powers available to the Authority should not be used as a matter of first resort — rather that collaborative action will better serve the future of the Basin. However, robust monitoring and evaluation, allied with transparent reporting, must support such an approach.
- The method for determining diversion limit compliance will involve an annual volume of 'permitted take' that will vary in response to variability in climate, flows and other factors. At the end of each water year, the Authority will audit whether the actual take for that year is in compliance with the permitted take and whether water resource plan rules have been correctly applied.
- Between the Basin Plan taking effect and the implementation of accredited water resource plans, the existing Cap process will continue under the auspices of the Murray–Darling Basin Agreement.
- The Monitoring and Evaluation Program will enable evaluation of whether the Basin Plan has been effective in achieving its objectives, and will also measure progress against targets and other outcomes.
- Regular public reporting will be vital to assure the community that progress in addressing Basin health is being made. It is proposed that an annual account of all environmental water in the Basin be published.
- The minimum period within which the Basin Plan must be reviewed is 10 years, although it may be reviewed earlier on the request of all Basin states or the Commonwealth Water Minister. In addition, the Basin Plan Monitoring and Evaluation Program must provide for 5-yearly reviews of the Environmental Watering Plan and the Water Quality and Salinity Management Plan.

To deliver the outcomes of the Basin Plan, the Authority will establish:

- a compliance and enforcement regime that ensures relevant parties are delivering on their obligations
- transparent reporting and review processes to communicate outcomes and progress to stakeholders and the community
- a future work program to determine what else needs to be done to further the objectives of the Basin Plan.



Vineyard near Wangaratta, Victoria

The Authority restates its commitment to the success of the Basin Plan through an 'adaptive management' approach — that is, one that recognises success, will require all parties to respond adaptively to the changing conditions facing the Basin, and the increasing knowledge of trends, condition of environmental assets and impact of management.

Adaptive management involves 'learning by doing': a feedback loop of monitoring, reviewing and where necessary changing approaches to respond to changing conditions in the Basin and new knowledge.

The scale involved in implementing the Basin Plan is significant because it involves, for the first time, coordinating and managing water resources across the Basin in the national interest for current and future generations. This will require the Commonwealth, Basin states and all parties affected to better manage water resources so that this becomes part of an ongoing and active process of learning, review and action. This is central to an adaptive management approach.

14.1 Compliance and enforcement

Roles of the participants

The *Water Act 2007* (Cwlth) sets out a new role for the Commonwealth in water resource regulation, compliance and enforcement, to run concurrently with Basin state legislation.

Scientists undertaking acid sulfate soil testing, Loddon River, Victoria

The Basin Plan will directly impose obligations on Commonwealth and Basin state agencies. These obligations will flow from the Environmental Watering Plan, the Water Quality and Salinity Management Plan, the Monitoring and Evaluation Program and trading rules. In addition there are explicit requirements for accreditation of water resource plans.

The Authority will be the primary regulator of compliance with the Basin Plan and water resource plan rules. It is expected that Basin states' water resource plans will be the primary means to ensure compliance of water entitlement holders.

Existing state transitional and interim water resource plans prevail over the Basin Plan to the extent that they include inconsistent provisions. Under the Water Act, the Commonwealth Water Minister must decide whether to accredit new water resource plans, taking the Authority's advice into account.

Responsive compliance approach

A range of measures will be available to the Authority to achieve compliance with the Basin Plan's provisions (as shown in Figure 14.1). Measures will range from helping regulated parties to understand their obligations, to employing the full force of the Water Act to ensure compliance.

In the first instance, the Authority will help regulated parties to understand and voluntarily meet their obligations through:

- education and training — the Authority may choose to implement education and training programs with the regulatory community, including the Commonwealth, Basin state water agencies, infrastructure operators and water rights holders
- engagement and negotiation — the Authority may engage with regulated entities to address compliance issues by discussion, negotiation and (non-statutory) written agreement
- incentives — the Authority (potentially in conjunction with other Commonwealth entities such as the Department of Sustainability, Environment, Water, Population and Communities) may choose to offer funding incentives to demonstrate best practice, to help with adjustment to compliant or best-practice behaviour, or as tied conditional funding for Basin Plan implementation (e.g. the Water for the Future program buybacks, infrastructure and other investments)
- public affairs and communications — delivery of key messages through the media, stakeholder forums and publications as part of a regulatory strategy
- behaviour change in a community or industry
- audit — a key tool in a successful compliance strategy, allowing identification of non-compliance without necessarily leading to enforcement, providing the problem is addressed; both internal audit by the regulated entities and audit by the regulator (using powers if necessary) can be part of this strategy.

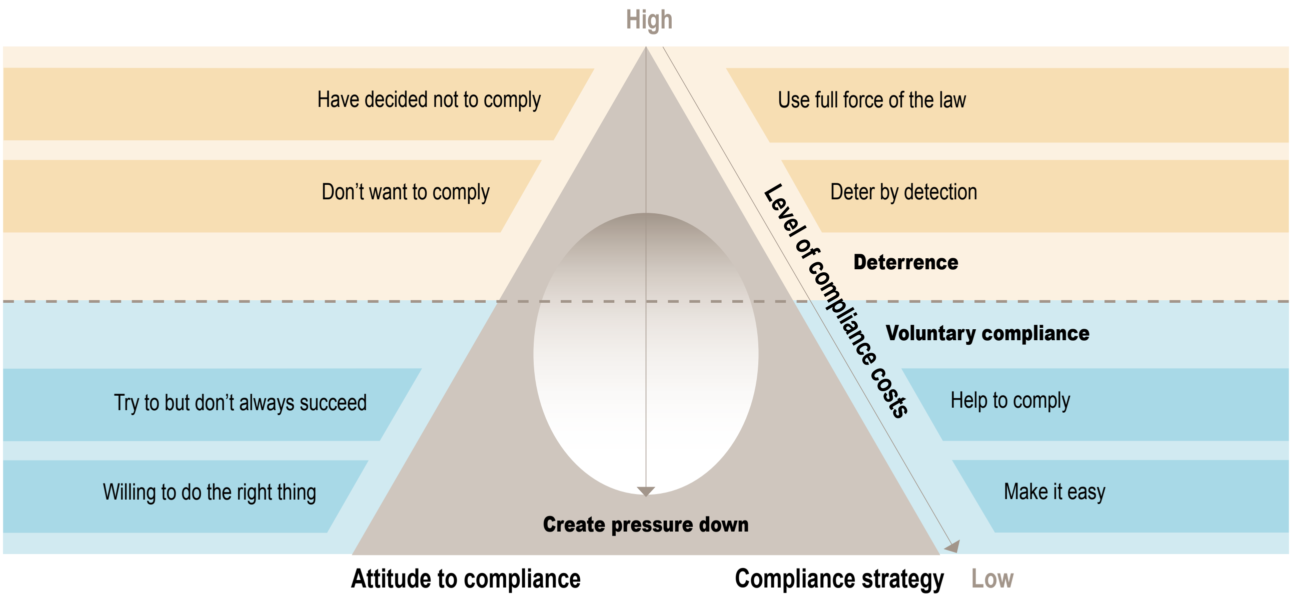


Figure 14.1 Compliance model pyramid

Source: Australian Fisheries Management Authority (2010)

Where these methods do not produce compliance, the Authority will enforce it through the transparent, consistent and accountable use of enforcement powers under the Water Act (noting that certain enforcement powers cannot be used against the Crown), including:

- requiring information to be provided to the Authority
- entering property for monitoring purposes
- applying to a magistrate to enter property for compliance monitoring purposes and to gather evidence

Irrigation near Cowra, New South Wales

- applying for a court injunction
- applying to a court for a declaration that a person or organisation is in contravention
- issuing enforcement notices
- entering into enforceable undertakings
- applying to a court for civil penalties for certain contraventions.

The Authority will be the enforcement agency for the Basin Plan obligations. While these enforcement powers extend to action against individual entitlement holders, it is proposed that this type of enforcement is better delivered at Basin state-level through compliance with water resource plans and that audit processes will play a significant role in ensuring compliance under the Basin Plan.

The Authority also considers that the extensive compliance and enforcement powers available to it should not be used as a matter of first resort — rather that collaborative action will better serve the future of the Basin. However, robust monitoring and evaluation, allied with transparent reporting, must supplement such an approach. In this way all parties will have access to the same evidence base, which will allow everyone to assess success and link strongly to adaptive management of the Basin's water resources.

The proposed Basin Plan will clearly and unambiguously indicate:

- what obligations apply
- to whom the obligations apply
- whether the obligations are imposed by the Basin Plan or whether the plan requires water resource plans to impose the obligations.

The Basin Plan's features will enable the regulated entities to identify their obligations, and enable the Authority to enforce them.

It is expected that enforcement of water resource plans by Basin states will be the primary means of compliance with water resource plan rules. While this is a state agency responsibility, the Authority will help through the application of consistent principles, a risk-based approach, training and support systems, and sharing of intelligence. These approaches will aim for a consistency in level of enforcement by Basin states.

Where Basin Plan or water resource plan obligations are contravened, a range of enforcement powers are available to the Authority (Water Act Part 8 — Enforcement), supported by powers to investigate and gather information and evidence (Part 10 — MDBA (special powers)).

The diversion limit compliance framework

The Basin's water resources will be managed within long-term average sustainable diversion limits (SDLs), which are the maximum volumes of water that can be taken over the long term from a water resource while reflecting an environmentally sustainable level of take.

The primary and default method for determining compliance with SDLs will be a volumetric annual limit that varies according to climatic conditions and relevant triggers in water resource plan rules.

Permitted and actual take definitions inform a diversion limit compliance test. Basin states are obliged to report compliance to the Authority. It is proposed to conduct and publish compliance audits to ensure the Basin states are correctly applying the compliance method.

A groundwater compliance method allows for the resource's characteristics such as slower response to rainfall. Permitted groundwater take will be based on calculations or an estimation of recharge rates for low-, medium- and high-risk aquifers.

Water resource plans will be required to contain rules that will be triggered when non-compliance is detected. These rules may, for example, require more conservative allocations to be made to remedy non-compliance with the SDL.

The Authority's most important initial responsibility will be to ensure that all stakeholders are aware of the new compliance framework. The diversion limit compliance framework impacts are likely to include increased scrutiny on the rules used to calculate allocations and permitted take.

Between the Basin Plan taking effect and the implementation of accredited water resource plans, the existing Cap process will continue under the authority of the Murray–Darling Basin Agreement. Any breach of the Cap by a Basin state during this period will not be enforceable under the Basin Plan.

The Authority intends to apply widely recognised principles of effective regulation such as transparently exercising discretion in deciding which enforcement powers to use and when.

14.2 Monitoring and evaluation

The Monitoring and Evaluation Program will enable evaluation of whether the Basin Plan has been effective in achieving its objectives, and will also measure progress against targets and other outcomes.

The program will therefore be a key component of review, adaptive management, improvement and, where necessary, amendment of the Basin Plan.

The Monitoring and Evaluation Program will:

- provide the framework for collection and analysis and publication reporting of the critical information needed to determine whether and how the Basin Plan is meeting its purpose, objectives and targets
- guide and facilitate data and information provision for annual reporting, and 5-yearly and 10-yearly reviews of the Basin Plan

Waterway assessment of the Wimmera River near Eversley, Victoria

- ensure, through reporting of outcomes, that Basin Plan activities meet Australian Government requirements for accountability and transparency, to enable learning and improvement
- provide the principal mechanism to reinforce, review and refine activities as part of an ongoing adaptive management process.

The monitoring and evaluation framework will address six key elements of the Basin Plan:

- ecosystem outcomes from the implementation of the Environmental Watering Plan
- water quality outcomes from implementing the Water Quality and Salinity Management Plan
- reporting on critical human water needs
- risks to the condition and availability of Basin water resources
- water trading and transfer rules effectively implemented
- socioeconomic impacts minimised.

The Monitoring and Evaluation Program will also establish the information needed to evaluate effectiveness of the Basin Plan, by using the approach of the Australian Government's framework for natural resource monitoring, evaluating, reporting and improvement.

The key method of this approach is to use program logic to identify cause–effect relationships between activities, expected outcomes and Basin Plan goals.

The expected outcomes are identified at immediate (0–5 years), intermediate (5–10 years) and long-term (10 or more years) scales. Indicators for these outcomes, which can be practically measured, will be selected in consultation with the Basin states before the Basin Plan commences.

Nine principles have been applied in the development of the Monitoring and Evaluation Program framework and will guide its implementation. They are:

- effective partnerships established between the Australian Government and Basin states by defining clear responsibilities and obligations for Basin Plan monitoring and evaluation activities
- program logic is the key tool for evaluating Basin Plan performance by establishing causal links between program activities and expected outcomes; conceptual frameworks and models are the basis for establishing causal links and for testing underlying assumptions

- best available scientific knowledge (biophysical, social and economic), evidence and analysis are used in the Monitoring and Evaluation Program's application to ensure credibility, transparency and usefulness of evaluation findings
- multiple lines and levels of evidence, taking into account quantitative and qualitative data, are used in evaluating progress toward achievement of Basin Plan activities and outcomes
- adaptive management through continuous learning is used to refine Basin Plan initiatives where required, and leads to adjustments in the plan programs, activities and targets
- cost-effectiveness of monitoring and evaluation is achieved by ensuring that benefits outweigh costs; existing monitoring programs and associated data are reviewed and used where appropriate to avoid duplication
- time and space scales are recognised and accounted for in evaluating the Basin Plan's performance
- consistent collection, collation, analysis and reporting methods are adopted by the Australian Government and Basin states
- stakeholder involvement in design and implementation of the program is encouraged.

For example, under the Monitoring and Evaluation Program key ecosystem outcomes will be monitored to determine the extent to which both hydrologic and ecological targets have been met. Key evaluation questions will be used to assess the extent to which (if any) the key environmental assets, key ecosystem functions, productive base or key environmental outcomes have been compromised.

The most critical outcomes are identified as obligatory reporting requirements. These reporting requirements establish the roles and responsibilities of the Basin states and the Commonwealth, as well as impose the obligation to act consistently with, or give effect to, these requirements. They are deliberately set at a high level to avoid embedding prescriptive technical detail in the Basin Plan, but specific enough to ensure that critical information and data will be available to evaluate the effectiveness of the Basin Plan over time.

Researchers in Reedy Swamp near Shepparton, Victoria

The Authority will also produce guidelines on compliance with the obligations in the reporting requirements. These guidelines will address technical methods and practical application. The Authority will consult Commonwealth agencies, Basin states and the research community on their content.

14.3 Transparent reporting and review

Through monitoring and evaluation, the Authority will build on the existing evidence base relating to the ecological health of the Basin and the management of its water resources, believing that such an evolving evidence base must be completely transparent and accessible by all. This will be a feature of the future work program. The Authority also believes that regular public reporting will be vital to assure the Australian community that progress is being made.

It is proposed that reporting will include the ecological health of the Basin, progress in implementing the Basin Plan, and levels of inflows and diversions.

Furthermore, the Authority will publish an annual account of all environmental water in the Basin (*Water Act 2007* (Cwlth) s. 32) and provide a water rights information service (s. 103).

These specific commitments will transparently report on the rebalancing of water for the environment and water for economic benefit.

14.4 Reviewing progress into the future

In addition to these proposed reporting commitments there is significant opportunity for formal review of progress.

While the minimum period within which the Basin Plan must be reviewed is 10 years, it may be reviewed earlier upon the request of all Basin states or the Commonwealth Water Minister.

In addition, the Basin Plan Monitoring and Evaluation Program must provide for a 5-yearly review of the Environmental Watering Plan and the water quality and salinity targets in the Water Quality and Salinity Management Plan.

There is also a requirement for a review of the operation of the *Water Act 2007* (Cwlth) by the end of 2014, and in particular whether management objectives and outcomes of the Basin Plan have been met. This review must also consider the extent to which the water market is operating efficiently, and whether the long-term average sustainable diversion limits are being met.

The National Water Commission will periodically report on the effectiveness of the implementation of the Basin Plan, while the Authority will continue to monitor and evaluate the suitability of individual Basin Plan provisions.

14.5 Delivering outcomes — a collaborative effort

This document outlines the range of responsibilities and contributions of the Authority, the Australian Government and the Basin states in the development of the Basin Plan as well as implementing the plan and delivering its outcomes.

The *Water Act 2007* (Cwlth) outlines the formal community consultation arrangements for contributing to the development of the proposed Basin Plan and to ongoing planning activities, through the Basin Community Committee. This committee, consisting of community members including water users, and Aboriginal people of the Basin, is established to provide advice to the Authority about the performance of the Authority's functions, including the preparation of the Basin Plan. The committee has made an important contribution to the work of the Authority to date.

There are also significant roles for other groups, including catchment authorities, natural resource management bodies, landcare groups, other non-government organisations that manage land or run natural resource management-related projects in the Basin, and community groups and individuals.

Much of the local-level implementation of the Basin Plan will occur through state water resource planning activities and in translating the use of environmental water into local watering plans and events. The Authority encourages people to be involved with these activities.

The Basin Plan will outline an Environmental Watering Plan and an associated planning process, including the formation of an Environmental Watering Advisory Committee with Commonwealth Environmental Water Holder representation and Basin state representation. Community advice will also feed into this committee through a community representative and an Aboriginal Basin nations representative.

Victorian Environmental Managers, 2008, Twelve Mile Creek, Victoria

Implementation of the Basin-level and local-level environmental watering plans will be complemented and enhanced by local natural resource management activities such as riparian revegetation, weed and feral animal control and soil conservation measures. The objectives of the Environmental Watering Plan to protect environmental assets and biodiversity are in common with those of many local and regional natural resource management activities undertaken by private landholders, land trusts, landcare groups, catchment management authorities and natural resource management bodies. Coordinated action that supports ecosystem-based management approaches in wetlands, floodplains and riparian zones will complement and contribute to achieving the broad goals identified in the Environmental Watering Plan.

The same is true of the Basin Plan's Water Quality and Salinity Management Plan. While the Basin Plan does not deal with land management activities, complementary land management activities will enhance and reinforce actions under the Water Quality and Salinity Management Plan's framework.

The Basin Plan will also outline a monitoring and evaluation framework; however, the Authority is aware that there are other activities under way in the Basin that could make significant contributions to the process of monitoring the effectiveness of the plan and the impact of the additional environmental water. Sometimes these non-mainstream monitoring activities can yield highly valuable information. The Authority is keen to talk to groups about their work and proposes to consult these groups over the coming year on the best way for them to be involved in implementation and monitoring issues as well as generally broadening a shared Basin knowledge base.

Integrated approaches to natural resource management at all scales will continue to be required to bring together the land use, planning and land management powers and responsibilities of state governments, landholders, community groups and non-government organisations and the Basin planning responsibilities of the Authority.

The Authority recognises the valuable contributions to Basin health made by the many government and non-government agencies, industry groups and individuals, and intends to build on those contributions in achieving the Basin Plan's outcomes.

15. Issues beyond the scope of the Basin Plan

- It is proposed that there will be scope for the Authority to 'accredit' environmental works and measures for their ability to achieve environmental watering objectives using less water. The mechanism for this proposal will need to be developed.
- It will be important that regional natural resource management plans are consistent with the arrangements proposed under the Basin Plan and that people implementing these plans are also engaged in the implementation of relevant parts of the Basin Plan.
- In comparing figures used in determining critical human water needs with international trends on water use efficiency it is clear that there is considerable scope to implement further water conservation, efficiency and reuse schemes to reduce the volumes required.
- There are likely to be opportunities for implementing the Basin Plan in a way that also contributes towards cultural objectives for Aboriginal people. A mechanism will need to be developed in water resource plans to ensure that people are aware of such opportunities, and that appropriate consultation occurs.
- The Authority will collaborate with Basin states, other Commonwealth agencies, research providers and community groups to implement an ongoing program to improve the knowledge and information base for the Basin.
- In providing additional environmental water through the proposed Basin Plan, the Authority is conscious that people may view this additional environmental water with concern in terms of flood inundation. The planning framework of water resource plans, ongoing appropriate operational decisions and an annual environmental watering plan will mitigate unintended flooding.

There are a number of issues that the Basin Plan will not directly address, but that will need to be considered by the Commonwealth and Basin state governments and stakeholders to ensure the plan can be implemented effectively. These include:

- environmental works and measures
- implications for river operations
- relationship of Basin Plan to natural resource management activities
- water sharing and South Australia's historical allocation
- Aboriginal cultural flows
- ongoing knowledge and research program, particularly regarding the evidence base
- overbank flows
- environmental water holdings.

These issues affect the people of the Basin and the way they will need to interact with the Basin Plan. Each is dealt with in the sections below.

Canoe tree at Daruka near Tamworth, New South Wales

15.1 Environmental works and measures

The long-term average sustainable diversion limit (SDL) proposals in this Guide are set on the basis of achieving environmental water requirements for the Basin with the infrastructure that exists today.

However, a number of works and measures under development have the potential to deliver elements of environmental water requirements more efficiently — for example, installing gates to flood particular wetlands without the need to achieve overbank flows, or installing levees to restrict flooding events to particular wetland areas. In less regulated or natural systems, there is relatively little opportunity or need to use such infrastructure as the main objective of environmental watering is to recreate more natural flow regimes to the extent possible. However, in highly regulated systems, the use of such infrastructure may have the potential to reduce the amount of water required to achieve particular environmental outcomes. The Australian and Basin state governments have indicated a willingness to explore opportunities for environmental works and measures to offset environmental water requirements, and thereby increase SDLs. For example, the Australian Government infrastructure scheme at the Menindee Lakes could enable an increase in the SDL through evaporative savings and better environmental management of the Menindee scheme.

The savings of such schemes are not anticipated to be large relative to the SDLs; however, the precise mechanisms for considering and potentially accrediting any such proposals would need to be worked out in consultation with Basin states and project proponents.

15.2 Implications for river operations

Operation of regulated rivers throughout the Basin involves making decisions about when and how water is released from storages in response to orders for the delivery of water to Basin states, irrigators, or holders of environmental water. The environmental water requirements of the Basin Plan will change the pattern of these orders — for example, by requiring higher flows in winter and autumn more akin to natural flow regimes. The net effect of these changes is difficult to generalise about. River operators across the Basin will need to assess the likely implications for their activities on a case-by-case basis.

The Authority will work with river operators across the Basin to ensure that the settings in the proposed Basin Plan can be delivered effectively.

15.3 Relationship of Basin Plan to natural resource management activities

The *Water Act 2007* (Cwlth) is clear that the focus of the Basin Plan is on matters relevant to the management of Basin water resources, and not the direct regulation of land use, natural resources other than water, or the control of pollution. All Basin states have existing mechanisms for integrating natural resource management at the regional level — for example, through the implementation of regional natural resource management plans. To the extent that these regional plans relate to the management of water resources, it will be important that they are consistent with the directions and arrangements proposed under the Basin Plan.

It will be important that the people implementing these regional natural resource management plans — for example, those based at the various catchment management authorities — are engaged in the implementation of relevant parts of the Basin Plan, such as the Environmental Watering Plan and the Water Quality and Salinity Management Plan. The Authority will seek advice from Basin states and the regional natural resource management bodies on how best to engage them in implementing the Basin Plan.

The Authority recognises the valuable contribution of the range of joint investments in natural resource management programs by Basin states that have occurred in the past, and is keen to build upon those into the future. These joint investments include the Basin Salinity Management Strategy, Sustainable Rivers Audit, The Living Murray, the Native Fish Strategy, the interstate water trade program and other knowledge-generation and investment activities.

15.4 Critical human water needs

The determination of a volume for critical human water needs in the River Murray system has been undertaken to ensure that the volume specified for each state has a consistent basis and approach. The method draws on recent experience of the use of water by communities during drought conditions, assuming that this will help define what is critical and what is not. However, it also means that the current level of water-use efficiency is 'built into' these volumes.

Testing the water of sedimentation and floccation tanks at a water treatment plant at Bathurst, New South Wales

In comparing figures used in this exercise with international trends on water use efficiency, it is clear that there is a considerable scope for River Murray communities and Australians more broadly to implement further water conservation, efficiency and reuse schemes to lessen the volume required for critical human water needs of communities dependent on the River Murray system. This relates to household and industrial use as well as distribution losses to deliver water for these needs. In some cases two-thirds of the volume required to meet critical human water needs is in losses to deliver water through open channels to the end use.

Agencies responsible for managing urban and rural water supplies will need to consider the scope for improved system efficiencies to offset population growth and climate change impacts. Such efficiencies would also have the potential to free up water within the long-term average sustainable diversion limits so that it can be used for other consumptive uses.

15.5 Water sharing and South Australia's historical allocation

There has been a sharing of water between New South Wales, Victoria and South Australia since 1915 when the River Murray Waters Agreement came into effect. Under that agreement New South Wales and Victoria agreed to equally share the resources of the Murray upstream of Albury, while retaining sole rights to use the inflows from their other tributaries. They also agreed to

Dartmouth Dam near Mt Beauty, Victoria

equally provide 1,500 gigalitres per year (GL/y) for South Australia plus any volume that New South Wales and Victoria did not store or use.

With the construction of the Dartmouth Dam in the 1970s that entitlement increased to 1,850 GL/y, and this volume is provided for in s. 88 of the Murray–Darling Basin Agreement, with special arrangements for exceptional circumstances (for example, when water is scarce). This volume incorporates water for human consumption (including in Adelaide) as well as water for irrigation and other purposes (including evaporation and other losses from the River Murray in South Australia and Lower Lakes).

The Basin Plan will create a significantly changed situation for South Australia, as it too will be required to operate within the new long-term average sustainable diversion limits (SDLs). Considerably altered flow regimes will travel through the system for the environment, including to the sea, as upstream states implement their parts of the Environmental Watering Plan and water held for the environment is delivered into South Australia.

The Murray–Darling Basin Agreement, Schedule 1 of the *Water Act 2007* (Cwlth) is being reviewed, as agreed by the Murray–Darling Basin Ministerial Council. This presents an opportunity for these historical arrangements to be reconsidered in light of the Basin Plan.

15.6 Aboriginal water culture

The concept of 'cultural flows' is relatively new to the language of natural resource managers and is not provided for in the *Water Act 2007* (Cwlth). Both the Murray Lower Darling Rivers Indigenous Nations (a confederation of 10 Aboriginal nations in the southern part of the Basin) and the Northern Murray–Darling Basin Aboriginal Nations (a confederation of 21 Aboriginal nations in the northern part of the Basin) have developed their definition of cultural flows as:

> Water entitlements that are legally and beneficially owned by the Aboriginal nations and are of a sufficient and adequate quantity and quality to improve the spiritual, cultural, environmental, social and economic conditions of those Aboriginal nations; this is our inherent right.

There are likely to be opportunities for implementing the Basin Plan in a way that contributes towards cultural objectives for Aboriginal people in the Basin. Ongoing dialogue with the two confederations will seek to identify these opportunities.

15.7 The evidence base

In developing the proposed Basin Plan the Authority has brought together the best available scientific knowledge and information as required by the *Water Act 2007* (Cwlth). This evidence falls into five broad categories: hydrology, ecology, water quality, social and economic.

Of the five broad categories of evidence the hydrology evidence is considered the 'best available' in terms of level of detail, historical record, completeness, availability, and fitness for purpose. By comparison, the ecological evidence base is mixed, with different data collected in each Basin state, invariably for different purposes, and to different standards. There is generally a good evidence base for long-term trends in water quality and salinity, particularly in the southern Basin. However, there are increasing requirements for real-time operational data on issues such as blue green algae. Social and economic data was used in developing the proposed Basin Plan to describe the social and economic fabric of the Basin and to understand the social and economic impacts of the Authority's proposals at community, regional and national levels.

Of the evidence available to the Authority, the social and economic evidence is the weakest. Much of the available local social data had to be aggregated to assess Basin and national impacts; and national and state economic data had to be disaggregated to better understand community and regional contributions. Furthermore, the Authority was required to re-aggregate data for non-standard geography — where the proposed Basin Plan boundaries differed from those determined by the Australian Bureau of Statistics (ABS), CSIRO and catchment management authorities.

Milang, Lake Alexandrina, December 2009, South Australia

Overall, the Authority addressed these issues by seeking regular and ongoing advice from a range of sources in order to obtain the short- and long-term data required for the development of the proposed Basin Plan. These sources include ABS, CSIRO, the Australian Bureau of Agricultural and Resource Economics and the state governments, involved in the day-to-day management of the Basin and its resources.

Additionally, the Authority has been unable to identify any consistent social and economic data that allows analysis of the flow-through impacts beyond the farm gate to the broader local economy and social fabric of the Basin. This is not to be unexpected in comparison to other evidence sets as there has not been a need to undertake this level of analysis prior to the development of the Basin Plan. As such, the Authority continues to commission work in this area.

The Authority is committed to transparency in its decision making and remains concerned that much of the evidence required to meet requirements of the Water Act is difficult to find, is often subject to restrictions on access, and not easy to integrate. To address this, the Authority has committed to making the total evidence base available for public scrutiny, within the constraints of intellectual property, privacy and confidentiality. All data, reports and models used in the development of the Guide (and eventually the

Talyawalka Creek near Menindee, New South Wales

final Basin Plan) will be available through the Authority website, www.mdba.gov.au, with access provided where possible.

In the short term, the Authority will continue to commission work to improve the evidence base, particularly on the social and economic aspects. For example, a cost–benefit analysis of each long-term average sustainable diversion limit (SDL) scenario is currently under way. Also, further work on modelling of the short-, medium- and long-term economic implications and downstream flow-on effects of introducing SDLs will be undertaken, including the impacts on the Aboriginal population. This work will contribute to the finalisation of the Basin Plan, and will also be made available for public scrutiny.

Ongoing knowledge and research program

Development of the Basin Plan has revealed a number of areas in which the knowledge and information base could be improved to better position the Authority to implement the provisions of the Basin Plan, and inform future revisions of the plan.

While information on surface-water hydrology is relatively strong, there is significant room to improve the knowledge base and monitoring network for groundwater. Similarly, the knowledge base on watering requirements for aquatic ecosystems and social and economic characteristics of the Basin could be significantly improved. Long-term monitoring sites will need to be established to help determine the efficacy of environmental watering.

While there are information gaps in some areas, information is available in others — but not in a comparable form across the Basin. This raises questions over the need to develop and implement appropriate and consistent standards for collecting and reporting data in the future.

The Authority believes that a whole-of-Basin knowledge and science framework is required, supported by common standards and systems for data collection and recording. Together these would maximise all participants' investment in research, science and data collection, and enable the building of a significant knowledge base of broad benefit to all.

The Authority will develop a research and information strategy focused on improving the evidence base to support implementation of the provisions of the Basin Plan, and informing future revisions of the plan.

Research areas may include:

- the environmental water needs of key environmental assets and key ecosystem functions, particularly more quantitative hydrological-ecological relationships
- best practice management of this environmental water
- investigation of alternative designs for the water market, drawing on the experience from the energy and property markets
- investigation of new strategies for river operations
- improving understanding of the vulnerability and resilience of Basin communities
- exploring avenues to provide micro-scale economic data and analysis
- improved methods for assessing the ecological benefits of the environmental water
- improving understanding of cultural water requirements for Aboriginal people
- continuing to refine our understanding of climate change impacts, forecasts and implications for the Basin
- linkages between the monitoring and evaluation program data and the Australian Water Resources Information System (Bureau of Meteorology), National Environmental Information System (Bureau of Meteorology), and the National Water Markets System (Department of Sustainability, Environment, Water, Population and Communities)
- opportunities to progressively standardise data collections across the Basin.

15.8 Overbank flows

Protecting and restoring the health of key ecosystem functions and key environmental assets in the Basin will require overbank flows. These are critical to connecting billabongs, wetlands and floodplains to the rivers and transporting nutrients and sediments. In providing for better managed environmental watering, the Basin Plan will help to achieve its environmental objectives and outcomes and meet the requirements of the *Water Act 2007* (Cwlth). However, the Authority is also conscious that people may view this additional environmental water with concern in terms of flood inundation.

The Authority has undertaken some preliminary work to assess the possible impact from overbank flows under the proposed Basin Plan. This shows that the overall risk of flood inundation is low. The environmental water requirements for the key environmental assets generally recommend flows up to the 5-year average flood interval, commensurate with the extent of flood-dependent vegetation and ecosystems. Urban development in this zone of flooding is limited and tightly controlled, and major infrastructure such as main roads and bridges are generally designed to accommodate much larger floods. Most flood-prone towns are protected by levees and contemporary flood protection design standards provide for much larger floods.

15.9 Environmental water holdings

Recent years have seen extensive investment in the purchase of environmental water by the Australian Government and some Basin states. The Authority recognises that the Basin Plan has to build on and make the best use of those investments. While the proposed Basin Plan will include provisions to account for this water, the Authority will undertake discussions during the consultation period with holders of environmental water to identify how held environmental water can be moved around to ensure there is capacity to respond to the Basin Plan's environmental priorities and get the best overall outcomes from environmental water.

16. Next steps

The *Guide to the proposed Basin Plan* comprises:

- Volume 1 — *Guide to the proposed Basin Plan: overview* (this document)
- Volume 2 — *Guide to the proposed Basin Plan: technical background* a discussion of each element of the proposed Basin Plan
- Volumes 3–21 — a discussion of the provisions of the proposed Basin Plan for each of the 19 regions of the Basin.

With the release of these documents, the Authority will commence a period of explaining its proposals. The release of the Guide also enables stakeholders to provide feedback on the Authority's proposals. The Authority invites feedback through regional meetings, by letter, or through the Murray–Darling Basin Authority website (see below).

When the proposed Basin Plan is released, the official 16-week public consultation period will commence, and the process of informing, explaining and listening will continue. Individuals, stakeholders and the community will be invited to make submissions on the proposed Basin Plan. Submissions received will be published on the Authority website, and when the public comment period has finished, a summary of the submissions received will be produced, together with information on any resulting amendments to the plan.

When the Authority has taken comments into account and finalised the Basin Plan, the Murray–Darling Basin Ministerial Council will consider it, with the Authority's assessment of the socioeconomic implications of any reductions in diversion limits. The Authority will then present the Basin Plan to the Commonwealth Water Minister for adoption and tabling in Parliament. It will become law when the minister adopts it, which is expected to happen in 2011.

With the adoption of the Basin Plan, the Authority will focus its efforts on the activities outlined in 'Putting the plan into effect' (Chapter 12) and 'Delivering the outcomes' (Chapter 14). The Authority will also undertake a significant work program to address those areas where further work has been identified as being necessary or beneficial.

Where to find more detail

More detail on the Guide, the proposed Basin Plan, the work of the Authority generally, and locations and timing of the Authority's engagement activities, including regional and metropolitan public meetings, can be found on the MDBA website (see below).

This includes information on how to provide feedback as well as additional detail (see Appendix B) on the technical issues and work that supports the positions outlined in this document. The website also contains factsheets on specific items of interest and a large number of frequently asked questions.

If you are unable to access this information on the web, your local library or local industry peak body should be able to assist. Alternatively you could contact the Authority on the 1800 number below, or email a request for a DVD containing electronic copies of volumes 1–21.

- MDBA website — www.mdba.gov.au
- Phone — 1800 230 067
- Email — engagement@mdba.gov.au

Appendix A — Acknowledgements

The Murray–Darling Basin Authority would like to thank the following individuals, organisations and communities for their support in developing the *Guide to the proposed Basin Plan*.

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Australian Competition and Consumer Commission

Australian Environmental Law Enforcement and Regulatory Network

Australian Government Solicitor

Basin Community Committee

Mr John Bennett

Mr Per Bertilsson, Stockholm International Water Institute, Sweden

Mr Drew Bewsher

Professor Asit K Biswas, Institute for Water Management, Mexico

Dr Dugald Black

Border Rivers–Gwydir Catchment Management Authority, New South Wales

Dr Donna Brennan, Centre for Agricultural Policy, Vietnam

Professor John Briscoe, Gordon McKay Professor, Harvard School of Engineering and Applied Sciences, United States

Bureau of Meteorology

Bureau of Rural Sciences

Dr Neil Byron, former commissioner of the Productivity Commission

Central West Catchment Management Authority, New South Wales

Mr Drew Collins of BDA Group

Condamine Alliance Inc, Queensland

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Department of Environment, Climate Change and Water (New South Wales)

Department of Families, Housing, Community Services and Indigenous Affairs (Commonwealth)

Department of Health (South Australia)

Department of Primary Industries (Victoria)

Department of Sustainability and Environment (Victoria)

Department of the Environment, Climate Change, Energy and Water (Australian Capital Territory)

Department of the Environment, Water, Heritage and the Arts (Commonwealth)

Department of Water and Energy (New South Wales)

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Ms Megan Dyson

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Environmental Evidence Australia

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National Water Commission

North Central Catchment Management Authority, Victoria

North East Catchment Management Authority, Victoria

Northern Murray Darling Basin Aboriginal Nations

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Mr John Shepherd

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Mr Garry Smith of DG Consulting

South Australian Arid Lands Natural Resources Management Board

South Australian Murray–Darling Basin Natural Resources Management Board

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South East Natural Resources Management Board, South Australia

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Western Catchment Management Authority, New South Wales

Mr Paul Wettin

Mr Bryan Whitefield

Wimmera Catchment Management Authority, Victoria

Mr Don Woolley

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Appendix B — Communication and engagement plan

Outline of the public consultation process for the Guide and for the proposed Basin Plan

The objectives of the engagement process for the Guide and proposed Basin Plan are to:

- provide information about the Guide and the proposed Basin Plan
- give opportunities for people to provide feedback on the Guide, to ensure the proposed Basin Plan is based on the best available information
- give opportunities for people to provide feedback on, and input to, the proposed Basin Plan, including through a formal submission process.

The key activities for the public consultation period have been divided into three stages. The first stage commences with the release of the *Guide to the proposed Basin Plan* and the final stage ends after the close of the public consultation period.

Stage 1 — release of the *Guide to the proposed Basin Plan*

Activities include:

- day of release briefings with key media representatives to detail what will be in the Guide and to outline the objectives of the consultation period
- briefing of peak bodies and key commentators immediately prior to the release of the Guide
- a mail-out to all licence holders/entitlement holders (as feasible), local governments, peak bodies and interest groups. This will include a letter explaining what is happening and outlining where to get further information.
- a special edition of Basin News eLetter about the release of the Guide
- Guide and information made available on the MDBA website and via phone
- regional public meetings in the first 4–5 weeks, including regional media activities
- bilateral state and territory agency briefings
- meetings of Northern Murray–Darling Basin Aboriginal Nations and Murray and Lower Darling Rivers Indigenous Nations
- technical workshop with peak bodies, including industry, conservation, local government, banking, property professionals and regional leaders, in Canberra
- MBDA attendance at relevant stakeholder-organised meetings
- online forum; use of Facebook, Twitter, email alerts; updates on 'what we have heard' to go on the MDBA website; and other ongoing communication and media activities
- analysis of feedback on the Guide for inclusion in the proposed Basin Plan as appropriate.

Stage 2 — release of the proposed Basin Plan

Activities may include:

- simultaneous release of a plain English summary of the proposed Basin Plan
- initiation of the submission process (a minimum of 16 weeks). MDBA will be able to accept submissions, in all formats including online, from the commencement of the formal consultation period. MDBA will acknowledge receipt of all submissions individually, but will not respond individually to submissions
- guidance will be provided to assist people to understand the process for preparing and sending in submissions
- regional meetings in Aboriginal communities
- attendance at stakeholder initiated meetings and workshops
- ongoing online forum and use of Facebook and Twitter
- ongoing media and communication activities
- regional and metropolitan public meetings
- a technical workshop with peak bodies, including industry, conservation, local government, banking and property professionals, in Canberra
- technical bilateral meetings with Basin governments and Commonwealth Agencies Working Group.

Stage 3 — after consultation period on the proposed Basin Plan

Activities may include:

- submission hearing process, which will provide an opportunity for selected submitters to present their views to the Authority
- detailed analysis of submissions
- amendment of the proposed Basin Plan as appropriate
- preparation of a report summarising the submissions received and explaining how the Authority took the submissions into account, including any alterations made to the proposed Basin Plan as a result of those submissions.

Appendix C — Surface-water SDL scenarios

Tables C.1, C.2 and C.3 present the surface-water SDL scenarios 1, 2 and 3 respectively. Detailed table notes follow.

Appendix C table notes

The tables are made up of six groups of columns:

1. **Without development** — this group of columns contains water balance data (flows, environmental water) which is based on a model run. The columns in this group are:
   - inflows — these are the best available estimates of the total long-term average inflows for each catchment under without-development conditions, which are based on current catchment conditions with all infrastructure and consumptive demands removed. This is not the same as pre-1788 conditions because land use in the catchments and its effect on runoff has not been (and cannot be) adjusted back to pre-1788 conditions. Inflows are based on modelled 1895–2009 average inflows adjusted by assuming that the models have been calibrated on data that has been affected by the estimated interceptions and unmodelled diversions. This means that the modelled inflows have been increased by interceptions and unmodelled diversions. Inflows shown for the Barwon–Darling and the Murray are only the internally generated additional inflows and do not include outflows from upstream tributaries. This allows total inflows for the Basin to be calculated by the sum of all inflows.
     Note: This definition for inflows is different to the inflow data based on the CSIRO Murray–Darling Basin Sustainable Yields Project modelled flows at the point of maximum flow under without-development conditions. While it provides one assessment of water availability it does not explicitly account for water used by the environment and losses up to the point of maximum flow.
   - water used by environment and losses — the difference between inflows and outflows. Under without-development conditions, this is made up of water absorbed by the local environment in the catchment, including wetlands, the riparian zone, and groundwater recharge.
   - outflows to downstream model — these are the long-term average outflows from modelled outflows for the 1895–2009 without-development model run, except for Eastern Mount Lofty Ranges / Marne Saunders outflow which is estimated from CSIRO Murray–Darling Basin Sustainable Yields Project data. Outflows for the Ovens and Goulburn are based on estimates intended to improve the accuracy of model calculations of these flows.
2. **With current diversion limits** — this group of columns contains water balance data (transfers, flows, diversions, environmental water) which is based on a model run. The columns in this group are:
   - transfers from out of Basin — these are transfers from out of the Basin that are associated with diversions accounted for under CDLs (current diversion limits) and SDLs (long-term average sustainable diversion limits). They include the Snowy Scheme transfers and transfers from the Glenelg catchment to Wimmera. There is a transfer from the Brisbane River catchment to Condamine–Balonne for Toowoomba's water supply, but the transfer is entirely piped, and associated diversions are not accounted for under the Condamine–Balonne CDL or SDL.
   - inflows — same as the equivalent without-development column.
   - CDL components and CDL total — current diversion limits are made up of two main components, which make up the total long-term average limit on diversions (including interceptions) which is currently in place. Not all diversions are limited by existing water resource plans or existing water management arrangements where a water resource plan has not been recognised under the Water Act. Where there are no current limits (e.g. some basic landholder rights) the current estimated level of use is included. This column contains the following sub-columns:
     - interceptions — these are estimates of interceptions by farm dams and forestry plantations. The accuracy of these estimates is low because of limited available data.
     - watercourse diversions — these are the long-term average diversions from watercourses allowable under existing state water resource plans, or existing water management arrangements. Floodplain harvesting is also included in these diversions. These diversion limits are after environmental water recovery associated with The Living Murray, the Snowy River Water for Rivers Project and the Wimmera–Mallee Pipeline Project, and also include permanent trade adjustments. Accordingly, these figures may be different from the Cap or 'plan limit' figures associated with these areas.
   - water used by environment and losses — the difference between inflows and outflows, adjusted for diversions. With development, this is made up of water absorbed by the local environment in the catchment, plus evaporation and losses resulting from water used for consumptive purposes. The water used by the environment is still the major component.
   - outflows to downstream model — these are the long-term average outflows from modelled outflows for 1895–2009 'with current diversion limits' model run, except for Eastern Mount Lofty Ranges / Marne Saunders outflow which is estimated from the CSIRO Murray–Darling Basin Sustainable Yields Project data. Outflows for the Ovens and Goulburn are based on estimates intended to improve the accuracy of model calculations of these flows.
   - outflows without development — outflows under CDL as a percentage of outflows under without development.
3. **Additional environmental water requirements** — hydrologic indicator sites and range of requirements from latest assessments. The columns in this group are:
   - hydrologic indicator sites — the number of hydrologic indicator sites derived from the key environmental assets (KEAs) and key environmental functions (KEFs) in the region.

Note: SDL — long-term average sustainable diversion limit, CDL — current diversion limit, KEA — key environmental asset, KEF — key environmental function, LTCE — long-term Cap equivalent, u/s — upstream, d/s — downstream

- range of additional environmental water requirements — the range of additional environmental water requirements from assessments based on the hydrologic indicator sites. The range is shown from high uncertainty to low uncertainty, utilising the terminology associated with environmental water requirements. The additional environmental water as a percentage of the current 'water used by the environment and losses' is also shown.
- range of water used by environment and losses — the high certainty and low certainty sub-columns here show the range of total 'water used by the environment and losses' by addition of the current amount with the range of additional water requirements.

4. **With SDLs** — water balance data (transfers, flows, diversions, environmental water) — estimates based on an integrated approach of modelling and analytical tools for additional environmental water requirements. Modelling will be necessary to improve estimates of flows. The columns in this group are:
   - transfers from out of Basin — same as equivalent with current diversion limits column.
   - inflows — same as equivalent 'without development' and 'with current diversion limits' columns.
   - SDL components and SDL total — SDLs are made up of two main components, which sum to the total long-term average sustainable diversion limit.
     - interceptions — these are shown as the same as interceptions under CDLs (except for Eastern Mount Lofty Ranges). However, Basin states will have flexibility in deciding how to implement SDLs, as described in this document.
     - watercourse diversions — these are the reduced diversions under SDLs based on the environmental water requirements within the range shown under additional environmental water requirements, assuming the full reduction is applied to these diversions.
   - SDL total — this is the total SDL.
   - water used by environment and losses — same as equivalent with current diversion limits column.
   - outflows to downstream model — these are estimated long-term average outflows under SDLs using analytical techniques. Further modelling will improve these estimates.
   - outflows without development — outflows under SDL as a percentage of outflows under without development.
5. **Changes in diversions and environmental water** — a range of data and statistics to show how diversions and environmental water change from 'with CDLs' to 'with SDLs'. The columns in this group are:
   - reduction in watercourse diversions — the reduction in diversions from watercourses (including floodplain harvesting), assuming that the full reduction is applied to these diversions. As indicated above, states will have flexibility in deciding how to implement SDLs.
   - percentage reductions in watercourse diversions — the reduction in watercourse diversions expressed as a percentage. A cap is applied to this reduction as indicated in the scenario description.
   - CDL – SDL totals — the reduction in diversions from CDL totals to SDL totals expressed in gigalitres per year (GL/y).
   - percentage reduction from CDL — the reduction in changing from CDL totals to SDL totals expressed as a percentage.
   - reduction required for local KEAs and KEFs — the part of the reduction that relates to satisfying the additional environmental water requirements relating to the local asset and function hydrologic indicator sites.
   - reduction required for downstream needs — the part of the reduction that relates to the additional downstream environmental water requirements in the Barwon–Darling or the Murray. There is some choice about where to source these requirements.
   - increase in water used by environment and losses — the difference between the 'water used by the environment and losses' under SDLs compared with under CDLs, expressed in GL/y.
   - additional outflow — the estimated additional outflow that results from the reduction in CDLs to SDLs.
6. **Managing impacts** — 30 June 2010 data on environmental water available for offset and the residual reduction from CDLs to SDLs. The columns in this group are:
   - environmental water available for offset (LTCE) as at 30 June 2010 — this is the long-term average annual volume of environmental water available at 30 June 2010 under entitlements that have been purchased by, or gifted to, the Australian Government, as well as entitlements held by Basin states. They are expressed in GL/y 'long-term Cap equivalents' (LTCE). This volume is available to offset any reductions from CDLs to SDLs.
   - residual reduction after current water recovery (LTCE) — This is the reduction remaining after offsetting the environmental water available against the total CDL to proposed SDL reduction.

Also, the tables are made up of four groups of rows:

1. **Darling and tributaries** — data for tributaries contributing to the Darling River, and the Darling River itself (split into the Barwon–Darling to Menindee Lakes and the Lower Darling downstream of Menindee Lakes). Intersecting Streams is a large SDL area that covers the New South Wales part of the Paroo, Warrego, Condamine–Balonne and Moonie regions. The Intersecting Streams row shows only diversions and interceptions for this SDL area. Inflows and outflows are not shown as these are covered in the rows above.
2. **Murray and tributaries upstream of Wentworth (excluding Darling)** — data for tributaries contributing to the Murray (excluding Darling), and the Murray River itself (split between New South Wales and Victoria as well as along its length to Wentworth). Disconnected tributaries are shown separately.
3. **Murray downstream of Wentworth** — data for the Murray below its junction with the Darling at Wentworth.
4. **Basin total** — totals for the entire Murray–Darling Basin.

Table C.1 Surface-water SDL scenario 1 (3,000 GL/y)

Region/SDL area	Without development			With current diversion limits							
						CDL components					
	Inflows (GL/y)	Water used by environment and losses (GL/y)	Outflows (GL/y)	Transfers from out of Basin (GL/y)	Inflows (GL/y)	Interceptions (GL/y)	Watercourse diversions (GL/y)	CDL total (GL/y)	Water used by environment and losses (GL/y)	Outflows to downstream model (GL/y)	Outflows as percent of without development outflows (%)
Darling and tributaries											
Paroo	688	688	0		688	9.7	0.2	9.9	678	0	–
Warrego	702	632	69		702	83	45	128	510	58	84
Condamine–Balonne region	2,035	1,466	569		2,035	290	712	1,002	792	241	42
Condamine–Balonne			569			265	706	971		241	42
Nebine			55			25	6	31		49	89
Moonie	202	106	96		202	51	32	83	48	71	74
Intersecting Streams (diversions only)	–	–	–		–	2.4	3.0	5.4	–	–	–
Border Rivers region	2,195	1,397	797		2,195	174	433	607	1,075	513	64
Border Rivers (Qld)						78	223	301			
Border Rivers (NSW)						95	210	305			
Gwydir	1,131	701	429		1,131	125	326	451	507	173	40
Namoi	2,128	1,300	828		2,128	165	343	508	967	653	79
Macquarie–Castlereagh	3,214	2,454	760		3,214	310	425	735	1,902	577	76
Total for tributaries contributing to Darling	**12,295**	**8,745**	**3,550**	**0**	**12,295**	**1,210**	**2,319**	**3,529**	**6,479**	**2,286**	**64**
Barwon–Darling	1,247	1,524	3,273		1,247	108	197	305	1,506	1,721	53
Lower Darling	6	879	2,399		6	6	55	61	645	1,021	43
Total for Darling including tributaries	**13,547**	**11,148**	**2,399**	**0**	**13,547**	**1,324**	**2,571**	**3,895**	**8,631**	**1,021**	**43**
Murray and tributaries upstream of Wentworth (excluding Darling)											
Disconnected tributaries											
Lachlan	1,755	1,755	0		1,755	316	302	618	1,137	0	
Wimmera-Avoca	399	399	0	60	399	62	74	136	323	0	
Total for disconnected tributaries	**2,155**	**2,155**	**0**	**60**	**2,155**	**378**	**376**	**754**	**1,460**	**0**	
Connected tributaries											
Ovens	1,804	76	1,728		1,804	58	25	83	13	1,708	99
Goulburn–Broken Region	3,559	300	3,259		3,559	152	1,607	1,759	200	1,600	49
Goulburn			3,259			109	1,593	1,702		1,600	49
Broken			262			43	14	57		225	86
Loddon	347	202	145		347	90	95	185	101	61	42
Campaspe	333	52	281		333	40	115	155	24	153	54
Murrumbidgee region	4,791	1,943	2,848	410	4,791	513	2,100	2,613	995	1,593	56
Murrumbidgee (NSW)						501	2,061	2,562			
ACT						12	39	51			
Kiewa	689	7	682		689	14	11	25	7	657	96
Total of tributaries contributing to Murray (excluding Darling)	**11,523**	**2,580**	**8,943**	**410**	**11,523**	**868**	**3,953**	**4,821**	**1,341**	**5,772**	**65**
Murray u/s Wentworth	4,436	1,628	11,751	527	4,436	149	3,338	3,487	1,000	6,248	53
Murray u/s Hume (NSW)							28	28			
Murray d/s Hume (NSW)						104	1,679	1,783			
Mitta Mitta (Victoria)							15	15			
Murray d/s Hume (Victoria)						45	1,616	1,661			
Total for Murray including all tributaries except Darling	**15,959**	**4,208**	**11,751**	**937**	**15,959**	**1,017**	**7,291**	**8,308**	**2,341**	**6,248**	**53**
Murray downstream of Wentworth											
Murray d/s Wentworth		1,720	12,430				704	704	1,524	5,038	41
Murray (NSW)							14	14			
Murray (Victoria)							25	25			
Murray (SA)							665	665			
Eastern Mount Lofty Ranges	120	47	73		120	11	*	11	40	67	92
Marne Saunders (diversions only)						1.8	*	1.8			
SA Non Prescribed (diversions only)						3.5	0	3.5			
Basin total	**31,781**	**19,278**	**12,503**	**997**	**31,781**	**2,735**	**10,942**	**13,677**	**13,996**	**5,105**	**41**

Note: SDL — long-term average sustainable diversion limit, CDL — current diversion limit, KEA — key environmental asset, KEF — key environmental function, LTCE — long-term Cap equivalent, u/s — upstream, d/s — downstream

… continued

* included in interception

Table C.1 Surface-water SDL scenario 1 (3,000 GL/y) continued

Region/SDL area	Additional environmental water requirements: Hydrologic indicator sites: Assets	Additional environmental water requirements: Hydrologic indicator sites: Functions	Range of additional environmental water requirements: High uncertainty (GL/y)	Range of additional environmental water requirements: Additional environmental water* (%)	Range of additional environmental water requirements: Low uncertainty (GL/y)	Range of additional environmental water requirements: Additional environmental water* (%)	Range of water used by environment and losses (excluding outflows): High uncertainty (GL/y)	Range of water used by environment and losses (excluding outflows): Low uncertainty (GL/y)
Darling and tributaries								
Paroo	0	4	0	0	0	0	678	678
Warrego	0	5	5	1	13	2	515	523
Condamine–Balonne region	2	5	203	20	520	50	995	1,312
Condamine–Balonne			203		520		203	520
Nebine			0		0		0	0
Moonie	0	1	1	1	13	11	49	61
Intersecting Streams (diversions only)			0		0		0	0
Border Rivers region	0	4	54	3	225	14	1,130	1,301
Border Rivers (Qld)							0	0
Border Rivers (NSW)							0	0
Gwydir	1	4	89	13	234	34	597	741
Namoi	0	5	31	2	123	8	998	1,090
Macquarie–Castlereagh	1	8	20	1	189	8	1,922	2,091
Total for tributaries contributing to Darling	**4**	**36**	**404**	**5**	**1,318**	**15**	**6,883**	**7,797**
Barwon–Darling	0	3	228	7	249	8	1,734	1,756
Lower Darling	1	2	19	1	43	3	664	688
Total for Darling including tributaries	**5**	**41**	**651**	**7**	**1,611**	**17**	**9,282**	**10,242**
Murray and tributaries upstream of Wentworth (excluding Darling)								
Disconnected tributaries								
Lachlan	3	5	44	4	158	14	1,182	1,295
Wimmera–Avoca	1	3	0	0	0	0	323	323
Total for disconnected tributaries	**4**	**8**	**44**	**3**	**158**	**11**	**1,505**	**1,618**
Connected tributaries								
Ovens	0	4	0	0	0	0	13	13
Goulburn–Broken region			352	20	1,072	60	552	1,272
Goulburn	1	5	349		1,063		349	1,063
Broken	0	3	3		9		3	9
Loddon	0	6	28	17	69	42	129	170
Campaspe	0	4	28	16	77	44	52	102
Murrumbidgee region	2	5	483	19	1,422	55	1,478	2,417
Murrumbidgee (NSW)			474		1,396		474	1,396
ACT			9		26		9	26
Kiewa	0	0	0	0	0	0	7	7
Total of tributaries contributing to Murray (excluding Darling)	**3**	**27**	**891**	**13**	**2,640**	**37**	**2,231**	**3,981**
Murray u/s Wentworth	4	5	1,168	16	2,635	36	2,168	3,635
Murray u/s Hume (NSW)							0	0
Murray d/s Hume (NSW)							0	0
Mitta Mitta (Victoria)							0	0
Murray d/s Hume (Victoria)							0	0
Total for Murray including all tributaries except Darling	**7**	**32**	**2,058**	**24**	**5,276**	**61**	**4,399**	**7,616**
Murray downstream of Wentworth								
Murray d/s Wentworth	2	7	246	4	556	8	1,770	2,079
Murray (NSW)							0	0
Murray (Victoria)							0	0
Murray (SA)							0	0
Eastern Mount Lofty Ranges	0	0	0		0		40	40
Marne Saunders (diversions only)							0	0
SA Non Prescribed (diversions only)	0	0	0		0		0	0
Basin total	**18**	**88**	**3,000**	**16**	**7,600**	**40**	**16,996**	**21,596**

Note: SDL — long-term average sustainable diversion limit, u/s — upstream, d/s — downstream

* as percent of water used by environment and losses plus outflows

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Table C.1 Surface-water SDL scenario 1 (3,000 GL/y) continued

Region/SDL area	With SDLs (estimated losses/outflows)							
			SDL components					
	Transfers from out of Basin (GL/y)	Inflows (GL/y)	Inter-ceptions (GL/y)	Watercourse diversions (GL/y)	SDL total (GL/y)	Water used by environ-ment and losses (GL/y)	Outflows to down-stream model (GL/y)	Outflows without develop-ment (%)
Darling and tributaries								
Paroo		688	9.7	0.2	9.9	678	0.0	
Warrego		702	83	27	110	529	58	84
Condamine–Balonne region		2,035	290	507	797	919	319	56
Condamine–Balonne		1,916	265	503	768	829	319	56
Nebine		119	25	3.6	29	40	50	91
Moonie		202	51	20	71	52	78	82
Intersecting Streams (diversions only)		–	2.4	2.2	4.6	–	–	–
Border Rivers region		2,195	174	347	521	1,109	565	71
Border Rivers (Qld)			78	180	259			
Border Rivers (NSW)			95	167	262			
Gwydir		1,131	125	237	361	549	220	51
Namoi		2,128	165	271	437	996	696	84
Macquarie–Castlereagh		3,214	310	321	631	1,961	622	82
Total for tributaries contributing to Darling	**0**	**12,295**	**1,210**	**1,733**	**2,943**	**6,793**	**2,559**	**72**
Barwon–Darling		1,247	108	154	262	1,573	1,970	60
Lower Darling		6	6	39	45	656	1,276	53
Total for Darling including tributaries	**0**	**13,547**	**1,324**	**1,926**	**3,250**	**9,022**	**1,276**	**53**
Murray and tributaries upstream of Wentworth (excluding Darling)								
Disconnected tributaries								
Lachlan		1,755	316	258	574	1,182	0	
Wimmera–Avoca	60	399	62	74	136	323	0	
Total for disconnected tributaries	**60**	**2,155**	**378**	**332**	**710**	**1,505**	**0**	
Connected tributaries								
Ovens		1,804	58	15	73	15	1,716	99
Goulburn–Broken region		3,559	152	1,159	1,311	236	2,012	62
Goulburn			109	1,151	1,260		2,012	
Broken			43	8	51		225	
Loddon		347	90	57	147	116	84	58
Campaspe		333	40	75	115	24	193	69
Murrumbidgee region	410	4,791	513	1,421	1,934	1,128	2,139	75
Murrumbidgee (NSW)			501	1,396	1,897			
ACT			12	26	38			
Kiewa		689	14	6.6	20	7	661	97
Total of tributaries contributing to Murray (excluding Darling)	**410**	**11,523**	**868**	**2,734**	**3,602**	**1,526**	**6,805**	**76**
Murray u/s Wentworth	527	4,436	149	2,432	2,581	1,300	7,887	67
Murray u/s Hume (NSW)					21			
Murray d/s Hume (NSW)			104		1,320			
Mitta Mitta (Victoria)					11			
Murray d/s Hume (Victoria)			45		1,230			
Total for Murray including all tributaries except Darling	**937**	**15,959**	**1,017**	**5,166**	**6,183**	**2,826**	**7,887**	**67**
Murray downstream of Wentworth								
Murray d/s Wentworth				521	521	1,646	6,992	56
Murray (NSW)					10.4			
Murray (Victoria)					18.5			
Murray (SA)					492			
Eastern Mount Lofty Ranges		120	7.9	*	7.9	43	68	93
Marne Saunders (diversions only)			1.8	*	1.8			
SA Non Prescribed (diversions only)			3.5	0	3.5			
Basin total	**997**	**31,781**	**2,732**	**7,945**	**10,677**	**15,041**	**7,060**	**56**

Notes: SDL — long-term average sustainable diversion limit, u/s — upstream, d/s — downstream

* included in interception

… continued

Table C.1 Surface-water SDL scenario 1 (3,000 GL/y) continued

Region/SDL area	Changes in diversions and environmental water								Managing impacts	
	Reductions in watercourse diversions (GL/y)	Reductions in watercourse diversions (%)	CDL – SDL totals (GL/y)	Reduction from CDL (%)	Reduction required for local KEAs and KEFs (GL/y)	Reduction required for down-stream needs (GL/y)	Increase in water used by environ-ment and losses (GL/y)	Additional outflow (GL/y)	Environmental water available for offset (LTCE) as at 30 June 2010 (GL/y)	Residual reduction after current water recovery (LTCE) (GL/y)
Darling and tributaries										
Paroo	0.0	0	0.0	0	0.0	0.0	0.0	0.0	0	0
Warrego	18.0	40	18.0	14	5	13	19	0	8	10
Condamine–Balonne region	205	29	205	20	203	2	127	78	1	204
Condamine–Balonne	203	29	203	21	203	0		78	0	203
Nebine	2.4	40	2.4	8	0	2		1	1	1
Moonie	11.7	37	11.7	14	1	11	4	7	1	11
Intersecting Streams (diversions only)	0.8	25	0.8	14	0.0	0.8	0	0	2.0	–1
Border Rivers region	86	20	86	14	54	31	34	52	4	82
Border Rivers (Qld)	43	19	43	14					4	39
Border Rivers (NSW)	43	21	43	14					0	43
Gwydir	89	27	89	20	89	0	42	47	64	26
Namoi	72	21	72	14	31	41	29	43	6	66
Macquarie–Castlereagh	104	24	104	14	20	84	59	45	57	47
Total for tributaries contributing to Darling	**587**	**25**	**587**	**17**	**404**	**183**	**313**	**273**	**142**	**444**
Barwon–Darling	43	22	43	14	43	0	67	249	30	13
Lower Darling	16	29	16	26	16	0	11	255	0	16
Total for Darling including tributaries	**645**	**25**	**645**	**17**	**463**	**183**	**391**	**255**	**172**	**473**
Murray and tributaries upstream of Wentworth (excluding Darling)										
Disconnected tributaries										
Lachlan	44	15	44	7	44	0	44	0	45	–1
Wimmera–Avoca	0	0	0	0	0	0	0	0	0	0
Total for disconnected tributaries	**44**	**12**	**44**	**6**	**44**	**0**	**44**	**0**	**45**	**–1**
Connected tributaries										
Ovens	10	40	10	12	0	10	2	8	0	10
Goulburn–Broken region	448	28	448	25	352	96	36	412	107	341
Goulburn	442	28	442	26	349	93		412	107	335
Broken	5.6	40	5.6	10	3	3		0	0	6
Loddon	38	40	38	21	28	10	15	23	3	35
Campaspe	40	35	40	26	28	12	0	40	5	35
Murrumbidgee region	679	32	679	26	474	205	133	546	64	615
Murrumbidgee (NSW)	665	32	665	26	474	191			64	601
ACT	13	34	13	26	0	13			0	13
Kiewa	4.4	40	4.4	18	0	4	0	4	0	4
Total of tributaries contributing to Murray (excluding Darling)	**1,219**	**31**	**1,219**	**25**	**882**	**337**	**186**	**1,033**	**179**	**1,040**
Murray u/s Wentworth	906	27	906	26	906	0	300	1,639	272	634
Murray u/s Hume (NSW)			7.3							
Murray d/s Hume (NSW)			463							
Mitta Mitta (Victoria)			3.9							
Murray d/s Hume (Victoria)			431							
Total for Murray including all tributaries except Darling	**2,125**	**29**	**2,125**	**26**	**1,787**	**337**	**485**	**1,639**	**451**	**1,674**
Murray downstream of Wentworth										
Murray d/s Wentworth	183	26	183	26	183	0	122	1,954	37	146
Murray (NSW)			3.6							
Murray (Victoria)			6.5							
Murray (SA)			173							
Eastern Mount Lofty Ranges	*		2.8	26	0.0	2.8	2.1	0.7	0	3
Marne Saunders (diversions only)			0	0	0	0	0	0	0	0
SA Non Prescribed (diversions only)	0		0	0	0	0	0	0	0	0
Basin total	**2,997**	**27**	**3,000**	**22**	**2,477**	**523**	**1,045**	**1,955**	**705**	**2,295**

Note: SDL — long-term average sustainable diversion limit, CDL — current diversion limit, KEA — key environmental asset, KEF — key environmental function, LTCE — long-term Cap equivalent, u/s — upstream, d/s — downstream

… continued

* included in interception

Table C.2 Surface-water SDL scenario 2 (3,500 GL/y)

Region/SDL area	Without development			With current diversion limits							
						CDL components					
	Inflows (GL/y)	Water used by environment and losses (GL/y)	Outflows to downstream model (GL/y)	Transfers from out of Basin (GL/y)	Inflows (GL/y)	Interceptions (GL/y)	Watercourse diversions (GL/y)	CDL total (GL/y)	Water used by environment and losses (GL/y)	Outflows (GL/y)	Outflows as percent of without development outflows (%)
Darling and tributaries											
Paroo	688	688	0		688	9.7	0.2	9.9	678	0	–
Warrego	702	632	69		702	83	45	128	510	58	84
Condamine–Balonne region	2,035	1,466	569		2,035	290	712	1,002	792	241	42
Condamine–Balonne			569			265	706	971		241	42
Nebine			55			25	6	31		49	89
Moonie	202	106	96		202	51	32	83	48	71	74
Intersecting Streams (diversions only)	–	–	–		–	2.4	3.0	5.4	–	–	–
Border Rivers region	2,195	1,397	797		2,195	174	433	607	1,075	513	64
Border Rivers (Qld)						78	223	301			
Border Rivers (NSW)						95	210	305			
Gwydir	1,131	701	429		1,131	125	326	451	507	173	40
Namoi	2,128	1,300	828		2,128	165	343	508	967	653	79
Macquarie–Castlereagh	3,214	2,454	760		3,214	310	425	735	1,902	577	76
Total for tributaries contributing to Darling	**12,295**	**8,745**	**3,550**	**0**	**12,295**	**1,210**	**2,319**	**3,529**	**6,479**	**2,286**	**64**
Barwon–Darling	1,247	1,524	3,273		1,247	108	197	305	1,506	1,721	53
Lower Darling	6	879	2,399		6	6	55	61	645	1,021	43
Total for Darling including tributaries	**13,547**	**11,148**	**2,399**	**0**	**13,547**	**1,324**	**2,571**	**3,895**	**8,631**	**1,021**	**43**
Murray and tributaries upstream of Wentworth (excluding Darling)											
Disconnected tributaries											
Lachlan	1,755	1,755	0		1,755	316	302	618	1,137	0	
Wimmera–Avoca	399	399	0	60	399	62	74	136	323	0	
Total for disconnected tributaries	**2,155**	**2,155**	**0**	**60**	**2,155**	**378**	**376**	**754**	**1,460**	**0**	
Connected tributaries											
Ovens	1,804	76	1,728		1,804	58	25	83	13	1,708	99
Goulburn–Broken region	3,559	300	3,259		3,559	152	1,607	1,759	200	1,600	49
Goulburn			3,259			109	1,593	1,702		1,600	49
Broken			262			43	14	57		225	86
Loddon	347	202	145		347	90	95	185	101	61	42
Campaspe	333	52	281		333	40	115	155	24	153	54
Murrumbidgee region	4,791	1,943	2,848	410	4,791	513	2,100	2,613	995	1,593	56
Murrumbidgee (NSW)						501	2,061	2,562			
ACT						12	39	51			
Kiewa	689	7	682		689	14	11	25	7	657	96
Total of tributaries contributing to Murray (excluding Darling)	**11,523**	**2,580**	**8,943**	**410**	**11,523**	**868**	**3,953**	**4,821**	**1,341**	**5,772**	**65**
Murray u/s Wentworth	4,436	1,628	11,751	527	4,436	149	3,338	3,487	1,000	6,248	53
Murray u/s Hume (NSW)							28	28			
Murray d/s Hume (NSW)						104	1,679	1,783			
Mitta Mitta (Victoria)							15	15			
Murray d/s Hume (Victoria)						45	1,616	1,661			
Total for Murray including all tributaries except Darling	**15,959**	**4,208**	**11,751**	**937**	**15,959**	**1,017**	**791**	**8,308**	**2,341**	**6,248**	**53**
Murray downstream of Wentworth											
Murray d/s Wentworth		1,720	12,430				704	704	1,524	5,038	41
Murray (NSW)							14	14			
Murray (Victoria)							25	25			
Murray (SA)							665	665			
Eastern Mount Lofty Ranges	120	47	73		120	11	*	11	40	67	92
Marne Saunders (diversions only)						1.8	*	1.8			
SA Non Prescribed (diversions only)						3.5	0	3.5			
Basin total	**31,781**	**19,278**	**12,503**	**997**	**31,781**	**2,735**	**10,942**	**13,677**	**13,996**	**5,105**	**41**

Note: SDL — long-term average sustainable diversion limit, CDL — current diversion limit, KEA — key environmental asset, KEF — key environmental function, LTCE — long-term Cap equivalent, u/s — upstream, d/s — downstream , * included in interception

… continued

Table C.2 Surface-water SDL scenario 2 (3,500 GL/y) continued

Region/SDL area	Additional environmental water requirements							
	Hydrologic indicator sites		Range of additional environmental water requirements				Range of water used by environment and losses (excluding outflows)	
	Assets	Functions	High uncertainty (GL/y)	Additional environmental water* (%)	Low uncertainty (GL/y)	Additional environmental water* (%)	High uncertainty (GL/y)	Low uncertainty (GL/y)
Darling and tributaries								
Paroo	0	4	0	0	0	0	678	678
Warrego	0	5	5	1	13	2	515	523
Condamine–Balonne Region	2	5	203	20	520	50	995	1,312
Condamine–Balonne			203		520		203	520
Nebine			0		0		0	0
Moonie	0	1	1	1	13	11	49	61
Intersecting Streams (diversions only)			0		0		0	0
Border Rivers region	0	4	54	3	225	14	1,130	1,301
Border Rivers (Qld)							0	0
Border Rivers (NSW)							0	0
Gwydir	1	4	89	13	234	34	597	741
Namoi	0	5	31	2	123	8	998	1,090
Macquarie–Castlereagh	1	8	20	1	189	8	1,922	2,091
Total for tributaries contributing to Darling	**4**	**36**	**404**	**5**	**1,318**	**15**	**6,883**	**7,797**
Barwon–Darling	0	3	228	7	249	8	1,734	1,756
Lower Darling	1	2	19	1	43	3	664	688
Total for Darling including tributaries	**5**	**41**	**651**	**7**	**1,611**	**17**	**9,282**	**10,242**
Murray and tributaries upstream of Wentworth (excluding Darling)								
Disconnected tributaries								
Lachlan	3	5	44	4	158	14	1,182	1,295
Wimmera–Avoca	1	3	0	0	0	0	323	323
Total for disconnected tributaries	**4**	**8**	**44**	**3**	**158**	**11**	**1,505**	**1,618**
Connected tributaries								
Ovens	0	4	0	0	0	0	13	13
Goulburn–Broken region			352	20	1,072	60	552	1,272
Goulburn	1	5	349		1,063		349	1,063
Broken	0	3	3		9		3	9
Loddon	0	6	28	17	69	42	129	170
Campaspe	0	4	28	16	77	44	52	102
Murrumbidgee region	2	5	483	19	1,422	55	1,478	2,417
Murrumbidgee (NSW)			474		1,396		474	1,396
ACT			9		26		9	26
Kiewa	0	0	0	0	0	0	7	7
Total of Tributaries contributing to Murray (except Darling)	**3**	**27**	**891**	**13**	**2,640**	**37**	**2,231**	**3,981**
Murray u/s Wentworth	4	5	1,168	16	2,635	36	2,168	3,635
Murray u/s Hume (NSW)							0	0
Murray d/s Hume (NSW)							0	0
Mitta Mitta (Victoria)							0	0
Murray d/s Hume (Victoria)							0	0
Total for Murray including all tributaries except Darling	**7**	**32**	**2,058**	**24**	**5,276**	**61**	**4,399**	**7,616**
Murray downstream of Wentworth								
Murray d/s Wentworth	2	7	246	4	556	8	1,770	2,079
Murray (NSW)							0	0
Murray (Victoria)							0	0
Murray (SA)							0	0
Eastern Mount Lofty Ranges	0	0	0		0		40	40
Marne Saunders (diversions only)							0	0
SA Non Prescribed (diversions only)	0	0	0		0		0	0
Basin total	**18**	**88**	**3,000**	**16**	**7,600**	**40**	**16,996**	**21,596**

Note: SDL — long-term average sustainable diversion limit, u/s — upstream, d/s — downstream

* as percent of water used by environment and losses plus outflows

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Table C.2 Surface-water SDL scenario 2 (3,500 GL/y) continued

Region/SDL area	With SDLs (estimated losses/outflows): Transfers from out of Basin (GL/y)	Inflows (GL/y)	SDL components: Inter-ceptions (GL/y)	SDL components: Watercourse diversions (GL/y)	SDL total (GL/y)	Water used by environ-ment and losses (GL/y)	Outflows (GL/y)	Outflows as percent of without develop-ment outflows (%)
Darling and tributaries								
Paroo		688	9.7	0.2	9.9	678	0.0	
Warrego		702	83	27	110	529	58	84
Condamine–Balonne region		2,035	290	472	762	940	333	58
Condamine–Balonne		1,916	265	468	734	850	333	58
Nebine		119	25	3.6	29	40	50	91
Moonie		202	51	19	70	53	79	82
Intersecting Streams (diversions only)		–	2.4	2.1	4.5	–	–	–
Border Rivers region		2,195	174	334	508	1,114	573	72
Border Rivers (Qld)			78	174	252			
Border Rivers (NSW)			95	160	255			
Gwydir		1,131	125	221	346	556	229	53
Namoi		2,128	165	260	426	1,000	703	85
Macquarie–Castlereagh		3,214	310	305	615	1,970	629	83
Total for tributaries contributing to Darling	**0**	**12,295**	**1,210**	**1,642**	**2,852**	**6,840**	**2,603**	**73**
Barwon–Darling		1,247	108	147	256	1,596	1,998	61
Lower Darling		6	6	37	42	666	1,296	54
Total for Darling including tributaries	**0**	**13,547**	**1,324**	**1,826**	**3,149**	**9,102**	**1,296**	**54**
Murray and tributaries upstream of Wentworth (excluding Darling)								
Disconnected tributaries								
Lachlan		1,755	316	245	561	1,194	0	
Wimmera–Avoca	60	399	62	74	136	323	0	
Total for disconnected tributaries	**60**	**2,155**	**378**	**319**	**698**	**1,517**	**0**	
Connected tributaries								
Ovens		1,804	58	15	73	15	1,716	99
Goulburn–Broken region		3,559	152	1,083	1,235	236	2,088	64
Goulburn			109	1,075	1,184		2,088	
Broken			43	8	51		225	
Loddon		347	90	57	147	116	84	58
Campaspe		333	40	69	109	24	199	71
Murrumbidgee region	410	4,791	513	1,304	1,817	1,151	2,233	78
Murrumbidgee (NSW)			501	1,281	1,782			
ACT			12	23	36			
Kiewa		689	14	6.6	20	7	661	97
Total of Tributaries contributing to Murray (excluding Darling)	**410**	**11,523**	**868**	**2,535**	**3,402**	**1,549**	**6,981**	**78**
Murray u/s Wentworth	527	4,436	149	2,276	2,425	1,330	8,190	70
Murray u/s Hume (NSW)					19			
Murray d/s Hume (NSW)			104		1,240			
Mitta Mitta (Victoria)					10			
Murray d/s Hume (Victoria)			45		1,155			
Total for Murray including all tributaries except Darling	**937**	**15,959**	**1,017**	**4,811**	**5,828**	**2,879**	**8,190**	**70**
Murray downstream of Wentworth								
Murray d/s Wentworth				490	490	1,655	7,337	59
Murray (NSW)					9.7			
Murray (Victoria)					17.4			
Murray (SA)					462			
Eastern Mount Lofty Ranges		120	7.4	*	7.4	43	68	93
Marne Saunders (diversions only)			1.8	*	1.8			
SA Non Prescribed (diversions only)			3.5	0	3.5			
Basin total	**997**	**31,781**	**2,731**	**7,445**	**10,177**	**15,196**	**7,405**	**59**

Notes: SDL — long-term average sustainable diversion limit, u/s — upstream, d/s — downstream

* included in interception

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Table C.2 Surface-water SDL scenario 2 (3,500 GL/y) continued

Region/SDL area	Changes in diversions and environmental water								Managing impacts	
	Reductions in watercourse diversions (GL/y)	Reductions in watercourse diversions (%)	CDL – SDL totals (GL/y)	Reduction from CDL (%)	Reduction required for local KEAs and KEFs (GL/y)	Reduction required for down-stream needs (GL/y)	Increase in water used by environ-ment and losses (GL/y)	Additional outflow (GL/y)	Environmental water available for offset (LTCE) as at 30 June 2010 (GL/y)	Residual reduction after current water recovery (LTCE) (GL/y)
Darling and tributaries										
Paroo	0.0	0	0.0	0	0.0	0.0	0.0	0.0	0	0
Warrego	18.0	40	18.0	14	6	12	19	0	8	10
Condamine–Balonne region	240	34	240	24	238	2	148	92	1	239
Condamine–Balonne	238	34	238	24	238	0		92	0	238
Nebine	2.4	40	2.4	8	0	2		1	1	1
Moonie	12.8	40	12.8	15	2	11	5	8	1	12
Intersecting Streams (diversions only)	0.9	29	0.9	16	0.0	0.9	0	0	2.0	-1
Border Rivers region	99	23	99	16	73	26	39	60	4	95
Border Rivers (Qld)	49	22	49	16					4	45
Border Rivers (NSW)	50	24	50	16					0	50
Gwydir	105	32	105	23	105	0	49	56	64	41
Namoi	83	24	83	16	41	42	33	50	6	77
Macquarie–Castlereagh	120	28	120	16	39	81	68	52	57	63
Total for tributaries contributing to Darling	**678**	**29**	**678**	**19**	**503**	**174**	**361**	**317**	**142**	**535**
Barwon–Darling	50	25	50	16	50	0	89	277	30	20
Lower Darling	18	33	18	30	18	0	21	275	0	18
Total for Darling including tributaries	**746**	**29**	**746**	**19**	**571**	**174**	**471**	**275**	**172**	**573**
Murray and tributaries upstream of Wentworth (excluding darling)										
Disconnected tributaries										
Lachlan	57	19	57	9	57	0	57	0	45	12
Wimmera–Avoca	0	0	0	0	0	0	0	0	0	0
Total for disconnected tributaries	**57**	**15**	**57**	**8**	**57**	**0**	**57**	**0**	**45**	**12**
Connected tributaries										
Ovens	10	40	10	12	0	10	2	8	0	10
Goulburn–Broken region	524	33	524	30	430	94	36	488	107	417
Goulburn	518	33	518	30	426	92		488	107	411
Broken	5.6	40	5.6	10	4	2		0	0	6
Loddon	38	40	38	21	32	6	15	23	3	35
Campaspe	46	40	46	30	33	13	0	46	5	41
Murrumbidgee region	796	38	796	30	574	221	156	640	64	732
Murrumbidgee (NSW)	780	38	780	30	574	206			64	716
ACT	16	40	16	30	0	16			0	16
Kiewa	4.4	40	4.4	18	0	4	0	4	0	4
Total of tributaries contributing to Murray (excluding Darling)	**1,418**	**36**	**1,418**	**29**	**1,070**	**348**	**209**	**1,209**	**179**	**1,239**
Murray u/s Wentworth	1,062	32	1,062	30	1,062	0	330	1,942	272	790
Murray u/s Hume (NSW)			8.5							
Murray d/s Hume (NSW)			543							
Mitta Mitta (Victoria)			4.6							
Murray d/s Hume (Victoria)			506							
Total for Murray including all tributaries except Darling	**2,480**	**34**	**2,480**	**30**	**2,132**	**348**	**538**	**1,942**	**451**	**2,029**
Murray downstream of Wentworth										
Murray d/s Wentworth	214	30	214	30	214	0	132	2,299	37	177
Murray (NSW)			4.3							
Murray (Victoria)			7.6							
Murray (SA)			203							
Eastern Mount Lofty Ranges	*		3.3	30	0.0	3.3	2.4	0.8	0	3
Marne Saunders (diversions only)			0	0	0	0	0	0	0	0
SA Non Prescribed (diversions only)	0		0	0	0	0	0	0	0	0
Basin total	**3,497**	**32**	**3,500**	**26**	**2,974**	**526**	**1,200**	**2,300**	**705**	**2,795**

Note: SDL — long-term average sustainable diversion limit, CDL — current diversion limit, KEA — key environmental asset, KEF — key environmental function, LTCE — long-term Cap equivalent, u/s — upstream, d/s — downstream, * included in interception

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Table C.3 Surface-water SDL scenario 3 (4,000 GL/y)

Region/SDL area	Without development			With current diversion limits							
						CDL components					
	Inflows (GL/y)	Water used by environment and losses (GL/y)	Outflows (GL/y)	Transfers from out of Basin (GL/y)	Inflows (GL/y)	Inter-ceptions (GL/y)	Water-course diversions (GL/y)	CDL total (GL/y)	Water used by environ-ment and losses (GL/y)	Outflows to down-stream model (GL/y)	Outflows as percent of without develop-ment outflows (%)
Darling and tributaries											
Paroo	688	688	0		688	9.7	0.2	9.9	678	0	–
Warrego	702	632	69		702	83	45	128	510	58	84
Condamine–Balonne region	2,035	1,466	569		2,035	290	712	1,002	792	241	42
Condamine–Balonne			569			265	706	971		241	42
Nebine			55			25	6	31		49	89
Moonie	202	106	96		202	51	32	83	48	71	74
Intersecting Streams (diversions only)	–	–	–		–	2.4	3.0	5.4	–	–	–
Border Rivers region	2,195	1,397	797		2,195	174	433	607	1,075	513	64
Border Rivers (Qld)						78	223	301			
Border Rivers (NSW)						95	210	305			
Gwydir	1,131	701	429		1,131	125	326	451	507	173	40
Namoi	2,128	1,300	828		2,128	165	343	508	967	653	79
Macquarie–Castlereagh	3,214	2,454	760		3,214	310	425	735	1,902	577	76
Total for tributaries contributing to Darling	**12,295**	**8,745**	**3,550**	**0**	**12,295**	**1,210**	**2,319**	**3,529**	**6,479**	**2,286**	**64**
Barwon–Darling	1,247	1,524	3,273		1,247	108	197	305	1,506	1,721	53
Lower Darling	6	879	2,399		6	6	55	61	645	1,021	43
Total for Darling including tributaries	**13,547**	**11,148**	**2,399**	**0**	**13,547**	**1,324**	**2,571**	**3,895**	**8,631**	**1,021**	**43**
Murray and tributaries upstream of Wentworth (excluding Darling)											
Disconnected tributaries											
Lachlan	1,755	1,755	0		1,755	316	302	618	1,137	0	
Wimmera–Avoca	399	399	0	60	399	62	74	136	323	0	
Total for disconnected tributaries	**2,155**	**2,155**	**0**	**60**	**2,55**	**378**	**376**	**754**	**1,460**	**0**	
Connected tributaries											
Ovens	1,804	76	1,728		1,804	58	25	83	13	1,708	99
Goulburn–Broken region	3,559	300	3,259		3,559	152	1,607	1,759	200	1,600	49
Goulburn			3,259			109	1,593	1,702		1,600	49
Broken			262			43	14	57		225	86
Loddon	347	202	145		347	90	95	185	101	61	42
Campaspe	333	52	281		333	40	115	155	24	153	54
Murrumbidgee region	4,791	1,943	2,848	410	4,791	513	2,100	2,613	995	1,593	56
Murrumbidgee (NSW)						501	2,061	2,562			
ACT						12	39	51			
Kiewa	689	7	682		689	14	11	25	7	657	96
Total of tributaries contributing to Murray (except Darling)	**11,523**	**2,580**	**8,943**	**410**	**11,523**	**868**	**3,953**	**4,821**	**1,341**	**5,772**	**65**
Murray u/s Wentworth	4,436	1,628	11,751	527	4,436	149	3,338	3487	1,000	6,248	53
Murray u/s Hume (NSW)							28	28			
Murray d/s Hume (NSW)						104	1,679	1,783			
Mitta Mitta (Victoria)							15	15			
Murray d/s Hume (Victoria)						45	1,616	1,661			
Total for Murray including all tributaries except Darling	**15,959**	**4,208**	**11,751**	**937**	**15,959**	**1,017**	**7,291**	**8,308**	**2,341**	**6,248**	**53**
Murray downstream of Wentworth											
Murray d/s Wentworth		1,720	12,430				704	704	1,524	5,038	41
Murray (NSW)							14	14			
Murray (Victoria)							25	25			
Murray (SA)							665	665			
Eastern Mount Lofty Ranges	120	47	73		120	11	*	11	40	67	92
Marne Saunders (diversions only)						1.8	*	1.8			
SA Non Prescribed (diversions only)						3.5	0	3.5			
Basin total	**31,781**	**19,278**	**12,503**	**997**	**31,781**	**2,735**	**10,942**	**13,677**	**13,996**	**5,105**	**41**

Note: SDL — long-term average sustainable diversion limit, CDL — current diversion limit, KEA — key environmental asset, KEF — key environmental function, LTCE — long-term Cap equivalent, u/s — upstream, d/s — downstream

… continued

* included in interception

Table C.3 Surface-water SDL scenario 3 (4,000 GL/y) continued

Region/SDL area	Additional environmental water requirements							
	Hydrologic indicator sites		Range of additional environmental water requirements				Range of water used by environment and losses (excluding outflows)	
	Assets	Functions	High uncertainty (GL/y)	Additional environ-mental water* (%)	Low uncertainty (GL/y)	Additional environ-mental water* (%)	High uncertainty (GL/y)	Low uncertainty (GL/y)
Darling and tributaries								
Paroo	0	4	0	0	0	0	678	678
Warrego	0	5	5	1	13	2	515	523
Condamine–Balonne region	2	5	203	20	520	50	995	1,312
Condamine–Balonne			203		520		203	520
Nebine			0		0		0	0
Moonie	0	1	1	1	13	11	49	61
Intersecting Streams (diversions only)			0		0		0	0
Border Rivers region	0	4	54	3	225	14	1,130	1,301
Border Rivers (Qld)							0	0
Border Rivers (NSW)							0	0
Gwydir	1	4	89	13	234	34	597	741
Namoi	0	5	31	2	123	8	998	1,090
Macquarie–Castlereagh	1	8	20	1	189	8	1,922	2,091
Total for tributaries contributing to Darling	**4**	**36**	**404**	**5**	**1,318**	**15**	**6,883**	**7,797**
Barwon–Darling	0	3	228	7	249	8	1,734	1,756
Lower Darling	1	2	19	1	43	3	664	688
Total for Darling including tributaries	**5**	**41**	**651**	**7**	**1,611**	**17**	**9,282**	**10,242**
Murray and tributaries upstream of Wentworth (excluding Darling)								
Disconnected tributaries								
Lachlan	3	5	44	4	158	14	1,182	1,295
Wimmera–Avoca	1	3	0	0	0	0	323	323
Total for disconnected tributaries	**4**	**8**	**44**	**3**	**158**	**11**	**1,505**	**1,618**
Connected tributaries								
Ovens	0	4	0	0	0	0	13	13
Goulburn–Broken region			352	20	1,072	60	552	1,272
Goulburn	1	5	349		1,063		349	1,063
Broken	0	3	3		9		3	9
Loddon	0	6	28	17	69	42	129	170
Campaspe	0	4	28	16	77	44	52	102
Murrumbidgee region	2	5	483	19	1,422	55	1,478	2,417
Murrumbidgee (NSW)			474		1,396		474	1,396
ACT			9		26		9	26
Kiewa	0	0	0	0	0	0	7	7
Total of tributaries contributing to Murray (except Darling)	**3**	**27**	**891**	**13**	**2,640**	**37**	**2,231**	**3,981**
Murray u/s Wentworth	4	5	1,168	16	2,635	36	2,168	3,635
Murray u/s Hume (NSW)							0	0
Murray d/s Hume (NSW)							0	0
Mitta Mitta (Victoria)							0	0
Murray d/s Hume (Victoria)							0	0
Total for Murray including all tributaries except Darling	**7**	**32**	**2,058**	**24**	**5,276**	**61**	**4,399**	**7,616**
Murray downstream of Wentworth								
Murray d/s Wentworth	2	7	246	4	556	8	1,770	2,079
Murray (NSW)							0	0
Murray (Victoria)							0	0
Murray (SA)							0	0
Eastern Mount Lofty Ranges	0	0	0		0		40	40
Marne Saunders (diversions only)							0	0
SA Non Prescribed (diversions only)	0	0	0		0		0	0
Basin total	**18**	**88**	**3,000**	**16**	**7,600**	**40**	**16,996**	**21,596**

Note: SDL — long-term average sustainable diversion limit, u/s — upstream, d/s — downstream

* as percent of water used by environment and losses plus outflows

… continued

Table C.3 Surface-water SDL scenario 3 (4,000 GL/y) continued

Region/SDL area	With SDLs (estimated losses/outflows)							
			SDL components					
	Transfers from out of Basin (GL/y)	Inflows (GL/y)	Inter-ceptions (GL/y)	Watercourse diversions (GL/y)	SDL total (GL/y)	Water used by environ-ment and losses (GL/y)	Outflows (GL/y)	Outflows as percent of without develop-ment outflows (%)
Darling and tributaries								
Paroo		688	9.7	0.2	9.9	678	0.0	
Warrego		702	83	25	108	531	58	84
Condamine–Balonne region		2,035	290	437	728	962	346	61
Condamine–Balonne		1,916	265	434	699	871	346	61
Nebine		119	25	3.3	29	40	50	91
Moonie		202	51	18	69	53	80	83
Intersecting Streams (diversions only)		–	2.4	2.0	4.4	–	–	–
Border Rivers region		2,195	174	321	495	1,119	581	73
Border Rivers (Qld)			78	168	246			
Border Rivers (NSW)			95	154	249			
Gwydir		1,131	125	205	330	564	237	55
Namoi		2,128	165	249	415	1,004	709	86
Macquarie–Castlereagh		3,214	310	290	600	1,979	635	84
Total for tributaries contributing to Darling	**0**	**12,295**	**1,210**	**1,548**	**2,758**	**6,891**	**2,647**	**75**
Barwon–Darling		1,247	108	141	249	1,618	2,026	62
Lower Darling		6	6	34	39	676	1,316	55
Total for Darling including tributaries	**0**	**13,547**	**1,324**	**1,722**	**3,046**	**9,185**	**1,316**	**55**
Murray and tributaries upstream of Wentworth (excluding Darling)								
Disconnected tributaries								
Lachlan		1,755	316	233	549	1,206	0	
Wimmera–Avoca	60	399	62	74	136	323	0	
Total for disconnected tributaries	**60**	**2,155**	**378**	**307**	**685**	**1,529**	**0**	
Connected tributaries								
Ovens		1,804	58	14	72	15	1,717	99
Goulburn–Broken region		3,559	152	1,008	1,160	237	2,162	66
Goulburn			109	1,000	1,109		2,162	
Broken			43	8	51		225	
Loddon		347	90	52	142	118	87	60
Campaspe		333	40	63	103	24	205	73
Murrumbidgee region	410	4,791	513	1,190	1,704	1,173	2,325	82
Murrumbidgee (NSW)			501	1,169	1,670			
ACT			12	21	34			
Kiewa		689	14	6.1	20	7	662	97
Total of tributaries contributing to Murray (except Darling)	**410**	**11,523**	**868**	**2,334**	**3,201**	**1,575**	**7,157**	**80**
Murray u/s Wentworth	527	4,436	149	2,124	2,273	1,359	8,488	72
Murray u/s Hume (NSW)					18			
Murray d/s Hume (NSW)			104		1,162			
Mitta Mitta (Victoria)					10			
Murray d/s Hume (Victoria)			45		1,083			
Total for Murray including all tributaries except Darling	**937**	**15,959**	**1,017**	**4,458**	**5,474**	**2,934**	**8,488**	**72**
Murray downstream of Wentworth								
Murray d/s Wentworth				459	459	1,664	7,677	62
Murray (NSW)					9.1			
Murray (Victoria)					16.3			
Murray (SA)					433			
Eastern Mount Lofty Ranges		120	7.0	*	7.0	43	68	93
Marne Saunders (diversions only)			1.8	*	1.8			
SA Non Prescribed (diversions only)			3.5	0	3.5			
Basin total	**997**	**31,781**	**2,731**	**6,946**	**9,677**	**15,356**	**7,745**	**62**

Notes: SDL — long-term average sustainable diversion limit, u/s — upstream, d/s — downstream

... continued

* included in interception

Table C.3 Surface-water SDL scenario 3 (4,000 GL/y) continued

Region/SDL area	Changes in diversions and environmental water								Managing impact	
	Reductions in watercourse diversions (GL/y)	Reductions in watercourse diversions (%)	CDL – SDL totals (GL/y)	Reduction from CDL (%)	Reduction required for local KEAs and KEFs (GL/y)	Reduction required for down-stream needs (GL/y)	Increase in water used by environ-ment and losses (GL/y)	Additional outflow (GL/y)	Environmental water available for offset (LTCE) as at 30 June 2010 (GL/y)	Residual reduction after current water recovery (LTCE) (GL/y)
Darling and tributaries										
Paroo	0.0	0	0.0	0	0.0	0.0	0.0	0.0	0	0
Warrego	20.3	45	20.3	16	6	14	21	0	8	12
Condamine–Balonne region	275	39	275	27	272	3	170	105	1	274
Condamine–Balonne	272	39	272	28	272	0		105	0	272
Nebine	2.7	45	2.7	9	0	3		1	1	2
Moonie	14.4	45	14.4	17	3	11	5	9	1	14
Intersecting Streams (diversions only)	1.0	33	1.0	18	0.0	1.0	0	0	2.0	–1
Border Rivers region	112	26	112	18	92	20	44	68	4	108
Border Rivers (Qld)	55	25	55	18					4	51
Border Rivers (NSW)	56	27	56	18					0	56
Gwydir	121	37	121	27	121	0	57	64	64	57
Namoi	94	27	94	18	51	42	37	56	6	88
Macquarie–Castlereagh	135	32	135	18	57	78	77	58	57	78
Total for tributaries contributing to Darling	**772**	**33**	**772**	**22**	**603**	**169**	**411**	**361**	**142**	**629**
Barwon–Darling	56	29	56	18	56	0	112	305	30	26
Lower Darling	21	38	21	35	21	0	31	295	0	21
Total for Darling including tributaries	**849**	**33**	**849**	**22**	**680**	**169**	**554**	**295**	**172**	**677**
Murray and tributaries upstream of Wentworth (excluding Darling)										
Disconnected tributaries										
Lachlan	69	23	69	11	69	0	69	0	45	24
Wimmera–Avoca	0	0	0	0	0	0	0	0	0	0
Total for disconnected tributaries	69	18	69	9	69	0	69	0	45	24
Connected tributaries										
Ovens	11	45	11	13	0	11	2	9	0	11
Goulburn–Broken region	599	37	599	34	508	91	37	562	107	492
Goulburn	593	37	593	35	504	89		562	107	486
Broken	6.3	45	6.3	11	4	2		0	0	6
Loddon	43	45	43	23	37	6	17	26	3	40
Campaspe	52	45	52	33	39	13	0	52	5	47
Murrumbidgee region	910	43	910	35	675	235	178	732	64	846
Murrumbidgee (NSW)	892	43	892	35	675	217			64	828
ACT	18	45	18	34	0	18			0	18
Kiewa	5.0	45	5.0	20	0	5	0	5	0	5
Total of tributaries contributing to Murray (excluding Darling)	**1,619**	**41**	**1,619**	**34**	**1,258**	**361**	**234**	**1,385**	**179**	**1,440**
Murray u/s Wentworth	1,214	36	1,214	35	1,214	0	359	2,240	272	942
Murray u/s Hume (NSW)			9.7							
Murray d/s Hume (NSW)			621							
Mitta Mitta (Victoria)			5.2							
Murray d/s Hume (Victoria)			578							
Total for Murray including all tributaries except Darling	**2,833**	**39**	**2,833**	**34**	**2,472**	**361**	**593**	**2,240**	**451**	**2,382**
Murray downstream of Wentworth										
Murray d/s Wentworth	245	35	245	35	245	0	141	2,639	37	208
Murray (NSW)			4.9							
Murray (Victoria)			8.7							
Murray (SA)			232							
Eastern Mount Lofty Ranges	*		3.7	35	0.0	3.7	2.8	0.9	0	4
Marne Saunders (diversions only)			0	0	0	0	0	0	0	0
SA Non Prescribed (diversions only)	0		0	0	0	0	0	0	0	0
Basin total	**3,996**	**37**	**4,000**	**29**	**3,466**	**534**	**1,360**	**2,640**	**705**	**3,295**

Note: SDL — long-term average sustainable diversion limit, CDL — current diversion limit, KEA — key environmental asset, KEF — key environmental function, LTCE — long-term Cap equivalent, u/s — upstream, d/s — downstream, * included in interception

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