

Issues Paper

Development of Sustainable Diversion Limits for the Murray-Darling Basin

November 2009

FOR DISCUSSION

This paper is released by the Murray–Darling Basin Authority for discussion.

Submissions on this paper are invited by **18 December 2009**

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Published by Murray–Darling Basin Authority
Postal address GPO Box 1801, Canberra ACT 2601
Office location Level 4, 51 Allara Street, Canberra City
Australian Capital Territory
Telephone (02) 6279 0100 international + 61 2 6279 0100
Facsimile (02) 6248 8053 international + 61 2 6248 8053
Email info@mdba.gov.au
Internet <http://www.mdba.gov.au>

For further information contact the Murray–Darling Basin
Authority office on (02) 6279 0100

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1. Executive Summary

The *Water Act 2007* (the Water Act) was made by the Commonwealth Parliament to enable the water resources in the Murray-Darling Basin to be managed in the national interest. It commenced in March 2008. In July 2008, the Australian Government and the Basin States (New South Wales, Victoria, Queensland, South Australia and the Australian Capital Territory) signed the intergovernmental Agreement on Murray-Darling Basin Reform. This led to a referral of certain constitutional powers from the Basin States to the Commonwealth, and resulted in amendment of the Water Act in December 2008.

A key element of the Water Act is the requirement that the Murray-Darling Basin Authority (the MDBA) prepare a Basin Plan for adoption by the Commonwealth Minister for Climate Change and Water. The Basin Plan will be a legally enforceable document that provides for the integrated and sustainable management of water resources in the Basin. The MDBA is working to a timetable that will produce a proposed Basin Plan by mid 2010 and the first Basin Plan in 2011.

The Basin Plan is required to set enforceable limits on the quantities of surface water and groundwater that can be taken from the Basin water resources. These limits must be set at a level that the MDBA, using the best available scientific knowledge, determines to be environmentally sustainable. This is defined as the level at which water in the Basin can be taken from a water resource without compromising the key environmental assets, key ecosystem functions, the productive base or key environmental outcomes of the water resource.

The need for sustainable diversion limits (SDLs) has arisen because of the enormous stress the water resources of the Basin are under as a result of past water-allocation decisions, prolonged drought, natural climate variability and emerging climate change.

This paper explores issues around developing SDLs for the Basin and describes the relationship between SDLs and the other elements of the Basin Plan. It sets out a proposed process for developing SDLs and how they could be expressed in the Basin Plan.

The issues paper is divided into two main parts. Section 3 provides some of the background and context to the Basin Plan, including a discussion about how environmental considerations will inform the development of SDLs, and how social and economic factors are to be addressed. It also explains how State water management arrangements will interact with the Basin Plan, in particular that SDLs and other key components of the Basin Plan will be implemented through accredited water resource plans (WRPs) developed by Basin States.

Section 4 of the paper explores some of the key issues the MDBA must consider in setting SDLs.

The first issue discussed is the identification of water resource plan areas (WRP areas). The Basin Plan must identify the boundaries for WRP areas to be used for accredited WRPs developed by Basin States. The boundaries currently provided for under the water management laws of the Basin States will, as far as possible, be used as a basis for identifying WRP areas. However, where catchments or groundwater resource units extend across State boundaries, they will be treated as whole water resource units before provisions for WRPs in each State are specified.

The paper then goes on to discuss the forms of take that are to be limited by SDLs. An SDL will not limit take from a water resource if the take would not contribute to the compromise of the environmental characteristics that the Water Act specifies as being important (i.e. the key environmental assets, key ecosystem functions, productive base, and key environmental outcomes of the water resource). Thus, the use of water held in dedicated environmental entitlements and in accordance with the environmental watering plan would not generally be take that is limited by an SDL. Importantly, SDLs are to include limits on the amount of water that can be taken by interception activities. Where a proposed interception activity is identified as being significant and above a specified size threshold, the MDBA is proposing to include requirements for relevant WRPs that establish suitable management approaches.

In regard to how SDLs should be set and expressed, the paper concludes that because of the natural variability across the Basin a flexible approach is needed to specifying SDLs. This will involve applying appropriate methods, including hydrological modelling, tailored to the nature of the take and the type of water resource.

Given the complexity of attempting to set combined surface water and groundwater SDLs, the general approach will be to set separate SDLs for surface water and groundwater. However, these will take account of current and future interactions between surface water and groundwater resources and will prevent the water available for consumptive use being allocated twice (i.e. double accounting).

At the same time as SDL options associated with meeting an initial draft set of environmental water requirements are being assessed through hydrological modelling, economic and social assessments will be undertaken across the Basin as a whole and of those irrigation areas of the Basin which account for the largest proportions of current water diversions. The results of the two sets of assessments will then be considered together, in an iterative fashion if need be, with the social and economic analyses being used to inform how, where and when water can be delivered to meet environmental requirements at least social and economic cost. Following any adjustments, there may be a need to review the SDL options and re-run the hydrological modelling and the analyses of potential economic and social impacts.

This issues paper is one important component in developing the Basin Plan. It builds an understanding of the matters to be covered in the plan and allows stakeholders to have an early input before the proposed Basin Plan is released for formal consultation in mid 2010.

The MDBA is interested in your views on the issues discussed in this paper. Submissions on this paper are invited by **18 December 2009** (see section 6).

2. How to use this paper

The Water Act requires the Murray-Darling Basin Authority to develop a proposed Basin Plan for adoption by the Commonwealth Minister for Climate Change and Water. The Water Act was amended in December 2008 to reflect the agreement of the Council of Australian Governments to refer certain constitutional powers from the Basin States to the Commonwealth. The Basin Plan will provide for the integrated management of the Basin water resources. One important requirement under the Water Act is that the Basin Plan set sustainable limits on the extraction of water in the Basin.

This paper explores issues around developing sustainable diversion limits (SDLs) for the Basin and describes the relationship between SDLs and the other elements of the MDBA's proposed Basin Plan. It discusses the process for developing SDLs and how they will be expressed in the Basin Plan.

This paper is to help people and organisations provide input to this key element of the proposed Basin Plan prior to its scheduled release in mid 2010.

The Water Act requires the MDBA to consult with the Basin States, the Basin Officials Committee and the Basin Community Committee in preparing the proposed Basin Plan, and allows it to undertake other consultation as it considers appropriate¹. The Water Act sets out how the MDBA must consult with the public and State governments on the proposed Basin Plan and requires consultation with the Murray-Darling Basin Ministerial Council on the final proposed Basin Plan².

The MDBA has developed a stakeholder engagement strategy for the Basin Plan³ to ensure a consistent, relevant and appropriate approach is taken to engaging all stakeholders in the development of the Basin Plan. The MDBA will release the proposed Basin Plan in mid 2010 for extensive public consultation.

This issues paper is one important component of the engagement process. It is an important step in building understanding of the issues to be covered in the Basin Plan and provides an opportunity for stakeholders to have input to its development. A range of questions are asked throughout the paper and you may wish to respond to these questions in your submission.

In your submission you should give evidence to support your views, such as data and documentation. There will be other opportunities to inform the MDBA's development of SDLs before the proposed Basin Plan is released for formal consultation in mid 2010, but you are encouraged to use this early opportunity.

Please read section 6 for details on how to make a submission, and use the submission cover sheet provided at the end of this paper. Your submission should reach us no later than **18 December 2009**. This will ensure that the MDBA can give your input due consideration in formulating the proposed Basin Plan. The MDBA will publish all submissions on its website unless requested not to.

¹ Water Act, s 42

² Water Act, s 43 and 43A

³ A stakeholder engagement brochure for the Basin Plan is available for download at www.mdba.gov.au

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The MDBA will acknowledge receipt and publish a summary of the issues raised in submissions along with how the issues will be addressed in the proposed Basin Plan.

See our website www.mdba.gov.au for further information including the Basin Plan Concept Statement, fact sheets, relevant research and technical reports and the Stakeholder Engagement brochure for the Basin Plan.

3. Context

3.1 Background

3.1.1 The Murray-Darling Basin

The Murray-Darling Basin (the Basin) covers more than 1 million square kilometres and is one-seventh of the Australian mainland. It covers parts of Queensland, New South Wales, Victoria and South Australia, and the entire Australian Capital Territory (Figure 1).



Figure 1 – Location of the Murray-Darling Basin

The Basin is home to a population of approximately two million people and includes the national capital - Canberra and other major population centres Toowoomba, Tamworth, Moree, Orange, Dubbo, Wagga Wagga, Griffith, Albury-Wodonga, Shepparton, Bendigo, Horsham, Mildura and Renmark. In South Australia in particular, many areas outside the Basin, most notably Adelaide, rely on the water resources of the Basin to complement their local water supplies.

The Basin is also Australia's most important agricultural area, producing over one-third of Australia's food supply. Agriculture areas in the Basin are predominantly for livestock production, particularly dryland sheep and cattle. Dairying is the main irrigated livestock industry, whilst important cropping activities include cereals (particularly wheat, barley and rice), oilseed, cotton and horticulture (particularly citrus, stone and pome fruits, grapes and vegetables).

The Basin also has many natural resources that are of high environmental value. Its wetlands are extensive and perform essential hydrological, biological and chemical functions, which support and maintain the productivity and health of the river systems. A number of the Basin wetlands are recognised under the Convention on Wetlands of International Importance (the Ramsar Convention).

3.1.2 Rainfall and hydrology

Rainfall and runoff vary through the Basin (Figure 2) and there is a distinct difference in rainfall and subsequent water availability between the north and the south. Rainfall in the north occurs predominantly over summer, whilst in the south it occurs mainly during the winter and spring seasons. Rainfall and runoff are highest in the south-east and southern margins of the Basin. This influences water availability through the Basin, with lower water availability in the north of the Basin when compared to the south (Figure 3). This affects agricultural activity and the nature of the environmental assets that depend on this water.

The total average available surface water in the Basin (based on the historic climate) is estimated to be 23,417 GL per year, made up of 8,028 GL per year (34%) for the Darling system and 15,389 GL per year (66%) for the Murray system. Current average surface water use across the MDB is 11,327 GL per year. Groundwater extraction was estimated to be 1,832 GL in 2004/05 (16% of the average surface water use across the Basin)⁴.

The river catchments in the north of the Basin cover the majority of the Basin's total land area, being twice the size of the Murray Basin in the south. However the area they drain is more arid. Cropping in the north is mainly summer cropping with greater reliance on highly variable, unregulated flows and private infrastructure. In the south, the major water supplies are regulated by large public dams for which seasonal forecasts can be assessed before each growing season.

⁴ CSIRO 2008

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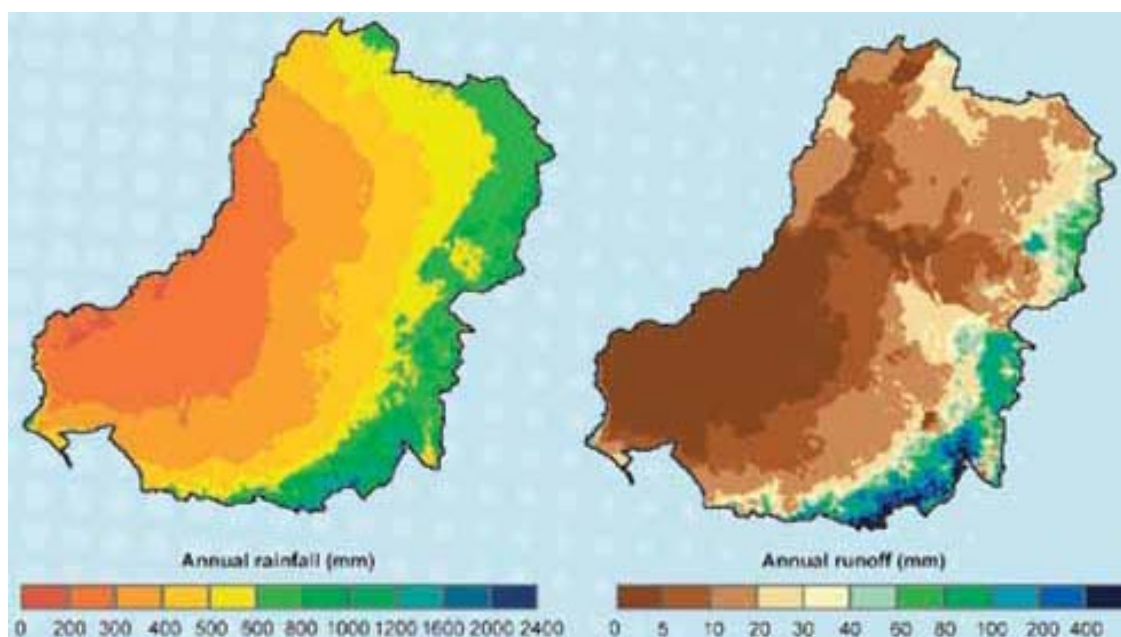


Figure 2 - Average annual rainfall (left) and modelled average annual runoff (right) for 1895 to 2006 (CSIRO 2008)

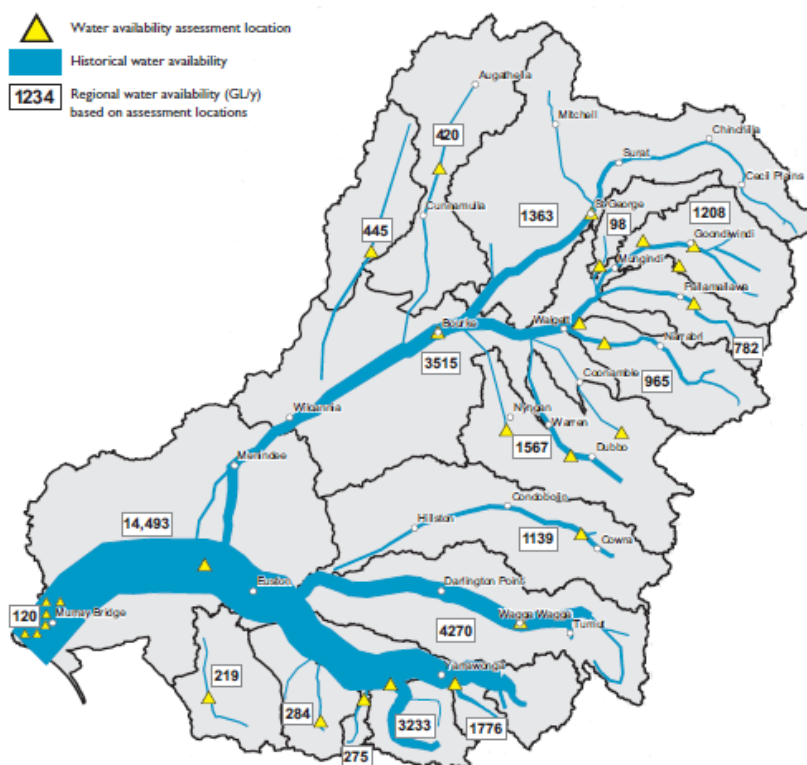


Figure 3 - Current average surface water availability across the Basin (CSIRO 2008)

Groundwater is an important source of water across the Basin with particular importance in specific areas. There are 20 major groundwater management units that represent 75% of the groundwater extraction in the Basin.

3.1.3 The *Water Act 2007*

The Basin is under enormous stress as a result of past water-allocation decisions, prolonged drought, natural climate variability and emerging climate change.

To enable the water resources in the Basin to be managed in the national interest, the Commonwealth Parliament passed the *Water Act 2007*, which commenced in March 2008. In July 2008, the Commonwealth of Australia and the Basin States (New South Wales, Victoria, Queensland, South Australia and the Australian Capital Territory) signed the intergovernmental Agreement on Murray-Darling Basin Reform. This led to the referral of certain constitutional powers from the Basin State Parliaments to the Commonwealth Parliament, and resulted in amendment of the *Water Act* in December 2008. Amongst other things, these amendments transferred the functions of the former Murray-Darling Basin Commission to the MDBA and enabled the Basin Plan to provide arrangements for meeting critical human water needs.

In summary, the objects of the *Water Act* are to:

- Enable the Commonwealth, in conjunction with the Basin States, to **manage** the Basin water resources in the national interest;
- **Give effect** to relevant international agreements and in doing so to **optimise** economic, social and environmental outcomes;
- **Ensure** a return to environmentally sustainable levels of extraction for water resources that are overallocated or overused;
- **Protect, restore and provide** for the ecological values and ecosystems of the Basin;
- Subject to the above two points, **maximise** the net economic returns to the Australian community from the use and management of Basin water resources;
- **Improve** water security for all uses of Basin water resources;
- **Ensure** broader management of natural resources in the Basin are taken into account;
- **Achieve** efficient and cost effective water management and administrative practices; and
- **Provide** for collection, collation, analysis and dissemination of information about Australia's water resources and the use and management of water in Australia.

A key element of the *Water Act* is the requirement that the MDBA prepare a Basin Plan for adoption by the Commonwealth Minister for Climate Change and Water.

The Basin Plan will be a legally enforceable document that provides for the integrated and sustainable management of water resources in the Basin. The MDBA is working to a timetable that will produce a proposed Basin Plan by mid-2010 and the first Basin Plan in 2011.

3.2 Development of the Basin Plan

The Basin Plan will take a consistent and integrated approach to managing the water resources in the Basin. Figure 4 shows the overall process of developing the key elements of the Basin Plan, and is taken from *The Basin Plan – A Concept Statement*. The Concept Statement explains in general terms the key elements and approach being taken in developing the Basin Plan and is available via the MDBA website⁵ or by contacting the MDBA by telephone (1800 230 067) or by email (engagement@mdba.gov.au).

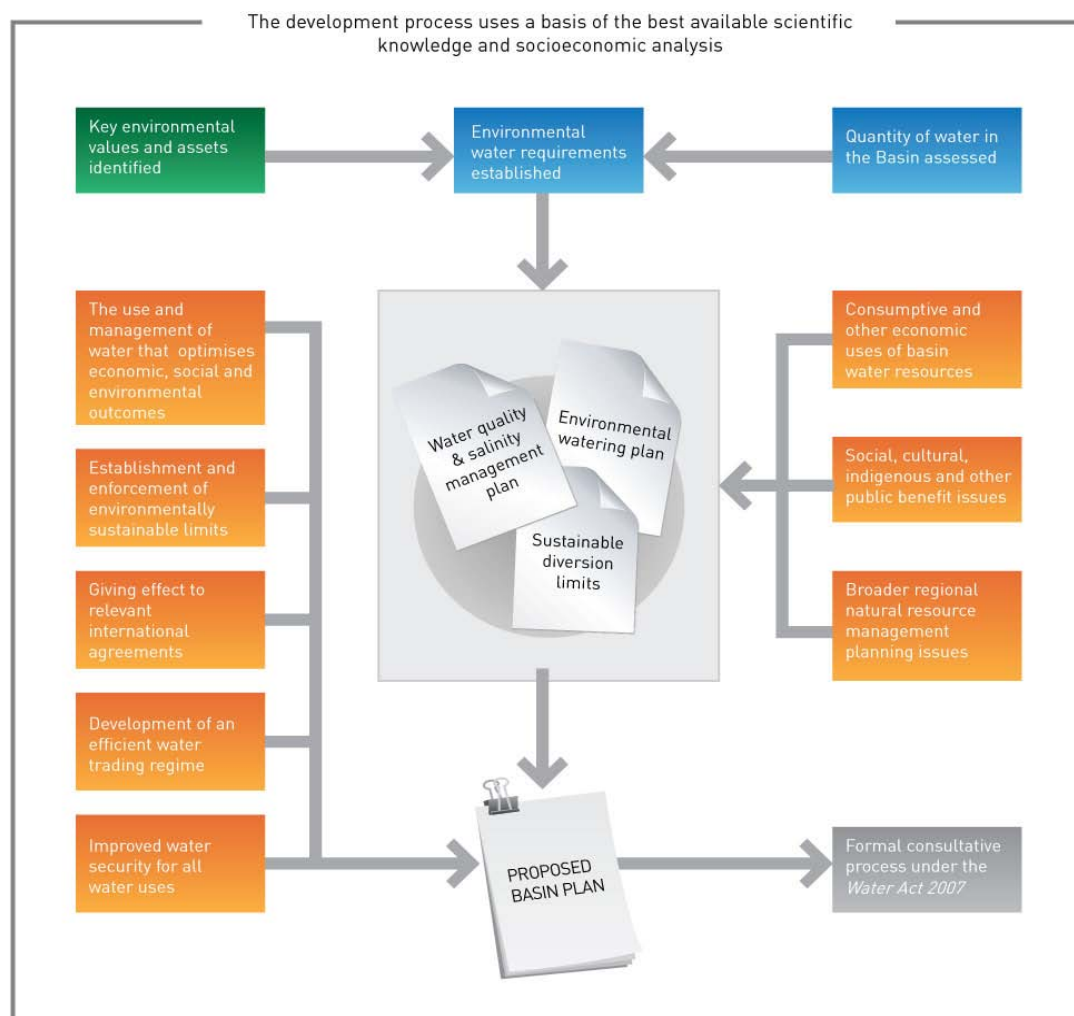


Figure 4 – Development of Basin Plan

⁵ http://www.mdba.gov.au/basin_plan/concept-statement

This Issues Paper focuses on issues relating to the setting of enforceable sustainable diversion limits (SDLs) on the quantities of surface water and groundwater that can be taken from the Basin water resources. These limits must be set at a level that the MDBA, using the best available scientific knowledge, determines to be environmentally sustainable. This is defined as the level at which water can be taken from a Basin water resource without compromising the key environmental assets, key ecosystem functions, productive base or key environmental outcomes of the water resource.

Figure 4 above shows the initial steps in the process of determining SDLs (and the other key elements of the Basin Plan) including:

- quantifying the Basin water resources;
- identifying characteristics of environmentally sustainable levels of take; and
- determining environmental water requirements.

These steps are described in sections 3.4, 3.5 and 3.6 respectively.

Other key elements of the Basin Plan include:

- an **environmental watering plan** to coordinate the management of environmental water across the Basin; and
- a **water quality and salinity management plan** that identifies the key causes of water quality degradation in the Basin and sets water quality and salinity objectives and targets for the Basin water resources.

These elements and their relationship with SDLs are described in sections 3.7 and 3.8.

Another important part of developing the Basin Plan will be to incorporate consideration of economic, social and indigenous assessments. The relationship of these assessments to the development of the Basin Plan is described in section 3.9.

The MDBA's approach to determining SDLs requires consideration of a number of issues, and these are explored in section 4 of this Paper:

- Which water resource plan areas should be used?
- Which forms of 'take' should be limited by SDLs?
- How should SDLs be determined to optimise economic, social and environmental outcomes?
- How should surface water – groundwater connectivity be dealt with?
- How should SDLs be set and expressed?

3.3 How existing plans interact with the Basin Plan

In developing SDLs, it is important to understand the relationship between the Basin Plan and state-based WRPs. SDLs and other key components of the Basin Plan will be implemented through accredited WRPs which will be developed by Basin States.

At the time the Basin Plan comes into effect, a number of state transitional WRPs and interim WRPs will also be in effect.

A transitional WRP is an existing plan made by a Basin State that is either listed in Schedule 4 of the Water Act or is recognised by a regulation under the Water Act. The various transitional WRPs listed in Schedule 4 will cease to have effect from late 2012 through to mid 2017. In the case of Victoria, it is intended to prescribe the water management arrangements in that state as transitional WRPs through regulation; these plans will continue to have effect until 2019.

An interim WRP is one that is made under a state water management law on or after 25 January 2007 and before the Basin Plan first takes effect. Interim WRPs cease to have effect at the end of 2014, or five years after they are made, whichever is later.

While a transitional or interim WRP is in effect, it prevails over the Basin Plan where there is any inconsistency. This means that the new SDLs and other provisions of the Basin Plan will not take effect in a WRP area until the transitional or interim WRP for the area expires.

As the transitional and interim WRPs expire and new WRPs are developed by the Basin States, the new WRPs will need to be accredited by the Commonwealth Minister for Climate Change and Water. The Basin Plan will set out the requirements with which state WRPs will need to comply in order to be accredited. The MDBA will advise the Commonwealth Minister for Climate Change and Water on whether individual WRPs comply with the requirements of the Basin Plan as part of this accreditation process. This process is designed to ensure consistency between WRPs and the Basin Plan.

3.4 Quantifying the Basin's water resources

Quantity of water in the Basin assessed

As shown in Figure 4, a first step in developing the Basin Plan is quantifying the Basin's water resources.

The Water Act requires the Basin Plan to include a description of the Basin's water resources and the context in which those resources are used⁶. The description is to include:

- the size, extent, connectivity, variability and condition of the Basin water resources;
- the uses to which the Basin water resources are put (including by indigenous people);
- the users of the Basin water resources; and
- the social and economic circumstances of Basin communities dependent on the Basin water resources.

This description will provide the context in which the requirements of the Basin Plan will apply, including SDLs.

River system modelling will be used as the basis for quantifying the surface water resources of the Basin, building upon the approach applied in the Murray-Darling Basin Sustainable Yields project⁷.

⁶ Water Act, s 22(1) item 1

These models can be used to describe the size, extent, connectivity and variability of surface water resources at a range of scales from flow quantities and variability at specific locations, to catchment and whole of Basin water availability. Their main role is to assist in determining the impact of levels of use on the Basin water resources. Work is underway to adapt the river system modelling used in the Sustainable Yields project for the purposes of developing the Basin Plan.

The groundwater resources of the Basin will generally be described in terms of their average annual yield, rather than in terms of total groundwater storage. Work is underway to refine the recharge estimates for Basin groundwater systems produced in the Sustainable Yields project.

The Basin's water resources are dependent on current and future climate, and developing appropriate future climate scenarios is an important input to quantifying the Basin's possible future water resources. The MDBA has sought independent scientific advice from the CSIRO and its research partners on appropriate climate scenarios to use in hydrologic modelling to guide the development of the Basin Plan. Based on this advice, the MDBA has decided on a suite of climate scenarios to use. The general approach and the agreed scenarios are summarised in Attachment A: Climate scenarios.

Socio-economic studies and the understanding of the use and users of the Basin's water resources will be of particular relevance. The MDBA is working to better understand the profile of the Basin community, where water is used, where it is sourced from and the wealth that it generates, along with the benefits it provides to communities, including indigenous communities, in cultural and non-commercial values.

The MDBA recognises that the implementation of SDLs will change the way Basin water resources are used in the future. Socio-economic studies will help determine the level of impact of changes in diversion limits and these findings will be included in products associated with the Basin Plan (including the plain English summary, the assessment of implications to be provided to the Ministerial Council and the assessment of impacts of the Basin Plan after five years).

3.5 Identifying characteristics of environmentally sustainable levels of take

Key environmental values and assets identified

Figure 4 also shows that identifying key environmental values and assets is an important first step in developing SDLs and other components of the Basin Plan.

The Water Act requires that SDLs must reflect an environmentally sustainable level of take⁸. This level of take must not compromise each water resource's:

- key environmental assets, or
- key ecosystem functions, or

⁷ CSIRO 2008

⁸ Water Act, s 23(1)

- the productive base, or
- key environmental outcomes.

These four characteristics are referred to in this paper as the ‘environmentally sustainable level of take characteristics’. These characteristics are interlinked in various ways, and once identified, they will be integrated and reviewed to ensure that they meet the requirements of the Water Act, and are consistent with the purposes of the Basin Plan.

3.5.1 Key environmental assets

Environmental assets are defined by the Water Act to include water-dependant ecosystems, sites with ecological significance and ecosystem services. The MDBA will identify water-dependant ecosystems and sites with ecological significance using two main steps. The first step will be to develop an inventory of recognised sites and water-dependent ecosystems in the Basin, and to map these back to physical locations in the Basin. The second step will be to develop and apply criteria that, when applied to these environmental assets, will determine which of them are to be considered key for the purposes of the Basin Plan.

The development of the inventory for the first step will involve the identification of known ecosystems and sites, primarily through the collation of existing inventories of environmental assets such as those compiled through Commonwealth, State, Territory and regional processes and initiatives. This will be coupled with consultation with Commonwealth, State, Territory and regional agencies and scientific experts to identify additional assets for inclusion in the inventory.

The criteria the MDBA proposes to use in the second step have been developed to be consistent with, and use elements of, the *National Framework and Guidance for Describing the Ecological Character of Australian Ramsar Wetlands*⁹ and the draft criteria for identifying high conservation value aquatic ecosystems. The criteria are:

- water-dependent ecosystems of formally recognised significance;
- natural, near-natural, rare or unique water-dependent ecosystems;
- water-dependent ecosystems that provide critical habitat;
- water-dependent ecosystems that support threatened species and communities; and
- water-dependent ecosystems that support significant biodiversity.

Further work will be undertaken to define ecosystem services as part of the environmental assets and ecosystem functions approach and to integrate this into the planning framework.

⁹ Department of the Environment, Water, Heritage and the Arts 2008

3.5.2 Key ecosystem functions

Ecosystem functions are the physical, chemical, and biological processes and exchanges that contribute to the self-maintenance of an ecosystem. Some examples of ecosystem functions are the provision of habitat, and the cycling of carbon and nutrients.

Ecosystem functions occur in a complex and hierarchical web. Understanding the full spectrum of ecosystem functions and their linkages is a difficult and complex task. There are many ecosystem functions that operate in the Basin. However, the Basin Plan cannot deal with matters other than those relevant to the use or management of the Basin water resources, so it will only address ecosystem functions that relate to hydrology.

Attempting to define environmental water requirements for each of the key ecosystem functions of each water resource would be difficult and complex, with a high degree of associated uncertainty. The MDBA will identify the fundamental physical processes relating to hydrology and geomorphology that underpin the key ecosystem functions of the Basin water resources. The MDBA proposes to define the environmental water requirements for these physical processes, rather than for each individual key ecosystem function, as these physical processes are much fewer in number, simpler to conceptualise, and can be more readily linked to hydrologic indicators than the functions themselves. The three physical processes that underpin the key ecosystem functions of the Basin's river systems are outlined in Table 1.

Physical Process	Examples of Dependent Key Ecosystem Functions
Inundation of river beds, banks and floodplains	<ul style="list-style-type: none"> ▪ Creation of physical habitats for plants and animals ▪ Mobilisation of carbon and nutrients
Material mobilisation, transport and dispersal	<ul style="list-style-type: none"> ▪ Creation and maintenance of physical habitats (eg scouring of river beds to create pools, deposition of materials to create bed formations and bank formations) ▪ Mobilisation, transport and dispersal of minerals and nutrients to wetland and floodplain ecosystems
Lateral, longitudinal and vertical flow connectivity	<ul style="list-style-type: none"> ▪ Transport of carbon, nutrients and minerals ▪ Dispersal of seeds ▪ Migration of aquatic animals for reproduction or foraging ▪ Export of pollutants (e.g. salt) from key parts of the river system (e.g. Murray mouth) ▪ Connectivity with groundwater

Table 1: Physical processes that underpin the key ecosystem functions of the Basin's river systems and examples of dependent key ecosystem functions

In order to determine the environmental water requirements of the three physical processes, it will be necessary to:

- identify the spatial and temporal scales at which the physical processes occur; and
- identify the spatial and temporal performance of the physical processes that is required to ensure that key ecosystem functions are not compromised.

These tasks are further described in Table 2.

Step	Task	Method and Inputs
1	Develop a conceptual model of the processes that defines the types of rivers where the processes occur (spatial scale) and the flow conditions under which they occur (temporal scale), including any requirements for seasonal variability	Extend the existing conceptual models developed for the Sustainable Rivers Audit ¹⁰ to provide a stronger link between physical processes and flow requirements
2	Using a functional categorisation of the Basin, spatially map the process zones described in the conceptual model	Extend the Functional Process Zones of the Basin, developed for the Sustainable Rivers Audit ¹¹ , to the required stream network resolution across the Basin
3	Develop a set of hydrologic metrics or indicators that can be used to represent the performance of the processes	It is likely that the Sustainable Rivers Audit hydrologic indicators will form a major input. Some additional indicators may be required.
4	Develop a layered structure of performance targets for the processes, based on what is required to avoid compromising key ecosystem functions	This will be informed by the conceptual model developed at Step 1 and the best available science

Table 2: Key tasks in the identification of spatial and temporal parameters of the physical processes underpinning key ecosystem functions of rivers

The primary outputs of the proposed method for identifying the environmental water requirements of key ecosystem functions will include:

- a conceptual model for the performance of physical processes underpinning key ecosystem functions, which will be applied consistently across the Basin according to a functional categorisation of its streams; and
- a layered set of performance targets for the processes, which can be applied spatially across the Basin.

3.5.3 Productive base and key environmental outcomes

Water resources provide for a range of uses including supporting environmental assets and ecosystem functions, irrigation, drinking water for people and animals, swimming, fishing and boating. The productive base of a water resource is maintained if the resource continues to have the capacity, in terms of volume, quality, and other aspects, to provide for these purposes. This is distinct from the actual use of the water for those purposes (e.g. for agricultural production).

The productive base of a water resource includes those attributes of the water resource that establish its capacity to contribute to social and economic outcomes. These characteristics include water quality that is suitable for human consumption. For example, the water required to not compromise productive base might include dilution flows to ensure water quality is suitable for drinking.

¹⁰ Whittington et al 2001

¹¹ Whittington et al 2001

Environmental outcomes are defined in the Water Act to include ecosystem function, biodiversity, water quality and water resource health. Key environmental outcomes will be heavily related to the other environmentally sustainable level of take characteristics.

It appears likely that if an SDL ensures that sufficient water is available to protect the key environmental assets and key ecosystem functions of a water resource, in many situations there will also be sufficient water to ensure that the productive base and key environmental outcomes of the water resource are not compromised. However, this is something that will be assessed on a case by case basis by the MDBA.

3.5.4 Integration and review of environmentally sustainable level of take characteristics

After the environmentally sustainable level of take characteristics are identified and characterised, it will be necessary for the MDBA to:

- determine the environmental watering requirements of key environmental assets and key ecosystem functions as a key contribution to the calculation of the environmentally sustainable level of take; and
- integrate the characteristics and undertake a Basin-wide review and gap analysis.

The integration of the environmentally sustainable level of take characteristics will involve analysis of the resulting network of key environmental assets, ecosystem functions, productive base and environmental outcomes. Using an approach based on contemporary conservation planning frameworks, it will be possible to make a relative assessment at a catchment and Basin scale of the comprehensiveness, adequacy and representativeness of the resulting ‘network’ of assets and functions.

The review process will require input from experts, convened to provide scientific advice on the robustness and defensibility of the resulting network of assets and functions. Subject to the outcome of this review, it may be necessary to prioritise the critical gaps, seek further data to address these gaps, and revisit the inventory of water-dependent ecosystems and sites with ecological significance where necessary.

3.6 Determining environmental water requirements

Environmental
water requirements
established

A key input to developing SDLs, as illustrated in Figure 4, is determining environmental water requirements.

3.6.1 Environmental watering requirements for key environmental assets

The environmental watering requirements for key environmental assets will be defined using a hydrological regime. This method has been used extensively in The Living Murray and in CSIRO's Sustainable Yields project and defines the watering regime for each asset in terms of the required:

- flow threshold (linked to the required inundation extent or depth);
- duration of flow;
- timing of flow;
- frequency of flow (average); and
- resilience period (maximum period between flow).

These requirements are specified for a particular location that has a strong linkage to the hydrology of the site and corresponds with a 'node' in a hydrologic model.

The water requirements for an asset are determined using a four step process:

1. Identify the key values of the relevant site (as per key asset criteria).
2. Define environmental objectives for those values, consistent with the Basin Plan objectives.
3. Determine the inundation extent and related flow rate required to achieve the objectives (spatial element of the water requirements).
4. Define the timing and frequency of the flow required by the plants and animals represented in the objective (temporal element of the water requirements).

Wherever possible the inundation extent and flow rate are quantified by analysing:

- digital elevation models;
- outputs from hydraulic models;
- historic flood extents; and
- vegetation maps.

This quantification provides clear and transparent linkages between hydrological and ecological components, and a high level of confidence.

The flow regime required by the different plants and animals represented in the environmental objectives for each asset will be determined based on the best available ecological understanding of the site. Flow requirements for key plants and animals are often described as a range which can differ between sites, so where possible other lines of evidence will also be used to assist in determining the required flow regime. For example, for river redgums, where there is a wide variation in flood frequencies reported in the scientific literature, the composition of understorey vegetation communities will be used to assist in determining the required flow regime, where possible.

3.6.2 Environmental watering requirements for key ecosystem functions

The method for determining key ecosystem functions will provide a conceptual framework for the performance of functions, which will then be applied consistently across the Basin according to a functional categorisation of its streams. It will also provide a layered set of performance targets for the functions which can be applied spatially across the Basin.

The standardised approach to key ecosystem functions discussed above, involving identification of physical processes, means that a consistent set of environmental flow metrics (or indicators) can be used to represent the environmental water requirements of the functions. The hydrologic metrics utilised in the *Sustainable Rivers Audit*¹² provide one set that will be drawn upon, although other metrics are likely to be added to this list. The metrics used in the *Sustainable Rivers Audit* are:

- high-flow metric = change in magnitude of high flows;
- low-flow metric = change in magnitude of low flows;
- zero flow metric = change in proportion of time with no flow;
- monthly variation metric = change in coefficient of variation of monthly flows;
- seasonal period metric = change in timing of minimum and maximum flows;
- mean annual discharge metric; and
- median annual discharge metric.

These metrics are unlikely to form the full set used, however they have certain strengths that add to their suitability. The first is the rigour that has been applied to their development and use in the audit. The second is that they are reported relative to a reference (natural) condition, rather than in absolute terms. This approach significantly reduces the effort required to implement the method. It is also a valid approach on the basis that:

- the performance of physical processes is linked to the hydrology of the system
- the ecology of the river system has evolved around the natural hydrology of the system, and the physical processes that were underpinned by that hydrology
- it can be safely assumed that these physical processes occurred to an effective level under natural conditions.

It is expected that other metrics will also be developed, using a similar reference approach. An example is the two-year annual recurrence interval flow, which is commonly linked to the performance of certain geomorphic functions in rivers such as channel forming processes¹³.

3.6.3 Other environmental water requirements

Environmental water requirements will need to include consideration of all aspects of 'environmentally sustainable level of take'. As indicated in section 3.5.3, in many situations the

¹² MDBC 2008

¹³ Gippel 2002

environmental water requirements for key environmental assets and key ecosystem functions will likely also be sufficient to ensure that the productive base and key environmental outcomes of the water resource are not compromised.

The environmental watering plan and the water quality and salinity management plan will operate together with SDLs and will also contribute to ensuring the productive base and environmental outcomes of the water resource are not compromised. In particular, the water quality targets in the water quality and salinity management plan will be reflected in SDLs, most relevantly in the key environmental outcomes specified in the Basin Plan. The relationship between these plans and SDLs is described further in sections 3.7 and 3.8.

3.7 Relationship between the environmental watering plan and SDLs

A central element of the Basin Plan is the environmental watering plan. Its purpose is to protect and restore the 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. In order to do this, the plan will safeguard existing environmental water, plan for the recovery of additional environmental water, and coordinate the management of environmental water across the Basin.



The environmental watering plan will specify:

- overall environmental objectives for the water-dependent ecosystems of the Basin;
- targets to measure progress against these objectives;
- an environmental management framework for environmental water;
- the methods used to identify environmental assets requiring water;
- the principles and methods to be used in setting the priorities for applying environmental water; and
- the principles to be applied in environmental watering.

The water-dependent ecosystems of the Basin are generally considered to be in decline, principally as a result of human induced changes. Chief amongst these is the reduction in water available to sustain water-dependent ecosystems. In this context, the Basin Plan will seek to address the unsustainable take of water for consumptive uses by limiting the amount of water that can be taken (through SDLs) and ensuring that the environmental water resulting from SDLs effectively contributes to achieving the environmental objectives. The environmental watering plan will be an important means of ensuring that this occurs.

The environmental watering plan will also present the methods for identifying environmental assets that require water. These will include the methods that are used to identify the key environmental assets for the purposes of determining the environmentally sustainable level of take (described above).

WRPs will have to demonstrate that they are consistent with the environmental watering plan in order to be accredited.

The environmental watering plan and SDLs will be closely related. SDLs will limit the take of water from the Basin water resources so that sufficient environmental water is available to prevent the compromise of certain characteristics of water resources (the 'environmentally sustainable level of take characteristics'). The environmental watering plan will, amongst other things, contribute to ensuring that the environmental water set aside by SDLs is used (in relation to timing and location) so that the relevant characteristics of each water resource are not compromised.

3.8 Relationship between the water quality and salinity management plan and SDLs

While a number of effective programs aimed at protecting water quality are already in place, there are still threats to the capacity of the Basin water resources, in particular, rivers, to provide water of adequate quality for drinking, for irrigation and industrial water, for recreational use, and for protecting aquatic ecosystems. In response, a key part of the Basin Plan is the water quality and salinity management plan.



The Basin's rivers are its natural drainage system, and the flow of waters from catchments to the ocean is important to protect local catchments from salt, pollutants and sediments, by transporting these to the ocean. This is particularly important in the southern part of the Basin. Without adequate flow of water in rivers, contaminants can accumulate unsustainably and water quality can become unacceptable to local users. Flow in rivers is also an effective management strategy to disperse algal blooms and reduce the risks of unsafe levels of algal toxins in water.

The water quality and salinity management plan will build on the National Water Quality Management Strategy and the Basin Salinity Management Strategy and will specify targets at various locations throughout the Basin. The salinity targets will be developed in the context of maintaining the quality of water in the rivers and groundwater of the Basin, allowing for sound adaptive, real time management and operational decisions, while containing salt loads from catchments, irrigation districts and floodplains and achieving salt export to the ocean. The water quality targets will in particular address the continuing risks of blue-green algal blooms and algal toxins on human health, from recreational water contact or drinking water, as well as maintaining water quality for irrigation and managing risks to aquatic ecosystems.

A range of actions will be required to achieve these targets, many of which will be actions that cannot be directly regulated or implemented through the Basin Plan. These actions include salt interception, improved land management, nutrient reduction, control of pollution and water management, noting that only water management actions can generally be regulated through the Basin Plan. Where the MDBA determines that flow is a limiting factor in achieving water quality and salinity targets, SDLs will ensure that water is available for these requirements. Water quality management will be a significant outcome from the Basin Plan and contribute to supporting the productive base and key environmental outcomes components of environmentally sustainable level of take for both surface water and groundwater.

3.9 Relationship between economic, social and Indigenous assessments and SDLs

The Water Act sets out a number of requirements with which the MDBA must comply in determining SDLs and developing the Basin Plan. For example, the Water Act states that the MDBA must, among other things:

- take into account the principles of ecologically sustainable development;
- act on the basis of the best available scientific knowledge and socio-economic analysis;
- have regard to the consumptive and other economic uses of Basin water resources;
- have regard to the management objectives of the Basin States for particular water resources ; and
- have regard to social, cultural, Indigenous and other public benefit issues¹⁴.

The Basin Plan is being developed to support the integrated management of the Basin water resources. The proposed plan will, among other things, identify key environmental assets and key ecosystem functions of each water resources, and their associated environmental water requirements. The proposed plan will be developed on the basis of a number of factors including best available scientific knowledge and social and economic analysis.

Initially, economic and social assessments will be undertaken across the Basin as a whole and for those irrigation areas of the Basin which account for the largest proportions of current water diversions and might potentially be significantly affected by any changes in future water availability. The aim will be to determine the potential implications for a range of possible changes in water availability.

At the same time, SDL options associated with meeting an initial draft set of environmental water requirements will be determined mainly through hydrological modelling (see section 4.5 for more details of the proposed approach).

The results of the two sets of analyses will then be considered together, in an iterative fashion if need be, with the social and economic analyses being used initially to inform how, where and when water can be delivered to meet environmental requirements at least social and economic cost.

Following any adjustments, there may be a need to review the SDL options and re-run the hydrological modelling and the analyses of potential economic and social impacts.

Once a final set of SDLs has been determined for inclusion in the proposed Basin Plan, an analysis of the social and-economic implications of the proposed Basin Plan will be undertaken. This analysis will form the basis of the MDBA's advice to the Murray-Darling Basin Ministerial Council on these implications. Basin States can use this information to make comments on the social and economic impacts of the Basin Plan.

¹⁴ Water Act, s 21(4)

The MDBA views community involvement, including Indigenous communities, as important input to the social and economic choices reflected in the provisions of the Basin Plan.

As indicated earlier, two types of social and economic analysis are proposed. The first involves the use of integrated Basin-wide economic impact scenario analyses to model and estimate the effect of potential changes in water availability on land and water use for the agricultural sector and subsequent flow-on effects for employment and incomes at the regional scale. The second involves more local scale social and economic assessments of those irrigation areas of the Basin that account for the largest proportions of current water diversions and might potentially be significantly affected by any changes in future water availability. These analyses will encompass consultation with stakeholders and will build on the range of previous studies conducted in the Basin over the last decade. The aim will be to combine the results of both sets of studies to provide estimates, based initially on a number of scenarios, of the potential impacts and implications of changes in water availability at the Basin-wide, regional and, where targeted, local scale.

To help obtain Indigenous input into the consideration and establishment of SDLs, the MDBA is consulting with Traditional Owners and other Indigenous stakeholders. The aim is to give voice to how Indigenous communities currently utilise and relate to water and to explain their values and connections to the environments likely to be influenced by the Basin Plan. This consultation process has commenced with local meetings, undertaking an analysis of the literature on Indigenous values and the environment, and holding larger workshops with both the Murray Lower Darling Rivers Indigenous Nations and Indigenous representatives from across the northern Basin. This approach will also involve an exploration of how Indigenous values and uses relating to water and the land may be adversely and/or positively affected by changes in water availability.

4. Issues

4.1 Which Water Resource Plan areas should be used?

The Basin Plan must identify the boundaries for water resource plan areas (WRP areas) and must specify the water resources to which each WRP will apply¹⁵. The Water Act requires there to be a WRP for each WRP area¹⁶.

For the Basin Plan to provide an integrated approach to the management of the Basin water resources, the discrete water resource units identified in the plan should, as far as possible, be based on physical resource boundaries, such as catchment boundaries for surface water resources and geological or hydraulic boundaries for groundwater.

The Water Act requires the WRP areas specified in the Basin Plan to align with State water planning areas as far as possible¹⁷. The Basin Plan is able to deviate from these boundaries in certain situations, such as where water resources are not currently covered by State WRP areas. Because the Basin Plan is required to determine SDLs for the Basin water resources as a whole, it is necessary for all the Basin water resources (i.e. all surface water and groundwater) to be covered by WRP areas and be subject to SDLs.

Because WRPs will be developed by individual Basin States¹⁸, each WRP area must be wholly contained within a single Basin State. Each WRP can be made up of one or more instruments¹⁹, meaning that a Basin State could submit a number of plans or other instruments to the MDBA for accreditation by the Commonwealth Minister for Climate Change and Water against the WRP requirements set out in the Basin Plan. Using surface water in the Lachlan catchment as an example, there could be an instrument for the regulated surface water system (akin to the current *Lachlan Regulated River Water Sharing Plan*), an instrument for the unregulated part where surface water use is significant (akin to the *Mandagery Creek Water Sharing Plan*), and a third instrument for the remaining surface water resources. The combination of these three instruments could constitute a WRP. The groundwater resources in the Lachlan would also need to be covered by WRP areas.

With the above considerations in mind, the MDBA is proposing the following approach.

The boundaries currently provided for under the water management laws of the Basin States will, as far as possible, be used as a basis for WRP areas. For surface water, these boundaries are largely based on natural water catchments. For groundwater, these boundaries are largely based on hydrogeological units.

¹⁵ Water Act, s 22(1) item 2

¹⁶ Water Act, s 54(1)

¹⁷ Water Act, s 22(1) item 2

¹⁸ Water Act, s 63

¹⁹ Water Act, s 63(1)

Consideration will be given to incorporating groundwater resources into catchment based WRP areas where the groundwater system lies wholly within the surface water catchment boundary. For groundwater resources that extend beyond surface water catchment boundaries, separate WRP areas may be defined.

Where catchments or groundwater resource units extend across State boundaries, they will be treated as whole water resource units for the purposes of developing SDLs and other WRP requirements, before the specific provisions for the WRP areas in each State are specified. Each State must separately develop its WRPs consistently with the limits of its legal jurisdiction, but is required to consult with adjacent States in the preparation of such WRPs²⁰. The identification of WRP areas will not hinder chief consideration of connectivity between water resources across the Basin, or the need to consider the Basin as an integrated whole.

Due to the inherent complexity of groundwater systems, an expert panel comprising State groundwater managers and the MDBA is being established for each jurisdiction. The expert panel will provide advice in determining the final form of the WRP areas for groundwater.

Questions

What are your views on the proposed approach to determining WRP areas as set out in this paper?

Do you have any suggestions you would like to provide to the MDBA in this regard?

4.2 Which forms of 'take' should be limited by the SDLs?

The Water Act introduces a new way of sharing water resources of the Basin, and in doing so uses terms and concepts with similarities and differences to the range of existing State legislation, the existing Murray-Darling Basin Cap arrangements and the National Water Initiative.

SDLs are the quantities of water that can be taken on a sustainable basis from the Basin water resources²¹. The reference to sustainable basis is further developed in the Water Act in the requirement that each SDL must reflect an 'environmentally sustainable level of take', that is, a level that, if exceeded for a water resource, would compromise the key environmental assets, key ecosystem functions, productive base or key environmental outcomes (hereafter referred to as the 'environmentally sustainable level of take characteristics') of the water resource²².

Take is defined in the Water Act as follows:

'Take water from a water resource means to remove water from, or to reduce the flow of water in or into, the water resource including by any of the following means:

- (a) pumping or siphoning water from the water resource;
- (b) stopping, impeding or diverting the flow of water in or into the water resource;

²⁰ Water Act, s 63(2)

²¹ Water Act, s 22(1) item 6

²² Water Act, ss 4 (definition of 'environmentally sustainable level of take') and 23(1)

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- (c) releasing water from the water resource if the water resource is a wetland or lake;
- (d) permitting water to flow from the water resource if the water resource is a well or watercourse;

and includes storing water as part of, or in a way that is ancillary to, any of the processes or activities referred to in paragraphs (a) to (d).'²³

The definition of take is broad and does not distinguish between taking for environmental purposes, consumptive purposes or other non-environmental purposes. It also differs substantially from the traditional view of 'diversions'. For example, take includes all impoundment of water, including in major public storages, and essentially equates to all activities which modify streamflow.

The provisions of the Water Act also recognise that SDLs are to include water that is taken by interception activities²⁴. Interception activity is defined as the interception of surface water or groundwater that would otherwise flow, directly or indirectly, into a watercourse, lake, wetland, aquifer, dam or reservoir that is a Basin water resource²⁵. Examples of interception activities include the capture of water in farm dams located away from watercourses, the capture of water on floodplains and afforestation.

SDLs are required to limit the take from water resources to a level that does not compromise the 'environmentally sustainable level of take characteristics' of those resources. Because the use of environmental water in accordance with the environmental watering plan will not compromise the 'environmentally sustainable level of take characteristics' of a water resource, it will not be take that is limited by the SDL. The Commonwealth Environmental Water Holder is an example of an entity that must use its water holdings in accordance with the environmental watering plan²⁶.

The water entitlements held by the Commonwealth Environmental Water Holder will retain their original characteristics. This means, amongst other things, that if and when there is a reduction in water allocations under WRPs, the Commonwealth Environmental Water Holder will be treated in the same way as all other entitlement holders. A fact sheet on the impacts of environmental water purchases on SDLs can be found on the MDBA website²⁷.

There are likely to be entities other than the Commonwealth that hold environmental entitlements (e.g. Basin States), and they may be required to use those entitlements in accordance with the environmental watering plan. Water that is held in dedicated environmental entitlements and used in accordance with the environmental watering plan would not compromise the 'environmentally sustainable level of take characteristics', and would not be take that is limited by SDLs.

It is possible that some take for purposes that can be described as 'environmental' in nature could still contribute to compromising 'environmentally sustainable level of take characteristics', and therefore would be take under the SDL.

²³ Water Act, s 4

²⁴ Water Act, s 20(b)

²⁵ Water Act, s 4

²⁶ Water Act, s 105(4)(a)

²⁷ <http://www.mdba.gov.au/files/publications/Basin-Plan-SDL-fact-sheet.pdf>

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In summary, take from a water resource will not be limited by the SDL if it does not contribute to compromising any of the ‘environmentally sustainable level of take characteristics’, i.e. if it was beneficial for those characteristics or had no effect on them.

The MDBA is proposing to deal with the complexity involved in specifying SDLs by using other elements of the Basin Plan, such as the environmental watering plan, WRP requirements and trading rules to ensure that some of the more broadly defined forms of take (e.g. releasing water from a wetland) occur in such a way that they do not contribute to compromising ‘environmentally sustainable level of take characteristics’.

SDLs will primarily limit the take of water for consumptive use, which is defined in the Water Act as the use of water for private benefit consumptive purposes including irrigation, industry, urban and stock and domestic use²⁸. The MDBA’s initial thinking on the main categories of take for the purposes of the SDL is described below and illustrated in Figure 5.

- Licensed take is, as the name suggests, the take of water under a licence (‘entitlement’) issued under State law, a plan made under State law or any other instrument made under State law. It includes licences for irrigation, urban and industrial use, but also includes, for example, licences which allow these uses to occur (i.e. conveyance licences for irrigation channel systems). Water for critical human needs generally falls within this category of take.
- Authorised take is take that is permitted or not prohibited under State law, but for which a licence is not needed. A well-known example of authorised take is take under a stock and domestic right, which generally allows an owner of land fronting a river to take an amount of water for stock and domestic use without licence.
- Licensed interception is the interception of water under a licence. It differs from licensed take in that the water is captured before it has flowed into a watercourse, lake, wetland, aquifer, dam or reservoir. Some interception of water on floodplains currently requires a licence.
- Authorised interception is the interception of water that is permitted or not prohibited under State law but for which a licence is not needed. It differs from authorised take in that the water is captured before it has flowed into a watercourse, lake, wetland, aquifer, dam or reservoir. Farm dams located away from water courses and designed to capture overland flow are generally examples of authorised interception.
- Incidental interception describes activities that have the incidental consequence of preventing water from flowing into a watercourse, lake, wetland, aquifer, dam or reservoir. For example, afforestation activities such as the establishment of plantation forests can incidentally intercept both surface water and groundwater.
- Unauthorised take and unauthorised interception are types of take and interception that are prohibited under State law (i.e. they are illegal).

²⁸ Water Act, s 4

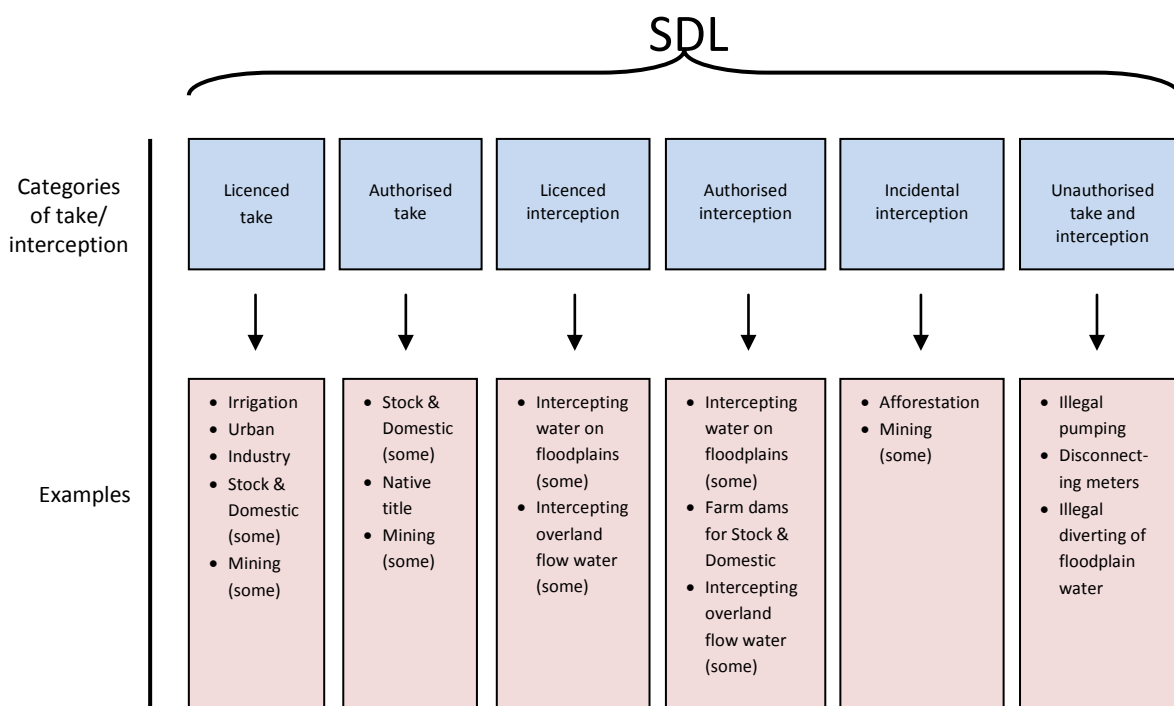


Figure 5 Main categories of take for the purposes of SDLs

Knowledge about the volumes of these various types of take varies widely. For example, the volume of much irrigation, urban and industrial licenced take is known with reasonable accuracy because it is metered. In contrast, the amount of water use under stock and domestic rights is often unmetered and largely unknown. However, some unmetered types of take (e.g. stock and domestic, capturing water on floodplains) may be estimated, more or less accurately, by a range of methods including models and landholder surveys.

As a result of the Basin Plan, it is expected that many areas of the Basin will have SDLs that are lower than the existing levels of use, although for practical reasons not all types of take will necessarily be affected. Further analysis will be undertaken by the MDBA to determine how different types of take will be limited by SDLs.

The purpose of SDLs is to limit the impact of water use on the environment. For this reason, it is net water use, rather than gross water use, that matters. The return of unused water occurs in a number of the irrigation areas in the Basin and in some urban areas (e.g. Canberra). The current Murray-Darling Basin Cap on diversions accounts for water on the basis of net use where there are arrangements to account for return flows. It is proposed that the SDL will do likewise subject to a review of such arrangements for consistency with the Basin Plan objectives. Further detailed work will be undertaken by the MDBA to specify the SDL provisions in this regard.

Question

What are your views on the proposed approach to ‘take’ limited by SDLs, as set out in this paper?

4.2.1 How should interception activities be treated?

As indicated above, the provisions of the Water Act recognise that SDLs are to limit the take of water by interception activities²⁹. Interception activity is defined as the interception of surface water or groundwater that would otherwise flow, directly or indirectly, into a watercourse, lake, wetland, aquifer, dam or reservoir that is a Basin water resource³⁰.

There are many interception activities occurring in the Basin. They include, for example, the interception of surface water and groundwater by afforestation activities, the capture of water in farm dams, and the capture of water from floodplains (e.g. harvesting floodwaters, various types of mining operations). The MDBA is currently cataloguing the range of interception activities in the Basin.

Because interception activities will generally involve take that is limited under the SDL³¹, the MDBA will need to estimate the amount of water being intercepted by existing activities. Some jurisdictions already do this for certain interception activities under the Murray-Darling Basin Cap, such as, for example, NSW estimating the amount of water taken from floodplains each year (so-called 'floodplain harvesting').

The Water Act requires the Basin Plan to specify a range of requirements for WRPs, including requirements relating to the regulation of interception activities with a significant impact on Basin water resources³². As part of this, the Basin Plan may require an assessment to be undertaken of interception activities with, or with the potential to have, significant impacts on a Basin water resource, to determine whether they are consistent with the relevant WRP before they are approved by the Basin State³³.

The MDBA will use the best available knowledge to determine which interception activities could have a significant impact on the Basin water resources. The test of significance can be applied on an activity-by-activity basis or cumulatively³⁴. This analysis will also inform the determination of thresholds of significance for each interception activity. For example, forest plantations covering more than a certain area, or farm dams greater than a certain volume, could be identified as interception activities that have a significant impact on water resources.

Where a proposed interception activity is identified as being significant and above a specified size threshold, the MDBA will include requirements for relevant WRPs that establish suitable management approaches. For example, specified kinds of interception activities may be required to hold a water access licence³⁵ equivalent to the volume being intercepted.

²⁹ Water Act, s 20(b)

³⁰ Water Act, s 4

³¹ Water Act, s 20(b)

³² Water Act, s 22(3)(d)

³³ Water Act, s 22(7)(a)

³⁴ Water Act, s 22(3)(d)

³⁵ Water Act, s 22(7)(b)

A practical and workable framework for determining which interception activities may have a significant impact on the Basin water resources, and the tests of significance for those activities, will be developed by the MDBA and reflected in the Basin Plan provisions.

Questions

What are your views on the proposed approach to treating interception activities as set out in this paper?

Which interception activities are significant enough to be explicitly identified in the SDL provisions?

4.3 How should SDL provisions be determined in a way that optimises economic, social and environmental outcomes?

Section 3.9 provides a general description of the relationship between economic, social and indigenous assessments and SDLs. A key aspect of these assessments is to determine how a given set of environmental water requirements across the Basin are satisfied at least economic and social cost.

The Basin Plan is also required to minimise social and economic impacts by setting temporary diversion provisions for the water resources of each WRP area³⁶. The purpose of these provisions is to provide for a transition period where the SDL for a water resource is lower than the long-term average quantity of water that has in fact been taken from that water resource. Temporary diversion provisions are added to their corresponding SDLs and must be reduced to zero within 5 years.

Section 4.5 sets out the proposed approach to setting and expressing groundwater and surface water SDLs. In determining SDLs across the Basin, there is likely to be a number of situations where there will be alternative options for sourcing water to satisfy environmental water requirements. The two main scales will be within valley sharing and inter-valley sharing. The latter will particularly apply to surface water where environmental water requirements in the more downstream sections of the Basin could be sourced from different catchments.

The proposed approach to within valley sharing of environmental water contributions will be to initially focus on minimising any average reduction in water availability to entitlement holders, while meeting the environmental requirements. Upon refinement and progress towards a minimised impact, further analysis could examine and estimate as far as possible any specific impacts on water users. This work could examine the nature of the changes in water availability in particular sequences (e.g. drought) rather than just the long-term average impact of such changes. It could also examine changes in the reliability profile of water supply to particular entitlements (with a particular reference to the nature of the types of enterprises that would be affected). Opportunities to ameliorate impacts whilst continuing to meet environmental water requirements would be explored.

³⁶ Water Act, s 24

4.3.1 Inter-valley sharing of environmental water contributions

When environmental water is required at locations downstream of the confluence of tributary systems, there will be various options for sourcing that water. For example, environmental water for sites along the River Murray (such as the Hattah Lakes in Victoria and the Chowilla Floodplain in SA and NSW), need not only come from the River Murray itself, but could also come from the Goulburn-Broken System and the Murrumbidgee River.

A range of factors need to be considered when deciding how to share the contribution of environmental water between upstream catchments, including social and economic factors and physical characteristics of the Basin river system, such as water delivery efficiency.

Sharing water contributions from upstream catchments could simply be on a proportional basis using either natural flows or the impact of current levels of diversion on the flow at the particular location. Some combination of these factors could also be used and any application would have to consider the physical ability of water to be supplied from a particular tributary. Physical aspects of the Basin river system, including channel capacities and delivery efficiencies, would also have to be considered, along with any environmental implications of changed flow regimes on tributary systems.

However, sharing water contributions in this way needs to consider the social and-economic consequences. For example, the gross value of irrigated agricultural production in various valleys could be a significant consideration in the distribution of contributions of water to downstream assets. This could be done either at a gross scale or on a 'per Megalitre' basis. A balance would need to be struck between minimising overall economic impact and avoiding, where possible, substantial localised consequences in a particular valley. The differing economic impacts of water reductions to various irrigated agricultural industries could also be part of this consideration.

4.3.2 Proposed studies

A range of economic and social studies are proposed to inform the analysis of options described in this section and section 3.9. The studies will aim to generate quantitative and qualitative information to provide:

- descriptions of the social, cultural and economic circumstances of the Basin, which will help build the MDBA's understanding of the context in which SDLs and the Basin Plan are being developed
- quantitative assessments of the likely economic and (to an extent) social impacts of scenarios arising from various SDLs, to allow comparison of the likely implications of alternative SDL options
- qualitative analyses of the likely social, economic and cultural impacts of adopting alternative SDLs, which will provide contextual information to enable better judgements to be made.

The studies are likely to involve:

- (a) **Statistical data.** Information will be sourced from the best available statistical data to analyse aspects of the Basin’s social and economic circumstances and their relationships to diverted water resource use (such as by regional communities, industries and Indigenous communities). The information will cover demographic, economic, water supply and use, land use and land management practice attributes.
- (b) **Economic and social impact scenario analyses.** Economic and social impact scenario analyses will be used to inform the MDBA’s understanding of the impacts of setting SDLs on Basin communities. For example, economic modelling will be used to estimate the effect of potential changes in water availability on land and water use for the agricultural sector and subsequent flow on effects for employment and incomes at the regional scale. In addition, finer resolution economic impact analyses, or local studies, will be commissioned in those places most likely to be affected by changes in water availability, in order to take the higher level analyses further and estimate the likely effects of potential changes at the local scale within communities. These studies are likely to have a strong qualitative dimension to them. Similarly, social and cultural impact analyses would be undertaken to help understand the effects of change on people and communities, including Indigenous communities, across the Basin as a whole and at the local community scale. This may also include a review of indicators of community vulnerability, resilience and adaptive capacity. It will be important to ensure there is some level of consistency of approach to these studies to enable comparisons to be drawn where appropriate.
- (c) **Contextual studies.** Contextual studies will inform the overall assessment of impacts and place these within the broader context of changes affecting Basin communities. For example, these would look at the range of previous studies undertaken in the Basin and the range of structural adjustment pressures facing irrigated agriculture and dependent communities so that the relative impact of alternative SDLs can be understood in a broader context

A significant challenge in undertaking these analyses in the available timeframe will be to engage with the Basin’s various communities of interest to gather information about social, cultural and economic values and anticipated impacts arising from changes in water availability.

Questions

What are your views on the proposed approach to optimising economic, social and environmental outcomes through SDLs as set out in this paper?

What is the best way to maximise input from particular communities of interest in the time available?

Do you have any suggestions you would like to provide to the MDBA in this regard?

4.4 How should surface water-groundwater connectivity be dealt with?

The Water Act states that the description of the Basin water resources must include information about the size, extent, connectivity, variability and condition of those resources³⁷. Attachment B provides further information on the nature of surface water-groundwater connectivity that occurs in the Basin and the significance of the issue in terms of current and potential impacts on water resources. Connectivity between surface water and groundwater will need to be considered in determining SDLs.

Surface and groundwater systems are not separate resources but are components of one system. Groundwater extraction may directly impact on surface water stream flow, by inducing leakage to groundwater over both short and long timeframes.

Stream losses from past and current groundwater extraction will increase into the future due to the delayed response in the movement of water in groundwater systems. If groundwater use increases, stream flow depletion will further increase over the next several decades.

Integrated management of surface water and groundwater resources is critical to ensuring their sustainability and for meeting the objectives of the Basin Plan.

The current integration of the management of surface water and groundwater in the Basin is generally inadequate leading to allocation of the same water twice (i.e. double accounting) in some cases, particularly where time lags are long.

The proposed approach to dealing with connectivity in the Basin Plan takes account of the points below.

- Given the complexity of attempting to set combined surface water and groundwater SDLs, the general approach will be to set separate SDLs for surface water and groundwater that take account of current and future interactions between surface water and groundwater resources and prevent double accounting.
- Groundwater systems in the Basin will be classified using a broad approach based on the conceptual model illustrated in figure 2, Attachment B, to identify those groundwater management units and connected surface water resources where management approaches need to be included in the Basin Plan.
- Management of connected systems will be considered in two categories: short-term management and long-term management:
 - Short-term management is aimed at managing stream flow impacts within a year or other short timeframe. Appropriate management approaches will be included in the Basin Plan as requirements for relevant WRPs³⁸.
 - Long-term management is aimed at ensuring long-term impacts are accounted for in setting surface water and groundwater SDLs where there is significant connectivity between the two.

³⁷ Water Act, s 22 (1), item 1(a)

³⁸ Water Act, s 22(1) item 11

Questions

What are your views on the proposed approach for dealing with surface water – groundwater connectivity as set out in this paper?

Do you have any suggestions you would like to provide to the MDBA in this regard?

4.5 How should SDLs be set and expressed?

The Water Act requires the MDBA to prepare a proposed Basin Plan that:

- sets SDLs³⁹
- determines how compliance with SDLs will be assessed⁴⁰
- sets out the requirements with which a WRP for a WRP Resource Plan area must comply with in order for it to be accredited⁴¹.

While the provisions of the Water Act place specific requirements upon the MDBA in the preparation of the Basin Plan, they also provide a considerable degree of flexibility. The Water Act requires the Basin Plan to include the maximum long-term annual average quantities of water that can be taken, on a sustainable basis, from the Basin water resources as a whole and from particular parts of the Basin water resources. However the Water Act also allows for long-term average SDLs to be specified:

- (a) as a particular quantity of water per year
- (b) as a formula or other method that may be used to calculate a quantity of water per year
- (c) in any other way that the MDBA determines to be appropriate⁴².

So, while SDLs must be presented as long-term average annual volumes, there are a variety of ways in which these limits could be represented in WRP requirements and in how compliance could be checked.

SDLs are required to place limits on a number of different forms of take with different degrees of significance and impacts. How well the different forms of take are measured and how well they are able to be analysed with the assistance of river system and groundwater simulation models also varies significantly. It is therefore important that a flexible approach is taken to specifying and assessing compliance with SDLs, by applying appropriate methods for the nature of the take and the type of water resource.

³⁹ Water Act, s 22(1) item 6

⁴⁰ Water Act, s 22(1) item 8

⁴¹ Water Act, s 22(1) item 11 and s 22(3)

⁴² Water Act, s 23(2)

4.5.1 SDLs specified only as a long-term average volume

The simplest way in which an SDL can be expressed and implemented is by specifying a long-term average volume as a limit which actual average take cannot exceed over a specified period of years. Rolling averages over a specified number of years could be used to determine the actual average take for compliance purposes. This approach may be suitable for some groundwater systems due to the buffering effect of a large storage volume in the system.

It may also be suitable for small, unregulated river systems, for small or dispersed groundwater systems, or for take associated with interception activities. The impacts of these forms of take at the Basin scale largely relate to cumulative downstream effects or local impacts. The cumulative impacts may be adequately managed by a long-term average SDL, and local impacts can be governed by access constraints, and may in any case be heavily influenced by the availability of the water resource.

However, for regulated river systems and significant unregulated systems this approach may have a number of disadvantages, especially where the way in which take varies over time and location impacts on the ability to provide for environmental water requirements. Also this approach is not responsive to the uncertainties of climate variability and climate change. The long-term average volume would need to be based on assumed climate conditions for the future, either a continuation of historic climate or an assumed climate change scenario. If the actual future climate varies markedly from the assumed conditions, then unintended impacts on consumptive users or the environment could result.

A variation to the above approach, particularly for groundwater systems, would be to specify SDLs as a formula reflecting a proportion of average annual recharge. The actual volume would change with any improvement in knowledge about average annual recharge, including the impacts of climate change.

4.5.2 SDLs specified with the assistance of models

For more significant forms of take, particularly from surface water systems, it is proposed that SDLs will be tailored to address the risks associated with the variations in diversions from year to year mentioned above.

Developed water systems are complex, due to highly variable and changing climatic conditions, the wide ranging approaches that have been taken to development and use of resources, and the range of rules and arrangements under which water entitlements operate. In response to this, river system and groundwater simulation models have been developed over a number of years to assist in water resource planning and management. These models are necessary tools to deal with the complexity involved in developing water planning arrangements, and in implementing these arrangements. Across the Basin, a number of river system and groundwater simulation models have been developed, and the MDBA will be using these models to determine SDLs that ensure adequate water is available for identified environmental water requirements (including requirements for water quality and salinity targets) in a way that optimises social, economic and environmental outcomes.

Various forms of these models will also continue to be used as part of implementing SDLs and other provisions of the Basin Plan.

SDLs specified and implemented with the assistance of models will relate to the forms of take that are explicitly represented in these models. Although not all forms of surface water take are represented in current models, the available suite of models can be used to reasonably represent the surface water resources of the Basin and the impact of take on streamflows, both locally and cumulatively, as demonstrated by the results of the CSIRO Sustainable Yields Project. (This project also identified the limitations and uncertainties of the current suite of models, and where improvements are required.) For groundwater resources, coverage is not as comprehensive; however most of the highly developed groundwater systems do have groundwater simulation models.

Groundwater models will be used in setting SDLs that may be mainly specified as a long-term average volume, as described above, but may be complemented by additional requirements such as the location of the take or the nature of recent recharge. These requirements would be determined to ensure that key environmental assets, key ecosystem functions, the productive base and key environmental outcomes of the relevant resources (eg water quality) are not compromised.

Specific issues relating to annual variability in groundwater systems include climatic factors that impact on recharge volumes, the volume of accessible groundwater storage within a particular system and the nature of its connectivity with surface water, including the inherent time lags involved. Furthermore, modifications to the management of surface water, including infrastructure efficiency measures, may result in reduced groundwater recharge volumes that need to be considered when setting SDLs. Such factors will be considered in the determination of the appropriate SDL methodology for groundwater systems.

For surface water systems represented by models, SDLs and associated WRP requirements will need to be specified to ensure that the annual variation in take is specified as well as the long-term average.

4.5.3 Current Murray-Darling Basin Cap arrangements for surface water

Since 1995, the Basin States have agreed under the Murray-Darling Basin Agreement to limit the consumptive use of surface water in the Basin. The mechanism for doing this is known as the Cap. Although the process of setting SDLs is different to the setting of the Cap, lessons may be learnt from the way in which the Cap arrangements have been implemented, particularly with respect to how the Cap is reflected in annual limits that are responsive to changing climatic conditions.

The current Cap arrangements limit surface water diversions through a combination of arrangements including fixed annual limits, long-term averages, and methods for determining annual limits. More details on the Cap and its implementation are available on the MDBA website⁴³.

⁴³ <http://www.mdba.gov.au/files/publications/Review-of-Cap-Implementation-2007-08.pdf>

To illustrate how the Cap limits diversions on an annual basis, for New South Wales and Victoria, diversions must be limited to diversions under baseline conditions as determined by reference to an approved model, where the baseline conditions reflect the level of development as at June 1994. After the end of each water year, the water resource infrastructure, management rules and levels of development associated with June 1994 are applied to the rainfall and flow conditions of the water year being calculated. The calculated water use under such conditions is compared to the actual water use to check Cap compliance. An ongoing accounting system of ‘credits and debits’ is associated with the annual process and allowances are made for water trade and water recovery for the environment.

One approach to expressing surface water SDLs would be to specify them as a defined adjustment from the Cap baseline conditions. It would be possible to determine these adjustments so that on a long-term basis, adequate water was made available to satisfy environmental water requirements. However this approach would provide a limited ability to adjust the annual variation of diversions, and would therefore not be able to provide the annual variability that is necessary to satisfy environmental water requirements.

Because of this limitation, while this approach has been satisfactory for use under the Cap and has generally been successful at preventing growth of surface water diversions beyond 1993/94 levels, it is not supported for the Basin Plan.

4.5.4 Developing surface water SDLs with the assistance of river system models

The proposed approach for developing surface water SDLs with the assistance of river system models is through the following steps:

1. Determine the implications for the current patterns of consumptive water use of providing the environmental water requirements (determined as described in section 3.6), by investigating combinations of changes in hydrologic management strategies that would achieve these requirements. This step would initially be carried out using the historic climate scenario (1895-2009).
2. Investigate how the changed hydrologic management regime performs under a range of possible future climates in terms of sharing the risk of climate change, and adjust the hydrologic management strategies so that environmental requirements are met and, in doing so, social, economic and environmental outcomes are optimised under each climate scenario.
3. Specify SDLs and related elements of WRP requirements so that environmental water requirements are able to be achieved through limits on:
 - (a) the long-term average amount of water that can be taken
 - (b) the annual variability of take within the long-term average limit
 - (c) the way in which long-term average diversions share the risk of climate change.

River system models include hydrologic representation of the range of different management arrangements currently used by jurisdictions to achieve the outcomes being sought in existing water plans. These include:

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- rules for allocating water to entitlements, including how inflows and storage are shared, reserve and carryover policies etc
- accruing and managing ‘reserves’ in dams for either specific environmental uses, or to be managed ‘adaptively’ to achieve specified environmental objectives
- target flows at certain points in the system under certain climatic or flow conditions to provide for the environment, including water quality
- minimum passing flow rules (eg below storages, or at points in river systems)
- unregulated flow sharing rules (eg rules limiting extraction at predetermined flows, or until predetermine flows are reached)
- restricting access to flows under specified conditions (eg to address risk of blue-green algal outbreaks)
- storage airspace rules
- rights to water which can be used adaptively for environmental purposes (eg water entitlements committed to the environment, ie ‘held environmental water’).

These management arrangements represent the toolkit available to achieve both environmental and consumptive objectives. Jurisdictions have adopted different mixes and specifications of these arrangements to achieve water management objectives.

Arrangements can range from a greater reliance on detailed rules which are locked in for the term of the water plan, to a greater reliance on adaptively managed environmental reserves or environmental entitlements such as those held by the Commonwealth Environmental Water Holder. The environmental water requirements in the Basin Plan will be provided for by a mix of these arrangements.

River system modelling will need to be based on assumptions about the mix of held environmental water and planned environmental water used to achieve the environmental water requirements. The proposed approach involves determining water management arrangements that provide the required limits on the taking of water, not only in terms of a long-term average, but also in terms of the annual variability within that long-term average. Modelling will be done at a catchment scale and at a Basin scale using the modelling framework developed by CSIRO for the Basin Plan. Environmental water requirements across the Basin will need to be satisfied in an integrated way. This is expected to involve iteration between the catchment scale and the Basin scale.

River system modelling will be undertaken initially in the context of the historical climate. Given the risks of climate change to water availability, analyses will also be undertaken to consider how this risk is best shared between the environment and consumptive users. Model runs will consider how the water management arrangements in the model share the impact of climate change between the environment and consumptive use, and what changes are necessary. A principle of *pro rata* sharing of climate change impact between consumptive users and the environment of any overall reduction in water availability due to climate change could be an appropriate starting point. For further details about climate scenarios, see Attachment A.

The process also involves the joint consideration of the environmental and the social and economic consequences of SDLs as described in section 4.3. The overall outcome will be model scenario runs for water management arrangements that achieve the environmental water requirements (including requirements for water quality and salinity targets) in a way that optimises social, economic and

Development of Sustainable Diversion Limits for the Murray-Darling Basin

environmental outcomes under both the historic climate scenario, and the three relevant climate change scenarios (extreme dry, median and extreme wet 2030 climate scenarios). The arrangements also need to take account of the connectivity between surface water and groundwater, as well as the outcomes of the short term climate sequences, described in Attachment A.

The results of these model runs will be converted into specifications for SDLs and related WRP requirements. These specifications will be an important component of ensuring that environmental water requirements can be achieved through the detailed accredited WRPs developed by Basin States, and that these WRPs also deal with climate change in the way specified in the Basin Plan.

The hydrological objectives associated with the environmental water requirements are proposed to be specified as part of the requirements for accredited WRPs developed by the Basin States, as well as the long-term average SDL for the historic climate scenario and the way in which long-term average diversions should vary for the climate change scenarios. It could be expected that the development of the WRPs by the States would see further refinement and specification of the water management arrangements whilst maintaining consistency with these requirements.

Once a WRP has been accredited and commences, the implementation of the water management arrangements used in the WRP will be the key way in which SDLs are complied with and environmental water requirements are satisfied. In order to demonstrate that the implementation of WRPs is complying with the SDL and other WRP requirements of the Basin Plan, models that are accredited as part of WRP accreditation are proposed to be used with the actual climate and inflows at the end of each water year to derive an annual estimate of diversions that should have been made under these arrangements. These 'clunk runs' will be a part of an annual audit and compliance process. Details of the compliance arrangements for the Basin Plan are still being developed.

The approach proposed above to setting SDLs with the assistance of river system models is a sophisticated basis for the specification of SDL requirements, both on an annual and long-term basis, which can be matched to the environmental water requirements for particular water resources. Use of the model arrangements associated with the accredited WRP also ensures actual water use is being assessed against the most contemporarily available planning tool.

The MDBA recognises that more detailed consideration is required on how this proposed approach will work in practice. Accordingly, the MDBA will continue to work with Basin States and other stakeholders to refine this approach.

Questions

What are your views on the proposed approach to setting and expressing SDLs as set out in this paper?

Do you have any suggestions you would like to provide to the MDBA in this regard?

5. References

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6. How to make a submission

There is no specified format for a submission

Submissions may range from a short letter on a particular topic to a substantial document covering a range of issues. Where possible you should provide evidence, such as relevant data and documentation, to support your views. While every submission is welcome, multiple, identical submissions do not necessarily carry any more weight than the merits of an argument in a single submission.

Please fill out the cover sheet

Each submission should be accompanied by a cover sheet on which submitting individuals and organisations can provide personal and organisational details. For submissions received from individuals, personal contact details (for example, home address, phone and fax number) in the text of the submission will be removed before it is made publicly available. Only the submitter's name and State or Territory of residence will appear in the published submission. A submission cover sheet is provided at the end of this paper and an electronic version is available on the MDBA website [www.mdba.gov.au]. Copyright in submissions sent to the MDBA resides with the author(s), not with the MDBA.

Submissions can be in a range of formats

Provision of electronic submissions through our website (www.mdba.gov.au) is preferred but submissions may be sent by fax, audio cassette or hard copy. Electronic submissions can be either a text document (.doc, .txt) or Adobe Portable Document Format (.pdf). Submissions will be published on the MDBA website in pdf format. Please ensure that the version sent to the MDBA is the final version and that you have removed any drafting notes, track changes, annotations and other hidden text and marked revisions. Please also remove any internal links and large logos and decorative graphics to keep the size down. This will enable the submission to be easily viewed and downloaded from the website.

Availability of submissions

The MDBA will treat all submissions received in relation to this issues paper as public documents and make them available on its website, unless the author of the submission clearly marks all or part of the submission as confidential or requests a delayed release for a short period of time. Submissions will be posted to the MDBA website's home page, where they will remain indefinitely. The MDBA will acknowledge receipt of submissions and will post on our website a summary of the issues raised in submissions and how the MDBA plans to address them in the proposed Basin Plan.

The MDBA is collecting information to inform policy decisions in relation to the preparation of the Basin Plan and person information received will be used only for that purpose. The MDBA will treat comments and submissions, as well as collect and store information, in accordance with the *Privacy Act 1988* (Cth). Any request under the *Freedom of Information Act 1982* (Cth) for access to a submission in relation to which a confidentiality request has been made will be determined in accordance with that Act.

Development of Sustainable Diversion Limits for the Murray-Darling Basin

Delivery of submissions

Submissions on this paper are invited by **18 December 2009** and should be submitted via our website:

www.mdba.gov.au

or sent to:

Post: Stakeholder Engagement Branch
Sustainable Diversions Limits Issue Paper
Murray-Darling Basin Authority
GPO Box 1801
Canberra ACT 2601

For general enquiries about the submission process call 1800 230 067.

Murray-Darling Basin Authority

SUBMISSION COVER SHEET

Developing Sustainable Diversion Limits in the Murray-Darling Basin

Please complete and submit this form with your submission.
Submissions on this paper are invited by **18 December 2009**

Organisation:.....

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Please note:

1. For all submission made by individuals, all personal details other than your name and the State or Territory in which you reside will be removed from your submission before it is published on the MDBA website.
2. Copyright in submission resides with the author (s), not with the MDBA.
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Please indicate if your submission:



Is ALL confidential



Contains SOME confidential material (provided under separate cover and clearly marked)

Attachment A: Climate scenarios

The MDBA will use river system and groundwater simulation models to investigate proposed SDLs. These types of models have been used in most water planning in the MDB in recent decades. They describe how much water is available and how that water is to be shared. The MDBA will use the current best available models, and will use and refine the model integration framework developed by the CSIRO in the recent MDB Sustainable Yields Project.

Key inputs to these models are sequences of climate information (e.g. rainfall and temperature) or climate-derived information such as river inflows. The MDBA has sought independent scientific advice from the CSIRO and its research partners (including partners in the South East Australia Climate Initiative) on appropriate climate scenarios to use in hydrologic modelling to guide to development of the Basin Plan. The report from CSIRO to the MDBA is available on the MDBA website.

Having considered the advice from CSIRO, the MDBA has decided on a suite of climate scenarios to use. The general approach and the agreed scenarios are summarised below.

Hydrologic information to guide water planning

In the past, water planning has primarily been based simply on historical climate and streamflow records. In recent years however, both global climate science and research from south eastern Australia have shown that records of the past are no longer a sufficiently robust basis for long-term planning. The aforementioned CSIRO report sets out the evidence that global warming has contributed to the current prolonged drought in south-eastern Australia, both through increased temperatures and lowered rainfall.

Given the high natural variability in the Australian climate and the complexities of the global climate system, scientists are not yet able to determine to what extent the current drought can be attributed to climate change rather than to long-term natural variability. It is most likely however, that our climate has begun to change in response to changes in the global climate system, and that greater change will occur in the future. Figure 1 provides an example of stream flow variability for Wentworth on the River Murray for the period 1895-2009.

The best information that science can currently provide regarding future climate comes from global climate models (GCMs). Although GCMs are reasonable at simulating the climate of the past, different GCMs provide widely ranging projections for the climate of the future – particularly rainfall projections which are of fundamental important to water resources planning.

There is therefore a high degree of uncertainty surrounding future climate, presenting new challenges for water resource planners. In the face of such uncertainty, the MDBA has adopted an approach based on exploring a wide range of plausible climate futures in order to better understand the vulnerabilities of the water resources system. This understanding will be used to develop water planning arrangements that avoid or minimise system failure regardless of future circumstances.

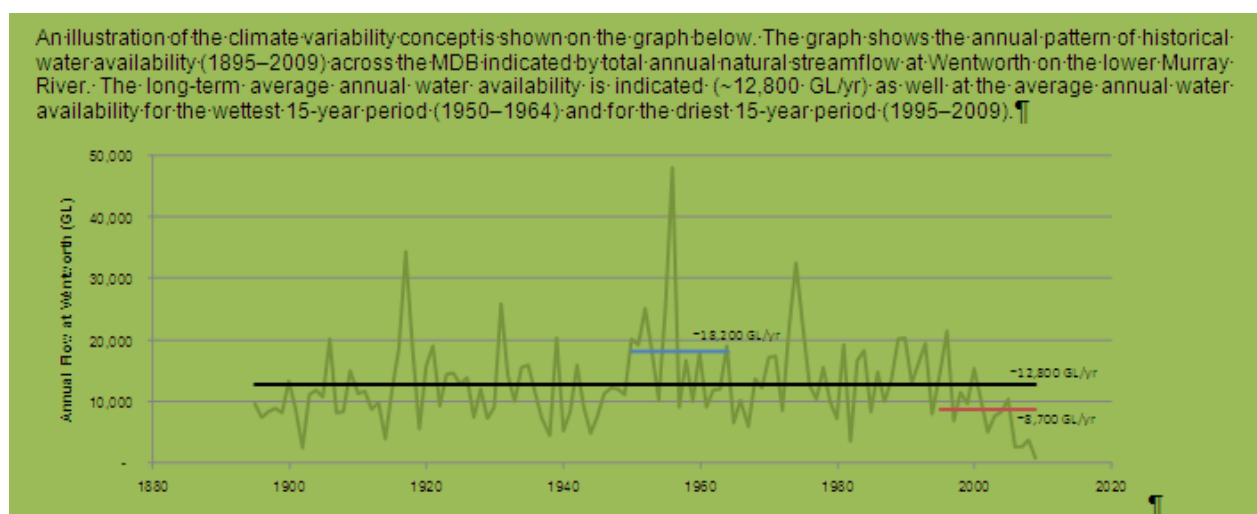


Figure 1: Stream flow variability for Wentworth on the River Murray for the period 1895-2009.

Long-term climate scenarios

Hydrologic modelling to inform the development of the Basin Plan will firstly consider existing water sharing arrangements and the historical climate in order to define a baseline – a reference point against which change can be assessed. The baseline climate period will be from July 1895— June 2009, as this is the longest period for which robust hydrologic information can be assembled Basin-wide.

To investigate proposed SDLs, hydrologic modelling will be undertaken using four long-term climate scenarios. The first will be the climate baseline. Basin Plan scenarios using the baseline climate are required in order to determine what fraction of proposed changes to diversion limits are not related to climate change.

The remaining three climate scenarios will represent the plausible range of climate change impacts by 2030. All three will be different scalings of the baseline climate, produced using the scaling methods developed in the CSIRO MDB Sustainable Yields Project. The three future climate scenarios will be referred to as the wet extreme, the median and the dry extreme.

The CSIRO MDB Sustainable Yields method considers three levels of global warming by 2030 using the same 15 GCMs for each level. The median is defined as the middle value (in terms of mean annual runoff) across the 15 GCMs for the medium warming level. The dry and wet extremes are the second driest and second wettest (respectively) in terms of mean annual runoff across the 15 GCMs for the high global warming level.

This approach considers two components of uncertainty – the uncertainty in the level of warming, and uncertainty in the hydrologic consequences of a given level of warming.

The second of these sources of uncertainty is by far the larger as shown the Table 1 (from the CSIRO MDB Sustainable Yields report for the Murray region), which shows the percentage changes in mean annual runoff for high, medium and low global warming. The bolding indicates the wet extreme, median and dry extreme scenarios.

	High Global Warming	Medium Global Warming	Low Global Warming
Second wettest GCM	+7% (wet extreme)	+4%	+2%
Median GCM	-14%	-10% (median)	-5%
Second driest GCM	-37% (dry extreme)	-26%	-12%

Table 1: Percentage change in mean annual runoff

As shown in Table 1, the dry and wet extremes are both associated with high global warming. This does not indicate a greater likelihood of higher warming, merely the greater climate uncertainty that is associated with higher levels of global warming.

Hydrologic modelling under the wet extreme, median and dry extreme future climate scenarios will be used to test the robustness of proposed SDLs under the wide range of plausible futures.

Outputs from the modelling will indicate how much water (on a year-by-year, and a long-term

average basis) could be diverted under each of these plausible climates, for each surface and groundwater resource and for the MDB as a whole, for a given set of proposed water management arrangements.

Climate variability

As well as the effects of long-term climate change it will be important to demonstrate how climate variability within each of the four long-term climate scenarios leads to variations in the volumes of water than can be sustainably diverted. This is expected to include indicating the volumes able to be diverted during both the wettest and the driest one, three, five, 10 and 15-year periods under each of the four climate scenario.

In Figure 1, above, which shows stream flow variability in the River Murray, water availability in the wettest period is 42% higher than the long-term average. In the driest period, water availability is 32% lower than the long-term average. Such graphs can be prepared for each of the long-term climate scenarios. Similar graphs could illustrate the volumes able to be sustainably diverted under different climate conditions.

Information like this will allow people to compare how the Basin Plan will affect water available for use under different climatic conditions. In particular, it will allow comparison between water access during the current drought to water access during similar, or indeed potentially more severe droughts in the future.

One example of the type of summary information that is likely to be presented to describe allowable diversion volumes under the Basin Plan for the entire Basin and for each water resource plan area (highlighting 15-year periods) is illustrated in Table 2.

		Total Allowable Diversion Volume (GL/yr)	
		Pre-Proposed Basin Plan	Post-Proposed Basin Plan
Historical Climate	Long-term average (1894–2009)	-	-
	Wettest 15-year period (1950–1964)	-	-
	Driest 15-year period (1994–2009)	-	-
Wet Extreme 2030 Climate	Long-term average (1894–2009)	-	-
	Wettest 15-year period (1950–1964)	-	-
	Driest 15-year period (1994–2009)	-	-
Median 2030 Climate	Long-term average (1894–2009)	-	-
	Wettest 15-year period (1950–1964)	-	-
	Driest 15-year period (1994–2009)	-	-
Dry Extreme 2030 Climate	Long-term average (1894–2009)	-	-
	Wettest 15-year period (1950–1964)	-	-
	Driest 15-year period (1994–2009)	-	-

Table 2: Allowable diversion volumes

Short-term climate sequences

While the four long-term climate scenarios will be the primary basis for modelling to inform environmentally appropriate and robust SDLs, the MDBA will also explore the near-term robustness of proposed SDLs using modelling with short-term climate sequences. This will enable modelling of the plausible pathways of transition from current water sharing arrangements to Basin Plan water sharing arrangements.

There are three key aspects to modelling this transition. Firstly, there are the known real-world starting conditions for the modelling, in particular the current water storage levels across the MDB and the current groundwater levels across the MDB.

Secondly, there are the known times at which transitional and interim WRPs under the Water Act will be replaced with WRPs which are compliant with the Basin Plan. The changes associated with the Basin Plan are implemented through Basin State WRPs from 2012 (the Mallee Prescribed Wells

Development of Sustainable Diversion Limits for the Murray-Darling Basin

Plan in South Australia) through to 2019 (when arrangements in the Victorian part of the Basin will come under the effect of the Basin Plan). The majority of surface water arrangements in New South Wales, Queensland and South Australia will come under the effect of the Basin Plan in 2014.

Thirdly, there is the unknown sequence of climate over the short-term. Modelling will be used to explore how this transition would occur under a range of possible short-term climate sequences drawn from the four long-term climate scenarios.

It is most likely that the greatest system vulnerabilities will be associated with a continuation of the current prolonged drought sequence. The short-term modelling is therefore expected to focus on the implications of a continued dry sequence. These investigations will particularly consider the robustness of the proposed SDLs with respect to both the environmental objectives of the Basin Plan and potential social and economic consequences.

It is expected that for surface water planning, the short-term sequences will be 15 years in length (2009–2024) to extend until the end of the 10-year accreditation period for the first significant WRPs that will be accredited under the Basin Plan. For groundwater planning, modelling with short-term climate sequences will be less important because changes in groundwater planning and management typically take many years to have effect.

Attachment B:

Surface water – groundwater connectivity

Streams interact with groundwater in many types of landscapes. The interaction takes place in three basic ways:

- **Gaining Streams** gain water from inflow of groundwater through the streambed.
- **Losing Streams** lose water to groundwater by outflow through the streambed.
- **Disconnected Streams** are separated from the groundwater system by an unsaturated zone below the stream, and lose water at a rate proportional to the permeability of the unsaturated strata.

A range of local conditions, including geology and proximity of production bores to the stream, influence the time it takes until the impacts of groundwater extraction are observed on stream flow and the extent to which that extraction will reduce stream flow (see Figure 1). The separate development of surface and groundwater has resulted in double accounting of the one volume of water in connected systems where there is a long time lag between groundwater extraction and the subsequent effects on stream flow. Research shows that the potential impact of past and current groundwater extraction on stream flow is one of the key uncertainties in determining Basin water resources.

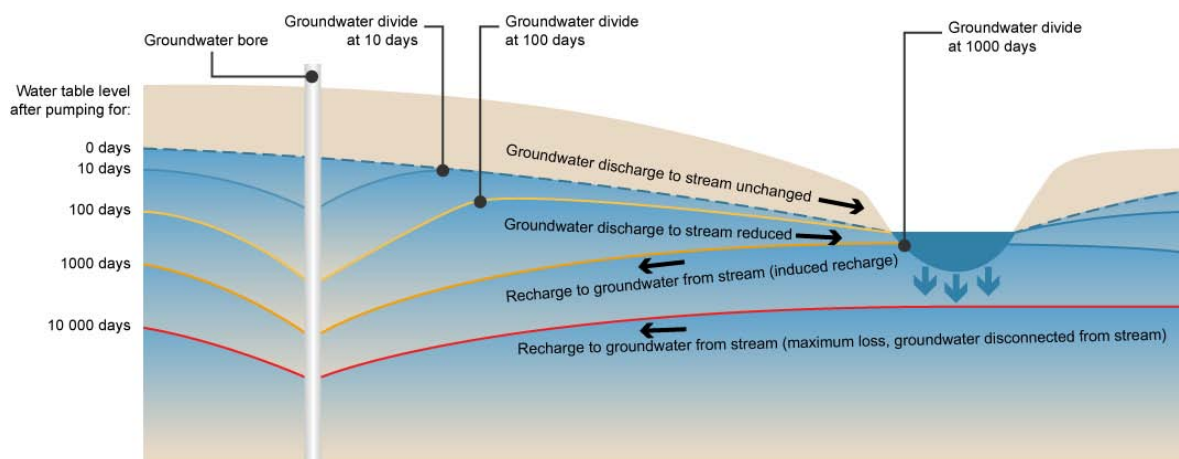


Figure 1: Example of interaction of stream and groundwater in response to a pumping bore (Source: The MDBA, after Evans, 2007).

Figure 1 demonstrates the dynamic relationship between groundwater levels after various pumping times, and the resulting impact on stream flow, for a hypothetical scenario. Under natural conditions, with no groundwater pumping, the water table isn't affected, and groundwater discharge to the stream remains unchanged. After 10 days of pumping, the water table is lowered in the immediate vicinity of the bore, creating a drawdown cone. After 100 days of pumping, a more expansive drawdown cone is developed, and the water table is lowered, reducing groundwater discharge into the stream and consequently reducing stream flow. After 1000 days of pumping, the groundwater

divide intersects the stream, and induces recharge to the groundwater system from the stream, consequently reducing stream flow. The stream has switched from a gaining stream at 0, 10 and 100 days of pumping, to a losing stream at 1000 and 10,000 days of pumping and becomes disconnected between 1000 and 10,000 days of pumping where losses from the stream into the groundwater aquifer occur at a maximum rate. Once maximum loss from the stream into the groundwater aquifer is reached, the rate of loss from the stream remains constant, regardless of any further reduction in groundwater level (i.e. due to further groundwater pumping). If groundwater pumping is reduced or ceases, the relationship between surface water and groundwater will change to reflect the changes in the water table. The magnitude of that change will determine the eventual impact on stream flow.

Interaction of groundwater and streams in the Murray-Darling Basin

Most catchments in the the Basin may be broadly classified into four distinct systems based on the nature of the connectivity between surface and groundwater, as described above. These systems are presented in the conceptual model in Figure 2, with an example of each system in Table 1.

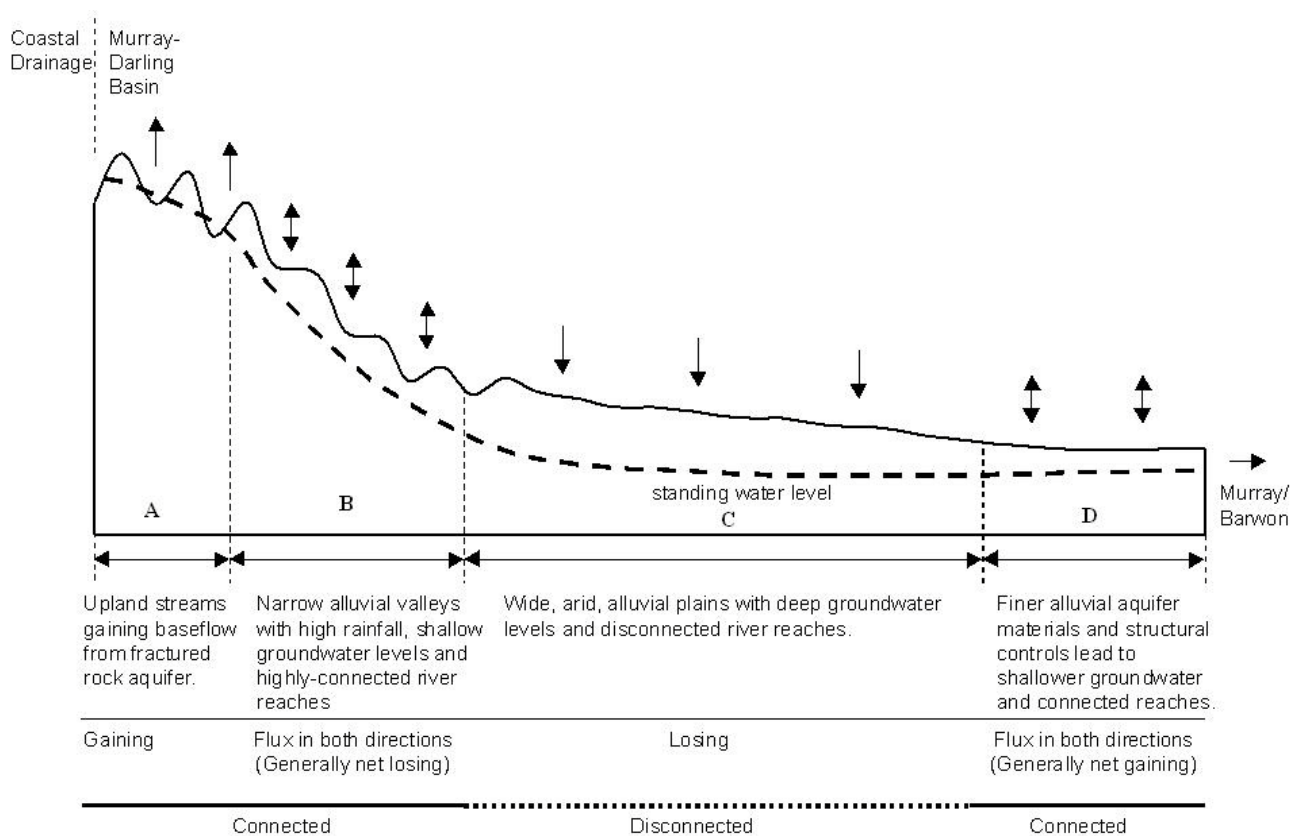


Figure 2: Conceptual model of the connectivity systems in the Murray-Darling Basin (Source: Braaten and Gates, 2002).

A ¹ Gaining	B ² Flux in both directions (net losing)	C ³ Losing (disconnected)	D ⁴ Flux in both directions (net gaining)
Murrumbidgee River upstream of Wagga Wagga	Namoi River between Gunnedah and the confluence with the Peel River	Namoi River between Narrabri and Walgett	River Murray Downstream of Wentworth

Table 1: Examples of connectivity systems in the Murray-Darling Basin (after Parsons, Evans and Hoban, 2008)

¹Steeper upland streams. Groundwater discharges to streams. Hence, streams are ‘gaining’.

²Narrow alluvial valleys, shallow groundwater systems and highly connected river reaches. In some places streams gain groundwater inflows, but the net result is generally that water is lost from streams to the groundwater system.

³Wide, arid, alluvial plains. Groundwater levels are deeper than the bed of streams, or ‘disconnected’. Further reductions in groundwater level do not affect the rate of loss from streams to groundwater.

⁴Finer alluvial aquifer materials and structural controls lead to shallower groundwater and connected reaches. In many cases the groundwater inflows are of poor quality. These areas coincide with areas targeted for salt interception schemes.

Current and predicted impacts of surface water – groundwater connectivity in the Murray-Darling Basin

Throughout the Basin, the general pattern observed by CSIRO (2008) shows gaining conditions in the highland areas, changing to variable gaining and losing conditions downstream (Figure 3). CSIRO (2008) reported that groundwater use is concentrated in 20 out of approximately 100 groundwater management units, and the impact of the current rates of groundwater extraction is estimated to be 447 GL/year of loss from surface water systems, although the full impact of the stream flow depletion is not yet apparent due to the delayed response in the groundwater systems. If future groundwater development were to occur this impact would be higher.

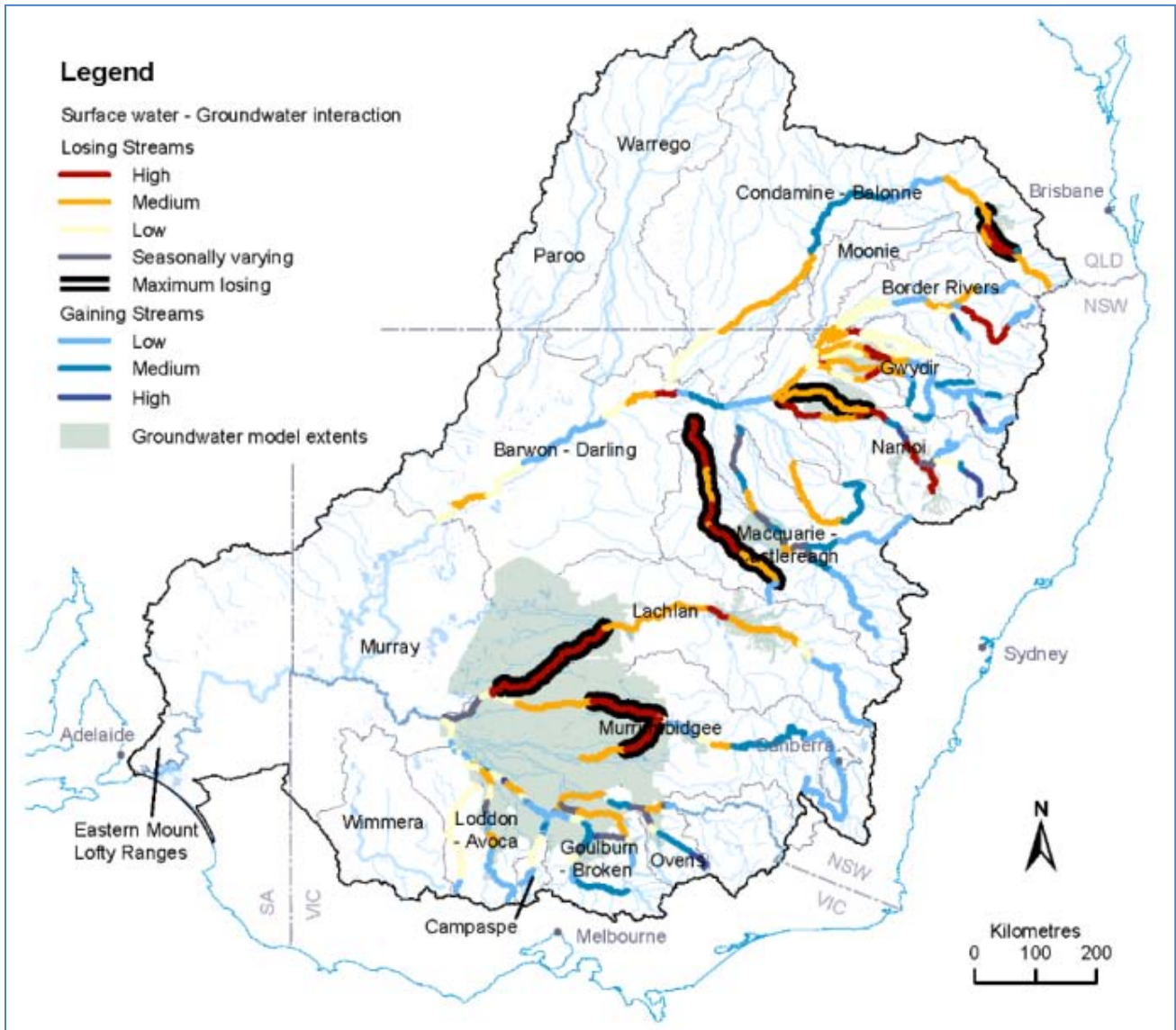


Figure 3 Surface water – groundwater connectivity in the Murray-Darling Basin (CSIRO, 2008)

Figure 3 shows surface water – groundwater connectivity in the Basin, as described in the CSIRO Sustainable Yields project. Losing streams (to groundwater) are depicted by red and yellow colours, and gaining streams (from groundwater) are depicted by blue. In each category, the rate of flux between surface water and groundwater is described as high, medium, and low. In seasonally varying streams, depicted by a grey line, river reaches vary from gaining to losing depending on the unique stream and water table conditions that vary over a year. Maximum losing conditions (the black lines) occur when the rate of loss from the stream is at a maximum rate, and once reached, remains constant. Under these conditions, the stream is disconnected from groundwater. This is represented in Figure 1 where losses from the stream recharge groundwater at a maximum rate.