REPORT

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Economic benefits and costs of the proposed Basin Plan

Discussion and Issues

Prepared for Murray Darling Basin Authority

Centre for International Economics
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Executive summary

This report

- **This report presents a discussion of the issues and challenges associated with undertaking a benefit–cost analysis (BCA) of the proposed Basin Plan. In this context, it presents some illustrative cost and benefit estimates associated with the three sustainable diversion limit (SDL) scenarios set out in the MDBA's *Guide to the proposed Basin Plan*.**
- **This report illustrates some of the broad orders of magnitude involved in the costs and benefits of the proposed Basin Plan and presents a range of estimates designed to reflect the genuine uncertainties in estimating benefits and costs.**
- **Due to the range of issues set out below, this report does not come to a definitive conclusion about the relationship between benefits and costs. However, looking at the mid-point of the various ranges suggests that the benefits are greater than the costs.**
- **This report draws on currently available information about ecological responses to increased environmental flows and the valuation of those responses, and discusses the limitations of currently available information.**
- **Data limitations — particularly related to ecological responses to increased flows and the associated economic valuation of these responses — mean that it is difficult to have a high level of confidence in associated estimates of benefits.**
- **In pointing out the strengths and weaknesses of current information, this report sets out the areas where more detailed information is required in order to allow more definitive estimation of costs and benefits.**
- **Importantly, while the information basis is currently limited, it is clear that there are likely to be considerable benefits from the Basin Plan. The policy challenge is to maximise these while minimising any costs.**

BCA and the proposed Basin Plan

- BCA is a tool designed to place the benefits and costs of a particular action or proposal on a common basis so that they can be compared and understood.
- Because the proposed Basin Plan involves a reallocation of the way in which water resources are used, it will inevitably involve a range of benefits and costs. BCA is an ideal framework for considering the balance of these benefits and costs and using this information to design robust approaches to the tasks of the Plan.
- The benefits side of the calculation includes the environmental and ecological benefits of increased flows to the environment.
- The cost side of the calculation involves the opportunity cost of reduced productive use of water — and the associated economic costs for communities reliant on irrigated agriculture — in the Basin.

Nature of the problem

- The Basin Plan provides a distinctive set of costs and benefits.
- The costs of the plan are observable and 'tangible' and can be measured with reasonable well understood techniques and 'market' data. They will be experienced by a relatively well defined set of communities.
- In contrast, the benefits are much more diffuse, more widely distributed and harder to define. They require more indirect techniques to value.
- Further, the economic costs are likely to be short term while the benefits will be much longer term.

Major challenges

- Applying BCA to the Basin Plan involves a number of major challenges — both in scientific and economic terms. In particular, there are five broad challenges where the current information base is not sufficiently robust to allow reliable calculation to be undertaken.

Challenge 1: understanding ecological responses

- On the scientific side, BCA requires understanding the extent to which the proposed increased environmental flows associated with the SDLs lead to incremental improvements in environmental outcomes.

- This means understanding the response of ecosystems to increased flows and measuring this response in terms of environmental attributes that can subsequently be valued.
- This requires addressing questions such as what effect do the increased environmental flows have on the number of native species, the frequency of bird breeding events and the quality of vegetation along the river?
- Current scientific knowledge of the ecological response to increased flows is limited. Illustrative analysis presented in chapter 2 and appendix A of this report makes a number of assumptions about the nature and extent of this response in order to illustrate some of the challenges involved.

Challenge 2: valuing ecological responses

- The economic valuation of the ecological responses is also challenging as many of the values associated with improved environmental outcomes cannot be directly measured using market or other objective empirical information.
- Rather, values for environmental outcomes (particularly the 'non-use' values) must be measured indirectly using a range of survey and statistical techniques. The economic science of these non-market valuation techniques is in a state of continual development.
- While there are currently a range valuation estimates available, they are not directly suitable for the task at hand and can only provide a very broad indication of the likely magnitude of results.
- This report (in chapter 2 and appendix B) provides an illustration of the order of magnitude values that emerge when currently available values are applied to an approximate ecological response methodology.

Challenge 3: accounting for other policy factors

- Outcomes under the proposed Basin Plan — benefits and costs — will depend on a wide range of policy settings outside the Plan itself. These policies will have a large influence on how environmental water will be delivered as well as on the ways in which regional communities can adjust. Chapter 4 provides a discussion of these other policy measures.

Challenge 4: distinguishing long term from adjustment costs

- The cost of the SDLs mostly consists of reduced returns to water used for productive purposes. These costs can be more readily measured using market information along with detailed information on the current patterns of water use. Chapter 3 and appendix E summarises these costs.

- **The full extent of the economic costs of the SDLs ultimately depends on the flexibility of the regional economies that are based around irrigation — in particular the extent to which resources currently used in irrigation related activities can be redeployed profitably in other activities.**
- **It is also important to make a distinction between short term, and transitory, adjustment costs and the long term losses of value that are permanent. The major focus of the BCA undertaken here is on the long term permanent loses of productive value.**
- **However, short term adjustment costs are clearly a major consideration. These are both economic and social.**

Challenge 5: future climate

- **The extent of costs and benefits of the proposed Basin Plan will also depend on how the future climate in the Basin evolves. Outcomes are likely to differ significantly between a dry future climate and a wetter future climate.**
- **Ultimately, both ecological responses and economic costs need to be understood in the context of a range of potential climate outcomes.**

Obtaining more information

- **Providing more precision on the benefits and costs of the Basin Plan — particularly the benefits — requires more information in a number of areas.**
- **More detailed information on the ecological responses to increased environmental flows associated with the SDLs is needed. This information provides the essential foundation for any subsequent analysis and should be a priority.**
- **A customised economic valuation study is required in order to frame the overall task of the Basin Plan appropriately. The scale of changes proposed in the Plan is considerably greater than the scale of changes considered in most studies undertaken to date. It will be particularly important to try to account for the genuine uncertainty in outcomes in this analysis.**

1 *Benefit cost analysis and the Basin Plan*

This report

This report sets out in detail the issues involved in undertaking a benefit-cost analysis (BCA) of the proposed Basin Plan and provides some illustrative results — using currently available information — of three proposed sustainable diversion limits (SDLs) associated with additional diversions for the environment of 3000, 3500 and 4000 GL.

Chapter 2 (with more detailed background provided in appendixes A, B, C and D) considers the benefits associated with the SDLs, in particular environmental and recreational benefits. A particular focus is on understanding the range of potential benefits, particularly where current information makes their measurement uncertain.

Chapter 3 (with more detailed background information provided in appendix E) considers the costs associated with the SDLs, in particular the long term costs of reduced irrigated production. As with benefits, a range of costs are considered, reflecting different assumptions about economic outcomes.

Chapter 4 considers the role of additional policies outside the Basin Plan in determining the costs and benefits of the Plan.

Chapter 5 discusses the additional information needed to provide more information on the tradeoffs involved in the Basin Plan.

Benefits and costs of the proposed Basin Plan

Water in the MDB has alternative uses. A consequence of the Basin Plan is likely to be a rebalancing of these uses with more emphasis on environmental outcomes and slightly less on productive uses.

Benefit–cost analysis (BCA) is in essence a technique that can be used to assess the changes in economic value that result from this change in water use.

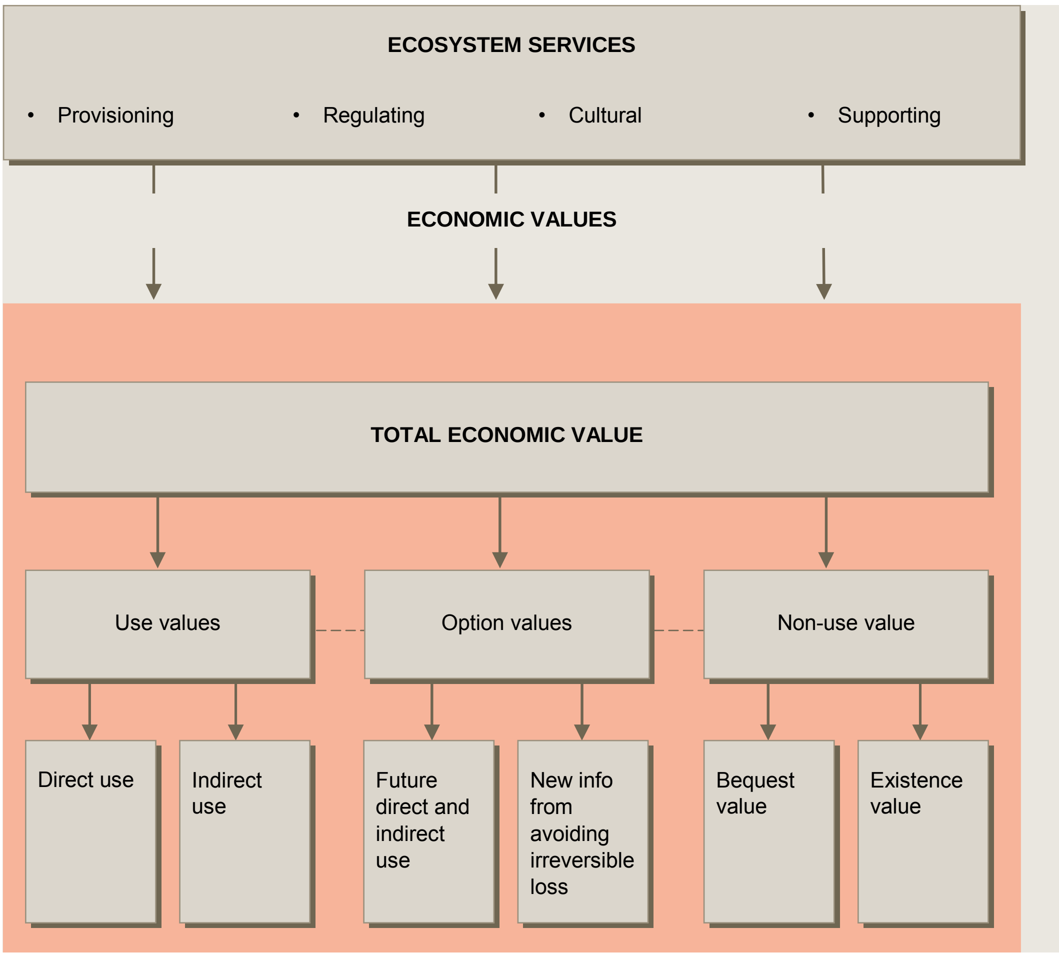
The starting point for BCA is the recognition that there are many values with water use in particular and with the general ecological services associated with river basins. These are illustrated in chart 1.1 which relates the notion of ecosystem services to the total value associated with these services. The breakdown illustrated in chart 1.1 was first developed in the 1970s and 1980s (see, for example, Pearce et al 1989) and has been more recently discussed in TEEB (2010) and Bateman et al (2011), for example.

Ecosystems provide a series of services that help generate other good and services that are valuable. One set of values relate to a range of 'use' values associated with irrigated agricultural production (and the flow on effects of this) as well as those associated with recreational and tourism use of water resources.

Another set of values relate to 'non-use' benefits associated with water, in particular ecological and environmental benefits associated with outcomes such as fish species, bird breeding events and so on.

From the perspective of the status quo, the reallocation of water use involves both costs and benefits (see chart 1.2). The *costs* are the *reduction* in (essentially productive use) current values, while the *benefits* are the *increases* in other (largely non-use or environmental) values. The overall objective of BCA is to compare these sets of changes in a common basis to provide an understanding of the overall change in value resulting from the Basin Plan.

1.1 **Sources of economic value from ecosystem services**



Source: Based on discussions in Pearce et al (1989) and TEEB (2010)

1.2 **Potential benefits and costs of SDLs**

Potential costs	*Potential benefits*
Reduction in the surplus product (profit) from water use by irrigators and other agricultural water users	Non-use benefits of improved environmental assets such as existence values for increasing bird abundance and fish numbers
Flow-on changes in economic surplus to other regional activities and population	Higher probability of achieving specified targets for environmental health
Potential flow-on to service provision, including government provided services, in regional areas	Improvements in water quality such as reductions in salinity loads, frequency and duration of algal blooms
Reduced agricultural activity to pay for fixed costs of regulated water provision and management	Changes in the level of water security for different customers, particularly those downstream
	Economic benefits for non-irrigated agriculture through increased productivity of wetlands
	Impact on flooding in the region
	Non-monetary use benefits of improved environmental assets, including recreational activities and flow-on impacts on the tourism sector

Source: The CIE.

It is important to note that in practice it is often difficult to distinguish the types of benefits set out in chart 1.1. This is particularly the case in the interaction between use and non-use values. The reasons that individuals have for particular values are subjective, and even when they are revealed in relatively objective data (such as market prices) the underlying rationale for those values is not always explicit.

Non-market valuation studies — which try to observe valuations in the absence of explicit market transactions — are often thought of as estimating non-use values for particular environmental outcomes. It is not always clear, however, even in these studies exactly what comprises the values that people express. They may be existence values, or bequest values, options values or even in some cases expected use values. This consideration is important in order to avoid double counting of benefits.

Some perspectives of BCA

Under the standard approach to BCA:

> Judgements regarding the relative merits of alternatives are made on the basis of their consequences for the wellbeing of people.[1]

That is, BCA is concerned with changes in value that are associated with people. Environmental outcomes, for example, do not have their own values, but are judged by their contribution to the welfare of people. The evaluation of wellbeing or welfare

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1 Bennett (2010), *Making Decisions About Environmental Water: An Economics Approach*, June.

is one of the major challenges of BCA. The standard approach that is taken is to measure the incremental changes in *economic surplus* (see box 1.3) associated with, in this case, changes in water use.

1.3 Economic surplus

The idea of economic surplus in BCA is designed to provide a common metric for comparing benefits and costs of a particular proposal. Economic surplus can be measured for both consumers and producers.

From the producer perspective, economic surplus is closely related to the idea of profits — an amount left over after all costs have been taken into account. Current use of water for irrigation generates a surplus for producers. It is this loss of surplus (not the loss of total revenue or gross value of production) that provides an appropriate measure of the cost of the proposed SDLs.

From the consumer or household perspective, economic surplus is a dollar measure of the 'utility' or 'economic welfare' consumers or households receive from the goods or services they 'consume' (or potentially consume in the case of environmental assets). This surplus is a measure of the benefits to households over and above the cost to them of 'consuming' the relevant goods or services.

There are a number of techniques for measuring the change in economic surplus, and this report draws on these in considering the benefits and costs of the proposed Basin Plan. Essentially, economic surplus can be measured using:

- relatively 'objective' market data combined with expectations about the behavioural response of producers and consumers. This is the approach taken to measuring the lost surplus associated with reduced water use for production;
- indirect market data, for example, actual expenditure on travel to recreational sites that indirectly reveals surpluses associated with the use of water related resources. This is the approach often taken to measuring recreational values; or
- 'stated preference' information where surpluses are revealed through sophisticated survey techniques designed to measure the preferences of households in cases where these preferences cannot be expressed in market transactions.

To be comprehensive, a BCA must consider the changes in all sources of value, even in cases where the measurement of this value may be difficult or controversial. However, as the discussion in this report sets out, there are a number of challenges that need to be addressed in order to measure changes in values that arise as a consequence of the SDLs.

Incremental benefits and costs

A BCA of a particular policy or program is concerned with measuring the *incremental* benefits and costs associated with that program. These incremental benefits need to be causally linked to the changes proposed.

In particular, analysis of additional diversions to the environment is concerned with the *incremental* benefits that these *additional* diversions produce. While it is clear, for example, that there are currently large environmental values associated with water use in the Murray-Darling Basin, the question for the analysis of the proposed Basin Plan is the extent to which the changes proposed in the Plan lead to incremental benefits (and costs).

As discussed further below, this is particularly challenging in the context of incremental ecological benefits as there is not necessarily a single functional relationship between flow (the key focus of the Plan) and ecological outcomes. A large number of other factors mediate this response.

The same is true for economic costs: while these are more directly related to flow changes, there are a large number of policy factors that will determine the ultimate economic outcomes.

These additional factors are considered in more detail in chapter 4.

The nature of the problem

One of the particular challenges of BCA in the context of the proposed Basin Plan is the exact nature of the benefit-cost trade-off being contemplated.

The costs of the Plan — reduced economic surplus from the use of irrigation water — are in a real sense observable and tangible. Even though a drought is not the same as the purchase of water contemplated by the Plan, irrigation communities are very aware of the costs of reduced water through their observation of the effects of drought.

The products produced by irrigation all have market prices, as do inputs to production. While additional assumptions are needed to estimate the economic surplus loss at a Basin-wide level, this loss of surplus is closely related to a loss of profits, which is broadly observable. Similarly, market prices for water (which are an approximate estimate of the marginal value of water in production) are easily observable.

Finally, the costs of the Plan are likely to be experienced by a well defined set of communities, essentially comprised of individuals that have staked (at least part) of their livelihood on irrigated production.

In contrast, the value of the ecological benefits of the proposed Plan are much more diffuse and harder to find. There is broad agreement that there are genuine benefits to be had here, but both their nature and the techniques used to value them are more indirect than the economic costs of the Plan. While costs may be concentrated, benefits are much more widely distributed, and those experiencing the benefits will not necessarily have as much at stake as those experiencing the costs — although there are, of course, cases where communities have much at stake in better ecological outcomes.

The nature of this problem is, of course, common to many environmental policies, however the scale of the Basin Plan makes these issues come out very sharply.

Discounting

Like many reform packages, the proposed Basin Plan involves a long timeframe of both costs and benefits. It is likely that costs will initially be high (particularly when accounting for adjustment costs) but that these will fall over time. It is possible that benefits will gradually increase over time, but may be small initially. The magnitude of net benefits will therefore likely vary over time — see chart 1.4 for an illustration.

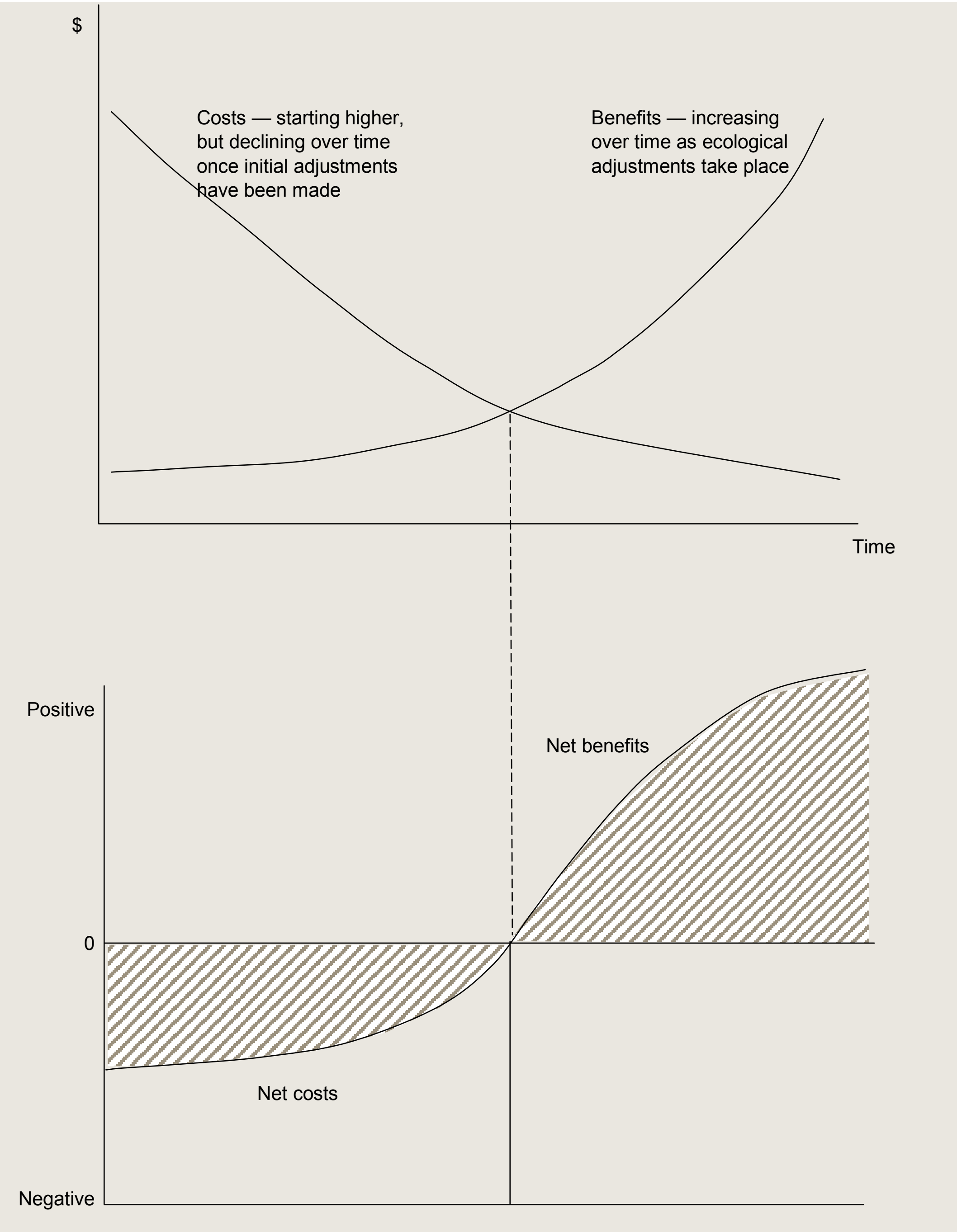
In order to compare costs and benefits which accrue over time, it is necessary to discount future period costs and benefits into current period values. Despite a vast literature on this subject, there is no general agreement on the appropriate discount rate to use. A recent publication (Harrison 2010) summarises some of the key issues involved.

Essentially, two different approaches can be taken to choosing a discount rate: a ‘prescriptive’ approach and a ‘descriptive’ approach (Harrison 2010).

- The prescriptive or normative approach specifies a discount rate based around ethical principles — mixing efficiency and equity considerations. It is frequently advocated when projects affect future generations. This approach gives a wide range of suggested discount rates, reflecting different value judgements.
- The descriptive approach to the social discount rate is based on the opportunity cost of capital observed in market transactions reflecting the time preferences reveal by consumers and producers. The descriptive approach is based around efficiency criteria.

Given the complexity of the issues involved and the lack of final resolution concerning a discount rate, the most practical approach is to use a variety of discount rates when summing benefits and costs over time, and to report the results in the form of a sensitivity analysis. As this study does not entail a definitive assessment of the net benefits, the illustrations presented in this report simply use a real discount rate of 7 per cent.

1.4 **Costs and benefits over time**



2 Benefits

What sorts of benefits arise from additional environmental diversions?

The major benefits from the increased environmental flows associated with the proposed SDLs are expected to be improved ecological and environmental outcomes. These improved outcomes can be expected to be reflected in increased values that people have for those outcomes within the Basin.

In valuation terms, there are a number of broad sources of benefit associated with improved environmental outcomes including:

- an increase in *non-use* values, including *'existence'* values, for a range of valuable ecological outcomes, such as the number of fish species and the frequency of waterbird breeding events;
- an increase in *use* values associated, for example, with recreation and other participatory use of water resources that depend on the quality of those resources and the environment around them; and
- changes in costs related to salinity and other 'ecological service' aspects of the river system.

How do these benefits relate to the process of setting the SDLs?

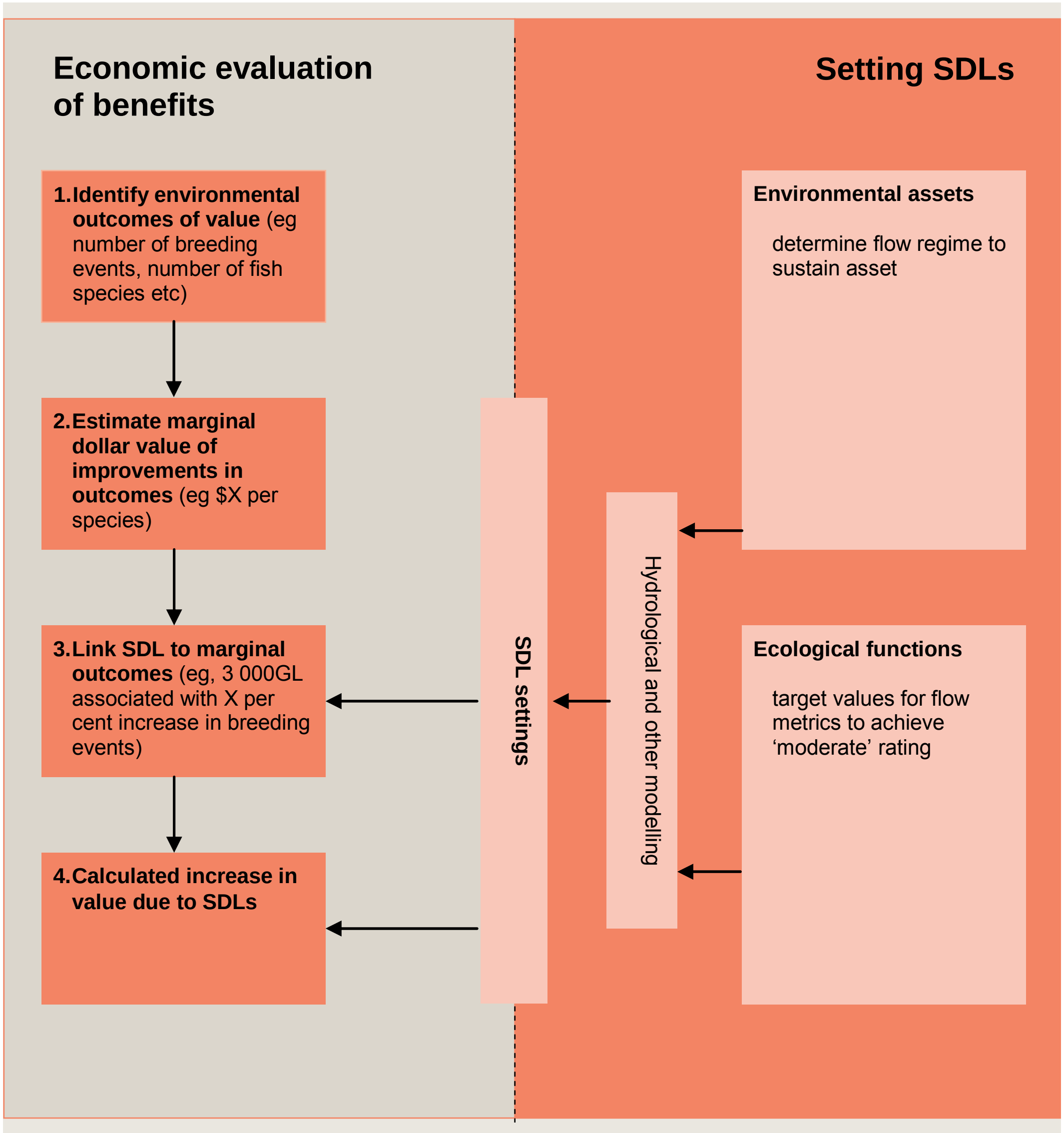
It is important to note that the process of developing the SDLs used by the MDBA to date does not directly make use of economic valuation of ecological outcomes. This means that the process by which the SDLs were calculated and the process by which they should be evaluated under a BCA are related, but quite distinct.

This is illustrated in chart 2.1. In summary, the SDLs have been set by considering the flows required to sustain a number of key environmental assets as well as to maintain a series of ecological functions. The process of calculating SDLs involved the definition of environmental assets and ecological functions, setting targets for each of these, and then using a range of modelling and analysis to determine the SDLs to achieve the desired outcomes for assets and ecological functions.

The targets defined for setting the SDLs cannot be separately valued as they do not directly correspond to the sorts of environmental outcomes that research has indicated people value. Ecological functions, for example, do not themselves represent goods that can be valued; rather they are a key input into the sorts of broader outcomes that people do value.

The environmental assets and the ecological functions can be seen as 'inputs' to a particular set of ecological and environmental outcomes which may have economic values. However, in setting the SDLs, these outcomes are not directly considered — rather, the prerequisite conditions for them are specified.

2.1 **Valuing benefits versus setting SDLs**



In contrast, the process of economic valuation (particularly non-use valuation) starts with identifying valued environmental outcomes and then estimating the dollar value of increments to that outcome. This step provides a major methodological challenge, but possibly the greater challenge is in the next step of relating the SDL settings directly to marginal outcomes. This step is often referred to as determining an ecological or biophysical 'response function'.

Both scientific and economic information needed

The valuation of benefits of SDLs thus clearly requires both scientific and economic information.

- The **scientific** information refers to the link between SDLs and ecological or biophysical outcomes.
- The **economic** information refers to the valuation (and in particular, the *marginal* valuation) of the ecological or biophysical outcomes.

What is the scientific understanding of SDLs and ecological outcomes?

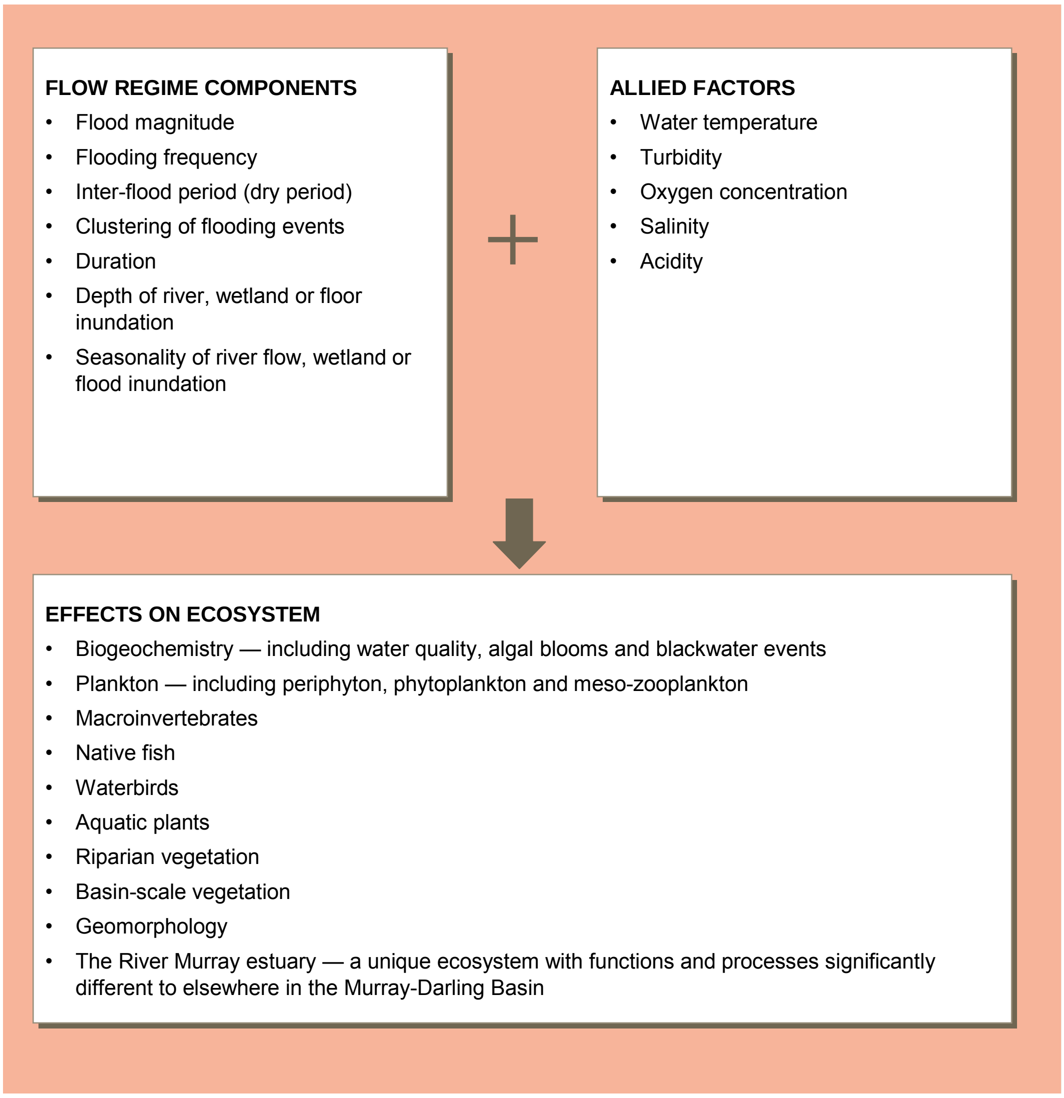
The relationship between ecological responses and changed flows is complicated. Indeed, there may be no single functional relationship between the two. Rather, the ecological response depends on the changes in the flow characteristics such as the change in daily flow volumes and changes in flooding patterns (for example, frequency, intensity) and not just changes in the long term average flow volumes.

Chart 2.2 illustrates the fact that the combination of flow regime components and allied factors leads to effects on the ecosystem. Recent analysis by CSIRO (Overton et al 2009) illustrates how complicated this relationship may be.

There is currently limited Basin-wide understanding of the ecological response to alternative flow regimes. While there is reasonable knowledge for some specific sites within the MDBA, modelling for individual river valleys is required to test against the Basin modelling of the MDBA. This gap in understanding has been highlighted in the recent study by the CSIRO which noted that:

> Ecological monitoring has focused on changes in abundance, occurrence and diversity of individual organisms or groups of related organisms. Very little is available that helps underpin responses to flow of ecological process and functions. A greater emphasis on monitoring such processes or at least simultaneous monitoring of groups of interacting organisms such as predators and prey (for example, birds, frogs and fish) is more likely to reveal relationships between flow and ecological responses at community and ecosystem scales (Overton et al 2009, p326).

2.2 **Linking flows to outcomes**



Data source: Overton et al (2009)

Illustrative approach taken in this report

Given that specific detailed ecological response modelling is not currently available for the additional environmental flows associated with the SDL scenarios, in order to provide an illustration of the orders of magnitude that may be involved, an approximate and illustrative approach to estimating the potential ecological response was developed using currently available information.

An illustrative approach

Ecological response analysis was undertaken for this report by ecologists at SMEC.[2] Analysis undertaken by SMEC involved first the specification of baseline ecological health and second, assumptions about the effect of increases in flow. The key resource for understanding baseline ecological health is a study prepared for MDBA by Ecological Associates. This study provided key information on the ecological condition of the:

- 18 Key Indicator Assets; and
- Basin Regions using indicators of:
  - the diversity and abundance of native fish and exotic fish;
  - the diversity and abundance of macroinvertebrates and those macroinvertebrate families that are sensitive to disturbance;
  - the extent and (where information was available) condition of native vegetation; and
  - the intactness of instream, riparian and floodplain habitat.

Due to data limitations and lack of detailed ecological response modeling, SMEC adopted a broad approach to estimating the change in each of the attributes resulting from alternative SDL scenarios. This approach involves the assumption that habitat quantity and habitat quality ***increase linearly with increasing water availability for environmental purposes***. While in reality this is unlikely to be the case, there is limited data to assess ecological responses to flow events, and the linear assumption made here helps in presenting the issues surrounding a benefit-cost analysis of the Basin Plan.

To emphasize this point: it is well understood that the linear assumption could involve both over and under-statement of ecological outcomes. It is not used here as a literal description of ecological responses but as a means of generating Basin-wide estimates that can be used to illustrate some of the orders of magnitude involved.

Four principles relating flow to ecological response

The approach adopted here is based on a conceptual model relating aquatic biodiversity to flow regimes (Bunn and Arthington 2002) that establishes four principles by which flow drives ecological responses over a range of spatial and temporal scales:

- Principle 1: Flow is a major, though not the only, determinant of physical habitat in streams, which in turn is a major determinant of biotic composition.

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2 The approach adopted necessarily reflected the budget and data limitations. In particular, the budget did not provide scope for separate detailed additional analysis to be undertaken and, instead, relied on a range of existing information.

- Principle 2: Aquatic species have evolved life history strategies primarily in direct response to the natural flow regimes.
- Principle 3: Maintenance of natural patterns of longitudinal and lateral connectivity is essential to the viability of populations of many riverine species by facilitating migration within river channels by providing access to normally disconnected floodplain habitats.
- Principle 4: The invasion and success of exotic and introduced species in rivers is facilitated by the alteration of flow regimes.

As noted above, characteristics of flow regimes such as the magnitude, frequency, duration, seasonal timing, period between floods, rate of rise and fall, variability, and regularity of flow events influence the nature of ecological responses to flow. However, the SDL scenarios and associated additional flows for the environment in the *Guide to the proposed Basin Plan* are phrased in terms of long-term average flows without clarity on their real time delivery to achieve the intended environmental benefits (as noted further in chapter 4, these features of the flow regime are associated with policies in addition to the Basin Plan).

The four principles above can be summarised for river systems with altered flow regimes to provide a hypothesis that increasing flows to approach the natural condition will improve the ecological function of river systems, providing other factors do not mask or suppress ecological responses to flow. This hypothesis is consistent with the basis upon which the SDL scenarios have been developed to improve river health within the Basin by returning water to the environment.

The nature of ecological responses to changes in flow is complex, varying among species, locations, flow events, and other factors that operate at different spatial and temporal scales. Accordingly, simple response relationships at large scales may be confounded by other factors, such as prevailing drought conditions, making it difficult to detect underlying relationships at catchment and Basin scales using available data that has been collected for other purposes (Overton et al 2009).

Despite the extensive analyses of ecological relationships to flow in the Murray-Darling Basin (Overton et al 2009), quantitative methods to predict ecological responses to long-term average SDL scenarios were not available for this project, and detailed modelling of selected indicators was beyond the scope of this study. Rather, a greatly simplified approach was adopted based on the four principles outlined above to estimate potential ecological responses to increased water availability under the three SDL scenarios.

The percentage increase in outflow in each catchment under each scenario (see table A.4) was used as an indicator of the potential equivalent increase in ecological condition for macroinvertebrates and fish, based on existing condition indices reported by the Sustainable Rivers Audit (Davies et al 2008)[3].

Separate estimates were derived in a similar manner based on the percentage increase in environmental water that does not drain back into the river and which is effectively lost from the system. As the lowland reaches of the Basin are most likely to be affected by the SDLs, the fish and macroinvertebrate data were restricted to the lowland zone of each region.

Assumptions

Estimating ecological responses for long-term average increases in water availability to allow cost-benefit analysis of alternative SDLs requires a number of assumptions regarding the interactions between hydrological characteristics and ecological functions and processes:

i. Modelled SDL data from MDBA can be used to estimate long-term average increases in the availability of environmental water for maintaining ecological assets and ecosystem functions. This assumption implies that there is a positive relationship between long-term average flows and critical characteristics of the flow regime that drive ecological responses.

ii. Water that is made available under the SDL scenarios can be delivered in a manner that optimises critical characteristics of the flow regime to achieve potential environmental responses. This assumption recognises the disparity between estimates of environmental water requirements, which have been estimated as daily flow units at key locations, and long-term annual average flows at the catchment scale. However, methods to down-scale SDL scenarios to site-specific flow events are not currently available.

iii. Following (ii) above, it was assumed that ecological responses to SDLs would be delivered via changes in daily flows, even though the mechanism for delivering environmental water requirements (e.g. through Water Management Plans) has not yet been developed.

iv. Ecological responses to changes in water availability are typically non-linear, with thresholds related to processes such as commence-to-flow heights in wetlands, and the river height at which over-bank flows occur. However, sources of non-linearity are difficult to identify at large spatial scales and over long-term average annual flows. Accordingly, it was assumed that changes in water availability under SDL scenarios would result in simple linear increases in habitat availability and quality, and that subsequently the condition of ecological

[3] Information on the condition of vegetation in each region (Ecological Associates 2010, which were derived from data provided by the MDBA) was not used because the scale of reporting covered whole regions, and could not be partitioned into habitats specifically affected by availability of environmental water.

communities would also increase linearly across increasing SDL scenarios. This critical assumption is justified on the basis that whilst ecological responses to changes in water availability are likely to be non-linear, using linear projections invokes fewer assumptions about the nature and drivers of non-linearity across the entire Basin and in each river valley for the purposes of economic analysis.

This assumption of linearity represents an oversimplification of the more realistic non-linear responses likely to occur following changes in water availability, but there is insufficient data to support development of suitable non-linear response curves using long term average flow data and regional and Basin scales.[4] While we recognise that the ecological response is likely to be far more complex, in the absence of detailed modeling of the ecological response to the SDL scenarios, then this approach offers a reasonable step that allows some economic valuation of changes in environmental health. Further details of the approach adopted are set out in Appendix A.

Summary of estimated ecological outcomes

Table 2.3 provides a summary of the key ecological outcomes measured for this report using the methodology described above (full details by region are provided in appendix A). Outcomes are provided for:

- Native fish abundance (defined as a percentage increase relative to current conditions).
- Frequency of bird breeding.
- Fish and macroinvertebrate condition (defined on a qualitative scale).
- Length of river in healthy condition. This is defined by applying the length of river in each catchment to the qualitative change in condition.

A couple of points on this table are worth noting.

- The analysis did not find substantive changes in ecological outcomes associated with additional environmental flows for the range of SDLs examined.
- For example, fish condition in over half the catchments covered was not projected to have any change in condition (13 out of 22). Only one or two catchments were estimated to improve to good condition.
- Similar results emerged for macroinvertebrate condition where no improvements were projected for 13 out of 22 catchments covered.

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4 It is possible that this information may be available for some catchments in the Basin. However, it was not available for all regions in the Basin which would limit our ability to adopt a consistent approach for this study.

- In terms of length of river restored to 'good' condition, this was estimated to be around 4 000 km based on a fish index, and up to 6 000 km based on a macroinvertebrate index.

Overall, there are mixed results for the predicted increment in ecological outcomes as flows to the environment are increased.

- In terms of native fish abundance, there is a steady but very slight increase with higher flows.
- For fish condition (and associated length of healthy river) there is only a gradual increase.
- For macroinvertebrate condition (and associated length of healthy river) there is a greater increment, but still only a gradual increase.

This may be a consequence of the linearity assumption noted above. However, it may also reflect something about the magnitude of the additional flows – for example, it may be that 'stepped' improvements in ecological outcomes may require much larger incremental environmental flows.

Coorong, Lower Lakes and the Murray Mouth

The analysis discussed above does not include the effects of the proposed SDL on the Coorong, Lower Lakes and the Murray Mouth (CLLMM). As will be discussed further below, there is some uncertainty about whether outcomes in the CLLMM should be valued separately to outcomes elsewhere in the Basin.

Research presented in Lester and Fairweather (2011) indicates that the incremental average flows required to maintain the CLLMM in a healthy condition are not large at around 410 GL per year on average. It is important to note, however, that this average hides the fact that the CLLMM need flow in dry years to maintain health. Therefore the way in which the additional water for the environment is delivered is crucial for a beneficial outcome. Recent research by CSIRO (2011) indicates that while all the *Guide* scenarios achieve environmental watering requirements on an average annual basis, it's possible that none of the scenarios achieves these on an annual basis, and only the 4 000 GL scenario may achieve the requirements on a 5 year rolling average basis[5].

In the evaluation discussion presented below, we assume that the values associated with the CLLMM occur under the 4000GL SDL, in line with the CSIRO report. We do this in order to illustrate the fact that benefits related to CLLMM may be of a 'threshold' nature — that is that they may only occur once a particular threshold SDL is achieved. Clearly, however, additional information and analysis is required to substantiate this assumption.

[5] CSIRO 2011, table 5.1.

2.3 **Summary of estimated ecological outcomes**

Ecological indicator	*3000 GL*	*3500 GL*	*4000 GL*
Native fish abundance	*Percentage increase* Range: 4 to 49 Average:26	*Percentage increase* Range: 5 to 64 Average:29	*Percentage increase* Range: 6 to 72 Average:33
Frequency of water bird breeding (same for all catchments, base once in every 6 years)	Once in every 4 years	Interpolated: once in every 3.5 years	Once in every 3 years
Fish condition (22 catchments covered)	*Number of catchments*: No change: 13 Poor to moderate: 6 Poor to good: 0 Moderate to good: 2 Extremely poor to very poor: 1	*Number of catchments*: No change: 13 Poor to moderate: 5 Poor to good: 1 Moderate to good: 2 Extremely poor to very poor: 1	*Number of catchments*: No change: 13 Poor to moderate: 5 Poor to good: 1 Moderate to good: 2 Extremely poor to very poor: 1
Macroinvertebrate condition (22 catchments covered)	*Number of catchments*: No change: 13 Poor to moderate: 7 Poor to good: 0 Moderate to good: 1 Very poor to poor: 1	*Number of catchments*: No change: 13 Poor to moderate: 6 Poor to good: 1 Moderate to good: 1 Very poor to poor: 1	*Number of catchments*: No change: 12 Poor to moderate: 6 Poor to good: 1 Moderate to good: 2 Very poor to poor: 1
Length of healthy river (km)	*Improvement in condition to 'good':* Fish index: 4 034 km MI index: 1 949 km *Any improvement in condition to 'good' or 'moderate':* Fish index: 10 412 km MI index: 13 220 km	*Improvement in condition to 'good':* Fish index: 4 116 km MI index: 4 058 km *Any improvement in condition to 'good' or 'moderate':* Fish index: 10 412 km MI index: 13 220 km	*Improvement in condition to 'good':* Fish index: 4 116 km MI index: 6 144 km *Any improvement in condition to 'good' or 'moderate':* Fish index: 10 412 km MI index: 13 489 km
Coorong, Lower Lakes and Murray Mouth	*No effect*	*No effect*	*Good chance of improvement to healthy condition (assuming appropriate management)*

Source: The CIE, SMEC. See Appendix A.

What is the information base for non-use values?

Non-use values have the troubling characteristic that they cannot be estimated with objective market value data. They must, rather, be determined by alternative techniques involving structured surveys to directly ask individuals about their values. A range of survey methods have been developed in the broad evaluation literature. In recent years, the most common technique has been a method known as 'choice modelling'. In this form of survey, participants are given a variety of choices for different hypothetical outcomes, with different costs associated with them.

Through an appropriately structured survey instrument and using statistical analysis of the results it is possible to calculate marginal or incremental values for particular characteristics.

In Australia, choice modelling is the dominant source of information about non-use ecological values related to rivers and wetlands.

In total almost 10 000 people in Australia have responded to the various choice modelling surveys concerning river health that have been undertaken over the past decade[6]. These people come from a range of locations and have been asked about a variety of values relating to a large number of different rivers and wetlands. Respondents have been both in the river catchments and outside of them. They have mostly been contacted via mailed questionnaires (although in some case these were dropped off and picked up).

Despite the relatively large databank of results, many of the studies are not directly comparable as each asks about slightly different attributes applied to different rivers or wetlands. Importantly, the studies undertaken to date have tended to look at individual rivers or wetlands and no study has sought values for a sequence of changes as broad and far reaching as those proposed under the *Guide to the proposed Basin Plan*.

Chart 2.4 summarises the sorts of values that have emerged from the choice modelling exercises undertaken in Australia. The most common set of attributes examined in these studies are native fish numbers, native fauna numbers, waterbird breeding and condition of riverside vegetation. As chart 2.3 shows, these attributes have each been defined slightly differently. For example, native fish outcomes have been measured as either the 'per cent of pre-settlement species and population' or as the 'absolute number of species' or as the 'percent of the original population'.

In some cases, studies have sought information on a once off payment that respondents would be prepared to make, while in other cases information has been sought on annual payments.

As chart 2.4 illustrates, a range of results has emerged. For example, marginal values for native fish range from around $2 to $9 per household per species protected. In general, values for native fauna have a larger range (with a higher maximum), while values for waterbird breeding tend to be highest.

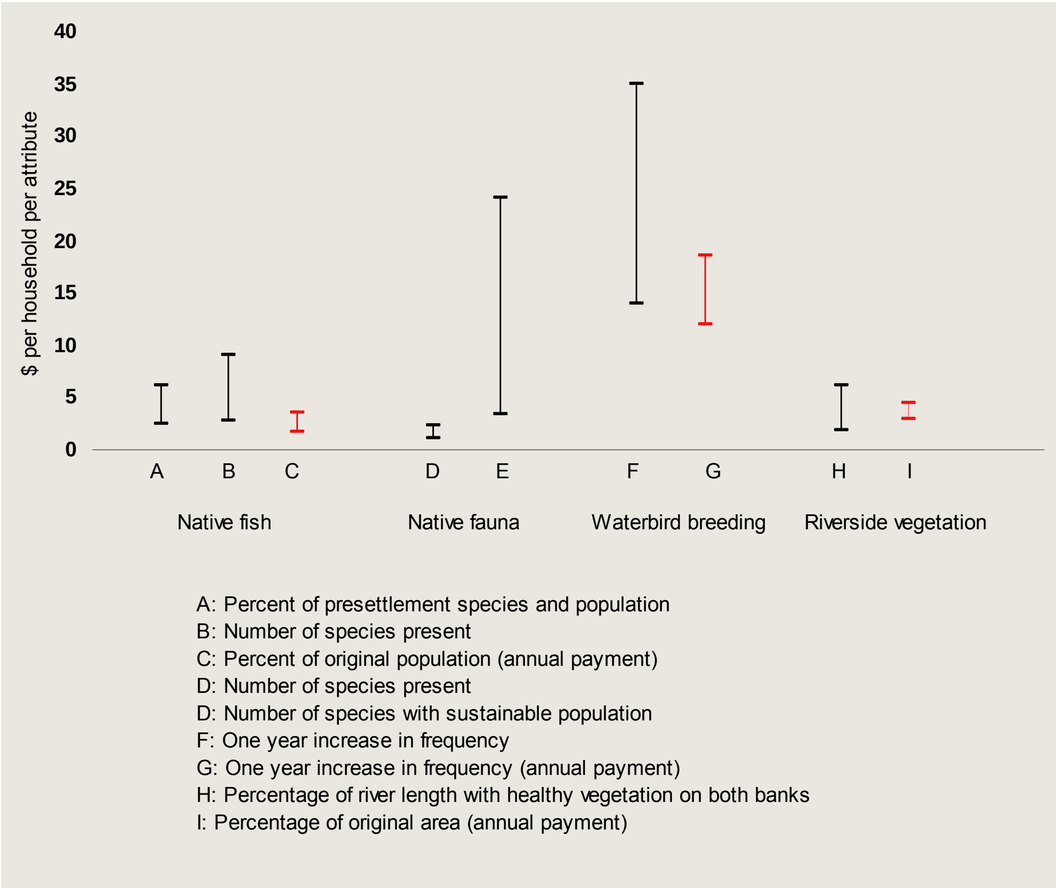
A recent meta-analysis of a range of choice modelling studies (Rolfe 2011, and Rolfe and Brouwer 2011) provides perspective on these various marginal values. The meta-analysis puts the various studies on a common basis by expressing the results in terms of willingness to pay per km of river improved (per household). Chart 2.5

[6] The average response rate for the various surveys is around 40 per cent, although there is a large variance around this number.

illustrates that per unit WTP tends to decline as the length of river covered in the analysis increases.

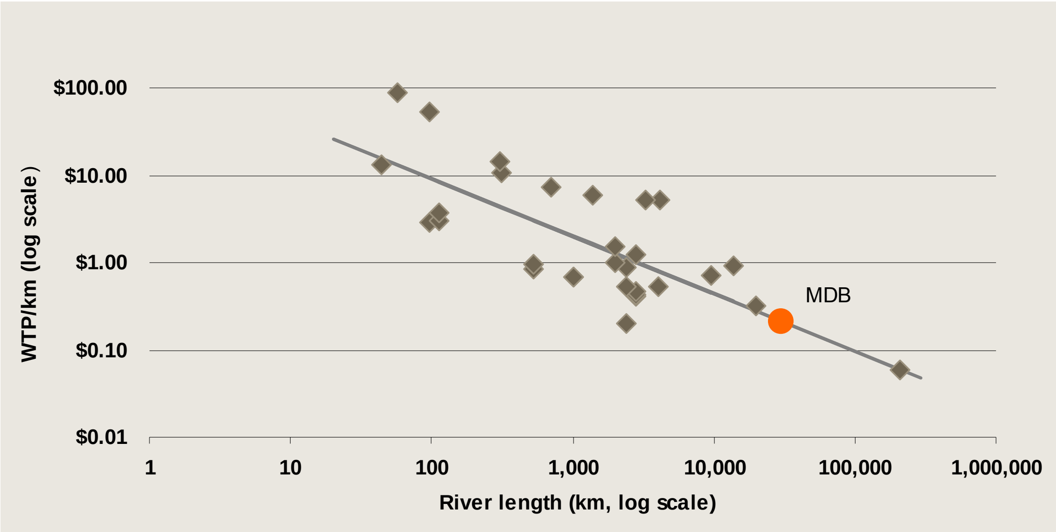
Overall, the Rolfe and Brouwer analysis found that the average WTP per km of river in good health was $3.13 (in present value terms) per household. This is equivalent to around $0.47 per household per year (Rolfe and Brouwer 2011 use a 15 per cent discount rate). As chart 2.5 illustrates, an appropriate value for a river system of the length in the MDB would be around $0.20 per household in present value terms. The average result would not be appropriate as it effectively applies to a shorter length river.

2.4 **Ranges of estimated values for particular attributes**



Data source: Various.

2.5 **River length and WTP**



Data source: Rolfe (2011).

Verification of studies

While a number of studies have sought to demonstrate that the results of stated preference type studies provide a good indication of how people may actually behave when confronted by a choice, it is, by definition, difficult to obtain independent verification of these sorts of values. One option is through comparison with overseas studies where stated preference techniques are routinely used for environmental valuation in a wide variety of contexts. Table 2.6 illustrates some results from selected overseas studies.

These studies are not, of course, directly comparable to those in Australia. In particular, they tend to focus on total ecosystem services rather than particular attributes (total ecosystems services can be thought of as the sum of individual attributes such as those summarised in chart 2.4). Taking this into account, it is clear that substantial environmental benefits have also emerged in overseas studies. In some cases the order of magnitude appears to be larger than estimated in Australia. This provides some indirect indication that the results derived in Australia are reasonable.

2.6 Summary of results, international stated preference studies

Study	***Indicators of ecosystem services and ecological status***	***Results***
Hanley et al (2006) *Estimating the Economic Value of Improvements in River Ecology Using Choice Experiments*	River ecology indicators of aquatic life including fish, plants and invertebrates.	Estimated that local residents were willing to pay between £18.19 and £20.17 (US$9.82 and US$10.89[a]) to improve the river ecology from fair to good in both the River Wear and River Clyde in the UK. This equates to US$4.09 and US$4.54 per household.[b]
Douglas, A. Taylor, J. (1999) *The Economic Value of Trinity River Water*	Per cent flows diverted to Sacramento River Number of adult spawning anadromous fish Quality of recreational boating	Estimated annual household benefits for augmenting the Trinity River instream flows and fish runs to be between US$106.70 (90% diversion to Sacramento River, 9000 fish) and US$803.64 million (30% diversion to Sacramento River, 105 000 fish). This equates US$149.94 and US$1129.36 (dependant on diversion level) per household.
Loomis et al (2000) *Measuring the Total Economic Value of Restoring Ecosystem Services in an Impaired River Basin*	Dilution of wastewater Natural purification of water Erosion control Habitat for fish and wildlife Recreation	Estimates that, on average, households would pay US$252 annually for additional ecosystem services along a 45 mile section of the Platte River in the US.
Holmes et al (2004) *Contingent Valuation, Net Marginal Benefits, and the Scale of Riparian Ecosystem Restoration*	Abundance of game fish Water clarity Wildlife habitat Allowable water uses Ecosystem naturalness	Estimates annual economic benefits (median WTP) for riparian restoration projects along the Little Tennessee River ranging from US$0.69 – US$3.48 per household per year (for 2 miles of restoration) to US$27.26 – US$53.76 per household per year (for 6 miles of restoration).

[a] Based on a conversion of 0.54GBP to each USD (average 2006 exchange rate).

[b] Based on an average household size of 2.4 persons.

Note: figures have been inflated from December of year of publication to September 2010 with ABS Consumer Price Index data, 6401.0, Australia.

Benefit transfer

A major objective of choice modelling and related studies has been to find a set of environmental values that can be 'transferred' from their original context (ie their original river system) to a range of other current policy contexts. This process, known as 'benefit transfer' has the potential to significantly reduce the cost of incorporating environmental valuations into benefit cost assessments.

To date, the process of benefit transfer has been limited in application because there is no comprehensive set of attribute values that can be transferred from one context to another or, more importantly, that can be transferred from smaller scale individual river changes to larger scale Basin wide changes.

For the task of estimating environmental values resulting from the Basin Plan, the current state of knowledge allows the calculation of benefits for individual rivers and wetlands but does not provide any indication of the way in which values for individual systems interact or whether the total value for Basin-level changes is the sum of the component system values. The process of generating this additional knowledge of non-market environmental benefits poses some significant technical challenges. As noted below, this is likely to require further investment of resources to resolve.

Summary of values for core environmental attributes

A recent study undertaken for the MDBA provided a summary of environmental values from a range of studies applied to regions in the MDB. These results are summarised in table 2.7 which shows the total present value of benefits associated with marginal increments in ecological outcomes.

2.7 Aggregate values for the native vegetation, native fish, waterbird breeding and waterbirds and other species for 19 Regions

	Native vegetation	***Native fish***	***Colonial waterbird breeding***	***Waterbirds and other species***
		$'000 (present value)		
	1% increase in healthy native vegetation	1% increase in native fish populations	1 year increase in frequency of breeding	Unit increase in number of waterbirds and other species present
	$`000	$`000	$`000	$`000
Barwon-Darling	3 594	667	24 693	3 578
Border Rivers	2 437	414	-	1 086
Campaspe	3 363	2 990	-	2 299
Condamine-Balonne	2 926	414	15 337	1 086
Mt. Lofty Ranges	1 494	1 329	-	1 022
Goulburn-Broken	5 019	4 463	-	3 431
Gwydir	3 482	667	24 693	1 749
Lachlan	3 482	667	24 693	1 749
Loddon-Avoca	3 363	2 990	-	2 299
Macquarie-Castlereagh	3 482	677	58 802	1 749
Moonie	1 961	277	-	728
Murray	79 098	73 794	375 369	12 203
Murrumbidgee	3 594	667	24 693	3 578
Namoi	3 482	667	-	1 749
Ovens	3 363	2 990	-	2 299
Paroo	2 598	414	15 337	1 086
Warrego	2 598	414	-	1 086
Wimmera	2 660	509	-	1 336

Source: Morrison and Hatton MacDonald (2010) *Economic Evaluation of Environmental Benefits in the Murray-Darling Basin*, Report prepared for the MDBA. p 32.

Notes: The values are presented in present value terms using real 2010 dollars. It utilises household numbers derived from ABS data for each state.

This compilation of a broad set of valuation studies, generally undertaken for individual rivers, inevitably involves a number of key assumptions. It does, however, provide a useful basis for understanding the order of magnitude of potential benefits. It is important to note again in using this analysis, however, that none of the individual studies drawn on for this summary were concerned with valuing changes of the scope proposed under the Basin Plan. Rather, they each focused on individual river systems.

An important question when considering aggregate values for ecological attributes is the population base that the per household values should be applied to. A common convention is to use the response rate from the underlying survey as a basis for deciding this. For example, if the underlying survey had a response rate of 50 per cent, then it is commonly assumed that the per household valuations could be applied to 50 per cent of the total population of households. The results in table 2.7 assume that 30 per cent of non-respondents have the same values as the respondents in the underlying surveys, leading to the per household values being applied to between 41 and 68 per cent of households

Another important assumption underlying table 2.7 is that for each of the regions (other than the Murray) only households within the same State as the relevant river are assumed to value outcomes for that river. In the case of the Murray, a proportion of households in all States are assumed to value outcomes.

It is interesting to note that within these overall results, the outcomes for the Murray River stand out in their overall magnitude. These results come from a recent Australia-wide choice modelling study of preferences relating to the Murray River (Morrison et al 2011).

There are a number of possible reasons for the very large values associated with the Murray. In particular:

- the Murray is an iconic river, passing through a number of States and with many camping, recreational and icon sites along its length. Of all the rivers in the Basin, it is the one most Australians will know about and identify with to some extent; and
- the per household unit values for the Murray are large, so too is the population to which these can be applied. The survey involved households for all States, and so the outcomes summarised in table 2.7 reflect the valuations by many more Australians than do those for other rivers.

Values for improvement in waterbird habitat in the Coorong

Importantly, the Morrison et al (2011) study also included a valuation for improvements in waterbird habitat in the Coorong. This was specified as one of four elements of the choice set (the other elements being waterbird breeding along the river, native fish in the river and healthy vegetation along the river). The estimated value for the Coorong was $4.3 billion (in present value terms) for improving the quality of waterbird habitat in the Coorong from 'poor' to 'good'.

There is some uncertainty as to whether it is appropriate to treat quality of habitat in the Coorong as a specific location while at the same time treating other locations along the Murray more generically. With this treatment there is a possibility both for double counting and for confusion about the difference between general attributes along the Murray on the one hand, and a specific attribute of the Coorong on the other.

This concern was recognised in the design and implementation of the Morrison et al study. One of the reasons for including the Coorong waterbird habitat as a specific element of the choice set was to explicitly provide a tradeoff between allocating water for upstream uses and allocating water for downstream uses.

The concern over this aspect of study design illustrates the complexity of estimating non-use benefits through stated preference techniques such as choice modelling. As noted elsewhere in this report, no study undertaken to date has been specifically framed for the scale and scope of changes proposed under the Basin Plan, so the information from existing studies can only be considered as illustrative of potential outcomes. On this basis, the illustrative estimates below also include values for the Coorong.

Valuation illustrations using available estimates

Table 2.8 sets out an illustrative valuation approach for components of non-use benefits. Of the core outcomes measured by choice modelling studies (and identified in table 2.7 above), we are able to explicitly value native fish abundance and frequency of water bird breeding.[7] We are unable to evaluate changes in vegetation condition and we have been unable to measure changes in the number of bird and other.

At the same time, we have been able to estimate some outcomes (fish condition and macroinvertebrate condition) designed to provide a valuation approach based on length of river improved.

Given the limitations in the information base, the challenges in estimating ecological outcomes and data gaps on a range of issues, we have chosen three alternative scenarios to illustrate the value of the ecological responses due to SDLs. While each of these scenarios have their limitations, the rationale for using them is to gain insights into whether the results in each provide guidance on the order of magnitude of the potential benefit (rather than a precise estimate of the benefit).

7 As discussed later, we were only able to value frequency of water bird breeding at a Basin wide scale due to the difficulties in disaggregating this information between regions.

2.8 Measured outcome and valuation approach taken for non-use benefits

Ecological outcome	*Scale*	*Valuation approach*
Core 'valuable' outcomes measured		
Change in native fish abundance	% increase relative to current diversion limits converted to number of species	Valued using willingness to pay estimates summarised in MHM (2010)
Frequency of water bird breeding	Number of years between events	Valued using willingness to pay estimates summarised in MHM (2010) at a whole of Basin scale.
Change in the state of the Coorong	Improvement from 'poor' to 'good'	Based on Lester and Fairweather (2011) and informal information, this improvement is assumed to take place at 4000GL. Valued using WTP estimates in Morrison et al (2011).
Core valuable outcomes not measured		
Number of bird and other species	Not measured due to insufficient information about the effect of additional environmental flows	Not valued
Vegetation condition	Not measured due to insufficient information about the effect of additional environmental flows	Not valued
Outcomes measured to provide alternative valuations based on length of river		
Fish condition response	Extremely poor, poor, moderate, good,	Used as an indicator of river health and converted to a **river length** and then a value using willingness to pay estimates **for length of healthy river**. This is an alternative outcome and not additive with the others.
Macro invertebrate condition response	Poor, moderate, good, very good	Used as an indicator of river health and converted to a **river length** and then a value using willingness to pay estimates for **length of healthy river**. This is an alternative outcome and not additive with the others.

Scenario 1

For scenario 1, we use the summary of benefits recently compiled by Morrison and Hatton MacDonald (MHM) for the MDBA as summarised in table 2.7. The rationale for this scenario is straightforward: given that there is currently no single study that assesses valuations at a Basin wide scale and in the full context of the Basin Plan, an initial indication can only be provided using existing studies. The caveats for this should be kept in mind.

For scenario 1, we calculate results for individual regions as well as Basin wide results by aggregating the individual regions. Given the diverse sources of the underlying valuations, aggregating across regions may tend to ***overstate*** total benefits. Values for Basin wide changes will not necessarily be the sum of individual changes; a Basin wide set of changes may well have a different character from changes in individual rivers.

At the same time, however, we have not been able to estimate outcomes for all of the attributes, which will tend to lead to ***understating*** the total benefits.

Note that in this and the other two scenarios, we separately identify the benefits for improving the Coorong from 'poor' to 'good' as a consequence of the 4000GL SDL scenario. As noted above, this is based on recent research by CSIRO (2011) and is used to illustrate the potential threshold nature of outcomes such as those in CLLMM. This is not intended to imply the benefits are zero for the other scenarios, only to point out the uncertainty of values for these scenarios.

Scenario 2

For scenario 2, we take the values for the Murray River reported in MHM and use these to represent values for the whole Basin. While, of course, the Murray is only one river with one set of ecological outcomes, this scenario assumes that it can be used to represent Basin-wide outcomes.

As for scenario 1, we have been unable to evaluate benefits for all of the attributes identified for the Murray.

Note that as for scenario 1 we also separately identify the value of benefits for improving the Coorong from 'poor' to 'good'.

In addition, under scenario 2 we illustrate the sorts of values that emerge if the assumed discount rate in the original study is reduced. The context for this is as follows: in the original MHM study, a range of source studies were used, each with a different approach to the timing of payments — some assuming a once off payment, and others assuming a stream of annual payments. In order to put these on a common basis, MHM used a discount rate of 28 per cent. When considering the Murray River results alone, it is not necessarily appropriate to use such a high discount rate, so an alternative is used for illustration.

Scenario 3

For this scenario, we attempt a different approach to valuation using estimates of the length of river that is improved as a consequence of the additional environmental flows. The bounds for this valuation are taken from a recent study by van Bueren and Bennett[8] as well as from the meta-analysis discussed above. These bounds should not be interpreted in the sense of a statistical confidence interval. Rather, we use them as a means to effectively increase the scope of the underlying scenarios.

Estimating the length of river improved is challenging, as noted above. To do so we use two broad indicators — fish condition and macroinvertebrate condition — and convert these to river lengths by assessing the length of river that experiences an improvement in either of these conditions.

In terms of valuation, we use two alternatives within this scenario. For scenario 3a, we only value improvements in condition that move to 'good'. For scenario 3b, we value improvements that move condition to either 'moderate' or 'good' at the same unit rate.

Estimated changes in non-use values

Table 2.9 summarises the estimated changes in non-use values for each of the scenarios outlined above.

Results for scenarios 1 and 2 are of similar order of magnitude ($3 billion to $5 billion) and show a steady increase as the additional environmental flows increase. The inclusion of the Coorong values increases the value of the 4000GL scenario to just over $8.5 billion.

Results for the components of scenario 3 show a much broader range ($1 billion to $11 billion) and within each sub-scenario do not tend to increase substantially as SDLs increase. This is a direct reflection of projected ecological outcomes noted above.

Interestingly, the averages result for scenarios 3a and 3b are of a similar order of magnitude to those for scenarios 1 and 2. This provides some indirect indication that this order of magnitude may be appropriate given the current information base. On the other hand, it is important to note that the valuation scope of the scenarios differs and that each one is effectively measuring different attributes.

Whose values are these?

As noted above, estimating total values for environmental attributes involves making assumptions about the population that the values should be applied to. On average, the results in table 2.9 assume that the values are applied to about 50 per cent of the total number of households in MDB states (this comes to around 4 million

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8 van Bueren. M and Bennett, J (2004) 'Towards the development of a transferable set of value estimates for environmental attributes' *Australian Journal of Agricultural and Resource Economics*, 48:1, pp. 1-32. This study contains a willingness to pay value per 10 km of river restored to a good condition. This value is actually a mix of use and non-use valuations.

households. Because most of the population in MDB states live in capital cities, this implies that the majority of these values are attributed to households living in the capitals (outside the irrigated regions themselves).

2.9 Summary of non-use value estimates (present value in 2010)

Scenario	*3000 GL*		*3500 GL*		*4000 GL*	
		$m		$m		$m
Scenario 1:						
Summary values from MHM (2010) summed across regions.		3 750		4 760		5 430
Values for the Coorong		**a**		a		4 274
Scenario 2a Using results for the Murray to represent the whole Basin — original discount rate (28%)						
Values for fish population and waterbird breeding		3 115		4 040		4 590
Values for the Coorong		**a**		**a**		4 274
Scenario 2b Using results for the Murray to represent the whole Basin — lower discount rate (15%)						
Values for fish population and waterbird breeding		4 782		6 201		7 046
Values for the Coorong		**a**		**a**		6 560
Scenario 3: Using alternative 'length of healthy river' basis for valuation — lower scenario based on van Bueren and Bennett ($0.0095 per km per year), upper scenario based on meta-analysis ($0.03 per km per year)						
Scenario 3a: only valuing improvement to 'good'						
	Lower	*Upper*	*Lower*	*Upper*	*Lower*	*Upper*
Fish indicator	1 074	3 382	1 095	3 451	1 095	3 451
MI indicator	519	1 634	1 080	3 402	1 635	5 151
Scenario 3b: valuing any improvement in condition (to 'moderate' or to 'good')						
	Lower	*Upper*	*Lower*	*Upper*	*Lower*	*Upper*
Fish indicator	2 771	8 729	2 771	8 729	2 771	8 729
MI indicator	3 518	11 082	3 518	11 082	3 588	11 304

a Values for the Coorong are explicitly reported for the 4 000GL scenario as some research (CSIRO 2011) indicates that this is most likely to achieved the valued improvement. There is some likelihood that other scenarios will do so as well, however it is unclear what weighting to apply to other scenarios to reflect this.

Source: CIE estimates.

Important caveats

None of these values presented above can be considered to be definitive. They are illustrations of outcomes that emerge when:

- applying the approximate ecological response methodology (which is known to be an approximation); and
- using existing valuation estimates, none of which are strictly appropriate for the scale of the Basin-wide policy proposed.

These results can only be considered as illustrative and we do not consider them to be sufficiently well founded to provide accurate information about these components of the benefits of the Basin Plan.

Estimates of use values

In addition to the non-use values set out above, the analysis for this report also includes estimates of a number of other values associated with the SDLs. These are summarised in table 2.10. Details are provided in appendixes C and D.

The most significant of these are the recreation benefits which are in turn based on analysis of the likely response of overnight visits to the Murray. The basis for this calculation is summarised in table 2.11.

2.10 **Summary of recreation and other benefits (present value in 2010)**

Benefit	*3000 GL*	*3500 GL*	*4000 GL*
	$m	$m	$m
Recreation	490	562	649
Salinity	91	87	84
Cost of flooding	2	2	2
Cost of dredging	13	14	14

Source: CIE estimates.

2.11 **Changes in visitor numbers**

Scenario	*Change in overnight visitor numbers (A)*	*Value per trip (B)*	*Value per year (C)*	*Total value, $2010 dollars (D)*
	No./year	$	$m/year	$m
3 000 GL	113 452	585	66	490
3 500 GL	133 463	585	78	562
4 000 GL	153 212	585	90	649

Note: Column C is column A multiplied by column B. Column D is the Present Value of this annual benefit over the period 2010 to 2030, using a real discount rate of 7 per cent and with the benefits only accruing from 2015 onwards. Column B is the average of use values reported in Morrison and Hatton MacDonald 2010.
Source: CIE analysis.

3 Costs

Loss of economic surplus

The cost of the proposed SDLs is the foregone net income from reduced productive use of water (in particular, irrigated agricultural production). In accordance with principles of BCA, this lost income should be measured as a loss of a 'surplus' from productive use. This surplus is akin to lost profits. Not all lost production translates into lost surplus, as it is possible that many of the resources previously associated with irrigated agriculture and related services could be productively re-deployed elsewhere in the economy. Indeed, the net income lost from the SDLs depends to a large extent on the flexibility of the economy in reallocating resources. The various studies of the losses from SDLs effectively make different assumptions about the flexibility of the economy.

The range of estimates of the broad economic cost of SDLs can be seen in the wide range of estimated outcomes from two studies commissioned by the MDBA. In national income terms, CoPS[9] estimated a 0.01 per cent reduction in GDP (relative to what would otherwise have occurred) as a consequence of the 3500 GL SDL. In contrast, ABARE-BRS[10] estimated a 0.13 per cent reduction in national income. This ten-fold difference arises from differences in assumption about economic flexibility at both the regional and national levels.

Approach taken in this report

This report illustrates likely costs by focusing on calculating a range for a particular estimate of the economic surplus loss as a consequence of the SDLs. Following an approach set out in Young (2005) and recently used in Dixon et al (2011) we measure this surplus loss as the reduction in the 'marginal product' of water as a consequence of a restriction of the quantity of water used for production (Appendix E provides some additional discussion and illustrates how this approach is also consistent with ABARE-BRS analysis of changes in 'profits' from reduced water use).

9 Wittwer, G 2010 'The regional economic impacts of sustainable diversion limits', unpublished report prepared for the MDBA, Centre of Policy Studies, Melbourne.

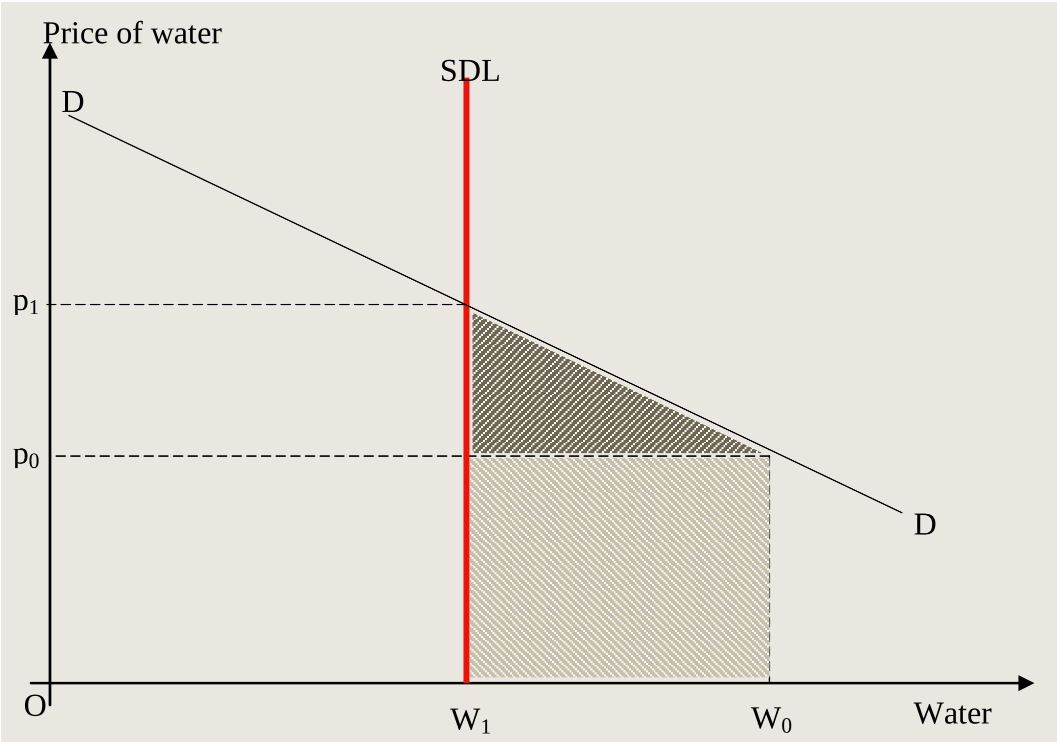
10 ABARE-BRS 2010 *Environmentally sustainable diversion limits in the Murray Darling Basin: socioeconomic analysis*, Report for the Murray Darling Basin Authority, Canberra.

The approach we take provides a convenient means of incorporating a range of scenarios concerning the overall flexibility of the economy, thus capturing one of the key factors driving economic costs.

Measuring the surplus loss

Chart 3.1 illustrates the notion of surplus that we calculate to measure the economic costs of the SDLs. The horizontal axis shows the quantity of water used in production. The SDL reduces this quantity from W_0 to W_1, which is equal to the new diversions allowed. The vertical axis shows the price of water which for this analysis is assumed to reflect the marginal product of water. The curve DD is the derived demand for water (as discussed below, this is itself determined by a number of factors). It shows the amount of water demanded for each price or, equivalently the marginal product of water at each level of water consumed.

3.1 **Estimating surplus loss from SDLs**



The surplus loss from the reduction in water use (W_0 to W_1) is equal to the sum of two shaded areas (a shaded rectangle and a shaded triangle). The shaded rectangle is simply equal to the quantity reduction in water use multiplied by the initial price of water. This amount provides a simple quick approximation to valuing the economic loss from an SDL. The shaded triangle component of the loss reflects the fact that as water is taken out of irrigation, the price of water will increase (or the marginal product will increase) so that there is a second component of the loss reflecting this.

The magnitude of the shaded triangle clearly depends on the slope of the curve DD. For a given reduction from W_0 to W_1, the steeper is DD, the greater the loss in total surplus.

The shaded areas in chart 3.1 can be calculated by observing current water prices, the quantity reduction in use implied by the SDL and by making assumptions about the overall flexibility of the economy in responding to the reduced water use.

Flexibility of the economy

The slope of the curve DD in chart 3.1 can be used as a measure of the overall flexibility of the economy in responding to reduction in water use. This overall flexibility (which is determined by a number of factors including the existence of a well functioning water market) can be summarised by the 'elasticity' of derived demand for water. Very 'inelastic' derived demand (a steep slope for DD) implies a relatively inflexible economy with a relatively high cost for reductions in water use. This inflexibility may arise, for example, through the use of factors of production that can only be used in association with water. In this case, reduced water use also results in lost surplus from these 'fixed' factors of production.

On the other hand, a flexible economy (a very flat curve DD) implies that factors of production can be reallocated to other uses, so that the loss from reduced water uses only relates to the lost surplus from the water use itself.

This notion of flexibility also applies to the domestic consumption of goods that are produced with irrigation. If domestic demand for these products is very inelastic, then the derived demand for water will also tend to be inelastic (ie a steeper curve DD) leading to higher costs from reduced water use. In this case, some of the loss of marginal product of water is experienced by consumers as well as producers. On the other hand, if demand is highly elastic (if there are many substitutes for Australian irrigated products) then the derived demand for water will tend to be more elastic and a lower cost from SDLs will be experienced by consumers.

Range of estimates

To estimate the surplus loss for each region as a consequence of the SDLs for that region, we use four sources of information:

- initial water use by region (ie W_0) taken from ABARE-BRS (2010, table A13);
- initial prices for water in each region (provided by ABARES from their water trade model);
- reductions in irrigated water use by region set out in the *Guide to the proposed Basin Plan: Overview* (appendix C);

- elasticities of derived demand for water (broadly, the slope of DD) ranging from -0.05 to -0.5, consistent with the range of values reported in the literature (see, for example, Dixon et all 2011).

Table 3.2 summarises the annual surplus losses for each region as a consequence under these assumptions for three SDLs.

3.2 Annual surplus loss as a consequence of SDLs

Region		*3000 GL*		*3500 GL*		*4000 GL*
	Lower	Upper	Lower	Upper)	Lower	Upper)
	$ million	$ million	$ million	$ million	$ million	$ million
Condamine	3.4	10.2	4.1	13.5	4.9	17.1
Border Rivers (QLD)	1.0	2.4	1.2	3.0	1.3	3.8
Border Rivers (NSW)	1.2	3.1	1.4	3.9	1.7	4.8
Warrego	0.1	0.4	0.1	0.4	0.1	0.5
Paroo	0.0	0.0	0.0	0.0	0.0	0.0
Namoi	2.9	7.5	3.5	9.5	4.0	11.8
Macquarie	2.8	7.8	3.4	10.0	3.9	12.4
Moonie	0.6	2.2	0.7	2.5	0.8	3.1
Gwydir	4.0	11.8	4.9	15.7	5.8	20.1
Barwon Darling	2.6	6.7	3.0	8.5	3.5	10.5
Lachlan	0.8	1.8	1.1	2.7	1.4	3.7
Murrumbidgee	48.1	153.7	58.7	203.9	69.8	259.5
Ovens	0.5	1.7	0.5	1.7	0.5	2.1
Goulburn Broken	14.0	41.5	17.1	54.8	20.2	69.5
Campaspe	3.5	11.7	4.1	14.8	4.8	18.3
Wimmera	0.0	0.0	0.0	0.0	0.0	0.0
Loddon	9.5	34.1	9.5	34.1	11.1	42.2
Murray (NSW)	10.3	30.4	12.5	40.2	14.8	51.0
Murray (VIC)	13.6	40.5	16.5	53.6	19.6	68.0
Lower Murray Darling	1.3	3.8	1.5	5.0	1.8	6.4
SA Murray	7.9	22.4	9.5	29.6	11.3	37.5
Eastern Mt Lofty Ranges	0.0	0.0	0.0	0.0	0.0	0.0
Total	**128.2**	**393.7**	**153.5**	**507.4**	**181.6**	**642.4**

Note: Lower refers to elasticity of -0.5. Upper refers to elasticity of -0.05.
Source: CIE estimates

Present value of losses

To put these annual losses on the same basis as the benefits reported in the previous chapter, they need to be converted to a present value. To do this, we make two alternative sets of assumptions:

- **Zero baseline water price growth.** Here we assume that the price of water remains constant in real terms.
- **Growth in the real price of water at 8 per cent a year**. This reflects an assumption that demand for water will continue to increase and is consistent with the

underlying simulations from the CoPS modelling (Wittwer 2010) which incorporate overall expansion of the economy.

For each of these assumptions, we assume that the SDLs are implemented in 2015, and we calculate the present value to 2030.

Table 3.3 summarises the results. In this table, the lower bound refers to the calculation assuming an elasticity of demand of -0.5 and assuming that there is no baseline growth in the real price of water. The upper bound refers to the calculation using an elasticity of demand of -0.05 and assuming that the baseline real price of water grows at around 8 per cent a year.

3.3 **Range of lost economic surplus as a consequence of SDLs** Present value

	3000 GL	*3500 GL*	*4000 GL*
	$m	$m	$m
Lower estimate	924	1 107	1 309
Higher estimate	4 491	5 789	7 329

Source: CIE estimates.

Distribution of the costs

The aggregate estimates above refer to the economy wide surplus loss as a consequence of reduced irrigated water use. The distribution of this cost depends, of course, on how this water is taken out of production. If water is purchased from producers (from taxpayer revenue) then most of the cost will be borne by the general taxpayer rather than individual producers.

One question that arises when considering this distribution is the extent to which reduction in irrigation activity in a particular region leads to surplus losses for activities unrelated to agriculture because of the removal of basic services within the region (once a 'threshold' is reached, for example). This issue is considered in appendix I, which does not find clear evidence for this threshold effect using the aggregate data available.

Adjustment and other social costs

The discussion above refers to the long run 'equilibrium' losses of economic surplus as a consequence of reduced water available for irrigation. In addition to these long run losses, it is likely that there will be a number of short term adjustment and social costs arising from the process of the reallocation of resources.

In economic terms, adjustment costs can be thought of as the use of real resources in order to facilitate the movement of resources from one use to another. By this definition, adjustment costs include:

- the opportunity cost of (temporarily) unemployed labour and capital;
- lower wages that may be needed to obtain employment in other industries;
- re-training costs;
- cost of capital rendered obsolete; and
- transition costs of shifting capital to one use or another.

Research is currently underway into the likely magnitude of some of these adjustment costs and the broader social costs associated with them (see, for example EBC 2011). However, as noted in appendix I, current estimates suggest that the projected changes in employment as a consequence of the SDL are very small compared with recent changes in employment in relevant regions.

One aspect of adjustment costs that is very hard to measure relates to personal costs such as psychological suffering as a consequence of uncertainty surrounding the proposed SDLs. Adjustment uncertainty itself involves both economic and social costs (see EBC 2011). It is worth noting that to some degree, this suffering could be minimised through the specification of a very clear policy framework relating to adjustment costs. Many major economic reforms in Australia have also been associated with appropriate adjustment packages.

4 Net benefits and the importance of other policy measures

Net benefits

The analysis in the previous two chapters presented a range for both the benefits and costs of the proposed SDLs. This range — reflected in a number of scenarios in the case of benefits — is designed to indicate the genuine uncertainty surrounding estimates of both benefits and costs (particularly benefits). Even within these scenarios, approximations made to generate the estimates mean that there is considerable scope to misestimate the magnitude of benefits.

These uncertainties make the comparison of costs and benefits particularly challenging. While recognising all the uncertainties involved it is important to note that:

- taking the mid-point or average of the benefits and costs and comparing them indicates that for the scenarios presented here, benefits are greater than costs; and
- the exact magnitude of this difference may vary considerably as different elements of the benefit scenarios are included in the average.

As noted further in chapter 5, a key implication of the net benefit comparisons is to ensure that the SDLs are actually implemented in a way that ensure the emergence of relatively high benefits with relatively low costs. As discussed further below, this is within the influence of a range of policy measures that may be outside the direct remit of the Basin Plan.

The importance of other policy measures

There are many individual elements to the water reform package. The proposed reduction in the SDLs is only one policy instrument (albeit an important one) to achieve policy objectives. It is important to therefore recognise that the proposed reductions in SDLs are being undertaken in the context of a range of other policy measures that are currently in place (or proposed to be enacted).

The magnitude of the impacts (in terms of both the benefits and costs) of the change in allocation of water available for consumptive use and for the environment will, therefore, be influenced by a range of other policy measures that may be in place at that stage. That is, the impact of the SDL scenario could be considered due to a combination of policy instruments. The magnitude of the impact of a given SDL scenario could change due to a change in another policy instrument.

Therefore, the ultimate costs and benefits of the SDLs will also depend on the combination of other factors. That is, the costs and benefits should ideally take account of the *joint* effects of a range of other policies. This chapter discusses some of the other policy instruments in place including:

- the approach to managing environmental water;
- water sharing plans;
- buyback and water infrastructure programs; and
- structural assistance programs.[11]

For the purposes of the BCA we are not in a position to quantify the joint effects of these programs or to estimate the benefits and costs of the SDL scenarios under alternative policy arrangements. This BCA also does not seek to determine the 'optimal' package of measures to achieve the outcome. Rather, we are only assuming a change in one of the measures under the existing mix of measures changes.

The interrelationships between individual measures have a bearing on the mix of individual measures but also on the sequencing of these measures.

Managing environmental water

Managing environmental water to achieve the maximum ecological benefit for the unit of water held is central to achieving a socially optimal balance between extractive water use and use for the environment. Depending on how the environmental water is managed, the same SDL scenario could result in differing environmental outcomes. Some of the variables in managing environmental water include:

- the volume of release occurring; and
- the timing of the releases.

For example, where the greatest environmental value is gained by flooding of wetlands, then the optimal management regime may be to hold back water in the storages and for infrequent releases to be made 'piggy backing' on existing flood events. Adopting such a strategy could have a range of possible offsetting effects such as:

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[11] There are likely to be a wide range of other programs that could impact on the outcome of the SDL scenario such as those programs designed to manage Acid Sulphate soils and salinity in specific catchments.

- increasing the magnitude of flooding along the river channel which could impact on townships along the way as well as causing greater erosion of river banks; and
- limiting 'air space' in storages to capture large floods and to provide flood mitigation benefits.

The precise nature of these outcomes is likely to vary between the catchments based on their specific topography, storage capacity and design and rainfall patterns. However, the timing and volume of environmental water releases are central to the outcomes likely to be delivered under alternative SDL scenarios. It could be that environmental water management techniques enhance or limit the environmental outcomes achieved through specified SDLs.

Commonwealth Environmental Water Holder

The Commonwealth Environmental Water Holder (CEWH) was established under the *Water Act 2007* to manage the water entitlements that the Commonwealth is currently acquiring. The CEWH is required to use its holdings to protect or restore environmental assets so as to give effect to relevant international agreements.

Recent figures suggest that 216 gigalitres of environmental water has been delivered to the environment so far under the *Water for the Future* initiative. However, the future amount of water available for use depends on the volumes acquired and seasonal water allocations.

The CEWH currently cooperates with Basin state governments and other key stakeholders in identifying possible environmental watering options. These options are assessed against the following criteria:

- the ecological significance of the asset;
- the expected ecological outcomes from the proposed watering action;
- the potential risks of the proposed watering action at the site and at connected locations;
- the long term sustainability of the asset, including appropriate management arrangements; and
- the cost effectiveness and operation feasibility of undertaking the watering.

However, water that is held in the Murray-Darling Basin will eventually be managed in accordance with the environmental watering plan specified in the Basin Plan. The criteria specified in this plan along with the amount of water available for the environment will have important effects on the management of environmental water and the outcomes derived from water entitlement purchasing. These policies are likely to interact with SDLs to produce unique outcomes. That is, the policy parameters surrounding the management of environmental water will be crucial in determining the ultimate benefits and costs derived from specified SDLs.

Water sharing plans and water resource plans

Water sharing plans (WSPs) are a key instrument of the planning process — they set out the outcomes and strategies for sustainable management and efficient use of water in each catchment. WSPs are currently in place in NSW, Victoria, South Australia and Queensland.

Water sharing plans establish rules for sharing water between the environment and water users for specified periods by:

- setting limits on extractions so that environmental water is not eroded, including the limits to apply under the Basin Plan;
- setting priority of supplies (for example, domestic use is prioritised over commercial use while high security may be prioritised over general security licences);
- defining rules for managing water, such as carry-over rights and group rostering arrangements;
- detailing water trading rules;
- setting the conditions that apply to licence holders;
- protecting landholder rights (extraction of water for household and stock use, collection of some water runoff and native title holder use of water);
- specifying parts of the WSP that can be changed without compensation; and
- setting monitoring and reporting requirements for the WSP.

Box 4.1 provides information on the contents of the WSP for the Murrumbidgee Regulated River Water source. It highlights the breadth of the water sharing plans which can impact on a wide range of other aspects of the water reform agenda.

4.1 Water sharing plan — Murrumbidgee Regulated River Water Source

The WSP for the Murrumbidgee Regulated River Water Source includes the following characteristics.

- It details the unit shares (or volumes) for each licence type — supplementary, high security, general security, irrigation services, local water utilities, domestic and stock access.
- It details the rules for carry-over — allocations under domestic and stock access licences cannot be carried over from one year to the next; allocations under general security licences can be carried over up to 0.3 ML per unit share.
- It details the rules for priority access — where there is not enough water to satisfy demand, water will first be distributed to domestic and stock access licences, local water utility licences and high security access licences. Remaining water will be shared between general security access licences.
- It specifies licence dealing rules:
  - supplementary water licence trade must be within the same supplementary water access zone (unless within 5 km);
  - cannot trade high security access licences after 1 September in each year;
  - cannot trade general security access licences after end-February in each year;
  - trade out of the water source area is only allowed into the Murrumbidgee Unregulated River Extraction Management Unit, the NSW Murray Regulated River Water Source or the Lower Darling Regulated River Water Source and is subject to rules in the other water source and the application of a conversion factor;
  - trade into the region is only allowed from the NSW Murray Regulated River Water Source or the Lower Darling Regulated River Water Source and is subject to rules in the originating region and the application of a conversion factor;
  - general security access licences can be converted to or from high security access licence subject to volume limits and a conversion factor;
  - the Minister can convert an irrigation services licence to general or high security licence on request of the licence holder;
  - the Minister can convert domestic and stock licence to domestic only on request of the licence holder;
  - the Minister can convert stock only licence to high security licence on request of the licence holder;

(Continued on next page)

4.1 **Water sharing plan — Murrumbidgee Regulated River Water Source**
(continued)

- licences can be transferred between States subject to interstate agreements and application of a conversion factor;
- trade is not allowed where the Minister determines it is not physically possible, or environmental water, domestic or stock rights, native title rights or the reliability of supply would be effected or if trade is after 31 January of the water year.

After the Basin Plan is adopted, the Basin states will continue to administer water entitlement and allocation arrangements through their Water Resource Plans (WRPs). Replacing existing WSPs with accredited WRPs will be necessary to implement the long-term average SDLs set out in the Basin Plan. The process of accreditation will ensure that the WRPs are consistent with the Basin Plan's diversion limits and other requirements.

The current plans begin to be replaced in 2012 and will be completely replaced by 2019. As such, uncertainty still surrounds the specific characteristics of WRPs and their likely interlinkages with SDLs. However, given the broad scope they have to determine water management and allocation arrangements, these WRPs have the potential to impact substantially on the overall benefits and costs yielded by each defined SDL scenario.

Water buyback and infrastructure programs

Water trading has been a key tool that has allowed water to be allocated to its highest value use, leading to a more efficient outcome. Investment in irrigation infrastructure has also been central to the Government's water reform response. The ability of market mechanisms to claw back water for environmental purposes, water trading rules, and irrigation investment are all likely to impact on the efficiency of SDL scenarios.

Both the Commonwealth and state governments have introduced a range of measures over recent years designed to recover water entitlements for environmental purposes. For example, substantial purchases of water for the environment have occurred in NSW under programs including Rivers Environmental Restoration Program (RERP), The Living Murray, NSW Wetland Recovery Program and Restoring the Balance in the Murray–Darling Basin program (RTB). According to recent estimates, the suite of operating water buyback programs has secured purchases of 810 GL. The majority of this was in the form of general security licences.

There are also a range of infrastructure programs that aim to deliver the improved water use efficiency. For example, the Commonwealth's $5.8 billion Sustainable

Rural Water Use and Infrastructure program invests in rural water projects that save water by upgrading out-dated and leaky irrigation systems.

While the term of these projects are finite, it is expected that the socioeconomic costs of SDLs specified in the Basin Plan will be mitigated to some extent by Government funded adjustment assistance, including entitlement buybacks and investments in water efficiency. Future programs and policies related to water buyback and infrastructure investments are likely to impact on the overall outcomes associated with SDL scenarios dependant on their scale, scope and design.

Structural adjustment assistance

Structural adjustment is the term used to refer to the process of change in the size and composition of an economy where the distribution of economic activity and resources between firms, industries or regions changes (McColl and Young 2005). Proposed SDL scenarios involve substantial reductions in current diversion levels and likely structural change in affected regional economies. Structural assistance packages may therefore be developed to assist affected parties to adjust to the short-term changes. Box 4.2 highlights previous structural adjustment assistance packages for water reforms that have been provided in NSW by both Commonwealth and NSW State Governments. Each state/territory government may have specific assistance programs in place in addition to any Commonwealth Government program.

4.2 Previous structural adjustment assistance packages for water reform

Structural adjustment assistance has previously been provided for water reform. In 1998, the Irrigated Agriculture Water Use Efficiency Incentive Scheme was introduced and ran for five years. The Scheme provided financial incentives to farmers outside land and water management plan areas to adopt best practice management and efficient technologies. The Scheme was delivered as part of the NSW Water Reform Structural Adjustment Program.

In 2005, groundwater licenses were replaced with tradable perpetual rights to groundwater under the Achieving Sustainable Ground Water Entitlements program. The program applied to Upper and Lower Namoi, Lower Murrumbidgee, Lower Gwydir, Lower Lachlan, Lower Macquarie and Lower Murray groundwater systems and resulted in a reduction in water available to most landholders. Financial assistance was provided to licence holders based on previous entitlements and use of water. A total of between $100 million to $125 million was allocated for licence holders, with the cost shared evenly between the Commonwealth and NSW State Government.

A $9 million Community Development Fund (CDF) was also established to strengthen the community's economic and social capacity in relation to the reduction in groundwater allocation. As of 2010 some groups were still in the process of implementing the CDF funded projects (for example a program run by Gwydir Valley Irrigators Association providing grants of up to $5000 per hectare for horticulture irrigation systems). Another example of a project funded by the CDF is $2.1 million for the Liverpool Plains Shire Council to seek a partial alternative water supply to allow the annual transfer of 500 ML of water to affected irrigators near Quirindi.

At this stage it is unclear what structural adjustment assistance may be required as the Basin Plan has not been finalised and the level of compensation to be paid for reduced water availability is not clear. It is therefore not possible at this stage to gauge the effect of potential structural assistance packages on the combined benefits and costs resulting from SDLs and other water reform measures.

Conclusions

There are a range of other policy levers that ultimately will have a bearing on the magnitude of the benefits and costs achieved under the SDL scenarios.

There are many individual elements to the water reform package. However, interrelationships between environmental water policies, water sharing plans, entitlement buybacks, infrastructure investments, market trading and structural assistance policies will have considerable implications for the efficiency and effectiveness of proposed SDL scenarios. Each of these individual policies will yield significant flow-on effects to the suite of policy measures. Therefore, the extent of the benefits and the costs achieved from SDLs will be dependent on the package of reforms.

5 Improving the information base

As noted in the discussion above, the current information base for assessing the benefits and costs of the proposed Basin Plan is subject to considerable limitations and needs to be enhanced before robust benefit-cost conclusion can be made. Two particular information gaps are relevant:

- understanding of ecological responses; and
- valuation of ecological outcomes.

Ecological responses

Purpose-designed data collection

Ecological responses to flow are complex, and observed responses at local scales are not necessarily reflected in large-scale data sets (Overton et al 2009, Saintilan and Overton 2010). Many existing data sets were collected for purposes other than detecting or predicting responses to changes in flow, and are not necessarily suited for this purpose. For example, the Sustainable Rivers Audit was designed to detect changes in ecological condition as a trigger for further investigation, and does not attempt to capture information on the causes of change.

Purpose-designed data collection programs are required to capture information on ecological condition and causal factors to support prediction of ecological responses to management interventions such as SDLs. The linear method used here to estimate potential ecological responses for the purposes of this discussion paper represents a substantial simplification of the complexity of ecological responses to changes in flow, and uses data that was not explicitly collected for the purpose of predicting responses to flows. Consequently, the results of this simplification for the purpose of benefit-cost analysis of the proposed SDLs must be considered as preliminary and indicative of potential responses.

Application of more sophisticated modelling approaches, supported by fit-for-purpose data, will allow improvements in estimates of environmental responses to SDL scenarios for selected indicators.

Accounting for ecosystem resilience

Methods to estimate changes in ecological condition, such as the approach adopted for this discussion paper, do not attempt to reflect changes in the resilience of ecosystem components. Resilience represents the capacity of ecosystems to recover from disturbance (Capon et al 2009). Ecosystems that have been severely damaged, or which are affected by multiple degrading processes, may have impaired ability to recover following the introduction of increased environmental water availability. However, scientific understanding of ecosystem resilience is currently limited, and accordingly, greater research emphasis is required to build knowledge of the ability of ecosystems to recover from disturbances such as long-term flow alteration. Economic analyses that do not take into account the reduced resilience of highly degraded ecosystems may over-estimate responses to increased flow, and by extension, the value environmental responses.

Effects of flow versus other interacting disturbances

The SDLs proposed under the Basin Plan represent only one tool for improving river health based on increasing environmental water allocations. There is compelling evidence that changes in flow have contributed significantly to the poor ecosystem health within much of the Basin. However, rivers in the Basin are variously affected by multiple interacting disturbances, and reinstating elements of the flow regime alone will not address other impacting factors. For example, increasing flows may not allow fish populations upstream of major barriers to recover unless fish passage is also provided. Future river management will need to address multiple forms of disturbance to optimise the extent and value of ecosystem recovery that is possible for a given level or type of investment.

Complexity and non-linearity of ecosystem behaviour

Ecosystem processes and behaviour are characterised by multiplicative interactions between ecosystem components. Linear estimation methods used for this paper do not attempt to capture the complex interactions among ecosystem components that may either amplify or suppress responses of some ecological indicators to changes in flow. Inclusion of non-linear estimation methods may improve the ability to discriminate economic benefits arising from ecological responses to different SDL scenarios.

Spatial and temporal scaling issues

Existing SDL scenarios provide estimates of environmental water availability at the Basin and catchment scales based on long-term average annual flows. However, ecological responses to flow tend to occur at the site scale over discrete flow events, or combinations of events that can be measured in terms of characteristics such as flow magnitude, duration, frequency, rate of rise and fall, seasonal timing, and predictability. This mis-match of scales between existing SDL flow estimates and the principal drivers of ecological responses makes it difficult to predict economic benefits arising from changes in environmental water availability with a high level of certainty.

Scale at which responses occur

Responses to different disturbances tend to be reflected at different scales. In the Barwon-Darling River, for example, individual habitat patches, geomorphological zonation of the river, and flow affect fish communities at different spatial scales (Boys and Thoms 2006). Simple statistical scaling of responses to catchment or Basin scales may therefore fail to detect responses that actually occur at different scales.

This issue of the scalability of responses to flow has been noted in several forms. For example, the hydrological effects of flow regulation typically diminish downstream of storages as unregulated tributary inflows progressively re-establish elements of the natural flow regime (Harris and Gehrke 1997). Similarly, the effects of forestry plantations on catchment water yields may be significant at a local scale in small catchments (e.g. Zhang et al 2007), but undetectable at the catchment scale (van Dijk et al 2007). It is therefore not surprising that attempts at Basin-scale analysis were unable to detect responses of some ecological indicators to changes in flow using existing data sets (Overton et al 2009).

The anomalies created by up-scaling or down-scaling ecological responses to flow therefore need to be addressed by careful design of data collection programs to account for the different spatial and temporal scales at which responses occur.

Spatial and temporal surrogacy

Large-scale responses of ecological communities, such as fish communities, to flow regulation are often evaluated by spatial comparisons among sites that are differently affected by changes in flow (e.g. Gehrke and Harris 2001, Overton et al 2009). This approach often involves the explicit assumption that spatial effects of flow alteration provide a surrogate for estimating temporal responses to flow at individual sites. Whilst spatial comparisons over relatively short time-scales can provide significant insights into relationships between ecological processes and flow alteration, there are relatively few long-term data sets that allow ecological responses to flow to be valued from an economic perspective.

Economic valuation

As noted in various places in this report, existing estimates of values (particularly non-use values) related to ecological outcomes from the proposed Basin Plan suffer from a number of limitations when taken out of their original context and applied to the full scope of the proposed Basin Plan. Most importantly, none of the studies undertaken to date canvass the scale of change contemplated in the overall plan.

A purpose built study, based around appropriate valuation methodologies[12] would bring a number of advantages compared with trying to use existing estimates beyond their original intended purposes. In particular, a customised study would:

- deal with the adding up issue (values for the full Basin are not necessarily the sum of individual studies);
- avoid the need for benefit transfer (that is, trying to apply values from other studies);
- provide updated information given recent developments in both policy and ecology in the overall Basin;
- identify marginal values for SDLs outside those considered in this report;
- allow analysis of particular attributes relevant to policy makers (or within policy control);
- allow more systematic assessment of a range of iconic assets (for example, particular wetlands);
- allow analysis of the links in valuation between upstream and downstream assets; and
- identify the role of uncertainty in determining values.

A custom study would also provide the opportunity to closely integrate emerging understanding of ecological responses with the valuation of those responses. In addition, it would also provide an opportunity to better match valued outcomes with the intent of the proposed Basin Plan, including by examining values for specific wetland systems.

A custom study would, of course, face a number of challenges, particularly dealing with the implications of the large rainfall and flooding in the past few months as well as dealing with the negative publicity in general surrounding the Basin Plan.

Key challenges

Key challenges in undertaking a purpose made economic valuation survey include the following.

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[12] There are strengths and weaknesses inherent in most evaluation methodologies. From the point of view of BCA, choice modelling provides a very flexible set of results that can form the basis of a flexible benefit-cost model. Choice modelling is not necessarily the most appropriate approach, however. Alternatives such as contingent valuation or any of the broad methodologies summarised in Bateman et al (2011, table 2) could also be considered.

- Aligning the specification of components of economic value with the emerging understanding of ecological responses. Economic values must be grounded in a realistic understanding of ecological responses. On the one hand, deriving values for which the ecological response is unknown will not allow any more precision in the valuation of benefits. On the other hand, estimates of values that do not fully reflect potential ecological outcomes may lead to a significant understatement of benefits.
- Allowing economic valuation to reflect genuine uncertainty surrounding ecological responses. While the typical approach to valuation is to multiply a particular response by a unit value, if the ecological response is genuinely uncertain, then the economic valuation needs to reflect this.
- Choosing valuation attributes that accurately reflect the intent of the Basin Plan — by considering the value of particular Ramsar wetlands, for example.
- Reflecting the full nature of the tradeoffs associated with the proposed Basin Plan. For example, in most choice modelling studies the 'payment vehicle' (that is, the means by which participants are asked to consider how much they are prepared to pay for environmental outcomes) are either an increment to water bills, or a small tax. Clearly, however, there are greater tradeoffs involved in the proposed Basin Plan, and there may be scope to specify payment vehicles to reflect this.

Maximising benefits and minimising costs

In the absence of additional information, these findings indicate the importance of ensuring that the SDLs are implemented in a way that maximises the outcomes for environmental benefits (so as to maximise the *value* of benefits) at the same time as increasing the flexibility of local economies to adjust to these changes.

Environmental outcomes will be maximised through the careful management of flow regimes associated with the SDLs. At the same time, environmental values will be maximised by ensuring the broadest possible reach and awareness of valuable environmental outcomes. The greater the population that is aware of, and values, the ecological outcomes, the greater will be the total value of benefits.

Economic costs are minimised by creating flexibility for communities to respond as well as by providing some certainty about what those responses will need to be. There are many options for the implementation of the SDLs — whether through buybacks or efficiency improvements, for example — and different configurations of these will have different implications for economic costs.

Finally, the fact that the higher incremental environmental flows appear to carry a greater risk of negative net outcomes suggests that an adaptive management approach to introducing these flows may be appropriate. Actual observation of outcomes for low incremental flows will provide crucial information about the need for, and effect of, higher flows.

Concluding comments

A major finding of this report is that the current level of understanding of:

- ecological responses to changes in flow; and
- the community valuation of the consequences of these ecological responses;

is not sufficiently robust to draw definitive conclusions about the relative costs and benefits of the proposed Basin Plan. This finding is consistent with broad conclusions emerging from studies around the world. For example, Bateman et al (2011) recently noted that:

> ... probably the most serious problems facing the effective and robust valuation of ecosystem services are gaps in our understanding of the underpinning science relating those services to the production of goods and the paucity of valuation studies and available data regarding the values of these goods. (p. 193)

While there are a relatively large number of valuation studies undertaken within the Basin, none of these currently phrases the analysis at a Basin-wide scale consistent with the nature of the economic problem posed by the Basin Plan.

This report has taken available information to generate estimates of both ecological responses to changes in flow and the valuation of these responses. The quantifications presented here should be taken as illustrative of the results that emerge using this information.

A key recommendation of this report is to continue the process of deriving more robust information on which to base benefit-cost analysis. In particular, a better understanding of ecological responses is essential to feed into any subsequent and customised economic valuation research.

PART 2

Appendices

A Changes in ecological health

The environmental benefits arising from each of the SDL scenarios relate to their contribution to improving environmental health of the MDB and the value that society places on these improvements. This appendix considers the expected improvements in ecological health under each of the alternative SDL scenarios.

The importance of flows to ecological health

The reduction in flows, particularly to wetlands, is considered to be the major driver of degradation of ecosystems and their dependent organisms. Many of the major wetlands in the MDB are believed to be in serious ecological decline with changes and contractions in vegetation communities, waterbirds, native fish and other oganisms.[13]

Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands is recognised as a major factor contributing to loss of biological diversity and ecological function in aquatic ecosystems, including floodplains. This link has been recognised for some time. In 2002, for example, the NSW Scientific Committee, established by the NSW *Threatened Species Conservation Act*, made a Final Determination to list the 'Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands' as a 'key threatening process' under Schedule 3 of the Act. Box A.1 summarises its findings and describes how altering the natural flow regimes in rivers and streams and their floodplains and wetlands impacts on ecological health.

13 Kingsford (2010), *Environmental Flows – How much and How do we manage them?,* June, p 10.

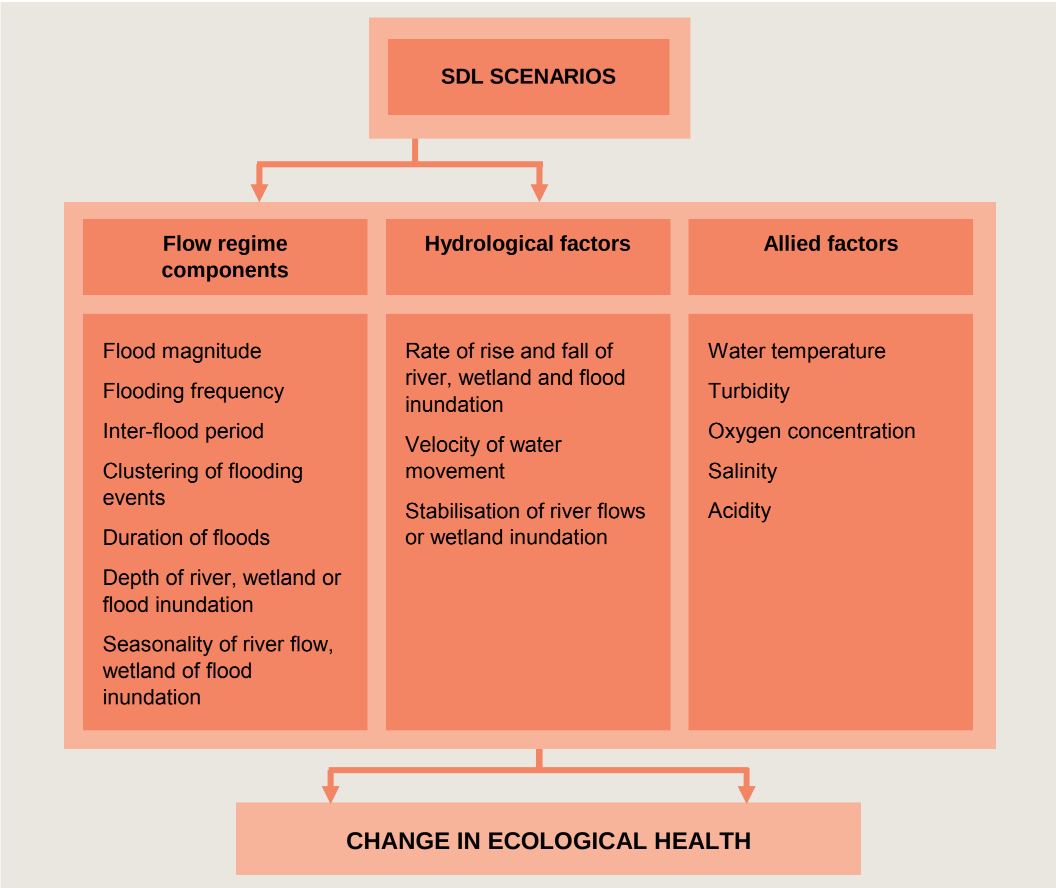
A.1 **Impacts of altering natural flow regimes**

- Reduction of habitat due to change in area, frequency and duration of flooding of floodplains and terminal wetlands
  - Extraction of water from channels and damming has substantially reduced flows. The area and extent and frequency of flooding of terminal wetlands have been substantially reduced. Distribution of organic matter (on which invertebrates and vertebrates depend) within rivers and floodplain wetlands depends on these flows.
- Increased flows causing more permanent flooding of some wetlands
  - Some floodplain wetlands have been used to store water from rivers altering their flow regime from intermittent to permanent inundation. This kills vegetation established in response to intermittent flooding, for example lignum and floodplain eucalypts. This leads to losses in habitat and decreased numbers of invertebrates and waterbirds as well as salinisation.
- Riparian zone degradation through altered flow patterns
  - Riparian zones and the organisms inhabiting them have been substantially altered as a result of change in flow patterns both from the catchment and along the length of the river. Such change in flows to and from floodplains has led to bank erosion, reduced nutrient filtering capacity and changes to stream behaviour. Aquatic communities throughout catchments and in coastal waters have been impacted by sedimentation and other changes following clearing of native vegetation which in turn alters the flows to and from wetlands on floodplains. Introduction of exotic plant species have also reduced stream flows.
- Increased habitat for invasive species
  - The creation of deeper, more permanent and disturbed habitat may permit the establishment and spread of exotic species that may displace native species. The disturbance of riparian zones by change in water regime may permit establishment and spread of semi terrestrial species (eg Willows, Blackberry)
- Loss or disruption of ecological function
  - Survival of ecological communities relies on the maintenance of ecological processes, species life cycles and their interactions. Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands may disrupt these processes. For example, deeper more permanent water or shallower less permanent water will change the physical, chemical and biological conditions that in turn will alter the biota. Species composition and the presence of particular life cycle stages will be changed. Disruption of ecological processes may continue long after initial flow alteration, causing continued decline in biological diversity.

Source: http://www.environment.nsw.gov.au/threatenedspecies/AlterationNaturalFlowKTPListing.htm

While there is a general understanding that environmental flows play an important role in ecological health, the precise nature of this relationship is extremely complex. CSIRO has also more recently undertaken a study that sought to more comprehensively understand the relationships between the condition of ecosystems and river flow regimes.[14] Chart A.2 provides an illustration of the potential key elements that could be influenced by the SDL scenarios.

A.2 **Illustration of SDL impact on ecological outcomes**



Source: CSIRO (2008)

The CSIRO report highlights that there are a wide range of other factors including vegetation clearance, exotic fish present and land uses (for example, grazing) that also affect the degree to which flow affects ecological responses.

The SDL scenarios, therefore, only relate to one factor (the hydrological inputs) that impacts on the ecological health of the alternative regions. However, the reduction in river flows remains the most serious and degrading factor on river and wetland

14 CSIRO (2009), *Ecological outcomes of flow regimes in the Murray-Darling Basin.*

ecosystems. These factors are interrelated and are considered as part of the broader framework for managing the catchments under the Basin Plan.[15]

In its study Overton et al (2009) analysed the existing data to determine ecological responses to flows across the Murray-Darling Basin. The study highlighted that there was a lack of robust data across the Basin to establish a set of ecological relationships with alternative flow regimes. It noted that:

> Ecological monitoring has focused on changes in abundance, occurrence and diversity of individual organisms or groups of related organisms. Very little is available that helps underpin responses to flow of ecological process and functions. A greater emphasis on monitoring such processes or at least simultaneous monitoring of groups of interacting organisms such as predators and prey (e.g. birds, frogs and fish) is more likely to reveal relationships between flow and ecological responses at community and ecosystem scales (Overton et al 2009, p326).

The gap in scientific understanding of the relationship between flows and the corresponding ecological response has also been noted by the National Water Commission in its biennial review of the progress of water reforms.[16]

Approach to assessing change in ecological health

The relationship between environmental flows and ecological responses is extremely complex. The extent to which changes in a wide range of attributes under alternative SDL scenarios can be estimated is dependent on data availability and detailed modeling at the regional level. However, ecological value data has not been found to be widely available.

We have therefore relied primarily on analysis conducted by SMEC Pty Ltd to estimate the potential changes in key environmental attributes under alternative SDL scenarios.[17] Data limitations and the fact that this is a relatively small component of the overall study led SMEC to adopt a broad approach to estimating the change in each of the attributes resulting from alternative SDL scenarios. This involves the

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15 For this project our focus is only on the changes in the ecological condition resulting from the alternative SDLs. We have assumed, therefore, that there are no changes to other policies (through the Commonwealth, State and territories, or through other groups). However, it is important to recognize that other policy actions being undertaken by a range of different groups could interact with changes to the SDLs to deliver better (or worse) ecological outcomes.

16 NWC (2009), *Australian water reform 2009: Second biennial assessment of progress in implementation of the National Water Initiative,* Canberra, p 85.

17 Dr Peter Gherke and his team from SMEC Pty Ltd were subcontracted by the CIE for this project in order to provide advice on the potential ecological response to the alternative SDL scenarios. Their role was not to conduct new research on the potential ecological response. Instead their role was to interpret existing analysis that had been undertaken. The approach adopted by SMEC was also restricted by the budget available for this task.

assumption that habitat quantity and habitat quality increase linearly with increasing water availability for environmental purposes.

Whilst the assumption of linearity is an oversimplification, there is insufficient data to support development of suitable non-linear response curves using long term average flow data and regional and Basin scales (we note this may be possible for particular river catchments for which there is data available). While we recognize that the ecological response is likely to be far more complex, in the absence of detailed modeling of the ecological response to the SDL scenarios, this approach offers a reasonable step that allows some economic valuation of changes in environmental health.

Estimate change in water in-system (environmental water and outflows)

To estimate likely environmental responses it is necessary to first understand the increase in water available to the environment under alternative SDL scenarios. The volume of water returned to the river consists of both 'environmental water' and 'outflows', the product of which will determine ecological condition. [18]

The MDBA conducted hydrological modeling and provided spreadsheet data on changes in the volume of environmental water and outflows for each of the 19 Basin regions under each of the SDL scenarios. Changes in environmental water and outflows were calculated as a percentage of current flows as well as pre-development flows. Percentage increases in flows relative to current flows were calculated for environmental flows, outflows and cumulative flows (i.e. addition of environmental flows and outflows) under each SDL scenario for each region. To gain an understanding of potential ecological responses of SDLs, these changes in percentage flow were then applied to fish, macroinvertebrate and vegetation data, as described below.

This approach allows changes in ecological condition to be driven by the amount of water returned to the rivers and wetlands, since this is the water that will determine ecological responses. No consideration is given to the different volumes of water extracted under each SDL scenario, how the SDLs are derived or where the extra environmental water is sourced.

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[18] *Environmental water* is calculated to be the volume of water required for identified key environmental assets and hydrological indicator sites, which are predominantly floodplain wetlands. These assets are primarily maintained by high flow events that either provide overbank flows, or which are high enough to be distributed away from the river by existing channel networks. *Outflows* also have a function in maintaining riverine functions that require in-channel flows less than the flows that are required to water environmental assets. Accordingly, this assessment draws on projected changes in both environmental water and outflows to estimate the changes in environmental condition that are likely to result.

Establish baseline ecological health

A recent study prepared for the MDBA by Ecological Associates is used to establish the broad baseline ecological health of catchments. It provides a useful reference point for understanding the current condition of environmental health in key indicator assets and Basin regions. The study provides information about the current ecological condition of the:

- 18 Key Indicator Assets; and
- Basin regions using indicators including:
  - the diversity and abundance of native fish and exotic fish;
  - the diversity and abundance of macroinvertebrates including those sensitive to disturbance;
  - the extent and (where information was available) condition of native vegetation; and
  - the intactness of instream, riparian and floodplain habitat.

The Ecological Associates study uses a range of existing scientific literature and provides useful qualitative aggregate information regarding the current ecological health of different catchments in the Basin.

However, the study notes difficulties in reaching conclusions (particularly in relation to assessing the state of the Key Indicator Assets) given significant data limitations and knowledge gaps. For example, in relation to the key Environmental Indicator Assets the study notes:

> It was intended to also report condition in relation to ecosystem viability: to describe the degree to which the ecosystem was altered such that fundamental ecosystem processes and viability were impaired. However, there is insufficient data to identify or describe the functions of the Indicator Key Environmental Assets and it would not be possible to assess ecosystem viability in a defensible manner.[19]

We have supplemented information provided by the Ecological Associates study with information from the Sustainable Rivers Audit in order to establish the baseline for examining the change due to SDLs

Define environmental attributes to estimate changes in ecological health

Within each river valley, modeled hydrological data on projected changes in both environmental water and outflows was used to estimate the responses of ecological attributes under alternative SDL scenarios. These attributes are used as proxy measures to estimate the changes in overall environmental condition that are likely to result.

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19 Ecological Associates (2010), *Condition Reporting of Basin Plan Regions and Indicator Key Environmental Assets,* June, p2-5

There are many attributes that make up the overall ecological health of the Basin. A study commissioned by the MDBA (Morrison and Hatton-MacDonald 2010) utilised four attributes for valuation purposes, including: recreation; the extent of healthy native vegetation; numbers of native fish; numbers of waterbirds; and the frequency of waterbird breeding events.[20]

Robust information to estimate the biophysical change for each of these attributes was not available. Therefore, at the regional level we have focused our analysis on changes in:

- the extent of healthy native vegetation — qualitative estimate has only been possible given data restrictions;
- the number of native fish;
- the health of macroinvertebrate communities; and
- the increase in frequency of bird breeding events.

To estimate changes in ecological health at the broader Basin scale we have also focused our analysis on changes in the length of each river channel falling into each ecosystem health category.[21]

Estimate ecological health at regional level

Within each river valley, modelled hydrological data was used to estimate the responses of vegetation, macroinvertebrates, and fish under each SDL scenario.

Extent of healthy native vegetation

Ecological Associates (2010) provides a qualitative assessment of the overall condition of vegetation for each of the regions. In order to provide an estimation of responses of vegetation to SDL scenarios, the qualitative assessment categories were assigned a numerical rating as follows:

- ‘Very Poor’ was assigned 1
- ‘Poor’ was assigned 2
- ‘Moderate’ was assigned 3
- ‘Good’ was assigned 4, and

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[20] The valuation of the changes in these attributes is discussed in the next chapter.

[21] Given limited data available on all the attributes valued by Morrison and Hatton MacDonald (2010), we have also used an alternative approach based on information on the length of healthy rivers to obtain alternative valuations that can be incorporated into the BCA at a basin-wide level. There were also methodological concerns about being able to aggregate the individual regional data to a whole of Basin level. The river length data allows a more robust basin-wide valuation.

- 'Very Good' was assigned 5.

Potential improvements in vegetation were then estimated by applying the percentage increase in flows relative to current flows to the numerical rating for each region. This was undertaken for environmental flows, outflows and cumulative flows (i.e. environmental flows plus outflows) under each SDL scenario. The estimated response was then subjectively re-assessed based on whether known threats to vegetation within the region (as documented by Ecological Associates 2010) were related to flows or not.

Specifically, for regions where threats included altered flow regimes or drought, the estimated response of vegetation was not altered, as increased flows are likely to relieve these threats to a degree such that vegetation condition would be expected to improve. In contrast, for regions where threats were unrelated to flows (e.g. land clearance, pest species, stock access), the estimated response of vegetation was altered by halving the percentage flow increases, as increased flows are not likely to relieve these threats.

Regions where threats include altered flow regimes and/or drought include:

- Condamine-Balonne, Border Rivers, Macquarie Castlereagh, Lower Darling, Wimmera-Avoca, Ovens, Loddon, Murrumbidgee, and Eastern Mount Lofty Ranges.

Regions where threats do not include altered flow regimes and/or drought include:

- Paroo, Warrego, Moonie, Gwydir, Namoi, Barwon-Darling, Lachlan, Goulburn and Campaspe.

No data was available for the Kiewa, Murray (upstream of Wentworth) and Murray (downstream of Wentworth) regions.

Native fish populations

Data on fish communities were obtained from Ecological Associates (2010) and the Sustainable Rivers Audit (SRA) Report.[22] For each region, fish data that was used included the following:

- native species count for the lowland zone
- abundance of native individuals for the lowland zone, and
- Fish Condition Index.

Potential improvements in fish species numbers were estimated by applying the percentage increase in flows (relative to current flows) for environmental flows, outflows and cumulative flows under each SDL scenario to the *native species count*.

22 Davies et al. 2008

The same process was applied to fish abundance data in order to estimate potential improvements in *fish abundances*. However, in order to enable more accurate comparison between regions, the fish abundance data was analysed in terms of proportions, with the current abundance assigned a value of 1.

The process was then repeated for the *Fish Index* data, and the expected responses of Fish Indices were graphed, indicating the lower and upper 95 per cent Confidence Limits of the current Fish Index score together with a reference condition value of 100 to represent the ideal Fish Index score. As per the SRA Report, the following categorisation is relevant to the Fish Index score:

- 0 to 19 is 'Extremely Poor'
- 20 to 39 is 'Very Poor'
- 40 to 59 is 'Poor'
- 60 to 79 is 'Moderate', and
- 80 to 100 is 'Good'.

It is to be noted that the grouping of data into valleys by the SRA Report was not completely consistent with the regions as assessed for the purposes of this report, and as such the following adjustments were required.

- Data used for the Barwon-Darling region are from the Middle Zone of the Lower Darling Valley;
- Data used for the Lower Darling region are from the Lower Zone of the Lower Darling Valley;
- Data used for the Murray (upstream of Wentworth) region are from the Lower Zone of the Central Murray Valley;
- Data used for the Murray (downstream of Wentworth) region are from the Lower Zone of the Lower Murray Valley;
- Due to the topography of the Eastern Mount Lofty Ranges, fish species and abundance data used for this region were not lowland species as used for all other regions; and
- No data were available for the Moonie region.

The condition of fish communities in floodplain habitats and in rivers is influenced by factors including barriers to fish passage, presence of alien fish species, habitat quality and quantity, riparian condition, fishing pressure, cold water pollution, water extraction, salinity and other water quality effects, disease and effects of fish stocking, as well as flow alteration.[23] Potential improvements in fish communities as a result of increased water availability under each SDL scenario will therefore be influenced by the interactions of multiple factors. However, the role of flow as a

[23] Murray-Darling Basin Commission 2004 and Ecological Associates 2010

driver of aquatic ecosystems ensures that increasing flow provides greater capacity to simultaneously address other issues that contribute to the current decline in native fish communities.[24]

Health of macroinvertebrate communities

Data on the condition of macroinvertebrate communities were obtained from the SRA Report. Potential improvements in macroinvertebrate communities were estimated by applying the percentage increase in flows (relative to current flows) to the Macroinvertebrate Index score for the Lowland Zone of each region. This was undertaken for environmental flows, outflows and cumulative flows (i.e. environmental flows plus outflows) under each of the SDL scenarios. Expected responses were graphed for each region, and the lower and upper 95 percent Confidence Limits of the current Macroinvertebrate Index score were presented on the graphs, together with a reference condition value of 100 to represent the ideal Macroinvertebrate Index score.

As per the SRA Report, the following categorisation is relevant to the Macroinvertebrate Index Rating:

- 0 to 19 is 'Extremely Poor'
- 20 to 39 is 'Very Poor'
- 40 to 59 is 'Poor'
- 60 to 79 is 'Moderate', and
- 80 to 100 is 'Good'.

It is to be noted that the grouping of data into valleys by the SRA Report was not completely consistent with the regions as assessed for the purposes of this report, and as such the following adjustments were required.

- Data used for the Barwon-Darling region are from the Middle Zone of the Lower Darling Valley;
- Data used for the Lower Darling region are from the Lower Zone of the Lower Darling Valley;
- Data used for the Murray (upstream of Wentworth) region are from the Lower Zone of the Central Murray Valley;
- Data used for the Murray (downstream of Wentworth) region are from the Lower Zone of the Lower Murray Valley;
- As the SRA Report separates the Macquarie and Castlereagh catchments, the Wimmera and Avoca catchments, and the Goulburn and Broken catchments, two graphs (i.e. one for each catchment) are provided for the Macquarie-Castlereagh,

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24 Walker et al 1995 and Thorp et al. 2006.

Wimmera-Avoca and Goulburn-Broken regions, applying the flow projections for the region to the individual catchment data; and

- No data were available for the Moonie Region or Eastern Mount Lofty Ranges.

Frequency of bird breeding events

In its *Guide the proposed Basin Plan* the MDBA has presented it estimates on the potential impact of alternative SDL scenarios on the impact water bird abundance in the region.[25] This was based on modelling of how waterbird breeding and populations may respond to improvements in environmental watering, based on a range of assumptions. In particular, the additional volume of environmental water is assumed to impact on the frequency of breeding events. Currently, it is assumed that a breeding event happens once in every six years. We have utilised the assumptions on changes in bird breeding events.

Estimate ecological health at the Basin scale

Basin-scale responses were assessed by the total length of river channel falling into each ecosystem health category, and by the number of regions assessed as falling into each category. Each of these approaches is discussed below.

River length approach

There is currently no single index of river health. We have therefore used indices where data is currently available as alternative proxy measures of river health, in order to gain an understanding of overall expected ecological responses at the Basin level. These indices provide information on fish condition and condition of macroinvertebrate communities.

The total stream length assigned to each of the five Fish Index and Macroinvertebrate Index categories (i.e. Extremely Poor, Very Poor, Poor, Moderate, Good) was calculated under current conditions and under the three SDL scenarios.

As the stream-length data had not separated the Barwon-Darling and Lower-Darling regions, the stream-length of the middle and upper zones of the Darling River was used for the Barwon-Darling, and the stream-length of the lower zone of the Darling River was used for the Lower-Darling region. As no Fish Index or Macroinvertebrate Index data were available for the Moonie Region or Eastern Mount Lofty Ranges, these stream-lengths were omitted from these analyses.

It should be noted that the channel length data used here is based on SRA Report for ‘fish river lengths’. The basic approach adopted in the SRA Report is to measure river

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25 MDBA (2010), *Guide to the proposed Basin Plan – Volume 1*, p 114.

lengths for first or second order streams in which SRA fish survey sites were located. Site selection was also based on a criterion that the minimum mean annual discharge was set at 5 GL, to exclude smaller streams that provide limited habitat. These streams were selected from the 1:250,000 AUSLIG river network data

Results

Changes in environmental water and outflows

Table A.3 presents the percentage change in environmental water and outflows relative to CDLs for each Basin region using modeled data output from the MDBA.

A.3 **Change in water availability relative to CDL**

	3000		***3500***		***4000***	
	Environmental water	***Outflows***	***Environmental water***	***Outflows***	***Environmental water***	***Outflows***
	% change	% change	% change	% change	% change	% change
Paroo	0	0	0	0	0	0
Warrego	4	21	4	21	4	21
Condamine-Balonne	14	32	16	38	18	43
Moonie	8	10	9	11	9	13
Border Rivers	3	10	4	10	4	13
Gwydir	8	27	9	32	10	37
Namoi	3	7	3	8	4	9
Macquarie Castlereagh	3	8	3	9	4	10
Barwon-Darling	4	15	6	17	7	18
Lower Darling	2	25	3	27	5	29
Lachlan	4	0	5	0	6	0
Wimmera-Avoca	0	0	0	0	0	0
Ovens	15	0	15	0	15	0
Goulburn-Broken	15	21	15	23	16	26
Loddon	13	23	13	23	14	30
Campaspe	0	21	0	23	0	25
Murrumbidgee	12	34	13	40	15	46
Kiewa	0	0	0	0	0	0
Murray u/s Wentworth	23	26	33	31	36	36
Murray d/s Wentworth	8	39	8	46	9	52
EMLR	8	1	8	1	8	1

Source: MDBA.

The table highlights that the scenarios result in no change in the water availability for the Paroo river. However, there are larger increases in the environmental water and outflow water available in the southern valleys such as the Murray and Murrumbidgee valleys.

Ecological responses to increased water availability may be maximised depending on the delivery regime. Current thinking with regard to environmental flows presumes that ecological benefits of a given quantum of environmental water can be maximised if the water is delivered in a manner that mimics key elements of the natural flow regime.

Without undertaking a detailed investigation of the interactions between ecology and hydrology, it is assumed for the purposes of this study that environmental water provided by SDLs can be delivered in such a way that maximised ecological responses. Similarly, it is assumed that additional threatening processes, such as barriers to fish migration and cold water pollution, will not obscure responses to increased flow, and will not prevent ecological responses to increasing environmental water availability. If these assumptions are not upheld, the ecological responses will be less than those described here.

Projected ecological health at regional level

Change in native fish populations

The condition of fish communities in floodplain habitats and in rivers is influenced by factors including barriers to fish passage, presence of alien fish species, habitat quality and quantity, riparian condition, fishing pressure, cold water pollution, water extraction, salinity and other water quality effects, disease and effects of fish stocking, as well as flow alteration.[26] Potential improvements in fish communities as a result of increased water availability under each SDL scenario will therefore be influenced by the interactions of multiple factors. However, the role of flow as a driver of aquatic ecosystems ensures that increasing flow provides greater capacity to simultaneously address other issues that contribute to the current decline in native fish communities.[27]

Estimated responses of *native fish abundance* under the SDL scenarios varied markedly among regions according to the magnitude of increase in water availability. The estimated responses are presented in Table A.4 below. Based on the long-term average flows used to derive water availability, the greatest increases in native fish abundance are expected to occur in the Murrumbidgee region. In the Murrumbidgee the cumulative response to increased environmental water and outflows is projected to be 46 per cent increase in native fish abundance under the 3000 GL scenario, increasing to 53 per cent and 61 per cent under the 3500 GL and 4000 GL scenarios.

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26 Murray-Darling Basin Commission 2004 and Ecological Associates 2010

27 Walker et al 1995 and Thorp et al. 2006.

A.4 **Estimated change in native fish abundance relative to CDL**

	3000	*3500*	*4000*
	% change	% change	% change
Paroo	0	0	0
Warrego	25	25	25
Condamine-Balonne	46	54	61
Moonie	18	20	22
Border Rivers	13	14	17
Gwydir	35	41	47
Namoi	10	11	13
Macquarie Castlereagh	11	12	14
Barwon-Darling	19	23	25
Lower Darling	27	30	34
Lachlan	4	5	6
Wimmera-Avoca	0	0	0
Ovens	15	15	15
Goulburn-Broken	36	38	42
Loddon	36	36	44
Campaspe	21	23	25
Murrumbidgee	46	53	61
Kiewa	0	0	0
Murray u/s Wentworth	49	64	72
Murray d/s Wentworth	47	54	61
EMLR	9	9	9

Source: SMEC Pty Ltd

Similar large responses in native fish abundance were anticipated in other regions, such as in the Murray River downstream of Wentworth, where responses to increased water availability were similar for both environmental water and in-channel end-of-system flows. In this region, native fish abundance under the combined influence of in-channel and environmental flows continued to increase from the 3000 GL scenario to the 4000 GL scenario. Native fish abundance under the 4000 GL scenario is projected to increase by up to 72 per cent.

In contrast native fish abundance is anticipated to increase by a maximum of 6 per cent in the Lachlan region under the 4000 GL scenario. This is presumably due to relatively limited flows being returned to the Lachlan compared to the current diversion limits.

In addition to native fish abundance, the number of *native fish species* reported in routine surveys is also projected to increase as rare species become more common. For example, in the Murray River downstream of Wentworth the number of native species expected to be encountered under the combined influence of environmental and in-channel flows increased from the current 10 species to 15 species under the 3000 GL scenario, 16 species under the 3500 GL scenario, and 17 species in the 4000 GL scenario. A similar response was noted in the Murrumbidgee region where an additional 5 species are anticipated to be encountered under the 4000 GL scenario. In contrast, many regions such as the Macquarie-Castlereagh exhibited only small projected increases in fish species richness, with just one additional species being recorded under the SDL scenarios.

The SRA Report applies a system of expert rules to derive a *Fish Condition index* from a suite of indicator metrics. The full range of indicators was not available for this study, so a surrogate Fish Condition was derived based on a 100-point scale with condition ratings scaled according to the same ranges used in the SRA Report (2008), with scores adjusted in linear fashion according to the anticipated increase in water availability and habitat accessibility. For most of the regions where the Fish Condition Index did not increase from the current rating, SDLs did result in a significant increase in the estimated index, but the response was not sufficient to increase the rating to the next higher band.

A summary of the expected fish condition responses is presented in the table below. The shaded rows indicate regions that are expected to improve in condition by one or more rating categories. Improvements in the *Fish Condition Index* were detected in eight regions (table A.5), with the Murray River downstream of Wentworth improving by two index categories, from Poor under current conditions, to Good under the 3500 GL and 4000 GL SDL scenarios.

A.5 **Summary of expected fish condition responses**

Catchment	*Current*	*3000 GL*	*3500 GL*	*4000 GL*
Paroo	Moderate	Moderate	Moderate	Moderate
Warrego	Poor	Moderate	Moderate	Moderate
Condamine Balonne	Moderate	Good	Good	Good
Moonie	No data	No data	No data	No data
Border Rivers	Poor	Moderate	Moderate	Moderate
Gwydir	Poor	Moderate	Moderate	Moderate
Namoi	Poor	Poor	Poor	Poor
Macquarie	Poor	Poor	Poor	Poor
Castlereagh	Extremely Poor	Very Poor	Very Poor	Very Poor
Barwon-Darling	Moderate	Moderate	Moderate	Moderate
Lower-Darling	Poor	Moderate	Moderate	Moderate
Lachlan	Poor	Poor	Poor	Poor
Wimmera	Very Poor	Very Poor	Very Poor	Very Poor
Avoca	Very Poor	Very Poor	Very Poor	Very Poor
Ovens	Poor	Poor	Poor	Poor
Goulburn	Very Poor	Very Poor	Very Poor	Very Poor
Broken	Very Poor	Very Poor	Very Poor	Very Poor
Loddon	Very Poor	Very Poor	Very Poor	Very Poor
Campaspe	Extremely Poor	Extremely Poor	Extremely Poor	Extremely Poor
Murrumbidgee	Poor	Moderate	Moderate	Moderate
Kiewa	Very Poor	Very Poor	Very Poor	Very Poor
Murray US Wentworth	Moderate	Good	Good	Good
Murray DS Wentworth	Poor	Moderate	Good	Good
EMLR	No data	No data	No data	No data

Source: SMEC Pty Ltd.

Change in macroinvertebrate communities

In general, macroinvertebrate communities are expected to respond positively to increased flows under SDLs due to improved environmental health of the system. However, it is to be noted that a range of other factors that have not been incorporated into this assessment influence macroinvertebrates, such as the quality of in-stream and riparian habitat.

A range of responses was displayed by macroinvertebrate communities within the various regions (table A.6). As expected, regions that are proposed for substantial increases in flows displayed the greatest response. For example, the effects of cumulative flows on macroinvertebrate communities within the Murrumbidgee

Region elevated the Macroinvertebrate Condition from Moderate to Good under all three SDL scenarios.

Notably, the predicted effect of cumulative flows under all three scenarios raised the Macroinvertebrate Condition beyond the upper Confidence Limit of the current condition, and under the 4000 GL scenario the predicted effect is sufficient to achieve a Macroinvertebrate Condition equivalent to that of the Reference Condition.

In contrast, regions that are proposed for very minor increases in flows displayed low levels of response. For example, the Lachlan Region displayed only a very slight increase in Macroinvertebrate Condition across all three SDL scenarios. However, as the current Macroinvertebrate Condition is very close to the upper bounds of the Poor category, the increase in flows was insufficient to bring the predicted Macroinvertebrate Condition score to Moderate under all three SDL scenarios.

A.6 Summary of expected macroinvertebrates responses

Catchment	*Current*	*3000 GL*	*3500 GL*	*4000 GL*
Paroo	Moderate	Moderate	Moderate	Moderate
Warrego	Poor	Poor	Poor	Poor
Condamine	Good	Good	Good	Good
Moonie	No data	No data	No data	No data
Border Rivers	Moderate	Moderate	Moderate	Good
Gwydir	Poor	Moderate	Good	Good
Namoi	Moderate	Moderate	Moderate	Moderate
Macquarie	Poor	Poor	Poor	Poor
Castlereagh	Poor	Poor	Poor	Poor
Barwon-Darling	Poor	Moderate	Moderate	Moderate
Lower-Darling	Poor	Moderate	Moderate	Moderate
Lachlan	Poor	Moderate	Moderate	Moderate
Wimmera	Poor	Poor	Poor	Poor
Avoca	Very Poor	Very Poor	Very Poor	Very Poor
Ovens	Poor	Poor	Poor	Poor
Goulburn	Poor	Poor	Poor	Poor
Broken	Poor	Moderate	Moderate	Moderate
Loddon	Poor	Moderate	Moderate	Moderate
Campaspe	Poor	Poor	Poor	Moderate
Murrumbidgee	Moderate	Good	Good	Good
Kiewa	Poor	Poor	Poor	Poor
Central Murray	Poor	Moderate	Moderate	Moderate
Lower Murray	Very Poor	Poor	Poor	Poor

Source: SMEC Pty Ltd.

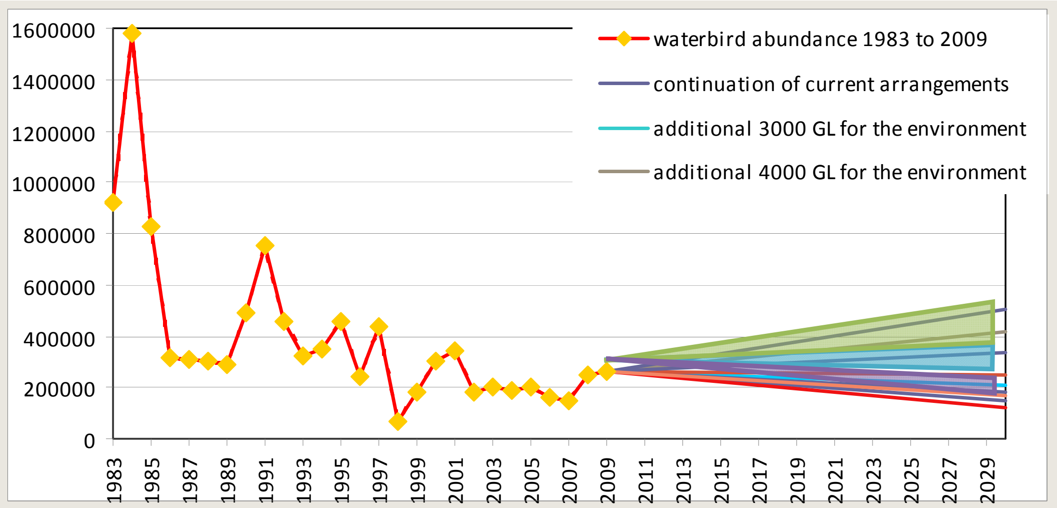
Increased frequency of bird breeding events

In its *Guide the proposed Basin Plan* the MDBA used a variety of assumptions to suggest that SDL scenarios will increase the frequency of bird breeding events to:

- one in every four years under the 3000 GL scenario
- one in every three years under the 4000 GL scenario, and
- one in every two years under the 7600 GL scenario.[28]

Chart A.7 highlights a significant decline in waterbird abundance since 1983 due primarily to breeding events being insufficient in frequency and scale. It is anticipated that this downward trend will continue under the current water management arrangements in place across the Basin. The SDL scenarios are expected to address the decline in waterbird populations by providing sufficient water to improve the condition of key waterbird habitats, and provide conditions suitable for more frequent and successful breeding events.

A.7 **Waterbird abundance in the South East Australia, 1983 to 2009**



[a] These projections assume a return to long-term average climate conditions, combined with best estimates of climate change impacts at 2030.

Data source: MDBA (2010), *Guide to the proposed Basin Plan*, Volume 1, p 116.

The 3000 GL per annum scenario is expected to slow decline in waterbird numbers and maintenance of current abundance. The 4000 GL per annum scenario is expected to increase waterbird numbers compared to current levels and provide for increased breeding opportunities.

The chart above presents a range of potential outcomes, reflecting uncertainty regarding the potential response in bird abundance. The data reflects waterbird numbers for the whole of South-Eastern Australia and incorporates data beyond the

28 The 3500 GL per annum scenario is assumed to lie in between the 3000 GL and 4000 GL scenarios.

MDB. Within the limited time of this project it has not been possible for us to disaggregate the data on a regional basis, however it is considered that this would be a useful exercise.

Nevertheless we have utilised the same underlying assumptions utilised by the MDBA (in terms of frequency of bird breeding events)

Estimate ecological health at the Basin scale

River length approach

To estimate changes in ecological health at the broader Basin scale our analysis considered changes in the length of each river channel falling into each ecosystem health category or the *river length approach.*

Macroinvertebrate condition

The assessment that quantified Basin-scale responses of Macroinvertebrate Condition noted that the greatest total channel length is currently classified as Moderate, with the second largest channel length rated as Poor.

Under the 3000 GL scenario some regions experience an improved status. However, it is only the Murrumbidgee River that changes to a Good status. The Condamine is already considered to have a Good state under current arrangements. The additional water for the environment reflected in the 3500 GL and 4000 GL scenarios move to the Border and Gwydir regions to a Good state (table A.8).

A.8 River health rating based on Macroinvertebrate Condition Index

ValleyName	*Length km*	*current*	*3000*	*3500*	*4000*
Paroo	2 070	M	M	M	M
Warrego	848	P	P	P	P
Condamine	3 758	Good	Good	Good	Good
Moonie					
Border Rivers	2 086	M	M	M	Good
Gwydir	2 109	P	M	Good	Good
Namoi	2 155	M	M	M	M
Macquarie	3 303	P	P	P	P
Castlereagh	725	P	P	P	P
Barwon-Darling	2 161	P	M	M	M
Lower-Darling	1 319	P	M	M	M
Lachlan	3 485	P	M	M	M
Wimmera	960	P	P	P	P
Avoca	492	VP	VP	VP	VP
Ovens	497	P	P	P	P
Goulburn	1 227	P	P	P	P
Broken	602	P	M	M	M
Loddon	1 118	P	M	M	M
Campaspe	264	P	P	P	M
Murrumbidgee	1 949	M	Good	Good	Good
Kiewa	90	P	P	P	P
Central Murray	476	P	M	M	M
Lower Murray	82	VP	P	P	P

Note: The length of the river is based on the Sustainable Rivers Audit using ‘fish length’. This approach does not incorporate minor tributaries but is based on first and second order rivers.

Source: SMEC Calculations.

Fish condition

Quantitative assessment Basin-scale responses for the Fish Condition Index revealed that the greatest extent of channel-length is rated as Moderate, with the second largest representation rated as Poor.

Under the 3000 GL scenario some regions experience an improved status. However, it is only the Condamine and Central Murray that move to a Good status. Providing additional water under the alternative scenarios considered does not significantly change the status with only the Lower Murray region changing from a poor to Moderate state (table A.9).

A.9 **River health rating based on Fish Condition Index**

ValleyName	*Length km*	*current*	*3000*	*3500*	*4000*
Paroo	2 070	M	M	M	M
Warrego	848	P	M	M	M
Condamine	3 607	M	Good	Good	Good
Moonie		-	-	-	-
Border Rivers	1 680	P	M	M	M
Gwydir	1 851	P	M	M	M
Namoi	1 359	P	P	P	P
Macquarie	2 417	P	P	P	P
Castlereagh	433	V Poor	V Poor	V Poor	V Poor
Barwon-Darling	1 057	M	M	M	M
Lower-Darling	478	P	M	M	M
Lachlan	2 782	P	P	P	P
Wimmera	550	V Poor	V Poor	V Poor	V Poor
Avoca	292	V Poor	V Poor	V Poor	V Poor
Ovens	283	P	P	P	P
Goulburn	1 118	V Poor	V Poor	V Poor	V Poor
Broken	576	V Poor	V Poor	V Poor	V Poor
Loddon	729	V Poor	V Poor	V Poor	V Poor
Campaspe	181	V Poor	V Poor	V Poor	V Poor
Murrumbidgee	1 438	P	M	M	M
Kiewa	90	V Poor	V Poor	V Poor	V Poor
Central Murray	427	M	Good	Good	Good
Lower Murray	82	P	M	Good	Good

Note: The length of the river is based on the Sustainable Rivers Audit using 'fish length'. This approach does not incorporate minor tributaries but is based on first and second order rivers.

Source: SMEC calculations.

Conclusions

In this appendix we have discussed some of the challenges of estimating the potential ecological response of the additional volume of environmental water represented under the alternative SDL scenarios. An understanding of the ecological responses is particularly important from the perspective of the BCA because the environmental attributes that the community typically values requires some understanding of the potential ecological response to the SDL scenarios.

The task of estimating the potential ecological response is particularly challenging given the requirement to cover regions throughout the whole MDB, each with unique hydrological and ecological characteristics. At this stage, the scientific evidence required to develop robust ecological response models is not available for each region, although progress can be expected in the next few years.

For the purposes of the BCA we have therefore relied on a broader approach which assumes a linear response to the volume of water in the channel and at the end of system. We recognise the limitations of this approach but, in the absence of detailed information on ecological response this approach provides a useful indication of broad potential ecological responses.

We have presented information on a range of estimates of changes in environmental attributes. Not all this information will be able to be incorporated into the BCA which depends also on the availability of information on community valuations of different environmental attributes. The next appendix seeks to place values on the changes in certain environmental attributes so that it can be directly incorporated into the BCA.

B Valuing changes in ecological health

People can value environmental improvement because they use or expect to use the environmental assets. Uses include activities such as swimming, fishing and bird watching. People can also value environmental assets unrelated to use. That is, they place value on the existence of environmental assets or the option that these assets provide even if they are not used. These are termed non-use benefits.

The previous appendix provides information regarding the potential range of change in key attributes of ecological health. This appendix uses those findings to estimate the potential value of these changes for inclusion in the BCA. It first utilises the findings of the Morrison and Hatton MacDonald (2010) study to derive values on a regional basis. We have also utilised separate information from a study by van Bueren and Bennett (2004) to estimate the values at a Basin-wide scale.

Overview of Morrison and Hatton MacDonald (2010)

The MDBA commissioned a study by Professor Mark Morrison from Charles Sturt University and Dr Darla Hatton MacDonald from CSIRO to review and summarise existing market and non-market valuation studies associated with Basin environmental assets and consider how these economic estimates of values may alter as a result of changes in current diversion limits.

The Morrison and Hatton MacDonald report utilises a range of existing market and non-market studies for the Basin that have already been conducted estimating use, indirect use and non-use values. From this the study derives values on specific attributes that can be utilised to assist in understanding the value of alternative SDL scenarios. Morrison and Hatton MacDonald have also conducted a separate survey to estimate the values that the community places on improved attributes in the River Murray.

Estimates of values for each region of the Murray–Darling Basin were identified for four non-use attributes: the extent of healthy native vegetation; numbers of native fish; numbers of waterbirds; and the frequency of waterbird breeding events. In addition the study also derives use values for recreational activities.[29] The study also separately estimates the community values associated with the Coorong.

The values derived for each of these attributes is summarised in table B.1. This allows us to multiply the underlying biophysical change in the relevant attribute (from the previous appendix) with the value in table B.1 for the particular catchment. In addition to the values in the table, there is an additional aggregate value of improving the Coorong from poor to good quality of $4.3 billion.

B.1 Aggregate values for the native vegetation, native fish, waterbird breeding and waterbirds and other species for the Nineteen Regions (base case)

	Native vegetation	*Native fish*	*Colonial waterbird breeding*	*Waterbirds and other species*
		$'000 (present value)		
	1% increase in healthy native vegetation	1% increase in native fish populations	1 year increase in frequency of breeding	Unit increase in number of waterbirds and other species present
	$`000	$`000	$`000	$`000
Barwon-Darling	3 594	667	24 693	3 578
Border Rivers	2 437	414	-	1 086
Campaspe	3 363	2 990	-	2 299
Condamine-Balonne	2 926	414	15 337	1 086
Mt-Lofty Ranges	1 494	1 329	-	1 022
Goulburn-Broken	5 019	4 463	-	3 431
Gwydir	3 482	667	24 693	1 749
Lachlan	3 482	667	24 693	1 749
Loddon-Avoca	3 363	2 990	-	2 299
Macquarie-Castlereagh	3 482	677	58 802	1 749
Moonie	1 961	277	-	728
Murray	79 098	73 794	375 369	12 203
Murrumbidgee	3 594	667	24 693	3 578
Namoi	3 482	667	-	1 749
Ovens	3 363	2 990	-	2 299
Paroo	2 598	414	15 337	1 086
Warrego	2 598	414	-	1 086
Wimmera	2 660	509	-	1 336

Source: Morrison and Hatton MacDonald (2010), p 32.

Notes: The values are presented in present value terms using real 2010 dollars. It utilises household numbers derived from ABS data for each state .

There are several points to note about the results in the table above.

- The values are derived assuming that the change in attribute occurred in a single region only and no others at the same time. Clearly this is not the case for the Basin Plan which has impacts across a wide range of regions at the same time.

29 In Appendix C we consider the recreational benefits associated with the SDL scenarios in more detail.

Therefore, in order to be able to use the values in the table for the analysis of the SDL scenarios it requires us to assume that there are no scale effects.[30]

- The full set of five attributes is not relevant for each region, as not all regions have substantial amounts of recreation or any colonial waterbird breeding.
- The study does not aggregate values across the entire population, but only assumes that a proportion of non-respondents (30 per cent) have values similar to respondents and that all other non-respondents have zero values.
- For the base case scenario values were only aggregated across households in the state in which regions occur, and it was assumed that households in other states do not have values for any changes in riverine health. This was assumed for all regions apart from the Murray.[31]

The study offers some caution about aggregating these values across the entire Basin, given that there may be some substitution effects. That is, if a single study sought to value improvements in the quality of the whole Basin, it may prove to be less than the sum of the parts.[32]

Valuation of change in ecological attributes — regional scale

In the first instance we have sought to utilize the findings presented in the Morrison and Hatton MacDonald study commissioned by the MDBA. In order to utilize the findings presented in the Morrison and Hatton MacDonald study we would need information for each of the 19 regions on the:

- proportional change in healthy native vegetation
- proportional increase in native fish populations
- number of years increase in the frequency of breeding of colonial waterbirds, and
- increase in number of waterbird and other species present.

As noted in the previous appendix, there are significant gaps in understanding how each of these attributes changes as a response to the SDL scenarios. The previous appendix presented estimates of the increase in the native fish populations which can be linked to the attribute valued by Morrison and Hatton MacDonald. However, for the remaining attributes noted above we were not able to provide estimates of the changes at a regional scale.

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30 As discussed in van Bueren and Bennett (2004) the community is likely to place much lower values (per unit of change) on large scale policies compared to policies that only impact on a particular region.

31 The study conducts sensitivity testing of aggregation assumptions (p 33–34).

32 Morrison and Hatton MacDonald (2010, p 4).

- *Frequency of waterbird breeding*. There is no data available of how the SDL scenarios would 'increase the frequency of waterbird breeding'. As presented in the previous appendix, the MDBA has used some broad assumptions on how the SDLs would change the frequency of waterbird breeding. We have used this information to estimate the change in value that would arise but note the simplistic assumptions used (as recognised by the MDBA).
- *Health of native vegetation.* Qualitative data is currently only available on the state of native vegetation and we were not able to obtain information on the 'percentage increase in the healthy native vegetation'.
- *Number of bird species*. There is no data available on the potential 'increase in the number of waterbird and other species present' as a result of the SDL scenarios.
- *Value of change in state of the Coorong.* There is limited information on the change in the state of the Coorong as a result the SDL scenarios — that is we do not know the extent to which the Coorong will move from a poor state to a good state under each of the SDL scenarios.[33]

Value of increase in native fish population

In the previous appendix we presented the estimated percentage increase in the native fish population under the alternative SDL scenarios. Using this information and the value estimates from the Morrison and Hatton MacDonald study (table 2.7) we can estimate the community value associated with the change in native fish population under each of the SDLs. These are presented in table B.2 below. The information is presented in net present value terms using a real discount rate of 7 per cent per annum over a 20 year period and assuming that the change only happens from 2015.

[33] As discussed later in this chapter, we also have some concerns regarding to which the value of the Coorong is already embedded in the specific attributes nominated in the Morrison and Hatton-MacDonald 2010 study.

B.2 **Regional benefits — increase in native fish population (NPV, $2010)**

Catchment	*3000 GL*	*3500 GL*	*4000 GL*
	$'m	$'m	$'m
Paroo	-	-	-
Warrego	7.4	7.4	7.4
Condamine-Balonne	13.6	15.9	18.0
Moonie	3.6	3.9	4.3
Border Rivers	3.8	4.1	5.0
Gwydir	16.6	19.5	22.4
Namoi	4.8	5.2	6.2
Macquarie Castlereagh	5.3	5.8	6.8
Barwon-Darling	9.0	10.9	11.9
Lower Darling	8.0	8.9	10.0
Lachlan	1.9	2.4	2.9
Wimmera-Avoca	-	-	-
Ovens	32.0	32.0	32.0
Goulburn-Broken	114.6	120.9	133.6
Loddon	76.7	76.7	93.8
Campaspe	44.8	49.0	53.3
Murrumbidgee	21.9	25.2	29.0
Kiewa	-	-	-
Murray	2 578.1	3 367.3	3 788.2

Note: This excludes the values associated with the Coorong.

Source: The CIE calculations

We illustrate the calculations in these tables for the Murrumbidgee valley. The Morrison and Hatton MacDonald study estimates a value of $0.667 m (in present value terms) for a 1 per cent increase in native fish population. As noted in table A.3, a 46 per cent increase in total water available for the environment is estimated to occur as a result of the 3 000 GL per annum scenario. This translates into a value of $30.7 m. However, given that the changes are assumed to be generated from 2015, this equates to $21.9 m in 2010 dollar terms, using a 7 per cent real discount rate.

Value of increase in frequency of bird breeding

Morrison and Hatton MacDonald have obtained values estimates of a one year increase in frequency of waterbird breeding. Using the following assumptions we have estimated the value of an increase in the frequency of bird breeding for each SDL scenario.

- Currently, it is assumed that a breeding event happens once in every six years.
- Under the 3000 GL scenario the frequency increases by two years to 'one in every four years'.
- Under the 4000 GL scenario the frequency increases by three years to 'one in every three years'.

We have assumed that the 3500 GL scenario lies in between the 3000 GL and 4000 GL scenarios.

The values associated with these changes are presented in table below. The information is presented in net present value terms using a real discount rate of 7 per cent per annum over a 20 year period and assuming that the change only happens from 2015.

B.3 **Regional benefits – increase in frequency of bird breeding (NPV, $2010)**

Catchment	*3000 GL*	*3500 GL*	*4000 GL*
	$'m	$'m	$'m
Paroo	21.9	27.3	32.8
Warrego	-	-	-
Condamine-Balonne	21.9	27.3	32.8
Moonie	-	-	-
Border Rivers	-	-	-
Gwydir	35.2	44.0	52.8
Namoi	-	-	-
Macquarie Castlereagh	83.9	104.8	125.8
Barwon-Darling	35.2	44.0	52.8
Lower Darling	-	-	-
Lachlan	35.2	44.0	52.8
Wimmera-Avoca	-	-	-
Ovens	-	-	-
Goulburn-Broken	-	-	-
Loddon	-	-	-
Campaspe	-	-	-
Murrumbidgee	35.2	44.0	52.8
Kiewa	-	-	-
Murray	535.3	669.1	802.9

Note: This excludes the values associated with the Coorong.

Source: The CIE calculations.

C Use benefits of changes in SDLs

Improved environmental conditions can lead to increased use or higher quality use of environmental assets, such as the Murray River. Some part of use values can be captured in increased market activity, such as increased tourism expenditure. However, a larger part of the use benefits will not reflect market activity but are improvements in welfare nonetheless.

Use benefits defined

People use waterways and environmental assets in a variety of ways. A survey undertaken in the Victorian Murray River Reserves in 2004–05 found that main uses of these reserves were for fishing, water skiing, swimming and sunbathing (table C.1).

C.1 **Uses of Victorian Murray River Reserves 2004–05**

Use	*Main activity undertaken*	*Activity undertaken*
	% of respondents	% of respondents
Fishing	42	51
Water skiing	12	13
Swimming	3	14
Canoeing	1	1
Informal social sport	2	2
Short walk	1	3
Cycling	1	6
Sunbathing	10	16
Sightseeing/spectating	-	3
Journey/tour	5	12
Eating/drinking	3	13
Overnight stays	4	8
Events & markets	2	2
Miscellaneous	14	21
White water rafting	-	2
Medium walk	-	1
Walk the dog	-	1
Total	100	171

Source: Parks Victoria 2005, *Parks visitation monitor: Murray River Reserves 2004-05*, November.

There has also been study of recreational activities undertaken at two iconic sites within the Murray — the Coorong in South Australia and Barmah Forest in

Victoria.[34] This study found that relaxing/getting away from it all was the most cited activity on these areas. Water featured in the responses of many of the visitors surveyed for its use for fishing, boating and water skiing, in addition to the enjoyment from simply being close to the water. Environmental conditions were also important to the activities of some respondents, whose most important reasons for visiting were bird watching and nature study.

Outside of reserves and national parks, rivers can be used for commercial tourism activities. These include boat tours or house boating, golf and venues situated along the river.

Use benefits capture the value that people place on the above uses of waterways or other environmental assets related to the condition of waterways. Some part of use benefits is captured in market activity — higher values for use of the Murray River will attract more tourists who will spend money getting to and in the local area. But a larger part of use benefits will reflect greater enjoyment of waterways by existing users.

Tourism in the Murray region

Tourism occurs throughout the Murray–Darling Basin. For the purposes of this analysis, and reflecting data availability, our focus is restricted to the areas around the Murray River. We consider:

- the amount of tourism activity in regions surrounding the Murray River;
- the extent to which this has changed over the past decade; and
- the proportion of tourism and the magnitude of changes in tourism related to changes in water and environmental conditions.

Tourism activity in the Murray River

Tourism Research Australia reports a profile of tourism activity in the Murray River Area.[35] In 2008-09, $1.4 billion was spent by the 6.7 million visitors to the region. These visitors spent 9.4 million nights in the area and their expenditure supported 10 200 tourism related businesses.

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[34] Dyack. B., J. Rolfe, J. Harvey, D. O'Connell and N. Abel 2007, *Valuing recreation in the Murray: an assessment of the non-market recreational values at Barmah Forest and the Coorong*, CSIRO: Water for a Healthy Country Research Flagship.

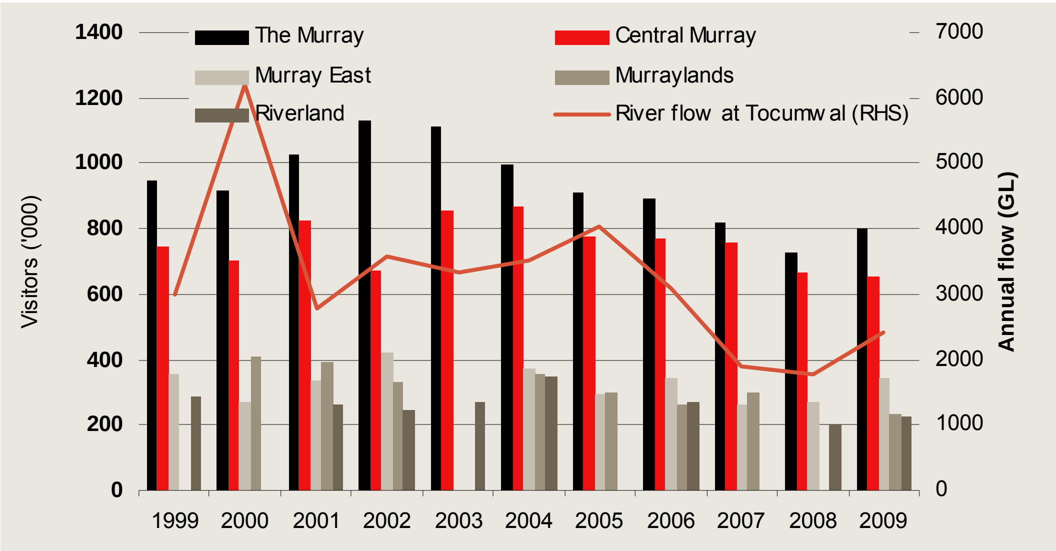
[35] Tourism Research Australia 2009, *Regional Tourism Profiles 2008/09: New South Wales, Victoria and South Australia, Murray River Area.*

Tourism changes in Murray River areas

There has been a decline in visitor numbers across the Murray regions over the past six to eight years (chart C.2). In the Murray region surrounding Albury, the Murray, visitor numbers decline by 30 per cent from 2002 to 2009. In the Central Murray, visitor numbers began to decline in 2004 and have declined by 25 per cent from then to 2009.

The drought is likely to be a contributing factor to this decline through a number of possible channels, one of which is environmental condition of the Murray and associated wetlands. For comparison, annual water flows at Tocumwal, which is between Echuca and Albury–Wodonga, are shown in chart C.2. This captures flow levels rather than the harder to measure environmental conditions.

C.2 **Visitor numbers in Murray River regions**



Note: Definition of regions. Central Murray covers the Victorian part of the Murray around Echuca, the Murray covers the NSW part of the Murray around Albury, Murray East covers the Victorian part of the Murray around Wodonga, Murraylands covers the South Australian part of the Murray around Murray bridge, Riverland covers the South Australian part of the Murray around Renmark.

Data source: Tourism Research Australia, Regional expenditure 2009 — Domestic overnight visitors; Victorian Water Resources Data Warehouse — http://www.vicwaterdata.net/vicwaterdata/home.aspx.

Tourism related to water

Only a small part of tourism activity in the Murray-Darling Basin is related to or impacted by changes in water availability for the environment and changes in the condition of the environment. Visitors can come for business purposes or to visit family and friends. It is very difficult to gauge the magnitude of tourism activity related to the condition of the Murray River because environmental conditions may be one factor in decisions to travel to the area or they may increase the length of stay or enjoyment of the Murray River area.

There are a number of relevant indicators of the importance if the Murray River to tourism in the region.

- Visitors that are attracted to the environment of the Murray River are more likely to be on holiday and to make use of the camping grounds along the river. Of the visitors to the region, 55 per cent were for holidays and 24 per cent involved caravan or camping accommodation.[36]
- 27 per cent of respondents to a survey conducted by Tourism Research Australia indicated that they visited the region to experience the Murray River, although for only 7 per cent of visitors this was the main reason for their visit.[37] Other reasons cited as the main reason for a visit are also potentially related to the condition of the Murray River including playing golf (4 per cent), experiencing nature (3 per cent) and to undertake nature based experiences (3 per cent).
- Visitor numbers are available for major Murray River sites such as the Coorong National Park, Murray River National Park and Victorian Murray River National Parks (including Barmah National Park and Hattah–Kulkyne National Park). These suggest visitor numbers of about 800 000 per year.[38] Some of these visitors may not be directly drawn for activities along the Murray River. The Victorian Environmental Assessment Commission considered that of the 5 million visitors to Tourism Victoria's Murray Region, 241 000 people or 5 per cent of visitors are drawn for camping and associated activities along the River Murray.[39]

The change in tourism numbers during the drought is another potential indicator of the importance of the River Murray for tourism. Tourist numbers have dropped by 20 per cent across the major areas surrounding the Murray River (see chart C.2) between 2002 and 2009. However, this change occurred over a period where there was declining water availability for the environment and for water users. This makes it difficult to isolate impacts on tourism related to nature based activities and business.

Where figures are available on national park usage through time (the South Australian National Parks), it is difficult to discern any change in usage related to lower water availability (chart C.3).

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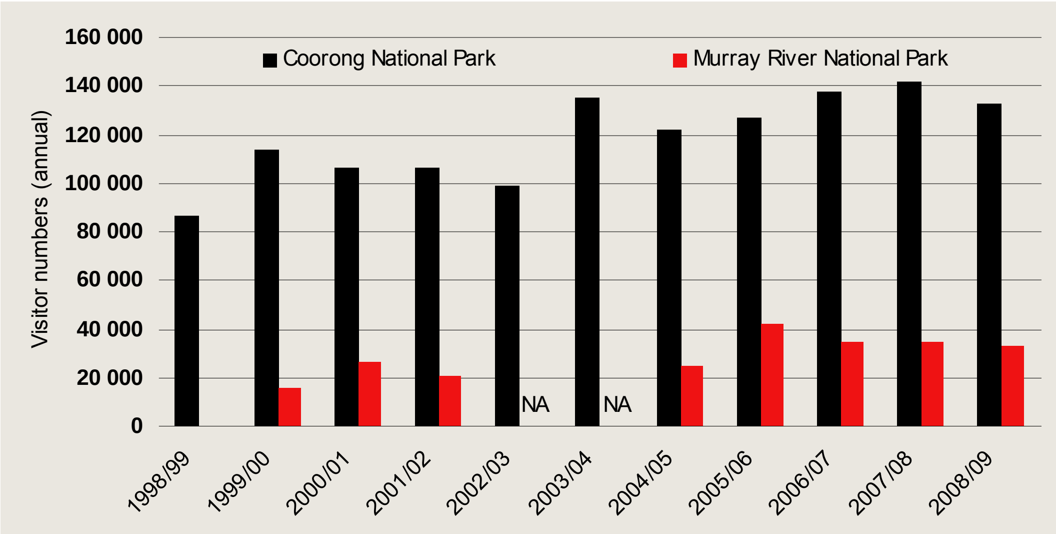
36 Tourism Research Australia 2010, *Impact of the drought on tourism in the Murray River region*, Destination Visitor Survey Strategic Regional Research Report — NSW, Vic & SA, Canberra.

37 Tourism Research Australia 2010, *Impact of the drought on tourism in the Murray River region*, Destination Visitor Survey Strategic Regional Research Report — NSW, Vic & SA, Canberra.

38 Information provided by South Australian National Parks for 2008-09; Parks Victoria 2005, *Parks visitation monitor: Murray River Reserves 2004-05,* November.

39 Victorian Environment Assessment Commission 2008, *River Red Gums Forest Investigation*, Final Report, July, p. 100.

C.3 Visitor numbers at South Australian National Parks



Data source: South Australian Department of Environment and Natural Resources.

There has been one specific study of the impact of the drought on tourism across the Murray region undertaken by Tourism Research.[40] The survey found that drought was a factor in a small number of people's decisions to visit or not visit the Murray River region. For example, 20 per cent of past visitors indicated that they would change their visitation to the area because of drought, with 2 per cent indicating that they would not visit the region because of drought.

C.4 Impact of the drought on tourism in the Murray River region

Impact of drought	*People who have visited the region in the past 10 years*	*People who have not previously visited the region but would consider visiting*
	% of respondents	% of respondents
Not impacted by drought	80	72
Visit different part of the Murray Region	4	5
Visit for shorter duration	5	6
Visit less often	9	11
No longer visit/not visit	2	4
Reduced expenditures	5	5

Source: Tourism Research Australia 2010, *Impact of the drought on tourism in the Murray River region*, Destination Visitor Survey Strategic Regional Research Report – NSW, Vic & SA, Canberra.

The survey of past and potential visitors also asked questions about what aspects of the river had changed and why their perceptions had changed (if they had). The most common reasons for having more negative perceptions of the Murray River region as a result of the drought were the impact on water levels in the Murray River (39 per cent of those with more negative perceptions) and the impact the drought has

40 Tourism Research Australia 2010, *Impact of the drought on tourism in the Murray River region*, Destination Visitor Survey Strategic Regional Research Report – NSW, Vic & SA, Canberra.

had on the landscape (26 per cent). The activities that were viewed as having deteriorated were those that related to water based activities.

The above figures suggest that changes in water levels can impact on tourism in the Murray River region. The scale of the changes in tourism will reflect the changes in water levels. The survey figures associated with the drought imply that this drought led to around a 5 per cent fall in visitor numbers. The survey is biased towards overnight visitors with 16 per cent of visitors surveyed having undertaken a day trip, while official statistics suggest that day visitors make up 58 per cent of all visits to the region. If we apply the 5 per cent change to official overnight visitor statistics[41], then the number of people not visiting because of the recent drought is 142 000 visitors per year.

The survey evidence is supported by trends in visitor numbers across the region. The number of overnight visitors to the region declined by 2.19 per cent per year from 1999 to 2008, faster than similar regions that were not in drought (which declined by 1.25 per cent).[42]

SDLs and use benefits

Changes in sustainable diversion limits can impact on tourism and recreational activities in a number of ways.

1. Tourism may be impacted by water levels and water quality. Low availability of environmental water leads to lower water levels in rivers and a higher chance of water quality issues such as blue green algae blooms. This channel of impact would be felt primarily by people wishing to use waterways for sight seeing, swimming, boating and fishing.
2. Tourism and recreational activities may be impacted by the condition of the environment. Changes in SDLs impact on environmental conditions such as presence and proliferation of fish and birds. These changes would be expected to flow through to changes in demand for fishing and bird watching.

The relationship between environmental conditions and tourism and recreational activities has been noted by users of the Murray-Darling.

> The decrease in fishing effort from 1.8 million fisher days in 2000/01 to 1.01 million in 2007/08, with a proportionally higher rate of decrease for shore-based fishers compared to boat-based ones, may partly be explained by the decrease in participation. However, several external factors, especially operating for the shorebased fishery, may also influence the decrease. These factors include the low water levels in SA freshwater regions

41 Tourism Research Australia 2009, *Regional Tourism Profiles 2008/09: New South Wales, Victoria and South Australia, Murray River Area.*

42 Tourism Research Australia 2009, *Regional Tourism Profiles 2008/09: New South Wales, Victoria and South Australia, Murray River Area.*

> (especially the lower River Murray, the Adelaide streams and private farm dams) that prevailed throughout the 2007/08 survey period. This may have reduced access for recreational fishers to their known fishing sites. This is supported from the observation that the percentage decrease in effort in the freshwater regions of the state since 2000/01 was greater than for the marine fishing regions.[43]

> Environmental watering in recent years has meant vegetation is recovering and frogs, fish and other species are beginning to flourish in lakes that have been dry since 1996. The watering has also lead to a spike in tourist visitor numbers to the [Hattah] Lakes and the surrounding Hattah-Kulkyne National Park.[44]

More formally, surveys of the use of the Coorong and Barmah Forest found that:

- over 60 per cent of respondents indicated that better environmental health would improve recreational fishing in the Coorong and Barmah Forest; and
- around 50 per cent of respondents indicated that better environmental health would improve other water based recreation activities, camping and walking in the Coorong and Barmah Forest.

Given these findings we expect that there will be tourism and non-market use benefits associated with increased water allocation to the environment and increased amounts of water making it to the end of the river.

Method for valuing changes attributable to SDLs

For the purposes of benefit cost evaluation, improved condition of waterways and wetlands could lead to:

- increased value (consumer surplus) for those who currently visit lakes, waterways and wetlands;
- value for those who visit lakes, waterways and wetlands once environmental conditions improve; and
- increased producer surplus for businesses that provide services to tourism.[45]

These changes are shown in charts C.5 and C.6. Chart C.5 shows the increase in consumer surplus from higher value from using public facilities. In this case the price of the facilities is typically zero. Both existing users and additional users obtain benefits.

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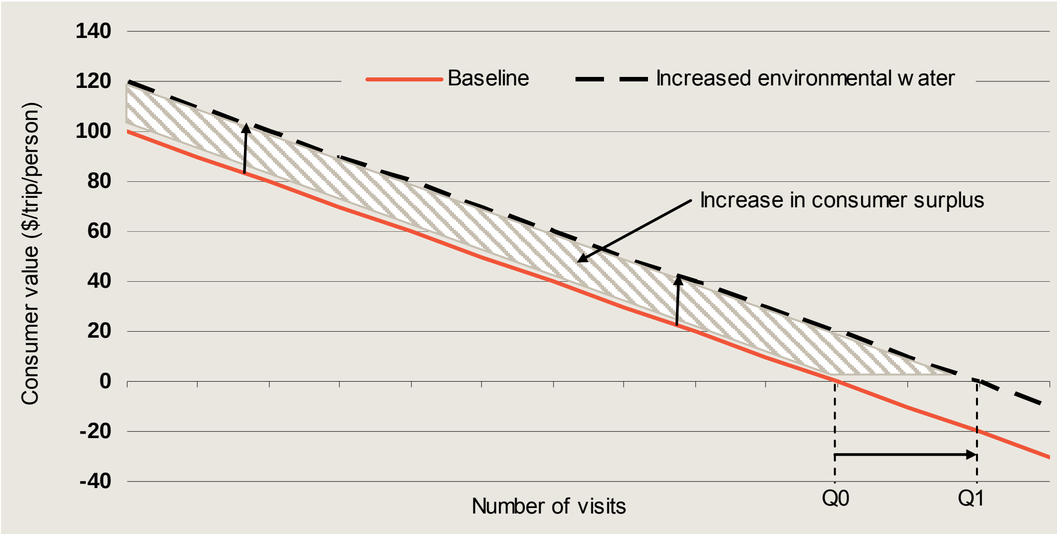
43 Primary Industries and Resources South Australia 2009, *South Australian Recreational Fishing Survey 2008-09,* South Australian Fisheries Management Series, Paper No. 54, December, p 68.

44 Parks Victoria 2010, *Murray River Guardian 2009-10*, p 4.

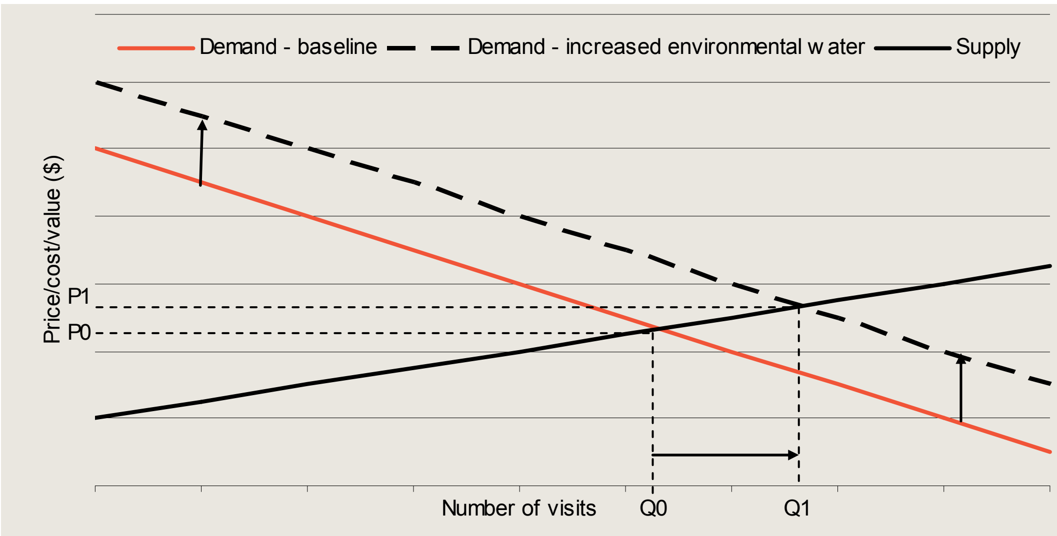
45 To some extent this may be shared with employees through higher wages for people working in tourism industries.

C.5 **Consumer surplus from increased value from public facilities**



Source: The CIE.

C.6 **Consumer and producer surplus from increased use of private facilities**



Source: The CIE.

Private operators can also benefit from increased demand (chart C.6). For example, increased demand for houseboats, trips on paddle steamers and accommodation in areas close to the river. In this case part of the increased demand will likely be obtained by businesses through higher prices, although consumers are still likely to benefit.

Issues related to overuse of an unpriced public asset (the tragedy of the commons) may also arise for visitation of parks if additional usage decreases the value for others. This is not factored into the charts above. There are typically other policies put in place that seek to limit these impacts such as permit systems for camping.

There have been a number of studies that have sought to include tourism impacts either in regional assessment or in BCA (box C.7). These studies have tended to find limited specific information on the change in tourism that can be attributed to the change in policy being considered. When these studies have been undertaken they typically estimate the change in visitor numbers and multiply this by a unit value per visitor. While this is a rough proxy for welfare benefits, it does not align conceptually with the consumer surplus and producer surplus measures in charts C.5 and C.6. For example, there may be benefits to existing users without any additional visitors to National Parks. New users are likely to have smaller benefits than existing users, reflected in their current decisions not to use the Murray River.

C.7 **Economic evaluations of tourism benefits**

Tourism benefits have been considered in a number of previous economic analyses relating to environmental change. Of most direct relevance for this study was the River Red Gums investigation undertaken by the Victorian Environmental Assessment Council (VEAC).[46] This study investigated the tourism benefits from changing the status of forest reserves along the Murray River to National Parks. Based on past evidence of changes in the use of native areas where status underwent similar changes, they expected an increase in tourist visitation of around 20 per cent.

The VEAC study also considered the extent to which provision of additional water for environmental assets would change estimates of the benefits. However, estimates of the impact of increased water availability on visitation were not made.

The NSW Department of Environment, Climate Change and Water have also conducted a number of studies investigating the regional economic impacts of National Parks.[47] These studies evaluate visitor expenditure attributable to National Park visitation and flow-on effects through regional economies. These studies cover some of the national parks relevant for the Murray-Darling Basin but do not consider changes in visitation due to changes in environmental conditions or water.

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46 Victorian Environment Assessment Commission 2008, *River Red Gums Forest Investigation*, Final Report, July, Appendix 1.

47 NSW Department of Environment, Climate Change and Water 2009, *Economic benefits of national parks and other reserves in NSW: Summary report,* October.

Estimates of changes in use from SDLs

The recent drought provides the most reliable evidence on the link between water levels (and hence environmental conditions) and visitor numbers and tourism. From the evidence presented above, we base analysis on the recent drought having led to about a 5 per cent fall in visitors across the Murray River region. This reflects evidence from a number of surveys and actual visitor changes.

However, not all evidence points in the same direction. For example, actual visitor numbers to the Coorong have not fallen despite this being a key site where lower water flows to the end of the Murray-Darling Basin system would be expected to translate into lower amounts or quality of use. This may reflect other factors such as population change and accessibility but nevertheless suggests that the impacts on tourism and recreation are not uniform or easy to quantify. Clearly, the changes will also depend on the rainfall conditions prevailing at the time.

The assumptions that we use to develop estimates are set out in detail below.

Water changes from the recent drought and SDLs

Water availability in the Murray-Darling Basin has been at historic lows in recent years due to prolonged drought. Over this time, the evidence available suggests that tourism related to visitation of waterways and wetlands fell. This gives some sense of how changes in water availability flow through to use and tourism.

The magnitude of the change in water along waterways of the Basin over the recent drought depends on where water levels are being measured. Across the entire Basin, CSIRO's modelling of recent (1997 to 2006) climatic outcomes versus the long term average indicates that inflows fell by 17 per cent and end of system flows by 50 per cent relative to long term averages based on current development and historical climate. If the years after 2006 were included these reductions would be larger.

The scenarios modelled in this report would generate increases in end of system flows of 38 per cent to 52 per cent relative to long term averages based on current consumptive water use and long term historical climate. The magnitude of the increase in environmental water is therefore of a similar order as the magnitude of the reduction in water that occurred over recent years.

Visitor numbers

We base estimates of the change in visitor numbers attributable to SDLs on the magnitude of historically observed changes to tourism during the drought, scaled according to the relative magnitude of the change in water reaching the end of the Basin. This involves assuming that the marginal benefits of additional water are constant across a large range of water scenarios. That is, an extra GL of water to the end of the system has the same impact on visitor numbers regardless of whether end

C.8 Water availability

Scenario	*End of system flows*
	% deviation from long term average
Recent climate (1997 to 2006)	-50
Scenario 1 — 3000 GL	38
Scenario 2 — 3500 GL	45
Scenario 3 — 4000 GL	52

Source: Murray Darling Basin Authority; CSIRO Sustainable Yields project 2008, Summary report, appendix A.

of system flows are 3000 GL/year to 8000 GL/year. This could overstate the value of increased water if there is declining value from each GL of additional water made available to the environment and river system.

Using these assumptions, the changes in visitor numbers from scenario 1 to scenario 3 range from an additional 113 000 visitors per year to an additional 153 000 visitors per year (table C.9).

C.9 Changes in visitor numbers

Scenario	*End of system flows relative to long term average (A)*	*End of system flows ratio to recent climate (B)*	*Tourism change relative to long term (C)*	*Over night visitor numbers (D)*	*Change in overnight visitor numbers (E)*
	%	No.	%	No./year	No./year
Long term projection	0	0	0	2 961 053	0
Recent drought (1997 to 2006)	-50	1.0	-5.0	2 813 000	-148 053
Scenario 1 — 3000 GL	38	-0.8	3.8	3 074 505	113 452
Scenario 2 — 3500 GL	45	-0.9	4.5	3 094 516	133 463
Scenario 3 — 4000 GL	52	-1.0	5.2	3 114 265	153 212

Note: Column B is column A divided by column A for the recent drought. Column C is column B multiplied by the change for the recent drought (5 per cent). Column D applied the change in column C to visitor numbers for 2008. Column E is column D less visitors under the long term projection.
Source: CIE analysis.

We do not include day visitors as the analysis of changes attributable to the drought was focused on overnight visitors and the average length of stay for trip values used later in this appendix is several days. This means that our figures may understate the actual use values of increased water availability for the environment. On the other hand, the drought involved reductions in water for extractive users and for the environment, while the SDL scenarios involve reductions in water for extractive users and increases in water for the environment. By using the drought as the basis, we are assuming the reduction in tourism from the recent drought reflected declining tourism related to the environment rather than declining tourism related to business activity. As such, this could overstate the tourism changes directly related to increased water for the environment.

Estimates of use value from SDLs

As noted above, it is not strictly correct to apply values related to current users to new users to determine the magnitude of additional consumer surplus created from a policy change. If there are limitations on numbers, such as limited camping capacity for example, then changes in visitor numbers could be small while changes in consumer surplus could be large, as those using the facilities have a better experience. Alternatively, applying the average value of existing users may overstate impacts if SDLs lead to many new users who only place small value on using the Murray River.

Nevertheless, there is no alternative given the studies that have previously been conducted. We adopt an approach of estimating value based on the value from a previous study conducted by CSIRO about the value of use of the Barmah and Coorong National Parks.

Estimates of value per use downstream

The main methods of estimating consumer value from activities related to recreation in the Basin are choice modelling and contingent valuation. Morrison and Hatton MacDonald set out these methods in detail and provide estimates of the value obtained from non-market recreational activities in Basin regions (table C.10). Only a small number of the Basin regions are expected to have value from recreational activities according to this study. Of these, the focus of this study is limited to the Murray as this is the only region for which we have evidence about visitor numbers for the region in total, visitation related to the Murray River and changes in visitation related to changes in water levels and environmental conditions.

For our purposes the key study is a CSIRO study of the values people place on use of the Coorong and Barmah National Parks.[48] This study used the travel cost method and contingent valuation method to estimate values for recreational use at each site. The conclusions were that the:

- value for visiting the Coorong National Park were in the order of $503 per adult per trip (in 2006 dollars); and
- value for visiting Barmah Forest (now National Park) were in the order of $529 per adult per trip (in 2006 dollars).

The research by CSIRO also asked about changes to access but not about the value placed on changes to environmental conditions.

48 Dyack. B., J. Rolfe, J. Harvey, D. O'Connell and N. Abel 2007, *Valuing recreation in the Murray: an assessment of the non-market recreational values at Barmah Forest and the Coorong*, CSIRO: Water for a Healthy Country Research Flagship.

C.10 Value of recreational activities across Murray-Darling Basin

Regions	Recreation			
	$ per person (adult) per visit			
	General recreation	Dams/ Lakes	Wetlands	Fishing at Dams/Lakes
Barwon-Darling	.	.	.	.
Border Rivers	.	.	.	.
Campaspe	.	.	.	.
Condamine-Balonne	.	.	.	.
Mt-Lofty Ranges	.	.	.	.
Goulburn-Broken	55.40	.	.	.
Gwydir	.	.	.	.
Lachlan	55.40	35.98		355.90
Loddon-Avoca	55.40	.	.	.
Macquarie-Castlereagh	55.40	35.98	561.28	355.90
Moonie	.	.	.	.
Murray	55.40	35.98	590.29[a] 366.00[b]	355.90
Murrumbidgee	55.40	35.98	.	355.90
Namoi	.	.	.	.
Ovens	55.40	.	.	.
Paroo	.	.	.	.
Snowy Mountains Scheme	.	.	.	.
Warrego	.	.	.	.
Wimmera	.	.	.	.

[a] Barmah-Millewa [b] Coorong.

Source: Morrison, M. and D.H MacDonald 2010, Economic valuation of environmental benefits in the Murray-Darling Basin, prepared for Murray-Darling Basin Authority, August.

We use an average of these figures, scaled up to 2010 dollars using the change in the consumer price index (CPI). This gives a figure of $585 per trip.

Estimates of use value downstream

The total value is estimated as the value per trip on average multiplied by the additional number of trips. We find that the SDLs would increase consumer surplus attributable to visits to the Murray River region by $66 million per year to $90 million per year (table C.11).

C.11 Changes in visitor numbers

Scenario	Change in overnight visitor numbers (A)	Value per trip (B)	Value per year (C)	Total value, $2010 dollars (D)
	No./year	$	$m/year	$m
Scenario 1 — 3000 GL	113 452	585	66	490
Scenario 2 — 3500 GL	133 463	585	78	562
Scenario 3 — 4000 GL	153 212	585	90	649

Note: Column C is column A multiplied by column B. Column D is the Present Value of this annual benefit over the period 2010 to 2030, using a real discount rate of 7 per cent and with the benefits only accruing from 2015 onwards
Source: CIE analysis.

Reduction in recreational value upstream

Offsetting the gain in recreational benefits of having more water downstream is a reduction in the water available in storages. This would depend on the exact nature of recreational use in the storages and the extent to which the MDBA chooses to manage the environmental water.

In regards to managing environmental water in the Murray, it is expected that under the SDL scenarios this would result in a reduction in storage levels at Lake Hume. The result is expected to be a reduction in the recreational value associated with Lake Hume.

The MDBA has estimated the value of recreation in Lake Hume and how this is impacted by lower storage levels. The value is of recreation is calculated by monthly use and recreational expenditure if the lake was full each year. Changes in the storage level of Lake Hume impact on the extent of recreational use of the lake, depending on different storage thresholds at different times of year. The estimated loss in recreational value is presented below.

C.12 **Estimated loss in recreational value in Lake Hume ($2010 dollars)**

	Baseline	*3000 GL*	*3500 GL*	*4000 GL*
	$m per year	$m per year	$m per year	$m per year
Average recreational value	3.3	2.7	2.6	2.4
Difference from baseline		-0.6	-0.8	-0.9

Source: MDBA, email correspondence 9 November 2010.

Discussion of estimates

The estimates presented above are for overnight visitation to the Murray River region. We do not estimate changes in value for other regions due to lack of data. We do not estimate changes in the value or number of day visitors again because of a lack of understanding of the value placed on visits by these visitors and the impact of water levels on these values. These factors suggest that the estimates could be a conservative estimate of the impact on use value of the SDLs.

D Other benefits from SDLs

There are a range of other potential benefits and costs that could arise from the increased environmental flows. For example, the SDL scenarios have potential water quality impacts. In the *Guide to the proposed Basin Plan*, the MDBA states that:

> Among the anticipated benefits, improvements in water quality are expected to enhance aesthetic and amenity values of water and water bodies, minimise risks to human and animal health, enhance ecological and conservation outcomes, and minimise financial costs by reducing water filtration and purification treatments for both commercial and human consumption needs.[49]

Some of the water quality issues that could potentially be impacted by the SDL scenarios include salinity, algal blooms and acid sulphate soils. Other potential impacts of a greater volume of environmental flows include flooding along rivers and productivity of floodplain grazing. Potential changes in the frequency and magnitude of flooding through a greater volume of water available for the environment could also result in additional costs to the community.

This appendix examines these potential impacts and attempts to place a value on the magnitude of the impacts.

Salinity impacts

Salinity is one of the best known threats to water quality in the Basin. The issue of salinity is complex relationship that depends on a wide range of factors, including site specific characteristics, land practices in the region and water use patterns. High-salinity events, for example, are related to factors such as:

- the location of major sources of salt;
- hydrologic loading on the landscape (including both rainfall and irrigation);
- salt mobilisation processes; and
- the flow regime available to dilute the impacts of salt loads on overall water quality.[50]

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[49] MDBA (2010), *Guide to the proposed Basin Plan*, Volume 2, p 231.

[50] MDBA (2010), *Guide to the proposed Basin Plan*, Volume 2, p46.

The impacts of salinity vary according to prevailing climate conditions at a point in time. As the MDBA's *Guide to the proposed Basin Plan* states:

> Risks are most pronounced during extremes of climate: extended dry periods when surface-water storage levels are low, providing little opportunity for dilution of saline groundwater inflows; and in wet periods when increased salt is mobilised from tributary valleys, irrigation areas and floodplains.[51]

Costs of salinity

Increasing salinity levels can have impacts on, for example:

- the environment (for example, native fish in freshwater systems);
- the agricultural sector (for example, through reduced crop yields); and
- local governments (for example, through increasing water filtration costs, greater road maintenance costs).

Impacts of SDL scenarios on salinity levels and cost

The alternative flow regimes proposed in the SDL scenarios can potentially change the salinity impacts at different points in the system. There are a range of possible ways in which the alternative SDL scenarios could impact on salinity.

- A greater volume of water in-stream that allows a greater dilution of salt loads in rivers. It provides a greater volume of water that can be utilised by authorities to dilute salt loads when required.
- Increased occurrence of large floods that can mobilise significant salt loads in wetlands and floodplains.
  - The MDBA has indicated that this occurred in the wetter years of the 1970s, 1980s and early 1990s, when large floods from both the Darling and Murray rivers inundated the lower Murray floodplain. These floods caused a fall in river salinity during the flood, but when the flood receded, salinity levels rose dramatically as a consequence of the primed groundwater system leaking highly saline groundwater back to the river.[52]
  - These impacts may occur in specific areas and are not proportionately spread throughout the catchment.

Understanding how the alternative SDL scenarios impacts on the salinity levels and their associated costs is a complex task and requires a detailed understanding of the

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51 MDBA (2010), *Guide to the proposed Basin Plan*, Volume 2, p45.

52 MDBA (2010), *Guide to the proposed Basin Plan*, Volume 2, p 47.

groundwater and surface-water hydrology within the various landscapes, and the in-stream salt transport mechanisms that affect the water resources of the Basin.[53]

Further, flows are just one of a range of factors that could impact on salinity levels. As the MDBA has indicated:

> Implementing regional-scale actions associated with salinity mitigation has included improved irrigation systems and on-farm water-use efficiencies, groundwater pumping, revegetation, and the incorporation of deep-rooted rain-fed grasses or fodder crops into agronomic systems to reduce groundwater recharge, which is the principal driver of salt mobilisation to rivers and streams (MDBA 2009a, p.231).

Given this, without detailed modelling it is difficult for us to assess the potential impact on salinity levels and associated costs.

Potential benefits of SDLs scenarios

While detailed modelling of all catchments is not available, the MDBA has undertaken some initial modelling for the River Murray to estimate the potential changes in the cost of salinity under the 3000 GL and 4000 GL scenarios compared to the baseline. The modelling was also based on the assumptions regarding the management of environmental water to meet the Environmental Watering Requirements of key assets along the Murray. That is, it incorporates detailed information regarding the volume and timing of flows throughout the year and at different points in the catchment. The results of this modelling are presented in table D.1 below.

D.1 **Estimated salinity cost for River Murray ($2010 dollars)**

	Baseline	***3000 GL***	***3500 GL***	***4000 GL***
	$m per year	$m per year	$m per year	$m per year
Average salinity cost	102.8	90.2	90.7	91.1
Difference from baseline		-12.6	-12.1	-11.7

Source: MDBA, email correspondence 9 November 2010.

The results illustrate that the cost of salinity falls by over $10 million per annum under the 3000 GL scenario compared to the baseline result. However, the 4000 GL scenario imposes a slightly higher salinity cost compared to the 3000 GL scenario. The reason for the higher salinity cost in the 4000 GL scenario is possibly due to the increased flooding in the wetlands which mobilises a greater quantity of salts. This highlights the complexities of modelling the costs of salinity and the non-linear relationship between flows and salinity impacts.

The MDBA's model for the River Murray used to calculate the average cost of salinity was developed in the late 1980s and it was last updated in 2005 (apart from

53 MDBA (2010), *Guide to the proposed Basin Plan*, Volume 2, p 231.

adjustments for inflation). The salinity costs included in the MDBA's modelling include the following items.

- ***Domestic salinity costs***. This includes the cost to the consumer of increased soap usage, increased maintenance to pipework and decreased life of appliances. This also includes cost to consumers in Adelaide and surrounds.
- ***Industrial salinity costs***. This relates largely to the cost to industry in South Australia of salinity in the River Murray whenever salinity levels are above a specified threshold limit. It includes the cost of pre-treating salty water as well as the increased energy and chemical costs incurred by more frequent blowing down of water in boilers.
- ***Agricultural salinity costs***. This element places a cost to agriculture of reduced yield as the salinity of water extracted from the river for irrigating crops increases. This cost element focuses on lost yield to stone fruit and citrus but does not include other crops such as grape vines.

Despite the potential limitations of the modelling undertaken by the MDBA, this provides a useful basis to understand the potential order of magnitude of the salinity cost impacts. This is likely to represent the *minimum* salinity cost impact which is likely to increase with additional cost items included in the modelling. That is, for the purposes of the BCA, we have assumed that the figures presented in table D.1 provide a useful estimate of the reduction in salinity costs.

Way forward

The salinity modelling undertaken by the MDBA provides a useful basis to commence further work in this space. It would be useful to extend the modelling to a greater number of regions in the Basin. Further, the MDBA has commissioned a further study of the cost of salinity to the Basin.[54] The cost elements reported in this report could be used to update the existing models so as to provide a more current estimation of the costs of salinity under different management options.

Possible avenues to pursue include the following.

- Gaining a more detailed understanding of the changes and incorporating these into the modelling. The modelling undertaken by the University of Queensland for the MDBA has the capability to be extended to incorporate the potential salinity impacts on agricultural production.
- Modelling both salinity and water flows as two key variables in the model where salinity is a function of the river flow, return flows and salt load in each catchment. We do have coverage of all 22 catchments and the cost impact is through the salinity damage function on crop yields which follows a threshold

54 RMCG (2009) *BSMS Cost Function Report*, July.

approach. This approach is considered similar to what the MDBA follows in its own work relating to salinity management.

Algal blooms

Algal blooms have always been present in the river system and are a natural phenomena, with their recorded history dating back to 1830.

The most concerning algal bloom impacts relate to blue-green algae outbreaks. In December 1991 the world's largest recorded blue-green algal bloom occurred, stretching for 1000 kilometers along the Barwon–Darling river system. In 2009 there was another well publicised bloom in the Murray River which occurred during Easter time, impacting on the recreational and tourism industry.

Flows and algal blooms

There are a range of factors that combine to cause the right condition for algal blooms to flourish. Flows are only one factor of several that impact on the frequency, duration and timing of algal outbreaks. Other factors include, for example, the level of nutrients in the system, the water temperature and available light. These factors usually combine to mean that algal blooms are more likely to occur in the warmer months of October to March.

The *Guide to the proposed Basin Plan* stated that:

> During recent periods of very low flow, blooms have probably become more intense and possibly more frequent. The regulation of the River Murray system ensures that the river continues to flow through most summers when blooms would otherwise have been most likely. However, during severe drought, the reduction or stopping of river flow, combined with the additional nutrients now present from eroded soils and waste discharges, means that intense blooms are more likely. The decay of algal blooms and associated low levels of dissolved oxygen can have catastrophic ecological effects.[55]

There are some studies available that has sought to establish minimum flow requirements (volume and velocity) to suppress bloom formation. One study estimates that changing flow requirements can, in the longer term, reduce bloom frequency at some sites on the Barwon–Darling by up to one-third.[56] A more recent study found that discharges of 300 ML per day (at a flow velocity of 0.03 metres per second) was found to be sufficient to prevent long periods of

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55 MDBA (2010), *Guide to the proposed Basin Plan*, Volume 2, p 48.

56 Mitrovic, S et al (2006), Modelling Suppression of Cyanobacterial Blooms by Flow Management in a Lowland River, *River Research and Applications*, Volume 22, pp 109-114.

persistent thermal stratification.[57] While there is some evidence emerging, the extent to which flow management strategies impact on algal blooms requires further analysis.

Cost of algal blooms

There are a range of potential costs of the algal outbreaks, particularly associated with blue-green algae outbreaks, such as:

- human health and animal health risks;
- tourism and recreation impacts for operators and visitors;
- impacts on community water supplies if equipment gets blocked or additional treatment is required to remove any dissolved toxins that are produced by some blue-green algae; and
- monitoring costs to Government agencies including sampling and testing samples.[58]

There can also be impacts to the environment of these toxic blooms. For example, as the bloom subsides, the dead and decaying algae can reduce the oxygen levels in the water, causing stress or death to other aquatic organisms such as fish.

The magnitude of the costs relating to algal blooms throughout the Basin is not readily available. The most comprehensive study that we are aware of was commissioned by the MDBC in 1999. In this study the cost of freshwater algal blooms were estimated to cost the Australian community between $180 million and $240 million per annum (in real 2000 dollars), as described in the table below. When estuarine blooms that affect fisheries, aquaculture and tourism are included the full cost of algal blooms would be much higher.

More recently the NSW Office of Water has commissioned a socioeconomic impact assessment of the River Murray blue-green algae blooms. The first stage of the study has recently been completed and does not seek to quantify the cost of algal blooms in the River Murray[59]. Nevertheless, through interviews with various stakeholders the study does provide some indication of the likely magnitude of the different cost elements. For example, the study indicates that of the 10 cost elements, 7 are believed

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[57] Mitrovic, S et al (2010), Use of flow management to mitigate cyanobacterial blooms in the Lower Darling River, Australia, *Journal of Plankton Research,* Volume 00, No. 0, pp. 1-13.

[58] Hill, C and Carter, G (2009), Determining an economic value for improved water quality in the Darling River, presented at the National Cyanobacterial Workshop, 12 August 2009. http://www.wqra.com.au/Cyano/Hill_Economic_assessment_bga_impacts_conference_paper.PDF , accessed 8 November 2010.

[59] Ernst and Young (2010), *Assessment of the Socio-economic impacts of Murray River blue-green algae blooms*, Report prepared for the NSW Office of Water, Stage 1, September.

to have a 'Low' or 'No' impact, 2 are believed to be 'Low/Medium' impact and only the impact on the tourism industry was rated as a 'Medium' impact.[60]

D.2 Cost of freshwater algal blooms (Australia, real 2000 dollars)

Type of cost	*Costs*
	$ m per annum
Joint management costs	9
Cost to extractive users	
▪ Urban water supplies	35
▪ Rural water supplies	60
▪ Stock and domestic water from farm dams	30
▪ Stock and domestic water from rivers, storages and irrigation channels	15
▪ Irrigation water supply	15
Cost to non-extractive users	76-136
Total	**180-240**

Source: Atech Group (1999) *Cost of Algal Blooms*, Report prepared for the MDBC and Land and Water Resources Research Development Corporation.

The NSW Office of Water has indicated that the cost of monitoring, managing and investigating blue-green algal blooms in NSW was approximately $1 million per annum in 2008–09 and 2009–10.[61] On top of this there was an additional $0.3 million per annum in annual laboratory fees for testing of samples. It is not clear the extent to which these costs would change with a greater (or less) frequency of algal blooms.

The NSW Office of Water has commissioned a study to assess the potential socioeconomic impacts blue-green algae blooms on the Murray River. The study provides information on the annual estimate of the costs associated with algal blooms for planned environmental protection. This includes the following additional cost items:

- sewage and stormwater management — $43 million per year
- agriculture and industrial wastewater management — $33 million per year, and
- rehabilitating land and water resources — $45 million per year.[62]

The study notes that some of these measures have already been implemented but a lot of expenditure is planned for the future. In this sense, it is possible that some of the future expenditure may not be required if the SDL scenarios reduced algal blooms.

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60 Ernst and Young (2010), *Assessment of the Socio-economic impacts of Murray River blue-green algae blooms*, Report prepared for the NSW Office of Water, Stage 1, September, p 59.

61 This only relates to salary and operating costs and excludes any capital costs that may have been incurred.

62 Ernst and Young (2010), p 9.

Potential benefits of SDL scenarios

In order to understand the potential benefits that the SDL scenarios can deliver from reducing the costs associated with algal blooms there needs to be an understanding of a range of elements:

- the relationship between the flows under the alternative SDL scenarios and algal blooms; and
- the extent to which the SDL scenarios changes the likelihood of an outbreak occurring as well as its duration and timing of occurrence.

Frequency, duration and timing of algal blooms

While algal blooms can have significant costs when they occur, toxic algal blooms are not frequent events. For a toxic event to occur it requires a combination of factors to come together at the same time such as low flow rates and high temperatures.

Further, the frequency of algal blooms is also dependent on the characteristics of the river which determines factors such as flow rates in the river. This is also, in turn, impacted by factors such as the drought. For example, the 2009 blue-green algae outbreaks in Lake Hume were attributed partly to the low level of the storage. Based on historical data the chances of a blue-green algae outbreak in Lake Hume increases significantly once storage levels are below 6 per cent of capacity, as occurred in March 2009.[63]

Currently, we were not able to obtain a historical record of the frequency and duration of algal blooms in the Basin. Some information on the recent blooms in NSW for the past few years is available. However, it does not provide a sufficiently long time series to establish the frequency of occurrence during drought versus non-drought conditions.

Impact of SDL scenarios on algal blooms

Given the findings of recent studies discussed above, we would expect that the SDL scenarios would have some impact on the frequency, duration and timing of algal blooms. However, the extent of this impact requires detailed modelling of each of the different catchments based on the flow management regime proposed for each of the SDL scenarios.[64] This impact would depend, for example, on assumptions regarding

63 NSW Office of Water (2009), *The Murray River Algal Bloom: evaluation and recommendations for future management of major outbreaks,*

64 Each of the different rivers would have different characteristics including the average volume and flow as well as the flows during drier periods. IT would also depend on the extent of regulation of river flows, the extent of nutrients in the system and the average summer temperatures. These factors would different across the catchments throughout the Basin.

how the environmental water will be released. For example, environmental water in storages could be released on a regular basis which would increase average flows or it could be held back and released in large volumes. These alternative regimes could also have differing impacts on the probability of an algal bloom within the storage and on the river. As noted above, a regime that released more water from Lake Hume would increase the chances of the storage reaching low levels and triggering an algal bloom.

Without such detailed modelling we are not in a position to estimate the potential benefits of the alternative SDL scenarios on reducing the cost of algal blooms.

Benefits of reduced flooding

One of the benefits of on-river storages is their ability to capture large flood events, thereby reducing the impact on those downstream of the storages. The extent to which a storage can mitigate against flood impacts depends on a range of factors such as the size of the storage, the extent of air-space available in storages when large flood events occur and the underlying hydrological characteristics of the catchments (such as the magnitude and frequency of large inflows events).

The management of the storages under the SDL scenarios also has a bearing on the flood-mitigation capacity of the storages. For example, if there is a greater volume of water required to be released from storages to meet environmental flow requirements then there would be greater air-space in the storages to capture major flood events and reduce the downstream impacts. On the other hand, if the regime for managing environmental water changes such that there is a greater quantity of environmental water held in storages and released less frequently (but in larger volumes) then the impacts on downstream flooding is potentially greater.

Cost of flooding

Flooding could impact on townships located close to rivers such thorough impacts on local road maintenance (including bridges) as well as cause greater erosion of river banks and damage to stock fences. These are likely to change depending on how the storages are managed to meet the targets specified in the Environment Watering Plans under each of the SDL scenarios.

Potential benefits of SDL scenarios

A detailed understanding of the nature and pattern of flows in the system for each SDL scenario (compared to the baseline) is required to better understand the impact that it has on flooding in each system.

The MDBA has conducted some modelling of the River Murray to understand the potential impact on flooding of the alternative SDL scenarios proposed. The modelling takes account of the management regime to meet the Environmental Watering Requirements for each of the indicator sites on the River Murray. This management regime essentially requires a greater volume of periodic inflows being released from Dartmouth and Hume storages throughout the year. As a result there is additional airspace that is available under the SDL scenarios compared to the baseline, allowing the MDBA to capture the major flood events. That is, regular releases to meet environmental demands allow a 'smoothing' of the peak inflow events.

The results of the modelling are presented in table D.3 below.

D.3 **Estimated reduction in cost of flooding for River Murray ($2010 dollars)**

	Baseline	*3000 GL*	*3500 GL*	*4000 GL*
	$m per year	$m per year	$m per year	$m per year
Average annual cost	1.95	1.72	1.67	1.62
Difference from baseline		-0.23	-0.28	-0.32

Source: MDBA, email correspondence 9 November 2010.

Based on the results in the table, the SDL scenarios result in benefits through reducing flooding and the associated costs in the River Murray.

Floodplain agricultural activities

A floodplain is relatively flat land adjacent to a river that experiences occasional or periodic flooding. Floodplain wetlands are essential to the maintenance of the hydrological, physical and ecological health of the riverine environment. Ecological communities on the floodplains have developed to suit this pattern of inundation. They periodically get replenished with silt, nutrients and organic matter during flooding. As a result, floodplain soils are amongst the richest agricultural soils anywhere. Some extent of farming and grazing enterprises can be supported on these floodplains.

While floodplain grazing is considered to be an important activity the extent of the grazing on floodplains is largely unknown. Further, there is limited information available regarding the SDL scenarios and their potential impacts on the productivity of the agricultural activity located on the floodplains.

Flows and flooding of wetlands

Increasing the volume of environmental flows has the potential to increase the extent of flooding on the floodplains. This increase in water is likely to result in improvements in the growth of grasses on the floodplains. This has the potential to improve the productivity of private land on the floodplains used for grazing by bringing in a greater load of nutrients and organic matter being deposited on the floodplain.

The extent to which the SDL alternatives compared to the baseline will impact on the extent of flooding of the floodplains will vary and also depend on the Environmental Watering Requirements for each of the icon sites. For example, in the case of the Murray River, the increase in the average volume of water available for the Murray will also be accompanied by a change in the management of environmental water. The result of this is that there is a greater volume of water regularly released from the storages to be provided to the environment. This results in additional airspace in the storages, thereby reducing the impacts of major flooding events. As a result of this, it can reduce the cost of flooding.

Potential benefits of SDL scenarios

There has been limited analysis to understand how the SDL scenarios would potentially impact on floodplain agricultural activities in the Basin.

Arche Consulting (2010) recently conducted a study for the Australian Floodplain Association that sought to estimate the socioeconomic benefits of floodplain grazing in the Basin. To our knowledge, this is the only study currently available that seeks to provide some quantification of the benefits of the SDL scenarios on agricultural activities.

Given the limited data on a broad regional scale, the study conducts three case studies of farms located on the Paroo River, on a tributary of the Warrego River and on the Darling River in Wilcannia.

The study provided estimates of the area of land in wetlands that are subject to floodplain agricultural activity in the Basin, based on assumptions regarding the change in flooding patterns and the change in productivity in response to the change in flooding patterns. The studies concludes amongst other things that, for the three case study farms, 'flooding adds approximately $6.8 million in gross profit over 15 years'.[65]

At this stage we are not able to provide broad estimates of potential benefits to agricultural activities on floodplains of the alternative SDL scenarios.

Dredging

The Murray Mouth performs an important function in delivering environmental health to the Basin for a range of reasons such as:

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65 Arche (2010, p 19).

- exporting salt and nutrients out of the Basin;
- maintaining water quality in the Coorong; and
- allowing migration of fish that require access to both fresh water and saline waters to complete their lifecycle.[66]

Increasing flows to the Murray Mouth is expected to result in an increase in the frequency in which the mouth is kept open. The MDBA has undertaken hydrological modelling to estimate how the alternative SDL scenarios would change the frequency in which the mouth is open.

Currently there is an annual cost associated with dredging to ensure that the mouth is open. Currently the cost is estimated at approximately $7 million per annum. An increase in the frequency in which the mouth is open can be expected to deliver benefits in regards to reduced costs associated with dredging. Table D.4 below provides estimates of the expected reduction in dredging costs.

D.4 **Estimated reduction in cost of dredging for River Murray ($2010 dollars)**

	Baseline	*3000 GL*	*3500 GL*	*4000 GL*
	$m per year	$m per year	$m per year	$m per year
Proportion of years the Murray Mouth is expected to be open	64%	90%	91%	92%
Probability weighted costs	2.52	0.7	0.63	0.56
Difference from baseline		-1.82	-1.89	-1.96

Source: The CIE calculations

Other ecological services

Improvements in the health of rivers and wetlands can also result in flow-on 'services' throughout the economy. As the Australian Conservation Foundation argues, a healthy ecosystem helps to make sure that the "natural resource base that underpins all agricultural activities, including irrigation, continues to function into the future".[67]

In the section above we have discussed the potential benefit to floodplain grazing that could arise from a greater level of flooding. However, the potential benefit could also extend to the irrigated agricultural sector. Some of this benefit could be associated with changes in salinity but there could also be other benefits from 'free' ecosystem services such as water filtration, pollination and prevention of pest predation.[68]

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66 MDBA (2010), *The Guide to the proposed Basin Plan - Volume 1,* Canberra, p 113.

67 ACF (2010), *Response to the Guide to the proposed Basin Plan,* December, p 3.

68 ACF (2010), p 3.

While we recognise the potential benefit, there is limited scientific information available that would allow us to estimate the incremental change in value of the ecological services associated with each of the SDL scenarios. Given this we have not incorporated any values associated with ecological services into our analysis.

Summary

This appendix provides estimates of other potential benefits associated with changes in the SDLs. The estimated benefits are summarised in the following table. There are other potential benefits discussed in this appendix (but not reported in the table) for which we have not been able to estimate the potential benefits. It would be useful for the MDBA to seek additional information on the potential magnitude of the benefits associated with each of the SDL scenarios.

D.5 **Summary of other benefits quantified ($2010 dollars)**

	3000 GL	***3500 GL***	***4000 GL***
	$m per year	$m per year	$m per year
Salinity impacts	12.6	12.1	11.7
Cost of flooding	0.2	0.3	0.3
Dredging	1.8	1.9	2.0
Total	**14.6**	**14.3**	**14.0**

Source: The CIE calculations

E Estimated socioeconomic costs

Decreases in water use will bring about a range of effects on agricultural production, input prices, and the overall returns from water. These effects can be understood in a variety of ways and have recently been examined using a number of economic models. This appendix examines these and tries to explain the differences between model results in order to understand the implications for benefit cost analysis.

Models of socioeconomic costs

The MDBA has recently commissioned a number studies to examine the potential socioeconomic impacts due to different levels of reduction in water availability. The MDBA commissioned three separate studies by ABARE-BRS, the Centre of Policy Studies (CoPS) and by the University of Queensland (UQ). Each of these studies used different regional economic models to estimate the socioeconomic impacts.

These regional economic models are powerful tools to help understand the expected direct impact on irrigated agriculture and the flow-on effects on regional economies. Modelling of this kind helps to isolate the expected impacts from a wide range of other factors that can also impact on regional economic performance such as fluctuations in global commodity prices.

As noted in appendix H these models evaluate changes from a specified baseline. The baseline includes, amongst other things, a regional economic profile of irrigation and non-irrigation farms in the region as well as a range of different businesses in the region, some of which are heavily reliant on irrigated agricultural activity. Each of the models are based on regional economic data of different time periods, and some are based on a combination of two time periods to provide a more accurate reflection of economic performance over a number of years.

As such the models used in the three studies commissioned by the MDBA have slightly different underlying assumptions which can have a significant impact on the results. Therefore, in interpreting the results of each of the studies it is important to understand the different assumptions embedded in the modelling.

There are a range of different assumptions in the three models. However, perhaps the most important difference is assumptions regarding the substitutability of different inputs in the production process. Another important assumption relates to assumed mobility of capital and labour between regions. These assumptions are likely to differ in the short term compared to the long term. Typically in the longer term there is greater flexibility in production systems and mobility of inputs that will limit the impacts of a reduction in water availability.

Overview of modelling results

This section provides an overview of the three studies commissioned by ABARE-BRS, CoPS and UQ. These studies are summarised in Boxes E.1 to E.4. Later in this appendix we discuss other studies commissioned by the MDBA to examine the potential socioeconomic costs that have not utilised regional models as the basis for their analysis.

E.1 **ABARE-BRS — Environmentally sustainable diversion limits in the Murray Darling Basin: Socioeconomic analysis**

This ABARE-BRS (2010) report, commissioned by the MDBA, uses both ABARE's water trade model (WTM) and AusRegion, ABARE's regional computable general equilibrium model, to look at the long run impact of the proposed SDLs on the gross value of irrigated agricultural production (GVIAP), irrigators' profit, gross regional product (GRP) and employment.

The main scenario analysed is one with the proposed SDLs and water trading. Other scenarios include no water trading, sensitivity scenarios on the level of the SDLs, and vulnerability scenarios which use a short run version of the water trade model to consider years of normal or low rainfall.

The results from the WTM show that the ability to trade water significantly reduces the impact of reduced water availability on GVIAP. The WTM also showed that the relationship between the reduction in surface water use and the reduction in GVIAP is almost linear. In all the scenarios, the broadacre industries such as cereals, hay, rice and other broadacre were the most affected by the SDLs.

The economy-wide impacts of reduced water use are projected to be relatively small. GRP for the MDB is projected to decline by 1.3 per cent while GDP is projected to decline by 0.13 per cent. The most affected regions were found to be Riverina and Western NSW. The impacts on employment are projected to be less than GRP, a reduction of 0.1 per cent for the MDB.

The report also included an assessment of the towns that would be most vulnerable to the introduction of SDLs by using a number of indicators such as the expenditure by irrigators per town resident and the towns in regions of land

(Continued next page)

E.1 ABARE-BRS — Environmentally sustainable diversion limits in the Murray Darling Basin: Socioeconomic analysis (Continued)

Per cent change in average annual water use, GVIAP and profit

	Without interregional trade	*With interregional trade*
	% change relative to baseline	% change relative to baseline
Water use	-29.1	-29.7
GVIAP	-16.5	-15.1
Profit	-8.2	-7..8

Source: ABARE-BRS 2010, tables 9 and 10, 3 500 GL scenario.

use that are expected to be most affected by the SDLs. Using this analysis, ABARE concluded that the most vulnerable towns were in the southern Basin, in particular Deniliquin, Coleambally, Kerang and Numukah.

A review of some relevant literature in the report found that the results of the ABARE analysis were consistent with other findings, although direct comparisons were difficult due to the different approaches taken, including different regional aggregations, different water trade assumptions, different assumptions in the level of water reductions and different variables reported.

E.2 CoPS — Regional economic impacts of sustainable diversion limits

The Centre of Policy Studies (CoPS) report (Wittwer 2010) examines the economic impacts of SDLs in the MDB using a dynamic general equilibrium model that includes water accounts. Four scenarios are explored and compared to the baseline, or forecast. The four scenarios cover the three different SDLs provided by the MDBA (3000 GL (scenario 2), 3500 GL (scenario 1) and 4000 GL (scenario 3) of water entitlements removed) assuming farmers are fully compensated, and one scenario where farmers are not compensated but 3500 GL of water entitlements are removed (scenario 4).

The distribution of the modelled SDLs was provided by MDBA. It is assumed that the Commonwealth purchases the water entitlements from farmers at the market price for water (based on the expected present value of the water entitlements). The baseline includes the buyback purchases that have already occurred, and the assumed reduction in entitlements in the scenarios are actually 3500 GL (and 3000 GL and 4000 GL) less the purchases that have already occurred. The baseline and policy scenarios also include droughts in 2015 and 2021.

(Continued next page)

E.2 **CoPS — Regional economic impacts of sustainable diversion limits** (Continued)

The model assumes there is water trade, but no interregional water trade occurs in the northern part of the MDB. Labour is mobile between regions. Land is fixed in each region, but the land can switch between irrigated and dry-land agriculture according to water supplies. Water supplies are fixed but can be traded out of some regions in the southern Basin.

Under scenario 1, total GDP for the MDB is projected to fall by 0.13 per cent in 2014 relative to the baseline. SDLs are projected to increase the price of water by about $50/ML in 2014 and the impact of the SDLs are greater in drought years. The price of land, however, falls as a result of the SDLs due to a land/water constraint thereby decreasing the land demanded for irrigation. The consequent increase in supply of dry-land pushes down the price. The opposing effects of higher water prices and lower land prices mean that the farmers that benefit most from the SDLs will be those that have high water to land ratios.

The decrease in irrigated output is partly offset by an increase in dry-land output. The effects increase over time reflecting reduced investment in irrigated sectors. Farm output declines in all sectors except for vegetables, which increases slightly due to the declines in the prices of land and a relatively low water intensity. The most affected sector is rice, with output projected to decline by around 16 per cent in 2014. Output from other sectors declines by less than 5 per cent.

The model shows that GDP losses increase over time as farm capital slowly declines. It is assumed that the payments received by farmers from the buyback increases consumption, with 5 per cent of the lump sum payment spent each year. The sectors that sell output to households, such as the services sector, could be expected to benefit from this increased consumption and therefore increase investment relative to the baseline. This increased investment could lead to a recovery in incomes for some regions. Aggregate consumption in 2014 is higher than the baseline due to the farmers' income from the water buyback.

E.3 UQ — Economic analysis of diversion options for the Basin Plan: returns to irrigation under reduced water availability

The impact of the Basin Plan on irrigated production is analysed in this UQ report for the MDBA (Mallawaarachchi et al. 2010). UQ uses a water allocation model with 19 regions within the Basin. The model includes data on water use, land use, farm profit and agricultural production for each region and commodity. It also incorporates three states of nature (normal, wet and drought) in which farmers are assumed to optimise activities given the amount of water available. The model assumes that factors of production are mobile and that technology options are available to irrigators so that as water availability declines different land use options are available.

UQ found that under the assumed change in diversion limits (these differ slightly from the assumed changes modelled by ABARE-BRS and CoPS), water use would decline by around 35.5 per cent compared to the baseline and the value of irrigated agricultural production would decline by around 16 per cent, assuming trade is allowed in the southern Basin. In a scenario where trade is not allowed, water use falls by 29 per cent and irrigated production by 20 per cent. The Basin wide results are summarised below. The results were found to differ between regions, with the greatest decrease in irrigated production expected in the Lower Murray-Darling region (42 per cent reduction in irrigated production from a 42 per cent reduction in water use, assuming no inter-regional water trade). UQ project that production of cereals would increase by 43 per cent in the Basin and rice production would fall by 61 per cent.

Per cent change in average annual water use, GVIAP and profit

	Without interregional trade	*With interregional trade*
	% change relative to baseline	% change relative to baseline
Water use	-29	-35
GVIAP	-20	-16
Profit	-19	-16

Source: Mallawaarachchi et al. 2010

E.4 CIE — Implications of water reforms for the national economy

This report written by CIE in 2004 looks at the contribution the irrigation sector makes to the Australian economy and estimates the national economic impacts of recent and future water reforms. The report makes use of the CIE's economy-wide general equilibrium model of the Australian economy with a base year of 1996-97. The model incorporates water trading between connected irrigation regions in the southern MDB.

In the report the economic impacts, both direct and indirect, of past changes in water use efficiency, enhanced trading, increased environmental flows and increased water charges are assessed.

The future reform analysed was a reduction in irrigation water to allow for increased urban and environmental water. Two scenarios were analysed: an administered scheme where pro-rata reductions are imposed on all users; and a market-based buyback of entitlements. Water diversions were assumed to be reduced by 5, 10, 15 and 20 per cent. The impacts of the reductions were assessed if the water was recovered from the southern MDB, the whole MDB or nationally. The following tables summarise the results of the analysis.

GDP loss from reducing irrigation diversion to the MDB and Australia using a market based approach

	5% reduction in diversion	*10% reduction in diversion*	*15% reduction in diversion*	*20% reduction in diversion*
	$m per year	$m per year	$m per year	$m per year
Southern MDB	18	88	156	229
Whole MDB	72	195	316	462
Australia	136	324	508	751

Source: CIE 2004.

Direct regional impacts of a 540 GL (10 per cent) reduction in the Southern MDB

	Administered		*Market based*	
	Change in water use	*Irrigation value added*	*Change in water use*	*Irrigation value added*
	GL	$m per year	GL	$m per year
Southern MDB	-543	-77	-543	-32
Northern and central MDB	0	4	0	1
Rest of Australia	0	27	0	-10
Total irrigated agriculture	-543	-46	-543	-41

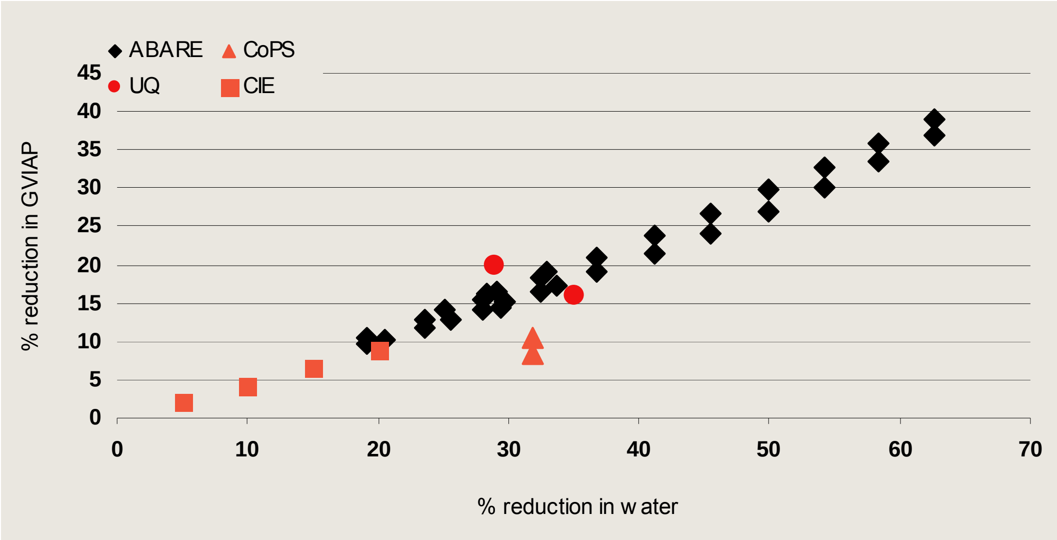
Source: CIE 2004.

The results show that the impacts of a market-based approach are less than that of an administered scheme as the irrigators are not compensated under the administered scheme. Industry results show that the greatest decrease in water use would occur in the rice, irrigated cattle and lamb and grains industries. The report also found that for reductions across the whole MDB, the central and northern regions of the Basin are most affected.

Gross value of production and SDLs

As chart E.5 illustrates, the change in the gross value of irrigated agricultural production (GVIAP) is broadly linear to the reduction in water use.

E.5 **Per cent change in GVIAP due to reduction in water availability in the MDB**



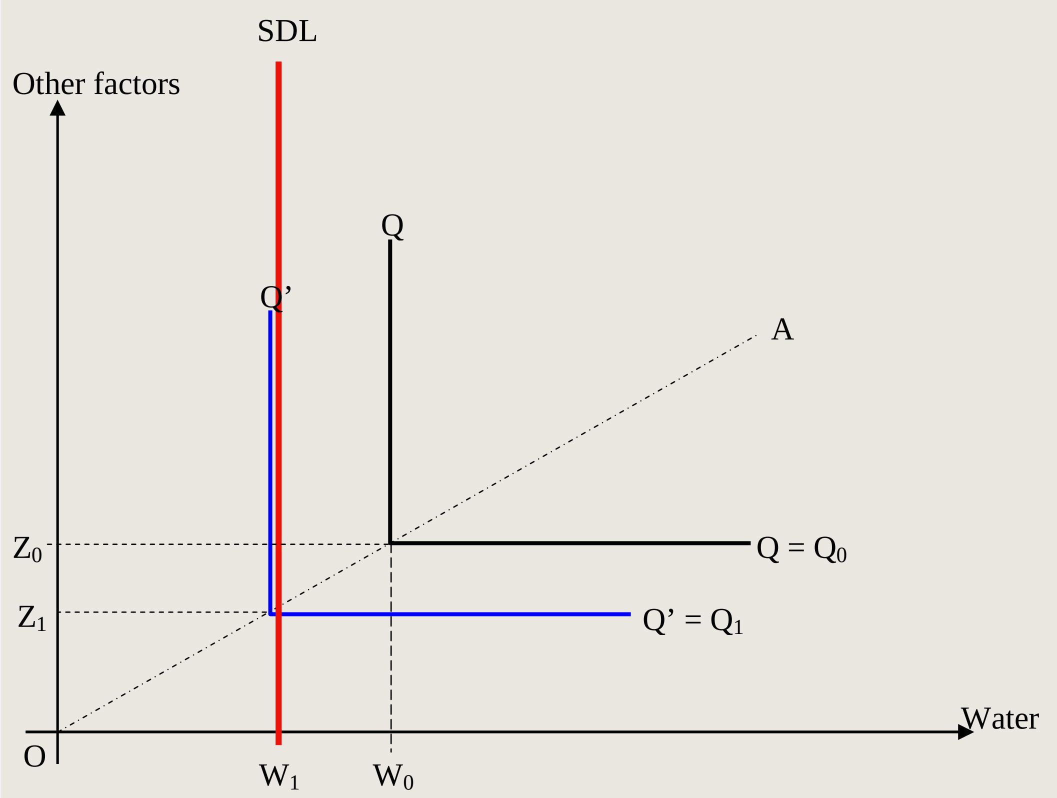
Data source: The CIE based on Wittwer 2010; ABARE-BRS 2010; Mallawaarachchi et al. 2010; CIE 2004.

Two possible extremes

A farmer uses water, along with other factors of production such as land, labour and capital, to produce agricultural products. The mix of factors used by the farmers depends on both the relative price of the factors and the rate at which the factors can be substituted for each other to produce the final product. The impact of the SDLs on agricultural production will depend on the extent to which factors of production can substitute for each other. Looking at two extreme cases, one where factors cannot substitute for each other at all and, one where factors are perfect substitutes, can provide an indication of the scale of the impacts the SDLs may have on irrigated agricultural production without having to know specific details of production systems.

The first extreme is if the factors of production are perfect complements and cannot be substituted for each other. Where goods are complements the different factors of production are used in fixed proportions to each other. In this case a reduction in the volume of water available would also mean an equivalent (in percentage terms) reduction in the other factors of production used. Assuming constant returns to scale, overall output would decline by the same percentage. Chart E.6 shows this graphically. The right-angled line QQ is the isoquant that shows the combinations of water and other factors that can be used to produce the quantity of output Q_0. When the water available is reduced from W_0 to W_1 the quantity Q_0 is no longer able to be produced. With the quantity of water W_1, the greatest quantity that can be produced is Q_1, shown by the isoquant Q'Q' that is the furthest to the top right but still consistent with W_1. As the factors are used in fixed proportions, the other factors of production can also be reduced by the same proportion as water, to Z_1. Assuming constant returns to scale, the overall level of production will fall by the same proportion as the reduction in water.

E.6 **Change in production from the introduction of the SDLs, no factor substitution**



Data source: The CIE

Therefore, for a 30 per cent reduction in water available to irrigated agriculture where factors are used in fixed proportions and other factors cannot be substituted for water, irrigated agricultural production would decline by 30 per cent. This is the upper bound of the reduction in irrigated production from a 30 per cent reduction in available water.

The opposite extreme is a case where factors are perfect substitutes. That is, a good can be produced from either one factor or another or a combination of both. Where one factor is not available, the same quantity of the final product can be produced using another factor. If this were the case, the imposition of the SDLs would reduce production to the extent that the SDLs reduce the value of total resources available to irrigated agricultural production. If water reductions were fully compensated then the compensation funds could be used to purchase other inputs to maintain the same level of production. Where there is no compensation for the water reductions the reduction in production would be equivalent to the reduction in available resources (the value of the water no longer available). This would be the percentage decline in water available multiplied by the share of water in total costs.

On average across the Basin, water costs are around 6 per cent of total costs of irrigated agricultural production (pers comm. ABARE-BRS).[69] Therefore for a 30 per cent reduction in water availability, assuming factors are perfect substitutes and water reductions are not compensated, irrigated agricultural production would decline by around 1.68 per cent. This is the lower bound of the reduction in irrigated production from a 30 per cent reduction in available water.

In reality the factors of production are neither perfect substitutes nor perfect complements. Factors of production can generally be substitutes to some degree and can substitute to a greater extent in the longer term. For example, farmers may be able to invest in capital equipment to improve irrigation efficiency and enable a smaller amount of water to be used to produce the same volume of output. However, they are not perfect substitutes and capital (or other factors of production) cannot completely replace water. Therefore, the impact the SDLs would be expected to have on irrigated output would be somewhere between the two extreme results discussed above. The modelling results produced by ABARE-BRS, CoPS and UQ all lay within these bounds (table E.7).

E.7 **Percent change in irrigated output, modelling and upper and lower bound estimates**

	Assumed reduction in water	*Modelled reduction in GVIAP*	*Estimated upper bound (no substitution))*	*Estimated lower bound (perfect substitutes))*
	%	%	%	%
ABARE 3000 GL	25.6	12.9	25.6	1.43
ABARE 3500 GL	29.7	15.1	29.7	1.66
ABARE 4000 GL	33.7	17.3	33.7	1.89
CoPS	31.8	8.5	31.8	1.78
UQ	29.0	19.6	29.0	1.62

Source: The CIE; The CIE based on Wittwer 2010; ABARE-BRS 2010; Mallawaarachchi et al. 2010.

Chart E.8 confirms that the reduction in the gross value of production is at most equal to the reduction in water use.

Comparing model results

The CoPS modelling shows a decline in irrigated output ranging between 0 and 16 per cent depending on the region. ABARE's projections show a larger decline in

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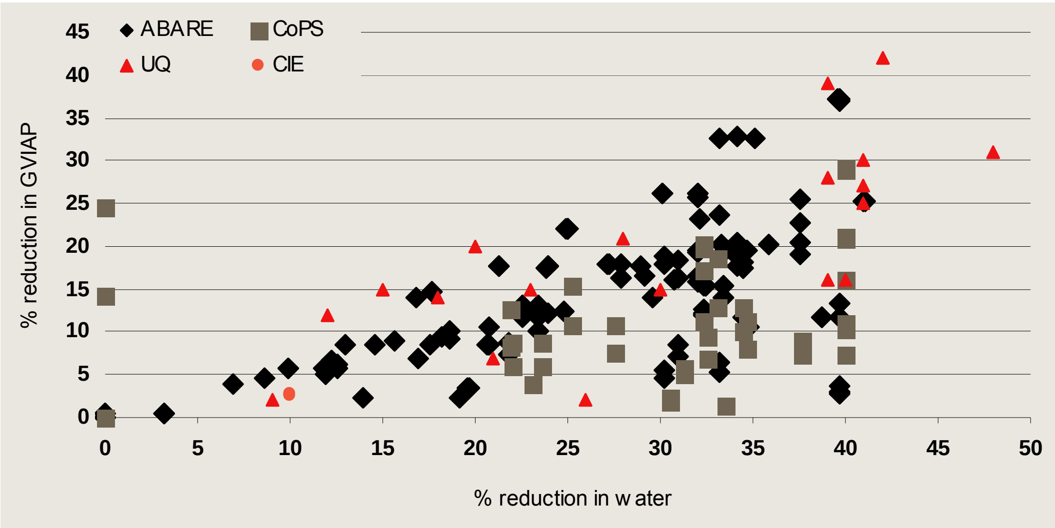
69 As part of its 2006 price determination IPART commissioned a farm survey by ABARE to determine, amongst other things, the total cost of water relative to other costs. The survey found that (using 2009/10 prices) bulk water costs represented between 0.9 to 4.7 per cent of total farm costs. IPART (2006, p151).

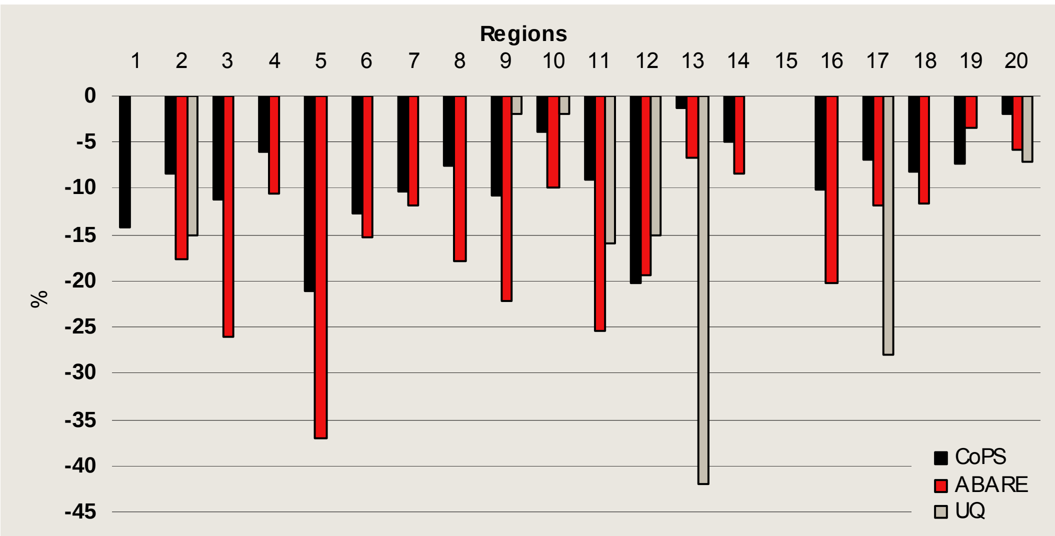
irrigated output of 15 per cent for the MDB (ranging between 0 and 37 per cent for the different regions) (chart E.9). The main reason for the difference is the extent that factors of production are assumed to be mobile in the models. The CoPS model implicitly assumes the factors of production are more mobile between the sectors of the economy than the ABARE model, therefore the impact of the SDLs is smaller.

E.8 Per cent change in GVIAP due to the reduction in water availability by MDB region



Data source: The CIE based on Wittwer 2010; ABARE-BRS 2010; Mallawaarachchi et al. 2010; CIE 2004.

E.9 Per cent change in irrigated output relative to the baseline



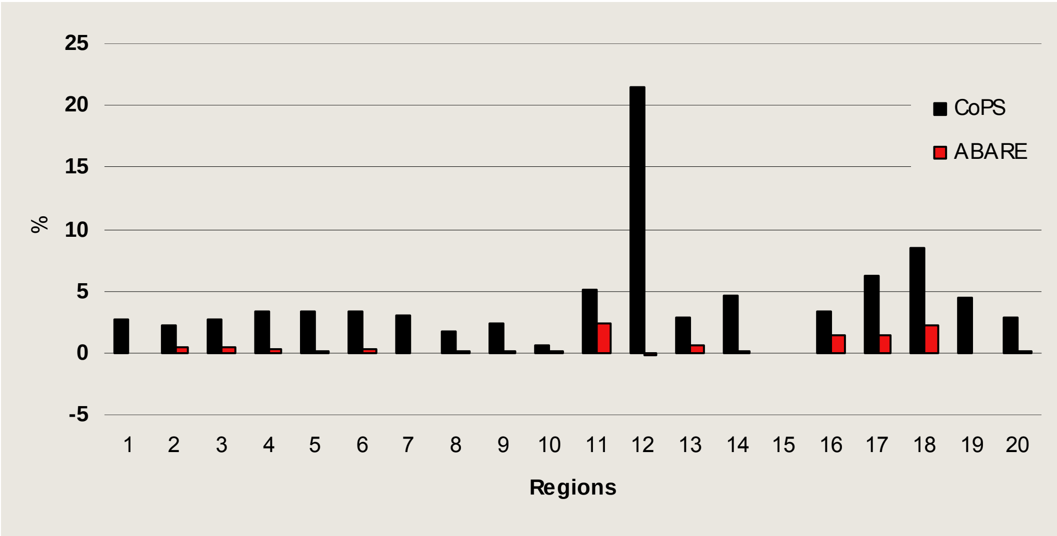
Note: Assumes 3500 GL SDLs, water trading and no compensation scenarios for ABARE and CoPS and assumes no inter-regional water trading in UQ results. UQ uses different regions so only results for those that correspond with ABARE and CoPS regions are included.

Regions: 1 Paroo; 2 Namoi; 3 Gwydir; 4 Border Rivers; 5 Moonie; 6 Condamine-Balonne; 7 Warrego; 8 Macquarie Castlereagh; 9 Barwon Darling; 10 Lachlan; 11 Murrumbidgee; 12 Murray NSW; 13 Lower Darling; 14 Murray Vic; 15 Wimmera-Avoca; 16 Loddon; 17 Goulburn Broken; 18 Campaspe; 19 Ovens; 20 Murray SA

Data source: The CIE based on Wittwer 2010; ABARE-BRS 2010; Mallawaarachchi et al. 2010

As irrigated agricultural output declines, and factors shift into non-irrigated agriculture, the output of non-irrigated agricultural output is projected to increase. The CoPS modelling projects non-irrigated agricultural production would increase by between 0 and 8.5 per cent in most regions, and by 22 per cent in the NSW Murray region. The ABARE modelling projects the change in non-irrigated agricultural production to be between -0.1 and 2.3 per cent relative to the baseline (chart E.10). The increase in output projected by CoPS is greater than that by ABARE which again can be attributed to the difference in implied factor mobility in the modelling frameworks.

E.10 **Per cent change in non-irrigated output relative to the baseline**



Note: Assumes 3500 GL SDLs, water trading and no compensation scenarios

Regions: 1 Paroo; 2 Namoi; 3 Gwydir; 4 Border Rivers; 5 Moonie; 6 Condamine-Balonne; 7 Warrego; 8 Macquarie Castlereagh; 9 Barwon Darling; 10 Lachlan; 11 Murrumbidgee; 12 Murray NSW; 13 Lower Darling; 14 Murray Vic; 15 Wimmera-Avoca; 16 Loddon; 17 Goulburn Broken; 18 Campaspe; 19 Ovens; 20 Murray SA

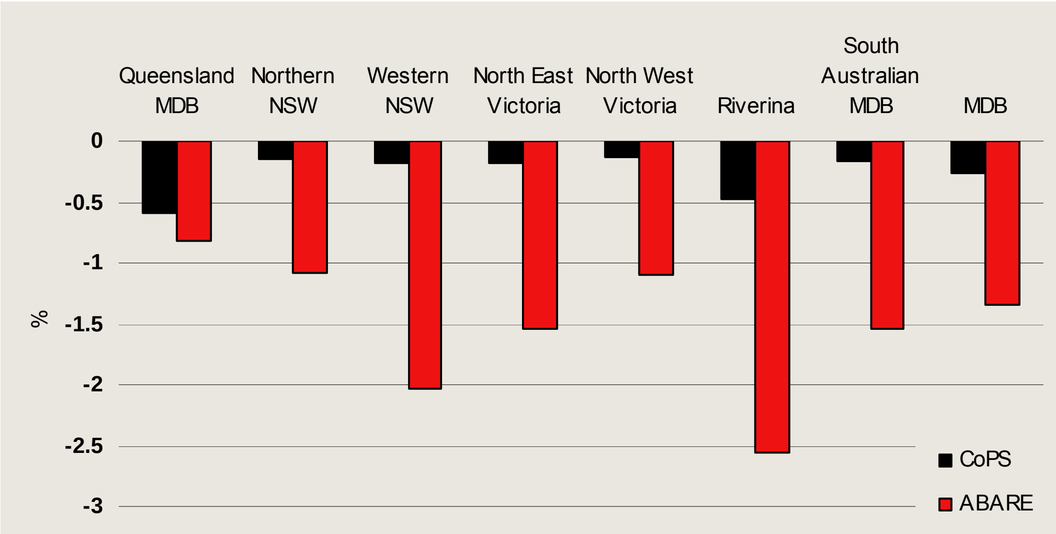
Data source: The CIE based on ABARE-BRS 2010 and Wittwer 2010

The overall economic impact of the SDLs will be a function of the impact on irrigated and non-irrigated agriculture as well as the flow-on impacts to other sectors of the economy and the level of compensation provided to water entitlement holders with the implementation of the SDLs. Both sets of modelling results show that the increase in non-irrigated agricultural production does not fully offset the declines in irrigated production. Overall, CoPS projects that, assuming no compensation is provided, the SDLs would reduce gross regional output of the MDB by 0.2 per cent in 2014. The corresponding projection by ABARE is that GRP would be 1.3 per cent lower in the scenario with SDLs than if there were no SDLs. The impacts are expected to differ slightly between the regions. Chart E.11 shows the per cent change in GRP relative to the baseline for the ABARE and CoPS modelling results for different regions (the CoPS regional results have been aggregated to be compared with the ABARE results).

Despite the differences in modelling approaches used, both sets of analysis show that the impacts of the SDLs on the MDB economy as a whole would be in the order of 0 – 1.5 per cent. The projected impact on Australian GDP ranges from a reduction of 0.01 per cent (CoPS projection) to 0.13 per cent (ABARE projection).

Overall, the expected impact of the SDLs on the economy of the MDB can be summarised using a measure of the change in GRP due to the change in water availability. Chart E.12 shows this measure for the CoPS and ABARE modelling for the different regions. It is clear from this chart that the expected impact from reduced water availability is much higher under ABARE modelling.

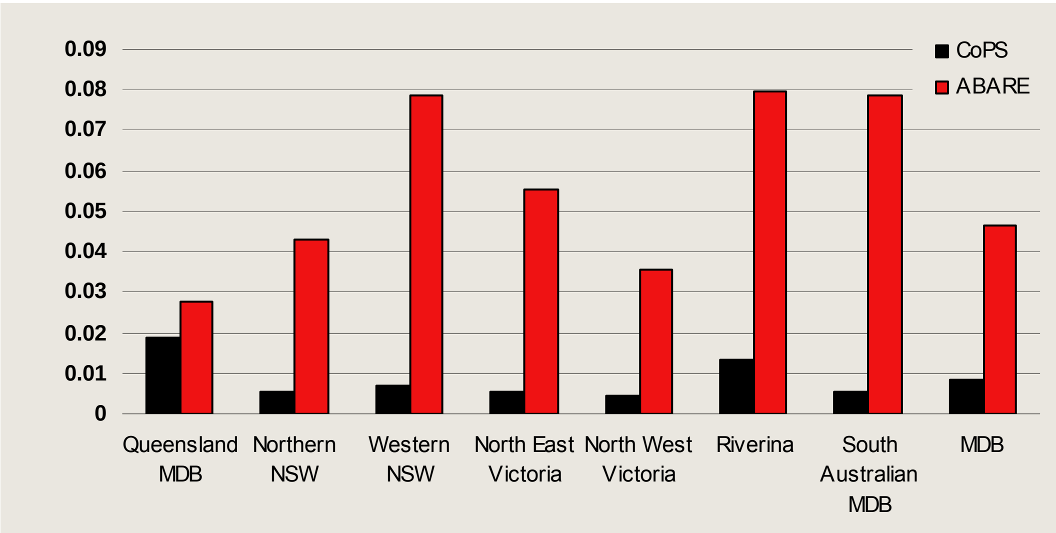
E.11 **Per cent change in gross regional product relative to the baseline**



Note: Assumes 3500 GL SDLs, water trading and no compensation scenarios

Data source: The CIE based on Wittwer 2010; ABARE-BRS 2010

E.12 **Ratio of change in GRP to water use**



Note: Assumes 3500 GL SDLs, water trading and no compensation scenarios

Data source: The CIE based on ABARE-BRS 2010 and Wittwer 2010.

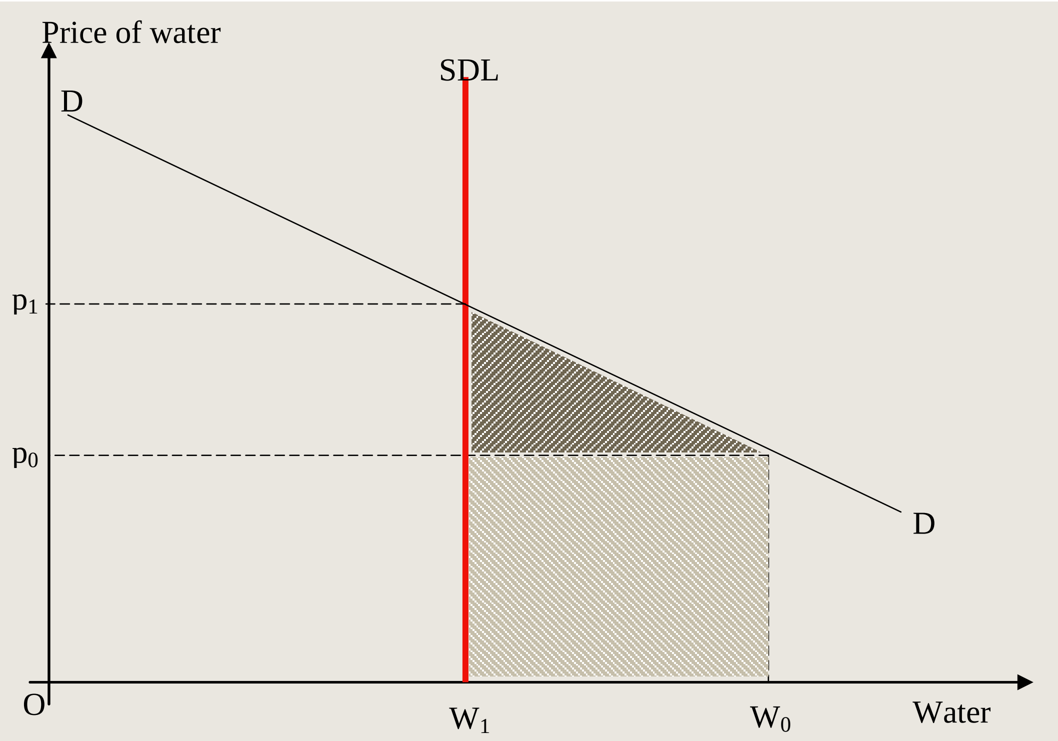
Welfare effects of decreased water use

The modelling discussed above allows a range of different indicators to be reported such as changes in the value of production and rates of employment. However, from the perspective of BCA these indicators are not indicators of 'welfare effects' from decreased water availability.

The welfare impact of the introduction of SDLs will mostly be felt by the holders of water entitlements. Water, as a factor of production, generates income for the water rights owner by contributing to the production of agricultural products. The income generated by using water to produce other goods is referred to as the returns to water. In general, water will be demanded up until the point that the return earned on the last unit of water used is equal to the price paid for the water (or the opportunity cost of holding the unit of water). The introduction of the SDLs reduces the water available and therefore reduces the returns to water. This loss in the returns to water is the primary welfare impact of the introduction of the SDLs.

The returns to water can be illustrated as the area under the derived demand curve for water between the origin (O) and initial quantity of water (W_0). Therefore the impact of the SDLs on the return or value of the water can be seen as the change in the area under the derived demand curve for water. Chart E.13 shows this area as the sum of the shaded rectangle and triangle.

E.13 **Derived demand curve for water**



Data source: The CIE.

The SDLs reduce the quantity of water used in agriculture (from W_0 to W_1) and drive up the price of water. The extent that the price increases in response to the SDLs depends on the price elasticity of demand for water. The more elastic demand is, the flatter the demand curve is and therefore the loss in returns to water would be less (smaller triangle area). If the demand is highly inelastic, the price response would be greater, the demand curve steeper and the triangle area and the estimated loss in returns to water would be greater.

The decline in the returns to water as a result of the SDLs can be estimated using the change in water, the initial water price and the change in the price of water. Results estimated this way are very similar to the modelling results produced by ABARE-BRS (2010). The economic modelling by ABARE-BRS (2010) reports the loss in returns to water as the change in profit in irrigated agriculture. Table E.14 compares the percentage change in profit from ABARE-BRS with estimates produced by a calibrated surplus calculation approach described above. The results differ in the southern Basin regions because of the effects of water trading that are included in the ABARE-BRS results but otherwise are similar.

E.14 **Estimated change in irrigators' profit due to SDLs, 3500 GL scenario**

	ABARE-BRS results	***Surplus calculation results***
	$m	$m
Condamine	7.7	8.3
Border Rivers (QLD)	1.8	1.9
Border Rivers (NSW)	2.2	2.4
Warrego	0.1	0.2
Paroo	0.0	0.0
Namoi	5.0	5.4
Macquarie	5.2	5.7
Moonie	1.8	1.9
Gwydir	8.9	9.5
Barwon Darling	4.2	4.6
Lachlan	1.9	2.1
Murrumbidgee	45.9	63.5
Ovens	-0.1	0.2
Goulburn Broken	16.1	14.0
Campaspe	4.0	2.5
Wimmera	0.0	0.0
Loddon	12.6	11.2
Murray (NSW)	8.7	12.4
Murray (VIC)	15.5	4.2
Lower Murray Darling	1.7	2.1
SA Murray	9.2	7.0
Eastern Mt Lofty Ranges	0.2	0.6
Grand Total	152.5	163.1

Source: The CIE; ABARE-BRS 2010

The change in the price of water can be determined using the elasticity of demand for water. The literature suggests that the elasticity of demand for water is inelastic at low prices but more elastic at higher prices and also more elastic in the long run. The elasticity differs between regions, time and activities. Literature reviewed by the Productivity Commission (Appels et al. 2004) reported short run elasticities between -0.03 and -2.81 and long run elasticities from -0.1 to -3.01. At higher prices the elasticity estimates ranged up to -3.52 and one estimate of -14.1. The long run elasticity of demand implied in the ABARE water trade model is around -0.3 (Hone et al. 2010). That is, a 10 per cent increase in prices would lead to a 3 per cent decrease in water demand.

Without knowing either the elasticity of demand or the change in the price of water, the lower bound of the change in returns to water or profits can be determined. This is the rectangular shaded area in chart E.13. These back-of-the-envelope calculations demonstrate the logic behind the results produced using the economic models and also provide an indication of the broad magnitude of the potential impacts of the SDLs.

Other studies commissioned by MBDA

E.15 **BDA Group — Review of social and economic studies in the Murray-Darling Basin**

The report by the BDA Group (2010) identifies the existing socioeconomic literature that is relevant to water use in the Murray-Darling Basin published since 2000. The BDA Group identifies 136 reports or studies. The reports that were reviewed looked at issues relevant to the Basin including the effect of weather and climate on returns to irrigated agriculture, the effect of environmental flow regimes on irrigated agriculture, the effect of water trade and pricing on irrigated agriculture, the off-farm impacts of changes to irrigated agriculture and the environmental value of aspects of the Basin. Most of the literature looks at the southern Basin and surface water flows.

The literature covered a number of different approaches: benefit cost analysis; regional economic impact analysis; social impact analysis; and multi-criteria analysis. It also discussed the different models used, both hydro-economic models and economic impact models based on input-output tables or CGE models.

The report discusses some of the difficulties in using a number of different studies together:

- summing the valuations of environmental improvements may overstate benefits as people value the first increment of environmental outcomes greater than subsequent increments;

(Continued next page)

E.15 **BDA Group — Review of social and economic studies in the Murray-Darling Basin** (Continued)

- summing the impacts on individual regions may understate the total impact on the larger region because the individual impact analyses only consider the impacts within the region, not the flow on benefits to other regions; and
- aggregation of social impacts is often not possible or relevant because of the indicators used.

Some observations from the literature reviewed that were included in the report include the following.

- Social impacts associated with water recovery measures are likely to be only short term as communities are constantly adapting to change.
- Restricting water entitlement trade reduces economic efficiency.
- Survey results indicate that dairy farmers tended to be buyers of temporary water allocations while horticulture farms are sellers.

E.16 **Marsden Jacob Associates (MJA) — Economic and social profiles and impact assessments for the Murray-Darling Basin Plan**

MJA et al. (2010) developed economic and social profiles of 12 regional irrigation communities in the MDB and assessed the potential social and economic impacts on these communities of a change in water availability. The report discusses the vulnerability of a community to a change in water availability in terms of the level of exposure, sensitivity and adaptive capacity of the community.

The analysis was done by developing community profiles based on existing data, face to face interviews with stakeholders and informed persons, and telephone surveys of irrigators, dryland farmers, businesses and community representatives. It was assumed that no compensation or transition support would be provided and hypothetical uniform percentage reductions in water availability from historical long term allocations would be 20, 40 and 60 per cent.

The research found that the industries most sensitive to SDLs would be dairy, horticulture and rice and the regions highly sensitive to SDLs are in the southern Basin as they have much greater proportion of agriculture using irrigation. The SA Murray, Sunraysia and Riverland regions in particular are sensitive to the introduction of SDLs as these regions have higher levels of socioeconomic disadvantage.

(Continued next page)

E.16 **Marsden Jacob Associates (MJA) – Economic and social profiles and impact assessments for the Murray-Darling Basin Plan** (Continued)

The responses indicated that a 20 per cent reduction in water availability could be managed by most farms and communities, although some respondents indicated they would exit irrigated agriculture. Under a 40 per cent reduction in water availability the impacts are anticipated to be greater and community viability may be threatened in the Riverland, Sunraysia, Macquarie and the Lower Balonne regions. Rice production, which is concentrated in Murrumbidgee and Central Murray, is expected to become unviable for many farms and rice mills are unlikely to operate. If water availability was reduced by 60 per cent the impacts are expected to be greater again. Catastrophic losses in economic activity are expected in water dependent communities of Namoi, Gwydir and Border Rivers and industries would significantly contract in Sunraysia and Riverland. Almost all rice farms in Central Murray and Murrumbidgee would become unviable and the dairy sector in SA Murray would close. In the GMID region the reductions would start to impose significant impacts with all but one of the seven dairy factories expected to close.

Finally, the report provided a discussion on options for governments to ease the transition to lower water availability. These included provision of full information about the proposed changes and any compensation, adequate time to understand the SDLs before they are implemented, and coordination across governments.

Conclusion

The modelling recently commissioned by the MBDA provides a range of expected socioeconomic impacts of changes to different levels of water availability. The results from the models (primarily the ABARE and CoPS results) can be used to provide a range of the welfare impacts of the SDLs.

- For the farm level results the change in irrigator profits will be used (and a measure consistent with this will be derived using CoPS results).
- For economy-wide results GRP can be used as the welfare measure.
- Conclusions to focus on modelling work and to use MJA as a ‘sense check’.

The orders of magnitude of CoPS and ABARE results are significantly different, illustrating that the net economic effects of SDLs depend on a variety of factors. Most importantly, they depend on the ability of regional economies to reallocate economic activity from irrigated to non-irrigated agriculture and from agriculture to other economic activities.

In the CoPS results, there is a much larger reallocation of activity (driven by changes in labour, land and capital prices) than is evident in the ABARE analysis. This is most easily seen in the difference between impacts on non-irrigated agriculture.

The modelling results produced are based on long run assumptions of factor mobility. The impacts are likely to be greater in the short term as there is less flexibility in production systems. Furthermore, the short term impacts of reduced water availability are likely to include adjustment costs. Measuring the scale and nature of these adjustment costs are beyond the scope of the economic models used in the commissioned reports. Some of these adjustment costs are incorporated into the discussion by MJA et al. (2010) but other sources of information should be examined to gain a full understanding of the potential scale and scope of adjustment costs resulting from the introduction of the SDLs.

In order to fully understand the various modelling results it is important to consider the underlying assumptions in the models and scenarios. These assumptions differ between the models used in the various reports and are the primary reason for the differences in results — a crucial assumption being the extent of water use reductions assumed.

Other assumptions that are likely to influence results include the following.

- The degree of water trade assumed to occur. It appears that the water trade assumptions are consistent across the three models examined.
  - No interregional trade in the northern Basin and no trade between the northern and southern Basins.
  - No trade scenarios still include trade within the region between activities so water flows to the highest value activity.
  - Physical constraints are in the models, but institutional constraints (for example the 4 per cent cap on trade outside an irrigation area) are not included.
- Most of the results assume that SDLs don't impact on the variability of supply and a reliable supply of water is maintained to allow for perennial horticulture.
- Profits from water sales are included in the profit measure from ABARE's WTM.

Regional trade flows don't sum to zero because of transmission efficiency factors in ABARE's WTM.

F Overview of water reform and the proposed Basin Plan

Overview of water reform in Australia

In 1994 the first ministers of the federal government and state and territory governments meeting as the Council of Australian Governments (COAG) agreed on a strategic water management framework aimed at developing a more sustainable water industry for Australia. Since then, all Australian governments have separately, and in partnership, grappled with implementing these issues and made substantial improvements in the way water is priced and managed.

At a landmark meeting in 2004, COAG again signed off an Intergovernmental Agreement on a National Water Initiative that builds on the work commenced in 1994 and is now the blueprint for changing the way Australia manages its water.

Following the National Water Initiative the then Commonwealth Government also enacted the *Water Act 2007* which commenced on 3 March 2008. The National Water Initiative (NWI) remains the blueprint for water reform in Australia. The NWI places greater emphasis on understanding surface water and groundwater systems of high conservation value are identified and appropriately managed. Determining the sustainable level of extraction is one of the first steps in water planning, as the NWI is committed to return over-allocated systems to sustainable levels of extraction.

The proposed Basin Plan

A major change that has occurred over the past few years has been the introduction of the Commonwealth *Water Act 2007*. The *Water Act* 2007 establishes an independent expert-based body known as the Murray Darling Basin Authority (MDBA). The MDBA will oversee water planning for the Basin as a whole, rather than state by state, for the first time. The MDBA will be required to prepare and implement an approved strategic plan (the Basin Plan) for the integrated and sustainable management of water resources in the Murray-Darling Basin.

The *Water Act 2007* establishes mandatory content for the Basin Plan, including:

- limits on the amount of water (both surface and ground water) that can be taken from Basin water resources on a sustainable basis — known as long-term average

Sustainable Diversion Limits (SDLs). These limits will be set for Basin water resources as a whole and for individual water resources (that is, individual catchments and aquifers within the Basin);

- strategies to manage risks to Basin water resources, such as climate change;
- what state water resource plans must address;
- an environmental watering plan specifying environmental objectives, watering priorities and targets;
- a water quality and salinity management plan; and
- rules about trading water rights in relation to Basin water resources.

The Plan will seek to protect and restore key environmental assets — rivers, streams, wetlands, forests, floodplains and billabongs — and key ecosystem functions which are essential to the life of the rivers and their surrounding landscapes, as well as to human activities and cultural values. The Basin Plan must also take into account the impact of this protection and restoration on individual communities, industries, regions and the wider economy.

The Basin Plan will identify key environmental assets and ecosystem functions of water resources that must be protected. It will also identify risks to the condition or continued availability of Basin water resources and provide strategies for managing those risks.

The central legal requirement of the Basin Plan is to set environmentally sustainable limits on the amount of water that can be taken in future from the Basin's water resources for consumptive purposes, known as a 'sustainable diversion limits' (SDLs). The SDLs are defined as the water available for consumptive use after water requirements of key ecosystems and environmental assets have been met.

The SDL scenarios will result in reductions in the volume of water that is available for consumptive use throughout the regions. The proportional reduction compared to current levels of extraction will differ between the MDB regions. Therefore, the Terms of Reference require the analysis to be conducted for each MDB region separately as well as for the region as a whole.

G Overview of SDL scenarios

This appendix provides further details regarding the SDL scenarios being considered for this review, including the process required to be undertaken to establish the SDLs. Further details regarding the approach to setting each of the SDL scenarios are included in the *Guide to the proposed Basin Plan* (Volumes 1 and 2).

Description of SDLs

The Water Act requires the Basin Plan to express SDLs as the maximum long term annual average limit on quantities of surface water and groundwater that can be taken on a sustainable basis from the Basin's water resources.[70] That is, SDLs represent the volume of water available for consumptive use after the environment has received what it requires. The Water Act refers to this as the 'environmentally sustainable level of take' and requires that this level of take must be established using the best available science.

Specifically, the environmentally sustainable level of take is to be based on a level of extraction for consumptive purposes that will not compromise key environmental assets (including water-dependent ecosystems, ecosystem services, and sites of ecological significance); key ecosystem functions; the productive base; or key environmental outcomes of the water resource. SDL proposals will apply to all forms of water extraction and include watercourse diversions such as for town and community water supplies, irrigation and industries, floodplain harvesting and interception activities such as farm dams and forestry plantations.

There are 19 regions that have been identified across the Basin for the purposes of the Basin Plan. However, a total of 29 surface-water SDL areas have been identified to cater for state borders and the hydrologic units used by Basin states for their existing and proposed water resource plans. SDLs will be set for all diversions in each of the 29 surface-water SDL areas that have been established.

The MDBA has determined that the additional amount of water needed for the environment was between 3000 GL per year to 7600 GL per year. This wide range reflects the fact that there is some uncertainty regarding the environmental outcomes

70 *Water Act 2007*, s22(1) item 6.

that can be achieved. Therefore, each of the SDL scenarios reflects different probabilities of achieving specified environmental objectives.

Objectives of SDLs

The Water Act specifies that SDLs should reflect an 'environmentally sustainable level of take'. As such, the Water Act seeks to ensure the return to environmentally sustainable levels of extraction of Basin water resources that are over-allocated or overused and improve water security. Further, the Act aims to protect, restore and provide for the ecological values and ecosystem services of the Murray Darling Basin. The Basin plan includes 18 Key Indicator Environmental Assets (KIEA) for which achieving these environmental outcomes will be particularly important.

Without limiting these environmental objectives, the Act also seeks to maximise the net economic returns to the Australian community from the use and management of the Basin water resources. That is, the Act means to optimise economic, social and environmental outcomes where they involve the Basin water resources.

In its *Guide to the proposed Basin Plan*, the MDBA set three objectives to achieve this optimisation. These include to:

- meet key environmental outcomes and address the ecological health of the Basin;
- ensure each catchment satisfies its own environmental requirements such that key water-dependent ecosystems in each catchment can be returned to good health; and
- minimise social and economic impacts on Basin communities and industries.[71]

The SDLs are also designed to achieve the obligations under the *Water Act 2007*. The Act (section 23(1)), for example, requires the MDBA to establish SDLs that reflect an environmentally sustainable level of take, that is a level of extraction that will not compromise the environmental water requirements of key environmental assets, including water-dependent ecosystems, ecosystem services, and sites with ecological significance; key ecosystem functions; the productive base; and key environmental outcomes for the water resource. In setting SDLs the Act also specifies the need:

> to give effect to relevant international agreements (to the extent to which those agreements are relevant to the use and management of the Basin water resources) and, in particular, to provide for special measures, in accordance with those agreements, to address the threats to the Basin water resources; and
>
> in giving effect to those agreements, to promote the use and management of the Basin water resources in a way that optimises economic, social and environmental outcomes[72]

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71 MDBA 2010, *Guide to the proposed Basin Plan — Volume 1*, p. 101.

72 Section 3 of the *Water Act 2007* describes the objectives of the Act.

Of particular importance in regards to the international agreements is the Ramsar Convention on Wetlands.[73] The Ramsar wetlands are recognised as being of national environmental significance under the Commonwealth *Environmental Protection and Biodiversity Conservation (EPBC) Act 1999.*

Approach to setting SDLs

The MDBA's approach to setting the SDL scenarios has been undertaken using the following steps:

1. establishing the current diversion limits and determining the environmental water requirements of the Basin;
2. assessing the socioeconomic impacts of meeting environmental water requirements;
3. determining the limit of reductions beyond which the socioeconomic impacts are unacceptably high;
4. analysing SDL scenarios that meet environmental water requirements and optimise socioeconomic impacts; and
5. proposing SDLs for the purposes of consultation.

The MDBA has undertaken a stepped approach to developing SDL proposals by bringing together environmental requirements and a consideration of social and economic impacts.

SDL scenarios considered

The MDBA have specified a range for SDL scenarios that involve an additional 3000 GL, 3500 GL and 4000 GL per year for environmental water. The MDBA has not considered additional water beyond this range due to the potential cost to irrigators and the community. That is, the MDBA has implicitly judged that the gains to the environment of providing, for example, an additional 7600 GL per annum to the environment would *not* outweigh the costs to the irrigators and regional communities.

The reduction in long term water availability specific to each region under each of these scenarios in specified in table G.1. This does not take account of the entitlement buybacks that have occurred over the past few years. That is, in some regions it is

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[73] This convention was agreed at Ramsar (in Iran) in 1971 and came into force in 1975. The resulting agreement known as the Ramsar Convention, is an intergovernmental treaty that commits its member countries to maintain the ecological character of the Wetlands of International Importance and to plan for the sustainable use of the wetlands in its territories.

possible that the reductions indicated in this table have already been achieved through the buyback program. Therefore, it is important to recognise that these reductions in water availability are *not* in addition to the reduction in water availability due to entitlement buybacks.

G.1 **Regional allocations of water reductions**

	Scenario 1		Scenario 2		Scenario 3	
	GL/y[a]	%[b]	GL/y[a]	%[b]	GL/y[a]	%[b]
Barwon-Darling	43	14	50	16	56	18
Intersecting Streams (diversions only)	0.8	14	0.9	16	1.0	18
Border Rivers (Qld)	43	14	49	16	55	18
Border Rivers (NSW)	43	14	50	16	56	18
Campaspe	40	26	46	30	52	33
Nebine	2	8	2	8	3	9
Condamine-Balonne	203	21	238	24	272	28
Marne Saunders (diversions only)	0.0	0	0.0	0	0.0	0
EMLR	2.8	26	3.3	30	3.7	35
Goulburn	442	26	518	30	593	35
Broken	6	10	6	10	6	11
Gwydir	89	20	105	23	121	27
Lachlan	44	7	57	9	69	11
Loddon	38	21	38	21	43	23
Lower Darling	16	26	18	30	21	35
Macquarie Castlereagh	104	14	120	16	135	18
Moonie	12	14	13	15	14	17
MURRAY NSW	474	26	556	30	635	35
MURRAY VIC	442	26	518	30	592	35
Kiewa	4	18	4	18	5	20
MURRAY SA	173	26	203	30	232	35
Murrumbidgee (NSW)	665	26	780	30	892	35
ACT	13	26	16	30	18	34
Namoi	72	14	83	16	94	18
Ovens	10	12	10	12	11	13
Paroo	0.0	0	0.0	0	0.0	0
Warrego	18	14	18	14	20	16
Wimmera-Avoca	0	0	0	0	0	0
BASIN TOTAL	3000	14	3500	26	4000	29

[a] Equal to current diversion limits minus SDLs.
b Equal to the percentage reduction in current diversion limits.
Source: MDBA calculations.

The table above illustrates that there are significant regional differences in the SDL scenarios. For example, there is no additional environmental water being proposed for the Paroo River. In contrast, a reduction in water availability for extractive uses of 35 per cent is proposed for the Murrumbidgee and Murray rivers.

From the *Guide*, the new SDLs will come into effect as existing water sharing plans expire — beginning in 2014 in Queensland, New South Wales and South Australia, and in 2019 in Victoria. Current surface water diversions for irrigation are limited by a cap on river diversions within the Basin, which was determined on the basis of historic use rather than sustainability. This is important to acknowledge from the point of view of a BCA where the timing of particular impacts is important to understand.

It should be noted that the SDL scenarios presented above reflect a change in the volume of water available to the environment based on a long term average. However, a long term average is only one element that needs to be considered in analysing the impact of an SDL scenario. There may be a different range of options for managing environmental water that all result in the same long term average but have differing impacts on the environment and the community. In particular, an understanding of the flow characteristics under each SDL scenario is critical in trying to understand the potential ecological response to the additional water.

Therefore, implicit in the SDL scenarios presented to us are also changes to the regime for managing environmental water. The changes in the management regimes are designed to achieve the targets set in the Environmental Watering Plans for each of the identified icon sites in the Basin. This change in the management regime is important as it is aimed at achieving the best environmental outcomes at these sites with the additional quantity of water available for each of the SDL scenarios.

The management of this environmental water to meet the targets at the icon sites can also have other side effects. This includes, for example, changes in storage levels which can influence recreational use of the storages as well as provide different levels of flood protection. These changes can also have other indirect impacts such as on salinity loads in the river.

Therefore it is important to understand in more detail the specific characteristics of the SDL scenario. These characteristics are important to understand the potential costs and benefits of the alternative scenarios.

H Approach to evaluating SDL scenarios

This appendix explains the framework used to draw together information on the benefits and costs of alternative SDL scenarios. The approach utilises a BCA framework, consistent with the Office of Best Practice Regulation (OBPR) Guidelines.[74]

Conceptual framework

The conceptual framework used to evaluate the alternative scenarios is based on the principles of neo-classical economics. This involves establishing criteria that are used to judge the superiority of the alternative options. Under the neo-classical economics approach:

> Judgements regarding the relative merits of alternatives are made on the basis of their consequences for the wellbeing of people.[75]

Under this framework, the environment does not hold some intrinsic right and is judged only on its contribution to the wellbeing of people. Therefore, the relative merits of the alternative scenarios are judged on their contribution to the overall wellbeing of society. The scenario that results in the greatest improvement to the wellbeing of society is the one that is judged to be the superior option.

The impacts of the alternative scenarios are described as costs or benefits to the wellbeing of society. All the costs and benefits associated with the alternative SDL scenarios need to be considered to enable a comprehensive assessment of the contribution to the wellbeing of society. This is embodied in the Terms of Reference for this project that requires the evaluation to 'specifically consider the value of environmental costs and benefits alongside other social and economic costs and benefits'.

This form of evaluation is typically known as a benefit–cost analysis. Guidelines have been issued by the Australian Government that detail the various steps required to

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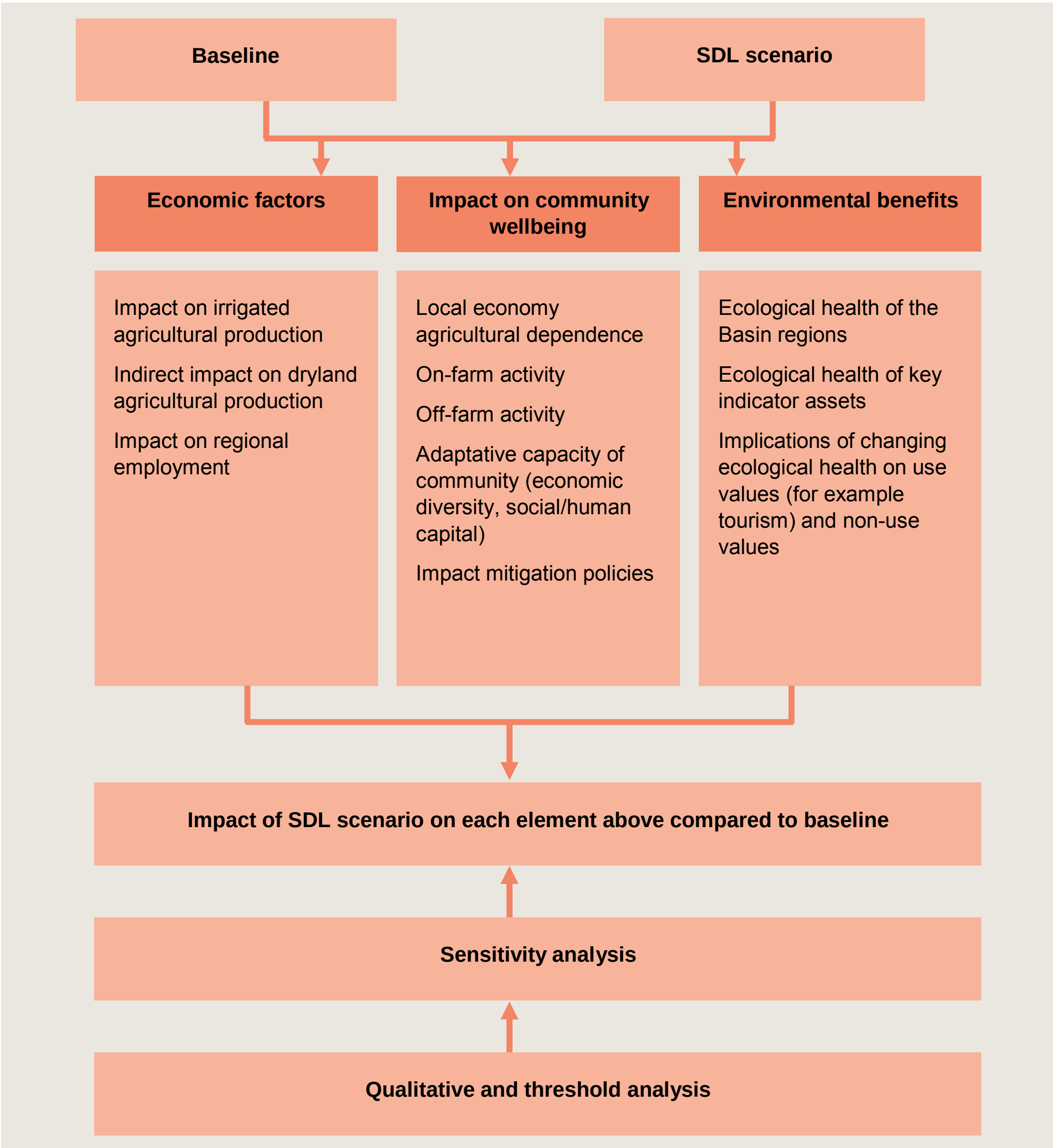
[74] A copy of the Guidelines is available from the following weblink http://www.finance.gov.au/obpr/cost-benefit-analysis.html

[75] Bennett (2010), *Making Decisions About Environmental Water: An Economics Approach*, June.

conduct a robust assessment. The methodology adopted for this project is consistent with these Guidelines.[76]

A schematic summary of the methodology is presented below.

H.1 **Overview of framework**



Data source: The CIE.

The general steps required to implement this methodology are discussed further below.

76 http://www.finance.gov.au/publications/finance-circulars/2006/docs/Handbook_of_CB_analysis.pdf.

Step 1 — establishing baseline

In order to examine the effects of alternative SDL scenarios, a baseline has to be developed. The baseline represents the outcomes that could reasonably be expected to occur in the absence of the Basin Plan given factors such as expected market conditions and changes in government policies which could, for example, limit (or enhance) the scope for water trading. It also includes expected future climatic conditions where there is a greater level of risk surrounding these estimates.

A baseline also has a time dimension. That is, it is not just based on today's situation but takes account of the underlying trends into the future as well. For example, if there is an underlying movement of the labour force away from the agricultural sector then this trend would be reflected in the baseline. Similarly, if the long term state of the environment is deteriorating due to, for example, climate change then this would also be reflected in the baseline.

While such factors need not be the focus of this analysis, it is important that the assumptions regarding these factors are considered carefully in establishing the baseline. The reason for this is to ensure that the BCA can focus on those changes solely caused by the SDL scenario and does not incorporate changes due a range of other elements.

Further the choice of elements that make up the baseline will also necessarily be informed by the assumptions utilised in existing studies commissioned by the MDBA. If, for example, the majority of the socioeconomic studies make certain assumptions regarding the baseline then it may be pragmatic to adopt a similar baseline for our study.

The baseline used in this report does not include the licences that have already and are continuing to be purchased by the Commonwealth and state governments or government funded programs to improve irrigation efficiency. These programs are considered as programs to assist the irrigation community to adjust to the new SDLs.

Step 2 — assessing changes from the baseline

The next step involves understanding the marginal changes from the baseline of alternative SDL scenarios. This will typically involve understanding how each of the SDLs impacts on a range of social factors (for example agricultural production and regional employment) and environmental factors (for example changes to the health of wetlands).

These changes will be complex and depend on a range of factors, many of which may not be known with certainty. Some of the changes may be a direct result of the change in SDL while other changes may occur indirectly as a result of changing the SDL. The magnitude and direction of these changes are likely to differ between the regions depending on their specific characteristics.

Step 3— converting the changes into a welfare impact

The information regarding the changes from the baseline (described in Step 2), may not be able to be directly incorporated into a BCA framework. That is, some of this information would require to be 'converted' into a form that can be used in the analysis. For example, the biophysical changes of alternative SDLs need to be converted into a change in societal wellbeing. Similarly, the economic impacts described through economy-wide modelling may need to be converted into a welfare impact.

Step 4 — aggregating the impacts

Once the changes are converted into welfare impacts they need to be aggregated in a consistent manner to assess outcomes so as to avoid issues such as 'double counting' of impacts. In aggregating it is important to identify the timing of each of the impacts. Some impacts may be immediate while other impacts may not result for some time. Our analysis will utilise discount rates (consistent with the OBPR Guidelines) to aggregate impacts that occur at different points in time.

Step 5 — sensitivity analysis

Typically in any economic analysis there are information gaps or key pieces of information are not known with certainty. Therefore, the purpose of sensitivity analysis is to test whether the results change under alternative assumptions of key parameters where there may be limited information.

Sensitivity analysis is a useful tool for the BCA. It will be able to inform the major drivers of benefits and costs in terms of aspects of the MDBA process that are least well understood.

Step 6 — threshold and qualitative analysis

Where marginal changes cannot be valued (in Step 3) and incorporated directly into the quantitative analysis, this information forms part of a qualitative assessment of the SDL scenarios. This assessment is likely to be most useful where it is difficult to distinguish between alternative SDLs scenarios. A qualitative assessment may help to further evaluate the merits of the scenarios. Where information on the potential scale of environmental change resulting from alternative SDLs is not available threshold analysis will also be used to test the extent of environmental change required for the SDL scenario to have benefits in excess of costs.

I Impacts of the recent drought

The socioeconomic modelling commissioned by the MDBA provides a useful basis to understand the potential impact of lower water availability due to reductions in the SDLs. In order to supplement the modelling results it is useful to consider how irrigated agriculture has responded to the drought over the past decade and the impacts that this has had on the community.

This appendix provides some data regarding the impact of the drought on regional communities over the past decade. We also present some additional data on the socioeconomic impacts on the Lachlan valley which has some of the lowest water allocations in recent times.[77] The information presented in this appendix is not intended to be a detailed empirical analysis but is intended to provide background information to assist in interpreting the results of the economic modelling.[78] We also recognise that irrigators and communities responses to a drought (which would be generally considered to be a short term event) could also differ to a long term reduction in water availability.

Baseline developments in population and services

Key points

ABS data and the ABS/ABARE/BRS report for MDBA show that:

- the population of the Basin increasing, although at a slower rate than the rest of Australia;
- the population of the Basin is becoming more concentrated in the larger urban centres;
- the number of people living in remote areas and small towns in the Basin is decreasing;

[77] There has also been a reduction in licence entitlements in the region due to a number of buybacks, although more recent data would be required to better understand these impacts.

[78] Further useful background information is also likely to be attained from a study on potential localized impacts that has been recently commissioned by the MDBA.

- the number of farmers in the Basin is falling but the number of older farmers (over 55) is increasing;
- the number of farms in Australia has been steadily declining;
- many small rural towns are already in decline; and
- services in rural towns have been declining for a number of reasons.

Based on these observations, and the magnitude of the changes in employment projected to occur as a result of the SDLs, it can be concluded that the estimated decline in employment as a result of the SDLs are relatively small in comparison to recent past changes.

Past changes in population in the MDB and regions

ABS/ABARE/BRS (2009) data indicates that between 2001 and 2006 the population of the MDB increased by 3 per cent (compared to over 6 per cent nationally). The most significant growth was in the Eastern Mount Lofty Ranges, Campaspe and Condamine-Balonne regions. Some regions, however, experienced declining populations, namely Paroo, Warrego, Moonie, Gwydir, Barwon-Darling, Lachlan and Wimmera.

The population changes within the regions indicate a trend of migration from remote and rural areas to urban centres. Those regions without large urban centres showed the greatest rate of population decline (Barwon-Darling and Paroo), while those areas with large urban centres, such as Toowoomba in Condamine-Balonne have experienced increasing populations (ABS/ABARE/BRS 2009). The number of people living in rural areas declined by around 1.7 per cent between 2001 and 2006, while the population of the large and medium sized urban centres (>5000) increased by 8 per cent. The population of remote and very remote areas of the MDB declined by 10 and 32 per cent respectively.

These findings are supported by Statistical Local Area (SLA) level data from the ABS which shows that the areas in the Basin with the greatest population decline between 2004 and 2008 were generally the SLAs with smaller populations and low population density (Bourke, Bulloo, Paroo and Warren). 100 per cent of the populations of the Bulloo and Paroo SLAs are classified as very remote. The population of Bourke is mostly classified as remote and Warren is predominantly classified as outer regional. Conversely, those areas that experienced population growth were generally more populated areas (such as Gr. Bendigo — Inner North and S'saye, Southern Downs — West and Mitchell — South). These areas have either 100 per cent or a majority of the population living in inner regional areas.

Judith Stubbs and Associates (2010) note that while there is a connection between water policy and impacts on communities, they also highlight that communities are continually evolving as a result of other influences. The broader context in which changes are occurring needs to be considered. The report by JSA also highlights that there has been inconsistencies between quantitative and qualitative data, with quantitative evidence suggesting that communities are resilient to decreases in water. However, members of the community remain concerned that a decrease in water entitlements would have negative social and economic impacts.

Past changes in employment

The largest employing sector in the Basin is wholesale and retail trade (14 per cent of employed persons) followed by public administration (12 per cent, including Canberra), agriculture (11 per cent) and education and training services (11 per cent). The industries that increased the most over the period from 2001 to 2006 were mining, Government administration and defence, and construction. The greatest decline in employment was in agriculture, fishing and forestry, declining by 12 per cent. Increases in employment have generally followed the patterns of population change, with the greatest increases in the larger urban centres at the expense of employment in smaller towns.

The number of farmers in the Basin fell between 2001 and 2006 by 7.4 per cent, similar to the trend observed throughout Australia. ABS/ABARE/BRS (2009) suggests that this trend may indicate a change in the structure of Australian agriculture driven by a number of factors including the working conditions and wages in agriculture compared to other industries. ABARE (2009) statistics show that the number of farms in Australia has been steadily decreasing since 1966. Between 1966 and 2007 the number of agricultural establishments declined from 198 200 to 140 704, a decrease of around 30 per cent. As with the observed declines in populations, the decrease in the number of farmers is most pronounced in the remote and very remote areas. The Murray and Murrumbidgee regions had the greatest number of farmers, but the greatest proportion of people employed as farmers were in the small remote regions (Moonie, Paroo, Gwydir and Barwon-Darling).

The agriculture sector has the greatest proportion of workers aged over 45 (68 per cent) and over 65 (19 per cent) in 2006. The number of farmers over 65 increased by around 11 per cent from 2001 while the total number of farmers decreased — a strong indicator of the aging population. The number of farmers across the other age groups (25–54) decreased. This pattern was consistent across all of the MDB regions. The high proportion of farmers in the older age brackets suggests that the decline in farmer numbers is likely to accelerate as these farmers retire.

Past changes in rural service levels

Alston (2002) discusses some of the drivers of social change in inland Australia. Some of the reasons for change raised by Alston include the lack of full-time work and education in rural areas which lead young people to leave rural communities; a decline in institutions, brought about by changes in government policies, reducing the services available in rural areas and also leading to a decline in employment opportunities. Alston suggests that the decline in government run services has been a result of a shift towards market driven services and centralisation of services to regional centres and capital cities. Alston considers six LGAs in detail and notes the decline in services observed between 1990 and 2002. These areas lost banking facilities as well as government social services, health services, education facilities, transport and private companies.

Beer and Keane (2000) suggest that the decline in services in rural SA have been driven by the privatisation of public sector utilities, the rationalisation of private sector activities and cuts to government programs that support rural communities. In addition to changes in government policies, the introduction of the internet and online services and a general shortage of doctors in Australia have contributed to a reduction in the service provision in regional areas. As government services and private companies withdraw from the regional areas not only do services decline but population and employment opportunities decrease.

Stayner (2006) describes a number of changes that have occurred in rural Australia over the past few decades, including:

- agricultural value adding has moved to regional centres and metropolitan areas;
- farm machinery is produced in metropolitan centres and overseas;
- economies of scale have driven machinery and other input suppliers to regional centres supplying large areas;
- technological developments and economies of scale has lead to the closure of smaller banking facilities;
- agricultural research and production of inputs such as chemicals, communication equipment and genetic material have scale economies and so are concentrated in fewer places;
- improvements in communications and transport have allowed farmers to source inputs from more distant centres; and
- non-agricultural businesses (retail, medical, education) have experienced technological developments that have lead to scale economies, changing consumer demands and easier access.

Together, these changes have led to the erosion of rural communities.

Comparing the employment results from SDL modelling with historical changes

The modelling results produced by CoPS indicate that in the first year after the introduction of the SDLs, employment in most of the regions would fall. The regions with the largest expected absolute change are Condamine-Balonne with employment falling by 76 full-time equivalent (FTE) and Goulburn-Broken (39 FTE).

The ABS SLA level data can be used to estimate the number of employed people over the period 2004 to 2008. These estimates show that employment has changed quite a lot in most areas. For example, the Indigo Pt A SLA, in the Ovens region, had a decrease in employment of 873 between 2004 and 2008. At the same time, employment in the Tamworth Pt A SLA (Namoi region) increased by 5560. In the Condamine-Balonne region as a whole, the number of employed people over this period increased by around 6400, averaging 1600 a year.

Based on the current patterns of population change, it is likely that further loss in jobs from the introduction of SDLs would be expected from the more regional SLAs. The SLAs in Condamine-Balonne with the greatest proportion of population living in remote or very remote areas are Balonne, Roma–Bendemere, Roma–Booringa, Roma–Waroo, Paroo, Bulloo, Brewrrina and Roma–Bungil. Together, these SLAs have a population (in Condamine-Balonne) of around 11 000, employment of around 7200 and nearly no change in employment between 2004 and 2008. The change in employment for the Condamine-Balonne region estimated by CoPS was 0.17 per cent. If all of these employment losses come from these remote and very remote SLAs the change in employment in these regions would be around 1 per cent.

It is also likely that the job losses could come from the areas more reliant on irrigation. The SLAs in Condamine-Balonne with the greatest proportion of agricultural land irrigated were Pittsworth, Jondaryan, Southern Downs–Allora, Clifton, Dalby–Wambo and Millmerran. The total population of these SLAs is 27 000. Employment in 2008 was 15 000 and the number of people employed decreased by 720 between 2004 and 2008. If the employment losses for the Condamine-Balonne region are concentrated in these regions, the change in employment in these areas would be around 0.5 per cent.

ABARE estimated the change in employment for the Queensland MDB region to be -0.09 per cent, around half of the rate of decline estimated by CoPS for Condamine-Balonne.

Long run estimates for changes in employment by CoPS are almost four times greater than the short run estimates. The Condamine-Balonne region is projected to lose 284 jobs by 2026. If concentrated in remote areas, this would be a decrease of around 4 per cent of employment in these areas and if concentrated in the irrigation areas the loss would be around 2 per cent.

In the Goulburn Broken region most of the population lives in inner regional areas. The areas with the greatest proportion of irrigated land were Gr. Shepparton–Part B West, Gr. Shepparton–Part A, Moira–West and Gr. Shepparton–Part B East. Together these SLAs have a population of around 80 000, the number of employed people is about 38 000 and the decrease in the number of employed people between 2004 and

2008 was 4500. If the total population decline estimated by CoPS fell on these SLAs, employment would fall by 0.1 per cent (compared to 12 per cent between 2004 and 2008). In the long run the change would be 0.3 per cent.

The examples in table I.1 show that the estimated decline in employment as a result of the SDLs are relatively small in comparison to recent past changes even when concentrated in particular areas of the MDB regions.

Threshold town size for provision of services

A key concern in the community from the introduction of SDLs and the resulting decline in economic activity and population is that small towns will lose services due to a lack of population.

Central place theory states that there is a threshold or minimum population or income needed for the sale of a good or service. For towns with populations lower than this threshold, the good or service would not be offered. There is limited literature, however, that attempts to quantify the threshold populations for different goods or services. Coon and Leistritz (2002) attempt to identify the threshold population levels for rural retail businesses in North Dakota. They find that the threshold differs between business type, and that the threshold has changed over time. Their results estimate the threshold populations in 2000 to be between 212 for eating places to 2606 for department stores. A comparison with similar study conducted in 1988 found that the thresholds have increased by between 150 and 1700 per cent (for drinking places and variety stores respectively). Other literature suggests that threshold populations could be around 2500-5000 (Darling and Tubene 1996; Besser 2008). Henderson and Taylor (2003) found that in Texas a hospital would require a population of 35 675 with per capita income of $18 000, 47 miles from the nearest metropolitan centre.

The following charts plot the population of SLAs in the MDB against the number of education, retail trade and health and community services businesses in the SLA. Charts I.2 and I.3 show that there is a broad linear relationship between population and the total number of businesses and the number of retail businesses. The relationship between population and education appears to be less clear, with a number of areas with populations up to 10 000 recorded as not having any educational businesses (which includes government businesses) (chart I.4). The relationship between health and community services and population is stronger with no areas with a population over 5000 recorded as having no services (chart I.5).

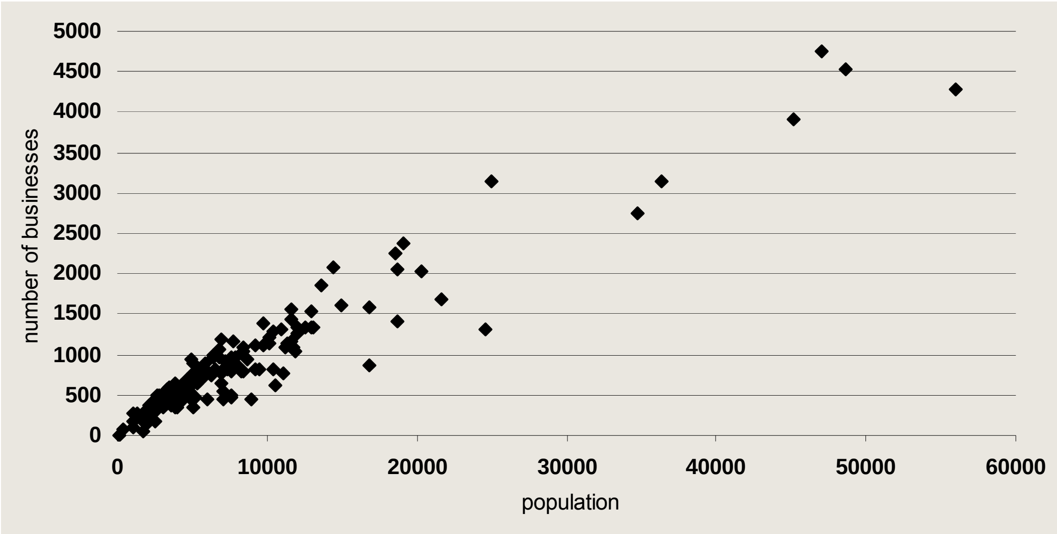
If a threshold existed, the graphs would show all points below a certain population having no businesses in a particular industry. Based on these scatter plots, there does not seem to be a clear threshold for these industries. It could be argued that the thresholds are 2000 for education and 1000 for health and community services and cultural and recreational services, but there are a number of SLAs with populations greater than these thresholds without the relevant services (see chart I.6).

I.1 Projected change in employment in NRM regions and past change in employment in remote SLAs

NRM Region	Projected change in employment	Projected change in employment	SLAs with remote populations	Past change in employment 2004-08	Projected change in employment if the regional impact is concentrated wholly within this SLA
	%	FTE		%	%
Paroo	-0.07	-1	Bulloo (S)	0.0	-0.34
			Quilpie (S)	30.7	-0.09
			Paroo (S)	17.1	-0.07
Namoi	0.017	7	Narrabri (A)	20.7	0.09
			Walgett (A)	9.4	0.18
Gwydir	0.041	3	Moree Plains (A)	21.5	0.03
Border Rivers	-0.137	-16	Goondiwindi (R) - Inglewood	4.4	-1.08
			Dalby (R) - Tara	-0.7	-0.94
Condamine-Balonne	-0.171	-1	Balonne	16.1	-0.03
			Roma – Bendemere	9.5	-0.16
			Roma – Booringa	7.5	-0.09
			Roma – Waroo	3.7	-0.16
			Paroo	17.1	-0.07
			Bulloo	0.0	-0.34
			Brewrrina	11.4	-0.11
			Roma – Bungil	-21.4	-0.09
Warrego	-0.063	-76	Murweh (S)	-5.1	-2.53
			Bourke (A)	16.8	-3.96
Macquarie-Castlereagh	0.019	-2	Coonamble (A)	23.1	-0.08
			Warren (A)	15.9	-0.09
			Warrumbungle Shire (A)	11.9	-0.04
Barwon-Darling	0.011	14	Cobar (A)	10.0	0.50
			Bogan (A)	-1.7	0.94
Lachlan	0.005	0	Parkes (A)	19.0	0.00
Murrumbidgee	-0.005	1	Carrathool (A)	-0.5	0.05
			Hay (A)	-0.7	0.06
Murray NSW	-0.021	-4	Balranald (A)	22.2	-0.24
Lower Darling	-0.025	-10	Wentworth (A)	7.3	-0.26
Murray Vic	-0.044	-1	Mildura (RC) - Pt B	4.9	-0.04
Loddon	-0.018	-25	Loddon (S) - South	4.7	-1.12
			Loddon (S) - North	5.1	-1.21
Campaspe	-0.104	-13	Campaspe (S) - Rochester	-9.5	-0.32
Murray SA	-0.045	-39	Southern Mallee (DC)	17.4	-2.95

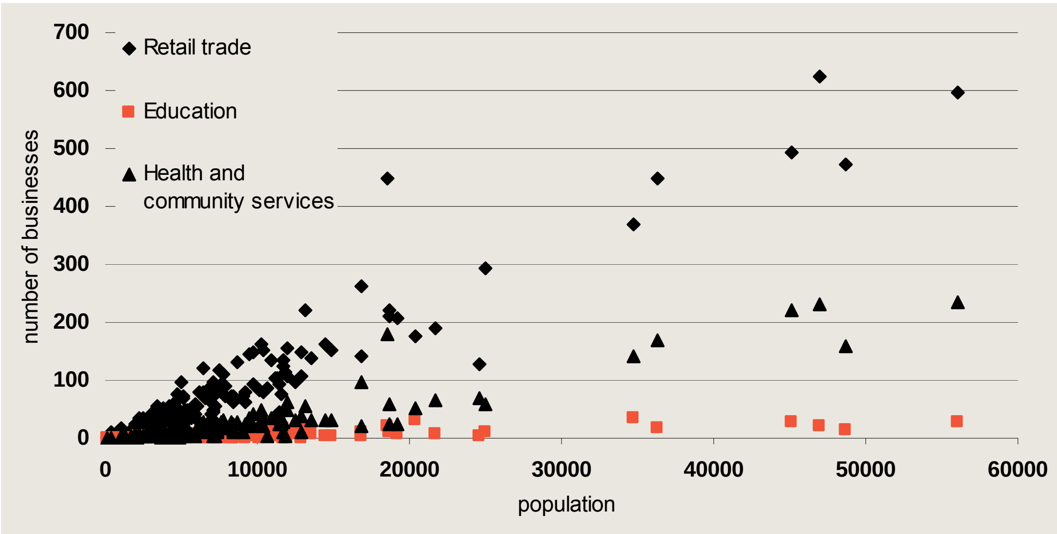
Source: Based on CoPS 2010 and ABS 2010.

I.2 Scatter plot of SLA population to the total number of businesses



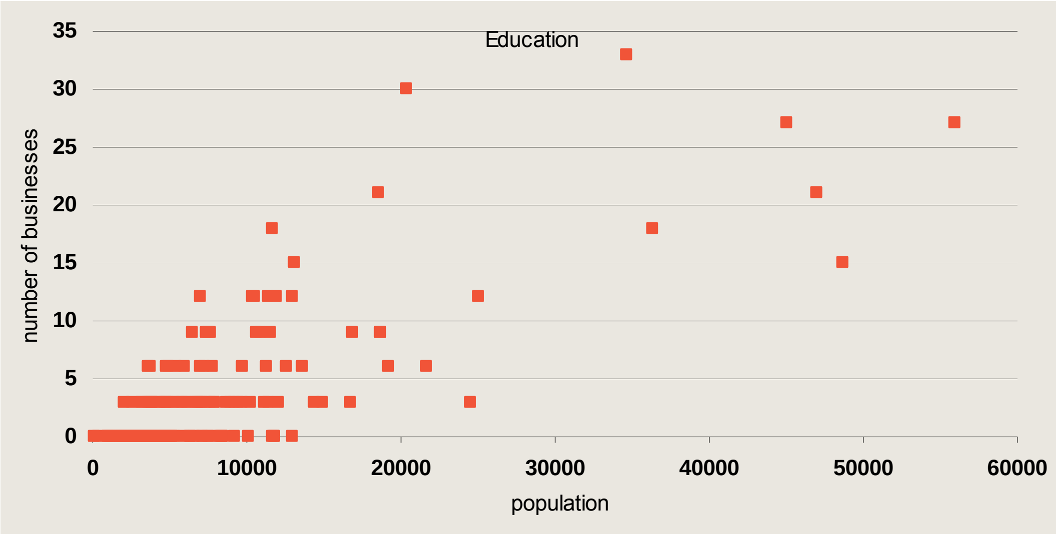
Data source: Based on ABS 2010.

I.3 Scatter plot of SLA population to the number of retail, education and health businesses



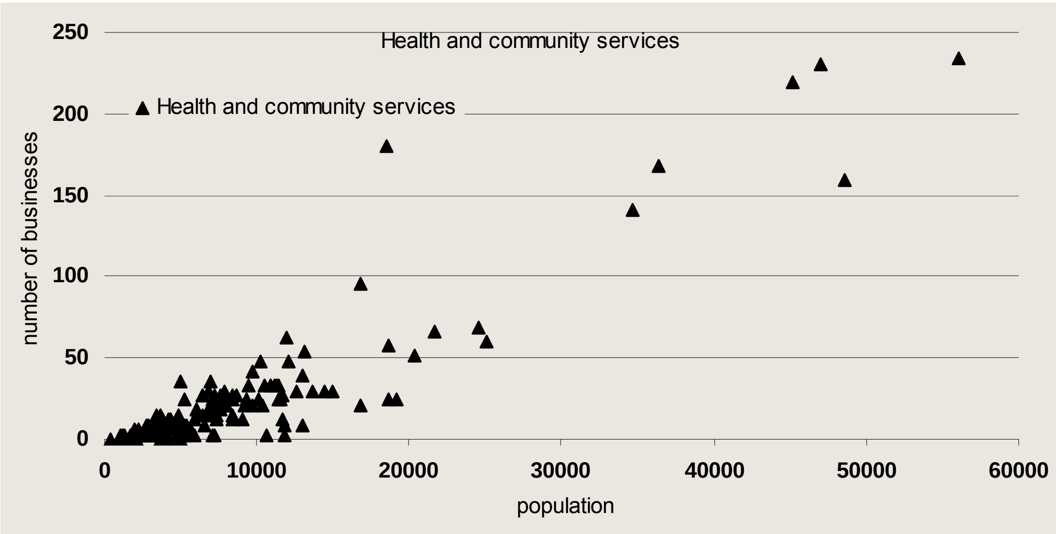
Data source: Based on ABS 2010.

I.4 Scatter plot of SLA population to the number of education businesses



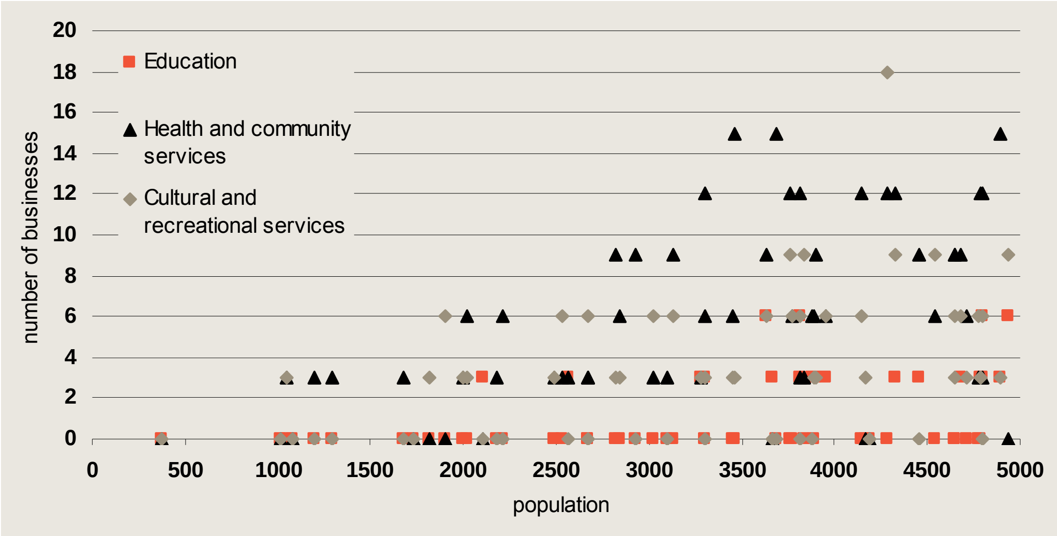
Data source: Based on ABS 2010.

I.5 Scatter plot of SLA population to the number of health and community service businesses



Data source: Based on ABS 2010.

I.6 **Scatter plot of SLA population to the number of education, health and cultural businesses (for SLAs with population below 5000)**



Data source: Based on ABS 2010.

Community resilience to decreased water availability in the Lachlan

The Lachlan region, located in central New South Wales, has experienced severe drought for most of the past decade. Dry conditions have impacted farm businesses with annual average water usage falling from 378 GL prior to the drought to just 84 GL over the five years to 2007–08. As such, the Lachlan region could yield important insights into the impact of reduced water availability on local communities.

We utilised readily available information from sources including the ABS and ABARE, drawing on time-series data during the recent drought to understand the changes. There has been some limitation in information availability to allow us to draw out a detailed time-series across all the relevant indicators. Nevertheless, by selecting a number of indicators it does help to provide some picture of community response.

Further, data is not always available for the current years which would provide additional insight into the response to low water availability. That is, the effects of the drought may have longer term implications that may not be immediately evident in the short term.

Regional overview

Around 85 per cent of land in the Lachlan region is used for agriculture. The latest ABS Agricultural Census indicated that the proportion of agricultural land used for irrigated agriculture was 0.9 per cent for the Lachlan Sustainable Yield Region (SYR) compared to 2.0 per cent for the Murray-Darling Basin.[79] Nearly one quarter of the farms in the region irrigated wine grapes, 10 per cent were dairy farms, and the remainder had a mix of broadacre and horticulture crops.[80]

Past demographic and economic trends in the Lachlan

Over the decade to 2009, the population of the Lachlan SSD has declined 2.5 per cent to around 55 000.[81] While smaller rural areas within the Lachlan subdivision have declined by up to 9 per cent, the population of larger regional centres such as Cowra has increased.[82] This is consistent with insights gained by MJA through regional consultations which suggested that 'population within the larger urban centres has been stable with mining being an important source of off-farm income and employment'.[83]

ABS Census data indicates that the number of people employed in the Lachlan region declined from around 25 000 in 1996 to 21 800 in 2006. However, over this period regional unemployment also fell from 9.2 per cent to 6.6 per cent.

Shifts in the industry composition of regional employment are also evident through Census data. For instance, while the Agriculture, Forestry and Fishing industry has consistently employed the greatest number of Lachlan residents, with 4961 employees in 2006, the dominance of the industry has decreased since the 2001 Census period. Over the same period employment in the mining, utilities, transport and accommodation and food services sectors have grown.

Chart I.7 shows employment figures for selected comparable industries in the Lachlan region over the past three Census periods.

While total household incomes in the Lachlan region have declined since 2006, wage and salary incomes have continued to grow since 2004 (Chart I.8). Also an indicator of general economic health, building approvals have been in decline since 2005 as has the value of total residential building. However, both the value of total building and the value of total residential building remain well above 2001 levels.

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79 ABS, ABARE and BRS 2009, Lachlan Sustainable Yield Region Regional Profile, prepared for the Murray Darling Basin Authority.

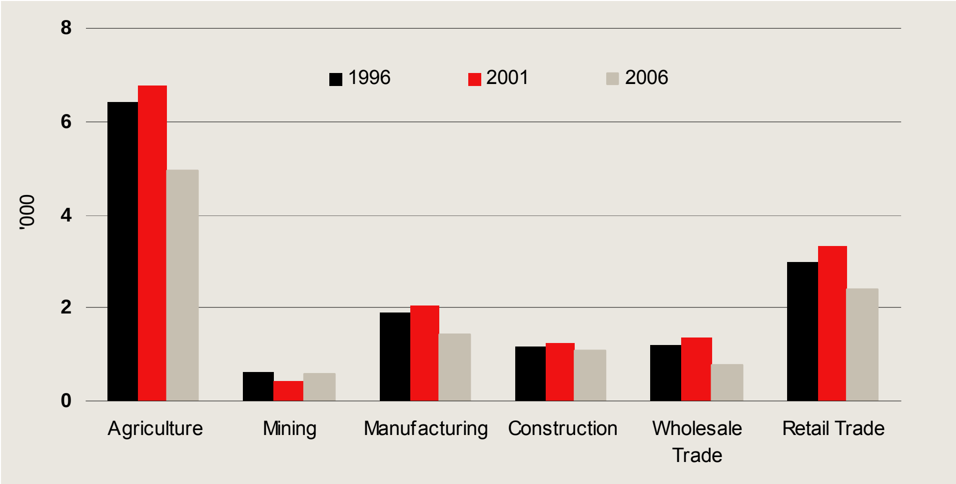
80 ABARE 2008, An economic survey of irrigation farms in the Murray Darling Basin — Lachlan regional profile, research report, September.

81 The ABS Lachlan SSD covers a smaller geographical area than the Lachlan SYR. SSD and SLA data were utilised given their geographical disaggregation and consistency over Census periods. The Lachlan statistical subdivision covers over 40 000 square km in central west NSW. It includes the major towns of Cowra, Parkes, Forbes and West Wyalong.

82 ABS 2010, Regional Population Growth, Australia, 2008–09, Cat. 3218.0.

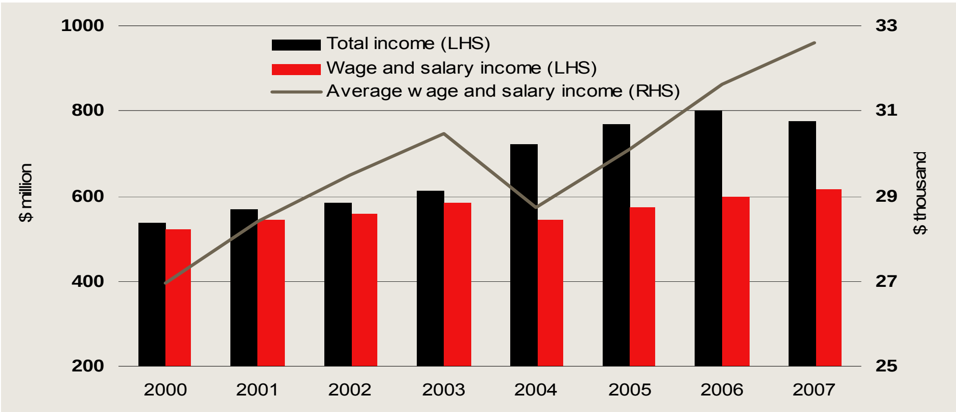
83 MJA 2010, Economic and social profiles and impact assessment in the Murray Darling Basin, prepared for the Murray Darling Basin Authority, May.

I.7 Employment in selected industries, Lachlan SSD



Data source: ABS Census data.

I.8 Income in the Lachlan region, 2000–2007



Data source: ABS National Regional Profile, 2000 to 2004 and 2004 to 2008.

Farm productivity and income

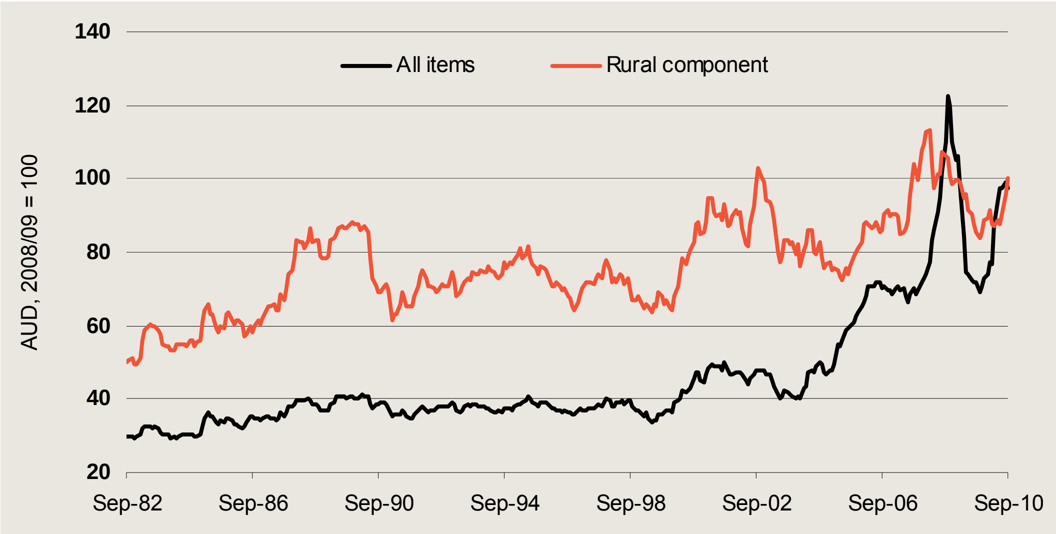
ABARE reports average cash income for Lachlan irrigation farms of around $73 000 in 2006–07, and an average farm business loss of around $37 950. Overall irrigators in the Lachlan region recorded an average rate of return to capital and management (excluding capital appreciation) of around 0.9 per cent. A lack of data prevents comparison of this figure with previous years,[84] however while the rate is positive it is also well below that of the Border Rivers (3.9 per cent) and Namoi (4.2 per cent) regions.

It is noted that despite declining water availability, farmers in the Lachlan may have benefited from rising commodity prices (Chart I.9) over part of the drought period,

84 The upcoming release of the ABARE 2009 survey of irrigators in the Murray-Darling Basin will provide updated data on the incomes and debt position of farms within the region.

which may have partially offset the income effects of drought. Although this is likely to depend on the exact mix of crops in the region over this period.

I.9 RBA index of commodity prices



Data source: RBA 2010.

Conclusions

Appendix E provided estimates of the potential socioeconomic impacts of the SDL scenarios using sophisticated general equilibrium models that seek to capture the direct and indirect impacts on towns. In this appendix we have sought to 'sense-check' the modelling results using data on recent trends in a range of different social and economic indicators. These trends during a significant drought provide some indication of how irrigators, related businesses and the broader community have responded during times of low water availability.

The general picture appears to be that there are a lot of underlying trends that are occurring in the agricultural sector and the Basin communities, irrespective to any changes in long term water availability due to the Basin Plan. It also indicates that there isn't a clear picture of a threshold for services. Services tend to rise and fall in proportion to the level of population in the particular region, rather than a large fall in services that would be evident if thresholds existed.

The Lachlan region in central NSW has been one of the worst hit areas over the last decade by the drought and through a reduction in long term water availability due to a number of substantial buyback of licences in the region. The historical data for this region suggests that the Lachlan region has suffered in terms of employment, population and economic activity during the past decade. However, the region has remained viable, despite the significant decline in water availability though shifts in population and employment structure.

While the discussion in this appendix suggests that irrigators and communities in the Basin will remain viable in the region, although there will be adjustment required. However, there are some gaps in the historical data, which limit our ability to deduce whether the viability of the Basin communities will continue into the future. For example, the data does not indicate whether there have been changes to the *quality* of services in the region such as schools or medical facilities. A medical facility may continue to operate with a lower population but there may be fewer doctors or a reduction in the hours operated. This type of information is not reflected in the data presented in this appendix.

The MDBA has recently commissioned an additional study that will provide more detailed information on the potential local impacts on the Basin communities of the changes in SDLs.

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