Economic Valuation of Environmental Benefits in the Murray-Darling Basin

Report Prepared for the Murray-Darling Basin Authority

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The Murray-Darling Basin Authority commissioned this report, amongst a number of consultancy reports, to examine a range of different aspects of the socio-economic implications of reducing current diversion limits. These studies were conducted at specific points in time during the development of the proposed Basin Plan and aimed to analyse the likely implications of a range of potential scenarios for reducing long-term average diversion limits in order to inform the MDBA on options for setting Sustainable Diversion Limits and other aspects of the proposed Basin Plan.

Executive Summary

The purpose of this report is to describe how environmental valuation can be used to support the development of sustainable diversion limits (SDLs) in the Murray-Darling Basin.

An understanding of the values that people hold for environmental, social and commercial consequences of changing water allocations and water management provides decision makers with a more complete picture of the impact of different resource allocations.

In economics, there are two main types of values: use values, which result both from the direct *in situ* as well as indirect use of a good, and non-use values, which is the value that the community has for improving the quality of a natural resource apart from any actual use. It is these values which are estimated using environmental valuation techniques.

Environmental valuation is used in several ways, including in cost-benefit analysis, understanding stakeholder preferences, pricing decisions and in litigation. In Australia, there has been increasing use of environmental valuation at a Commonwealth and State level, for a range of policy decisions and project evaluations. This is paralleled with increasing use in other countries, such as the USA, United Kingdom and New Zealand.

There are three main approaches for valuing changes in environmental quality, involving market prices, revealed preference and stated preference techniques. Market prices allow values for some direct uses to be explicitly measured. Revealed preference techniques indirectly use market data such as travel costs or house prices to value environmental quality, while stated preference techniques (including contingent valuation and choice modelling) make use of surveys to value environmental quality. Overall, confidence amongst economists is greater in the market based and revealed preference approaches because they can be verified using market data. However, stated preference techniques are the only approaches that can be used to estimate non-use values, and subsequently there is a recognition of a need to use them, though cautiously, and also to seek to improve their accuracy.

There is a range of existing market and non-market studies for the Murray-Darling Basin that have already been conducted estimating use, indirect use and non-use values. These values are summarised in this report. A methodology is proposed through which these values could be utilised to assist in the setting of SDLs. Using this methodology, values estimates for each region of the Murray-Darling Basin are identified for up to five attributes: recreation, healthy native vegetation, native fish, frequency of waterbird breeding, and waterbirds and other species. 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. In addition, the aggregate value of improving the Coorong from poor to good quality, which is $4.3 billion, is also identified. This methodology involves the use of the existing estimates, as well as benefit transfer, which is the extrapolation of existing estimates to secondary case study sites. It is necessary to use benefit transfer as there are some regions where no

primary studies are available. The use of these valuation estimates will require estimation of the effect of SDLs on relevant environmental attributes.

The emphasis in this report has been made to produce defensible value estimates based on the empirical literature (published and high quality grey literature reports). For example, many of the original studies used in identifying values have used one-off payment vehicles which is regarded as very conservative (Whitehead and Blomquist 2006). In the one case where a multi-year payment vehicle was used (Morrison et al 2010), a high rate of time preference was selected based on empirical studies of economic behaviour to calculate present values. A second conservative choice was not to aggregate values across the entire population, but only a proportion of households based on the response rate and a proportion of non-respondents (Morrison 2000). A further conservative choice was made for the base case scenario where 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. Offsetting these conservative choices, valuation estimates were developed separately for each region. If cost-benefit analysis for each region is conducted separately, this is appropriate. However, if the values are to be aggregated across the entire Murray-Darling Basin, one caveat on this approach is there may be some substitution effects. That is, if a single study sought to value improvements in the quality of the whole Murray-Darling Basin, it may prove to be less than the sum of the parts. However, this effect may not be that large as in the base case the values are only aggregated over the respondents in the State in which the asset is located.

The results presented in this report represent best available evidence about economic benefits of environmental improvements in the Murray-Darling Basin. However, it is apparent that there are a number of limitations with the data used to generate these estimates, that various assumptions have been required, and that further research is needed to refine these estimates. The results should therefore be seen as an important information source when understanding benefits in the Murray-Darling Basin, but only one informational input into this process.

Recommendations are made for capacity building in the area of environmental valuation. While there is a pool of existing studies, some are dated, and differences in methodology complicates comparison of values, and many were not designed to be transferable from their original setting. There is also a need for new studies to improve understanding of how values change across different types of regions, as well as other studies to improve the accuracy of using environmental valuation for assisting in the setting of SDLs.

1. Defining Economic Values for Natural Resources

Economists are interested in all of the aspects of a resource that a community thinks are important and not just the commercial aspects. Consequently, from a welfare economics perspective the economic value of a natural resource includes both use and non-use values.

Use values

Use values[1] result from either the direct *in situ* use of a good, or the *indirect* use of a good (see Figure 1). In a riverine context, this includes some commercial values, such as for tourism, commercial fishing, and forestry or grazing in wetland areas. However, these market values do not fully capture the use value associated with improving riverine health. Other relevant aspects of direct use values include the following:

- *Recreation* - a lot of the recreation at a natural resource (e.g., bushwalking, fishing, swimming) is not conducted by tourists. Also the value that tourists receive from recreating at a natural resource may substantially exceed the price paid.

- *Amenity* - which is the value homeowners receive from living near a natural resource

Indirect use includes values for some ecosystem services. This is pertinent for the effects of SDLs on water quality. Examples of indirect use values resulting from changes in riverine health include:

- *Water treatment costs* from declining water quality, particularly increased turbidity

- *Damage costs* experienced by downstream households, industry and infrastructure because of increased salinity

Non-use

Non-use (or passive use) value reflects individuals' willingness to pay to preserve a resource apart from any *in situ* use. In a riverine context, this includes values for healthy vegetation, native fish populations, water quality, waterbirds and other species, and various icon sites.

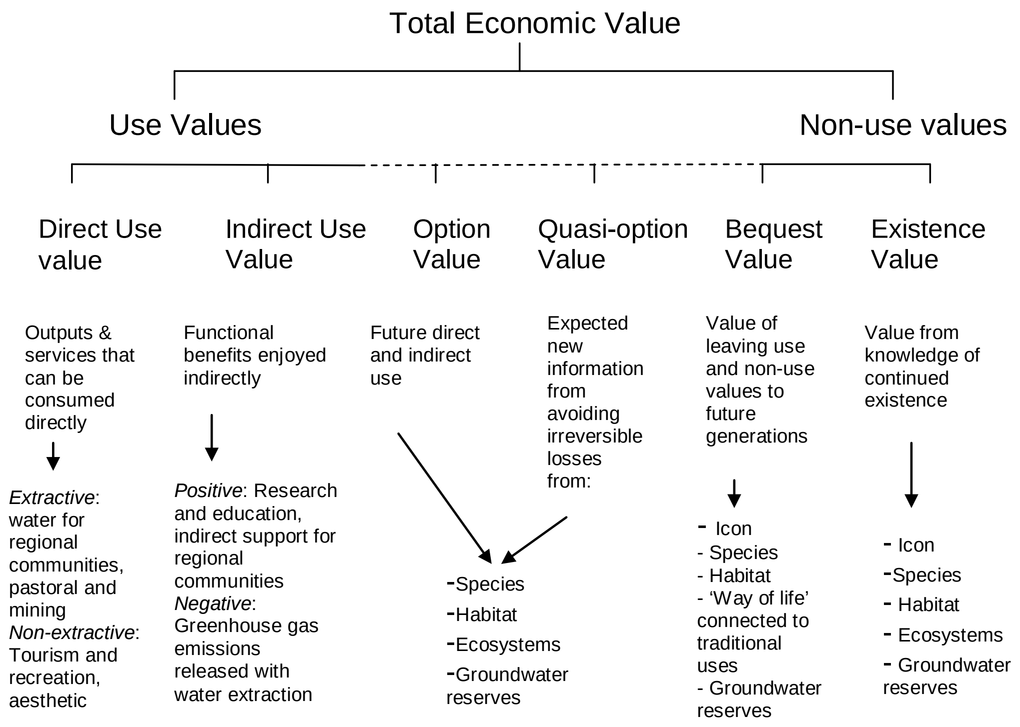
These non-use values may result for various reasons, including bequest, altruistic, stewardship and self-seeking motives. The magnitude of non-use value depends on various factors, such as the existence of close substitutes and the supply of the resource.

An important qualifier when estimating non-use values is that because of limitations associated with valuation techniques, analysts are generally unable to estimate the entire non-use value of a natural resource. They are able to estimate the non-use values associated with marginal changes in the quality of a natural resource. Note that this is, however, different for use values, where it is possible to estimate both the entire use value

[1] An aspect of use value that has been the subject of some debate in the literature is option value. This reflects the value that individuals place on uncertainty. The view of the literature is that it should not be separately estimated, and is regarded as being something of a theoretical curiosity (see Morrison 2009 for further explanation).

associated with a natural resource (e.g., total value of a forest for timber) and the marginal values associated with changes (i.e., reductions in yield if a forest is protected).

Figure 1: Types of Market and Non-Market Values



Source: Rolfe (2010)

Total Economic Value

The concept that is the most relevant measure of value for most economic analyses is total economic value. Total economic value is the overall value that an individual has for a good, and includes both use and non-use values, where total economic value = use value + non-use value.

An important point in any discussion of total economic value is that total economic value can only generally be estimated for marginal changes in environmental quality. It is possible, for example, to estimate the total economic value associated with an SDL. But it is not possible to identify the total economic value of an icon site. This is because it is only possible to estimate non-use values for marginal changes in environmental quality.

Economic Values Versus Non-economic Values

This discussion of value has been from the perspective of the mainstream economics literature. Other social science literatures (e.g., rural sociology, economic geography, geography, marketing) also refer to "values" though the understanding of value is substantively different. In these literatures, values typically refer to individual attitudes, including environmental attitudes, which are typically measured using psychographic multiitem scales (e.g. VALS). Sometimes these scales are used to understand the contribution of specific natural resources to well being, such as with sense of place scales (e.g., Williams and Vaske 2003). The main difference between these literatures and economics is that value is not generally expressed in monetary terms.

2. How Economic Values Can be Used in Practice

Cost-benefit analysis for environmental and non-environmental applications

Historically, the main use of environmental valuation has been as an input in cost-benefit analysis. Market and non-market valuation has been used to estimate the benefits (costs) associated with improving (declining) environmental quality, which have then been compared to the costs of a range of project alternatives to address these issues. The results of a cost-benefit analysis assist in identifying which allocation of resources produces the greatest net-benefits, and the highest relative return for the costs expended (benefit/cost ratio). This has included riverine applications; indeed, cost-benefit analysis was initially developed in the USA for evaluating water resource developments, particularly dams.

These values are also used in many non-environmental applications. In transportation, they have been used regularly to assess the value of a statistical life and the value of travel time. They are increasing used in health to understand the value of morbidity in health studies

EXAMPLE: Surface Water Drainage Cost-Benefit Analysis, SA

Primary Industries Rural Solutions South Australia completed a cost-benefit analysis of projects to improve drainage and wetland quality in the Upper SE of SA (Bright and Tengrove 2007). There were private benefits from improved flood mitigation and increased production and public benefits from improving wetlands (Hatton MacDonald and Morrison 2005).

The present value of costs was $18m. The value of production benefits was $14.5m, non-market benefits for improving wetlands was $25.4m, and so total benefits were $39.9m.

The project largely generated public benefits. When non-market values were included, the project had a benefit cost ratio of 2.2. However, when excluded, the benefit-cost ratio was 0.8.

Understanding stakeholder preferences

As well as identifying the direct value of a particular good, non-market valuation can be used to understand the preferences of different stakeholder groups (e.g., Hatton MacDonald and Morrison 2005). Specifically, non-market valuation might be used to understand how the preferences of those who live within a catchment or in the locality of a natural resource differ from those who live elsewhere in a state or country. Or alternatively it can be used to understand the preferences of those who would be negatively affected by a particular change, and compared to the preferences of those who would benefit.

Example: Preferences for Habitat Management in the Upper South East, SA

Households in Adelaide were found to be willing to pay $0.73 / 1000 ha of scrublands, $1.04 / 1000 ha for grassy woodlands and $1.41 / 1000 ha of wetlands.

In contrast, households located in the Upper South East were willing to pay $0.97 / 1000 ha of scrublands, $0.45 / 1000 ha of wetlands and nothing for grassy woodlands.

The lower values for preserving additional grassy woodlands and wetlands among households in the Upper South East reflected the importance of these areas for agricultural uses.

Pricing decisions

Non-market valuation techniques are used to inform micro-economic analysis, particularly pricing decisions for public goods and utilities. The techniques have been used for setting entry fees to national parks; to understand consumer willingness to pay for improved quality of supply for water or electricity; and for setting the price of other products such as phone words and copyrighted music (see Section 4 for details).

Litigation

Non-market valuation has been widely used in the courts in the USA (e.g., Czarneki and Zahner 2005), and is increasingly being used for this purpose in other countries. In the USA it has frequently been used for damage assessment under the Comprehensive Environmental Response, Compensation and Liability Act (CERLA), while in Australia it was recently successfully used in a Federal Court (Copyright Tribunal) case as a basis for setting licence fees for the use of copyrighted music in nightclubs.

3. Potential Use of the Existing Valuation Literature for Assisting in Decision Making in the Murray Darling Basin

Understanding how the results from existing valuation studies might be used for the setting of SDLs in the Murray Darling Basin requires the answering of three questions. First, what estimates are available; second, how can they be used in setting SDLs; and third, what other information is required to apply these estimates? These questions are considered next.

Availability of Valuation Estimates

In this section previous valuation estimates from the Murray-Darling Basin are briefly reviewed. The focus in this section is solely on studies conducted in the Murray-Darling Basin, and not from elsewhere in Australia, to give perspective on the sorts of primary estimates currently available.

Use values

A number of travel cost and contingent valuation studies have estimated recreational use values in the Murray-Darling Basin since the 1980s. The values for most of these studies (in current dollars) are about $30-70 per visitor. However, a recent travel cost study found much higher values for recreation at two icon sites ($561/trip for the Barmah Wetlands and $270/trip for the Coorong) (see Dyack et al., 2007 and Rolfe and Dyack forthcoming). Across Australia and internationally many studies have estimated recreational use values, and this includes various meta-analyses.

EXAMPLE
Recreational use value was estimated to be $270/trip for the Coorong (Rolfe and Dyack forthcoming).
At an estimate of 112,500 visitors per year to the Coorong, total recreation value is about $30.4 million per year.

Several studies have examined how recreational use values change with riverine quality, including Morrison and Bennett (2004), Bennett et al., (2008a), Crase and Gillespie (2008) and Dyack et al., (2007).

Indirect use values

Several studies have examined indirect use values associated with changes in water quality and water availability in the Murray Darling Basin.

There are studies on the effect of salinity on downstream damage costs. Connor (2008) found the avoided treatment cost for food production by irrigators and drinking water for urban and industries in the lower MDB due to reduction of salinity of 91 µS/cm was $353 million.

Estimates have also been made of the savings in water treatment costs from maintaining natural wetlands. Schmidt (2008) estimated that the avoided costs from the lower Murray dairy swamps in South Australia have a filtration value of $1180 to $12700 /ha /yr.

Non-use values

A number of studies have been undertaken estimating the non-use values associated with improved riverine and wetland health in the Murray-Darling Basin over the past 15 years. While it is not straightforward to compare the results of the studies because of differences between the studies (including what was valued and methodology), it is possible to identify ranges of values for specific attributes and how values are changing across asset classes.

Native vegetation: A few studies have sought to estimate the value of an additional 1000 hectares of healthy vegetation and have found a value of $1-5[2]/household (Whitten and Bennett 2001, Hatton MacDonald and Morrison 2005, Bennett et al., 2008b). The majority of studies have however valued a 1% change in the area of healthy native vegetation (Morrison and Bennett 2004, Rolfe and Windle 2006, Bennett et al., 2008a, Morrison et al.,

[2] All non-use value estimates have been presented in 2009 dollars.

2010). For most rivers the range was $2.20 to $5.70, but for the Murray the value was higher at $13.72[3] for 1% change.

<u>Fish species and populations:</u> Morrison and Bennett (2004) valued increasing the number of fish species present in the Gwydir and Murrumbidgee and found values of $3.3-3.5/species/household. The majority of studies however valued increasing the population of native fish (Whitten and Bennett 2001, Bennett et al., 2008a, Bennett et al., 2008b, Morrison et al., 2010). Values were lowest for smaller to medium sized rivers/areas ($0.5-5.1 for a 1% increase in fish populations per household), and was highest for the entire Murray River ($15.4 / 1% increase).

<u>Waterbird Breeding:</u> Several studies have investigated communities' willingness to pay to increase the frequency of colonial waterbird breeding in the Gwydir Wetlands, Macquarie Marshes and in wetlands along the Murray River (Morrison et al., 1999, Morrison 2002, Morrison et al., 2002, Morrison et al., 2010). Values (per household) for the Gwydir Wetlands and Macquarie Marshes ranged from $14-34 per year (increased frequency). The values for the Marshes were overall larger than for the Gwydir Wetlands, and the value for the Murray was, consistent with other attributes, much higher at $65/year.

<u>Waterbirds and other species:</u> Several studies have valued providing habitat suitable for an endangered/protected/threatened waterbird or other species, with values ranging from $4.3-7.4/species/household (Morrison et al., 1999, Whitten and Bennett 2001, Morrison 2002, Morrison et al., 2002, Morrison and Bennett 2004). One study found willingness to pay to increase the number of waterbirds and other species with sustainable populations of $3.89/species/household (Bennett et al., 2008a).

<u>Other values of interest:</u> A couple of studies have valued changes in the quality of icon and other sites. This includes a recent choice modelling study valuing willingness to pay to improve the health of the Coorong from poor to good quality of $173/household/year (for 10 years) (Morrison et al., 2010). This can be compared to an earlier (1996) contingent valuation study that valued preserving the quality of the Coorong at $57/household (Bennett et al., 1998). Another study valued improving the quality of the much smaller Gol Gol swamp and produced much smaller values of $12 per household (Bennett and Whitten 2001b).

How non-use values change across asset classes and time

In general it appears that the values held for the Murray River are much larger than other rivers. This is likely to reflect the greater significance of the Murray and its attention in the media in recent years[4]. For fish populations and waterbird breeding, there was evidence that the values were larger for more significant rivers/wetlands. There was also some but less strong evidence of this for native vegetation. In contrast, values for providing habitat for waterbirds and other species did not appear to be a function of asset class. In general,

[3] Several studies such as this one involved payment over multiple years. For these studies, a 28% discount rate was used, as previous research has indicated that relatively large discount rates are appropriate in this context.
[4] In part it may also reflect methodological differences.

values appear to have been increasing over time, with more recent studies producing larger value estimates for a number of attributes.

How will using environmental values help the process of setting SDLs?
Environmental valuation provides information on the benefits of a SDL which can be compared to costs to agriculture for reallocating of water. It also provides information on relative value of water for different environmental goals, including providing water to different riverine attributes (e.g., waterbird breeding vs native vegetation), providing water to different locations (upstream vs downstream) and to different asset classes. A simple example of how to use these values is shown in the box below. The benefits in this example can be compared to the costs to determine whether the change is economically efficient, and whether other options are more appropriate.

EXAMPLE
An SDL is established for a region of the Murray that is projected to increase healthy vegetation (calculated for whole river) by 1.7%, but there is no effect on fish, waterbirds or recreation.

Present value of 1% change in native vegetation along the Murray is worth $79 million to the Australian community (Morrison et al., 2010).

Benefit of the SDL is 1.7 * $79m = $134m

Given that valuation estimates are not available for all regions, one option is to make use of benefit transfer where primary estimates are not available. Using benefit transfer, valuation estimates are extrapolated or transferred from a primary valuation context to a similar secondary context. The use of benefit transfer is described in more detail in Section 6 of this report.

The information collected from primary studies and benefit transfer could be used as an additional input for helping prioritise where water should be allocated by identifying where the value of water for environmental uses is highest. These values could also be compared to the opportunity cost of reallocating water away from agriculture in particular regions. It would be expected that there would be cases where:

- Environmental values are high, and costs to agriculture from reallocating are low
- Both environmental values and costs to agriculture from reallocating are high
- Both environmental values and costs to agriculture from reallocating are low
- Environmental values are low, and costs to agriculture from reallocating are high

Requirement for other information

An important task in utilising environmental values is being able to identify the effect of each SDL on the various attributes of riverine health (i.e., healthy native vegetation, fish populations etc). Generally there appears to be good knowledge about the effects of water allocations on vegetation (Overton and Doody 2008), and resources may be available for modelling the effect of the SDLs on the other attributes. In practice, determining the effects of SDLs on attributes may require questioning of ecological experts if modelling capability is not available. In the past this has been done using Delphi type approaches (e.g., BDA Group and Gillespie Economics 2004).

For recreational use values, information is also needed on recreational use and how the number of recreational trips in the basin will be affected by improving riverine quality. Some data are currently available on recreational use in the Murray River (Crase and Gillespie 2008, Howard 2008, Dyack and Rolfe forthcoming) and could be collected for other parts of the basin.

When developing valuation tables, decisions will need to be made about how many households the values should be aggregated over. Many but not all valuation studies that have estimated non-use values have only collected data within a single state. Two studies have examined how values change across states for national level assets within the Murray-Darling Basin (Bennett et al., 1998, Morrison et al., 2010) and did not detect significant differences. Less information is available about the extent of out-of-state values for less significant regions, so assumption swill need to be made about whether and what proportion of households of other states to extrapolate values over. These issues are discussed in greater detail in Section 7 of this report.

4. Use of Non-Market Valuation in Australia and Overseas

In Australia there has been increasing use and approval of non-market valuation at both a Commonwealth and State government level. This contrasts with the situation in the 1990s when there was greater concern about the validity of non-market valuation.

At a Commonwealth government level, recent examples of the use of non-market valuation include the following:

- *Federal Court* (Copyright Tribunal) set fees for use of copyrighted music in nightclubs on the basis of a non-market valuation study that involved the use of choice modelling.
- *Commonwealth Dept of Environment* in 2009 used non-market values (from a choice modelling study) for determining the benefits of waste management options (e-waste policy) which was approved by the *Office of Best Practice Regulation* (*Dept of Finance and Regulation*). The Dept of Environment is currently undertaking (June 2010) a second non-market valuation study focusing on container deposit schemes.
- *Australian Communications Authority* used non-market valuation (choice modelling survey) to identify the value of phone words and to set pricing.

As a further example of Commonwealth support for the use of non-market valuation, the Secretary of the Treasury Dr Ken Henry recently gave a speech (4 March, 2010[5]) recommending the use of non-market valuation. He notes that "The Office of Best Practice Regulation advises Australian Government agencies that revealed preference valuation is potentially credible (p5)". For stated preference applications he is more circumspect, noting that because of the greater potential for making mistakes when answering surveys (than in market situations) that "Policy makers need to exercise great care, therefore, in relying on such survey results when shaping environmental programs." Significantly he does not dismiss the use of stated preference techniques but rather advocates their use by "experts to gain a better understanding of what matters to the wider population (p11)", a position supported by Stiglitz[6], Sen and Fitoussi (2009) as Dr Henry notes. Dr Henry also recognises the limitations of solely relying on expert judgement (e.g., through a multicriteria analysis) which "reflects the expert's subject valuation of the environment" and "gives a false impression of scientific certainty" and "may allow preconceived conclusions and the influence of consulted stakeholders to be embedded in the approach, without this being readily detected and subject to scrutiny" (p10).

State government agencies have also regularly used non-market valuation. This includes:

- Setting of entry fees for national parks (e.g., NSW National Parks and Wildlife Service).
- State government regulators have endorsed non-market valuation (stated preference surveys) for determining consumer values for quality of supply for water and electricity (e.g., IPART).
- Environment agencies from NSW, Victoria, Queensland and South Australia have used non-use values in a range of cost-benefit analyses involving riverine health and biodiversity:
  - ✓ the *NSW Government* used results from various choice modelling studies to estimate non-market values for cost-benefit analyses involving environmental flow options for the Hawkesbury-Nepean River (BDA Group and Gillespie Economics 2004) and for the Shoalhaven River (BDA Group and Gillespie Economics 2006); a cost-benefit analysis involving cold-water pollution mitigation in the Murray-Darling Basin; and various cost-benefit analyses involving the assessment of the impacts of mines on streams, swamps, vegetation and aboriginal sites where the values were evaluated using choice modelling (e.g., Gillespie Economics 2009).
  - ✓ the *Victorian government* used non-market valuation (results from a choice modelling study) for inter alia setting flow targets for river redgum forests (Gillespie Economics, DCA Economics and Environmental and Resource Economics 2007).
  - ✓ the *South Australian* government used non-market valuation (choice modelling) for a cost-benefit analysis involving the restoration of wetlands in the Upper South East of South Australia (Bright and Trengrove 2007).

[5] http://www.treasury.gov.au/contentitem.asp?NavId=008&ContentID=1747

[6] Joseph Stiglitz is a former Chief Economist of the World Bank and Nobel Prize winner; Amartya Sen is also a Noble Prize winner.

The growing use of non-market valuation in Australia has been paralleled in some overseas countries. In the UK[7], its use is well accepted and it is widely used for decision making involving water. Specifically, it is used by the Environment Agency in England and Wales to appraise river and coastal water policy and project decisions, it was used to support the framing of the Marine and Coastal Access Act 2009 which established marine conservation zones around the UK, and it is also used in appraisals by Natural England on assessing environmental resource protection including rivers, wetlands and marine areas. Non-market valuation also forms the basis of water company business plans on consumer demand for water supply, quality, and waste water disposal including its effect on river water quality and ecosystem services in England and Wales. These are submitted to Ofwat, the water industry regulator.

In the US[8] there is also a relative long history of using non-market valuation in government decision making involving water resources. Examples include: (1) decisions about the restoration of Green Bay which involved the US Departments of Interior, Justice and Commerce and the State of Michigan, (2) the US Clean Water Initiatives by the US Departments of the Interior which drew on the results of a contingent valuation study, and (3) the decision to remove the dam on the Elwah River by state and federal agencies which was also based on the results of a contingent valuation study. Further details on these and many other examples of decisions that have drawn on results from non-market valuation studies are described in Appendix 1.

5. Environmental Valuation Techniques

Now that the different uses of valuation estimates have been described, the different approaches that can be used to estimate these values are reviewed next. This includes market-based approaches, revealed preference techniques and stated preference techniques.

Market based techniques

For some aspects of use, it is possible to derive estimates of use values associated with riverine management from existing market data. For some goods this is relatively straightforward, such as the value from reductions in tourism or commercial fishing that result from declines in water quality or quantity. For other effects of declining riverine health, estimates of value may be derived by identifying damage costs or preventative expenditures. For example, information about the reduced cost of treating potable water provides an indication of the benefits of better water quality from increasing instream flows (e.g., Connor 2008), while the replacement costs for infrastructure and equipment provides a lower bound estimate of the value that the community has for improving water quality. However, one of the limitations of using market based approaches is that they only provide

[7] This information was supplied by Professor Ken Willis, University of Newcastle Upon Tyne.

[8] This information was supplied by Professor Kevin Boyle, Virgina Tech, who obtained the data from the US EPA.

a lower bound on community willingness to pay. The full community willingness to pay will normally exceed lower bound estimates because additional benefits are included.

In practice many of the additional values for improving water quantity and quality can only be estimated by using revealed or stated preference techniques, which are described next.

Revealed preference techniques

Revealed preference techniques use information from related markets to impute a value for non-market goods. A related market is one that indirectly reveals values for a good; that is, there is some relationship between prices paid in a market and environmental characteristics of a good, allowing value to be imputed. The most commonly used revealed preference techniques are the hedonic price and travel cost methods.

Hedonic Price Method

The hedonic price method is used to estimate amenity values from residing nearby a natural resource. It can also be used to demonstrate the changes in amenity values from variations in the quality of natural resources. Hedonic pricing is based on the idea that a person's preferences for different goods (such as housing) depends on the features or attributes of those goods. Hence a person's willingness to pay for a property will reflect the attributes of that property, including house characteristics (e.g., the number of bedrooms, bathrooms), lot characteristics (e.g., size, slope) and environmental characteristics (e.g., proximity to schools, access to green space, beaches, see Hatton MacDonald et al., 2010). Using statistical methods, it is possible to control for a wide range of aspects of real estate and isolate the effect on property prices of the features that you are wanting to value, such as access to riverine quality (see Tapsuwan et al., (in review) for the value of proximity to the River Murray in South Australia).

Travel cost method

The travel cost method is used to value recreational quality or changes in recreational quality. The basic idea of the travel cost method is that information on travel costs and reductions in the number of site visits at greater distances from a site can be used to estimate a demand curve for recreation and thus recreational use value. This technique is regularly used by State government agencies to estimate recreational values (Gillespie 1997). While used less frequently for this purpose, it can also be used to demonstrate the change in use value associated with changes in the quality of a recreational site (e.g., Crase and Gillespie 2008, Rolfe and Dyack forthcoming). There are several different types of travel cost method, including the zonal travel cost model, the individual travel cost model, and the random-utility travel cost model. The different versions differ in their ability to produce estimates of the value of changes in recreational quality.

Stated preference techniques

A second class of techniques that can be used to estimate non-market values are those based on the stated preferences of individuals. Stated preference techniques involve using surveys from which estimates are derived of non-market benefits of different resource use alternatives. Because they rely on the use of surveys, stated preference techniques can be used in more applications than revealed preference techniques. For example, they are the only approaches that can be used to estimate non-use values. The two main stated preference techniques are contingent valuation and choice modelling.

Contingent valuation

Prior to the development of choice modelling, contingent valuation was the most widely used stated preference technique for estimating non-market values. Contingent valuation involves estimating non-market values through directly questioning respondents about their willingness to pay for specific options. The basic idea of contingent valuation is that respondents are presented with a description of a change (e.g., a project to improve the quality of a wetland), and a question is asked to identify their willingness to pay for this change to occur (e.g., would you support a referendum to achieve outcome X at a cost of $Y).

While it has a long history, the contingent valuation method has been a relatively controversial technique. This partly reflects its politicisation due to its usage in several high profile cases (e.g., the Exxon-Valdez oil spill[9] and mining in the Kakadu Conservation Zone, Bennett and Carter 1993, Bennett 1996). In the USA, contingent valuation was subject to a review by a panel set up by the National Oceanic and Atmospheric Administration and chaired by two Nobel prize winners (Ken Arrow and Robert Solow) to assess the appropriateness of using contingent valuation in damage assessment (Arrow et al., 1993). The panel concluded that contingent valuation provided a useful starting point for damage assessment and provided a number of recommendations regarding the design of contingent valuation studies. Since the early 1990s there have been various developments in the contingent valuation literature that have increased understanding of how to effectively design contingent valuation questionnaires, including of approaches that have been demonstrated to eliminate yea-saying (e.g., Morrison and Brown 2009).

Contingent valuation has continued to be used in Australia (e.g., Bennett, Morrison and Blamey 1998, Greiner and Rolfe 2004, Access Economics 2009, Cooper, Crase and Burton 2010), the USA, UK and New Zealand. However, decision makers have remained more cautious about using contingent valuation than its cousin, choice modelling. Yet contingent valuation does have its advantages. It is analytically simpler, particularly where the goal is to produce a single valuation estimate for a program. It is easier to use contingent valuation for valuing particularly complicated goods. Further, there is evidence that contingent valuation produces estimates that are either equal to or more conservative than choice modelling (e.g., Magat et al., 1988, Hanley et al., 1998, Stevens et al., 2000, Mogas et al., 2006).

Choice Modelling

Over the past 15 years choice modelling has increasingly been used for non-market valuation, and is more common that contingent valuation, particularly in Australia. Nonetheless, the approaches share many similarities: they are both survey based methodologies, share some underpinning theoretical foundations and have many common design features.

[9] Exxon invested heavily in trying to discredit the technique because of its use in damage assessment.

The main differences between contingent valuation and choice modelling relate to how goods are described, and in the way valuation questions are asked. With contingent valuation, respondents value single scenarios. In contrast, choice modelling is a multi-attribute technique. That is, goods are decomposed into their constituent attributes (e.g., area of native vegetation, fish population etc). Respondents then choose between alternatives that are described using these features and a household cost. These choices are repeated many times and by observing how respondents' choices change as the attributes of the alternatives change, it is possible to infer how much respondents are willing to pay for each attribute. For example, if increasing waterbird breeding in frequency by one year has the same effect on utility as an increase in household costs of $20, this indicates the household willingness to pay for waterbird breeding.

Choice modelling has frequently been used to estimate recreation and non-use values associated with riverine health, particularly in Australia (e.g., Morrison, Bennett, Blamey and Louviere 2002; Morrison and Bennett 2004; Bennett et al., 2008; Morrison, Hatton MacDonald, Boyle and Rose 2010). Choice modelling is also frequently used in other non-environmental applications, including transportation, health, tourism and marketing.

Attitudes of Economists to Environmental Valuation Approaches

In general, many economists have historically been most comfortable with market and related-market (i.e., revealed preference) data. This is because of the possibility of direct market validation of value estimates. This attitude was reflected recently by Dr Ken Henry, the Secretary of the Treasury, who commented in his speech of 4 March 2010 that "These 'revealed preference' techniques have the advantage of being connected with people's decision to actually part with their money".

This same confidence is not as universally shared for stated preference techniques. In some countries such as the UK, stated preference techniques are quite highly regarded and widely applied in decision making. In Australia and the USA, there is a greater diversity of perspectives, though it is apparent that they are increasingly used in decision making. Many more pragmatic economists (including Dr Ken Henry) recognise that, while they do not have a market analogue for validation, stated preference are the only currently available approaches for assessing non-use values and understanding the preferences of the wider community for preserving various natural assets. Hence, we should make use of them, though cautiously, and attempt to improve their accuracy. Interestingly, Dr Henry's view echo those of the NOAA panel lead by the Nobel Laureates Ken Arrow and Bob Solow, and indeed the decision making processes of an increasing number of Australian and State government agencies.

A further point about stated preference approaches is that, in Australia, choice modelling is more highly regarded than contingent valuation. This is partly because it has not been used in as many controversial cases, but also because of the widespread use of choice modelling in related disciplines where it has been demonstrated to work effectively.

Before leaving the discussion of the relative benefits of valuation approaches, it is worth noting the results from the literature that has compared the convergent validity of the different approaches. Convergent validity is achieved when measures which are thought to be related in theory are shown to be related or equivalent (depending on the hypothesis) through statistical tests.

Interestingly, it is not the case that estimates generated using revealed preference approaches are more conservative than those generated using stated preference techniques. Carson et al., (1996) conducted a large meta-analysis and found that the recreation use and amenity value estimates generated using stated preference techniques were somewhat but not greatly smaller than equivalent estimates generated using travel cost or hedonic price models.

Further, estimates generated using revealed preference approaches are not less immune from the influence of the choices of the analyst. Indeed, previous studies have demonstrated that analysts can substantially affect values generated by both travel cost models (Smith et al., 1986; Carson et al., 1996) and hedonic models (Graves et al. 1988).

6. Benefit Transfer

While a number of non-market valuation studies have been conducted in the Murray-Darling Basin which can be used as an input into the process of setting SDLs, there remain regions where no primary data are available and it is necessary to extrapolate existing values. The reuse of existing valuation estimates in another context is known in the economics literature as benefit transfer. There is now a relative extensive literature on the use of benefit transfer. The main types of benefit transfer are summarised in Rolfe and Bennett (2006) and are shown in Table 1. Single point value transfer is the simplest of the approaches and typically involves the use of values generated using the contingent valuation or travel cost methods. Marginal point value transfer and benefit function transfer are now far more common, as they are able to utilise the results from choice modelling applications as this approach generates attribute values. However, the possibility of using these two approaches still relies on their being suitable source or original studies available to transfer. Meta-value analysis is much less common in Australia, though there are exceptions (e.g., Morrison and Bennett 2004). In the USA, meta-value analysis has been widely used to understand recreation values and the variables that drive them (Shrestha, Rosenberger and Loomis 2007).

When performing benefit transfer, Rolfe (2006, p.18) recommends doing the following:

1. Assess the target situation to identify key assets and attributes of interest
2. Identify source studies that are available
3. Assess site differences (e.g., whether the key attributes or their levels are the same across the sites)
4. Assess whether the population is different across key parameters

5. Assess framing issues e.g., differences in the scale and scope of the issue, policy mechanism, payment vehicle or political context
6. Assess statistical modelling issues

Table 1: Types of Benefit Transfer Methods

Transfer method	**Description**	**Example**
Single point value transfer	A single value is transferred without adjustment from source study to target site	A wetland protection value of $50/person is transferred from case study site A to site B
Marginal point value transfer	A single value that allows for site differences is transferred	A wetland protection value of $2/hectare/person is transferred from case study site A to site B. The values are adjusted for the size of the area protected.
Benefit function transfer	A valuation function is transferred, allowing for variety of site differences	A wetland valuation function that involves several attributes is transferred from case study site A to site B
Meta-value analysis	Results of several studies are combined to generate a pooled model	Results from studies A, X, Y and Z are pooled to estimated a value for Site B

Source: based on Rolfe (2006), p.16

Following these stages provides a guide on how to choose appropriate source studies, and how to adjust values to allow for differences between the original study and the context at the site of interest. These recommended stages were used to inform the process of deriving non-market values from the existing literature for valuing improvements in the Murray-Darling Basin, which are presented next.

7. Non-Market Values for the Murray-Darling Basin

In this section of the report we now present value estimates and overview the process for deriving estimates of the aggregate non-market value of changes in the value of key environmental assets across regions of the Murray-Darling Basin.

7.1 Identification of Key Areas and Attributes of Interest

The first step in the benefit transfer process is to identify the main regions in the Basin and the attributes of interest in each of the regions. A total of 19 regions are listed in Table 2, together with an indication of the Key Environmental Assets in each of these regions.

Table 2: Regions and Key Environmental Assets in Each Region

	Regions	Key Environmental Assets in each Region
1	Barwon-Darling	Lower Darling System (including Lakes Cawndilla and Menindee)
2	Border Rivers	
3	Campaspe	
4	Condamine-Balonne	Lower Balonne Floodplain, Narran Lakes
5	Eastern Mt-Lofty Ranges	
6	Goulburn-Broken	Lower Goulburn Floodplain
7	Gwydir	Gwydir Wetlands
8	Lachlan	Booligal Wetlands, Great Cumbung Swamp, Lachlan Swamp
9	Loddon-Avoca	
10	Macquarie-Castlereagh	Macquarie Marshes
11	Moonie	
12	Murray	Barmah-Millewa Forest, Coorong and Lakes Alexandrina and Albert, Edward Wakool River System – incl Werai Forest, Gunbower Koondrook Perricoota Forests, Hattah-Kulkyne Lakes, Riverland - Chowilla Floodplain including the Lindsay–Wallpolla Islands
13	Murrumbidgee	Lower Murrumbidgee Floodplain, Mid Murrumbidgee Wetlands
14	Namoi	
15	Ovens	
16	Paroo	
17	Snowy Mountains Scheme	
18	Warrego	
19	Wimmera	Wimmera River Terminal Lakes

An examination of the Australian non-market valuation literature indicates that a range of estimates are available for the following attributes. Some studies have valued other attributes (eg water quality, aboriginal[10] artifacts) but there is a much smaller range of estimates available and hence they have not been included in this analysis. The first of these is for a use value (recreation) while the others all involve non-use values.

- Recreation
- Native vegetation
- Native fish
- Frequency of waterbird breeding
- Waterbirds and other species

Not all of these attributes will be relevant for all sites. For example, recreation is limited at a number of sites (e.g.,Gwydir Wetlands), but occurs more intensively at others (e.g., Coorong and Lower Lakes, Barmah-Millewa Forest). Similarly, some sites are important as

[10] A study of Indigenous values associated with improved riverine health in the Northern Territory was conducted by Zander and Straton (forthcoming).

sites for colonial waterbird breeding (e.g., Macquarie Marshes, Barmah-Millewa Forest) while others are not (e.g., Edwards-Wakool River System). Each of the attributes of relevance to the 18 key environmental assets is listed in Table 3.

Table 3: Relevant Attributes for the Nineteen Regions

Regions	Water Based Recreation	Native vegetation	Native fish	Colonial Waterbird breeding	Waterbirds and other species
Barwon-Darling		X	X	X	X
Border Rivers		X	X		X
Campaspe		X	X		X
Condamine-Balonne		X	X	X	X
Eastern Mt-Lofty Ranges		X	X		X
Goulburn-Broken	X	X	X		X
Gwydir		X	X	X	X
Lachlan	X	X	X	X	X
Loddon-Avoca	X	X	X		X
Macquarie-Castlereagh	X	X	X	X	X
Moonie		X	X		X
Murray	X	X	X	X	X
Murrumbidgee	X	X	X	X	X
Namoi		X	X		X
Ovens	X	X	X		X
Paroo		X	X	X	X
Snowy Mountains Scheme		X	X		X
Warrego		X	X		X
Wimmera		X	X		X

7.2 Selection of Source Studies

The next step involves selecting studies relevant for deriving estimates for each of these attributes. Fortunately there is a relatively large literature of Australian studies conducted in the Murray-Darling Basin, though some are now becoming dated.

Because of the number of studies available in the Murray-Darling Basin, and the likelihood of greater error from using studies derived in a different context, the selection of studies has been limited, for all attributes apart from recreation, to those studies conducted within the Murray-Darling Basin. For recreation, Australian studies from outside of the Murray-Darling Basin have been included because of the few studies available from within the Basin.

Each of the studies available and the key attributes valued in these studies are summarised in Table 4.

Table 4: Potential Source Studies and Attributes Valued in Each Study

Study	Location	Attributes valued				
		Recrea-tion	Native veget-ation	Native fish	Colonial Waterbird breeding	Waterbirds and other species
1. Bennett, Dumsday, Howell, Lloyd, Sturgess and Van Raalte (2008)	Goulburn River	X	X	X		X
2. Bennett, Dumsday and Gillespie (2008)	Victorian River Redgum Forests, Murray River		X	X		
3. Bennett and Whitten (2002)	Upper South East	X				
4. Crase and Gillespie (2008)	Lake Hume, Murray River	X				
5. Hatton MacDonald and Morrison (2005)	Upper South East, SA		X			
6. Morrison (2002)	Macquarie Marshes		X		X	X
7. Morrison and Bennett (2004)	Gwydir and Murrumbidgee Rivers	X	X	X		X
8. Morrison, Bennett, Blamey and Louviere (2002)	Macquarie Marshes and Gwydir Wetlands		X		X	X
9. Morrison, Hatton MacDonald, Boyle and Rose (2010)	Murray River		X	X	X	
10. Rolfe and Dyack (2010)	Coorong and Barmah Millewa Forest (Murray River)	X				
11. Rolfe and Prayaga (2006)	Boondooma Dam, Bjelke-Petersen Dam and Fairbairn Dam, QLD	X				
12. Sinden (1988)	Ovens and Kings Rivers	X				
13. Whitten and Bennett (2001)	Murrumbidgee River		x	X		X
14. Whitten and Bennett (2001)	Upper South East		X			X
15. Rolfe and Windle (2006)	Condamine River		X			

As some of the studies were conducted in the listed regions, they do not involve benefit transfer; rather this is simply the use of data collected from primary studies. However, in some of these primary studies estimates were not derived of the value of all relevant attributes. Further, for some regions, no primary studies have been conducted. In these latter two cases, the use of benefit transfer is necessary.

Given the set of available source studies, the next step is to identify the most suitable for valuing each of the attributes in each of the nineteen regions. As noted, in some cases this will involve the use of primary studies while for other some attributes in some regions benefit transfer will be required. The most appropriate studies for valuing each of the relevant attributes in each of the regions are summarised in Table 4[11]. The numbers in each of the cells in Table 5 relate to the study number in Table 4.

For the recreation attribute, multiple studies have been identified of being of relevance for certain regions. This is because the various source studies that have valued recreation have valued different types of recreation (e.g., dams, wetlands, general, fishing). Therefore, more than one study has been identified for transfer depending on the type of recreation relevant in a region.

Multiple relevant studies have also been identified in one other situation – this is for the Macquarie Marshes where several primary studies have been undertaken that all used a similar methodology, but were undertaken using different samples and at different points in time. For this case, a weighted average of the values will be calculated.

No appropriate studies have been identified for transferring values for the Snowy Mountains Scheme, as no equivalent valuation studies have been conducted for this area. It is recommended that for the purpose of any analysis of non-market benefits that this be treated as part of one of its contiguous catchments.

Note that in all cases apart from the Campapse, Loddon, Ovens and Moonie regions the values from the primary studies indicated in Table 5 have been directly applied. In these four cases, the values from the primary study have been reduced by one-third. This is because the source case study site used for benefit transfer is a much more substantial river and region, and in the case of the Goulburn River having greater proximity to Melbourne, all of which is likely to result in larger non-use values.

[11] The benefit transfer selection criteria suggested by Rolfe (2006) were used to select the most appropriate secondary estimates where primary estimates were not available. Justification for these choices is given in Appendix 2.

Table 5: Studies Used to Provide Value Estimates for Attributes in the Nineteen Regions

Regions	Recreation				Native vegetation	Native fish	Colonial Waterbird breeding	Waterbirds and other species
	General recreation	Dams/ Lakes	Wetlands	Fishing				
Barwon-Darling					7(M)	13	8(G)	7(M)
Border Rivers					7(G)	13		7(G)
Campaspe					1	1		1
Condamine-Balonne					15	13	8(G)	7(G)
Eastern Mt-Lofty Ranges					1	1		1
Goulburn-Broken	12				1	1		1
Gwydir					7(G)	13	8(G)	7(G)
Lachlan	12	4		11	7(G)	13	8(G)	7(G)
Loddon-Avoca	12				1	1		1
Macquarie-Castlereagh	12	4	10(B)	11	7(G)	13	6,8(M)	7(G)
Moonie					15	13		7(G)
Murray	12	4	10(B&C)	11	9	9	9	1
Murrumbidgee	12	4		11	7(M)	13	8(G)	7(M)
Namoi					7(G)	13		7(G)
Ovens	12				1	1		1
Paroo					7(G)	13	8(G)	7(G)
Snowy Mountains Scheme					N/A	N/A		N/A
Warrego					15	13		7(G)
Wimmera					7(G)	13		7(G)

Notes: 7(G)- Gwydir River, 7(M)- Murrumbidgee River, 9(G) – Gwydir Wetlands, 9(M) – Macquarie Marshes, 10(B) – Barmah-Millewa, 10(B&C) – Barmah-Millewa and Coorong

7.3 Selection of a Benefit Transfer Approach

Rolfe (2006) presented four types of benefit transfer that differ in their level of sophistication. The simplest of the four approaches is *single point value transfer*. As noted earlier, this is primarily used for values generated using contingent valuation or travel cost methods where a household or individual value for an activity or a proposed change is derived. The second approach is *marginal point value transfer*. This approach is used when values have been derived for attributes of a good, such as from a choice modelling application. The advantage of this approach is that it is possible to more closely match the changes in environmental quality at study and policy sites when transferring values. The third and fourth approaches, *benefit function transfer* and *meta-value analysis*, are currently not viable alternatives for this context. *Benefit function transfer* is not viable given the number of studies required to value each of the attributes across the regions. Use of a pooled model (*meta-value analysis*) is technically possible, and would help to adjust for methodological differences across studies as well as provide values that are more nuanced for site differences; further exploration of this alternative is recommended for future research.

As values for the recreation attribute were generated using the travel cost method, single point value transfer has been used to identify consumer surplus per visit at relevant sites. For the remaining attributes, marginal point value transfer has been used.

7.4 Attribute values

Next in Table 6, values for recreation, native vegetation, native fish species, waterbird breeding, and the presence of waterbird and other species are presented for each of the regions. When interpreting these estimates, the following should be noted:

1. All values have been converted to current dollars (2010)
2. Where values have been reported for more than one population in a single study (e.g., Morrison and Bennett 2004), a single value has been calculated by weighting the estimates based on the population of each of the areas for which the separate values were calculated.
3. A key assumption when presenting these values is whether to use present values or annual values. The majority of studies have used one-off payment vehicles, although a couple of studies (e.g., Morrison et al., 2010) used payment vehicles that involved annual payments over a fixed period. However, the use of one-off payments is recognised in the literature as being a very conservative design feature (Whitehead and Blomquist 2006). This is because respondents are required to pay for an environmental improvement in one year only, despite income constraints and that

benefits may be received over a much longer time period. In addition, there are many examples of levies that occur over multiple years (e.g., South Australian Murray River improvement levy). However, given that the results from the majority of studies were derived using one-off payment vehicles, present values have been used. This does however require the calculation of present values for studies that have used multiple year payment vehicles, which requires the selection of a discount rate. Several studies have shown that respondents use quite high rates of time preference (ie discount rates) when one-off and multi-year payment schedules are compared in both field studies and experimental settings (Harrison et al., 2002, Kovacs and Larson 2008, Bond et al., 2009). A rate of time preference of 28% has been selected based on the empirical evidence provided by Harrison et al., which is applied in calculating present values. While this value may appear large, it is commensurate with rates found in time preference experiments (Frederick et al., 2002). There is though evidence that discount rates may be context specific. Given the wide range of experimental results, we have selected empirical results which correspond most closely to how respondent may be thinking about the payment vehicle over 5 to 10 year time frames when responding to surveys. It is important to acknowledge that there are strong views within environmental economics on the use of discount rates. Some economists advocate very low discount rates in environmental applications with intergenerational costs and benefits (rates which approach zero). For this argument to hold, the analyst is implicitly assuming that survey respondents are discounting the payment vehicle the same way as the government in the treatment of costs and benefits of the proposed project. There is not enough empirical evidence at this point to support this latter view. Further research is required to better understand this complex problem.

Table 6: Attribute Values for the Nineteen Regions

Regions	Recreation				Native vegetation	Native fish	Colonial Waterbird breeding	Waterbirds and other species
UNITS	$ per person (adult) per visit				$ per household (present value)			
	General recreation	Dams/ Lakes	Wetlands	Fishing at Dams/Lakes	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
Barwon-Darling					2.26	0.46	13.87	2.25
Border Rivers					2.19	0.46		1.10
Campaspe					5.69	5.06		3.89
Condamine-Balonne					2.63	0.46	13.87	1.10
Mt-Lofty Ranges					5.69	5.06		3.89
Goulburn-Broken	55.40				5.69	5.06		3.89
Gwydir					2.19	0.46	13.87	1.10
Lachlan	55.40	35.98		355.90	2.19	0.46	13.87	1.10
Loddon-Avoca	55.40				5.69	5.06		3.89
Macquarie-Castlereagh	55.40	35.98	561.28	355.90	2.19	0.46	33.08	1.10
Moonie					2.63	0.46		1.10
Murray	55.40	35.98	B-561.28 C-270.13	355.90	13.72	12.80	65.11	3.43
Murrumbidgee	55.40	35.98		355.90	2.26	0.46	13.87	2.25
Namoi					2.19	0.46		1.10
Ovens	55.40				5.69	5.06		3.89
Paroo					2.63	0.46	13.87	1.10
Snowy Mountains Scheme								
Warrego					2.63	0.46		1.10
Wimmera					2.19	0.46		1.10

Notes: 8(G)- Gwydir River, 8(M)- Murrumbidgee River, 9(G) – Gwydir Wetlands, 9(M) – Macquarie Marshes, 13(B) – Barmah-Millewa, 13(B&C) – Barmah-Millewa and Coorong

In addition to the values listed in Table 6, Morrison, Hatton MacDonald, Boyle and Rose (2010) estimated that the value of improving the quality of the Coorong from poor to good quality was $172.7 per household per year for 10 years, or $741.44 in present value.

7.5 Aggregate Values for Non-use Attributes

The values for the attributes other than recreation presented in the previous section are all household values and need to be aggregated before they can be used to calculate the benefits associated with improvements in environmental quality. Aggregation involves extrapolating the sample results across the population. The least conservative approach to aggregative involves assuming that all households in the community have the average sample value. However, it is unlikely that non-respondents to a survey have the same value as respondents. For this reason, some researchers only extrapolate to a proportion of the population based on the response rate to a survey (Loomis 1987). In effect they assume that all non-respondents have a zero value for improving environmental quality. An alternative approach was suggested by Morrison (2000). He debriefed non-respondents and concluded that 30% of non-respondents were likely to have the same values as respondents, and that the remainder most likely had a zero value. This approach has been followed in various studies (e.g., Hatton MacDonald and Morrison 2005, Bennett et al., 2008b) and is used here.

The response rates for each of the studies used to derive the values for the attributes (apart from recreation) is shown in the second column of Table 7. Assuming that 30% of non-respondents have equivalent values to respondents, the extrapolation percentage can be calculated for each study, and is shown in the final column of Table 7.

Table 7: Response Rates and Percentage of Households for Extrapolating Values

Study	Response Rate	Percentage of non-respondents likely to have values	Extrapolation percentage
Bennett et al., (2008a)	17.0%	24.9%	41.9%
Whitten and Bennett (2001)	32.3%	20.3%	52.6%
Morrison, Bennett and Blamey (1999)	49.4%	15.2%	64.6%
Morrison (2002)	49.0%	15.3%	64.3%
Morrison, Bennett, Blamey and Louviere (2002)	49.4%	15.2%	64.6%
Morrison and Bennett (2004)	39.6%	18.1%	57.7%
Morrison, Hatton MacDonald, Boyle and Rose (2010)	54.2%	13.7%	67.9%
Rolfe and Windle (2006)	50.0%	15.0%	65.0%

These extrapolation percentages are combined with the estimate of the number of households in a state to identify the values that households in a particular state have for a given attribute. Population and household numbers for each of the states of the Murray Darling Basin and Australia are presented in Table 8. The number of households is calculated by dividing the population by the number of people per household, which is 2.6 (ABS 2006).

Table 8: Population size, household size, number of households, and number of households for aggregation of values

	Population	Household size	Number of households
New South Wales	7,165,400	2.6	2,755,923
Victoria	5,473,300	2.6	2,105,115
Queensland	4,450,400	2.6	1,711,692
South Australia	1,629,500	2.6	626,731
Australia	22,065,700	2.6	8,490,654

Another key assumption relates to the geographic extent of the market. Some studies are clearly nationally based. For example, the study by Morrison et al., (2010) valuing the Murray River involved a large national sample, and it is clearly a nationally iconic river. Thus it is appropriate to aggregate values for the Murray across the Australian population. Using the same data set as Morrison et al., (2010), Hatton MacDonald et al., (2010) focused on differences in willingness to pay among the States and Territories and found similarity between values in NSW, SA and the Rest of Australia, though some spatial heterogeneity was identified as Victoria had a lower willingness to pay and the ACT had a higher willingness to pay for some attributes. A second study by Bennett et al., (1998) found that respondents in NSW and South Australia had similar values for the Coorong. Similar results were found by Loomis (2000) who found when evaluating six different resource preservation programs that residences across six states in which the unique or threatened species reside only held a fraction (about 13%) of the national value. Overall, these results suggest that for environmentally significant regions or assets, it may be appropriate to extrapolate values beyond the state in which respondents reside. However, for other less significant assets it is less clear from the literature what should be done. Mishra and Mishra (forthcoming) provided evidence that for less significant assets it may not be appropriate to extrapolate values beyond the state in which the asset is located. Mishra and Mishra (forthcoming) conducted research in the context of how people evaluate disasters. They found that people consider locations within a state to be part of the same superordinate category but out-of-state locations to be part of a different superordinate category. While this study was not conducted in the context of non-market valuation, it does suggest that respondents may not have the same values for environmental assets located in their own state compared to other states.

The most significant and well known icon sites in the Murray-Darling Basin (apart from those on the Murray River) are arguably the Macquarie Marshes and the Gwydir Wetlands, and these are potential candidates for being valued by respondents outside of NSW. Other nationally and ecologically significant assets are Narran Lakes and the Lowerbidgee Wetlands, though these are less well known to the community and it is hence less clear whether the values for these wetlands should be extrapolated outside of NSW. Other key environmental assets are identified in Table 2. In the analysis presented below, only for the Murray River have values been aggregated across all of Australia. Otherwise, in the base case values have only been extrapolated across households in the state the region is predominantly located. For the regions in which the above wetlands are located, sensitivity analysis is conducted to determine the effects of either fully or partly extrapolating values for these wetlands to households outside of the state in which they are located.

The aggregate values for the four attributes (other than recreation) are presented in Table 9. These are present values. Each has been calculated by multiplying the corresponding cell in Table 6, by the extrapolation percentage for the study used to derive the value in Table 7, by the corresponding state population for the region in Table 8 (or the Australian population in the case of the Murray River). The one missing aggregate value from the study is for improving the quality of the Coorong from poor to good quality. The aggregate value for this improvement using this aggregation approach is $4.3 billion ($4,274,515,831).

In Table 9 it is apparent that the largest values for each of the attributes are for the Murray River. For most of the remaining attributes, the next highest values are for the Goulburn River, while the lowest are for the Moonie River. In general, the values for the NSW and Victorian rivers are fairly similar for vegetation, fish and waterbirds and other species, though the values for Queensland and South Australian rivers are lower. The values for waterbird breeding primarily occur for rivers in NSW and Queensland, though the values for waterbird breeding are higher in NSW than Queensland.

The aggregate value of an improvement in riverine health in one of the catchments can be calculated by identifying the increase in non-use values and adding to this the increase in recreation value. The increase in non-use values can be found by summing the value of changes in each of the individual attributes in Table 9. Thus for the Murray, if there were a 10% increase in healthy native vegetation, a 15% increase in fish populations, the frequency of waterbird breeding increased by 3 years, and the number of waterbird species and other species increased by 20, the total increase in non-use value would be as follows:

$$\$79{,}098{,}000 \times 10 + \$73{,}794{,}000 \times 15 + \$375{,}369{,}000 \times 3 + \$12{,}203{,}000 \times 20 = \$3.27 \text{ bn}$$

If the quality of the Coorong also improved from poor quality to good quality, the total change in non-use value (present value) for the Murray River and the Coorong would be approximately $7.5 bn.

The change in use values is derived by first identifying the change in visitor numbers for the various types of recreation listed in Table 6. The increments in visitor numbers are then multiplied by their respective recreation values in Table 6 which are then summed to obtain the change in recreation value. As an example, Dyack et al (2007) estimated that annual visitor numbers at the Coorong are 112,500 and at the Barmah Wetlands are 30,000, while Crase and Gillespie (2008) estimated that annual visitors at Hume Dam are 100,000. Howard (2008) discusses other visitor numbers along the Murray (eg boating, fishing, riverside recreation), and while an exact figure for other forms of recreation is not identified, it appears to be at least 400,000 per year. Assuming a 25% increase in visitor numbers at each of these sites, and multiplying by their respective values in Table 6 produces an annual value of $17.5m. The present value of this, assuming a 5% discount rate over 30 years, is $270m. This increase in recreation value would be added[12] to the change in non-use value to derive the total economic value of improvements to riverine health along the Murray River.

Two further sets of aggregate non-use values are presented in Tables 10 and 11, to demonstrate the sensitivity of the results to some of the aggregation assumptions. In Scenario 1 in Table 10 it is assumed that 25% of households in other states value improvements in riverine quality in regions that contain key environmental assets, but in no other regions. In Scenario 2 in Table 10 it is assumed that 50% of households in other states value improvements in riverine quality in regions that contain key environmental assets, and 20% of households value improvements in quality in other regions.

[12] There is a possibility of double counting when adding together the use and non-use values for the Murray as 40% of respondents in the study by Morrison et al (2010) had previously been sight-seeing along the Murray River. However, given the relative magnitude of use and non-use values, this is unlikely to have a substantive effect on the total economic value of any improvements in riverine health.

Table 9: Aggregate Values for the Native Vegetation, Native Fish, Waterbird Breeding and Waterbirds and Other Species for the Nineteen Regions (base case)

Regions	Native vegetation	Native fish	Colonial Waterbird breeding	Waterbirds and other species
UNITS	$'000 (present values)			
	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
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	$667	$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
Snowy Mountains Scheme				
Warrego	$2,598	$414		$1,086
Wimmera	$2,660	$509		$1,336

Table 10: Aggregate Values for the Native Vegetation, Native Fish, Waterbird Breeding and Waterbirds and Other Species for the Nineteen Regions (Scenario 1)

Regions	Native vegetation	Native fish	Colonial Waterbird breeding	Waterbirds and other species
UNITS	$'000 (present values)			
	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
Barwon-Darling	$5,463	$1,014	$37,539	$5,439
Border Rivers	$2,437	$414		$1,086
Campaspe	$3,363	$2,990		$2,299
Condamine-Balonne	$5,823	$824	$30,522	$2,162
Mt-Lofty Ranges	$1,494	$1,329		$1,022
Goulburn-Broken	$8,825	$7,848		$6,033
Gwydir	$5,294	$1,014	$37,539	$2,659
Lachlan	$5,294	$1,014	$37,539	$2,659
Loddon-Avoca	$3,363	$2,990		$2,299
Macquarie-Castlereagh	$5,294	$1,014	$89,392	$2,659
Moonie	$1,961	$277		$728
Murray	$79,098	$73,794	$375,369	$12,203
Murrumbidgee	$5,463	$1,014	$37,539	$5,439
Namoi	$3,482	$667		$1,749
Ovens	$3,363	$2,990		$2,299
Paroo	$2,598	$414	$15,337	$1,086
Snowy Mountains Scheme				
Warrego	$2,598	$414		$1,086
Wimmera	$4,677	$896		$2,349

Table 11: Aggregate Values for the Native Vegetation, Native Fish, Waterbird Breeding and Waterbirds and Other Species for the Nineteen Regions (Scenario 2)

Regions	Native vegetation	Native fish	Colonial Waterbird breeding	Waterbirds and other species
UNITS	$'000 (present values)			
	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
Barwon-Darling	$7,333	$1,361	$50,385	$7,300
Border Rivers	$4,367	$742		$1,947
Campaspe	$5,403	$4,804		$3,694
Condamine-Balonne	$8,720	$1,234	$45,707	$3,238
Mt-Lofty Ranges	$5,244	$4,663		$3,585
Goulburn-Broken	$12,631	$11,232		$8,635
Gwydir	$7,106	$1,361	$50,385	$3,569
Lachlan	$7,106	$1,361	$50,385	$3,569
Loddon-Avoca	$5,403	$4,804		$3,694
Macquarie-Castlereagh	$7,106	$1,361	$119,982	$3,569
Moonie	$3,513	$497		$1,304
Murray	$79,098	$73,794	$375,369	$12,203
Murrumbidgee	$7,333	$1,361	$50,385	$7,300
Namoi	$4,932	$944		$2,477
Ovens	$5,403	$4,804		$3,694
Paroo	$4,655	$742	$27,485	$1,947
Snowy Mountains Scheme				
Warrego	$4,655	$742		$1,947
Wimmera	$6,695	$1,282		$3,363

7.6 Next Steps in Applying Value Estimates

For these values to be applied in the identification of benefits associated with SDLs and other proposed changes, information is required about the "dose-response"; that is, how much the additional water will lead to improvements in environmental quality in a metric that is consistent with the values from these studies. In some cases this has already been achieved (Santilan and Overton 2010). However, further work in developing and applying ecological indicators may be required.

In addition, for the recreation attribute information is needed about visitor numbers in each of the regions where riverine recreation occurs, and how visitor numbers are likely to change given improvements in river health. Some data on visitor numbers is currently available for the Murray River (Howard 2008). When interpreting effects on recreation from changes in riverine health, it needs to be recognised that some recreational activities, such as boating and fishing have developed opportunistically in the Murray-Darling system with the development of irrigated agriculture (Howard 2008). Boating on Lake Hume, and regattas during high summer irrigation flows are examples. Some of these recreational activities might be adversely impacted by changes in flow regimes, though these negative effects on recreation may be offset by improvements in nature based recreation.

7.7 Summary of Key Assumptions

The results presented in this report rest on several key assumptions, which have been discussed above but are now repeated. These include:

a) That is appropriate to use the values from existing studies, though there are methodological differences between the studies.

b) When calculating present value that a discount rate of 28% is appropriate.

c) That a proportion of non-respondents (30%) have values similar to respondents and that all other non-respondents have zero values.

d) For the base case analysis, that respondents outside of the state of the environmental asset do not have values for the asset (apart from the case of the Murray River).

e) That the existing studies provide an adequate guide to the underlying community values for the whole Murray-Darling Basin.

f) That the values for each region are not affected by the supply of resources (environmental quality) in other regions.

It is recommended that sensitivity analysis is conducted to test the effect of the first three key assumptions, and that a pooled model be estimated in future research to enable adjustment for methodological differences across studies.

7.8 Further Research

In this report information has been provided about non-market values of key environmental assets in the Murray-Darling Basin. It is apparent that there are several opportunities to improve the accuracy of these estimates. As well as increasing the number of studies available and their recency, information is needed on (1) the values of attributes for different types of regions/catchments, particularly those that are smaller and have fewer significant assets; (2) understanding how the values for attributes in these regions change in states/territories different to which respondents reside; and (3) information on the values held by non-respondents. This would provide greater clarity for the appropriateness of assumptions relating to aggregation of values. The issue of how respondents may be discounting payments in a survey versus the discounting that occurs as part of cost-benefit analysis of public expenditures in the context of environmental management needs to be addressed. Further research could also be undertaken on the values people have for different recreational activities, and how these values change with different flow regimes and levels of river quality. Further research is also needed to understand how values are altered by improvements across multiple regions rather than single regions.

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Appendix 1: Examples of the Use of Non-Market Valuation in US Government Decision Making

Green Bay Fishing Valuation Studies

Studies were incorporated into formal determinations through official, dated signature by the authorized official of the U.S. on behalf of the Department of Interior, Department of Justice, and Department of Commerce as well as the State of Michigan and two tribes. The agreement formally reviewed by the public, including both a Federal Register notice and a series of 5 public hearings with official transcripts. The studies had a profound effect on cleanup negotiations, which eventually led to the formation of the Intergovernmental Partnership (which added the U.S. EPA and the State of Wisconsin), and has resulted in agreements for over $1B of work by PRPs (so far).

Supporting, electronic documents can be found here:

http://www.fws.gov/midwest/FoxRiverNRDA/documents/recfish.pdf

http://www.fws.gov/midwest/FoxRiverNRDA/documents/RCDP-1.pdf

U.S. Clean Water Initiatives

United States Department of the Interior, 1994. President Clinton's Clean Water Initiative: Analysis of Benefits and Costs. EPA 800-R-94-002 (NTIS Document No. PB94-154101). Washington DC: Office of Water, United States Environmental Protection Agency.

Was based on:

Carson, Richard T., and Robert Cameron Mitchell, 1993. "The Value of Clean Water: The Public's Willingness to Pay for Boatable, Fishable, and Swimmable Quality Water," Water Resources Research, Vol. 29, No.7:2445-2454.

This work has also been used for a number of U.S. EPA rule-making regulations.

Air Quality

The Economic Report of the President (2009) includes net benefits of federal policies to improve air quality (Table 3-1, p. 115).

These estimates were obtained from regulatory impact analyses conducted by the U.S. Environmental Protection Agency (EPA) that relied on benefit-transfer procedures to develop some of the clean-air benefit estimates (e.g., U.S. EPA, 2005, p. 4-48, Table 4-11). U.S. Environmental Protection Agency. 2005. *Regulatory Impact Analysis for the Final Clean Air Visibility Rule of the Guidelines for Best Available Retrofit technology (BART) Determinants Under the Regional Haze Regulations.* EPA-452/R-050-004.

Dam Removal on the Elwah River

Stated-preference study was instrumental in determining the removal of that dam by state and federal agencies:
http://www.elwhainfo.org/elwha-river-watershed/dam-removal/decisions-remove-dams/economics-dam-removal

Loomis, J. 1996. "Measuring the economic benefits of removing dams and restoring the Elwha River: Results of a contingent valuation survey." *Water Resources Research.* Volume 32, Number 2.

Others:

- Visibility in National Parks, the Rowe et al. work was used to justify putting scrubbers on the Navajo Power Plant to reduce visibility problems in the Grand Canyon.

- Valuation of Grand resources by Bishop, Boyle and others have influence the management of the Colorado River.

- Valuation work by Mansfield and other on snowmobiles has affected the management of snowmobiles in Yellowstone national Park during the winter.

- U.S. Forest service uses nonmarket values on a regular basis.

Appendix 2 – Justification of the Selection of Valuation Studies for Each Region

In this appendix explanation is given to the rationale for the choice of source studies in Table 4 of the report.

For the recreation attribute, values for four different types of recreation were identified. The value for general recreation was based on the study by Sinden (1988) as this study identified the value of riverside recreation in the King-Ovens system and few other studies were available that were not at unique assets (e.g., Rolfe and Dyack forthcoming). The Crase and Gillespie (2006) study was selected for the value of recreation at dams/lakes as it is the only study of this type available in the Murray-Darling Basin. The study by Rolfe and Dyack (forthcoming) and Dyack et al., (2007) was selected for the Barmah Wetlands and the Coorong as it is a primary study. This study was selected for wetland based recreation at the Macquarie Marshes as it is the only wetlands based recreation study available. For fishing, no within catchment studies were available; hence a study from Queensland by Rolfe and Prayaga (2006) was selected.

In terms of the selection of non-use value attributes, several criteria were used to select the most appropriate study based on the benefit transfer guidelines in Rolfe and Bennett (2006). These included: (1) similarity of regions, (2) whether the region is located primarily in the same state as the source study, and (3) proximity to major urban centre. For each of the regions, the justification for the choice of source study in Table 4 is presented in Table A2-2.

Table A2-2: Justification for the Selection of Source Studies for Non-use Value Attributes

Region	Native vegetation	Native fish	Colonial Waterbird breeding	Waterbirds and other species
Barwon-Darling	Similarity to Murrumbidgee, in NSW	Similarity to Murrumbidgee, in NSW	Major wetlands have greater similarity to the Gwydir Wetlands than Macquarie Marshes or Murray River Wetlands	Similarity to Murrumbidgee, in NSW
Border Rivers	Proximity and similarity to the Gwydir, partly in NSW	Similarity to Murrumbidgee, partly in NSW		Similarity to Gwydir, partly in NSW

Campaspe	Similarity to Goulburn, Victorian river; values reduced by 30% because smaller river and catchment	Similarity to Goulburn, Victorian river; values reduced by 30% because smaller river and catchment		Similarity to Goulburn, Victorian river; values reduced by 30% because smaller river and catchment
Condamine-Balonne	Primary study available	Similarity to Murrumbidgee, partly in NSW	Major wetlands have greater similarity to the Gwydir Wetlands than Macquarie Marshes or Murray River Wetlands	Similarity to Gwydir, partly in NSW
Eastern Mt-Lofty Ranges	Proximity to State capital	Proximity to State capital		Proximity to State capital
Goulburn-Broken	Primary study available	Primary study available		Primary study available
Gwydir	Primary study available	Similarity to Murrumbidgee, in NSW	Primary study available	Primary study available
Lachlan	Similarity to Gwydir, in NSW	Similarity to Murrumbidgee, in NSW	Major wetlands have greater similarity to the Gwydir Wetlands than Macquarie Marshes or Murray River Wetlands	Similarity to Gwydir, in NSW
Loddon-Avoca	Similarity to Goulburn, Victorian river; values reduced by 30% because smaller river and catchment	Similarity to Goulburn, Victorian river; values reduced by 30% because smaller river and catchment		Similarity to Goulburn, Victorian river; values reduced by 30% because smaller river and catchment
Macquarie-Castlereagh	Similarity to Gwydir, in NSW	Similarity to Murrumbidgee, in NSW	Primary studies available	Similarity to Gwydir, in NSW
Moonie	Similarity to Condamine, mostly in QLD; values reduced by 30% because smaller river and catchment	Similar to Murrumbidgee; values reduced by 30% because smaller river and catchment		Similarity to Gwydir, partly in NSW; values reduced by 30% because smaller river and catchment
Murray	Primary study available	Primary study available	Primary study available	Goulburn a major tributary, most similar study available.

Murrumbidgee	Primary study available	Primary study available	Major wetlands have greater similarity to the Gwydir Wetlands than Macquarie Marshes or Murray River Wetlands	Primary study available
Namoi	Similarity to Gwydir, in NSW	Similarity to Murrumbidgee, in NSW		Similarity to Gwydir, in NSW
Ovens	Similarity to Goulburn, Victorian river; values reduced by 30% because smaller river and catchment	Similarity to Goulburn, Victorian river; values reduced by 30% because smaller river and catchment		Similarity to Goulburn, Victorian river; values reduced by 30% because smaller river and catchment
Paroo	Similarity to Condamine, mostly in QLD	Similarity to Murrumbidgee, partly in NSW	Major wetlands have greater similarity to the Gwydir Wetlands than Macquarie Marshes or Murray River Wetlands	Similarity to Gwydir, partly in NSW
Snowy Mountains Scheme	N/A	N/A		N/A
Warrego	Similarity to Condamine, mostly in QLD	Similarity to Murrumbidgee, partly in NSW		Similarity to Gwydir, partly in NSW
Wimmera	Similarity to Gwydir in terms of distance from state capital	Similarity to Murrumbidgee in terms of distance from state capital		Similarity to Gwydir in terms of distance from state capital