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The 2011 Basin Plan, Climate Change and the Buy-Back

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Abstract

The long-term success of the Basin Plan and the Buy-Back will be judged by the capacity of the allocated public funding to deliver water to the environment, potable water supplies for the community and water for irrigation. Water property rights in the Murray-Darling Basin can be divided into four distinct groups (ground water, high security, general security and supplementary) reflecting their inherent capacity to deliver water supplies in response to climatic conditions in a given year. The price paid for these entitlements reflects their ability to provide water under known climate variability. The optimal portfolio of water entitlements needs to encapsulate this information in order to determine which entitlements to purchase, the number needed and their location in the river system in order to deliver net social benefits.

The optimal portfolio of entitlements is further complicated by the climate transitioning from a known mean and variance to a new mean and variance. The spatial impact of climate change on water resources is not uniform. Hence what is seen as a good portfolio now may in fact be sub-optimal in the future.

The aim of this paper is to illustrate the benefits of a state contingent framework for describing the optimal portfolio of water entitlements under a changing climate. By explicitly determining the real value of water entitlements in normal, drought and wet states of nature, we can determine the Buy-Back's ability to achieve the Basin Plan's goals and suggest an optimal entitlement mix to deliver long-term economic, social and environmental benefits under climate change.

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Introduction

The Basin Plan is designed to restore the balance between all water users (environment, irrigators and urban supplies) in Australia's Murray-Darling Basin (Basin). By determining a sustainable diversion limits (SDL) for the Basin negative externalities associated with over-allocation of water resources to irrigation are then mitigated. Negative externalities include environmental harm and dissolved salts in the water impacting all water users. Water resources in the Basin are described as the second most variable in the world (Khan 2008). Consequently irrigation water property rights have been developed to represent this uncertainty in water supply (i.e. normal, droughts and floods). Water property rights can be classified within four groups which have a declining reliability of supply: ground water, high security water, general security water and supplementary entitlements. The unique nature of catchment inflows then determines the reliability of each entitlement and ultimately determines their value to irrigators.

Under the Basin Plan the cost of transferring water resources from irrigators to other users occurs at the public expense. In this paper we only examine the ability to reallocate water resources between all users by purchasing water entitlements from irrigators. Thus with a defined public budget the question for the government then becomes: "what is the optimal bundle of goods to purchase in order to achieve the adjustment for maximum net social benefit?" Social benefits in this paper are determined by irrigation economic activity, minimising salinity levels and achieving minimum standards for environmental flows. If social benefits to the environment and salinity targets are specified by climatic variability (or climate states of nature) then the entitlements purchased, must be able to secure water supply by state of nature within the budgetary expense. Complication to the problem is added by the introduction of climate change. As the spatial change to the known mean and variance of future water supply is not uniform, what is seen as a good portfolio of rights to purchase now may be sub-optimal in the future. The objective of this paper is to examine the role of climate change in selecting an optimal bundle of water entitlements to obtain the Basin Plan's proposed SDL.

To achieve these goals this paper has been divided into the following sections. First a discussion to why the Basin Plan was developed is provided. Secondly a rational as to why explicitly modelling conjunctive water resources and environmental targets under climate variability and climate change is important is presented. Thirdly the way the state contingent model described in Adamson, Mallawaarachchi and Quiggin (2007) was adapted to this problem is outlined. A series of findings regarding the future of water resources and the possible Basin Plan outcomes are then detailed before final comments are made.

Why is a Plan needed for the Murray Darling Basin?

The Basin is of national importance in Australia due to its size, environmental assets, and economic activity. Approximately 14% Australia (approximately 1,000,000 Km2) lies within the Basin borders and 80% of the Basin is dedicated to agriculture. The Basin produces about 40% of Australia's gross value of agricultural production of which one third of the value of the Basin agricultural output is derived from irrigation activities. Within the Basin's borders there is an estimated 440,000Km of river systems feeding over 30,000 wetlands scattered over 25,000 Km2. Over 10% of Australia’s population lives in the Basin and a further 5% in Adelaide are dependent on the river systems delivering potable drinking supplies (Adamson, Quiggin & Quiggin 2011).

The total average conjunctive water resource in the Basin is estimated to be 26,500 GL comprised of 2,300 GL of ground water, 1,200 GL of transfers into the Basin from the Snowy River and the remaining inflows from rainfall runoff. The estimated current diversion limits (CDL) for irrigation is about 48% and a further 2% provide potable water resources. However, as the Basin is regarded as having the second most variable runoff inflows in the world, the use of averages is misleading (Khan 2008). The natural flows within the Basin are subject to long periods of below average flow offset with large inundations. The spatial patterns of rainfall within the Basin are summer dominate in the north and winter dominate inflows in the south. Water supply in the southern Basin is generally considered to be more reliable than the north due to large scale capital infrastructure works (i.e. dams and water transfers from the Snowy River). This perception of reliability in the southern Basin was tested and found wanting during the recent drought.

Historically, two management approaches for dealing with water supply variability have been adopted. First a short run response of penalising environmental supply to maintain irrigator supplies is adopted, with the goal that sequential time periods compensates environmental flows. Second, announcements concerning the percentage of allocation to be delivered to irrigators, subject to the description of the entitlements risk, are made throughout the year.

The recent drought started in 2000 (The Productivity Commission 2009) and lasted until the 2010. During the initial drought phase the above management strategies were adopted but after multiple successive years of low inflows past known parameters, management changes occurred. For example, by 2005-06 high security licences in the Goulburn region fell to only 30 per cent of their face value (National Water Commission 2011). The reduction in water supply not only caused a short run price response on the allocation market in 2007-08 but ultimately forced significant changes in production and management responses in the subsequent season (Mallawaarachchi & Foster 2009). By 2008-09 Basin wide irrigation diversions were 4,100 GL, approximately one–third of diversions in 2001-02 (MDBA 2010c). By late 2009, arguably for the first time ever, iconic environmental assets received water before irrigators to prevent total ecosystem collapse (MDBA 2011). This drought has forced the re-examination of the sustainable level of diversions in the Basin via the 2007 Water Act.

Water Resources, Climate Variability vs Change and Basin Plan Objectives

Water resources in the Murray-Darling Basin have been over-allocated to irrigators causing a series of negative externalities degrading both private and public goods and services. If irrigation production systems and river management strategies are tuned to only average water availability, then under drought periods water resource scarcity then causes significant economic loss via irrigation capital exposure, environmental degradation and reduction in quality for potable water supplies.

These problems are exasperated under climate change as both mean and variance of water supplies alters Adamson, Mallawaarachchi & Quiggin (2009). Thus any attempts to develop sustainable diversion limits within the Basin must consider both the variability of supplies under the current climate and the variability of water supplies under climate change.

Both the environment and irrigators have adapted to the natural cycles of droughts and floods. Irrigators adapt by changing not only the output (commodity produced) but how they allocate inputs. For example, dairy producers sold water and purchased fodder (Ashton & Oliver 2011). While the environment evolved to these natural patterns and has adapted taking advantage of existing production systems (McIntyre et al. 2011). However, as water resources are both limited and over allocated to irrigators, in times of scarcity exceeding known variances in water supply (i.e. the severity and longevity of the recent drought) systems that are inflexible (perennial horticulture) fail to cope adequately in the short term. This is the issue with climate change. If the new mean and variance of inflow patterns alter then in the long-run management systems have to adapt or a reallocation of resources occurs. In this paper we keep the environmental objectives the same and examine how resources could be reallocated.

Climate Change

Australia's policy settings for climate change mitigation are derived from the Garnaut Climate Change Review. During that process a number of alternative climate change scenarios were developed and the impact on water resources in the Murray Darling Basin are described in Quiggin *et al.* (2008). From that study the following three climate change scenarios are examined over two time periods (2050 and 2100).

The first scenario is that described as the best Estimate (median) strong mitigation scenario where stabilisation of 450 ppm CO_2 equivalent (CO_2 stabilised at 420 ppm) is reached by 2100, 50th percentile rainfall and relative humidity surface for Australia, 50th percentile temperature surface. Mean global warming reaches ~1.5°C in 2100. Hereafter referred to as Climate 450 Avg (2050 or 2100).

The second scenario is the best Estimate (median) mitigation scenario where stabilisation of 550 ppm CO_2 equivalent (CO_2 stabilised at 500 ppm) is reached by 2100, 50th percentile rainfall and relative humidity surface for Australia, 50th percentile temperature surface. Mean global warming reaches ~2.0°C in 2100. Hereafter referred to as Climate 550 Avg (2050 or 2100).

The third scenario is a dry mitigation scenario where stabilisation of 550 ppm CO_2 equivalent (CO_2 stabilised at 500 ppm) is reached by 2100, 10th percentile rainfall and relative humidity surface for Australia (dry extreme), 90th percentile temperature surface. Mean global warming reaches ~2.0°C in 2100. Hereafter referred to as Climate 550 Dry (2050 or 2100).

This paper does not consider a scenario where the climate becomes wetter as simply under that scenario the problems associated with over-allocation are mitigated by nature. Rather this paper is testing what may happen when resource scarcity occurs compared to the current climate. If then Basin Plan is designed to achieve a rebalance for net social benefits we need to know the objectives.

Basin Plan

Possingham (2001) and Pannell (2009) and (2001) argue that to maximise the benefits from policies designed to address natural resource externalities they must have clear goals. As Rostow (1959) explains that in order to encourage economic growth policy objectives need to understand how the law of diminishing marginal return applies equally to natural resources, demand elasticises and production function discontinuities. In the case of water...

> "An integrated analysis that makes environmental considerations explicit, could estimate the benefits of alternative environmental allocations and determine the optimal trade-offs between consumptive and non-consumptive uses of water. It could thus highlight potential synergies and opportunities to maximise social returns from the government investment."(Mallawaarachchi et al. 2010)

Therefore any evaluation of the long term success of the Basin Plan must have defined environmental and social targets that specify improvements by climatic states and by climate change. This paper helps the policy discussion as no economic review concerning climate change and the Basin Plan was commissioned during its last incarnation. During a review of one Basin Plan proposal, the environmental and social targets were defined as a minimum flow of 1,000 GL arriving at the Coorong and the maximum salinity in water arriving to Adelaide as 800 EC (Adamson, Quiggin & Quiggin 2011).

To achieve these targets water needs to be purchased from willing sellers. As the actual volume of water delivered to rectify any specific environmental asset or other externality along the Murray-Darling Basin in a given year is dependent on the mixed bundle of entitlements purchased and climatic conditions. Therefore we need to know the costs of purchasing water entitlements from irrigators, the amount of water each entitlement will deliver by climatic state, the number of entitlements in the Basin and the Basin Plans recommendation of SDL.

Table 1 outlines the proposed changes to both ground and surface supplies under the Basin Plan. Here we see that ground water extractions have been allowed to increase by 1,798 GL. There is a proposed surface diversion reduction of 1,631 GL identified by each catchment in the Basin. While a further 143 GL and 971 GL is expected to come from diversions somewhere in the Northern and Southern Trading zones respectively. This causes a total net change of 947 GL being removed from the conjunctive Basin water resources.

Table 2 identifies the estimated total existing entitlements by catchment within the Basin. There is an estimated 3,582 GL of high security entitlements, 7,230 GL of general entitlements and 6,081 GL of supplementary entitlements. The estimate cost to purchase these rights from irrigators under the Buy-Back is also listed. Here we see that the greater the reliability of supply (i.e. high security) the more the government has been willing to pay to permanently secure these rights. The annuity from selling water to the government is the annual return from investing any water sold at 7%. This value then helps determine the opportunity cost for irrigators from selling their water to using their water for irrigation. The option to sell water is modelled as a production system choice.

Table 3 provides the estimation of the reliability of each surface water entitlement by climatic state of nature. In this paper ground water has been assumed to be guaranteed. This information then determines calculated in Table 4 which outlines the maximum possible diversions that could happen in each state of nature if there was sufficient water flowing in the system.

The Buy-Back strategy has $3.1 billion set aside to purchase water from willing sellers. From the data provided this budget then has to purchase back 2,750 GL of surface water. For simplicity it has been assumed that all ground water will eventually go to irrigated agriculture. The cost of purchasing ground water has been set to zero for this exercise. This decision has been made as it is likely that this increased ground water extraction may in part be due to coal seam gas. As water is a by-product of the gas extraction system (Johnston & Ganjegunte 2008), it has been assumed that all the water is used for irrigation.

The next section defines the methodology and the model created to examine this problem.

The Model

Decision making in agriculture must incorporate uncertainty. Uncertainty abounds in agriculture since decisions and their outcomes are ultimately influenced by both external and internal variable. There are two main approaches for dealing with uncertainty in economics. The first has been to adopt stochastic production functions to describe the result of a decision but this approach fails to differentiate between production and management inefficiency on the outcome (O'Donnell & Griffiths 2006). This approach implies that decision makers remain passive in their management to outside information (Chambers & Quiggin 2007). In practical modelling terms this means a drought is represented by only a decrease in income either due to the function describing yield (e.g. as water use falls, output falls) and/or changes in price.

The second approach to modelling uncertain derives from contributions by Arrow (1953) and Debreu (1959). They provided the insight that uncertainty could be represented by a set of states of nature. In other words, every possible outcome can be described within a state of nature (e.g. climatic event). Within each state of nature, irrigators actively respond by changing the inputs they use (e.g. water and labour), the product they produce (i.e. whether to stop irrigation and produce a dryland crop) and the technology used to produce output. This allows for production to be described with multi-output technology within a state space. A producer's response to each state of nature (e.g. drought) is based on their knowledge about that state of nature and past experiences of outcomes from state based decisions (i.e. changes in inputs and outputs). Current state decisions are then made on that knowledge and they respond by altering inputs to influence the final output in order to meet their objective function. This allows the state contingent approach to examine production outcomes and a decision maker's ability as separate entities. In practical modelling terms this means that a producer's response to a drought can be represented by not only changing the commodity produced (i.e. switch from irrigated to dryland commodity) but the inputs used to produce that commodity alter. As the state contingent approach also allows for the description of both social and environmental objectives to be specified by climate state it then helps determine the feasibility of the Basin Plan.

The model described here was first outlined in Adamson, Mallawaarachchi & Quiggin (2007). But as this paper determine the national benefits of policy the global solution (maximise benefits for the Basin) and not the sequential solution (maximise benefits for each catchment as water flows). The first attempt at modelling the Buy-Back using this approach was undertaken by Adamson, Oss-Emer & Quiggin (2011). That paper used the 2010 SDL estimations and this paper has not only been adapted to use the 2011 SDL levels but has developed a whole new section dealing specifically diverging production systems produced with surface and ground water resources to provide greater understanding on climate change.

The model attempts to maximise the net returns for water use in the Basin subject to a series of production, social and environmental constraints. Equation 1 provides the objective function for the model which aims to maximise economic return for irrigation in all catchments (k) in the basin. There are 21 catchments in the model (K=21). Net economic return N[Y] is derived from the area A of commodity R grown in each region multiplied by the return of that commodity by the probability of that state (S) of nature occurring πS. Return is based on the yield (Q) multiplied by price (P) net the total costs (C) of production in each region of the basin.

$$N[\mathrm{Y}] = \sum_{\mathrm{R}} \sum_{\mathrm{S}} \pi_{\mathrm{S}} \left[\mathrm{A}^{\mathrm{R}} \times \mathrm{Q}_{\mathrm{S}}^{\mathrm{R}} \times (\mathrm{P}-\mathrm{C})_{\mathrm{S}}^{\mathrm{R}}\right] \qquad 1$$

Subject to:

$$\sigma_{\mathrm{s}}^{20}/0.64 \leq 800\ \mathrm{EC} \qquad 2$$

$$\sum \mathrm{K_s}\pi_{\mathrm{s}} \leq \mathrm{CAP}_{sw} \qquad 3$$

$$\sum \mathrm{K_s}\pi_{\mathrm{s}} = \mathrm{CAP}\ k_{gw} \qquad 4$$

Wksk ≤ fksk 5

$$\mathrm{A_k R_{1..5}} \leq \mathrm{AHort_k} \qquad 6$$

$$\mathrm{A_k R_{1..27}} \leq \mathrm{Atotal_k} \qquad 7$$

$$\sum \mathrm{L_{rk}} \leq \mathrm{L_k} \qquad 8$$

This is subject to Equation 2 where Adelaide's water quality must be less than 800 EC in each state of nature. Where is the salinity in milligrams per litre (σ) converted into electrical conductivity (EC) by dividing it by 0.64. The separation of surface water (sw) and ground water (gw) CAP allows for careful examination of the consequences to changes to total diversion levels under the Basin Plan. Equation 3 allows for surface water use within the Basin to be less than the available entitlements (i.e. Cap) on average. This allows irrigators to actively respond to climatic conditions by determining water inputs and selling water within the identified trading zones to maximise overall net returns. Equation 4 fixes ground water entitlements to the given catchment and all water must be used in each given state. In the model extractions described for the urban and dryland use under the CAP, all catchments apart from Adelaide are removed from inflow before the model is optimised to ensure that they received their allocations. Equation 5 ensures that the surface water used must not exceed the amount flowing within the river system. Equation 6 states that the area dedicated to horticulture in any catchment must be less than equal to the horticultural constraint in that area. While Equation 7 ensures that total area dedicated to irrigation in any region, produced by both surface and ground water, must be less than the total area available in that region. Equation 7 allows broadacre activities to expand over horticultural area if required. Equation 8 ensures that there is sufficient operator labour to undertake the irrigation activity mix in a region.

As πS Is the probability of the state occurring, $\sum \pi_s = 1$ i.e. every state is identified), where 0< π≤1 (i.e. the states must have a chance of occurring). Here π 1to3 = (0.5, 0.3, 0.2). The three states of nature (S) are modelled which are represented by alternative Basin wide inflows. These states are Normal (the expected long term average inflows derived from (MDBC 2006)), Drought (0.6 X Normal Inflows), and Wet (1.2 X Normal Inflows). The model uses a conjunctive approach to water resources. Consequently total water inflows are dependent upon inter-basin transfers, surface supplies and ground water supplies. The model uses a directed flow network where the Basin is divided into 21 catchments (K) which consists of 19 irrigation areas plus Adelaide and the Coorong (default for flow to sea).

The area of production by catchment is defined by A which is a matrix of production systems (K × R) × S. There are 26 production systems (R) consisting of 21 irrigation activities, 3 options to sell water entitlements (E), plus Adelaide Water plus a dryland production system. There are twelve distinct commodities (M) included in this version include citrus, grapes, stone fruit, pome fruit, vegetables, cotton, rice, wheat, sorghum, pulses, oilseeds and dairy. These 12 commodities are transformed into 21 irrigation systems due to the adoption of multiple irrigation technologies (flood versus drip) and ability of annual cropping only to switch between dryland and irrigated commodities. In this model once an area is allocated that production system must occur in all states. Therefore an area dedicated to citrus must always be dedicated to citrus in all states of nature. While an area dedicated to annual cropping could consist of an irrigated commodity in a normal and wet state of nature but transition to a dryland crop in the drought. Irrigators can sell 3 water surface entitlements (E) (high security, general security and supplementary security) and each licence has a catchment and state specified ability to deliver a given percentage of their face value (see Table 3).

Catchments are based on disaggregated Catchment Management Regions (CMRs) to help model the directed flow network of both water and salt (Murray-Darling Basin Ministerial Council 2001). Here water flows (fks) out of a given catchment are equal to inflows (net of evaporation and seepage) less extractions (net of return flows). Extractions are determined endogenously by land use decisions as described below, subject to limits imposed by the availability of both surface and ground water. This structure allows for the determination of total irrigation use, the flow to the Coorong and water quality arriving at Adelaide.

The second critical factor in describing A is the matrix R where the state contingent production systems are defined. In this model unlike previous versions production systems are now described as being produced by either ground water or surface water. Each state of nature for each r will derive an independent representation of yields (Q), prices (P), costs of production (C) and input requirements (N) and each matrix has a form of (21 X 27). The production systems are derived from (K × M) × S, where M represents commodities. A commodity is a single enterprise in a given state in a given catchment. This data is based on a series of regional gross margin budgets that provide the data for the five inputs modelled (N= water, land, labour, capital and cash input). This version of the model has 12 distinct commodities (M) plus urban water for Adelaide and water for the Coorong. Consequently there are (M+2)×S ×2 distinct state-contingent commodities.

Area is divided into two classifications horticulture and broadacre commodities (i.e. broadacre crops and pasture), for each k based on irrigated area in 2001 (ABS 2004). 2001 was considered the last normal year in the Basin. The model allows for irrigation expansion by allowing a 45% increase for R horticulture activities and a maximum increase of 80% in total area irrigated. Irrigated area in k is constrained by Equation 9 (which ensures that horticultural productions systems can only be grown on horticultural land) and Equation 10 (where the total area of land irrigated must not exceed maximum area). These two equations then prevent the model being dominated by horticultural R and allow broadacre R to expand into horticultural area if profitable. Any land not allocated to irrigated area becomes a dryland enterprise. The model can therefore illustrate catchment (k) based expansion or contraction in irrigation systems based on opportunities for irrigators.

Yield (Q) has a dimension of (K × R) ×S and represents the output derived for that state of nature. Net return per hectare is described in the model as (P-C). Where price (P) paid for output has a matrix of (M × S). For simplicity it has been assumed that the price paid in all regions for each commodity is uniform by state of nature. Production costs are represented by (C). Here cost for producing one hectare of commodity R for each K in each S can be written as the sum of capital costs (i.e. capital costs do not change by state of nature and are modelled as an annual cost) plus operator labour costs (LC) (i.e. hours (L) is multiplied by a constant price (LP)) plus variable costs (VC) as in Equation 9. Equation 10 details variable costs which are derived from the sum of casual labour (CL) (i.e. hours multiplied by a constant price) plus contractor costs (Con) plus machinery costs (Ma) plus chemical costs (Ch) plus water use (W) multiplied by water price (Wp) plus other costs (O).

$$R_{ks} = \sum(CC_k + LC_{ks} + VC_{ks}) \qquad 9$$

$$VC_{ks} = \sum(CL_{ks} + Con_{ks} + Ma_{ks} + Ch_{ks} + (W_{ks} \times Wp_{ks}) + O_{ks}) \qquad 10$$

Equation 11 deals with the amount of operator labour (L) required to produce ∑r in k. Here we ensure that the amount of labour in a region (derived from ABS 2004 data and based on number of farms X 2 people X 2,500 hours/person) is adequate to meet the needs the chosen production systems.

Salinity is now modelled as a constraint rather than a dynamic impact on production negating the discontinuous function described in Adamson et al. (2007). Salt loads (tonnes) are represented in state contingent terms reflecting salt immobilisation in soil in drought times and mobilisation during the wet states. Salinity level (σ) is determined by the state contingent salt load (tonnes) entering the catchment and the flow at that catchment (see Equation 10).

This allows for the first objective of the Basin Plan to be examined, the quality of water arriving at Adelaide

$$\sigma_s^k = s_s^k / f_s^k \qquad 11$$

The second objective of the Basin Plan was to ensure that a minimum flow of 1,000 GL reached the Coorong in the drought state (s=2) is expressed in Equation 12.

$$\mathrm{fks}_s^{21} \geq 1{,}000\ \mathrm{GL} \qquad 12$$

The Buy-Back (B) approach has been constrained to ensure that the number of surface water entitlements (E) bought in a catchment (k) does not exceed the total number of entitlements in that catchment, see Equation13. Equation 14 is designed so that the portfolio of entitlements bought in each catchment is greater than or equal to the defined change under the SDL CAP. This is necessary so that, as illustrated in Table 1, not only are the defined catchment reduction meet but so the extra volume that comes from the northern or southern trading zones occurs at the lowest opportunity cost. Lastly in Equation 15, the budgetary constraints of the Buy-Back are ensured.

$$B_{ke} \leq \sum ke \qquad 13$$

$$B_{ke} \geq \mathrm{SDL}_k \qquad 14$$

$$\sum B_{KE} \leq \mathrm{Budget} \qquad 15$$

The state contingent approach allows for discontinuous environmental and production functions to be classified as alternative functions within each state of nature. This specification of environmental, urban or private requirement by state of nature then helps determine the type and number of water property rights needed to meet that demand by state of nature.

Results

The modelled results are summarised in Tables 5 to 10. Table 5 illustrates the change between ground and surface water use within the Basin in all states of nature. Table 6 provides data concerning the flow reaching the Coorong and the quality, measured in salinity terms, of Adelaide's water supply. Table 7 highlights the implications of the Buy-Back and the Basin Plan if climate change impacts are not considered when purchasing entitlements. Table 8 outlines how the economic return within the Basin is derived from ground water irrigation, irrigation returns from surface water diversions and the annuity irrigators receive from water sales. Table 9 specifies the paper value of the entitlements bought, the expected volume of water they would return to environmental flows and the cost to implement the Buy-Back strategy. Table 10 outlines the benefits of targeting willing sellers in given catchments in order to achieve the proposed environmental targets to minimise transmission losses.

Chart 1 illustrates what may occur if the Buy-Back is optimised purely based on the current climatic conditions. Here the area and water use is not altered and only the river flow has been modified based upon reductions in expected inflows under a changing climate. Even under the best option of a 450 scenario by 2050 the flow to the sea has fallen from 1,288 GL in the SDL current climate, drought state, to only 126 GL. The impacts of setting the Buy-Back without climate change considerations becomes visible worse for each remaining scenario to such an extent that by 550 Dry scenario in 2100 there would be no flow to the Coorong in an state. Logically there would have to be a reduction in the face value of existing entitlements to prevent this from occurring in all climate states. However, if the Buy-Back considers the climate change impacts environmental flows can still occur.

Chart 1: Climate Change impacts on Buy-Back decisions based on current climate

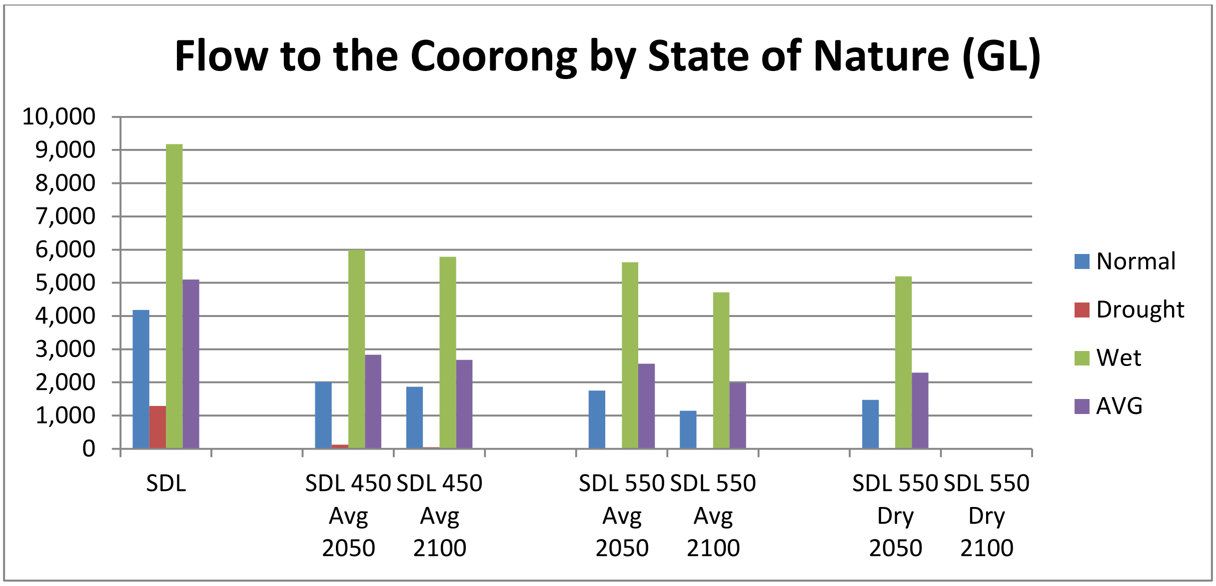
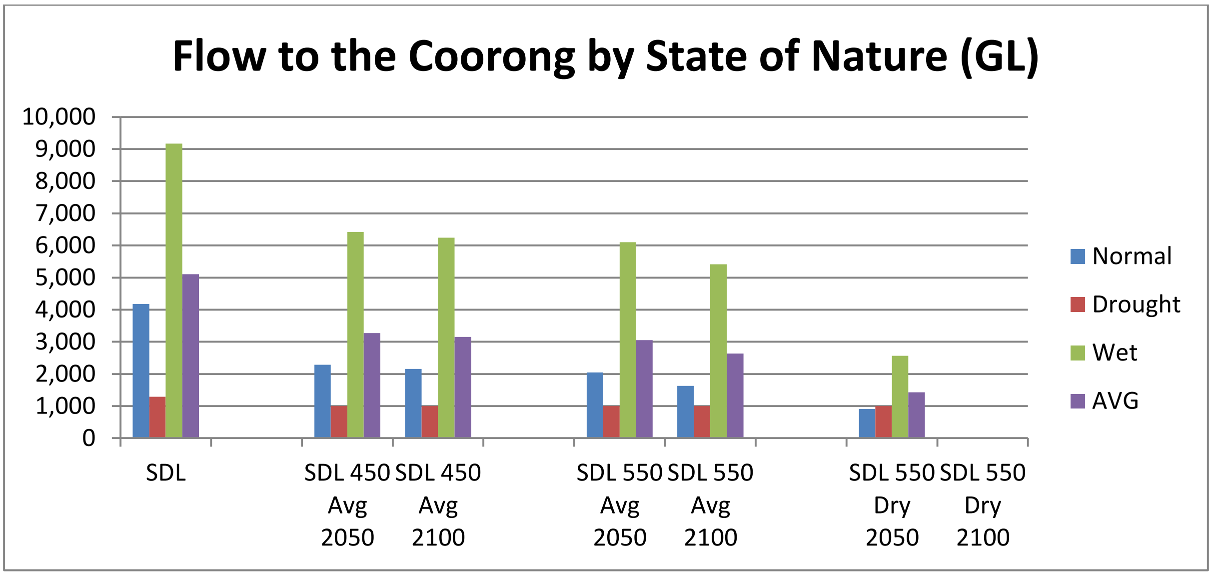


Chart 2 illustrates that the 1,000GL flow requirement to the Coorong can occur until 550 Dry 2050. The 550 Dry 2100 cannot be achieved as there are insufficient inflows to deliver 1,000 GL of water to the Coorong even without any surface irrigation diversions.

Chart 2: Incorporating climate change into the Buy-Back process



However, the cost to achieve the 1,000 GL arriving at the Coorong in the drought state of nature under a 550 Dry Scenario by 2050, cannot be achieved within the $3.1 billion outlay under the Buy-Back, nor can it be achieved the proposed reductions in CDL by catchment proposed under the Basin Plan (see Table 9). However, as the increase to achieve the environmental targets in 550 Dry 2050 is $9.1 Billion. This figure exceeds the current outlay to purchase both entitlements ($3.1 Billion) and the modernisation program ($5.8 billion). As Wentworth Group of Concerned Scientists (2010) discusses it is cheaper to return flows via the Buy-Back than infrastructure work this is an unrealistic outcome but highlights the issues involved. Here the model was allowed to take as much water from willing sellers within the Basin from where the model not only maximised Basin wide returns (see Table 10). As the model includes conveyance losses as it travels through the river system and it optimise decisions at a national scale some areas get penalised unrealistically. However, the logic behind why the model makes decisions to achieve the objectives is sound.

One thing is noticeable under the Basin Plan is that a net economic benefit , on average $100 million per annum, occurs within the Basin as water use transitions from the current diversions to the new sustainable diversion limits (see Table 6). This is caused by the increase in ground water supplies. As illustrated in Chart 3 once water resource scarcity increases under climate change the net return per ML of ground water over surface water starts increasing rapidly. This implies that as less water becomes available the remaining surface entitlements face value contracts. This suggests that the policy in fact causes inequality based upon whether the irrigators own ground water entitlements over surface water entitlements.

Chart 3: Overall Average Net Return $/ML

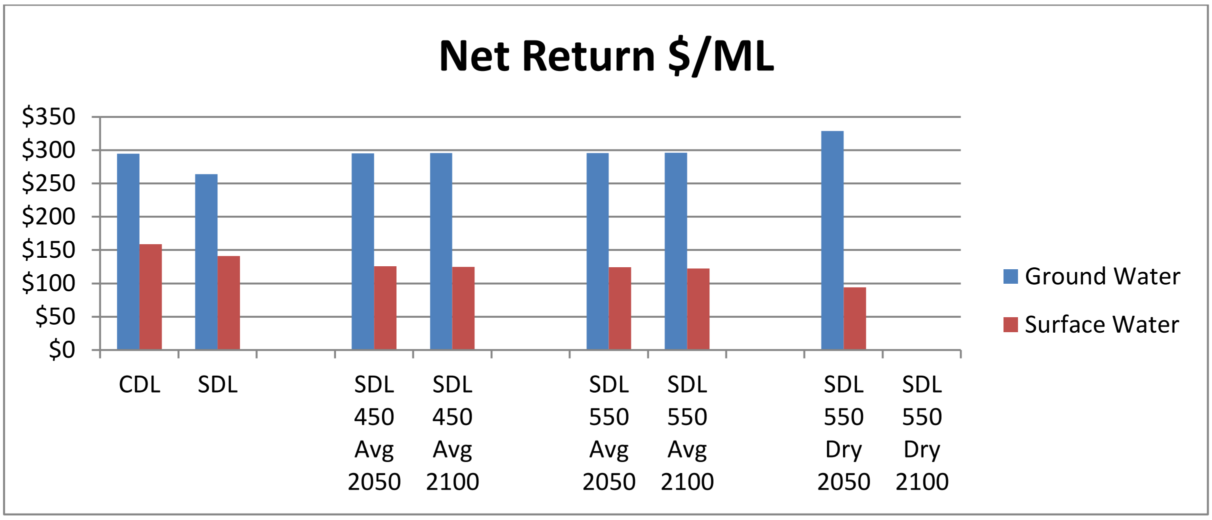
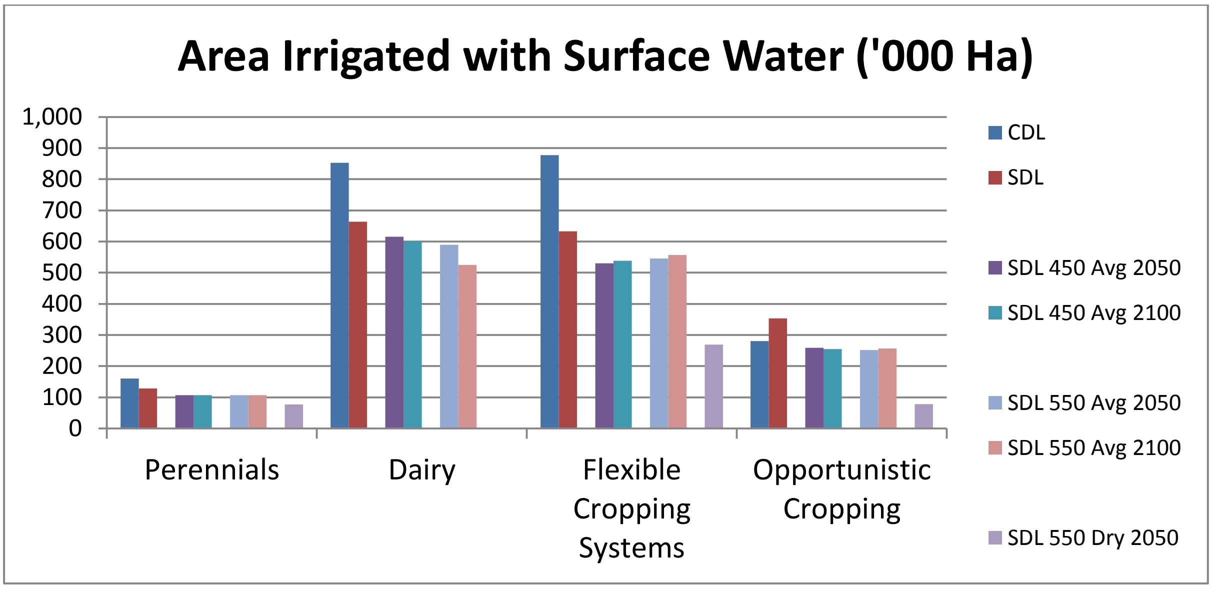


Table 6 suggests that under existing climate conditions that there will be more water arriving at the Coorong under the SDL, especially in drought conditions (i.e. increase from 93GL with CDL to nearly 1,300 GL with SDL). The increased river flow under the proposed SDL then help reduce the salt arriving at Adelaide. However, as the climate changes these benefits are reduced especially when considering the average flows to the Coorong where the wet pulse flows are reduced when compared to the SDL. At the same time in order to still keep irrigation activities occurring to maximise net economic returns the production systems have switched to free water up in the drought states for the environmental flow. This then forces irrigators to use more water in the normal and wet states of nature degrading the quality of water arriving at Adelaide in both identified states and on average. This then suggests that long term planning for Adelaide's water supply will still be required.

In Chart 4 we see the contraction of perennials and dairy production systems, which require water in all states, is in part offset by an expansion in flexible and opportunistic cropping (i.e. only irrigate in the wet states of nature). The change in what is produced is also combined with a reduction in the area dedicated to irrigation activity. Area irrigated with surface water under the CDL is estimated at over 2.1 million Ha, falling to 1.8 million Ha under the SDL to only 0.4 million Ha in the SDL 550 Dry scenario.

Chart4: Change in Production Systems (‘000 Ha)



Concluding comments

The incorporation of environmental and social goals within economic frameworks is possible. Such strategies not only allow for the trade-offs to be determined within policy changes but illustrate the risks to policy objectives under climate variability and change impacts on water supply. The Basin Plan effectively transfers surface entitlements into ground water entitlements. This helps preserves the economic activity of irrigators under a changing climate. However, change in irrigation practices will occur and those with surface entitlements, including the environments share, will be worse off under a climate with decreased water supply. The Buy-Back process needs to consider the true objectives of the program in order to determine not only the spatial acquisition of the entitlements from willing sellers but the price it is willing to pay for specific water entitlement characteristics by state of nature. Such deliberations will also have to consider the future ability of surface entitlements to keep delivering the assumed true face value of the property right to deliver water.

Not only could the Buy-Back achieve the SDL on its own, improving social and environmental outcomes, but it also adequately compensates irrigators for their water. This suggests that the further expenditure under the irrigation modernisation program can be questioned. Either it can be used to further offset existing and future negative externalities by returning more flows to the environment or questions about maximising the benefits from this public expenditure needs to be raised. The failure to carefully stipulate the benefits and objectives of both publically funded programs then suggests a wealth transfer to irrigators. However, if the funds were designed to compensate the wider Basin community for the changes to existing systems then it can be justified.

Bibliography

Adamson, D, Mallawaarachchi, T & Quiggin, J 2007, 'Water use and salinity in the Murray Darling Basin: A state-contingent model', *Australian Journal of Agricultural and Resource Economics*, vol. 51, no. 3, pp. 263-81.

—— 2009, 'Declining inflows and more frequent droughts in the Murray–Darling Basin: climate change, impacts and adaptation', *Australian Journal of Agricultural and Resource Economics*, vol. 53, no. 3, pp. 345–66.

Adamson, D, Oss-Emer, M & Quiggin, j 2011, *Property Rights & Water Buy Back in Australia's Murray-Darling Basin*, RSMG Working Paper Series, The School of Economics, The University of Queensland.

Adamson, D, Quiggin, J & Quiggin, D 2011, *Water Supply Variability & Sustainable Diversions Limits: Issues to Consider in Developing the Murray-Darling Basin Plan*, RSMG, School of Economics, The University of Queensland, Brisbane.

Australian Bureau of Agriculture and Resources Economics and Sciences 2011, *An economic survey of irrigation farms in the Murray-Darling Basin: Industry overview and region profiles, 2008-09*, by Ashton, D & Oliver, M, vol. ABARES research report 11.2, ABARES.

Bureau of Meteorology 2011, *National Water Account 2010*, ed. Bo Meteorology, Bureau of Meteorology, Canberra, Canberra, viewed 27/02/12, <http://www.bom.gov.au/water/nwa/2010>.

Chambers, R & Quiggin, J 2007, 'Information value and efficiency measurement for risk-averse firms', *Journal of Productivity Analysis*, vol. 27, no. 3, pp. 197-208.

Johnston, CR & Ganjegunte, GK 2008, 'Irrigation with coalbed natural gas co-produced water', *Agricultural Water Management*, vol. 95, no. 11, pp. 1243-52.

Khan, S 2008, 'Managing climate risks in Australia: options for water policy and irrigation management', *Australian Journal of Experimental Agriculture*, vol. 48, pp. 265-73.

Mallawaarachchi, T, Adamson, D, Chambers, S & Schrobback, P 2010, *Economic Analaysis of Diversion Operations for the Murray-Darling Basin Plan: Returns to irrigation under reduced water availability: A commission study for the Murray-Darling Basin Authority*, UQ Business School Commercial, The University of Queensland.

McIntyre, S, McGinness, HM, Gaydon, D & Arthur, AD 2011, 'Introducing irrigation efficiencies: prospects for flood-dependent biodiversity in a rice agro-ecosystem', *Environmental Conservation*, vol. 38, no. 03, pp. 353-65.

2011, *Proposed Basin Plan*, by Murray-Darling Basin Authority, Murray-Darling Basin Authority, Canberra.

O'Donnell, CJ & Griffiths, WE 2006, 'Estimating State-Contingent Production Frontiers', *The American Journal of Agricultural Economics*, vol. 88, no. 1, pp. 249-66.

Pannell, D 2009, 'Making the Most of 'Caring for our Country'', paper presented to ABARE Outlook 2009, Canberra, 3-4 March 2009, viewed 16 December 2010, <http://www.abare.gov.au/interactive/outlook09/_files/nrm_Pannell.pdf>.

Possingham, HP 2001, 'The business of biodiversity: applying decision theory principles to nature conservation', *Tela*, vol. 9, no. 1, pp. 1-37, viewed 22/03/2011, <http://www.acfonline.org.au/uploads/business_of_biodiversity.pdf>.

Quiggin, J, Adamson, D, Schrobback, P & Chambers, S 2008, *Garnaut Climate Change Review: The Implications for Irrigation in the Murray-Darling Basin*, Garnaut Climate Change Review.

Rostow, WW 1959, 'The Stages of Economic Growth', *The Economic History Review*, vol. 12, no. 1, pp. 1-16.

The Productivity Commission 2009, *Government Drought Suport: No. 46, Februrary 2009*, Productivity Comission, Canberra, viewed 25/02/2010, <http://www.pc.gov.au/__data/assets/pdf_file/0010/86275/drought-support.pdf>.

Wentworth Group of Concerned Scientists 2010, *Sustainable Diversions in the Murray-Darling Basin: An analysis of the options for achieving a sustainable diversion limit in the Murray-Darling Basin*, Wentworth Group, <http://www.wentworthgroup.org/uploads/Sustainable%20Diversions%20in%20the%20Murray-Darling%20Basin.pdf>.

Table 1: Proposed Change in Extractions by Catchment & Region

Catchment	Trading Zone	Net Change in Volume	
		Ground Water	Surface Water
Condamine	Northern	29.8	-60.0
Border Rivers QLD	Northern	95.7	-8.0
Warrego Paroo	Northern	264.0	-9.0
Namoi	Northern	0.0	-10.0
Central West	Northern	0.0	-65.0
Maranoa Balonne	Northern	19.9	-40.0
Border Rivers Gwydir	Northern	353.0	-49.0
Western	Northern	277.9	-6.0
Lachlan	Unconnected	481.2	-48.0
Murrumbidgee	Southern	0.0	-320.0
North East	Southern	0.0	-32.9
Murray 1	Southern	0.1	-7.9
Goulburn Broken	Southern	-21.6	-387.3
Murray 2	Southern	1.3	-131.0
North Central	Southern	0.0	-194.5
Murray 3	Southern	1.1	-117.9
Mallee	Southern	84.8	-30.4
Lower Murray Darling	Southern	0.1	-13.2
SA MDB	Southern	210.8	-101.0
	TOTAL	**1,798.0**	**-1,631.0**
Further Reduction Trading Zones		**Northern**	-143.0
		Southern	-971.0
		TOTAL Surface Reductions	**2,745.0**
		TOTAL Net Change (Ground + Surface)	**-947.0**
			Data From (Murray-Darling Basin Authority 2011)

Table 2: Entitlements by Catchment, Costs to Purchase, Annuity Value

Catchment	Entitlement Security (ML) 1				Cost to Purchase ($/ML) 2				Annuity from Water Sale ($/ML)		
	High	General	Supplementary		High	General	Supplementary				
Condamine			1,398				$161				$15
Border Rivers QLD			587				$161				$15
Warrego Paroo			125				$161				$15
Namoi	5	286	255		$2,050	$836	$161		$194	$79	$15
Central West	18	632	143		$2,050	$1,268	$161		$194	$120	$15
Maranoa Balonne			932				$161				$15
Border Rivers Gwydir	16	773	375		$2,239	$836	$161		$211	$79	$15
Western			196				$161				$15
Lachlan	31	615	68		$2,050	$683	$161		$194	$64	$15
Murrumbidgee	377	1,888	697		$2,050	$991	$218		$194	$94	$21
North East	196	79	61		$2,123	$1,283	$0		$200	$121	$18
Murray 1	6	50	20		$2,248	$1,283	$218		$194	$121	$21
Goulburn Broken	1,221	706	139		$2,237	$1,283	$196		$211	$121	$19
Murray 2	96	834	334		$2,248	$1,283	$218		$194	$121	$21
North Central	913	432	161		$2,333	$1,283	$200		$220	$121	$19
Murray 3	86	750	301		$2,248	$1,197	$218		$212	$113	$19
Mallee	156	73	12		$2,209	$1,197	$199		$209	$113	$19
Lower Murray Darling	11	111	275		$2,248	$836	$161		$194	$79	$15
SA MDB	449				$2,242				$212		
TOTAL	3,582	7,230	6,081								

1: (Bureau of Meteorology 2011)

2: Data derived from http://www.environment.gov.au/water/policy-programs/entitlement-purchasing/average-prices.html data accessed Feb 2010

Table 3: Estimated Reliability of Entitlements by Climate State (%)

	Normal			Drought			Wet		
	High	**General**	**Supplementary**	**High**	**General**	**Supplementary**	**High**	**General**	**Supplementary**
Condamine	0.00	0.00	0.20	0.00	0.00	0.15	0.00	0.00	0.60
Border Rivers QLD	0.00	0.00	0.40	0.00	0.00	0.30	0.00	0.00	0.60
Warrego Paroo	0.00	0.00	0.30	0.00	0.00	0.20	0.00	0.00	0.60
Namoi	1.00	1.00	0.40	0.75	0.40	0.20	1.00	0.90	0.60
Central West	1.00	0.60	0.25	0.75	0.25	0.15	1.00	0.75	0.60
Maranoa Balonne	0.00	0.00	0.20	0.75	0.20	0.15	1.00	0.80	0.60
Border Rivers Gwydir	1.00	0.55	0.20	0.75	0.15	0.10	1.00	0.80	0.55
Western	0.00	0.00	0.50	0.00	0.00	0.20	0.00	0.00	0.60
Lachlan	1.00	0.40	0.30	0.75	0.15	0.10	1.00	0.75	0.60
Murrumbidgee	1.00	0.80	0.35	0.75	0.40	0.20	1.00	0.90	0.80
North East	1.00	0.85	0.15	0.75	0.50	0.05	1.00	0.95	0.75
Murray 1	1.00	0.85	0.15	0.75	0.50	0.05	1.00	0.95	0.75
Goulburn Broken	1.00	0.85	0.15	0.75	0.50	0.05	1.00	0.95	0.75
Murray 2	1.00	0.85	0.15	0.75	0.50	0.05	1.00	0.95	0.75
North Central	1.00	0.85	0.15	0.75	0.50	0.05	1.00	0.95	0.75
Murray 3	1.00	0.85	0.15	0.75	0.50	0.05	1.00	0.95	0.75
Mallee	1.00	0.70	0.15	0.75	0.40	0.05	1.00	0.80	0.75
Lower Murray Darling	1.00	0.50	0.10	0.75	0.20	0.05	1.00	0.80	0.60
SA MDB	1.00	0.00	0.00	0.80	0.00	0.00	1.00	0.00	0.00
									Data matched to existing CDL

Table 4: Estimated Maximum Surface Water for Current Diversions by State of Nature

	Estimated TOTAL Water (GL)			
	Normal	**Drought**	**Wet**	**Average**
Condamine	387.2	317.3	946.3	540.9
Border Rivers QLD	246.0	187.3	363.4	269.5
Warrego Paroo	38.0	25.5	75.6	46.8
Namoi	567.5	400.8	647.1	558.0
Central West	543.3	303.4	688.2	538.8
Maranoa Balonne	258.1	211.5	630.9	360.6
Border Rivers Gwydir	558.4	207.7	883.1	585.7
Western	98.8	39.9	118.5	92.9
Lachlan	391.9	217.0	627.4	427.6
Murrumbidgee	2,455.6	1,501.5	2,958.0	2,415.5
North East	287.2	204.4	331.8	284.0
Murray 1	55.0	34.0	72.0	55.9
Goulburn Broken	2,014.1	1,447.7	2,168.1	1,947.0
Murray 2	916.2	567.0	1,200.2	931.6
North Central	1,315.0	919.4	1,455.0	1,277.9
Murray 3	824.5	510.2	1,080.1	838.4
Mallee	210.8	148.5	225.4	202.7
Lower Murray Darling	99.4	49.3	270.3	140.6
SA MDB	554.9	465.1	554.9	536.9
Adelaide	206.0	206.0	206.0	206.0
TOTAL	**12,027.9**	**7,963.5**	**15,502.1**	**12,257.3**

Table 5: Results, Water Use (GL)

	Ground Water				Surface Water				TOTAL Diversions			
Basin Plan Review	**Normal**	**Drought**	**Wet**	**Average**	**Normal**	**Drought**	**Wet**	**Average**	**Normal**	**Drought**	**Wet**	**Average**
CDL	2,288.7	2,288.7	2,288.7	**2,288.7**	13,253.2	6,994.1	17,248.6	**13,200.0**	15,541.9	9,282.7	19,537.2	**15,488.7**
Buy-Back												
SDL Current Climate	4,086.7	4,086.7	4,086.7	**4,086.7**	10,188.1	5,447.2	14,450.1	**10,518.5**	14,274.8	9,533.9	18,536.8	**14,605.2**
Climate 450 Avg in 2050	4,086.7	4,086.7	4,086.7	**4,086.7**	9,647.9	4,583.7	12,974.3	**9,633.0**	13,734.6	8,670.4	17,061.0	**13,719.7**
Climate 450 Avg in 2100	4,086.7	4,086.7	4,086.7	**4,086.7**	9,635.5	4,500.0	12,903.6	**9,588.8**	13,722.2	8,586.7	16,990.3	**13,675.5**
Climate 550 Avg in 2050	4,086.7	4,086.7	4,086.7	**4,086.7**	9,627.1	4,431.7	12,847.5	**9,554.1**	13,713.8	8,518.4	16,934.2	**13,640.8**
Climate 550 Avg in 2100	4,086.7	4,086.7	4,086.7	**4,086.7**	9,348.7	4,075.4	12,532.0	**9,249.0**	13,435.4	8,162.1	16,618.7	**13,335.7**
Climate 550 Dry in 2050	4,086.7	4,086.7	4,086.7	**4,086.7**	2,824.6	534.2	3,435.6	**2,549.8**	6,911.3	4,620.9	7,522.3	**6,636.5**
Climate 550 Dry in 2100	**Infeasible solution due to environmental target being greater than natural flow**											

Table 6: Results, Flow to Coorong (GL) and Adelaide's Water Quality (EC)

	Flow to Coorong (GL)				**Adelaide Salinity (EC)**			
Basin Plan Review	**Normal**	**Drought**	**Wet**	**Average**	**Normal**	**Drought**	**Wet**	**Average**
CDL	2,862.9	92.8	8,670.5	**4,051.2**	494.3	486.4	328.4	**443.0**
Buy-Back								
SDL	4,183.5	1,288.4	9,173.3	**5,101.4**	416.6	376.9	338.9	**385.3**
Climate 450 Avg in 2050	2,284.6	1,000.0	6,420.5	**3,268.4**	630.1	345.0	439.5	**515.9**
Climate 450 Avg in 2100	2,152.6	1,000.0	6,245.2	**3,149.9**	664.1	347.0	451.7	**536.9**
Climate 550 Avg in 2050	2,043.7	1,000.0	6,101.3	**3,052.2**	695.1	348.7	462.1	**555.9**
Climate 550 Avg in 2100	1,626.4	1,000.0	5,414.4	**2,637.5**	800.0	327.6	502.4	**616.3**
Climate 550 Dry in 2050	908.7	1,000.0	2,568.0	**1,424.7**	800.0	161.9	654.8	**628.8**
Climate 550 Dry in 2100	**Infeasible solution due to environmental target being greater than natural flow**							

Table 7: Flows to Coorong if Buy-Back ignores climate change (GL)

	Ground Water			
Buy-Back	**Normal**	**Drought**	**Wet**	**Average**
SDL	4,183.5	1,288.4	9,173.3	**5,101.4**
Climate 450 Avg in 2050	2,013.3	126.5	5,991.1	**2,829.3**
Climate 450 Avg in 2100	1,872.6	51.2	5,784.8	**2,682.0**
Climate 550 Avg in 2050	1,757.8	0.0	5,616.6	**2,563.9**
Climate 550 Avg in 2100	1,142.7	0.0	4,714.6	**1,985.7**
Climate 550 Dry in 2050	1,475.7	0.0	5,199.2	**2,297.6**
Climate 550 Dry in 2100	0.0	0.0	0.0	**0.0**

Table 8: Economic Return ($'m)

	Ground Water				Surface Water				Annuity from Water Sales				Total Economic Values			
Basin Plan Review	**Normal**	**Drought**	**Wet**	**Average**	**Normal**	**Drought**	**Wet**	**Average**	**Normal**	**Drought**	**Wet**	**Average**	**Normal**	**Drought**	**Wet**	**Average**
CDL	612.5	366.2	982.1	**674.1**	2,332.5	887.5	3,739.3	**2,465.6**					2,945.0	1,253.7	4,721.4	**3,139.7**
SDL	1,009.0	633.6	1,490.0	**1,078.2**	1,950.2	680.7	3,017.5	**2,016.5**	293.2	293.2	293.2	293.2	3,252.4	1,314.2	4,507.6	**3,241.3**
Climate 450 Avg in 2050	1,109.3	661.9	1,733.0	**1,206.9**	1,755.8	603.7	2,420.5	**1,724.8**	293.2	293.2	293.2	293.2	2,865.1	1,265.6	4,153.5	**2,931.7**
Climate 450 Avg in 2100	1,109.9	661.7	1,733.9	**1,207.5**	1,743.3	604.5	2,398.7	**1,712.2**	293.2	293.2	293.2	293.2	2,853.3	1,266.2	4,132.5	**2,919.6**
Climate 550 Avg in 2050	1,110.4	661.6	1,734.6	**1,207.9**	1,733.3	605.3	2,380.9	**1,702.0**	293.2	293.2	293.2	293.2	2,843.8	1,266.8	4,115.5	**2,909.9**
Climate 550 Avg in 2100	1,112.6	659.7	1,737.8	**1,209.6**	1,679.9	615.7	2,278.5	**1,646.6**	293.2	293.2	293.2	293.2	2,792.5	1,275.5	4,016.2	**2,856.2**
Climate 550 Dry in 2050	1,233.1	684.1	1,964.3	**1,342.7**	659.6	280.0	877.7	**649.1**	858.0	858.0	858.0	858.0	1,892.7	964.1	2,842.0	**1,991.8**
Climate 550 Dry in 2100	**Infeasible solution due to environmental target being greater than natural flow**															

Table 9: Buy-Back Data

	Water Rights Bought by Security				Volume Returned					TOTAL COST ($'billions)
Buy-Back	**High**	**General**	**Supplementary**		**Normal**	**Drought**	**Wet**	**Average**		
SDL	689.8	1,049.1	2,663.5		2,009.6	1,191.7	3,480.4	**2,287.2**		**$3.1**
Climate 450 Avg in 2050	222.9	2,148.2	2,661.6		2,223.2	1,186.6	3,939.3	**2,530.7**		**$3.1**
Climate 450 Avg in 2100	222.9	2,148.2	2,661.6		2,223.2	1,186.6	3,939.3	**2,530.7**		**$3.1**
Climate 550 Avg in 2050	222.9	2,148.2	2,661.6		2,223.2	1,186.6	3,939.3	**2,530.7**		**$3.1**
Climate 550 Avg in 2100	255.7	2,082.2	2,729.6		2,217.2	1,178.7	3,947.1	**2,528.5**		**$3.1**
Climate 550 Dry in 2050	2,503.5	3,226.9	1,914.7		4,997.4	2,999.3	6,621.0	**5,084.9**		**$9.1**
Climate 550 Dry in 2050	**Infeasible solution due to environmental target being greater than natural flow**									

Table 10: Average Return Flow by Catchment

Catchment	SDL: Current	450 Avg 2050	450 Avg 2100	550 Avg 2050	550 Avg 2100	550 Dry 2050	550 Dry 2100
Condamine	80.9	46.5	46.5	46.5	46.5	0.0	**Infeasible solution due to environmental target being greater than natural flow**
Border Rivers QLD	7.0	7.0	7.0	7.0	7.0	0.0	
Warrego Paroo	40.7	46.4	46.4	46.4	46.4	0.0	
Namoi	8.4	8.4	8.4	8.4	8.4	0.0	
Central West	57.2	55.4	55.4	55.4	55.4	174.8	
Maranoa Balonne	76.0	105.1	105.1	105.1	105.1	0.0	
Border Rivers Gwydir	41.9	39.6	39.6	39.6	39.6	421.2	
Western	5.1	5.1	5.1	5.1	5.1	0.0	
Lachlan	38.0	309.0	309.0	304.6	304.6	214.5	
Murrumbidgee	799.8	829.3	829.3	877.4	877.4	1,398.5	
North East	23.8	23.8	23.8	23.8	23.8	18.9	
Murray 1	6.2	6.2	6.2	6.2	6.2	6.2	
Goulburn Broken	351.0	335.4	335.4	335.4	335.4	907.2	
Murray 2	103.6	103.6	103.6	103.6	103.6	103.6	
North Central	279.4	159.9	159.9	195.9	195.9	907.2	
Murray 3	93.3	175.2	175.2	93.3	93.3	175.2	
Mallee	52.9	52.9	52.9	52.9	52.9	201.5	
Lower Murray Darling	125.0	125.0	125.0	125.0	125.0	125.0	
SA MDB	97.0	97.0	97.0	97.0	97.0	431.0	
TOTAL	**2,287.2**	**2,530.7**	**2,530.7**	**2,528.5**	**2,528.5**	**5,084.9**	