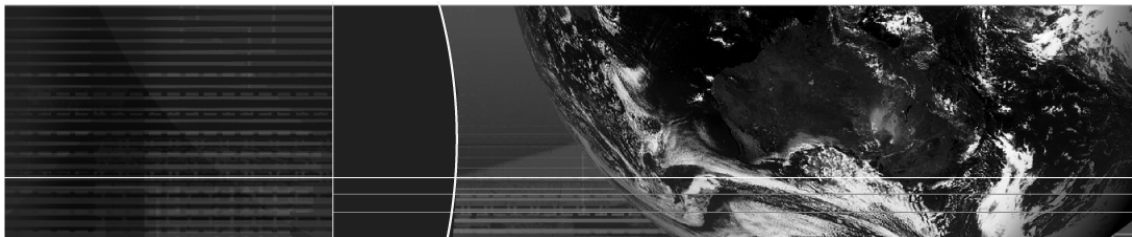




Australian Government
**Australian Bureau of Agricultural
and Resource Economics**



Purchasing water in the Murray Darling Basin

ABARE report for the
Department of Environment and Water Resources

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Summary

In the presence of a market, open market purchases are likely to be the most cost effective mechanism for purchasing water. There may, however, be some opportunity to purchase water at below the market price in the early stages of the buyback programme.

- Where water markets are institutionally isolated, and environmental benefits are independent of where water is purchased, the government can minimise budgetary outlays by purchasing water in the cheapest markets.
- Where environmental benefits are not independent of where water is purchased, an environmental index will be needed to compare the environmental benefits derived from purchasing water from different irrigation systems within a physically connected system, or across irrigation systems in physically disconnected systems.
- While this index may be quite crude in the early stages of a buyback, it will be essential if the government is to target purchases from regions which offer the greatest value for money (environmental benefits per dollar of funding).
- Open market purchases will also be the most cost effective option for targeting regional purchases to achieve additional water quality outcomes in physically connected systems that are institutionally disconnected.
- Current restrictions on interregional trade will reduce the potential for trade to undo the additional environmental benefits achieved through regional targeting.
- It will not be possible to achieve additional water quality outcomes by targeting specific irrigators within a region using open market purchases.
- Targeting specific irrigators within a region will require the use of an auction.

In the absence of a market, and when competition from potential bidders is weak, the discriminatory price auction is likely to be more efficient. A reserve price may help to improve efficiency when competition is weak and to limit the potential for bidder collusion in a repeated auction format.

-
- An auction is a mechanism in which the distribution of information between buyer and seller plays a crucial role. Information should not be published about the average or the maximum accepted bid or the distribution of bids received in preceding bidding rounds.

If utilities retire infrastructure, irrigators located near this infrastructure will have little choice other than to transfer their entitlement to land located near infrastructure that is not to be closed down, to sell or lease their entitlements, or to sell their annual allocations.

- The government could purchase entitlements from and/or provide structural adjustment payments to these irrigators.
- Since subregional targeting is required, a select auction will be required
- There is significant potential for irrigators to collude under a select auction.
- One way to avoid paying inflated prices to these irrigators in systems where there is an existing market would be to confine the auction to allocating structural adjustment assistance. The government would not purchase entitlements, with irrigators having the choice of selling or leasing their entitlements in the market.

A government purchase of water entitlements will reduce the volume of water available for irrigation, leading to an increase in the market price of water.

- The size of the price impact will be determined by the volume of water purchased and the price elasticity of demand for irrigation water, and not influenced by the mechanism used to purchase water.
- Price rises will be higher in regions where a higher percentage of the available water is purchased, and where the demand for water is inelastic
- The level of asset fixity in a market may be a critical factor in determining the number of irrigators willing to sell water at a given price.
- Investment in improved on and off-farm irrigation infrastructure has the potential to increase water availability where a proportion of the water savings are retained by irrigators. The off-setting price impact of these programmes will ultimately depend on the net change in water availability.

Table 1: Summary of assessment

| | Cost effectiveness | Government transactions costs | Irrigator transaction costs | Information Asymmetry |
|---|---|---|---|---|
| Buying back for the environment (general purchase) | | | | |
| <i>In presence of market</i> | | | | |
| Open market purchase | Is likely to be the most cost effective way of acquiring water for the environment in areas with established markets | Relatively low | Relatively low | Limited opportunity for strategic behaviour |
| Auction | A discriminatory price tender may be useful to achieve strategic purchase of water if used in conjunction with restrictions on future trade | Information and administrative costs higher than for open market purchase | Compliance costs may be higher than for open market purchase | Increased opportunity for irrigators to act strategically (compared to open market purchase). |
| <i>In absence of market</i> | | | | |
| Auction | A discriminatory price tender likely to be most cost effective | Information, administrative, and assessment costs likely to be high | Compliance costs will be high (potential to limit these costs through expression of interest bids) | High potential for strategic behaviour (collusion) – a discriminatory auction should help to limit this |
| Buyback/assistance for reconfiguration (targeted purchase) | | | | |
| Open market purchase | Not suitable for targeting below irrigation district level | | | |
| Auction | A select auction may be more cost effective than a posted-price offer | Information costs, specifically search costs are likely to be high if the government helps to identify irrigators | Compliance costs are likely to be lower than for the other tenders as government will have targeted the auction offer | A select auction provides very high potential for strategic behaviour (particularly collusion) |

1. Introduction

On 25 January 2007 the Prime Minister announced a \$10 billion National Plan for Water Security. The main components of the Plan include a commitment by the Commonwealth Government to invest \$5.9 billion over 10 years to modernise Australian irrigation, with a further \$3 billion being committed to address overallocation in the Murray Darling Basin. The \$3 billion to address overallocation will be split between buying back irrigation water entitlements and assisting irrigators in unviable or inefficient sections of irrigation schemes to exit the industry.

Specifically, the goals of the over-allocation programme are to:

- acquire additional entitlements for environmental flows; and
- provide assistance to irrigators in unviable or inefficient parts of irrigation schemes to exit the industry.

The latter goal will support the modernisation programme for off-farm delivery infrastructure.

The objectives of this research are to:

- identify the main mechanisms for buying back entitlements and/or distributing structural adjustment assistance;
- assess the suitability of these instruments; and
- identify the impact of buying back entitlements on water prices.

2. *Purchase mechanisms*

While there are a number of mechanisms for the government to buy back water entitlements for the environment, this analysis will be confined to investigating the suitability of open market purchases and various voluntary auction mechanisms. Open market purchases refer to a situation where the government enters existing water markets to purchase entitlements. Auctions, on the other hand, can be used to purchase water in irrigation systems where markets do or do not exist. Auctions can also be used to target irrigators at a subregional level, whereas open market purchases cannot distinguish between irrigators within a region.

Box 1 – A water entitlement

A water entitlement is a resource access right, and is often defined as an ongoing share of water resources that become available over time. Like a share in a public company, the return on a water entitlement has an average yield and is associated with a level of reliability or variability. For example, a 100ML entitlement may have an average yield of 90 per cent (ie 90ML).

The average yield for water entitlements will often vary between irrigation systems, and between security classes within an irrigation system. For example, in New South Wales, a high security entitlement within an irrigation system may have an average yield of 90 per cent, compared to 60 per cent for general security water. Moreover, the variation in allocations around the average yield for the high security entitlement may be very low, whereas there may be a high level of variation for the lower security entitlement. These characteristics are reflected in the market price of entitlements, with higher yielding entitlements with low variability attracting a higher price than lower yielding entitlements with high variability. This is because high yielding entitlements with low variability allow irrigators to engage in a wider range of productive activities, such as irrigated permanent horticulture, which require access to a highly reliable water source.

For a particular class of water entitlements within an irrigation district the entitlements are all the same, that is, they are homogenous. This homogeneity means that the entitlements will have the same market price. As the variability of a class of entitlements varies across irrigation districts the water prices across irrigation systems also vary.

Open market purchase

Water entitlements are currently traded in the Murray Darling Basin. This trade is facilitated by entitlements being separated from land title, entitlements being divisible (the potential to sell part of an entitlement), and market participants being aware of the yield and reliability of entitlements being traded. For a more detailed description of water entitlements see box 1.

The market price for water is determined by the transactions of buyers and sellers in the market. The buyer states the price they will pay for water — the offer to buy, while the seller states the price they are willing to receive to sell water — the offer to sell. A transaction occurs when the offer to buy is the same price as the offer to sell. It is common for offers to buy and offers to sell to sit in the market unmatched — in these circumstances the highest offer to buy is lower than the lowest offer to sell.

The government has a choice regarding the price of the offer. The likelihood of the offer to buy being matched with an offer to sell increases as the price increases. In a market with many trades it is likely that an offer to buy at the market price would soon be matched with an offer to sell. In a market with little trade the government could make an offer to buy that is above the average market price to elicit interest from sellers.

There are a variety of organisations that provide water trading platforms and exchange services in the Murray Darling Basin. The government would need to place offers to buy in each of these trading platforms to maximise the probability of a trade occurring. An offer to buy would specify: the irrigation district or trading zone from which the water is to be purchased, the quantity sought, the per mega litre price, and the duration of the offer. While an open market purchase would allow the government to target water purchases to the level of the irrigation district or trading zone, it will not facilitate the targeting of specific locations or individual irrigators within these systems.

Auction (tender)

An auction is a mechanism that can be used to purchase or sell a good (or service) in the presence or absence of a market. Auctions are commonly referred to as tenders in Australia, although this is not the case internationally. In order to avoid confusion, and to comply with the international terminology, the term auction will be used in the remainder of this paper.

Auctions are commonly used to purchase goods where there is no established market. Under these circumstances auctions provide an opportunity to purchase goods at a lower cost compared to posted-price offer (a set price) systems because they introduce an element of competition between bidders. Bidding reveals information about values and enables the government to discriminate between competing bids. Moreover, the

government is able to control the allocation of funds by setting the rules under which the bids are selected (Latacz-Lohmann and Vaan der Hamsvoort 1997).

Auctions can also be used to target the non-price attributes of bids submitted by irrigators. This in turn provides the government with an opportunity to use auctions to target subregional outcomes that cannot be achieved when purchasing water in an open market.

Basic auction theory refers to the sale of a single good (or service) to a single buyer through one of four basic auction types. These include: the ascending-bid auction¹ (also called the open, oral, or English auction), the descending-bid auction² (also called the Dutch auction), the first-price sealed-bid auction³, and the second-price sealed-bid auction⁴ (also called the Vickrey auction). Each of these single unit auctions have the potential to achieve similar outcomes in terms of revenue raised and allocating goods to bidders who value the good most.

In the context of the National Plan for Water Security, auctions would be used to purchase (rather than sell) water from multiple (as opposed to single) sellers. This has the potential to significantly complicate matters, with Klemperer (2004) stating that it will be more difficult to achieve efficient outcomes using multiunit auctions. Klemperer also notes that the literature on multiunit auctions is relatively new, and often conflicting.

Multiunit auctions

While auctions can be used to buy or sell a good, auction theory generally refers to the sale of goods. When selling goods the goal of the auction is to maximise revenue. When purchasing goods, however, the goal will be to minimise costs (assuming that the good is homogenous). Since the flow of goods and the goal of the auction are reversed when purchasing, auctions that are held for the purchase of goods are sometimes referred to as

¹ In open ascending-bid auctions (English auctions) the price is steadily raised by the auctioneer with bidders dropping out once the price becomes too high. This continues until there remains only one bidder who wins the auction at the current price.

² In open descending-bid auctions (Dutch auctions) the price starts at a level sufficiently high to deter all bidders and is progressively lowered until a bidder indicates that he is prepared to buy at the current price. He or she wins the auction and pays the price at which they bid.

³ In first-price sealed-bid auctions the bids are submitted independently without knowing what the other bids are. The highest bid wins, paying a price equal to the exact amount that he or she bid.

⁴ In second-price sealed-bid auctions (Vickrey auctions) the bids are submitted independently without knowing what the other bids are. The highest bid wins, paying a price equal to the exact amount of the second highest bid.

reverse auctions. The following descriptions are given in the context of a reverse auction. There are two types of multiunit auctions — discriminatory price auctions and uniform price auctions.

Uniform price auction

In a uniform price auction each bidder submits a sealed bid stating the price they are willing to receive per unit of a good, and the number of units they are willing to sell. The goods are sold at a single price — determined by the highest winning bid or (more commonly) the lowest rejected bid. The lowest bid is selected first, followed by the second lowest bid and so on until the unit target is achieved or the budget is exhausted. The uniform price auction corresponds to the second-price sealed bid auction in the single unit case (Latacz-Lohmann and Vaan der Hamsvoort 1997) and may be called a generalised Vickrey auction (Hailu and Thoyer 2005). Under a uniform price auction successful bidders receive the same price — the lowest rejected bid, which will be higher than the value of their bid for all individuals.

Discriminatory price auction

In a discriminatory price auction each bidder submits a sealed bid stating the price they are willing to receive per unit of a good, and the number of units they are willing to sell at that price. As with the uniform price auction the lowest bid is selected first, followed by the second lowest bid and so on until the target is achieved or the budget is exhausted. In a discriminatory price auction each successful bidder receives the value of their bid.

Variations to standard auctions

There are a number of variations to the standard auctions discussed above. One variation is an expression of interest auction. In a formal tender auction, the offers made by irrigators in bid submissions would be legally binding. Under an expression of interest auction, however, submissions would not be binding, and the government would subsequently have to make legal offers to buy, which participants can either accept or reject. A drawback of the expression of interest auction is the risk that irrigators who have agreed to sell water in principle back out before conveyancing is finalised. The Living Murray Pilot Environmental Water Purchase used an expression of interest auction format (Appendix A).

Another variation to the standard auction is a select auction. This type of auction allows the government to target outcomes by imposing restrictions on who can submit bids.

Single and multi round auctions

A single round auction (also called a one-shot auction) is when there is just one bidding round. A multiple round auction (also called a repeated, dynamic, rolling or iterative auction) is where there is more than one bidding round. The length of a round is defined as the period in which bids are submitted, assessed and either accepted or rejected.

Rounds can have a duration of days, weeks or even months (the Living Murray Pilot Environmental Water Purchase had a new round every week (Appendix A)). The bidding within a round is called simultaneous if each bidder only submits one bid and sequential if each bidder has the opportunity to revise their bid.

The number of rounds of an auction have important implications for the bidding strategies of the participants and hence the overall outcome of the auction (discussed further in chapter 4). Essentially, bidders tend to learn from the outcomes of previous bidding rounds, and to use this information to update their bids (Latacz-Lohmann and Schilizzi 2005).

Open and sealed bidding

Sealed bidding refers to a situation where bidders submit bids that are not revealed to other auction participants. This is in contrast to an open bidding system where auction participants are aware of the bid prices submitted by other participants.

Uniform price and discriminatory price auctions use sealed bidding in order to increase competition between auction participants. The effectiveness of sealed bidding in increasing competition between participants is likely to be eroded where there are multi round auctions, with multi round auctions providing bidders with an opportunity to analyse the results of preceding bidding rounds, and to use this information to update their bids. Bidder learning and associated strategies are discussed further in chapter 4.

Reserve prices

A reserve price is a price above which bids will not be accepted. A bid below the reserve price does not necessarily imply that the bid will be accepted —the reserve price is part of the wider assessment process. In open bidding the reserve price may be publicly known. Conversely, in sealed bidding the reserve price is generally not revealed. While the reserve price is not explicitly revealed in multistage auctions, participants tend to learn from the outcomes of previous rounds, with the previous cut-off price for the auction often being interpreted as the implicit reserve price.

The use of a reserve price is influenced by the expected number of bidders in an auction and their potential bidding strategies. Although in a multistage auction it is likely that bidder learning between rounds will lead to discovery of the reserve price (whether explicit or implicit) and have an ‘anchoring’ effect on future bids.

3. *Criteria for assessment*

The buyback programme has two goals, to acquire additional environmental water, and to encourage/assist irrigators located near delivery infrastructure that is to be retired to either relocate or exit the industry. The mechanisms for buying water entitlements and distributing assistance to irrigators affected by the retirement of infrastructure will be assessed in terms of their potential to:

- achieve the goals of the buyback programme, and
- maximise the net benefits from intervention.

These mechanisms will also be assessed in terms of the opportunities they provide for irrigators to engage in strategic behaviour and inflate the price at which they offer entitlements to the government. The effectiveness of all purchase mechanisms to cost effectively acquire water for the environment will be influenced by the strategic behaviour of irrigators.

Effectiveness

Effectiveness refers to how well an instrument achieves its objective. Hence, the degree of certainty with which an instrument achieves its stated goal, or its dependability, will be an important consideration in instrument selection (Industry Commission 1997). For example, an instrument that does not allow for targeting irrigators within an irrigation system will fail to achieve the goal of assisting irrigators located near infrastructure that is to be retired to relocate or exit the industry. In a similar vein, open market purchases will fail to acquire water in an irrigation system where there is no water market.

Efficiency

The goal of buying back entitlements for environmental use should be to maximise the net environmental benefits from these purchases. If there were no transaction costs and the environmental benefits derived from water purchased from irrigators were independent of where irrigation water is used, the goal of maximising net environmental benefits from additional water would simply involve minimising the cost of acquiring this water. This would in turn involve purchasing water in such a way that equalises the marginal cost of acquiring water across irrigators. The marginal cost of acquiring an additional megalitre of water in an irrigation system where water is traded is reflected in the traded price of water. For example, if the traded price of water in system A was \$1000ML, and \$1500ML in system B, the government would minimise the cost of purchasing water by purchasing water in system A until the price of water had risen to

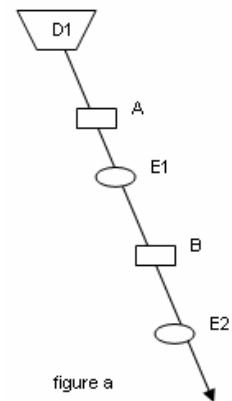
\$1500ML. If more water was needed, it would then purchase water in both systems, ensuring that the price was equalised in both systems.

In many cases, the environmental benefits derived from additional water sourced from irrigators will not be independent of the location of where this irrigation water is used. If it were possible to attach a monetary value to environmental benefits, the net environmental value of purchases would be derived by subtracting the costs of purchasing water from the dollar value of the environmental benefits received. The net environmental benefits from government funding would in turn be maximised at the point where the marginal net environmental benefits derived from sourcing an additional megalitre of water for environmental use from different irrigation systems were equalised across these systems.

The difficulty, expense and time required to derive rigorous monetary estimates for environmental values to trade-off competing environmental values suggest that some alternative will be needed to represent these values. A simplified environmental index may be constructed instead. To do this it will be necessary to first identify the environmental assets that need to be protected. The location and nature of these assets will in turn determine whether the location of entitlements and the type of entitlement will be important considerations when purchasing water. In order to illustrate how the location and type of environmental asset can influence purchases, consider box 2.

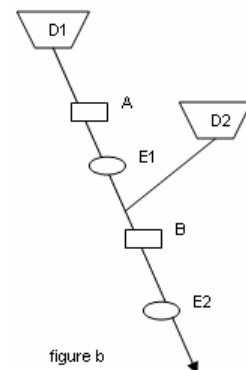
Box 2 – Trading off environmental assets

Consider the river system illustrated in figure a. D1 represents the storage system located at the headwaters of the river, A and B represent the location of two irrigators and E1 and E2 represent the location of two environmental assets. Consider in the first instance a situation where environmental assets E1 and E2 are located instream, and do not consume water, with water used to satisfy these assets remaining in the river system for downstream use. Further, assume that the timing of flows needed to satisfy E1 and E2 is not important. Under these circumstances, additional water sourced from irrigators located further upstream in a river system should be capable of watering more environmental assets than water sourced from irrigators located further downstream, and hence, location will be an important consideration when purchasing water. Water purchased from irrigator A is capable of watering environmental assets E1 and E2 if this water remains in the river system following use at E1. In this example, water used by irrigator B already waters E1 so purchasing water from B only provides additional benefits to E2. However, purchasing water from irrigator A provides benefits to E1 and E2.



In contrast, there will be no difference in the level of environmental benefits derived from sourcing water from irrigators A or B if this water is consumed by the environmental asset (for example, a wetland located on a floodplain), and not returned to the river system (assuming spatial differences in transmission losses and water quality following irrigation use are negligible). That is, there are no return flows. If water is purchased from irrigator A, A will not extract this water, allowing it to flow downstream to E1 or E2. If water is purchased from irrigator B, this water could be intercepted for use at E1 following release from the storage, or let flow downstream to E2.

Further, consider the situation illustrated in figure b where irrigator B holds two different water entitlements, one tied to storage D1 and the other tied to storage D2. It is assumed that irrigator A's entitlement is tied to D1. Also, assume that environmental assets consume water. Under these circumstances, purchasing entitlements tied to D1 will provide more environmental watering opportunities than purchasing entitlements tied to D2. In the example, purchasing entitlements tied to D1 will provide the environmental manager with the flexibility to water environmental asset E1 or E2, whereas purchasing entitlements attached to D2 will only be capable of



watering environmental asset E2. However, this added flexibility would need to be traded-off against other entitlement attributes, such as the price and quantity of water.

From these simple examples it is apparent that as more detail is added, the assessment of the relative value of environmental benefits and the most appropriate purchase of water is likely to quickly become complex and resource intensive. If it is necessary to consider any third party impacts associated with changes to return flows the assessment will become more complex again. The potential third party impacts of changing patterns of water use are outlined in Heaney et al. (2006).

In addition, if the asset in question is a wetland which would normally only be watered in a high flow year, general or lower security entitlements may be capable of achieving the environmental goal. Conversely, maintaining minimum flows in a dry year may require access to higher security water.

Transaction costs

Transaction costs will be a major factor in determining whether intervention should occur in the first place, and secondly, to determine whether a particular instrument is more cost effective in achieving a desired policy outcome than other instruments. Transaction costs refer to a range of costs, including information costs and administration costs. It is important to be aware that some transaction costs will be incurred irrespective of the mechanism used to purchase water.

Information costs

Information costs will be a significant component of transaction costs. The major information problem likely to confront the government — and one that will be incurred irrespective of which instrument is used to purchase water — will be the fact that environmental benefits tend to be non-market benefits. In the absence of transaction costs, and in situations where the environmental benefits derived from additional water are not independent of the location of where irrigation water is used, the net environmental benefits derived from government funding will be maximised at the point where the marginal net environmental benefits derived from sourcing an additional megalitre of water for environmental use from different irrigation systems are equalised across these systems. The difficulty and expense in deriving rigorous monetary estimates for environmental values suggest that some alternative will be needed to represent these values.

One alternative is to derive an environmental index that will allow competing environmental values to be traded off against each other. The derivation of such an

index will involve the government trading off the additional benefits derived from undertaking more sophisticated assessments of environmental values and the higher costs associated with these assessments. It may be necessary to use a relatively crude index initially, given the governments' commitment to start purchasing water in the near term, and to work on the construction of a more sophisticated index to guide purchases later on in the programme. An example of a simple index would be to give a higher priority to providing additional water to wetlands that are both internationally recognised under international treaties and which have been identified as vulnerable (such as under the Ramsar Convention), compared to other vulnerable wetlands that are not internationally recognised.

Administration costs

Administration costs may also be an important determinant of the appropriateness of a particular mechanism. Administration costs refer not only to the costs incurred by government trading in the market or running an auction, but also to the costs incurred by irrigators trading in the market or in preparing and submitting bids to auctions.

Government costs

The government will incur administration costs irrespective of whether it purchases water in an open market or through an auction. For example, it will incur search costs in identifying opportunities to purchase water in the open market. This is likely to involve monitoring a number of markets and exchange services, as well as employing brokers to identify purchase opportunities. Other costs will include any exchange fees associated with the purchase of entitlements. Existing water markets have transaction costs embedded within them. These costs may include exchange fees for brokerage services and fees and charges related to applying to the regulating authority to approve the trade. These costs are generally accounted for in the offer to buy, with the seller receiving the offer price less the fees and charges.

The administration costs associated with running an auction are likely to be higher than purchasing water in an open market (see Box 3 for a description of the steps involved in running an auction), and to increase the more administratively complex the auction is. Some of these administration costs include the costs in communicating to irrigators the government's intention to purchase water within their region, collating and assessing bids, deriving a reserve price and preparing contracts for irrigators. The government may also incur costs if it chooses to provide assistance to irrigators to engage independent advisors to assist them in filling out bid proposals. For example, the government provided financial assistance (\$1500) to eligible bidders in the Fisheries Business Exit Assistance programme to seek financial advice prior to the auction closing (Appendix A). The government also incurred administration costs in providing

independent conservation advisors to assess the benefits of covenants at the farm level to assist bidders to prepare bids for the Forest Conservation Fund (see Appendix A).

Box 3. Steps in running an auction

Generally an auction will follow four basic steps. In the first instance, the goals and budget for the auction are determined, and any relevant criteria needed to assess bids identified. In most cases, the government will not reveal the reserve price, budget or volumetric target to prospective bidders. The second step will usually involve alerting interested parties that the government is running the auction to purchase water, and issuing relevant documentation and related information to these parties. Often independent assistance is provided to assist interested parties in preparing and submitting bids. The next step will involve assessing bids at the close of the submission period, and selecting bids based on their ranking under the pre-set assessment criteria. The final step will involve conveyancing selected bids.

The government may also incur costs if it wishes to reduce the incentive for irrigators to trade water back into regions (or sub-regions) where it has purchased water to achieve the additional goal of improving downstream water quality.

Irrigator costs

Irrigators will also incur transaction costs when selling water to the government. For example, similar to the government, irrigators will incur search costs when selling water in the open market. Moreover, irrigators will have to prepare bid documents if they choose to participate in an auction. The cost involved in preparing bid documents will depend on the complexity of the auction design. A more complex auction may require irrigators to acquire and understand more information, and thus involve a higher cost. It is important to realise that the transaction costs for the irrigator are not just financial costs, but include a range of opportunity costs. For example, the opportunity cost of time devoted to understanding, preparing and submitting tenders.

Asymmetric information and strategic behaviour

Strategic behaviour is the general term used to describe actions taken by market participants to influence the outcome of an interaction⁵. Strategic behaviour includes cooperative or collusive actions to improve joint outcomes, as well as individual or

⁵ Sometimes strategic behaviour is referred to as 'gaming'. This term is derived from the name given to the study of strategic behaviour — game theory.

noncooperative actions to improve the outcomes of individuals. The potential for strategic behaviour is determined by the level of asymmetric information and the number of market participants.

Asymmetric information refers to the situation where one market participant has more, or better, information than the other market participant. A key information asymmetry for the government in irrigation systems where water is not traded will be the lack of knowledge regarding the marginal value of water used for irrigation. This asymmetry will increase the potential for irrigators to overbid in an auction process, which will reduce cost effectiveness and lead to less water being purchased for a given budget. Incentives for irrigators to reveal truthful information in an auction process are discussed in chapter 5.

It is clearly stated in the National Plan for Water Security that \$3 billion is available for buying back water entitlements and providing assistance to irrigators located in unviable or inefficient parts of irrigation schemes to exit the industry. The sheer size of the funding may provide an incentive for irrigators to engage in strategic behaviour by either 'holding out' in the market for a higher price in the belief that the money will have to be spent at some point, or to inflate bids in an auction. While the government has revealed that it will spend \$3 billion over 10 years, it has not revealed the timetable for the expenditure, the volumetric target, or the split between the buyback and structural adjustment. This may help limit the potential for, or extent of, strategic behaviour by irrigators.

4. Assessment of purchase mechanisms

The goals of the buyback programme are to address the problem of over-allocation in the MDB and provide assistance to irrigators located in unviable or inefficient part of irrigation schemes to exit the industry. The following assessment will consider the potential for different purchase mechanisms to achieve these goals in the presence or absence of a market.

Buyback for the environment

As discussed earlier, the public nature of the funding assigned to this component of the Plan will increase the incentive for irrigators to behave strategically by overbidding in an auction or by ‘holding out’ in the market. Regardless of the purchase mechanism, not revealing; volumetric targets, the reserve price, or the budget shares allocated to buying back entitlements and structural adjustment, will — to some extent — reduce the potential for this kind of strategic behaviour.

In the presence of a market

In the main, open market purchases are likely to be the most cost effective mechanism for purchasing water in systems where there is a market. There may, however, be some opportunity to purchase water at below the market price in the early stages of the buyback programme, which may warrant the use of a discriminatory price auction prior to purchasing water in the market. A discriminatory price auction is likely to be preferred because of its potential to purchase water at a lower budgetary cost than a uniform price auction. Ultimately, the decision to use an auction in the early stages of the buyback programme will depend on whether the expected budgetary savings (in terms of reduced purchase costs) outweigh the additional transaction costs.

Potential to purchase water at below the market price

The potential to purchase water below the market price seems limited. However, there may be a number of reasons as to why irrigators may be prepared to sell water at below the market price. For example, in thin markets where there is no current market price, irrigators may not know how the value of their entitlement would relate to the market price that would result if renewed trade occurred. Where this is the case the government may be able to purchase entitlements from these irrigators for less than if they entered the market and in doing established a current market price. This would only be possible if irrigators did not see the price others were selling their entitlements for, as would be the case in a sealed bid auction. One reason markets may be thin is the reticence of irrigators to purchase additional entitlements given increased uncertainty as to the future yield and reliability of these entitlements. Additionally, irrigators who are

financially stressed may be willing to submit relatively low bids under an auction to increase the probability of an immediate sale which will allow them to restructure their finances or to exit the industry. These opportunities are likely to be limited to regions with thin markets and to disappear as seasonal conditions improve.

Irrigators who hold ‘sleeper’⁶ or ‘dozer’⁷ entitlements may also be willing to submit relatively low bids. They may be willing to do this if they perceive there is a risk that these entitlements will be revised down more heavily than entitlements that are fully activated when water sharing plans are revised during the transition to a new basin-wide cap in the Murray Darling Basin. These concerns may be based on recent events such as the downward revision to groundwater entitlements in New South Wales based on irrigators ‘history of extraction’ under ‘The Achieving Sustainable Groundwater Entitlements Program’ (Murphy 2006).

Altruism may also motivate some irrigators to sell water for environmental use for less than the market price. It is expected that there will only be a limited number of people that willing to accept a price below the market price because of altruism, however. For example, a survey of the adoption of land management practices in the Great Barrier Reef catchment found that voluntary adoption of on-farm management practices will only occur where the private on-farm benefits generated from adoption are larger than the private on-farm costs incurred by the farmer (ABARE, 2006). This evidence suggests that the there will be a limited number of irrigators that are willing sell to their water for less than the market price.

As stated above, the potential to acquire entitlements at less than the market price may warrant the use of a discriminatory price auction, to elicit water at less than the market price. The potential for this mechanism to deliver significant budgetary savings may be limited, however, if recent buyback auctions in the Murray Darling Basin have already elicited bids by irrigators willing to sell entitlements at below the market price. (These buyback auctions include The Living Murray Pilot Environmental Water Purchase tender and the New South Wales RiverBank tender (see Appendix A))

Implications for purchase costs

The most cost effective option for purchasing large volumes of water for the environment in systems where markets exist will be to purchase water in the open market. This will be the case irrespective of whether the environmental benefits derived from purchases are dependent or independent of the location of where water is

⁶ A sleeper entitlement is when the entitlement has not be utilised over a defined period of time.

⁷ A dozer entitlement is a entitlement that has only been partially used over a defined period.

purchased. In situations where the environmental benefits are independent of where irrigation water is purchased, the government should simply purchase water in the cheapest market. The government can easily do this by comparing prices across physically disconnected systems, and across regions within physically connected but institutionally disconnected systems. In the event that there were no restrictions in interregional trade, the market price for water would converge across systems, and there would be no cost advantage in targeting systems.

If environmental benefits are dependent on the location of purchases, some form of environmental index will be required to compare the environmental benefits derived from purchasing water from different irrigation systems within a physically connected system, or across irrigation systems in physically disconnected systems. Open market purchases will remain the most cost effective option for acquiring water, with the costs of developing an environmental index being incurred irrespective of which purchase mechanism is used. As stated earlier, this index may be quite crude in the early stages of a buyback, however, it will be essential if the government is to target purchases from regions which offer the greatest value for money (environmental benefits per dollar of funding). The potential to source water from lower cost markets under these circumstances will depend on whether there are a number of institutionally isolated markets upstream of the environmental asset in need of protection. Where this is the case, the environmental flow can be sourced from the lowest cost market upstream of the asset. Of course, the further upstream an environmental asset is, the less choice there will be in the number of markets that can be used to satisfy the environmental flow. This will also be the case where there is only one irrigation system in a physically disconnected system.

Open market purchases are likely to be the most cost effective option for purchasing water in systems where markets exist if the government has no desire to achieve additional water quality outcomes by targeting individual irrigators within regions. Transaction costs are likely to be lower than running a formal auction, and there will be less potential for irrigators to collude. This is not to say that some irrigators will not hold out for a better price at some stage in the future. This is likely to happen under both open market purchases and auctions, however.

Achieving additional water quality outcomes

Open market purchases will also be the most cost effective option for targeting regional purchases to achieve additional water quality outcomes in physically connected but institutionally disconnected systems. For example, it may be possible to purchase water from regions that have highly saline return flows to the river system, thereby reducing the salt load of the river system. The current restrictions on interregional trade would reduce the potential for water to be traded back into a region that has been targeted, acting to safeguard any improvements in downstream water quality. It will not be possible guarantee that the additional benefits achieved by targeting purchases from

specific regions will be maintained in the presence of unrestricted interregional trade. Current restrictions on interregional trade will reduce the potential for trade to undo the additional environmental benefits achieved through regional targeting (although these are to be phased out over time). Targeting regional purchases will be problematic in the presence of unrestricted interregional trade, however. Under these circumstances, some form of trade restriction (which will involve some costs) may be required to prevent water being traded back into targeted systems if environmental benefits are to be maintained

It will not be possible to achieve additional water quality outcomes by targeting specific irrigators within a region using open market purchases. This is because an offer to sell in the market does not provide information regarding the location of water use within a region. In order to target subregional outcomes, an auction could be used. The auction process allows the government to collect additional information regarding the location of water use and what it is used for. This information could then be used to target additional water quality benefits from irrigators located in subregions with highly saline return flows. However, the auction would need to be supported by an additional mechanism to reduce the incentive for irrigators who have been targeted to trade water back to their farm. One option for maintaining water quality benefits would be to attach a covenant to the land irrigated on prior to sale of the entitlement (for examples of covenants on land see the Forest Conservation Fund tender (Appendix A)) or through subregional restrictions on trade.

Potential for strategic behaviour in the market

There is limited potential for strategic behaviour as there are relatively minor information asymmetries in the presence of a market. However, there may be strategic behaviour (in terms of holding out) due to overall programme size and design.

In the absence of a market

Traditionally, in the absence of markets, regulatory or posted-price approaches have been used to achieve environmental outcomes. More recently auctions have been used to generate a range of bids with funds allocated to those with the lowest opportunity cost (that satisfy the environmental outcome). In this way the auction results in a proxy market. For this reason auctions are generally used in the absence of markets.

Auctions are more efficient than posted-price approaches because the bidding process reduces the information advantage of individuals by creating a competitive environment. The efficiency of an auction is most heavily influenced by the type of auction used, the number of rounds, the potential bidder behaviour (given the auction format), and the influence of bidder learning on bidder behaviour. As a water buyback auction would be a multiunit auction the following discussion is limited to the multiunit context.

Single round multiunit auctions

Although a single round multiunit auction will not be suitable given the timeframe and size of the buyback programme, it is easier to understand the efficiency impacts of the multistage auction in comparison to the one stage auction.

Compared to the uniform price auction, the discriminatory price auction provides a smaller incentive for bidders to bid their true marginal value for water. In a single round price discriminating auction sellers face uncertainty about acceptance, but not about price — since the price obtained will be the bid price. When contemplating increasing the bid price, a seller trades off the decreased probability of acceptance against a higher trading surplus if accepted. The trading surplus is the difference between the price received and the true marginal value. The bidder has an incentive to misrepresent costs and submit offers higher than the true marginal value of water — otherwise no trading surplus is earned (Cason and Gangadharan 2005).

By contrast, in the uniform-price auction (where the price paid is the lowest rejected bid), all the successful bidders receive a price that exceeds their bid price. In a uniform price auction each bidder has a greater incentive to reveal their true marginal value since submitting an offer greater than the value lowers the probability of the bid being accepted — but does not (significantly) raise the price at which the item might be sold (Cason and Gangadharan 2005).

Although the uniform price auction provides a better incentive to reveal true marginal value, it is often a less efficient auction format overall, compared to the discriminatory price auction. Cason and Gangadharan (2005) found that although uniform price auctions have better cost revelation properties this auction format does not achieve full efficiency. This is because the uniform price was set by the first rejected seller's price offer and all successful sellers received this price per unit. Successful sellers, therefore, receive prices that exceed their offers and values — and earn trading surpluses. Hence, in order to induce bidders to reveal their true marginal value the government must pay a price higher than the marginal value (information rent) (Ferraro 2007). Whether information rents are higher under a uniform price based on true opportunity costs or under differentiated prices based on inflated marginal values must be determined empirically.

Under both auction formats there is limited potential for strategic behaviour, especially with many bidders.

Multi round multiunit auctions

The main difference between single round and multi round auctions is that it facilitates bidder learning. Bidder learning may result in positive or negative impacts. For instance, Rolfe and Windle (2006) note that when the auction process is complex or unfamiliar, multi round auctions provide participants with an opportunity to learn about the auction process. Conversely, bidder learning may lead to modification of bidding strategies that lead to less competitive, and hence less efficient, outcomes.

Cason et al. (2005) suggest that the chance to revise offers, as opposed to a single binding offer, may also be seen as ‘fairer’ by bidders. Allowing revisions (or using a uniform-price auction) can make many bidding errors costless. However, the advantages of allowing revisions have to be weighed against the administrative costs. Moreover, allowing for feedback and revision can make collusion easier.

The risk of bidder learning is quite high in ‘networked’ industries such as farming, where information is spread quickly through efficient communication networks of producer organisations or lobby groups. One important design challenge is to contain the scope for bidder learning — as well as that of collusion (Latacz-Lohmann and Schilizzi 2005).

The opportunity for learning and behaving strategically can easily invalidate the predictions of single round auction theory (Klemperer 2002). Hailu and Schilizzi (2004) found that the efficiency benefits of single round auctions are quickly eroded under dynamic settings of a multi round auction. Both theory and practice suggest that collusion is a particularly critical issue when auctions are repeated frequently. In a dynamic setting, bidders may learn to coordinate their strategies, and hence compete less aggressively with each other in order to raise profits over the level that would be attained in a static setting (Fabra 2001).

The relative performance of the different auction formats depends not only on the scope for bidder learning but also on the level of competition amongst the bidders. Fabra (2001) found that bidders in a discriminatory auction could not achieve a better outcome when they collude — alternatively collusion under a uniform price auction leads to better bidder outcomes (higher trading surpluses or information rents). While Hailu and Thoyer (2005) found that the uniform price auction is more efficient when competition is strong (with overbidding making the discriminative price auction more expensive than a uniform price auction), when competition is weak the discriminatory auction is more efficient.

A large pool of bidders induces competitive pressures and reduces incentives to collude or otherwise behave strategically. How many participants constitute a ‘large’ pool will depend on local conditions and the auction environment (Ferraro 2007). Given that generally the markets for water entitlements in the Murray Darling Basin are considered

‘thin’ (with limited trade) it is likely that the number of bidders in an auction would also be limited.

A reserve price may be used to overcome inefficiency when competition is weak or when there is a risk of bidder collusion (in a multi round auction) (Latacz-Lohmann and Vaan der Hamvoort 1997). Announcing that a reserve price has been set — without revealing the precise price — adds to the risk that bidders might lose an auction by bidding too high (Latacz-Lohmann and Schilizzi 2005). If the specific reserve price is revealed it may lead to an ‘anchor’ bias — where bidders anchor their bids to the reserve price. The draw back of a reserve price is that it limits the winners’ potential gain from an auction — this effect may discourage bidder participation and reduce bidding competition. In addition, in a multi round auction it is likely that bidder learning between rounds will lead to discovery of the reserve price and have an anchoring effect on future bids.

In the Living Murray Water Through Efficiency auction (see Appendix A) the possibility of a second round was left open in the auction. It is likely that the desired affect of implying that there was only single round was to bring about more competitive bidding and provide an incentive for irrigators to bid close to the marginal cost of investments in technical water use efficiency.

To limit the speed of bidder learning Latacz-Lohmann and Schilizzi (2005) recommend that under no circumstances should information be published about the average or the maximum accepted bid or the distribution of bids received in preceding bidding rounds. The benefits of auctions decline with the amount of information shared by the two parties — an auction is a mechanism in which the distribution of information between buyer and seller plays a crucial role. Another potential remedy for bidder learning is to change the rules of the auction in each bidding round. For example, the bid assessment criteria could be changed.

The number of rounds in a multi round auction will influence the administration costs of the auction. The more rounds the higher the administrative costs of running the auction. This is something which needs to be weighed against the potential benefit of having more auction rounds.

Buyback/assistance for reconfiguration

The second goal of the buyback programme is to encourage irrigators located in unviable or inefficient parts of schemes to exit the industry. If utilities retire infrastructure, irrigators located near this infrastructure will have little choice other than to transfer their entitlement to land located near infrastructure that is not to be closed down, to sell or lease their entitlements, or to sell their annual allocations. The

government could provide a structural adjustment payment to these irrigators to facilitate:

- relocation to an irrigation spur that is not to be closed down;
- transition to dryland farming; or
- exit from farming.

Since subregional targeting is required, a select auction (also referred to as a select tender) will be required to allocate assistance or purchase water from irrigators located near infrastructure that is to be retired. However, there is significant potential for irrigators to collude on the price they are willing to accept to sell their entitlement and exit the industry under a select auction. A select auction is the easiest auction to collude on since irrigators can easily identify who to collude with. One way to avoid paying inflated prices to these irrigators in systems where there is an existing market would be to confine the auction to allocating structural adjustment assistance, with assistance being offered in the form of a flat, one-off payment. The government would not purchase entitlements, with irrigators having the choice of selling or leasing their entitlements in the market.

5. Market impacts of the buyback

A government purchase of water entitlements will reduce the volume of water available for irrigation, leading to an increase in the market price of water. The size of the price impact will be determined by the volume of water purchased, and not influenced by the mechanism used to purchase water. The price transition path may vary, however, depending on the speed with which water entitlements are acquired.

Individual markets

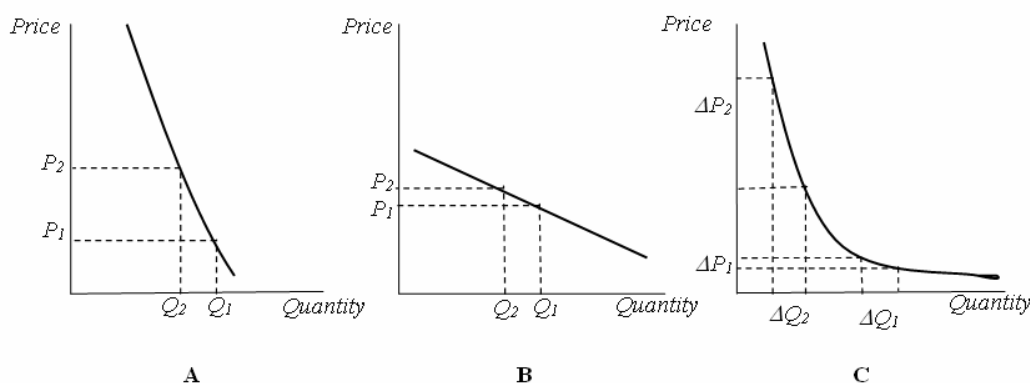
The impact of a buyback on the price of water in any given market will be dependent on the volume of water purchased relative to the total volume of water available for irrigation, and the elasticity of demand for irrigation water in each market. Price rises will be higher in regions where a larger percentage of the available water is purchased, and where demand for irrigation water is more inelastic.

The price elasticity of demand refers to the responsiveness of the demand for irrigation water to changes in price. Inelastic water demand means that users find it difficult to adapt production decisions to reductions in water availability, and thus have a high willingness to pay to avoid such reductions. In contrast, elastic water demand means that users have more flexibility to adapt and will be less willing to pay to avoid a reduction in water use. Irrigators with permanent horticultural plantings are therefore likely to exhibit a more inelastic demand for water than irrigators who irrigate seasonal crops.

This is demonstrated in the figure 2 below. Panel *A* represents the demand curve for a region where there is a relatively high concentration of high value irrigated activities (e.g. horticulture), while panel *B* displays a more elastic demand curve representative of a region with a lower concentration of these activities. The price response ($P_2 - P_1$) to an identical reduction in quantity ($Q_2 - Q_1$) is much higher in panel *A* than in panel *B*.

In many cases there will be a more diverse range of activities carried out in an irrigation system, as represented by panel *C*. The price elasticity of demand will be much higher for a given reduction in the volume of water available for irrigation at Q_2 than at Q_1 .

Figure 2: Demand for irrigation water



The most recent estimates of demand elasticities for irrigation water in Australia appear in Bell, Gali and Gratton (2007), and are presented in table 1. These estimates indicate that the demand for water in horticulture (fruit and vegetables) is price inelastic, as expected. The elasticity estimate of -0.8 for fruit and vegetables indicates that in response to a 10 per cent increase in price, the volume of water demanded by these industries would fall by 8 per cent (alternatively, an 8 per cent reduction in quantity available can be expected to result in a 10 per cent increase in price). In contrast, a 10 per cent increase in the price of water would be expected to result in a 14 per cent decrease in water demanded by the dairy industry. Estimates of the elasticity of demand for water used for irrigation are discussed in detail in Appendix B.

Table 1 - Estimated irrigation water demand elasticities by activity, PC (2007).

| Activity | Estimate |
|---------------------------|----------|
| Nurseries | -0.9 |
| Vegetables | -0.8 |
| Grapes | -1 |
| Fruit | -0.8 |
| Grain & other | -1.4 |
| Mixed crops and livestock | -1 |
| Sheep | -1 |
| Beef | -0.9 |
| Dairy | -1.4 |
| Sugar | -1.9 |
| Cotton | -1.4 |
| Group average | -1.2 |

Source: Bell, Gali and Gratton (2007)

Table 2 contains estimates of regional water use by activity in the southern Murray Darling Basin. Briefly, these estimates suggest that it may be possible to source significant quantities of water from regions specialising in lower value activities such as pasture and annual crops in the Murrumbidgee and New South Wales Murray irrigation regions compared to regions such as the Victorian Mallee and South Australian Murray regions, which specialise in permanent horticulture.

Table 2 - Estimated water use in major irrigation regions of the Southern MDB, 2000-01, gegalitres ^a

| | Goulburn (VIC) | North Central (VIC) | Mallee (VIC) | Murrumbidgee (NSW) | Murray (NSW) | River Murray (SA) |
|---------------------------|-------------------|---------------------------|-----------------|-----------------------|-----------------|-------------------------|
| Sheep / Beef | 88 (5%) | 193 (11%) | 6 (3%) | 342 (17%) | 197 (9%) | 28 (7%) |
| Dairy | 1 435 (86%) | 1 461 (82%) | 24 (11%) | 61 (3%) | 991 (43%) | 56 (14%) |
| Cereals / Grains | 21 (1%) | 65 (4%) | 2 (<1%) | 313 (15%) | 151 (7%) | 3 (<1%) |
| Cotton | - | - | - | 89 (4%) | - | - |
| Rice | 14 (<1%) | 4 (<1%) | - | 971 (48%) | 894 (39%) | - |
| Fruit | 67 (4%) | 10 (<1%) | 36 (16%) | 68 (3%) | 1 (<1%) | 69 (17%) |
| Grapes | 9 (<1%) | 4 (<1%) | 117 (53%) | 99 (5%) | 6 (<1%) | 194 (49%) |
| Vegetables / Tree nuts | 18 (1%) | 19 (1%) | 38 (17%) | 38 (2%) | 6 (<1%) | 41 (10%) |
| Total | 1 670 | 1 789 | 222 | 2 009 | 2 280 | 395 |

Source: Bryan and Marvanek (2004); includes both surface and groundwater use; regions used in this study are based on Catchment Management Authority boundaries; brackets denote the share of the commodity in total regional water use.

^a 'The water requirements of agricultural commodities in this study is defined as an estimate of the typical irrigation water application rates per unit area for each commodity and is represented in ML/ha. Water requirements represent the typical evapotranspirative requirements of the land use, plus typical losses including seepage, percolation and leakage. It does not represent the *actual amount* of irrigation diversions, rates of application, or crop water use but rather an *estimate*. Typical water requirements for each irrigated commodity were determined for each major irrigation area within each ABARE region. Climate is taken into account insofar as similar commodities in moister climates require lower irrigation rates than in drier climates within the MDB. This data was sourced primarily from the ANCID Australian Irrigation Water Provider Benchmarking Reports for 1998/99 and 2000/01 (ANCID 2000, 2002) and augmented using expert knowledge and experience.'

Asset fixity

The presence of fixed assets may significantly increase the cost of acquiring water in some markets. Asset fixity refers to the influence that large fixed assets have on the economic decisions of irrigators, relative to the decisions they would make in response to changing economic conditions if they had no large fixed assets. Irrigators engaged in high valued activities (e.g. horticulture) typically have significant investments in on-farm assets that have little or no salvage value in another use. The marginal value of water that is used in conjunction with these high value fixed assets is high — without water these assets are worthless. If these fixed assets have not reached the end of their economic life, irrigators will need to be paid a price that matches the marginal value that they derive from water use with these assets. The larger the net present value of the remaining cash flows of the asset, the stronger the economic incentive would have to be to induce irrigators to sell their water. Consequently, the age distribution of existing investments in a market may be a critical factor determining the number of irrigators willing to sell water at a given price.

Disconnected markets

Regional markets for irrigation water in the southern Murray Darling Basin are largely disconnected. While significant intraregional trade is common within individual irrigation systems, trade between irrigation regions is largely restricted. This has resulted in significant variations in the marginal value of water use across irrigation systems, as reflected in regional water prices (see Appendix C).

The main institutional constraint on interregional trade is the 4 per cent threshold limit imposed on net out-of-scheme permanent trade (NWI 2005). This threshold limit will be reviewed in 2009, and is due to be fully removed in systems outside the southern Murray Darling Basin by 2014. The 4 per cent threshold will also be reviewed in the southern Murray Darling Basin in 2009, with a view to raising the threshold to a higher level if considered appropriate. The easing of these restrictions over time will lead to a reduction in the differential between regional prices. If this were to occur, the cost of purchasing water would be independent of location. There would continue to be price differentials across markets that are physically disconnected, however.

The price impact of modernisation

Investment in improved on and off-farm irrigation infrastructure has the potential to increase water availability where a proportion of the water savings are retained by irrigators. Any government investment of irrigation infrastructure will therefore off-set to some extent the reduction in water availability resulting from a buyback. The price impact of the modernisation component of the Plan will ultimately depend on the net change in water availability; this being the volume of water purchased by the government less infrastructure savings which are returned to irrigators.

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Appendices

Appendix A – Examples of previous tenders

New South Wales RiverBank

New South Wales (NSW) RiverBank is an environmental fund that was established and is administered by the NSW Department of Environment and Climate Change to acquire permanent water entitlements for stressed and valued inland rivers and wetlands. The program commenced in 2006 and targets river valleys that are not covered by the Living Murray Initiative – including the Macquarie, Gwydir, Murrumbidgee and Lachlan. Funding is for \$105 million over five years. Entitlements have been purchased through two channels. First, a single round expression of interest tender was held, using what appears to be closed bidding. Participants were contacted within six weeks after the closing date and notified of the bid result. Second, after the expression of interest process closed, irrigators were encouraged to contact NSW RiverBank to negotiate a private sale. In some ways, this was a less formal expression of interest tender. Tenders are planned for each year of the NSW RiverBank programme. The NSW RiverBank program is ongoing.

Living Murray Water Through Efficiency

The Living Murray programme was established in 2002 and is funded by the Commonwealth, New South Wales, Victorian, South Australian and Australian Capital Territory governments. The Water Through Efficiency tender was run in late 2006 and early 2007, as part of the Living Murray programme. The objective was to address overallocation in the Murray River system. The Department of Agriculture, Fisheries and Forestry administered the program initially. Responsibility was subsequently transferred to the Department of Environment and Water Resources. The irrigators were required to offset the impact of reduced water use on production by increasing water use efficiency. The tender was a formal process, with legally binding submissions and sealed bidding. Although it was run for only a single round, the possibility of a second round was left open in the beginning. Plans for further rounds were abandoned based on the results of the tender. Just three submissions were successful, resulting in the recovery of 450 megalitres at \$1 700 per megalitre. More than 45 submissions were rejected (Doak 2007). Grafton (2007) blamed the poor outcome on making purchases conditional on the users undertaking water saving measures.

Living Murray Pilot Environmental Water Purchase

In 2007, the Water Through Efficiency tender was succeeded by the Pilot Environmental Water Purchase, which was run by the Murray Darling Basin Commission. Murray River system irrigators were asked to submit expressions of interest to sell permanent water entitlements. These submissions were compared to the independently determined current market price for that type of entitlement. Feedback was provided within a week to allow unsuccessful participants to submit further bids. The program was closed four weeks into the eleven week project because enough expressions of interest had been received to meet the objective of acquiring 20 gegalitres. According Wendy Craik, “we have learnt [through the pilot] that people appreciate the opportunity to submit non-binding expressions of interest and that they liked receiving feedback rapidly (MDBC 2007).”

Fisheries Business Exit Assistance

The Fisheries Business Exit Assistance tender was administered by the Commonwealth Department of Agriculture, Fisheries and Forestry. The tender was part of a broader structural adjustment programme that was designed to assist some fishers to leave the industry. The tender was run in 2006 in Commonwealth fisheries across Australia. The funding available was \$150 million. The tender had sealed bidding and was run over two rounds. Submissions made by participants to surrender fishing permits were legally binding. Details on successful and unsuccessful submissions from the first round were announced before the second round. In the second round, tender forms were sent directly to fishers that participated in the first round with details common to both stages already filled in. Although some regions were specifically targeted, there was flexibility in the second round to reallocate funding between regions to maximise the net benefits from the buyback.

Forest Conservation Fund

The Forest Conservation Fund is a market based program that is intended to conserve old growth and under reserved forest communities on private land in Tasmania. The project is overseen and funded by the Commonwealth Department of Environment and Water Resources. The first round of the tender was held in early 2007. Bidding was sealed and initial submissions were not legally binding. Independent conservation advisors were paid by the government to assess the environmental benefits of placing covenants on private land. Different conservation options were presented to landholders and individual covenants were designed that protected, maintained or improved existing forest communities. Conservation advisors also assisted in developing other aspects of the bids, but were not permitted to advise landholders on their bid prices. Submissions were ranked according to: the financial consideration sought; the conservation value of the land; the management activities that the landholder had proposed to undertake; and the level of security offered in the agreement.

Queensland Vegetation Incentives Programme

The Vegetation Incentives Programme used an auction mechanism to allocate payment to landholders for the protection of non-remnant vegetation. It appears that the auction used sealed bids and employed a discriminatory payment mechanism. The auction was run over multiple stages, allowing the Queensland Department of Natural Resources and Mines to adjust the mechanism. The first round required landholders to agree to a covenant that severely restricted land use. There was also concern over the credibility of the Queensland government's willingness to renegotiate. This inflexibility raised the opportunity cost of participation and consequently bid prices. Moreover, landholders strategically overbid because they overestimated their lands' environmental value. Only five offers met the environmental criteria, but all were rejected since bids exceeded the reserve price. In the second round, a menu of contracts allowed for differentiation amongst types of landholders, however, this was implemented after the expressions of interest were received. Therefore, it is not possible to measure the effect this would have on bidder behaviour. Participation increased in the second round, however, much of the increased participation was in the North Coastal region, where a respected officer helped landholders prepare their bids. Bids were accepted in this round, however, there were transaction costs, risks and holding out which influenced bidder behaviour. Respectively the difficulty in coming up with a bid, (especially with regards to estimating the opportunity cost of non productive land), the uncertain auction process, and fractured relationship between landholders and the state government all affected participation and raised bid value.

Appendix B - Price elasticity of demand for irrigation water

Estimating the price elasticity of demand for irrigation water is problematic as it will vary significantly depending on the region, the farm activity, market conditions, climatic conditions and a range of other factors. Further the elasticity is likely to vary at different points along the same demand curve. There will also be differences between the short and long run price elasticity of demand. In the short run irrigators have limited capacity to make changes to production technologies and the mix of farm activities. The short run elasticity of demand for irrigation water will depend significantly on prevailing seasonal conditions and the state of the cropping cycle. In the long run farmers can make changes to the mix of activities. For example, they can move from water intensive to less water intensive crops or even to dryland crops. Farmers can also adopt new technologies including water efficiency improving irrigation technologies. As such it is expected in the long run demand for irrigation water will be more elastic than in the short run. The Productivity Commission has completed two papers on this specific issue: Appels, Douglas and Dwyer (2004) review previous attempts to estimate the price elasticity of demand for irrigation water in Australia; while Bell, Gali and Gratton (2007) provide some new estimates based on empirical data.

Appels et al. (2004) note that there has been very little econometric analysis on the topic due to a lack of suitable data given that water markets are still relatively new. As such the majority of existing research has involved the use of mathematical programming models. These models estimate elasticities indirectly given various assumptions and the optimising behaviour of farmers. The table 1 is recreated from Appels et al. (2004) and shows a range of elasticity estimates from existing literature.

Mathematical programming models of irrigation demand often ignore the yield effects of reduced water availability and assume that production technologies are highly inflexible. For example they may not allow for the adoption of new technology or adjustments to the mix of inputs. Under these assumptions a producers main response to reduced water availability (or equivalently higher prices) is to move away from irrigated production into dry land production.

As such, a feature of these models is that response of price to changes in water availability is 'lumpy', rather than smooth. As water availability is reduced it is the lowest value activities that become unprofitable first with production switching to dryland activities. The higher value activities such as horticulture are the last to make this switch, see for example Hafi et. al. (2001).

Table 1: Elasticities from various models of irrigated water demand, Appels et al. (2004)

| Study reference | SR/LR | Price Range | Elasticity | Region |
|---|-------|-------------|----------------|------------------------------|
| Hall (2003) | | \$0-\$100 | -0.11 to -0.14 | |
| Jayasuriya, Crean and Hannah (2001) | | \$0-38 | -0.02 | Lachlan Valley (NSW) |
| | | \$38-\$47 | -0.72 | |
| | | \$47-\$77 | -0.82 | |
| | | \$77-\$98 | -3.52 | |
| Pagan et. al (1997) | SR | \$10-\$30 | -0.03 | Murrumbidgee |
| | | \$30-\$50 | -1.19 | |
| | | \$50-70 | -2.81 | |
| | LR | \$10-\$30 | -0.04 | |
| | | \$30-\$50 | -0.25 | |
| | | \$50-70 | -3.01 | |
| Collins, Hall and Scoccimarro (1996) | | \$0-\$28 | 0 | Southern MDB |
| | | \$28-\$38 | -0.14 | |
| | | \$38-\$50 | -0.2 | |
| Hall, Poulter and Curtotti (1994) | | \$20-\$80 | -0.99 | Southern MDB |
| Mallawaarachchi, Hall and Phillips (1992) | | \$12-\$37 | -0.34 | Murrumbidgee |
| Reas, Struggess and Associates (1991) | SR | \$0-55 | 0 | Goulburn and Murray (VIC) |
| | | \$55-\$70 | -1.15 | |
| | MR | \$0-\$55 | 0 | |
| | | \$55-\$70 | -1.65 | |
| Briggs-Clark et. al (1986) | | \$4-\$21 | -0.13 | Murrumbidgee and Coleambally |
| | | \$21-\$42 | -0.65 | |
| | | \$42-\$51 | -3.8 | |
| | | \$52-\$58 | -14.1 | |

Given these assumptions such models often give low elasticity (highly inelastic) estimates relative to econometric studies. Further, they often predict demand to become increasing elastic as water becomes more scarce. This contradicts expectations that the demand for water would become increasingly inelastic at lower levels of availability due largely to demand from horticulture. While these models are useful they have clear

limitations. In particular, elasticity estimates derived in this way are likely to be less realistic than studies using observed responses.

Bell et al. (2007) conducted a comprehensive econometric analysis of demand for irrigation water. Bell et al. (2007) compiled a large farm level data set with the cooperation of the ABS which enabled the price elasticity of demand for irrigation water for 10 agricultural industries to be estimated. The Bell et al. (2007) estimates are shown below.

Table 2: Estimated irrigation water demand elasticities by activity, Bell et al. (2007).

| Activity | Estimate |
|---------------------------|----------|
| Nurseries | -0.9 |
| Vegetables | -0.8 |
| Grapes | -1 |
| Fruit | -0.8 |
| Grain & other | -1.4 |
| Mixed crops and livestock | -1 |
| Sheep | -1 |
| Beef | -0.9 |
| Dairy | -1.4 |
| Sugar | -1.9 |
| Cotton | -1.4 |
| Group average | -1.2 |

These estimates are to be considered short run estimates in that land area, farm capital and labour are assumed to be fixed. The estimates can be interpreted as industry average elasticities given average industry water use. What is interesting and encouraging about these results is that demand for water in horticulture (fruit and vegetables -0.8) is more inelastic than for other industries such as grains (-1.4) and dairy (-1.4) which is consistent with expectations. The estimates are for the most part close to 1, when elasticity is 1 this means that a 10 per cent reduction in quantity would be expected to translate into a 10 per cent increase in price.

Scheirerling et al. (2006) conduct a meta analysis on the elasticity of demand for irrigation water which includes 24 US studies. The 24 studies adopted three broad approaches: mathematical programming (13), field experiments (7) and econometric studies (4). Field experiments yielded the lowest elasticity (most inelastic) estimates, while econometric studies yielded on average the highest. They estimated a mean price elasticity of -0.48 across all studies, with estimates ranging from 0.001 to 1.97.

The average estimate for mathematical programming was 0.45, 0.15 for field experiments and 0.62 for econometric studies. This would seem consistent with the Australian experience where the PC (2007) estimates were substantially higher (more elastic) than previous non-econometric estimates. Scheirerling et. al. (2006) estimated a meta regression model to investigate the variation in these estimates. One key result was that high value crops were associated with significantly lower estimates (high value crops tend to display a more inelastic demand for irrigation water than low value crops).

Appendix C – Historical water trade data

Tables 1 through 4 show information on the number of trades and the volume traded for both general and high security entitlements.

Table 1: Selected Trade in General Security Permanent Entitlements, NSW MDB, 2005-06 ^a

| | Number of Trades | Volume (ML) | Average Volume (ML) | Average Price (\$/ML) | Value (\$) | Average Value (\$/trade) |
|----------------------|---------------------|----------------|---------------------------|-----------------------------|-------------------|--------------------------------|
| NSW Murray | 10 | 1 231 | 123 | 662 | 814 460 | 81 446 |
| Murrumbidgee | 1 | 486 | 486 | 800 | 388 800 | 388 800 |
| Lachlan | 3 | 750 | 250 | 610 | 457 500 | 152 500 |
| Central West | 3 | 60 | 20 | 1 433 | 86 000 | 28 667 |
| Namoi | 2 | 1 182 | 591 | 2 091 | 2 471 495 | 1 235 748 |
| Gwydir/Border Rivers | 3 | 6 784 | 2 261 | 2 572 | 17 448 651 | 5 816 217 |
| Total NSW MDB | 22 | 10 493 | 477 | 2 065 | 21 666 906 | 984 859 |

^a excludes trade with a reported price of zero and trade under sections 71M and 71X of the Water Management Act.

source: NSW Department of Natural Resources

Table 2: Trade In Permanent Entitlements, VIC MDB, 2004-05

| | Number of Trades | Volume (ML) | Average Volume (ML) |
|--------------------------------|------------------|---------------|------------------------|
| First Mildura Irrigation Trust | 30 | 1 049 | 35 |
| Goulburn Murray Water | 545 | 42 224 | 77 |
| GWM Water | 2 | 40 | 20 |
| Lower Murray Water | 277 | 38 351 | 138 |
| Total VIC MDB | 854 | 81 664 | 96 |

source: ABS 2006

Table 3: Indicative Recent Prices for Permanent Entitlements, VIC MDB

| | <i>Average Price 2006-07 (\$/ML)</i> | <i>Average Price 2005-06 (\$/ML)</i> |
|-----------------------|--|--|
| Greater Goulburn | 1 471 | 1 045 |
| Pyramid Bort | NA | 1 050 |
| Central Goulburn | 1 201 | 986 |
| VIC Murray (region 7) | 1 125 | 1 084 |
| Torrumbarry | NA | 1 255 |
| Ovens | NA | 875 |

source: www.watermove.com.au

Table 4: Trade In Permanent Entitlements, SA MDB, 2004-05

| | <i>Number of Trades</i> | <i>Volume (ML)</i> | <i>Average Volume (ML)</i> |
|--------------|-------------------------|--------------------|--------------------------------|
| River Murray | 237 | 23 867 | 101 |

source: ABS 2006