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Water Trading in the MDBC: How well is the market functioning?

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Water Trading in the MDBC: How well is the market functioning?

Revised title

Double trouble: The importance of accounting for and defining water entitlements consistent with hydrological realities

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Abstract

When water entitlement and water sharing systems are mis-specified, that is specified in a manner that lacks hydrological integrity, inefficient investment and water use is the result.

Using Australia's Murray Darling Basin as an example, this paper attempts to reveal the economic consequences of entitlement mis-specification. Options for specification of entitlement and allocation systems in a way that has hydrological integrity are presented. It is reasoned, that if entitlement and allocation system were set up in this manner the result would be an efficient allocation regime that would autonomously adjust to climatic shifts, changes in prices and changes in technology whilst maintaining environmental integrity.

Key Words

Interception, water accounting, water rights, water markets, water trading

1. Introduction

Entitlement systems (rights) evolve through time and typically tend to be designed and developed in times when water is not scarce. As a direct result, they often end up being specified in a manner that is inconsistent with the hydrological realities that constrain choice in fully committed systems. Arguably, inconsistent specification is not a serious issue if allocations are conservative and trade is not possible. In systems where water resources are scarce and trading is offered as an option enabling the efficient management of scarcity, however, entitlement mis-specification can allow an entire system to trade into serious trouble. In particular, when water entitlements specified in a manner that is inconsistent with the way that water flows across land, through soil and down rivers, the collective result tends to be a set of individual market decisions that try

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to allocate rights to water which in reality does not exist. Typically, the eventual result is inefficient water use and inefficient investment

Examples of entitlement specifications that are inconsistent with hydrological realities are common, particularly in Australia. As noted in Australia's National Water Initiative (NWI) (CoAG 2004), one of the most common forms of entitlement mis-specification is the description of entitlements and associated water allocation rules in a manner that does not account for the "interception " Section 55 of the agreement states that

> "*The Parties recognise that a number of land use change activities have potential to intercept significant volumes of surface and/or ground water now and in the future. Examples of such activities that are of concern, many of which are currently undertaken without a water access entitlement, include:*
>
> - *farm dams and bores;*
> - *intercepting and storing of overland flows; and*
> - *large-scale plantation forestry."*

While this potential is recognised, most of the entitlement systems and water sharing processes used in Australia and elsewhere have not yet been changed to ensure that decisions associated with the use of water are efficient. As pointed out in Australia's NWI, the main problem with this approach is that it allows people to adopt practices that "intercept" water that otherwise would have been available for use elsewhere. Whenever the extent of water interception increases, in a fully allocated system, either allocations to formal entitlement holders must be reduced or the amount available to environmental managers reduced. The hydrological reality is that whenever one person uses more water someone else or something else must get less.

Another form of entitlement mis-specification is failure to account for shifts to a drier (possibly due to climate change) or even to a wetter regime in a regime where water allocations can not be carried forward from one year to the next. In these regimes, it is common for more water to be allocated to the environment in wet years and very little in dry years. If the shift to a drier regime is long term, however, this approach results in the emergence of a regime that is allocating too much water to consumption and not enough to the environment. In a trading regime, the result is too much investment in water use and not enough investment in the maintenance of environmental values not associated with production..

One example of a suite of systems that lack hydrological integrity are those used in most of Australia's Southern Connected Murray Darling Basin . Aware of the adverse consequences of defining allocation and use rules that are inconsistent with hydrological principles, the Murray Darling Basin Commission has begun researching what it calls "Risks to the shared water resources." So far the commission has formally recognised six "risks" to water allocation regimes in the Basin

1. climate change
2. increased groundwater use

3. increased number of farms dams
4. bushfires
5. afforestation; and
6. reduced flow from irrigation

Of these six “risks”, only two are correctly termed “risks” - climate change and bushfires.. These “risks” would be more appropriately described as “entitlement debasing activities”; debasing in the sense of an erosion of the entitlement reliability. Drawing attention to the adverse impacts of one of these – increased groundwater use – Evans (2007) defines the problem as one of “double counting”.

Double counting involves the allocation of the same water to two groups of entitlement holders without recognising that once one person – a groundwater user – has extracted it, this same water can not be used elsewhere. As a consequence, whenever there is an increase in the rate of groundwater extraction, the amount of water that ultimately enters the surface water system is decreased.

Estimates of the extent of double counting, or as many prefer to call them, interception problems or over-allocation problems in the Murray Darling Basin vary. When the effects of climate change and bushfires are put to one side,[1] estimates suggest that the failure to define allocation arrangements in a manner that has hydrological integrity can be expected to erode the irrigation potential of the Murray Darling Basin by between 20 to 30% of water entitlements currently allocated to consumptive purposes (Young and McColl, 2003; van Dijk *et al.* 2003).

In this paper, we search for guidelines and opportunities to specify entitlements and associated allocation rules which, because they are specified in a manner that is consistent with basic hydrological principles and accounting rules, can be expected to encourage efficient investment in water allocation regimes that allow water entitlements and allocations to be traded.

We begin by describing a standard entitlement and associated water sharing regime and then search for robust ways to specify entitlements and significant water supply affecting activities in a manner that enables efficient investment decisions to be made.

2. Entitlement and water sharing regimes

To make it easier to present options, we assume a stylized tradeable water entitlement and water sharing regime similar to that which Australia’s NWI requires States and Territories to implement. In essence, this regime requires

- Water entitlements to be defined as tradeable shares of all the water allocated for use in defined pools of water;

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[1] A recent CSIRO study has observed that the worst-case scenario for the impact of the 2003 bushfires in Victoria’s alpine region would be a reduction in annual water yield of 80,000 ML in 2020 (Benyon 2008).

- Water sharing plans to set out the rules for determining how much water to allocate periodically to each defined pool of water;
- All water users to hold a site-specific use approval that would normally specify a maximum volumetric delivery entitlement;[2]
- The transfer of water entitlements, water allocations and delivery entitlements from one entity to another at minimal cost and without any administrative impediment to trade;
- Surface water users being able to choose to hold entitlements to a reasonably reliable "high security" stream of allocations and/or a much more variable stream of allocations made to a "general security" pool; and
- An allocation to be set aside each year to cover evaporative losses and to maintain a minimum flow to the sea.

In addition to these arrangements required under Australia's NWI we also include an arrangement that

- Allows unused allocations, less an adjustment for evaporation losses, to be carried forward for use in a subsequent time period.

Note that under this regime, allocations to the environment are imperfectly specified. Despite the usual array of legislative statements implying that the allocation regime should be one where environmental needs should be met first, in practice, this is not the case. The usual approach is to define the nature and reliability of each consumptive entitlement and assume that this will leave enough water for environmental and other purposes. This approach of incompletely defining the environment's and the river system's interests gives them a residual rather than a prior interest.

Analysing the consequences of the extent of failure to specify entitlements and water sharing plans in a manner that is consistent with hydrological realities, Close (2007, pers. com.) has estimated that in the Murray Darling Basin's Southern Connected River Murray System, the impacts of adverse changes in water supply are such that 83% of the impact falls on the environment and only 17% falls on consumptive users. The main reason for this is that the allocation rules in water sharing plans tend to assume away the possibility that the reliability of the supply system could significantly change during the life of the plan.

In passing we note that this residual entitlement problem can be solved by specifying the environment's and consumptive interests in an identical manner and putting in place a regime that requires allocations to be made to each in proportion to 'their' share. This, however, does not deal with the problem that this paper focuses on – increases in water supply affecting activities by land users outside the boundaries of the formal water entitlement system.

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[2] In some systems, delivery entitlements are defined using a separate instrument and made tradeable on either a permanent or temporary basis.

3. Information and investment

Conceptually, there are at least two economically efficient approaches to the management of the many challenges associated with entitlement mis-specification. The first option is to assign responsibility for managing all the risks associated with them to formal entitlement holders, keep them regularly informed of the extent to which the reliability of their entitlement is likely to be eroded, and importantly, amend the water sharing plans to make it clear that allocations per entitlement will be reduced (reliability will be decreased) as the amount of water available for allocation decreases.

The second option is to put in place land-use controls and other processes that either require their adverse effects on entitlement reliability to be offset or, alternatively, expand the boundary of water entitlement system so that significant water supply affecting activities are included. Those responsible are always required to hold entitlements equivalent to the size of their affect on the allocation system. Choice between the offset approach and the inclusion approach requires consideration of administrative costs, transaction costs and equity issues.

4. Entitlement and Sharing Plan Objectives

A related issue is the question of objectives selection for the system. For the purposes of this paper, we assume that the system should be defined in a manner that can simultaneously pursues six objectives

1. Hydrological sustainability limit –limit allocations for use (environment and consumption) to the amount of water available in the system less the amount needed to provide for evaporation, required transfers to other systems, and for a minimum flow to the sea.
2. Efficient Investment – encourage continuing economic development through preference for arrangements (water markets) that will encourage the economically efficient allocation of resources through time.
3. Transaction Cost – minimise the costs of adjusting allocations and responding to changing environmental, economic and social conditions.
4. Administrative Cost – minimise administrative costs associated with
    - Negotiating changes to the system
    - Monitoring compliance
    - Maintaining records.
5. Distributive Equity – avoid arrangements that make it possible for one group of water users to act in ways that shift costs to another group of water users.

Following on from our earlier work, we stress that entitlement specifications should be robust in the sense that they designed to cope with rare abnormal events and by doing this withstand the test of time (Young and McColl 2002).

5. Specification issues and options

We can now turn to consideration of options to manage water supply affecting activities that can undermine the reliability of tradeable entitlements to receive seasonal water allocations. It is important to recognize that as this water is intercepted every year, it is equivalent to the erosion of high security entitlement as most of the processes take the water first, no matter how wet or dry conditions are.

5.1. Plantation forestry

When land is converted from annual to perennial vegetation or some other significant water affecting activity, the amount of water per hectare that either evaporates or is transpired increases and less water than otherwise would be the case runs off into surface water systems or seeps through the soil into groundwater.

Research on these processes suggests that the difference between the amount of water intercepted by perennial plants and annual plants increases with rainfall (Vertessy et al. 2000, 2003; Hairsine and van Dijk 2008). For water managers, this empirical observation is important as the majority of water supplied to river systems, like the River Murray system comes from upper catchment high rainfall areas that are well suited to both plantation forestry and grazing. Re-establish a forestry plantation and the amount of water that runs off reduces significantly. High up in the Eastern Divide where annual rainfall exceeds 1120 mm per annum and the majority of water in the River Murray derives from, plantation establishment reduces water yield by around 2.5 ML per hectare. Assuming that around 80% of this water yield reduction reduces river flow, in current 2007/8 entitlement prices the cost of buying the equivalent water used at $2,200 per ML of High Security entitlement is around $4,400 per hectare (Young and McColl 2006).

In summary, the impact of plantation forestry in a high rainfall area is to make river and groundwater systems drier – drier in perpetuity. To put the above estimates in perspective, the Murray Darling Basin Ministerial Council's "first step" in restoring River Murray flows aims to secure 500 GL from consumption. Plantation forestry is expected to reduce mean water supply in the Southern Connected River Murray system by between 550 GL and 1,400 GL by 2026 (van Dijk 2006). If this happens, then all the claimed benefits of the proposed first step 500GL will be dissipated.

The effects of plantation forestry on water supplies are similar to those of any other perennial plant system. In addition to all the above considerations, as perennial plants can establish deeper root systems, in places where groundwater is relatively close to the surface, these plants can access groundwater directly. For example, in the groundwater system in the lower south east of South Australia, research suggests that plantation forest trees can access groundwater down to a depth of six meters below ground level. In areas where the groundwater is closer than six meters to the surface, these trees have an un-metered opportunity to extract as much water as they need from the groundwater system. The estimated rate of extraction is in the vicinity of 1.82 to 2.55 ML/ha (See Table 1).

Table 1 Estimated impacts of plantation forestry on water supplies in the South East of South Australia

Industrial plantation forest	Groundwater management area	Extraction by plantations where

type	recharge reduced by:	underlying water table median depth is less than 6 metre:
Short rotation (hardwood)	78%	1.82 ML/ha/year
Long rotation (softwood)	83%	1.66 ML/ha/year
Hardwood coppiced for a second harvest cycle		2.55 ML/ha/year

Source: South East Natural Resource Management Board Consultation Document (2007)

The question that we can now turn to is that of whether or not it would be more efficient to assign a prior right to forest plantation developers to access as much water as they need or to put in place rules that bring water market disciplines into any decision to establish a plantation. If the latter market discipline option is not pursued, then there is no way to optimise investment between the forestry plantation sector and all other sectors.

Conceptually, the plantation forestry can be brought into the water sharing planning system via one of three options:

1. A ***full allocation system*** that requires the plantation area owner to operate like any other irrigator and secure sufficient allocations to account for the estimated annual impact. In essence, an account would be established for each forest and each land owner required to keep their water account in positive balance. They could do this by holding entitlements, buying water allocations and/or clear felling forest.)
2. A ***partial allocation system*** that requires the plantation area owner to hold a pre-specified number of entitlements per hectare and, if future estimates of additional deemed impact occur, make good any deficit when the forest is clear felled.
3. An ***offset approach*** that requires each plantation owner to purchase and surrender sufficient entitlements to insure all other entitlement holders against the risk of a decline in water availability as a result of the proposed increase in the area under forestry.

Each of the above systems has different risk implications for the forest industry, other water users, the environment and the body responsible for issuing and managing water entitlements. For simplicity, we assume that conversion of a landscape from a grassland into a plantation forest requires a development permit. As summarised in more detail in Table 2, each option has to be evaluated from the viewpoint of incentives given to existing plantation owners and those considering whether or not to establish a new plantation.

Whilst a full allocation system can be made to work, the costs of running such a system are expensive, and as water use can only be estimated using modelling approaches, it is likely to result in many arguments among plantation and other users.

Similarly, whilst politically attractive, introduction of a partial allocation system is problematic if market conditions change and it no-longer pays to clear fell a plantation. If for example, it became more economically attractive to use a forest as a perpetual carbon sink, then the partial approach would have the same effect on entitlement reliability as a decision not to account for any forestry interception. If one is interested in a robust entitlement system, the partial allocation system should be rejected on the simple grounds that it does not provide a solution in circumstances where it becomes more profitable to retain rather than clear the forest. Ultimately, one can envisage a system that requires and facilitates interaction between the carbon sequestration market and the water market.

One of the key features of the offset approach is that it has much lower administrative costs and transaction costs as it does not require making an estimate of the annual amount of water that is extracted by each plantation area. Instead, it relies upon an estimate of the average amount of water that a typical forested area would be expected to use and the surrender of entitlements equivalent to the estimated impact of the forest. The result is a system that enables each entitlement to be defined in terms of the amount of water held in storage or extractable from an aquifer.

Another key feature of the offset approach is that it enables formal recognition that increases in forestry expose all other water users to increased allocation reliability risk. For every new forest area, this is achieved by requiring the forester to provide a once-off insurance premium to the all other entitlement holders, who as a result of the increased forestry, face increased risk, particularly if an adverse shift to a drier regime occurs. In practice, some entitlement is formally transferred to all other existing entitlement holders, who in each subsequent year will receive more allocations than would otherwise be the case. Whilst the number of entitlement shares transferred is likely to be small, its merit is that it fully informs all remaining entitlement holders that they are exposed to increased allocation risk and that if an adverse climate shift occurs allocations per share will be reduced in an appropriate manner.

A variant of the above options included in Table 2 is the proposition that in each region an attempt should be made to define a threshold area of land that for aesthetic, conservation, environmental service and other reasons, should be under some form of permanent vegetation. Under such a regime, it would only be necessary to bring forestry into the entitlement and allocation regime when the area under plantation exceeds the threshold above which the adverse effects of increased permanent vegetation –whether by forestry or for conservation purposes – should be offset.

Table 2 Key features and summary of implications for existing and new plantations by each system option

	Full allocation system	**Partial allocation system**	**Offset approach**
Entitlement to be issued to land owners where there is an existing forest plantation	Share entitlements are issued in proportion to the estimated amount of current recharge interception and direct groundwater extraction currently deemed to be occurring.	As for a full allocation	Land owner, issued with a legally binding commitment to receive share entitlements equivalent to the deemed increase in recharge and reduced direct groundwater extraction when a forest permit is surrendered or permanently removed.
Action required to establish a forest plantation in an area where the forest area threshold has been exceeded	Source sufficient allocations to enable forest allocation account to be kept in positive balance by buying entitlements, leasing entitlements or buying allocations. No requirement to source a water entitlement before applying for a forest licence as the land holder would be allowed to secure allocations on an annual basis.	Must secure access to an entitlement sufficient to offset the deemed impact of recharge interception and direct groundwater extraction.	Must secure and surrender access to an entitlement sufficient to offset the deemed impact of recharge interception and direct groundwater extraction PLUS any adverse climate change insurance premium. This premium is reallocated to existing entitlement shareholders.
Nature of responsibility for adjustment if deemed values or allocations per share decline	<u>Annual</u>. In every year, the shareholder's closing allocation account must be non-negative. As with any other irrigator, if the closing account is negative administrative action is taken. As the water market in many regions could remain thin the forestry industry can be expected to hold some water entitlement shares in "reserve." Plantation investment risk is more dynamic if allocation announcements are made on an annual rather than, say, every 5 years..	<u>At clear felling</u>. When a forest is clear felled, it may not be replanted until as a result of either increased recharge, decreased direct groundwater extraction or the purchase of announced allocations the account in returned to a positive state. If there is, say, a 20% decline in allocations per share, then this would result in a 100% debt every five years and require either the entire area under forest to be fallowed for a year or the licensed area reduced by an equivalent percentage so that the debt is gradually cleared.	<u>None until the announced allocation per share held by all other water users drops to zero.</u> At this point in time, foresters would be required either to clear fell a proportion of their forest and/or purchase sufficient allocations or surrender sufficient shares to have the same effect.
Implications for other entitlement share holders	All water users are treated equally. Forestry industry can be expected to hold more entitlement than it needs. Costs of estimating and accounting for water use by forestry are likely to be significant. The forest industry can be expected to argue that deemed use estimate should be adjusted for annual rainfall, forest age, etc. Without care, the system could become so detailed that it becomes extremely difficult to manage.	For irrigators, the downside risk is substantial and management of this could prove difficult. There is a significant opportunity for the forest industry to game the system and accumulate debits that are not cleared.	Other entitlement holders receive an increased entitlement and if there is no adverse climate shift, a greater allocation

5.2. Farm dams

The effects of each additional farm dam on water supply is similar to that of a plantation forest. As with a forest, inflows into dams and evaporation losses are significant and both un-metered and un-meterable. Nevertheless, it is possible to estimate that amount of water which, as a result of interception, is not available elsewhere in the system.

In the Murray Darling Basin, CSIRO has estimated that water supply reductions as a result of farm dam development over the next 20 years is likely to be somewhere between 250 GL and 3,000 GL. Every ML of farm dam storage is estimated to reduce flow by 0.84 ML. Once again, the amounts are significant and likely to be greater than the first step towards improving environmental allocations. Moreover, as with plantation forestry, this water is equivalent to a high security allocation in the sense that farm dams tend to capture every drop of water that reaches them until the dam is full. At a price of $2,300/ML, the entitlement cost of offsetting a dam that "uses" 5 ML per year would be around $9,240.

Most States now include policies that require permission to build dams in excess of a specified storage volume. In Victoria, for example, permission is required to build dams with a capacity which, depending upon wall height is greater than 20 ML to 50 ML (DSE 2007). In New South Wales, farmers are allowed to build dams that capture up to 10% of run-off. As yet, however, no state has implemented the obvious solution of requiring an aspiring dam builder to purchase and surrender a water entitlement equivalent to their expected impact of future water supplies. An alternative approach, which could also be used for forestry, is to inroduce an array of dam trading rules that either allows trading of dam capacity and/or allows dams to be built when others of equivalent size are removed from the catchment.

While much small farm dam construction is for stock and domestic purposes, many small dams can add up to a lot of interception. In areas where there is considerable subdivision occurring, it may be more administratively efficient to assign responsibility for offsetting the impacts of increased farm dam development to local governments rather than farm by farm. Local governments could use satellite imagery to assess retrospectively the extent of impact, and provide the quantity of entitlements estimated as necessary to offset the impact of increased small farm dam development in their region. Once again, and as with forestry, the offset rules put in place could require the surrender of an adverse climate change insurance premium that is transferred to all other entitlement holders.

5.3. Groundwater connectivity

The effects of groundwater development on opportunities to use surface water and vice versa are different to those associated with forestry and farm dam development. The problem here is one of managing interaction and exchange between two metered use systems that sit side by side with one another. Very close to a river, extraction from groundwater systems has almost the same effect as extraction from the river itself. Further away, however, the effect is delayed and the exact location and extent of the effect on river flow difficult to determine. At the zone of interaction between a river and an aquifer, typically rivers are defined either as a gaining river because the aquifer is flowing into it or a losing river because the river is recharging the aquifer. In severe droughts and when groundwater development is excessive, a ‘gaining’ river can change into a ‘losing’ river.

In such situations, one of the necessary conditions for efficient water use is that the two systems be managed as one. That is, an arrangement must be put in place that ensures that increased allocations (or takings) from one system lead to transparent reductions in allocations to the other system. At the very least, this requires the extent of groundwater development to be reported to the holders of surface water entitlements and statements made as to the likely affects of these approved developments on their future water allocations.

In Australia’s recent drought and as allocations to high security entitlements were reduced, a number of irrigators purchased groundwater entitlements that were some distance from the Murray River and then transferred these groundwater entitlements to a location very near the River. As allocations per groundwater share were not reduced during the drought in the same way that allocations per surface water shares were reduced, this enabled these new groundwater users to access much more water than otherwise would have been the case. As well as being inefficient, such arrangements are also inequitable, as those located elsewhere in the system can not act to prevent these new groundwater users from accessing water that was previously available to them.

5.4. Increased Irrigation efficiency

As a general rule, increases in the efficiency of water use are achieved partially by reducing evapo-transpiration and partially by reducing return flows to the river through reduced accessions through the root zone to groundwater and/ or reduced surface drainage back to the river. Surface drainage back to the river can also be reduced by installing on-farm a drainage recycling dam. In addition, reducing channel seepage to groundwater, either on-farm or in water supply systems, can also reduce return flow. Unfortunately, less return flow ultimately means that less water is available elsewhere in either the system from which it was taken and/or from the groundwater system. In short, reductions in evaporation and transpiration are real savings, but most other so-called savings as a result of increased water supply or irrigation efficiency come at a cost of the capacity to allocate water to other users and /or to the environment.

Unlike many water entitlement allocation systems in the United States of America, where water entitlements are defined as “nett” entitlements, most water entitlements in Australia are defined as “gross” entitlements. This authorises the entitlement holder to take water but does not require any of that water to be returned back to the system.

The problem is that, as a general rule, irrigation developments tend to begin with the use of relatively inefficient technology which leaks or returns lots of water back to the system. As the irrigation industry further develops and markets drive investments in technology to improve irrigation efficiency, the result is a reduction in the amount of water that is available to others. Recent estimates undertaken for the Murray Darling Basin Commission suggest that the future impact of increases in irrigation efficiency are likely to be less than those associated with farm dams and forestry. Pursuit of increased irrigation efficiency was one of the very first consequences of the introduction of water trading. During the period from 1995 to 2001, Bryan and Marvanek (2004) estimated that the area under irrigation in the Southern Connected River Murray System increased by 20% without any significant breach of the maximum amount of surface water that was diverted. Under such conditions, this increase in area irrigated must have been achieved primarily by a reduction in return flows, partly as a result of increases in the technical efficiency of irrigation.

5.5. Salinity interception

Salinity interception is a special form of groundwater use whose impact on the quantity of water available to irrigators has still not been officially acknowledged by the Murray Darling Basin Commission. Along the River Murray, the process involves construction of a curtain of groundwater wells to pump saline groundwater otherwise returning to the river to off-river evaporation basins (at a rate that is sufficient to virtually stop this water (and salt) from entering the river). The problem is that whilst salinity interception provides gains in terms of decreased river salinity, it does so at the cost of increased water use and a decrease in the volume of water that flows down the river. Moreover, those responsible for operating these schemes are neither required to hold an entitlement nor an allocation.

In a dry year, like 2006/07, the salinity interception schemes located along the River Murray pump approximately 22 GL, whilst in an "average" rainfall year around 32 GL is pumped and in a wet year it has been necessary to pump as much as 50 GL of water from the system (Pfieffer pers. com, 2008). Whilst all of this water was taken from saline groundwater aquifers next to the river and contains considerable salt it is remains a volume of water that ultimately would have entered the river. Once again there is a flaw in the accounting system that could be resolved by requiring the operators of these schemes to hold an entitlement and limit the amount of water they extract to the size of their allocation.

Interestingly, whilst all these schemes have been required to pass a cost-benefit assessment, none of these assessments have included the cost of buying the necessary water entitlement. In a year like the current one, when allocations to high security entitlements are currently at 32%, in order to operate the scheme without entering the market to acquire the necessary allocations it would be necessary for the system manager to have held 69 GL of high security entitlement.

5.6. Adverse climate shifts

The last water allocation problem that we wish to explore in this paper is the question of how best to account for long term shifts in water supply availability as a result of adverse climate change or simply a shift to a drier regime. Drier regimes have occurred several times in the River Murray system during the last century and appears to be occurring now (see Figure 1). One of the main unappreciated consequences of a shift to a drier regime is that for every reduction in total inflow into the system, much less water is available for use as the system still evaporates as much water, and some flow to the sea is still required. An important relationship to keep in mind is that between rainfall in a catchment and inflow into storages. In the Murray Darling Basin, for example, a ten percent decrease in rainfall results in an average reduction in system inflow of around 30%.

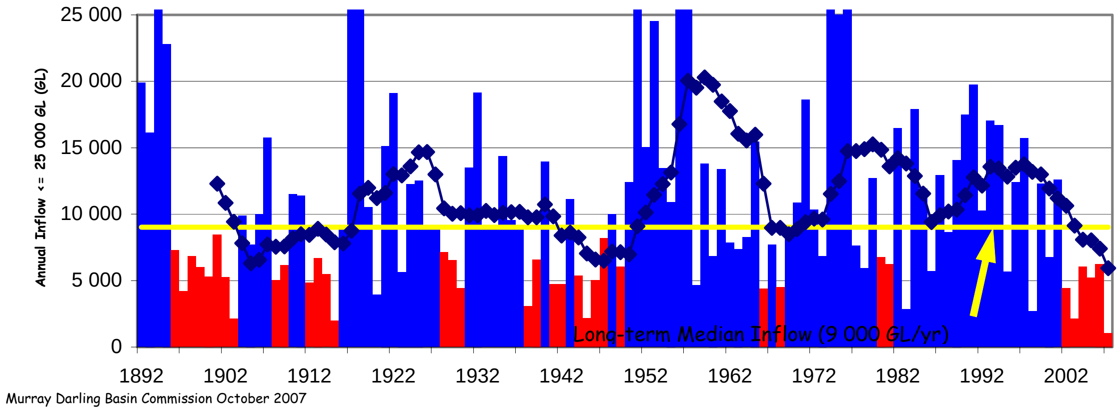

Figure 1 **Total River Murray System Inflows (including Darling River)**
Modelled Current Conditions - extended Droughts shown in Red
10 year moving average shown in dark blue
Source: MDBC, Pers.Com. 2007.

Consider, for example, a river with a mean inflow of 10,000 GL per year, evaporative losses of 2,000 GL per year, a mean flow to the sea of 1,000 GL per year and a mean environmental allocation of 1,500 GL. Under such a regime, the amount available to allocation to irrigators would be (10,000 – 2,000 – 1,000 -1500) = 4,500 GL. If the mean rainfall supplying such a system declines by 10%, then inflows into the system could be expected to decline to 7,000 GL. If allocations to the environment and flows to the sea remain the same, then the amount available to irrigators would be (7,000 – 2,000 -1,000 - 1,500) = 1,500. That is a 40% reduction in inflows requires a 57% reduction in allocations to consumptive users and the environment.

For the impacts of such climate related changes to be managed as a natural part of the system rather than as a crisis, and in a manner that forces water resource managers and water users to plan for it, the most efficient entitlement system is one that has hydrological integrity, including a capacity to adapt to climate shift and climate change. Amongst other things, this requires an amount to be set aside to account for system evaporative losses and provide for a minimum flow to the sea. If allocations can be carried forward to the next year, used or sold, then the efficient solution is to allocate the remainder in proportion to each sectors (environment and consumption) share.

Moreover, in order to enable efficient risk management in systems where allocations are made to a high security and a general security share pools, the relative size of each pool must be kept in balance. This can be achieved by defining the maximum size of the high security pool as say a fixed percentage of the 10 year moving average of all allocations made to both pools. Such a set of allocation rules would force all water resource managers and water users to take full account of the prospect that the amount of water available will change through time and make appropriate investment decisions accordingly. In particular, it would force all industries to consider how variable allocations to high security entitlement holders are likely to be – they would never be seen as guaranteed allocations.

6. Ways forward

The purpose of this paper has been to reveal the consequences of defining water entitlements and allocation rules in a manner that lacks hydrological integrity. As a general rule, the result is the emergence of a suite of over-entitlement and over-allocation problems, of environmental problems, and of the erosion of water entitlement reliability in a manner that was predicted by very few people. As a result, in Australia and elsewhere a wide array of inefficient investment decisions have been made.

Approaches to dealing with these problems and establishing a system that has hydrological integrity, including a capacity to adapt to climate shift and climate change have been described. In addition to the development of low cost entitlement and allocation markets, elements of the pathway forward include specification of the water entitlements as shares, definition of share pools in a way that recognises the reality of system evaporative losses irrespective of inflows and the need to allow some water to reach the sea. The other main element is the introduction of practices that require the offset of the adverse impact of un-metered and un-meterable forms of water use, and the management of connected ground and surface water systems as one.

As outlined in this paper, proposing solutions to these problems is relatively simple. In practice, however, overcoming the political and institutional difficulties associated with transforming a mis-specified water allocation system into one that has hydrological integrity will be a significant challenge.

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