PROPERTY ENTITLEMENTS AND PRICING POLICIES FOR A MATURING WATER ECONOMY

ALAN RANDALL

University of Kentucky, Lexington, 40546, U.S.A. *

The Australian water economy is entering a mature phase characterised by inelastic supply of 'new' water and the need for expensive rehabilitation of aging projects. Thus, the policy focus will turn increasingly toward ways of restraining water demand and reallocating existing supplies. A *prima facie* case is made that the efficiency loss from current water pricing and allocation policy is significant. After considering the relevant welfare economics theory, the theory of administered prices and marketable property rights and some American proposals for reform, a system of transferable water entitlements is proposed and developed.

A basic premise of the argument to follow is that the Australian water economy, for the most part, is entering a mature phase (Watson and Rose 1980). Thus, the issues, priorities and relative cost of alternative solutions in the future will be quite different from those of the earlier expansionary phase. Changed circumstances will render the traditional solutions considerably more costly and less effective. Increasing awareness throughout the water industry of these emerging circumstances may produce a policy environment receptive to timely and pertinent contributions from economists.

The Maturing Water Economy

An expansionary water economy is characterised by relatively low social cost of expanded water use, in total and at the margin. As the demand curve for delivered water shifts rightward, new projects can be developed on favourable sites. Not only are the immediate costs fairly low, but the costs arising as aging facilities need expensive renovation and delayed or unforseen impacts (such as rising water tables and salin-

TABLE 1

Characteristics of Expansionary and Mature Phases

Item	Expansionary phase	Mature phase
1. Long-run supply of impounded water	Elastic	Inelastic
2. Demand for delivered water	Low, but growing; elastic at low prices, inelastic at high prices	High and growing; elastic at low prices, inelastic at high prices
3. Physical condition of impoundment and delivery systems	Most is fairly new and in good condition	A substantial proportion is aging and in need of expensive repair and renovation
4. Competition for water among agricultural, industrial and urban uses, and instream flow maintenance	Minimal	Intense
5. Externality, etc., problems	Minimal	Pressing: rising water tables, land salinisation, saline return flows, groundwater salinisation, water pollution, etc.
6. Social cost of subsidising increased water use	Fairly low	High, and rising

ity) emerge are yet to be presented. The false impression that water is cheap may well gain currency under such conditions. If society chooses, it can subsidise water use at quite moderate cost in the near term and satisfy, via new projects, the increased demands thus induced.

During the expansionary phase, public policy economists seem chiefly concerned with the appropriate rate of expansion and subsidisation of the water economy by the public at large. Thus, one observes a major concern with project evaluation and benefit cost analysis (Watson and Rose 1980); the concern with water pricing tends to be framed in terms of public subsidisation of water rather than the efficient use of strictly limited supplies of water (Davidson 1969).

By its very nature, the expansionary phase inevitably comes to an end.[1] The mature phase of the water economy is characterised by sharply rising incremental cost of water supply, more direct and intense competition among different kinds of users, and greatly increased interdependencies among water uses (Table 1). It appears that much of the Australian water economy has already entered the mature phase.[2]

The economist is likely to identify a much broader array of problems, and more pressing but less tractable problems, in the mature water economy. Since some expensive development project opportunities will remain on the agenda and an array of proposals to rehabilitate aging projects and to ameliorate adverse effects of existing projects will emerge,

[1] The distinction between the expansionary and mature phases of the water economy is drawn sharply in dichotomous terms (Table 1) for pedagogical purposes akin to those underlying Howe's (1979) distinction between frontier and Ricardian economies. However, it is more realistic to view the two phases as different segments of a continuum.

[2] Exceptions are most likely to be found on the Queensland coast.

project evaluation and benefit cost analysis will remain important. If anything, the increasingly complex interdependencies and environmental interactions involved will increase the challenge facing the benefit cost analyst (Randall 1982a). Since those communities of interest which successfully pressed for subsidised water resources development during the expansionary development phase will surely press for subsidised rehabilitation of their aging projects, it is unlikely that the economic concern with subsidisation will become less relevant. However, other aspects of pricing will acquire increasing prominence.

The attention of participants in the policy process will be focused on the role of price in:

(a) generating revenues to finance new developments and the rehabilitation of aging projects;

(b) dampening the growth in the quantity of water demanded; and

(c) promoting and directing the reallocation of water in response to emerging patterns of absolute and relative scarcity, externality and similar problems, and conflicts among different kinds of water users.

Economic Issues in Water Resource Allocation

Hydrological systems are complex *per se* and in their interactions with land, the weather system, the ecosystem, and the social and economic systems. On the other hand, mainstream economics is methodologically oriented toward simplification and abstraction. Nevertheless, economic analysis has much to offer those who seek to understand water issues and evaluate alternative policy strategies.

Efficiency

The value of water may be defined in terms of resource cost, opportunity cost or social cost. Resource cost is the cost of providing the water itself; opportunity cost is the value of that water in its best alternative use; and social cost is its true cost to society. In the event of unpriced adverse or beneficial effects of water supply and use, social cost may diverge from resource and/or opportunity cost. However, in an efficient equilibrium state, the resource cost, opportunity cost and social cost of water are all equal at the margin, and all are equal to the price of water.

There is considerable literature concerning efficiency in water resource allocation; some relevant contributions are cited in the discussions of pricing and property rights below.[3] In addition, there is an even larger literature on benefit cost analysis and similar techniques for sorting efficient water resource investments from the inefficient (US Water Resources Council 1973, 1979; Mishan 1976; Randall 1982a).

At this very general level of discussion, it is appropriate to draw attention to two classes of problems frequently encountered in the search for efficiency: market failure and second-best considerations.

The conventional wisdom notion of market failure suggests that inefficiency results from externalities, common property resources, public good and natural monopoly. Recent analyses have cast doubts on some market failure concepts (Coase 1960; Cheung 1970; Randall 1983).

[3] An extensive reference list is provided in Randall (1982b).

Nevertheless, it is clear that inefficiency may result from non-exclusiveness and non-rivalry in consumption (Davis and Whinston 1967; Randall 1983). These phenomena occur with disquieting frequency in the water economy. Recreational uses are often non-exclusive and non-rival or congestible; use of water to carry pollutants or salinity loads is non-exclusive, while pollution and salinity are non-rival discommodities to affected parties; and the benefits of high quality water in ecosystem support are non-rival.

The theory of second-best (Lipsey and Lancaster 1956-7) may be stated as follows: where an economy is fundamentally and pervasively inefficient, elimination of one particular source of inefficiency will not necessarily improve matters, but may make them worse. Davis and Whinston (1965) and Mishan (1962) argued that changes which promote efficiency within a sector, perhaps the water economy, are unlikely to make things worse. However, the second-best problem remains a cause of concern in some aspects of the water economy. For example, voluntary transfers of water among users (an efficiency-promoting change) may conceivably result in increased use of water to produce heavily subsidised commodities.

Regional Economic Development

An adequate water supply has historically been a *sine qua non* for major urban and industrial agglomerations, and water availability is established as a significant explanatory variable in location theory; that is, cities locate where there is assured water. Some governments have chosen, for regional development purposes, to reverse the typical pattern of causation; that is, to bring water to some poorly supplied locations to encourage urban development. In some cases, such induced urban development has gathered momentum to the point where urban populations can effectively demand major new water works and interbasin water transfers to permit continued growth.[4]

In Australia, irrigation has often been promoted as encouraging agricultural populations and viable country towns in arid regions. The closer settlement orientation of irrigation development in the Murray and Murrumbidgee valleys (Langford-Smith and Rutherford 1966; Davis 1968) were clearly intended not only to provide opportunities to farm but also to serve regional economic development goals. Casual observation suggests that irrigation-based towns in arid regions have similar potential to agriculture-based towns in more humid regions, and face similar problems. However, the formal literature on regional economic development impacts of irrigation in Australia is sparse (Paterson 1974; Woolmington 1974). The substantial US literature has been summarised recently by Young (1978) and Stoevener and Kraynick (1979). The US Water Resources Council (1973) has established guidelines for *ex ante* evaluation of regional economic development impacts in water resource planning.

---

[4] In the U.S.A., the Central Arizona Project and the State Water Project (California) are cases in point (Kelso, Martin and Mack 1973; Goodall, Sullivan and DeYoung 1978; Maass and Anderson 1978).

Equity

Economists have long been concerned with the concept of equity and its implementation in economic planning. In a long and tortuous intellectual history, utilitarianism, the compensation test (potential Pareto-improvement) approach, and the Samuelson-Bergson social welfare function have been proposed but found wanting (e.g. see Arrow 1951). The author prefers the approach of Buchanan (1975, 1977), building on the work of Rawls (1971), who seeks to define just processes rather than equitable outcomes. Whatever emerges from just processes is *ipso facto* just, or equitable.

This constitutional-contractrarian[5] approach is based on three first principles, that is, statements which are either axiomatic or capable of gaining unanimous consent. These are:

(a) whatever the individual wants is good for the individual;

(b) whatever set of social rules commands unanimous assent at the outset is an acceptable starting point, or constitution; and

(c) whatever changes can thereafter be made by voluntary exchange among all affected parties are acceptable.

Operationally, these principles call for establishment of a just constitution behind a Rawlsian veil of ignorance, and Pareto-safety thereafter. In short, the subsequent (i.e. contractrarian) stage may be operationally feasible, but the constitutional stage seems infeasible.

These considerations lead me to abandon the search for equity *de novo*, seeking instead to change an established system in ways which are efficiency-promoting and which can be implemented in a Pareto-safe fashion. This approach is imperfect, as it abandons the second of the three first principles. Nevertheless, it encourages efficiency-inducing resource re-allocation via voluntary consent. The consensual aspect is important, since efficiency-promoting changes which are not Pareto-safe would be likely to encounter vigorous opposition from those currently benefitting from inefficient arrangements in the water industry.

Water Pricing

Approaching water pricing from the perspective of resource cost, there are two different concerns: the economics of water delivery systems and the economics of augmenting water supply.

Concern with the economics of delivery systems has spawned a massive literature on marginal cost pricing in decreasing-cost and increasing-cost systems, and peak-load pricing where demands upon the system are time variable (Hotelling 1939; Coase 1946, 1947; Houthakker 1951; Margolis 1957; Ansari 1966; Greenhut 1966; Turvey 1969, 1976; Baumol and Bradford 1970; Kay 1971; Panzar 1976; Starrett 1978). For a given water delivery system of fixed capacity, marginal delivery cost is relatively low and fairly constant until the capacity constraint is approached. On the other hand, the fixed costs of such a system are high and average delivery cost continues to decrease until the capacity constraint is approached. But this is insufficient reason to conclude that water delivery is a decreasing-cost industry. With the inevitable rightward movement of the demand for water, quantity demanded even-

---

[5] Buchanan's (1977) term.

tually exceeds the capacity of a given delivery system. Opportunities for inexpensive extension of the system are eventually exhausted, and new, larger, delivery systems are required. Thus, it is possible that the long-run marginal cost of water delivery is increasing rather than decreasing.

An exclusive focus on the economics of delivery systems assumes that the water resource itself is free. But it is not free in either the resource cost or the opportunity cost sense. From a resource cost perspective, the long-range marginal cost of water in managed rivers increases quite markedly as the lower-cost opportunities for water storage works become exhausted and the supply of water can be augmented only by higher-cost works. Considering together the cost of water storage and delivery, the only viable assumption is that the long-run marginal cost of delivered water is increasing.

Efficient allocation usually requires that marginal units (of any good) be priced at their marginal cost. However, in the case of water, several complications arise. First, given the lumpiness of storage and delivery systems, marginal resource cost in the short run may be much lower than in the long run if system capacity is not utilised fully.[6] Second, given the increasing-cost nature of the water industry,[7] pricing of all water at marginal cost would generate surplus revenues for the water authorities. Thus, multi-part or increasing block tariff structures[8] may be appropriate for non-profit water authorities.

The theory of water pricing is further complicated by the intertemporal nature of water storage and delivery and the stochastic nature of precipitation, water inflow, and water demands (Hotelling 1931; Riley and Scherer 1979; Manning and Gallagher 1980). Complex irrigation planning and reservoir management models, incorporating various signalling systems including price feedbacks, have been constructed (Dudley, Howell, and Musgrave 1971a, 1971b; Dudley 1972; Dudley, Musgrave and Howell 1972; Sobel 1975).

Valuable as these sophisticated contributions may be, considerable potential exists for efficiency improvements in the water industry from application of more basic marginal cost pricing principles. Further, a water pricing policy based on these principles would help solve problems concerning expansion of the water industry over the long term. Quantity demanded under efficient pricing structures would provide a continuous stream of information as to whether system capacity at any time was inefficiently large or small.[9] In addition, marginal cost pricing would tend to restrain the growth in quantity demanded. There is some evidence that the price elasticity of demand for irrigation water is considerably greater

---

[6] There is some controversy about how best to approach efficient allocation in such cases. Pricing at LRMC would prolong the underutilisation of capacity. On the other hand it is quite possible that pricing at SRMC would generate inadequate revenues to meet the fixed cost of existing facilities or to finance the next expansion (Starrett 1978). Pricing at SRMC would surely give users incorrect signals about the long-run scarcity of water.

[7] In all cases but the short-term with under-utilised capacity.

[8] Multi-part and block tariff structures are conceptually quite different. The simplest multi-part tariff involves a lump-sum charge independent of consumption and a parametric charge per unit used. Block tariffs involve quantity discounts or premiums, with price being determined by the level of use.

[9] Given that capacity can be increased only in relatively large indivisible units, the timing of capacity augmentations is an important issue. Turvey (1976) is among those who have recently addressed the timing question in this context.

than zero in absolute value (Flinn 1969; Guise and Flinn 1970; Cull 1979), while there is even more evidence, along the same lines, for residential water demand (Howe and Linaweaver 1967; Hanke 1970; Young 1973; Morgan 1973; Gallagher and Robinson 1977).

Even if the water authority succeeded in eliminating persistent shortages and surpluses, the stochastic nature of both water inflow and demand would generate short-term shortages and surpluses. Shortages could always be eliminated by price increases. However, that would involve temporary departure from long-run marginal cost pricing and, in addition, might provoke an adverse political reaction. More likely, a non-price rationing system would be held in reserve for implementation in periods of water shortage.

In summary, it should be possible for a water authority to design and implement a system of administered prices which would do a reasonably good job of equating resource cost and opportunity cost at the margin in the long run, while raising sufficient revenue to cover the total cost of water delivery. Such a strategy does, however, have some disadvantages. It has been argued that the information requirements for an efficient system of administered prices are demanding (Phelps, Moore and Graubard 1978), and much of this information would necessarily be gathered by trial-and-error experimentation. Unfortunately, information is expensive and mistakes made in the trial-and-error process may be costly. A further disadvantage of this pricing strategy is that it would reduce effective subsidisation of irrigators, eroding the capital value of established irrigation farms. Thus, vigorous opposition from established irrigators is predictable, and the resultant political pressures may make it difficult to institute and maintain an efficiency-oriented system of administered prices.

Markets in Water

An alternative approach to efficiency in water resource allocation would focus, at the outset, on opportunity cost rather than resource cost. A market in delivered water would be established. Entitlements to water would be created and distributed initially among water users. Subsequent transfer of entitlements would be permitted, and it is predictable that such transfer would result in effective pricing of water to users at its opportunity cost. That is, the annualised unit value of the entitlement plus the unit charge levied by the authority would, together, equal the long-run marginal opportunity cost of the water.

Systems of marketable water rights have been widely canvassed in the economics literature (Milliman 1959; Hartman and Seastone 1965; Musgrave and Lesueur 1973; Phelps, Moore and Graubard 1978). Economists have generally viewed marketable water rights favourably and, as recently as May 1980, a RAND Corporation study funded by the State Legislature recommended that California adopt such a system (Baker 1980).

While marketable water rights proposals vary in detail, all would institute water entitlements as legal property instruments, vested in the individual and negotiable independently of the land. The various proposals differ, however, in terms of the particular specification of rights transmitted by the entitlement and the initial distribution of entitlements.

The rights transmitted by negotiable entitlements must be specified in terms of the secure expectations of the right holder and the duties and obligations of the water authorities. Particular issues requiring resolution include:

(a) the time-span of the entitlement and provisions for rental rights to deliveries in the event that long-term entitlements are specified;

(b) the method of accommodating the stochastic nature of water availability (possibilities include individual rights to some specified small fraction of water available for delivery, and the specification of different classes of entitlements in terms of reliability, i.e., the probability of water delivery);

(c) the time and place of delivery;

(d) the ownership of tailwaters and return flows and the attendant obligations upon the owner; and

(e) the conditions under which entitlements could be transferred, with special reference to transfers which would change the time and/or location of water demand.

The way in which these questions are resolved will influence the possibility of achieving efficiency in the market for water and the precise characteristics of any efficient solution achieved. In general, provisions which impede trade will preclude Pareto-efficiency (Cheung 1970).

The initial distribution of entitlements could be handled in a variety of ways. At the extremes, entitlements to all available water could be auctioned off by the water authority thus halting the subsidisation of irrigators, or distributed free to irrigators on the basis of historical patterns of water use. An intermediate solution would involve free distribution of entitlements for highly reliable deliveries (i.e. current water rights and allotments — see below) with entitlements to excess water auctioned off by the authority when available. To permit a well-functioning market in entitlements, it is necessary that water charges levied by the authorities be known in advance and be predictable well into the future.

A market in water entitlements would have two clear advantages vis-a-vis a resource cost pricing policy pursued by a water authority. First, centralised information costs would be reduced, as the market would tend to generate the necessary information and market users would bear the information costs. Second, a system of marketable rights to water deliveries would correct a wide range of allocative deficiencies which may be inherent in any particular water pricing policy followed by the authorities. Since water would be priced (in the rights market) at its opportunity cost to the user, it would tend to be efficiently used even if the charges collected by the water authorities failed to cover resource cost in total or at the margin.

It is concluded that a system of marketable water entitlements would effectively price water at its opportunity cost to the user. But would it equate opportunity cost with resource cost at the margin? The short answer is 'no', unless the water authority itself is a participant in the market (Manning and Gallagher 1980). This could be accomplished by specifying only short-term entitlements to be auctioned off by the water authority. Such a solution would quickly equate opportunity cost with resource cost at the margin, but would be anything but Pareto-safe to current irrigators. An alternative, in which the authority would auction

entitlements for only that water made available through new projects, would be Pareto-safe to both current and new irrigators. This approach would equate resource cost with opportunity cost at the margin — not immediately, but eventually as demand shifts to and beyond the market-clearing level.

Below, a system of transferable water entitlements is proposed for Australia, and many of the concerns raised in this section are discussed in more detail. First, however, the existing institutional environment of the Australian water industry is discussed, and an analysis suggesting that misallocation of water causes significant efficiency losses in Australia's major river basin is presented.

Australian Water Management Institutions and Pressures for Change

Starting with Victoria in 1886, state governments established their authority over water in streams (Davis 1968; Clark and Renard 1974). Riparian rights abated whenever they came into conflict with state authority. At that time, individual riparians were granted licences to divert water for livestock and domestic use. All other diversions were prohibited, except where diversion licences were granted under relevant legislation. These basic principles have been maintained through to the present time, although the institutional procedures for their implementation have undergone some evolution (Davis 1968).

The current situation may be summarised as follows. Diversion licences (permits) may be granted by the state. The area to be irrigated and/or the quantity of water to be delivered is restricted and a fee may be charged. Renewals are not automatic. They may be denied for a variety of reasons, most commonly, failure to establish beneficial use. Usually the relevant legislation does not require agencies to grant or renew licences or permits but, on the other hand, does not specify criteria for denial of applications. Water authorities, therefore, enjoy considerable administrative discretion. However, that discretion is used conservatively in practice: the authorities tend to act as though they enjoy much less discretion than exists under a strict interpretation of the legislation (Davis 1968).

Construction of new reservoirs may usher in a period when new licences are routinely granted, followed by a moratorium on new licences when it is deemed that water supplies have been fully committed. Agencies consider themselves at liberty to licence new diversions, even if the possibility exists of interference with pre-existing use. There is no priority of old licences over new licences (Davis 1968).

In times of actual or threatened shortage, licences and permits may be suspended, revoked, or modified. The various state authorities have devised administrative procedures to deal routinely with water shortages. In some jurisdictions, all licences and permits are reduced proportionally. In others, high value perennial crops may enjoy priority over other crops and improved pastures, while other uses may have lowest priority (Davis 1968).

The customary solution to impending long-term, as opposed to seasonal, water shortages has been the construction of new reservoirs. This is taken to be a state responsibility, although, since federation, the Federal Government has often made substantial contributions to the cost

of capital works. The Federal hand in water management has, by and large, remained unobtrusive. The Federal Government may be a party to interstate agreements, and is a party to, for example, the River Murray Agreement (Clark and Renard 1974; Johnson 1974). The role of the River Murray Commission, however, is quite limited. It has been argued that the Commission has no clear legal mandate to undertake some of its relatively few activities (Clark 1975). Since the mid-1960s, the Federal Government has maintained the Australian Water Resources Council, an organisation which serves a limited role in the formulation of water policy on a national basis, but which has relatively few powers beyond those of persuasion.

Irrigation development in the Murray and Murrumbidgee Valleys was, to a very considerable degree, co-ordinated with closer settlement programs (Langford-Smith and Rutherford 1966). State governments resumed land, provided diversion weirs and water delivery systems to the farm boundary, and allocated the newly subdivided farm land to individual settlers. The size of irrigation blocks was determined on the basis of home maintenance area concepts, and the settlers often leased land from government authorities, rather than acquiring freehold titles. In many settlements, only returned servicemen were eligible. The long and relatively complicated history of irrigation land settlement in the Murray basin has been documented by Langford-Smith and Rutherford (1966).

While private diverters are licensed, the privilege of water use in government-sponsored irrigation areas and districts is assigned, in the various states, on the basis of water rights or allotments, as the case may be. To encourage intensive irrigation, it is often the policy that irrigators must pay for their water rights or allotment regardless of use (Davis 1968). Additional water beyond the right or allotment may be purchased when available and when permitted, often at a unit price which differs from that charged for the right or allotment.

Usually, the state water authorities are expected to cover the costs of operation and maintenance of the water management and delivery system with revenue from the sale of water (Watson and Rose 1980). Thus, irrigators in government-sponsored irrigation areas and districts pay much less then the full resource cost of the water they use. In N.S.W., private diverters who provide their own pumps and distribution channels typically pay fees much lower than those paid by area and district irrigators; the fee often covers only the estimated cost of metering. In S.A., private diverters pay only a metering charge for their allotment, but a sharply rising charge (equivalent, in the highest priced block, to that paid by urban users) for additional deliveries.

Irrigation water charge schedules within a single river system, the Murray-Darling, vary dramatically (Table 2). There are flat rate schedules (Victoria), sharply declining block schedules (N.S.W.)[10] and sharply increasing block schedules (S.A.). Not only that, but the base block in S.A. is priced more than three times higher than its N.S.W.

[10] The sharply declining block charge schedule for water in N.S.W. irrigation areas serves to reduce year-to-year fluctuations in Water Resources Commission revenues, but is inimical to demand restraint and efficient water allocation—a classic instance of administrative convenience over-riding resource allocation objectives.

TABLE 2

Area Irrigated and Water Deliveries, Murray-Darling Basin (1975-76) and Representative Water Charges (1977)

State and type of project	Area irrigated (ha)				Total water deliveries (ML)	Water charges Base charge—Marginal charge ($/ML)
	Horticulture	Rice	Pastures other crops	Total		
N.S.W. public	17 288	65 654	274 897	357 839	1 826 525	4.50 – 1.00
N.S.W. private[a]	17 875	–	1 002 809	1 020 684	1 300 000(approx)	0.37 – 0.37
Vic. public	33 956	–	416 646	450 602	2 039 073	3.50[b] – 3.50
Vic. private[c]	11 142	–	619	11 761	306 000	n.a.
S.A. public, and irrigation trusts	12 041	–	4 813	16 854	441 000	14.40 – 57.20
S.A. private	26 266	–	16 700	42 966	n.a.	metering charge—40.00 to 85.00[d]

[a] Figures for State total and does not include cotton (=18 617 ha). Not available for River Murray System, *per se*.
[b] For Goulburn-Murray irrigation areas. (*Source*: Robertson 1977)
[c] Nyah, Red Cliffs, Merebein, Robinvale only (direct from river by pumping); remainder n.a. (*Source*: State Rivers and Water Supply Commission of Victoria 1976)
[d] In 1980, highest block of excess water was priced at $270/ML, i.e. the price paid by urban users. (*Source*: S.A. Engineering and Water Supply Department 1980)

counterpart, while the quality of delivered water is lower (Maunsel and Partners 1979).

If the pricing and allocation procedures for irrigation water seem complex and confusing, those for urban and industrial water are more so. Various quasi-government authorities bear responsibility for providing water to particular localities. Where appropriate, these authorities have entered into agreements with irrigation authorities for water supplies, thus bringing agricultural and urban water demands into direct competition. Schedules of charges vary widely in complexity and economic sophistication, but many local authorities make little use of the price mechanism to restrain demand (Gallagher and Robinson 1977). In some localities, residential water use is unmetered and revenue is collected via water rates, that is, a property tax. In others, property taxes cover a substantial basic allocation to each household while excess water is priced volumetrically. In such an arrangement, price operates to restrain only those demands in excess of the basic allocation, which may exceed average household water use.

Demands for in-stream flows — for navigation and recreation, and to dilute salinity and pollution loads — are met by appropriate reservoir management strategies. In the Murray Valley, the River Murray Commission plays a role in ensuring that the up-stream states make appropriate contributions to in-stream requirements.

Australian water management institutions are encountering considerable pressures for change. These pressures are mostly financial, in the first instance, but they ultimately reflect the realities of the water economy: aging works in need of rehabilitation, unrestrained demand growth pressing against sharply rising resource cost of new supplies, and a reduced tolerance among clientele groups for obviously inefficient restrictions on water allocation. These pressures are generating some response by the water authorities. For example, S.A. has liberalised the conditions under which private diverters may combine their water allotments; Queensland has proposed to auction some of the irrigation farms to be established using Burdekin project water (thus accruing for the State Government some of the economic surplus from irrigation development which has previously been distributed as windfall gains to selected farmers), and in several major cities, notably Perth, Adelaide, and Newcastle, consideration is being given to redesigned pricing policies to restrain demand for new works and generate revenues to rehabilitate old ones.

The tenor of recent internal documents of various water authorities, and of consultants' reports to them, suggests to me that these few visible changes may be merely the tip of the iceberg. Further, publicly circulated documents bearing the Federal Government's seal of approval have recently called for far-reaching changes in the *modus operandi* of the Australian water industry (Australian Water Resources Council 1978; Newman 1979). Conditions are currently favourable for a wide-ranging debate on the future of Australia's water institutions and for a significant input from the economics profession.

Efficiency Losses in the Murray-Darling Irrigation Complex

In general, inefficiency resulting in economic loss occurs whenever
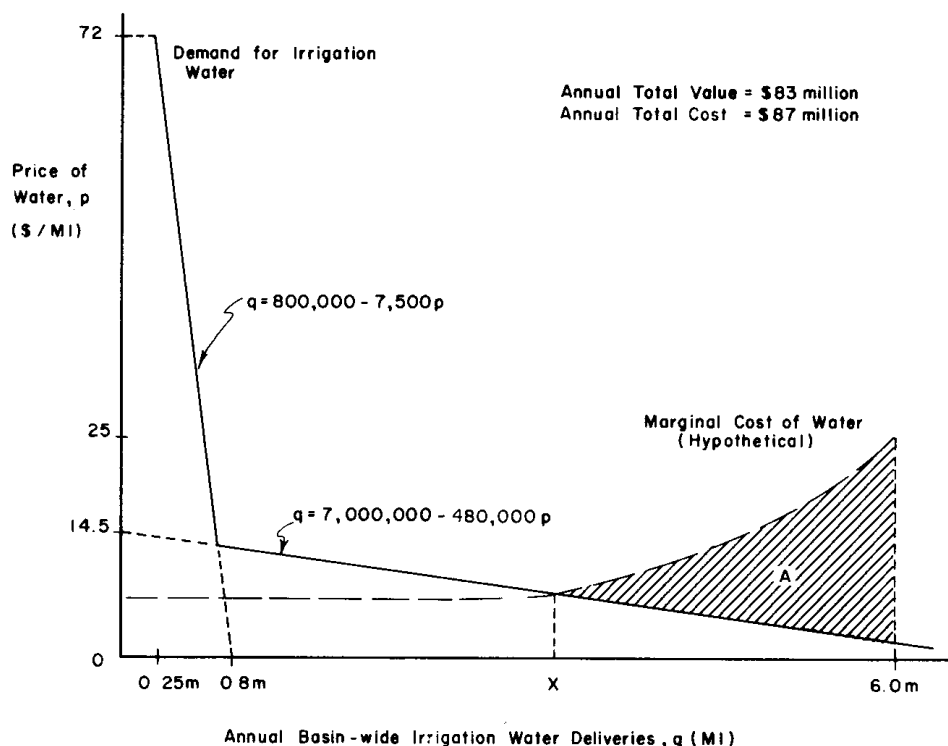
FIGURE 1 — Estimated demand for Murray-Darling irrigation water, and (hypothetical)
                                        marginal cost
Note: X = the (hypothetical) efficient size of the Murray-Darling irrigation complex (in
       million ML delivered annually).
       A = The (hypothetical) loss from over-expansion of the basin-wide irrigation
       complex.

there is failure to equate resource cost, opportunity cost, and social cost
at the margin. The existence of social cost not reflected in either resource
cost or opportunity cost can be demonstrated clearly in the Murray-
Darling basin; the salinity problem (Maunsel and Partners 1979) is a
manifestation of such social cost. However, the social cost has yet to be
estimated. In addition, no attempts have been made to estimate the loss
resulting from misallocation between agricultural and other uses (e.g. ur-
ban and industrial diversions, and in-stream flows). It is possible,
however, to attempt the less demanding task of a crude, first approxima-
tion of the efficiency losses from water misallocation within the
agricultural sector in the Murray-Darling basin.

It is necessary to estimate the annual value in agricultural use of
Murray-Darling water. For this purpose, the demand relationships
estimated by Flinn (1969) were adjusted for inflation and metrication and
extrapolated from the Murrumbidgee Irrigation Area (MIA) to the whole
Murray-Darling basin. The heroic assumptions underpinning such a pro-
cedure are self-evident. The results are displayed in Figure 1. Integration
under this regional demand curve for water yields a potential annual
value of $82.85m, assuming all water is efficiently allocated among
irrigators.

Revenues to water authorities from charges for Murray-Darling water amount to about $26.5m. A current rule-of-thumb is that revenue from charges recovers about one-third of the full resource costs of water provision.[11] Irrigators in public projects use about 4.5m ML annually and pay about $25m for it. The one-third rule-of-thumb would suggest an annual resource cost of about $75m for providing the water they use. Private diverters use about 1.5m ML, and pay only about $1.5m for it. Assuming that private diverters pay about one-eighth of the resource cost of providing the water they use, that cost would amount to about $12m. These estimates suggest that, for the Murray-Darling basin, the annual resource cost of providing water for agriculture are about $87m.

Since the potential total annual value of irrigation water was estimated at about $83m, and the total resource cost of its provision at about $87m, it seems that the total benefit cost ratio for all Murray-Darling irrigation is potentially around unity. Nevertheless, it seems that the system has been considerably over-expanded. The marginal cost of the water in the system probably exceeds $25/ML, while the marginal charge is $1.00/ML for N.S.W. public project irrigators and $0.37/ML for N.S.W. private diverters (Table 2). The situation is illustrated in Figure 1 (in which the MC curve is entered as a dashed line to indicate uncertainty concerning its precise shape).

As reported above, the potential annual value of irrigation water is about $83m assuming that all water is efficiently allocated among irrigators. However, the marginal water prices to which irrigators respond vary widely within the basin—from $0.37/ML to $85.00/ML in 1977, and from $0.37/ML to $270/ML in 1980 (Table 2). Assuming the farmers use water so as to equate its on-farm marginal value with its marginal price, this wide disparity among marginal prices ensures inefficient allocation of irrigation water among farm firms, as shown in Figure 2.

The annual value of these efficiency losses may be approximated using the following simple model. Assume:

(a) there are two sectors: f consisting of large-area farms and s of small, mostly horticultural farms;

(b) all farms within a given sector have identical linear demand functions for irrigation water;

(c) within each sector there are m classes ($k = 1, 2, \ldots, m$) of farms such that all farms in class k face the same marginal price for irrigation water, but the marginal price differs across classes.

Using conventional notation, the annual aggregate demand for irrigation water by class k farms in sector f is given by:

(1) $$Q_{fk} = \alpha_{fk} + \beta_{fk}P_{fk},$$

and the efficiency loss by:

(2) $$L_{fk} = 0.5(Q_{fk} - \overline{Q}_{fk})(P_{fk} - \overline{P})$$
$$= 0.5\beta_{fk}(P_{fk} - \overline{P})^2,$$

[11] Internal documents of the Victorian and S.A. water authorities confirm this broad estimate, while analyses of costs and charges in the Bundaberg, Queensland, project indicate charges exactly equal to one-third of unit costs (Watson and Rose 1980).
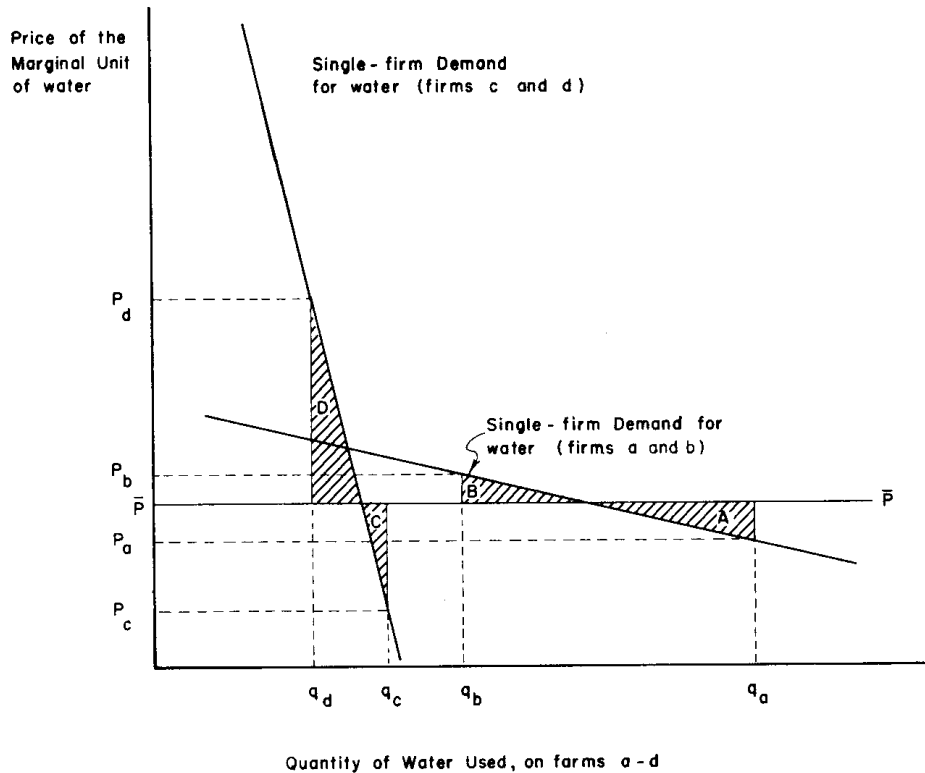
Quantity of Water Used, on farms a-d

FIGURE 2—Efficiency losses A, B, C, and D, from inconsistent water prices facing two pairs of identical farm firms.

where L_{fk} = the annual efficiency loss for class k farms in sector f;

P_{fk} = the marginal price for irrigation water faced by class k farms in sector f;

$\bar{P}$ = the quantity-weighted average of the marginal water prices;

Q_{fk} = the annual quantity of irrigation water demanded at price P_{fk}; and

$\bar{Q}_{fk}$ = the annual quantity of irrigation water demanded at price $\bar{P}$.

It follows that the annual efficiency loss in sector f is:

$$(3) \qquad\qquad L_f^* = \sum_{k=1}^{m} L_{fk}$$

The annual efficiency loss in sector s can be defined analogously, thus giving the basin-wide annual efficiency loss:

$$(4) \qquad\qquad L^* = L_f^* + L_s^*.$$

To estimate L^*, this model was implemented using aggregate sectoral demand curves (Figure 1), water price data (Table 2), and 'guesstimates' of sectoral water use inferred from total water use and sectoral land use (Table 2). (Details are available from the author.) L^* was estimated to be \$18m annually, at 1977 prices. This efficiency loss from price-induced misallocation of water between firms reduces the total annual value of irrigation water in the basin from its potential level of \$83m to a realised value of \$65m.

The main points from the above discussion are listed below.

(a) The revenue to water authorities from charges for irrigation water is about $26.5m annually.

(b) The full resource cost of providing that water is about $87m annually.

(c) The potential value of irrigation water to farmers is about $83m but, as a result of inconsistent pricing policies, its realised value is more like $65m.

(d) It is clear that, however close the total value of water and its total resource cost may be, the system has over-expanded beyond the point where the marginal value of water equals its marginal resource cost.

(e) At a cost of about $60.5m (i.e. $87m-$26.5m), the irrigation complex provides a subsidy to farmers of total value $38.5m (i.e. $65m-$26.5m). With efficient inter-firm water allocation, that subsidy could amount to $56.5m annually.

(f) If it were possible to establish an efficient market in rights to irrigation water, the efficiency loss, would be substantially eliminated. If water authority revenues were unchanged in total, the annual rent value of water entitlements would be about $56.5m (i.e. the potential value of water minus the revenue from water charges). Long-term entitlements to water would acquire a total capital value of about $500m, or an average of $83/ML of entitlement. The value in trade of, say, long-term entitlements to the marginal million ML delivered would, however, be lower (about $30/ML, by my estimate).

(g) Consider a rice farm in the MIA using 1600 ML annually and having a market value of about $200 000. Using the average capital value of water entitlements, $83/ML of entitlement, the value of water entitlements would account for about 65 per cent of the market value of the farm.

These calculations, while crude first approximations, provide *prima facie* evidence that significant economic losses exist and can be attributed to over-expansion of the basin-wide irrigation system and misallocation of the available water supply due to inconsistent pricing policies. It must be remembered that the above calculations omit consideration of two important constellations of concerns: first, the divergence between market-revealed resource cost and social cost (the salinity problem is merely the most obvious manifestation of this divergence); and second, the demands which urban and industrial users of water would likely reveal if permitted to compete more directly with agricultural users. Full consideration of these concerns would be expected to reveal total misallocations of which the misallocation within agriculture is merely a part.

Some US Proposals for Reform

American water policy in arid and semi-arid regions is of interest because the problems there are qualitatively similar to those in Australia (Hartman and Seastone 1965; Haveman 1965; Kelso, Martin and Mack 1973; Maass and Anderson 1978; Martin 1979; US Department of the Interior 1980). However, the US problems are perhaps more serious and

the resultant conflicts more intense. Furthermore, US water laws and institutions exhibit more diversity and greater flexibility than their Australian counterparts,[12] thus providing experience with arrangements yet untried in Australia.[13]

The American literature includes several interesting proposals for reform of water institutions. Gaffney (1962) proposed an administrative auction system within (but presumably not between) water districts. His proposal has three elements:

(a) the district 'watermaster' would conduct frequent auctions to establish the bid price for specific deliveries of water which would go to the highest bidders;

(b) an additional transportation charge, independent of the bid price, would be paid by the user, the charge being highest for distant users on channels in poor repair; and

(c) the fixed costs of the water system would be paid by land taxes, these taxes being highest for those who own land on good channels and nearest to the diversion point.

Milliman (1959) proposed a system based on long-term transferable entitlements to water. These entitlements would acquire a capital value and shorter-term rentals would be permissible. In these respects, this proposal is very different from that of Gaffney. Milliman would recognise the interdependencies and communities of use which exist in complex surface and groundwater systems and would entertain either a regulatory approach or a system of damage charges to handle these problems.

Phelps, Moore, and Graubard (1978) proposed a system of long-term transferable water entitlements to some small fraction of available flows and all return flows therefrom. Water authority approval would be required for sale or rental of entitlements as a safeguard against exchanges which would impose high costs on the water system. However, they propose that the law be clearly written to ensure that denial of approval occurs only with good reason. The main contribution of Phelps, Moore, and Graubard is to spell out in considerable detail the workings of what is basically a time-honoured proposal. They make a plausible case that many of the common objections to transferable water entitlements are surmountable.

Seckler and Young (1978), in response to recent controversies about the 160-acre limitation on the size of irrigation farms receiving subsidised Bureau of Reclamation water, propose a modified water transfer system. Their focus is almost entirely on first-time water use in agriculture and, unlike the two proposals discussed immediately above, pays little attention to return-flows, pollution, and transfers among agricultural, urban,

---

[12] See, for example, Trelease (1957, 1965, and 1974), Bain, Caves and Margolis (1966), Davis (1968), Maloney and Ausness (1969), Goodall, Sullivan and DeYoung (1978), and Phelps, Moore and Graubard (1978).

[13] For example, Gardner and Fullerton (1968) show that arrangements for renting water within a Utah irrigation district permitted some efficiency gains, while a subsequent agreement allowing water rentals across district boundaries increased the realised efficiency gains. Huszar and Sabey (1978) show that a rental market would increase efficiency in the first-time use of diverted water and in the use of return-flows, while reducing pollution loads reaching the river.

B

industrial and in-stream users. They recognise five goals for irrigation policy:

(a) efficiency in food production;
(b) regional economic development;
(c) opportunities for small farmers;
(d) viable rural communities; and
(e) administrative feasibility and cost-effectiveness.

Their proposal has four basic elements:

(a) water, not land, should be controlled (compare the various proposals for transfer of water independently of land);
(b) a two-tier price system for water, comprising a quota at a (low and subsidised) base price, and additional water at the market price;
(c) any *bona fide* farmer may purchase a water quota at the base price; and
(d) land may be leased without limit—to permit economies of size—but all water on leased land would be sold at the market price.

The base quota is essentially a welfare program, so the amount of the quota and its price should be determined on welfare grounds (e.g. maintenance of viable farms generating a reasonable net income) and therefore may vary between districts. The market price—which would apply to additional water, water used on leased land and all non-quota water transferred to new uses and users—would surely be higher than the base price. Thus, some relatively inefficient large operations may be forced to sell out to small farmers who qualify for the base price. Seckler and Young recognise that politically powerful large operators (who exist only because of a long history of non-enforcement of the 160-acre limitation) may oppose their proposal. Hence, they suggest that individual water districts be given a choice between implementing the proposal or strict enforcement of the 160-acre limitation law.[14]

A Proposal for Transferable Water Entitlements (TWE)

Following the above discussion of the Australian water industry, the relevant economic theory, water law and institutions, the economic losses from inefficient arrangements in the Murray-Darling basin, and some American proposals to deal with similar problems, it seems appropriate to sharpen the focus by presenting a specific reform proposal.

The basic outline for a system of marketable water rights in Australia is as follows. Entitlements for the delivery of water in each year for some arbitrarily large period of years would be created. These entitlements may specify the season of delivery and that deliveries would be made on the basis of some rotation or schedule convenient to the water authority. These entitlements may be sold at any time during their life, and the water deliveries guaranteed thereunder may be rented or leased for shorter periods. Concerns with uncertainty of delivery would be handled either by specifying rights to some small fraction of available flow or by

[14] Thus, unlike the Milliman (1959) and Phelps-Moore-Graubard (1978) proposals, the Seckler-Young proposal does not rely on Pareto-safety for established water users to facilitate change.

specifying different classes of rights, each with a different probability of delivery. While these different ways of dealing with the uncertainty issue would result in somewhat different market behaviours, either would seem to be workable.

While title to water deliveries would be vested in individuals independently of the land, the water authorities clearly have a legitimate interest in the conditions under which transfer of water is permitted. Since the entitlements would obligate the water authorities to deliver water, each time the sale or rental of an entitlement is recorded it should specify the timing and location of delivery. Sales or rental agreements which involve a significant change in timing or location of delivery should require the approval of the water authority. Such approval is necessary to ensure that unreasonable and unexpected costs of delivery are not borne by the water authority. On the other hand, relevant legislation should provide considerable encouragement for the water authorities to approve all transfers except those which would impose unreasonable hardship on the authority. Obviously, where the transferee is willing to bear any additional costs of delivery, there is little ground for obstinance on the part of the water authority.

It is essential that water entitlements indicate (on the deed, or in the body of law which specifies the rights conveyed with the deed) the authority's revenue policy, the schedule of charges which will be levied and the conditions under which the charges may be amended. I suggest that considerations of equity and political acceptability should be dominant in determining the level of charges. Efficiency in using the currently available supplies of water is handled by transferability of rights, *per se*; efficiency in the development of new supplies of water is addressed below.

Consider, first, established irrigation projects. Since most current irrigators have, in some real sense, already paid for the capital value of any subsidies implicit in underpriced water deliveries, equity considerations would tend to suggest that water tariff policy should not be dramatically changed in such a way as to increase the average charge for water. Political considerations lead to a similar conclusion, since irrigators would surely resist major increases in the average level of water tariffs. On the other hand, if persuaded that a TWE system would, if anything, increase their attainable wealth, they may well favour a move toward transferable rights.

Accordingly, I suggest that, for those irrigation projects for which currently available water is committed, the subsidisation of irrigators should be treated as a non-issue. TWE should, therefore, be written so as to provide assurance that the current practice, whereby revenue from water charges is expected to cover only operation and maintenance costs, will be continued into the indefinite future. Further, established irrigators should receive entitlements based on historical patterns of water use. Thus, they would not be threatened with economic injury via price increases or quantity reductions.[15]

---

[15] A reviewer suggests an opposing viewpoint: the possibility of eventual changes in water pricing policy will surely be reflected in the market value of assets and is perhaps already being so reflected. Thus, the reviewer is less impressed than the author with arguments that Pareto-safety requires continued subsidisation of established irrigators.

Established irrigators have formed reasonable expectations that the public will bear the costs of rehabilitation works. The notion of Pareto-safety, which is basic to the discussion immediately above, suggests that this expectation should be fulfilled. However, it may be appropriate to place some time limit on public responsibility for rehabilitation of water supply and delivery systems. Perhaps the entitlements to established irrigators should permit increases in real water charges to cover capital costs of rehabilitation occurring more than, say, 30 years after the entitlement is first issued.

Now consider new irrigation projects. The rationale for earlier subsidised irrigation developments (i.e. the role of irrigation in land settlement schemes, and the hope that irrigation would tend to stabilise export income) no longer seems so pressing. Further, while I have argued that efficiency in the allocation of water should be achieved in a manner which is Pareto-safe to current irrigators, Pareto-safety in no way requires the creation of new groups of subsidised irrigators.

It seems appropriate to require that irrigation authorities earn sufficient revenue to cover the total resource cost of any additional water supplies. However, there would be no requirement that the authorities accrue all of their revenue from water sales. The authorities would create transferable entitlements to the newly provided water, distributing these entitlements by auction. Their revenues would then be composed of two elements: revenue from water sales and revenue from the initial sales of water entitlements. The second source of revenue would yield substantial one-shot receipts, easing the capital management problems facing water authorities. Water planners would derive much of their demand information from careful observation of the already-existing market in transferable water rights, rather than from synthetic budgets for proposed irrigation undertakings. Under such an arrangement, one would expect the authorities to pursue relatively conservative investment policies.

The apparent over-expansion of Murray-Darling irrigation suggests that it may be some time before major new storage works in that basin could be justified. Eventually, with the rightward shift of demand, new projects could become economically feasible. From that point on, the proposed auctioning of entitlements to new water would tend to maintain the long-run marginal equality of resource cost and opportunity cost.

An effective TWE system would need to include a number of additional concerns: drainage and return flows; the transfer of water from agricultural to urban and industrial uses; and the provision of in-stream flows for navigation and recreation purposes, to dilute pollutant and salinity loads, and to maintain the ecosystem support function.

It seems clear that tail waters and return flows will become increasingly valuable as the market in TWE effectively raises the opportunity cost of water to the user. One would expect to observe increased investment in on-farm retention and re-use of these waters. It is also likely that, depending on conditions of slope and elevation, tail water and return flows may be more valuable to a new user than to the original user. There is no good reason to stifle an emerging market in tail waters and return flows. The simplest solution, it seems, would be to vest ownership of tail waters with the original water title holder.

In some cases, salinity levels and/or pollution loads may give tail waters and return flows negative values. It would seem desirable to devise ways to force the original user to bear responsibility for these degraded waters. Unfortunately, a system of effluent charges may be somewhat unwieldy in operation. Thus, it may be necessary to continue and expand current programs in which the water authorities take responsibility for drainage and for intercepting degraded drainage waters, and tube-well pumping where high water table and salinity problems coincide. Nevertheless, it seems certain that the more sparing water applications which would be encouraged by a market in water rights would reduce these problems from their present levels.

It is envisaged that a market in TWE would ultimately reallocate some water from irrigation to various industrial and urban uses. The fact that it would have such a result, while compensating irrigators by paying them the on-farm opportunity cost for water released, is one of its appealing attributes. Nevertheless, particular property instruments appropriate for irrigation water may be less appropriate for water in industrial and urban uses. Delivery schedules appropriate for irrigation may be less appropriate in these alternative uses, while there is no reason to assume that water tariff schedules appropriate for irrigation would be equally appropriate in these alternative uses. Procedures for redrafting the provisions of the water entitlements following their sale and reassignment to quite different uses would need to be developed. So long as these procedures were reasonable, and published in advance, it is not expected that they would impede transfer of water across these various categories of uses.

The matter of in-stream flow requires resolution. The easiest solution would be one in which the water authorities were required to maintain satisfactory minimal in-stream flows, regardless of water demand in other uses.[16] In extremely dry years, any water in excess of that needed to maintain the required in-stream flows would be delivered to entitlement holders. The economist can imagine circumstances in which, for example, organised groups of recreationists and wildlife enthusiasts would purchase water entitlements and leave them unused to augment, at their own expense, in-stream flows beyond the required minima. Realistically, one would not expect such behaviour to be especially prevalent. But, it is hard to conceive of any resource misallocation which would result from its occurrence.

Gainers, Losers, and Political Feasibility

It is useful to consider in general terms the distribution of gains and losses from implementing this proposal and thus the likely array of proponents and opponents. While a system of TWE would represent a more radical rearrangement of the relationship between water authorities and their clientele than would a system of efficient administered prices, it may nevertheless generate more effective political support and less opposition.

Water authorities

Officials in the various water authorities could be expected to raise

[16] This is basically the current policy, as negotiated through the River Murray Commission (Clark 1975).

several objections to the TWE proposal. Nevertheless, those provisions for authority approval of sale and rental agreements, and those which deny any obligation on the part of the authorities to deliver water they do not have, serve to defuse most of these objections. The remaining objections would be based on administrative costs associated with the sale and rental of entitlements and the longer-term need for new structural works if and when TWE lead to significant locational shifts in the demand for water.

The first of these is fairly trivial: the administrative burden would change qualitatively, but is unlikely to grow in total magnitude. The second is more substantive. There are many kinds of capital-intensive public sector services and utilities which face location-specific demands for service: electricity and gas, education, highways, telephone and telegraph, as well as irrigation water. Among these, irrigation water supply stands almost alone in its institutionalised capacity to dictate the location of demand for its services. Yet, it is difficult to find compelling reasons for such special treatment. My feeling is that the water authorities could, if necessary, adapt to market-determined location of demand much as have the above-mentioned suppliers of other location-specific demand services. Note that the difficulty is not one of financing — transferees would be required to pay any additional costs that the transfer imposes on the system — but of reorienting the planning procedures which the authorities use. Nevertheless, one could predict some opposition to TWE from within the water authorities.

Irrigation Farmers

TWE offers Pareto-safety and potential gains to the vast majority of existing irrigation farmers. Thus, one would predict that careful explanation would lead to massive political support for TWE from that sector. Irrigation farmers are already displaying an appreciation of the advantages of transferability. Private diverters have supported S.A. reforms liberalising the conditions under which private diversion permits may be amalgamated. MIA rice-growers have on occasion lobbied for rule changes permitting some trading of water deliveries during the growing season. Hearsay reports of water trading among individual members of private diversion co-operatives are common.

Perhaps the only group of existing irrigation farmers who may oppose TWE, upon receipt of full information, are those who are determined to continue farming in less favored sub-districts. If many of their neighbors sold their TWE, the remaining farmers may fear that the authorities would eventually cease channel maintenance and water supply. In such an event, these farmers could sell their land and TWE separately for at least as much as their irrigation farms are now worth, but that may not be consolation enough.

It is possible that some groups of farmers who are not irrigators may harbour the hope that governments will eventually provide subsidised water works for them too. Such groups would not support TWE since, in the form proposed above, it eliminates subsidisation of new irrigation developments.

Rural Community Interests

The kinds of changes which would eventually result from operation of a TWE system can be described as a form of rural reconstruction, which is long overdue in some older irrigation districts. Nevertheless, reconstruction tends to hasten the inevitable decline of some less favoured rural communities, and thus TWE could attract the opposition of some local community interests. In other communities, one would expect TWE to usher in a period of local expansion, and thus those local interests would likely support TWE.

Rural reconstruction has been a politically acceptable policy in the past, and as such has promoted inevitable on-farm readjustments (Kingma and Samuel 1977; Threfall 1977). Its marginal effects on declining rural communities do not seem to have diminished its political support.

The General Public

While the general public has been willing to support subsidised expansion of irrigation in the past, one suspects that the near-term future demand for rehabilitation of existing works and costly expansion of facilities will exhaust public generosity. The TWE proposal, which encourages reallocation of existing water supplies, conservation of water at the margin and the reduction of the salinity problems which arise from over-watering and casual handling of drainage, while at the same time eliminates the creation of new subsidised irrigation projects, would seem likely to generate public support. To ensure that support, it would be desirable to require the authorities to carefully monitor non-rival discommodity problems (e.g. salinity) and to deny transfers which would exacerbate such problems. Informed members of the general public would be unlikely to support policies which would make these kinds of problems worse.

After considering the likely array of proponents and opponents to TWE, the most interesting findings are that considerable support could be generated among irrigation farmers, while officials of the water authorities may drag their feet. On the other hand, reform proposals based on efficient administered prices are likely to generate opposition from irrigation farmers and water authority officials. The general public, however, is unlikely to remain tolerant of existing policies, given the imperatives of the maturing water economy.

References

Ansari, K. (1966), 'The marginal cost pricing theory and irrigation', Oxford Economic Papers 18(3), 344-51.

Arrow, K. (1951), Social Choice and Individual Values, Wiley, New York.

Australian Water Resources Council (1978), A National Approach to Water Resources Management, AGPS, Canberra.

Bain, J., Caves, R. and Margolis, J. (1966), Northern California's Water Industry, Johns Hopkins University Press, Baltimore.

Baker, G. (1980), 'Water planning called inadequate', Sacramento Bee, 5 May.

Baumol, W. and Bradford, D. (1970), 'Optimal departures from marginal cost pricing', American Economic Review 60(1), 265-83.

Buchanan, J. (1975), Between Anarchy and Leviathan, University of Chicago Press.

——— (1977), Freedom in Constitutional Contract, Texas A & M University Press, College Station.

Cheung, S. (1970), 'The structure of a contract and the theory of a non-exclusive resource', *Journal of Law and Economics* 13(1), 49-70.

Clark, S. (1976), 'Submission', in River Murray Working Party, *Report to Steering Committee of Ministers*, AGPS, Canberra.

—— and Renard, I. (1974), 'Constitutional, legal and administrative problems', in H. Frith and G. Sawer (eds), *The Murray Waters*, Angus and Robertson, Sydney.

Coase, R. (1946), 'The marginal cost controversy', *Economica* 13(51), 169-83.

—— (1947), 'The marginal cost controversy: some further comments', *Economica* 14(53), 150-3.

—— (1960), 'The problem of social cost', *Journal of Law and Economics* 3(1), 1-44.

Cull, P. (1979), 'A comparison of water use efficiency of cotton production in Israel and Australia', in Australian National Committee of the International Commission on Irrigation and Drainage, *Irrigation Efficiency Seminar*, Sydney (May 15-17).

Davidson, B. (1969), *Australia: Wet or Dry?* Melbourne University Press.

Davis, O. and Whinston, A. (1965), 'Welfare economics and the theory of second best', *Review of Economic Studies* 3(1), 1-14.

—— and —— (1967), 'On the distinction between public and private goods', *American Economic Review* 57(2), 360-73.

Davis, P. (1968), 'Australian and American water allocation systems compared', *Boston College Industrial and Commercial Law Review* 9(1), 647-711.

Dudley, N. (1972), "Irrigation planning: optimal interseasonal water allocation', *Water Resources Research* 8(3), 586-94.

——, Howell, D. and Musgrave, W. (1971*a*), 'Optimal interseasonal irrigation water allocation', *Water Resources Research* 7(4), 770-88.

——, —— and —— (1971*b*), 'Irrigation planning 2: choosing optimal acreages within a season', *Water Resources Research* 7(5), 1951-63.

——, Musgrave, W. and Howell, D. (1972), 'Irrigation planning 3: the best size of irrigation area for a reservoir', *Water Resources Research* 8(1), 7-17.

Flinn, J. (1969), 'The demand for irrigation water in an intensive irrigation area', *Australian Journal of Agricultural Economics* 13(2), 128-43.

Gaffney, M. (1962), 'Comparison of market pricing and other means of allocating water resources', in *Water Law and Policy in the Southeast*, Institute of Law and Government, University of Georgia, Athens.

Gallagher, D. and Robinson, R. (1977), *Influence of Metering, Pricing Policies and Incentives on Water use Efficiency*, Australian Water Resources Council Technical Paper 19, AGPS, Canberra.

Gardner, B. and Fullerton, H. (1968), 'Transfer restrictions and misallocation of irrigation water', *American Journal of Agricultural Economics* 50(3), 556-71.

Goodall, M., Sullivan, J. and DeYoung, T. (1978), *California Water: A New Political Economy*, Allanheld Osmun, New York.

Greenhut, M. (1966), 'On the question of realism in economic theory and the regulation of public utilities', *Land Economics* 42(1), 260-7.

Guise, J. and Flinn, J. (1970), 'The allocation and pricing of water in a river basin', *American Journal of Agricultural Economics* 52(2), 411-21.

Hanke, S. (1970), 'Demand for water under dynamic conditions', *Water Resources Research* 6(5), 1253-61.

Hartman, L. and Seastone, D. (1965), 'Efficiency criteria for market transfers of water', *Water Resources Research* 1(2), 165-71.

Haveman, R. (1965), *Water Resource Investment and the Public Interest*, Vanderbilt University Press, Nashville.

Hotelling, H. (1931), 'The economics of exhaustible resources', *Journal of Political Economy* 39(2), 137-75.

—— (1939) 'The relation of prices to marginal costs in an optimal system', *Econometrica* 7(2), 151-4.

Houthakker, H. (1951), 'Electricity tariffs in theory and practice', *Economic Journal* 61(241), 1-25.

Howe, C. (1979), *Natural Resource Economics*, Wiley, New York.

—— and Linaweaver, F. (1967), 'The impact of price on residential water demand', *Water Resources Research* 3(1), 13-32.

Huszar, P. and Sabey, M. (1978), 'Improving irrigation return flow quality with a water rental market', *Water Resources Bulletin* 14(3), 978-83.

Johnson, K. (1974), 'The role of the River Murray Commission', in H. Frith and G. Sawer (eds), *The Murray Waters*, Angus and Robertson, Sydney.

Kay, J. (1971), 'Recent contributions to the theory of marginal cost pricing: some comments', *Economic Journal* 81(322), 366-71.

Kelso, M., Martin, W. and Mack, L. (1973), *Water Supplies and Economic Growth: An Arizona Case Study*, University of Arizona Press, Tucson.

Kingma, O. and Samuel, S. (1977), 'An economic perspective of structural adjustments in the rural sector', *Quarterly Review of Agricultural Economics* 30(3), 201-15.

Langford-Smith, T. and Rutherford, J. (1966), *Water and Land: Two Case Studies*, Australian National University Press, Canberra.

Lipsey, R. and Lancaster, K. (1956-7), 'The general theory of second best', *Review of Economic Studies* 24(2), 11-32.

Maass, A. and Anderson, R. (1978), . . . *and the Desert Shall Rejoice: Conflict, Growth, and Justice in Arid Environments*, Massachusetts Institute of Technology Press, Cambridge.

Maloney, F. and Ausness, R. (1969), *A Model Water Code for Florida*, University of Florida Press, Gainesville.

Manning, R. and Gallagher, D. (1980), 'Optimal water pricing and storage: the effect of discounting'. Paper presented to the 9th Conference of Economists, Brisbane.

Margolis, J. (1957), 'Welfare criteria, pricing and decentralization of a public service', *Quarterly Journal of Economics* 71(3), 448-64.

Martin, W. (1979), 'Returns to public irrigation development and the concomitant costs of commodity programs', *American Journal of Agricultural Economics* 61(5), 1107-14.

Maunsel and Partners (1979), *Murray Valley Salinity and Drainage: Development of a Co-ordinated Plan of Action*, Murray Valley Study Steering Committee, Canberra.

Milliman, J. (1959), 'Water law and private decision-making: a critique', *Journal of Law and Economics* 2(2), 41-63.

Mishan, E. (1962), 'Second thoughts on second best', *Oxford Economic Papers* 14(3), 205-16.

—— (1976), *Cost-Benefit Analysis*, 2nd ed., Allen and Unwin, London.

Morgan, D. (1973), 'Residential water demand: the case from micro data', *Water Resources Research* 9(4), 1065-7.

Musgrave, W. F., and Lesuer, J. F., (1973), 'Large dams and drought', in J. Lovett (ed.), *The Environmental Economic and Social Significance of Drought*, Angus and Robertson, Sydney.

Newman, L. (1979), *Commonwealth Government Water Policy Statement*, House of Representatives Weekly Hansard No. 5, (March 28) AGPS Canberra.

Panzar, J. (1976), 'A neoclassical approach to peak load pricing', *Bell Journal of Economics* 7(2), 521-30.

Paterson, J. (1974), 'Urbanization and the use of Murray waters', in H. Frith and G. Sawer (eds), *The Murray Waters*, Angus and Robertson, Sydney.

Phelps, C., Moore, N. and Graubard, M. (1978), *Efficient Water Use in California: Water Rights, Water Districts and Water Transfers*. The Rand Corporation, Santa Monica.

Randall, A. (1982a), 'Economic surplus and its application in benefit cost analysis', *Review of Marketing and Agricultural Economics* (in press).

—— (1982b), 'Resource allocation in a maturing water economy', in *Water Allocation*, Bulletin No. 4, Australian Rural Adjustment Unit, University of New England, Armidale.

—— (1983), 'The problem of market failure', *Natural Resources Journal* (in press).

Rawls, J. (1971), *A Theory of Justice*, Harvard University Press, Cambridge.

Riley, J. and Scherer, C. (1979), 'Optimal water pricing and storage with cyclical supply and demand', *Water Resources Research* 15(2), 233-9.

Robertson, A. G. (1977), *Report on Goulburn-Murray Irrigation District Inquiry*, State Rivers and Water Supply Commission of Victoria, Melbourne.

Seckler, D. and Young, R. (1978), 'Economic and policy implications of the 160-acre limitation in Federal reclamation law', *American Journal of Agricultural Economics* 60(4), 575-88.

Sobel, J. (1975), 'Reservoir management models', *Water Resources Research* 11(6), 767-76.

S.A. Engineering and Water Supply Department (1980), 'Position paper on irrigation water pricing policy' (mimeo).

Starrett, D. (1978), 'Marginal cost pricing of recursive lumpy investments', *Review of Economic Studies* 45(2), 215-27.

State Rivers and Water Supply Commission of Victoria (1976), *Annual Report*, 1975/76, Melbourne.

Stoevener, H. and Kraynick, R. (1979), 'On augmenting community economic performance by new or continuing irrigation developments', *American Journal of Agricultural Economics* 61(5), 1115-23.

Threlfall, P. (1977), 'Government reconstruction and adjustment assistance measures in the Australian rural sector', *Quarterly Review of Agricultural Economics* 30(3), 177-200.

Trelease, F. (1957), 'A model water code for river basin development', *Law and Contemporary Problems* 22(2), 301-11.
—— (1965), 'Policies for water law: property rights, economic forces and public regulation', *Natural Resources Journal* 5(1), 1-29.
—— (1974), 'The model water code, the wise administrator, and the goddam bureaucrat', *Natural Resources Journal* 14(2), 207-29.
Turvey, R. (1969), 'Marginal cost', *Economic Journal* 79(314), 282-99.
—— (1976), 'Analyzing the marginal cost of water supply', *Land Economics* 52(2), 158-68.
US Department of Interior (1980), *Interim Report: Acreage Limitation*, Federal Water and Power Resources Service, Washington.
US Water Resources Council (1973), 'Water and related land resources: establishment of principles and standards for planning', *Federal Register* 38 (174, part III), September 10.
—— (1979), 'Procedures for evaluation of national economic development benefits and costs in water resources planning (level C): final rule', *Federal Register* 44(242, Part IX), December 14.
Watson, W. and Rose, R. (1980), 'Irrigation issues for the eighties: focusing on efficiency and equity in the management of agricultural water supplies'. Paper presented to the Annual Conference of the Australian Agricultural Economics Society, Adelaide.
Woolmington, E. (1974), 'Urban decentralization in the Murray River Basin', in H. Frith and G. Sawer (eds), *The Murray Waters*, Angus and Robertson, Sydney.
Young, R. (1973), 'Price elasticity of demand for municipal water: a case study of Tucson, Arizona', *Water Resources Research* 9(4), 1068-72.
—— (1978), 'Economic analysis and federal irrigation policy: a reappraisal', *Western Journal of Agricultural Economics* 3(2), 257-67.