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A Tradable Permit Scheme for Salt Emissions in North Central Victoria

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Table of Contents

Introduction

Regional and state policy makers are increasingly interested in finding alternative policy mechanisms for managing salt emissions arising from agricultural activities. This interest is the result of a number of factors. First, the cost of public works aimed at reducing the salt load in the Murray River has increased rapidly. Some estimates place the cost of reducing the salt load at Morgan to create a Salt Disposal Entitlement at approximately three million dollars for each entitlement (J Ginnivan *pers comm*). This has motivated some policy makers to raise the issue as to whether there is a greater role for private investment in abatement works and how such investment could be encouraged.

Second, the escalating cost of salt abatement works has motivated some regional policy makers to consider mechanisms for managing salt emissions within catchments. The idea is to use such mechanisms to better align the timing of salt emissions with the seasonal flows in major rivers. This would increase the efficiency of use of Salt Disposal Entitlements from a regional perspective.

Third, the introduction of a market in transferable water entitlements has resulted in the permanent trading of water between catchments, with an associated relocation in the potential for salinity emissions. Some regional policy makers are interested in identifying mechanisms for securing some of the wealth transfers entailed in the relocation of potential salinity emissions for communities that are perceived to have been disadvantaged by water trading.

Fourth, the policy environment at a State and Federal level has become increasingly focused on outcomes (Petris 2005). This has led policy makers to seek greater surety that their investment in policies intended to promote abatement are actually achieving permanent reductions in salt emissions into rivers.

Theoretically, a market in transferable salt emission permits has the potential to:

- Encourage private investment in abatement works

- Align the timing of salt emissions with the seasonal flows in major rivers
- Redistribute wealth transfers entailed in the relocation of potential salinity emissions
- Provide greater surety that permanent reductions in salt emissions into rivers are achieved.

As a consequence, state and regional policy makers have become particularly interested in the role that markets in emission permits can play as mechanisms for managing salt emissions from agriculture.

In this paper we hope to contribute to the understanding that policy makers have of the role of such markets by presenting an illustrative example of a market in transferable salt emission permits. The example we describe is intended, in a practical sense, to take into account the biophysical and institutional realities of the region in which it would be implemented.

The example we present is of a hypothetical market in transferable salt emissions for irrigated agriculture in the North Central Catchment Management Authority. In developing our example we drew on our knowledge of the market in salt discharges operating in the Hunter Valley of New South Wales and the market in nitrogen emissions proposed for Lake Taupo, New Zealand. Much of the logic of this paper directly follows (Kaine and Higson 2004).

In the next section we outline the mechanisms that are currently employed to manage salt emissions from irrigated agriculture in North Central. We then describe a feasible, though hypothetical, market in salt emissions. Included in the description is a discussion of the operation of the market, trading rules, and the allocation of permits. We then move to a discussion of compliance issues and finish by discussing the implications of the market with respect to the distribution of wealth in the community.

Current approaches to managing salt emissions

In North Central Victoria salt emissions originate from the intersection of groundwater with the irrigation drainage network in the region and from rainfall run-off. The majority of salt emissions in North Central originate from groundwater.

Two mechanisms are used to influence salt emissions from irrigated agriculture in North Central. One mechanism is a mix of programs that support the voluntary implementation of Best Management Practices on irrigation farms in the region. The second mechanism is a program of public investment in updating regional infrastructure. These programs have been implemented through the regional Land and Water Management Plans of the North Central Catchment Management Authority. These Plans have been in operation since 1989, albeit in different forms.

The programs that support voluntary adoption of best management practices include activities such as extension and community participation projects. They also include the provision of economic incentives to encourage the adoption of best practices such as whole farm plans, irrigation reuse systems, sub surface drainage and community surface drainage schemes. The public investment in regional infrastructure has included the remodelling of channel delivery systems and the building of primary surface drains into which the smaller community schemes drain.

A policy of reducing salt emissions by promoting the voluntary adoption of best practices has three strengths. First, a voluntary approach is broadly consistent with social values of importance to rural communities such as autonomy in making decisions, reward for effort and self-reliance. A voluntary approach allows landholders to make their own decision about the relevance and effectiveness of each management practice for their farm context and to decide whether to adopt the practice accordingly. Second, the use of incentives to achieve policy objectives may also be politically attractive because incentives partly compensate landholders for adopting practices that produce environmental benefits for all of the community. Third, an approach that focuses on promoting best practice avoids the serious difficulty of finding ways of measuring individual contributions to diffuse source emissions.

The voluntary approach to achieving environmental objectives does suffer from a number of weaknesses see (Kaine and Johnson 2004). First, the environmental objective may not be achieved because insufficient numbers of landholders adopt the practices. Second, the environmental objective may not be achieved because even widespread adoption of best practice is unable to reduce emissions to desirable levels. Third, landholders may adopt best practices but implement them in ways that do not achieve the environmental objective.

A market in tradable salt emission permits overcomes the weaknesses of a policy based on voluntary adoption of best management practices. Most importantly, a market in emissions through the 'capping' of emissions provides certainty that the environmental objective can be achieved. A market in tradable emission permits also has the potential to stimulate private investment in infrastructure to manage emissions, which may reduce the pressure for public investment in updating regional infrastructure. Furthermore, a market in emissions, in theory, enables the environmental objective to be achieved at the lowest possible economic cost to the community (Montgomery 1972).

A serious technical difficulty with markets for diffuse emissions is the problem of defining the emissions of individual landholders. For emissions to be tradable they must be measurable and controllable. There are also social and political difficulties with emission markets. It is compulsory for landholders that generate emissions to participate. The 'capping' of emissions effectively places the importance of river salinity before the existing rights of landholders and in doing so will redistribute wealth between landholders and the rest of the community.

Despite these difficulties interest in emission markets has grown for a variety of reasons as we described earlier. In the remainder of this paper we describe how the technical difficulties of a 'cap and trade' market in salt emissions from irrigated agriculture might be overcome so that such a market could be introduced in to the North Central irrigation region.

A 'cap and trade' market in salt emissions

As noted earlier a fundamental problem in designing tradable permit schemes for emissions from diffuse sources are the technical difficulties associated with measuring and controlling emissions, see (Higson and Kaine 2004). This has a number of consequences.

First, emissions from diffuse sources can only be estimated on the basis of land use factors that are associated with emissions such as type and areas of perennial or annual crops and pasture, soil type, and so on. Hence, the market we describe depends on the use of simulation models to estimate the salt emissions of individual landholders.

Second, the volume of emissions into rivers in the short term can depend on factors beyond the control of landholders (such as rainfall). Third, landholders' lack of control over emissions in the short term has the potential to increase river salinity to unacceptable levels as their emissions may, in total, exceed the assimilative capacity of the river in the short term. We resolve the problem of limiting total emissions in the short term to short term variations in the assimilative capacity of rivers by introducing two types of permits - salt emission permits and salt disposal permits.

The purpose of <u>salt emission</u> permits is to restrict salt emissions in the long term from irrigated agriculture to the long-term assimilative capacity of rivers in the catchment. All landholders that generate salt emissions are required to hold salt emission permits that match the average of their long-term emissions.

The purpose of <u>salt disposal</u> permits is to provide a mechanism for restricting salt emissions from irrigated agriculture in the short term to manage short term variations in the assimilative capacity of rivers in the catchment. A salt disposal permit may only be owned by a landholder that has the capacity to store and discharge salt at will such as those with a turkey's nest or evaporation basin for example.

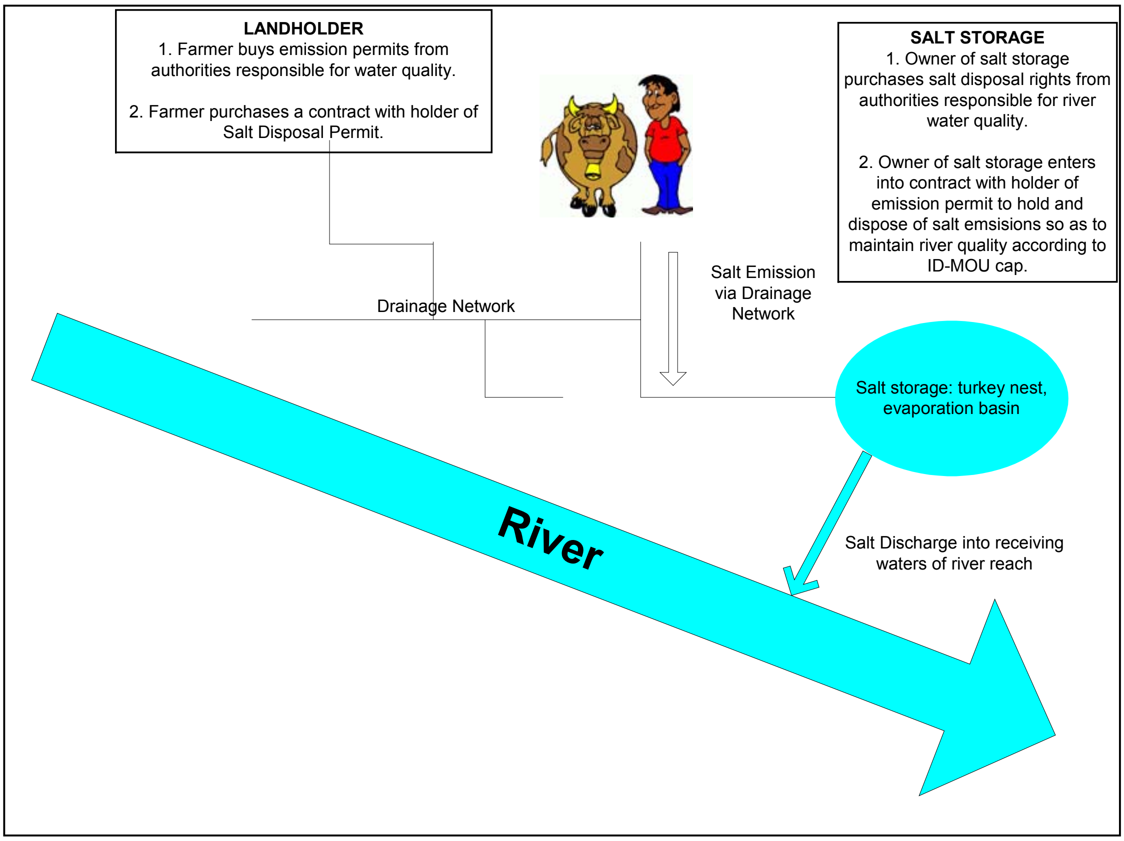

Figure 3.1. Schematic of market in salt emission permits and salt disposal permits to manage salt emissions in North Central.

All landholders with a salt emission permit must have a contract for disposal of their salt emissions with the owner of a salt disposal permit. The linking of salt emission permits with salt disposal permits creates incentives for private investment in the harvesting and storing of salt emissions. This raises the possibility of matching salt emissions in the short term to variations in the assimilative capacity of rivers in the short term. The fundamental concepts underlying emission and disposal permits are illustrated in figure 3.1.

Salt emissions from landholders are intercepted by the regional drainage system. Landholders with a salt disposal permit harvest and store emissions from the drainage network. Stored emissions may then be disposed of by discharge into the river when conditions allow.

The design of this market means that in practice landholders with salt emission permits must have a contract with one or more downstream landholders that possess a salt disposal permit. Provided the volume of salt emission permits matches the volume of salt disposal permits then, in the long run, salt emissions from irrigated agriculture will match salt disposals into the rivers. Provided there is sufficient capacity for storing salt in the region, variations in emissions can be aligned with variations in the assimilative capacity of the rivers in the short term to ensure water quality standards are maintained.

3.1 Salt emission cap

The 'cap and trade' markets in salt emission and salt disposal permits we have designed are based on the assumption that virtually all saline groundwater and run-off from irrigated agriculture in the catchment is intercepted by the local or regional drainage network. The drainage network may include natural streams. These networks then drain into one or more rivers in the catchment for which maximum salt concentrations have been set. These concentrations may be defined for points in the landscape such as end of valley, end of river, end of drain or end of river reach, depending on the preferences of stakeholders.

The maximum salt concentrations, together with the volume of water in the rivers over a period of time, define for our purposes the assimilative capacity of the rivers with respect to salt. This capacity is the 'cap' aspect of 'cap and trade' markets. The salt emissions cap is the total amount of salt emissions available for distribution among landholders. The cap is the total amount of salt emissions landholders in aggregate may legally generate.

Hence, the salt emissions cap defines the supply of the resource (assimilative capacity of the rivers) available for trading among landholders. The smaller the cap relative to the emissions of landholders the scarcer and more valuable is the resource, and the more valuable the right to generate salt emissions.

For the purpose of salt emission permits we defined the salt emission cap between two points in a river as the average annual assimilative capacity of the river in the long term. For salt disposal permits we defined the salt emission cap between two points in a river as the daily assimilative capacity of the river. In the long term, the average daily cap for salt disposal permits should match the cap for salt emission permits. Hence, landholders' uncontrolled emissions of salt in the short term should equate over the long term with the assimilative capacity of rivers in the long term.

The cap for salt emission permits is defined algebraically by expression 1 in box 3.1. The cap for salt disposal permits, and its equivalence with the cap for salt emission permits, is defined algebraically in box 3.2

3.2 Salt emission permits

Salt emission permits entitle landholders to a specified share in the salt emission cap (see expression 2 in box 3.1). That is, the permit entitles the landholder to a percentage of the long term, average annual assimilative capacity of the relevant river. The salt emission permit can be expressed either as a percentage of the cap or as the equivalent load in kilograms per relevant unit of time.

The period of time in which emission permits are denominated is a critical issue in market design. On the one hand emission permits should not be denominated in periods of time that are shorter than the rate at which at least some landholders can implement abatement actions. Otherwise landholders may find themselves inadvertently contravening the conditions of their permits yet lacking the capacity to comply with these conditions. On the other hand, permits should not be denominated in periods of time that are substantially longer than the rate at which most landholders can implement abatement actions.

To do so would unnecessarily reduce the rate of transfer of emission permits between alternative land uses thereby reducing the efficiency of the market and imposing economic losses on the community.

The dynamic behaviour of the supply of the natural resource is another consideration in determining the time of denomination of permits. Generally speaking, the aggregate volume of emissions authorised through the permits should change over time in accord with changes in the capacity of the environment to assimilate emissions.

SEC is the salt emissions cap
E_j is the salinity emission permit allocated to landholder J
k_j is the percentage of the 'cap' allocated to landholder J
$\hat{c}$ is the maximum salt concentration permitted in the river
c_t is the salt concentration in the river in period t
v_t is the water flow in the river in period t
x_{pj} is the p-th emissions related input for landholder j

The 'cap' for salt emission permits (SEC) is given by:

(1) $SEC = 1/n \sum (\hat{c} - c_t)\, v_t$ for $t = 1, 2, \dots, n$

And the salinity emissions allocated to landholder j are given by:

(2) $E_j = k_j \,.\, SEC = k_j / n \sum (\hat{c} - c_t)\, v_t$ and $\sum k_j = 100$ for $j = 1, 2, \dots, m$

The salinity emissions allocated to a landholder can be expressed in terms of production inputs by:

(3) $E_j = f\,(x_{1j}, x_{2j}, \dots, x_{pj})$

In the long run the total emissions allocated to landholders equal the cap:

(4) $\sum E_j = \sum (\hat{c} - c_t)\, v_t$ for $j = 1, 2, \dots, m$; $t = 1, 2, \dots, n$

Box 3.1 Algebraic expression for the salt emission 'cap' and permits

In the context of a Northern Victorian river, landholders may vary their emissions in the long term by, for example, altering their mix of crops and pastures. However, they do not have the capacity to adjust their emissions in line with short-term variations in the assimilative capacity of rivers. By defining emission permits as shares of the long-term average of the assimilative capacity of the river, the short term rate of salt emissions which is beyond the control of landholders is divorced from the long term volume of emissions which, we assume, they can influence.

Since actual emissions of salt produced by individual landholders cannot be measured their share of the cap must be translated into measurable production inputs related to salt emissions (see expression 3 in box 3.1). The translation of the share of the salt cap into measurable production inputs also describes the control landholders can exert over their emissions of salt in the longer term. The only practical means by which this translation can be done is through the use of salt budgeting models. Hence, as is the case with nitrogen emission market being introduced in New Zealand (Kaine and Higson 2004;Environment Waikato 2003) the cornerstone of the emissions market is a nutrient budgeting model for agricultural land uses.

The amount of salt emissions produced in the long term by landholders is known to be a function of their cultural practices, soil type, water use and other factors (Whitfield DM et al. 2004). There are a number of salt budgeting models currently used in the SDE accounting processes of the regions. The Integrated Catchment Model (INTECA) is a model built around the assumptions of the current catchment Land and Water Management Plans (Robertson et al. 2004). This model incorporates most of the assumptions made in the SDE accounting process and is based on sound scientific assumptions (Whitfield DM et al. 2004). However, this model has not been tested for accuracy on a catchment scale.

SKM developed a model for estimating salt emissions from Barr Creek properties using a different approach (Sinclair Knight Merz 2003). The SKM model was developed from statistical analysis of historical data to explain the impact of climate, land use, best management practices, water allocations and water trading on salt emissions. Models similar to the SKM model have been tested and found accurate on a catchment scale. However, these models are based on limited historical records that do not necessarily reflect the full range of historical conditions that may be experienced in a catchment (Duncan et al. 2005).

Although developed in different ways, both models estimate salt emissions into the drainage network using contextual characteristics such as soil type, rainfall, water use, area and type of pasture or crop, and evapotranspiration.

In using a model to calculate salt emissions the model acts as a mechanism for imputing landholders' use of their share of the salt emissions cap. To achieve the cap the aggregate volume of imputed emissions calculated using the model should be less than or equal to the cap. Therefore, each landholder should have an emission permit sufficient to match their imputed emissions. Furthermore, the total of the emissions calculated using the model for all landholders with permits should approximate emissions of salt across the catchment in the long term. This means the salt budget model must be reasonably accurate at a catchment scale and free of bias at the level of the individual.

By defining emission permits in terms of processes embodied in the salinity model the difficulty of measuring actual salinity emissions is avoided. Hence, the measurement difficulties typically associated with diffuse source pollution are circumvented. Furthermore, as emissions are determined in the model on the basis of estimated relationships between emissions and contextual characteristics the model can be used to infer constraints on those characteristics, which are related to agricultural production processes such as soil or pasture and crop type. This means that the salt emission permits for a particular landholding can also be expressed in terms of the contextual characteristics of that holding as well as units of salt emission.

This creates five advantages. First, because permits can be expressed in terms of contextual characteristics then, in principle, permits can define constraints on the permissible combinations and levels of inputs into agricultural production processes such as areas of annual and perennial irrigated pasture. This allows the landholder to evaluate salt emission permits in terms of the economic value of the combinations of production inputs and management practices possession that the permit allows. The inputs would be translated to give the emission equivalent of tonnes salt per annum to facilitate trading. In other words, the permits can be expressed in terms of the opportunities for using land they make available, which is precisely the basis on which landholders will value the permits.

This perspective is consistent with Lancaster's product attribute theory (Antonelli 2004;Lancaster 1966;Lancaster 1971;Hoehn, Frank L., and Kaplowitz 2003). In this fundamental work Lancaster argued that demand for a product is not for the product as such. Rather the value of a product lies in the attributes of the product and potential those attributes provide to purchasers to meet their needs. In the context of salt emission permits this means that the value landholders derive from permits resides in the additional economic opportunities the permits allow them in terms of land use.

Second, expressing emission permits in terms of contextual characteristics such as crop and pasture type means that trades can be visualised in terms of familiar farm management measures which facilitates the exchange of emissions between landholders.

Third, a unit of salinity emissions creates different economic opportunities in different locations depending on the farming context. Conversely, a particular combination of different crops and pastures will require a different volume of emission permits in different contexts. Hence, any trade in emission permits between landholders requires determining the relevant changes in the production possibilities for each of the landholders. In other words, an exchange rate must be calculated to determine the rate at which emissions in one context convert to a unit of emission in another context. This exchange rate is embodied in the salt budgeting model and is given by the relationship between estimated emissions and the contextual characteristics, including inputs to agricultural production processes.

Fourth, expressing emission permits in terms of permissible combinations and levels of inputs into agricultural production processes such as hectares of perennial or annual pasture facilitates monitoring of landholder compliance. In principle, inputs to agricultural production processes are measurable whereas emissions are not.

Fifth, by expressing emission permits in terms of combinations of crops and pastures, best management practices and water use, emission permits are defined and documented in a manner consistent with the new regulatory framework planned for governing the use of water. For example, the proposed water use component of an 'unbundled' water right is likely to be defined by variables such as: permitted crops and pastures; best management practices; and maximum limits on water use (Victorian Government Department of Sustainability and Environment 2004).

Note that by describing emission permits as shares in the long run assimilative capacity of rivers and defining those shares in terms of a production process embodied in a salt budget model, the permits are defined, and the market operates largely independently of actual salt emissions in the short term. This does not mean the market in emission permits is unrelated to emissions of salt and the salinity of rivers. As new knowledge is acquired about the relationship between the contextual characteristics of agriculture and emissions then the salt emission model may be refined. As a consequence we would expect that over time estimated and actual emissions will become more closely correlated.

The market in emission permits may also be linked to actual emissions of salt and the salinity of rivers through the market in salt disposal permits.

3.3 Salt disposal cap and salt disposal permits

Salt disposal permits are shares in the actual assimilative capacity of rivers over a specified period of time (see box 3.2). Hence, the 'cap' for salt disposal permits is the actual capacity of rivers to assimilate salt over a specific period. Since the capacity of rivers to absorb salt will vary over time depending on water flow and salt loads from other sources, the cap on salt disposals is a 'variable' cap that changes over time depending on conditions in the rivers.

Provided the 'cap' for salt emission permits matches the long term average of the 'cap' for salt disposal permits, the volume of salt emissions from landholders should match the capacity of the rivers to assimilate salt in the long run (expression 6 in box 3.2).

Landowners with salt disposal permits align the short term, uncontrolled emissions of landowners with salt emission permits with short-term variations in the assimilative capacity of rivers. They do this by harvesting and storing salt emissions from the drainage networks then releasing the stored emissions into rivers when they have the capacity to absorb salt.

SEC is the salt emissions cap
SDC_t is the salt disposals cap for period t
D_j is the salinity disposal permit allocated to landholder J
k_j is the percentage of the 'cap' allocated to landholder J
$\hat{c}$ is the maximum salt concentration permitted in the river
c_t is the salt concentration in the river in period t
v_t is the water flow in the river in period t

The 'cap' in a particular period t for salt disposal permits (SDC_t) is given by:

(5) $SDC_t = (\hat{c} - c_t)\, v_t$ for $t = 1, 2, \ldots, n$

Note that as t approaches the long run the average salt disposal cap is:

(6) $1/n \sum SDC_t = 1/n \sum (\hat{c} - c_t)\, v_t$ for $t = 1, 2, \ldots, n$

The right hand side of expression (5) is the same as the expression for the salt emissions cap (SEC) given earlier by expression (1) in box 3.1. In other words, the average salt disposal cap will approximate the salt emissions cap in the long run.

The salt disposal permit allocated to landholder j is given by:

(7) $D_j = k_j \,.\, SDC_t = k_j \sum (\hat{c} - c_t)\, v_t$ and $\sum k_j = 100$ for $j = 1, 2, \ldots, m$

Box 3.2 Algebraic expression for the salt disposal 'cap' and permits

For this arrangement to succeed a condition of ownership for salt emission permits is that the owners enter a contract for disposal of their emissions with an individual or organisation with a disposal permit. The arrangement also requires that a condition of ownership for salt disposal permits is that the owners have a demonstrated capacity to store saline water and discharge it at will. This condition could be fulfilled by an individual or organisation with drainage diversion rights, a purpose built storage or evaporation basins.

In addition, a procedure for periodically notifying owners of disposal permits of the assimilative capacity of rivers is required. Notifications could be made through broadcast media and the Internet.

The concept of storing salt within the landscape and then disposing of it when suitable capacity to assimilative salt becomes available in the river is able is not new. The sub-surface drainage programs in North Central and the Goulburn Broken operate on the premise that salt will be stored within the landscape and discharged when conditions allow. The difference in our proposal is that disposal permits give individuals and organisations flexibility in how they manage salt storage and disposal. Theoretically, this flexibility will allow the equating of the marginal costs of abatement across the scarce assimilative capacity of the river, drainage diversions, purpose built storages and evaporation basins.

3.4 Trading rules for salt emission permits

Trading rules should be simple and enhance the managerial flexibility of permit holders (Stavins 2001). We suggest trading in salt emission permits can occur between market participants at anytime and throughout the region.

A central register would be established that would record details of permits and record those interested in buying or selling permits. This would help coordinate market transactions in a number of ways by reducing compliance costs and reducing search costs for landholders. For example, the establishment of a central register would also facilitate enforcement of the conditions attached to ownership of permits. That is, purchasers of emission permits arrange matching contracts for disposal of their salt.

We described earlier that, for a number of practical reasons, emission permits were expressed in terms of the contextual characteristics of land holdings such as combinations of crop and pasture as well as shares in the emission cap.

Consequently, when a trade is negotiated between landholders, the limits on these characteristics must be adjusted correspondingly for both landholders. Presumably, the catchment management authority would calculate these adjustments and amend their records accordingly, especially if the authority is responsible for monitoring and enforcing compliance with conditions attached to emission permits.

In addition, trades in salt emission permits would require matching adjustments in the contracts both landholders have arranged for the disposal of their emissions.

In principle, trading of permits may be initiated in two ways. Typically, trading will be initiated by landholders in response to changes in their circumstances. Our view is that trading of this type should be possible at any time, as this will be consistent with current water trading arrangements. However, trading may also be initiated in response to changes in the parameters and relationships in the salt budgeting model. These changes may arise perhaps as a result of calibration of the model with new information on aggregate salt emissions or the introduction of new agricultural technologies and practices.

A change in the parameters and relationships in the salt budgeting model means the relationships between relevant contextual characteristics such as areas of crop and pastures and estimates of salt emissions will change. This has two implications. One implication is that changes are made to the estimated emissions for each landholder would be revised accordingly given the schedule of agricultural inputs and practices allowed by their emission permit. Landholders whose re-estimated salt emissions were in excess of their share of the salt emissions cap would be allowed a period of grace to reconcile the difference, for example, three-months. They may increase their share of the cap by purchasing or leasing additional emission permits in order to continue their farming operations as specified in the original permit. Alternatively, they may adjust their farming operations appropriately to reduce emissions to their original share of the cap.

The second implication of a change in the relationships between contextual characteristics and emissions of salt as predicted by the salt budgeting model is that the total of the emissions estimates made with the model may differ from the cap for salt emissions based on the assimilative capacity of rivers. The simplest way to consider this implication is to treat the difference as an indirect change in the emission cap. Note that new information on say, climatic data, may lead directly to a revision in the emissions cap itself. This raises issue as to how to adjust salt emission permits in aggregate to match direct, or indirect, changes in the salt emissions cap.

A variable cap and trade program is one approach to resolving this issue (Higson and Kaine 2004). Generally, a variable cap suits situations where the supply of the natural resource is highly variable and market participants can adjust their use of the resource rapidly. This approach involves expressing emission permits as a fixed proportion of a variable target rate of emissions that is revised on a regular basis. The actual volume of emissions authorised under a permit would then be revised each time the salt budgeting model is revised. This concept is similar in principle to the annual revisions made to the total allowable catch in fisheries (Guerin 2003). We believe this method to be impractical in the case of salt emission permits because such revisions would place unrealistic demands on landholders to alter their land use in order to accommodate changes in the cap.

Alternatively, the issue as to how to adjust salt emission permits in aggregate to match direct or indirect changes in the salt emissions cap could be resolved by implementing a fixed cap and trade program as we have proposed, and authorising the catchment management authority to trade emission permits. The catchment management authority purchases emission permits from landholders when the total emissions estimated using the model exceed the cap and sells emission permits when the cap exceeds estimated emissions. This approach appears feasible provided the real or implied changes in the emission cap are small relative to the total volume of emission permits issued.

Modifications to the salt budgeting model or the salt emissions cap could introduce a significant element of uncertainty into the emission permits market, both for landholders and the catchment management authority. A number of possibilities involving insurance, futures and options may be considered that would allow market participants to manage their exposure to this uncertainty.

Insurance might be most appropriate in situations where the salt budgeting model is updated infrequently and the likelihood of a substantial change in estimates of emission is small. In this instance, landholders would use insurance to protect their income in the event of a dramatic change in their estimated emissions.

Futures and options may be most appropriate in situations where alterations to the model are relatively frequent. Futures allow landholders to limit their financial risk should they have to purchase additional permits following a change in emission estimates.

Options allow landholders the right but not the obligation to purchase or sell emission permits for an agreed price if certain conditions are fulfilled at some point in the future. In principle, options can be designed to automatically activate the purchase or sale of a specific quantity of emission permits depending on the outcome of the modification of the salt model. Options may also apply to leasing of emission permits.

The buyer of the options has the right or choice to exercise the agreement while the seller of an option must fulfil the conditions of the trade should the buyer choose to exercise the option. For example, in buying a call option the purchaser secures the right to purchase a nominated quantity of emission permits should the modification to the model lead to a change in their estimated emissions. The purchase of a call option also enables the purchaser to ‘lock in’ the price at which emission permits will be purchased. This may be an advantage if the market price of emission permits is volatile.

3.5 Trading rules for salt disposal permits

Trading in salt disposal permits appears to be a much simpler affair than trading in salt emission permits. Disposal permits are defined simply as shares in the measurable assimilative capacity of, say a reach in river, over a period of time.

Consequently, the complications attached to using a model to estimate emissions are avoided with disposal permits. We suggest trading in salt disposal permits can occur between market participants at anytime and throughout the region so the capacity to store and discharge drainage water is able to move in line with water trading in the region and to maximise use of the assimilative capacity of rivers

A central register would be established that would record details of disposal permits and record those interested in buying or selling permits. This would help coordinate market transactions in a number of ways by reducing search costs for landholders wishing to trade permits. The establishment of a central register would also facilitate enforcement of the conditions attached to ownership of permits regarding infrastructure for harvesting, storing and releasing salt flows from the regional drainage network.

Trades in salt disposal permits between different reaches in a river would require corresponding adjustments to be made in the salt disposal cap in each reach. In addition, any trade in disposal permits would require that those landholders with contracts for the disposal of their emissions that are covered by the permits be notified of the change in ownership of the permits.

There are some practical issues that would need to be considered when the contracts for disposal of salt emissions from a drainage network are shared between two or more owners of salt disposal permits. The complexity of these issues depends on the degree of spatial separation of the owners of the disposal permits, and the degree of spatial segregation among the landholders with which they have contracts for salt disposal.

The contracts for disposal describe the relative shares in salt emissions to which the owners of disposal permits are entitled. Consequently, owners of disposal permits could share emission flows in the network according to these relativities when the degree of spatial segregation among landholders is low. When owners of disposal permits are located at different points in the drainage network harvesting of salt emissions will require adjustments to allow for any upstream releases for disposal purposes. This means that owners of salt disposal permits would be required to monitor salt concentrations and flow rates in the drainage network at the point of extraction, as well as flow rates at the storage intake and release points.

Variations in the salt disposal cap due to fluctuations in river flow and salt loads from other sources introduce a significant element of uncertainty into the market for disposal permits. There is the possibility of using futures and options as a way to manage exposure to this uncertainty. Since there will be considerable and frequent variations in the capacity of rivers to assimilate salt, futures and options in contracts for disposal rights may be the most a practical way of managing these variations.

Monitoring and compliance

4.1 Monitoring compliance

Compliance with the conditions of salt emission permits would be monitored with reference to the mix of inputs into agricultural production processes (such as hectares of perennial or annual pasture) that are used to estimate emissions in the salt budgeting model and are specified in the permit.

Monitoring may entail monthly, quarterly or annual self reporting of inputs and management practices by landholders with random checks conducted under the auspices of the catchment management authority.

Monitoring of compliance with regard to salt disposal permits would require the installation of flow and salinity concentration meters on the outlets from storages.

4.2 Penalties for illegal emissions

Landholders should be liable to pay a penalty for emissions in excess of their entitlement and the penalty for unauthorised emissions must be sufficient to deter landholders from illegally discharging on a systematic basis.

The determination of the penalty to be exacted per unit of emissions needs careful consideration since the penalty will effectively place a ceiling on the prices at which permits are traded. If the penalty is set too low the penalty for discharging illegally will be lower than the cost of purchasing emission permits to discharge legally. Consequently, the demand for permits could fall to zero. Hence, if penalties are not set at sufficiently onerous levels the price of permits could be bid down to the level of the penalty. Since the price of permits cannot rise above the ceiling imposed by the penalty the market for emission permits would fail to function effectively.

Ideally, for the market to function without being unduly influenced by the penalty, the penalty must be set at a rate higher than highest marginal net benefit a landholder will gain from salt emissions. In terms of conventional economic analysis this rate is given by the intersection of the demand curve for emission permits with the price axis (Kaine and Reeve 1993). At a minimum, we suggest that penalties be applied per unit of discharge in excess of the permitted level and those landholders be liable for fines at least equivalent to the unit price at which emission permits trade. Repeat offenders may be penalised by forfeiting their permits.

The likelihood of prosecution for unauthorised emissions must also be sufficiently high to deter landholders from illegally discharging on a systematic basis. This means legislative support must be available so that landholders can be prosecuted for breaching the terms of either their emission or discharge permits. If prosecutions for recovery of penalties and forfeiture of permits do not have a high probability of success then penalties can be effectively evaded. Establishing a market in emission permits is problematic in such circumstances, as the right to discharge is no longer exclusive to those in possession of emission permits.

Issues in market establishment

A critical issue in establishing markets, as with any policy intervention, is the way in which property rights and wealth are redistributed within the community. The distribution of gains and losses among landholders by establishing a market in salt emissions is determined by the initial allocation of permits among landholders in conjunction with the standard set for water quality. Having described a market in emission and disposal permits in detail the issues entailed in allocating these permits will now be addressed for the market we have described.

5.1 Distribution of adjustment costs

The setting of a standard for water quality both in terms of an acceptable salt concentration within a river reach and tonnes of salt allowed to discharge into the river are the most important determinants of distribution of adjustment costs between landholders and the rest of the community. As noted earlier, the limited control landholders can exert over emissions of salt effectively prevents them from substantially adjusting their emission rate in the short term without making highly disruptive changes in their land management. In practical terms the more rapidly the total rate of emissions need to be reduced to achieve the desired standard of water quality, the greater the burden of adjustment that will fall on landholders.

A case might be made that other stakeholders should at least partially compensate landholders for the adjustment costs incurred by the latter if a relatively rapid reduction in emissions is desired. Such compensation could be made in a variety of ways such as using public money to purchase and retire land from agricultural production.

The initial allocation of emission permits is probably the most important determinant of the way in which adjustment costs are distributed among landholders themselves. As noted earlier, the limited control landholders can exert over emissions effectively prevents them from substantially adjusting their emission rate in the short term without making highly disruptive changes in their land management. Consequently, the adjustment costs faced by landholders increases the smaller their allocation of emission permits relative to their historical rate of emissions. Hence, a rule that gifts all landholders an equal allocation of emissions, sometimes termed ‘averaging’, effectively transfers wealth from landholders with relatively high emissions to landholders with relatively low emissions. Landholders with high emissions are forced to cease operations and make disruptive changes in land use or purchase permits from landholders with low emissions in order to continue their activities.

In the context of North Central such a rule may disadvantage landholders with high emissions such as dairy farmers relying on flood irrigation of perennial pastures, compared to landholders with low emissions such as orchardists with micro-irrigation. This may not be socially acceptable to the rural community. Hence, allocation of permits on the basis of historical emissions may be the most widely acceptable rule and the least likely to require compensation for those landholders most affected.

There maybe some concern with this approach in relation to the adoption best management practices. Gifting on the basis of historical emissions could be seen as disadvantaging those who have adopted best management practices before emissions are capped. This would depend on the extent that models used to describe emissions incorporate best management practices and the differences in abatement costs between landholders.

Allocation of permits on the basis of historical emissions does, however, raise the issue as to how the initial allocation of permits should be adjusted over time to be consistent with changes in the emissions cap. One approach is to institute proportionate reductions in the volume of emissions that permits allow until the aggregate volume of permits matches the cap. These reductions may be phased in over a period of time. This approach places the burden of the cost of adjusting to the cap on landholders. This approach distributes the costs of adjustment unequally among landholders. Those landholders that are least able to adjust their emissions will bear a relatively greater proportion of the costs compared to landholders that are better able to adjust their emissions.

An alternative approach is for the catchment management authority to institute a program of purchasing emission permits from landholders until the volume of emission permits remaining in the ownership of landholders matches the emission cap. The program may operate over a considerable period. This approach places the burden of the cost of adjusting to the cap on the rest of the community, assuming the government provides the funding for the purchasing program. This approach is consistent with the view that, as the cap on emissions is instituted at the expense of landholders for the benefit of the community, the community should meet the costs of adjustment.

We suggest a share of the salt disposal cap be allocated to landholders that have invested in evaporation basins and, thereby, already possess an implicit right to dispose of salt. Subsequently, tenders could then be invited for the purchase of the remaining share of the salt disposal cap. Landholders submitting tenders would need to demonstrate a capacity to develop the infrastructure for harvesting and storing saline flows from the regional drainage network.

5.2 Price discovery for emission permits

Ideally, a high volume of trading on the emissions and disposal market in the short term would promote price discovery, which would facilitate decisions by all parties regarding the return to investing in abatement measures. In principle, the prices at which permits are exchanged are a function of the differences in the marginal abatement costs faced by landholders and differences among landholders in the economic return to emissions. Provided there is some variation in economic returns to emissions to landholders, and some variety among them in the cost of implementing abatement measures, then trading should occur.

The greater the degree of variability among landholders in economic returns to emissions and the greater the extent to which those returns change over time, the more likely a high volume of trading will occur in the short term. For example, the price of agricultural products such as fruit, grapes, milk, lamb, beef and wheat are key determinants of the profitability of agricultural operations. Consequently, these prices are also key determinants of the economic value of emission permits. To the degree that these prices vary over time, both in absolute and relative terms, the economic value of an emission permit will differ across agricultural enterprises. In theory this means the price that landholders are willing to pay in order to lease or purchase an additional permit will change over time in accord with changes in the economic returns to different land uses. Those landholders experiencing an increase in returns may seek to acquire additional permits to take advantage of the increase. Those landholders experiencing a decrease in returns may choose to lower production and sell or lease permits to offset their loss.

Similar arguments can be advanced to suggest the greater the degree of variability among landholders in terms of abatement costs the greater the opportunities for the exchange of permits among landholders. Much will depend on the flexibility with which landholders are able to modify their emissions by changing cultural practices or differences in cost of implementing abatement options of different industries.

Relatedly, changes in the relationships between contextual characteristics and estimated emissions as embodied in the salt budgeting model will prompt the exchange of permits. As discussed earlier, modifications to the salt budgeting model are likely to result in changes to estimates of landholders' emissions given the combination of agricultural inputs they are allowed by their permits. Differences among landholders in the opportunity costs of taking measures to adjust emissions relative to the prices of emission permits and contracts for salt disposal, are likely to encourage some landholders to dispose of a portion of their permits and to encourage other landholders to acquire permits. The greater the sensitivity of estimates of emissions to changes in the salt budgeting model the greater the volume of trading in permits.

The functioning of the price mechanism for emission permits in the short term may also be influenced by the manner in which emission permits are allocated among landholders. In circumstances where landholders are allocated permits using a rule that results in their initial allocation of permits differing from estimates of their historical emissions, a high volume of trading may be expected in the short term. While this encourages price discovery there are, as described earlier, significant equity implications arising from the wealth transfers entailed in such rules.

The price of emission permits will also be influenced by the availability of capacity for disposing of salt. If the volume of disposal permits is substantially lower than the volume of emission permits in a particular sub-catchment then contracts for disposal of emissions will be relatively expensive. This would mean that emission permits would trade at a discount relative to other sub-catchments. Alternatively, if the volume of disposal permits is substantially higher than the volume of emission permits in a particular sub-catchment then contracts for disposal of emissions will be relatively inexpensive. This would mean that emission permits would trade at a premium relative to other sub-catchments.

Finally, price discovery will be influenced by the rules governing eligibility to enter the market and trade in emission permits. The more restricted the number of participants that may trade in the market the greater the degree of distortion in prices for emission permits. Ideally, market participation should be unrestricted if the market is to be contestable (Baumol 1982;Langridge and Sealey 2000;Paech 1998). This would mean individuals may purchase emission permits without being landholders but individuals who are landholders and are undertaking activities that discharge salt must possess emission permits. Some stakeholders may not be comfortable with tradable emission permits unless the right to possess emission permits is restricted. See (Schillizzi 2006) for a further discussion of the equity issues associated with market mechanisms.

5.3 Price discovery for disposal permits

In principle, the prices at which disposal permits are exchanged will be a function of the availability of assimilative capacity in rivers and the capacity to store salt to the overall demand for disposal created by landholders with emission permits. And the demand for emission permits depends in turn, on the marginal abatement costs faced by landholders and differences among landholders in the economic return to emissions.

A key issue in the establishment of the market for disposal permits is the process by which landholders owning emission permits enter into contracts for salt disposal when few landholders will possess the infrastructure needed to satisfy the conditions for owning a disposal permit. A period of time is required to allow investment in infrastructure to occur.

We suggest allowing landholders, initially, to own emission permits without a contract for disposal provided they pay a levy proportional to the volume of emissions their permit allows. The rate of the levy could be increased over time thereby rendering salt emissions increasingly expensive. Landholders with emission permits who have entered a contract for disposal are exempt from the levy. Landholders will increasingly seek to enter disposal contracts as the rate of the levy increases. Hence, the imposition of the levy creates a 'demand' for disposal contracts which, in turn, creates an incentive for entrepreneurial landholders to invest in disposal infrastructure and acquire a disposal permit.

Variation in economic returns to emissions to landholders, and variety among landholders in the cost of implementing abatement measures will generate differences across sub-catchments in the premiums landholders with emission permits will pay for the disposal of salt. Variations across sub-catchments in the costs of disposal infrastructure and suitability for evaporation basins, together with variations among reaches in the assimilative capacity of rivers, will generate differences across sub-catchments in the premiums landholders with disposal permits will accept for disposing of salt.

The greater the degree of variability among reaches in the availability of assimilative capacity through time the greater will be the opportunity for landholders with disposal permits to lease their permits and engage in futures and options trading in disposal permits.

As the price of disposal permits depends partly on the demand for disposal contracts from landholders that own emission permits, the factors that influence price discovery in the market for emission permits will also indirectly influence price discovery in the market for disposal permits. These factors include:

- the price of agricultural products;

- the costs landholders incur when modifying their emissions by changing agricultural practices;
- changes in the relationships between contextual characteristics and estimated emissions as embodied in the salt budgeting model;
- the allocation rule used to distribute emission permits to landholders;
- rules governing eligibility to enter the market and trade in disposal permits.

Finally, as with emission permits, price discovery for disposal permits will be influenced by the rules governing eligibility to enter the market and trade in emission permits. The more restricted the number of participants that may trade in the market the greater the degree of distortion in prices for emission permits.

5.4 Gifting of emission permits and windfall gains

The nature of the emission permits that have been proposed in this report is such that whatever procedures are followed in allocating permits, there will be an element of 'gifting' in the allocation procedure. Landholders that are allocated permits will, in effect, be freely granted the right to discharge salt within the limits of the assimilative capacity of rivers in the region. We believe that 'gifting' may be defended as compensation for the curtailing landholders' previously unlimited emission rights in exchange for the enforcing the rights of others in water quality. We also believe that it may be impractical as well as impolitic to compel landholders to purchase permits in this context.

Given then, that the allocation of permits would necessarily involve an element of 'gifting', at least some transactions in permits will involve an element of 'windfall' gains. In most cases, however, this windfall will represent only a fraction of the price at which permits are exchanged. For example, when a landholder sells permits, the sale must be associated with a measurable reduction in emissions in order to proceed. Hence, for the landholder to realise a profit on the transaction, the revenue obtained from the sale of permits must exceed the cost of the measures they undertake to lower their emissions. While such profits may be regarded as a windfall they also reflect the fact that relatively low cost measures are being employed to reduce emissions.

The size of such windfall profits will be limited by the operation of the market mechanism. Through trading, the price of permits is equated with unit abatement costs thereby eliminating supernormal profits. If abatement is inexpensive then the demand for permits will be relatively low since emissions can be reduced at low cost. At the same time, the potential supply of permits for sale will be relatively high since landholders can reduce emissions at relatively low cost thereby releasing surplus permits for sale. Thus, if there is ample scope for lowering emissions by implementing abatement measures that are relatively inexpensive, then the price at which permits will be exchanged in the market will be correspondingly low. Hence, the opportunities for landholders to secure windfall gains will be limited.

Discussion

In the introduction to this report we observed that there are a number of motivations for the growing interest in cap and trade markets for salt emissions. One important motivation was to demonstrate achievement of environmental objectives. The development of the salt emissions and salt disposal cap provide a degree of certainty that environmental objectives will be achieved, provided appropriate resources are devoted to ensuring compliance with the conditions of permits.

A second important motivation was to increase private investment in salt abatement measures. The introduction of a market in salt emission permits of the type of we have described creates economic incentives for landholders to invest in abatement measures on-farm. The more restrictive the cap on emissions compared to historical emissions the higher the price of an emission permit. The higher the price of emission permits the greater the return to investing in abatement measures and selling permits. Also, the higher the price of emission permits the greater the return to offsetting any increase in emissions associated with increasing agricultural production by investing in abatement measures rather than purchasing permits.

The introduction of a market in salt disposal permits of the type of we have described creates economic incentives for landholders to invest in abatement measures off-farm such as evaporation basins. The more restrictive the cap on salt disposal compared to salt emissions the higher the return to owning a disposal permit and investing in disposal infrastructure such as storages and evaporation basins. Hence, the creation of markets in emission and disposal permits creates incentives for private investment in structures such as evaporation basins.

Another important motivation for the growing interest in a salt emissions market was to better align the timing of salt emissions with the seasonal flows in major rivers. This would increase the efficiency of use of Salt Disposal Entitlements from a regional perspective. The creation of markets in both emission and disposal permits allows the timing of salt emissions to be aligned with the seasonal flows in major rivers. The market in emission permits provides control over aggregate emissions in the long term but, of itself, does not influence the timing of emissions. This is achieved by linking the market in emission permits to a market in disposal permits. The market in disposal permits provides an economic incentive for private investment in infrastructure for harvesting and storing salt emissions, so as to release emissions in line with seasonal variations in the capacity of rivers to assimilate salt.

Some of the growing interest in a salt emissions market is motivated by a concern to better secure the future of communities that have been perceived to be disadvantaged by water trading. The argument is as follows. When water is traded between communities there is a compensating transfer of wealth. The right to discharge salt into the environment is an economic asset and that this asset is being transferred between communities through water trading. However, a compensating transfer in wealth does not occur to offset the indirect trade in salt emissions.

Some have argued this reasoning is mistaken because the compensation for the transfer of the right to discharge salt is incorporated in the compensation for the transfer of water. This argument is undermined if those buying water are compelled to make payments for the right to discharge salt in the future to a third party. Others have argued that the case for compensating disadvantaged communities is mistaken because the communities did not possess the right to dispose of salt to begin with. The legitimacy of this argument depends on perceptions of cost sharing and relative benefit in regard to abatement works undertaken in the past and, possibly, perceptions as the extent to which the discharge rights that are being transferred properly fall within the ambit of inter-governmental agreements on salinity.

Given the case for compensating disadvantaged communities has merit the markets we have designed provide a means for the transfers of wealth to compensate for the transfer of rights to discharge salt to be made explicit. Where water is purchased to allow an activity that will contribute salt to the environment, that trade must be accompanied by the purchase of a commensurate volume of salt emission permits and the negotiation of a contract for salt disposal. Hence, the sale of the right to discharge salt is distinguished from the sale of the right to water. Note that the purchaser may acquire the water and the salt emission permits from different sources. However, even in this case, the fact remains that the seller of the water retains their salt emissions permit as an asset for future sale.

There are three further issues we will consider in this discussion. The first concerns the markets in emission and disposal permits and the existing allocation of drainage diversion licences. Drainage diversion licences allow landholders to harvest water from regional drainage network under certain conditions. Landholders pump the harvested water in storages for subsequent use in irrigations. In principle, the markets in salt emission and disposal permits can operate independently of drainage diversion licences. Although the diverters are harvesting salt emissions, they are simply modifying the distribution of emissions at the end of the drainage network in the short term. Theoretically, the average volume of salt emissions in the long term is unaffected by their activities.

The presence of landowners with drainage diversion licences does raise the interesting possibility that owners of disposal licences may pay diverters to intercept and store emissions on their behalf (provided the diverter can control releases back into the drainage network).

The presence of landowners with drainage diversion licences may add a practical complication to the exercise of disposal permits in situations where the owner of the licence is located downstream of the owner of a disposal permit. A mechanism may be required to ensure the downstream diverter does not inadvertently extract disposal releases.

Second, there is the issue of the compatibility of a market in emission and disposal permits with the Salt Disposal Entitlements issued under the inter-government agreement on the Murray Darling Basin (Murray-Darling Basin Commission 2003). Ownership of these entitlements is vested in the relevant state governments. As such they cannot be traded among individuals, though the right to exercise the discharges these entitlements allow could be tradable.

The complications ownership of salt disposal entitlements introduces can be avoided by restricting the emission and disposal permits we have designed to rivers other than the Murray. We have assumed that the assimilative capacity of these rivers is defined at the point at which they enter the Murray and that the salt concentration target for these rivers is consistent with the salt targets for the Murray.

The third issue we consider is the possible consistency between the markets we have proposed and the provisions covering the proposed water use licences. Water use licences are being developed as part of the 'unbundling' of water rights foreshadowed by the Victorian government (Victorian Government Department of Sustainability and Environment 2004). The purpose of water use licences is to provide a policy mechanism specifically for regulating the environmental effects of the use of water including the effects of the use of water on water quality (Victorian Government Department of Sustainability and Environment 2004). In this regard, the intent of the markets we have designed is entirely consistent with the purpose of water use licences. In addition, the national policy for managing water resources specifically endorses the concept of market mechanisms as a means for regulating water use (Productivity Commission 2005). Consequently, we believe the market designs we have presented in this paper are, in principle, consistent with the concept of a water use licence and provide one means of giving expression to such licences with respect to regulating salt emissions.

Conclusion

Regional and state policy makers are increasingly interested in finding alternative policy mechanisms for managing salt emissions arising from agricultural activities for many reasons. One alternative, markets in salt emission permits, has attracted increasing interest from policy makers. This interest is understandable given the theoretical benefits they offer which include incentives to encourage private investment in abatement works and incentives for private investment in infrastructure to align the timing of salt emissions with the seasonal flows in major rivers. Importantly, cap and trade markets also offer greater surety that permanent reductions in salt emissions into rivers are achieved, that the lowest cost mix of investment in abatement is obtained, and that the limited emissions that are permitted go to their highest value use.

In this paper we have described hypothetical 'cap and trade' markets in transferable salt emission and salt disposal permits for irrigated agriculture for the North Central region of Victoria. In designing our markets we drew on our knowledge of the market in salt discharges operating in the Hunter Valley of New South Wales and the market in nitrogen emissions proposed for Lake Taupo, New Zealand.

Our aim in designing these markets was to provide concrete examples of 'cap and trade' markets that would provide a basis for more informed debate among policy makers about the advantages and disadvantages of such markets, and the practical institutional and political issues involved in the implementation of markets. Hence, the markets we designed were intended, in a practical sense, to take into account the biophysical and institutional realities of the region in which they could be implemented.

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