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A tradable permit scheme for phosphorus emissions in the Goulburn Broken catchment

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Melinda Leth, Geoff Kaine and John Ford

Department of Primary Industries, Victoria

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1. Introduction

Phosphorus is a limiting nutrient in many Australian rivers. Consequently, significant increases in phosphorus loads may lead to a decline in river health. When high phosphorus loads are combined with low water flows and high water temperatures rapid growth of blue-green algae occurs, reducing the concentration of oxygen in rivers. This may threaten the ability of rivers to sustain native aquatic flora and fauna. Blue-green algae may also reduce the aesthetic value of waterways for recreational use and affect the quality of potable water.

The Murray Darling Basin Commission has identified the Goulburn Broken Catchment as a major contributor of nutrients, in particular phosphorus, to the River Murray. Intensive irrigated farming operations in the catchment, such as dairying, were identified as the primary contributors of phosphorus in the region.

To manage phosphorus emissions, the Goulburn Broken Catchment Management Authority established nutrient targets and set priorities for management practices at a catchment and farm scale. The Authority, in conjunction with its catchment partners, set a target of 50 per cent reduction in the phosphorus load from irrigation drains by 2016 (GBCMA 2003). To achieve this target, a package of policy instruments was implemented including regulation, charges, incentives and extension. Collectively these instruments were intended to increase the efficiency of water use on farms and to facilitate the adoption of recommended practices to help reduce phosphorus emissions.

Recent monitoring of rivers in the catchment indicates the policy has been successful as phosphorus emissions have fallen below the target. However, the success of the policy has been questioned (Leth, Ford and Murdoch 2004). Some catchment partners are concerned the target will not continue to be achieved because drainage flows are expected to increase with a return to more customary rainfall patterns (Leth, Ford and Murdoch, 2004). This uncertainty is placing pressure on the catchment partners and the dairy industry to demonstrate improved environmental performance and to create confidence that water quality targets will be met whatever the seasonal conditions in the future.

In this context the catchment partners have expressed interest in novel policy instruments such as 'cap and trade' markets to help address their concerns. Economic theory suggests cap and trade markets offer many advantages to traditional instruments for managing environmental issues on the grounds of efficiency and effectiveness. Theoretically, the imposition of a 'cap' on emissions provides a guarantee the water quality target will be achieved while the ability to trade enable the target to be achieved at least cost to the community.

Although a relatively untried as a policy instrument for managing nutrient emissions from diffuse sources such as agriculture, cap and trade schemes are being trialed in a number of countries (Higson and Kaine 2004). A few, such as the Grasslands Selenium Trading Scheme and the Lower Boise Nutrient Trading Scheme in the United States and the Dutch Nutrient Trading Scheme, have been implemented. A tradable emission scheme is also being implemented by Environment Waikato for managing nitrogen emissions from agriculture in the Lake Taupo catchment in New Zealand (Kaine and Higson 2004). These schemes hold many useful insights into the design and implementation of a cap and trade scheme for managing phosphorus in the Shepparton Irrigation Region.

In this paper we describe a hypothetical cap and trade scheme for agricultural emissions of phosphorus in the Shepparton Irrigation Region. The market we have designed is built on the assumption that there is a need for disposal of phosphorus laden water in excess of what might be used on land. We have assumed that if phosphorus laden water can be disposed of on land, for example, by diversion as is currently practiced by landholders with diversion licences, then that would mean the disposal permit market would not be necessary. The emission permits market would meet the environmental goals of the catchment alone.

The purpose of the paper is to facilitate discussions on the advantages and disadvantages of a cap and trade scheme and assist catchment partners in making an informed decision on the relative merits of this new instrument in their context.

Our objectives for this paper are to:

- Outline the current package of policy instruments
- Describe a feasible cap and trade scheme for phosphorus emissions
- Discuss some key issues in implementing such a market

In the next section we will outline the biophysical context of phosphorus in irrigated agriculture. We then review the current package of policy instruments and highlight some of the advantages and challenges facing these instruments in meeting the water quality target. In doing so the paper provides the rationale for the addition of a cap and trade scheme and the benefits and consequences of its introduction.

In section four we describe how a cap and trade scheme may operate in practice by describing markets in phosphorus emission and disposal permits, both of which are required to meet the water quality targets and objectives of catchment partners. We then discuss issues important to the establishment of a market. In conclusion, we provide a summary of the key findings and implications.

2. Phosphorus cycling in the Shepparton Irrigation Region

The irrigated dairy industry in the Shepparton Irrigation Region is the major agricultural source of phosphorus emissions to the River Murray. The industry largely contributes phosphorus to the environment as a result of run –off (rainfall induced and irrigation) from well fertilised, grazed pastures.

Phosphorus primarily leaves irrigated dairy farms dissolved in run-off water or attached to sediment in run-off. The run-off collects in farm drains that are connected to regional surface water drains. Where farms or sections of farms are not connected to surface drainage, phosphorus may enter neighbouring properties as surface run-off.

Irrigated dairy farms generally use fertilisers that are high superphosphate and dissolved active phosphate. Fertiliser is applied once or twice a year to promote pasture growth. Fertilisers are also used to establish annual pasture or newly planted perennial pasture after land forming. Fertilisers may become a source of phosphorus in the environment when applied too closely to an irrigation or rainfall event or after the pasture has been grazed.

Dairy effluent is collected and stored in ponds. The ponds are designed on the basis of size of the dairy herd and plant and to accommodate a one in ten year rainfall event. Effluent ponds require careful management to prevent the unintentional release of effluent into waterways, which is a particular concern during the wet winter months. With the introduction of extension services to help farmers manage dairy effluent in winter months, the impact of effluent has been reduced.

There is also a small amount of phosphorus that enters the farm system from channel outfalls through the distribution network.

3. Current approaches to managing phosphorus

A mix of policy instruments is used to manage phosphorus emissions in the Shepparton Irrigation Region. This mix includes regulations, recommended best practices, incentives and extension. We will describe each of these and then discuss the strengths and weaknesses of the mix.

3.1 Regulating effluent discharge

The Environment Protection Act 1970, State Environment Protection Policy (Waters of Victoria 1970) is the policy that is specifically designed to address nutrient emissions from irrigated agriculture. The Act states (State Government of Victoria 1970):

> *"Wastes and wastewater from intensive agricultural industries (excluding fish farms and aquaculture) must not be discharged to surface waters".*

Under this legislation intensive livestock industries in the Shepparton Irrigation Region, primarily dairy farms, are required to contain livestock effluent on-farm. To ensure that farmers comply with the legislation the Environmental Protection Authority regularly conduct audits of farms to assess whether farmers are meeting their legal requirements. Farmers are issued with a pollution abatement notice for non-compliance and face prosecution if the cause of non-compliance is not dealt with within a suitable timeframe.

3.2 Best management practices for nutrients

To support dairy farmers efforts to comply with the legislative requirements for managing nutrients the Goulburn Broken Catchment Management Authority, in conjunction with its partner organisations, have developed effluent management guidelines that recommend best practice for the management of dairy effluent and nutrients. These guidelines focus on the design, installation and management of effluent ponds.

Effluent ponds are not mandatory. Dairy farmers have the flexibility within the current legislation to determine the most appropriate method to manage effluent for their farm context. However, the Catchment Management Authority and the catchment partners consider effluent ponds to be best practice. An extension service is provided to help farmers implement the effluent management guidelines. A State wide industry code of practice is being developed for effluent and feed pad management.

Guidelines for the management of fertiliser application have also been developed to help reduce phosphorus emissions. The guidelines are intended to assist dairy farmers in correctly timing the application of fertiliser with irrigation and rainfall events to maximise pasture growth and reduce emissions.

3.3 Regulating water use

The reduction of nutrient discharge can be linked to improved irrigation efficiency resulting from the introduction of the Water Market in which farmers are granted a license to irrigate. An irrigation license comprises a water right and a water allocation. The establishment of an irrigation licence under the Water Act 1989 and the Shepparton Irrigation Region Land and Water Management Plan regulates the amount of water available to a landholder. While the licence limits the amount of water available to a landholder for irrigation, the licence does not regulate the rate of water that can be applied to land. The Victorian Government has foreshadowed changes to farmers' irrigation licences (Victorian Government Department of Sustainability and Environment 2004). A water right will be 'unbundled' into three components – a water share, a delivery share and a water use licence. The purpose of a water use licence is to minimise the adverse environmental impacts from irrigated agriculture (Victorian Government Department of Sustainability and Environment 2004). The licence will set minimum environmental standards for individual farms or groups of farms, and will describe the property to be irrigated, the annual use limit and the rights to drainage.

3.4 Incentives to increase water use efficiency

The Goulburn Broken Catchment Management Authority offers and extensive incentive and extension program to encourage dairy farmers to implement irrigation best practice. The purpose of the incentives is to increase the rate of adoption of recommended irrigation practices that are designed to increase the efficiency of water use on-farm and thereby minimise nutrient emissions from farms. To encourage the reuse of water on farms, incentives are available for recycle dams. To reduce the volume of water leaving the farm through increased efficiency in water application incentives are available for automatic irrigation.

3.5 Surface drainage

In the Shepparton Irrigation Region, surface drains are constructed to alleviate flooding of low-lying land and reduce the impact of salinity. These drains are the main routes by which emissions of phosphorus from farms reach waterways. Farmers contribute to the cost of constructing drains through a cost-share arrangement with the Goulburn Broken Catchment Authority and Goulburn-Murray Water. Farmers connected to the drain are also charged an annual drainage fee. This fee is based on the amount of irrigation water used and the area of land the water is being applied, which collectively provide a proxy for drainage discharge. A flat rate fee is also charged per farm to cover administration and maintenance costs.

Farmers located along a surface drain may apply for a drainage diversion licence. A high-flow diversion licence allows farmers to divert drainage water and store the water in turkey-nest dam during high flow conditions. A low-flow diversion licence allows farmers to divert drainage water at any time. This water can be used to irrigate specific paddocks or mixed with channel supply.

Farmers with drainage diversion licenses are charged an annual fee for the right to divert water. Drainage diversion is viewed as beneficial for all parties as it contributes to productivity in dry conditions for farmers, increases water-use efficiency and reduces phosphorus emissions.

An unknown part of the phosphorus load is generated from the surface drain itself. Hence an important part of phosphorus control is by structural means such as nutrient stripping and sediment loss within the drain, associated wetlands along the drain route or wetlands prior to entry into the rivers.

3.6 Information services

Government and dairy industry research and extension services support the adoption of best management practices within the catchment. Best management practices are conceived and developed by research activities. Extension provides advice and information on the types of best management practices available to help increase farm productivity, improve water use efficiency and reduce the environmental impact of irrigated dairying.

3.7 Advantages of current approaches

The current package of policy instruments relies primarily on the implementation of best management practices to reduce phosphorus emissions. An important advantage of this reliance on recommended best practices is that the serious difficulties and high costs associated with attempting to measure individual contributions to diffuse emissions are avoided. Emissions will be reduced to the extent that farmers implement best practices, and the practices themselves provide a basis for monitoring compliance.

The adoption of these practices is encouraged partly through the threat of prosecution but mostly through the provision of incentives. The provision of incentives encourages the voluntary adoption by farmers of the management practices recommended by the catchment partners. A voluntary approach to adoption of best practice allows farmers to evaluate the relevance of the practice for their farm context and decide whether to adopt the practice accordingly. Hence, 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 to achieving natural resource policy objectives is also politically attractive. Voluntary instruments such as incentives compensate farmers, at least partially, for adopting practices that produce environmental benefits that are enjoyed by all the community.

3.8 Disadvantages of current approaches

A voluntary approach to achieving environmental objectives does suffer from some important weaknesses (see Kaine and Johnson 2004). First, the environmental objective may not be achieved because insufficient numbers of farmers adopt the practices. Where the private costs of adoption are high, efforts to accelerate adoption by providing financial incentives to reduce the costs of adoption may be prove inadequate.

Second, the environmental objective may not be achieved because even widespread adoption of best practice is unable to reduce emissions to desirable levels. In other words, the target level of emissions cannot be achieved simply through the implementation of abatement technologies. The target can only be achieved by the closure of at least some farm enterprises.

Third, landholders may adopt best practices but implement them in ways that do not contribute effectively to achieving the environmental objective. Kaine and Johnson (2004) provide examples of best practices being adopted and implemented in ways that create private benefits for landholders at the expense of environmental benefit.

For example, the adoption of recycle dams in border check irrigation is one of the recommended best practices for increasing the efficiency of water used on farm and reducing phosphorus emissions. Recycle dams are intended to act as a safety net by preventing the uncontrolled release of water and nutrients into waterways in the event a paddock is over watered. To maximise the environmental benefit of recycle dams the dam must be empty at the commencement of irrigation. However, Kaine and Johnson (2004) show that in many instances recycle dams are managed to maximise commercial gain. Producers use recycle dams to exert greater control over the timing of irrigation by ordering water in advance and storing water in the dams. Consequently the dam is full at the beginning of the irrigation thereby reducing the potential effectiveness of the dam to capture run-off. Hence, farmers may manage recycle dams in a manner that is inconsistent with achieving the policy objective.

Finally, relying on incentives to promote implementation of a prescribed set of best practices may mean the emissions target is achieved at greater cost than would be the case with other instruments. Assuming, as is highly likely, that the marginal cost of phosphorus abatement varies between farmers, then theoretically, the emissions target is achieved at least cost to the community at the point where the marginal cost of abatement is the same for all farmers. Hence, the least cost combination of abatement measures that will achieve the emissions target will involve different farmers investing in different levels of abatement.

In other words, the phosphorus emissions target will be achieved at least cost to the community by having different farmers implementing different combinations of best practices. This contrasts with the current policy that, at least implicitly, requires all farmers to adopt the same best practices for reducing phosphorus.

3.9 A ‘cap and trade’ approach

A market in tradable phosphorus emission permits can overcome the weaknesses of a policy based on voluntary adoption of best management practices. Most importantly, through the ‘capping’ of emissions a market in emissions provides greater certainty that the environmental objective can be achieved.

Cap and trade markets also create flexibility for landholders to adopt different management practices and production processes over time in response to changes in economic conditions, abatement measures and production technology. In doing so, a market in emissions permits enables the environmental objective to be achieved at the lowest possible economic cost to the community, at least in theory (Montgomery 1972).

There are some serious difficulties in establishing a cap and trade market for diffuse source emissions such as phosphorus from agriculture. An important technical difficulty is the problem of defining the emissions of individual landholders. For emissions to be tradable they must be measurable and controllable. In addition it can be difficult to align individual emissions with the aggregate catchment emissions. This is complicated by the non-conservative nature of phosphorus in the environment where it may be recycled unpredictably.

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 achieving water quality targets before the existing rights of farmers and in doing so will redistribute wealth between farmers and the rest of the community.

In the remainder of this paper we describe how the technical difficulties of a ‘cap and trade’ market in phosphorus emissions from irrigated agriculture might be overcome so that such a market could be introduced in the Goulburn Broken.

4. A ‘cap and trade’ market in phosphorus emission permits

A cap and trade consists of three components. The first is a ‘cap’ or limit on total phosphorus emissions leaving the catchment. This limit may be defined with respect to the whole catchment or specific areas within the catchment.

The second component is an emission permit that embodies a property right specifying the volume of phosphorus emissions each farmer is legally entitled to discharge. The total volume of discharges allowed by the emissions permits must equal the 'cap' for the catchment.

The third component is a market mechanism where emission permits can be traded, either in whole or in part, and on a temporary or permanent basis.

As we 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. This has a number of consequences for designing a market in phosphorus emissions from agriculture. First, emissions from diffuse sources can only be estimated on the basis of proxies that are associated with emissions such as numbers of livestock, types and amounts of fertiliser applied, areas of annual crops and pasture, soil type, and so on. Hence, the market we describe depends on the use of simulation models to estimate the phosphorus emissions of individual farmers.

A second problem is the volume of emissions into rivers in the short term can depend on factors beyond the control of farmers such as rainfall. A consequence of farmers' lack of control over emissions in the short term means the volume of emissions can, in aggregate, diverge from the assimilative capacity of the rivers in the catchment. We resolve the problem of matching aggregate emissions in the short term to short term variations in the assimilative capacity of rivers by introducing two types of permits - phosphorus emission permits and phosphorus disposal permits.

The purpose of phosphorus emission permits is to restrict phosphorus emissions in the long term from irrigated agriculture to equal the long-term assimilative capacity of rivers in the catchment. All farmers that generate phosphorus emissions are required to hold phosphorus emission permits that match the average of their long-term emissions.

The purpose of phosphorus disposal permits is to provide a mechanism for restricting phosphorus emissions from irrigated agriculture in the short term to match short term variations in the assimilative capacity of rivers in the catchment. A phosphorus disposal permit may only be owned by a landholder that has the capacity to store and discharge phosphorus at will. For example, a landholder may have the capacity to divert flows from drains and store them in a turkey's nest for subsequent use or release.

All farmers with a phosphorus emission permit must have a contract for disposal of their phosphorus emissions with the owner of a phosphorus disposal permit. The linking of phosphorus emission permits with phosphorus disposal permits creates incentives for private investment in the harvesting and storing of phosphorus emissions. This raises the possibility of matching phosphorus emissions in the short term to variations in the assimilative capacity of rivers in the short term.

A fundamental assumption underpinning the design of the market we propose is there is a need for disposal of phosphorus laden water in excess of what might be used on land. We have assumed that if phosphorus laden water can be disposed of on land, for example, by diversion as is currently practiced by landholders with diversion licences, then consequently the disposal permit market would not be necessary. The emission permits market alone would meet the environmental goals of the catchment.

The fundamental concepts underlying emission and disposal permits are illustrated in figure 3.1. Phosphorus emissions from farmers are intercepted by the regional drainage system. Landholders with a phosphorus disposal permit harvest and store emissions from the drainage network. Stored emissions may then be used for irrigation or disposed of by discharge into the river when conditions allow.

Practically, farmers with phosphorus emission permits must have a contract with one or more downstream landholders that possess a phosphorus disposal permit. Provided the volume of phosphorus emission permits matches the volume of phosphorus disposal permits then, in the long run, phosphorus emissions from irrigated agriculture will match phosphorus disposals into the rivers. Provided there is sufficient capacity for storing phosphorus 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.

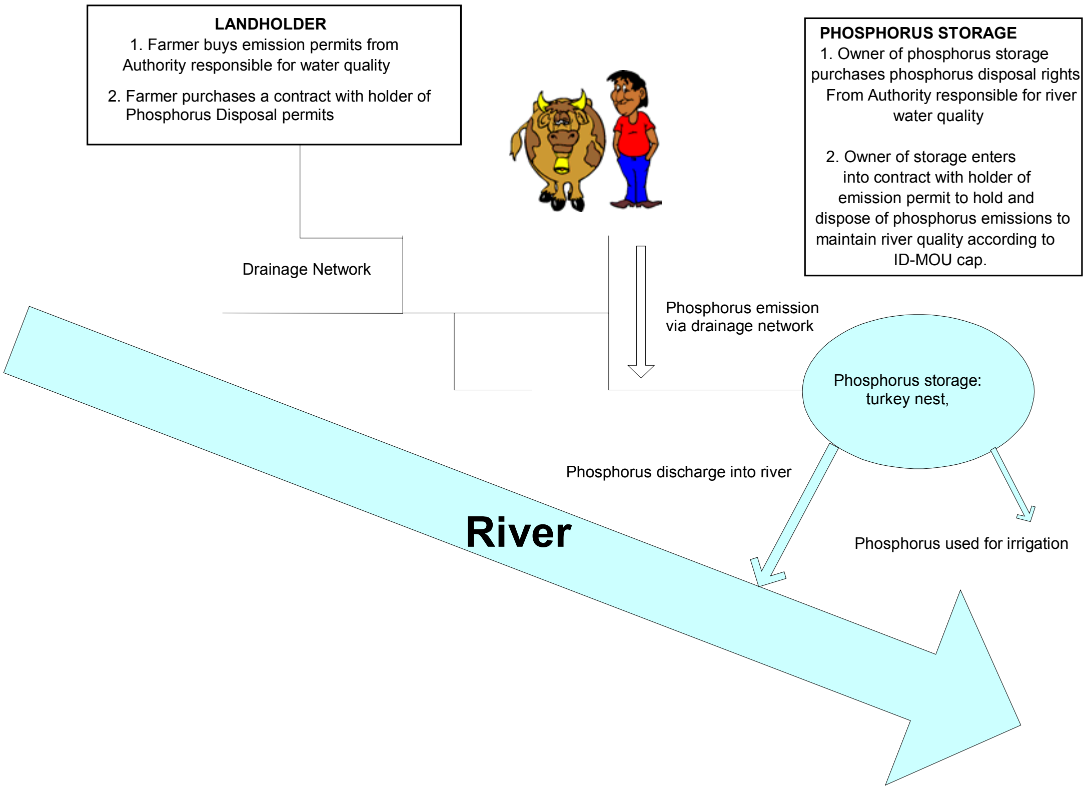

Figure 1. Schematic of market in phosphorus emission permits and phosphorus disposal permits to manage phosphorus emissions in Goulburn Broken.

4.1 The phosphorus emission cap

The 'cap and trade' markets in phosphorus emission and phosphorus disposal permits we have designed are based on the assumption that the local or regional drainage network intercepts virtually all run off from irrigated agriculture in the catchment. The drainage network may include natural streams. These networks then drain into one or more rivers in the catchment for which maximum phosphorus 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 phosphorus 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 phosphorus. This capacity is the 'cap' aspect of 'cap and trade' markets. The phosphorus emissions cap is the total amount of phosphorus emissions available for distribution among farmers. The cap is the total amount of phosphorus emissions farmers in total may legally generate.

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

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

The cap for phosphorus emission permits is defined algebraically by expression 1 in Box 4.1. The cap for phosphorus disposal permits, and its equivalence with the cap for phosphorus emission permits, is defined algebraically in Box 4.2.

SEC is the phosphorus emissions cap
E_j is the phosphorus emission permit allocated to landholder J
k_j is the percentage of the 'cap' allocated to landholder J
$\hat{c}$ is the maximum phosphorus concentration permitted in the river
c_t is the phosphorus 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 phosphorus emission permits (SEC) is given by:

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

And the phosphorus 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 $j = 1, 2, \ldots, m$

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

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

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 $j = 1, 2, \ldots, m$; $t = 1, 2, \ldots, n$

Box 4.1 Algebraic expression for the phosphorus emission 'cap' and permits

4.2 Phosphorus emission permits

Phosphorus emission permits entitle farmers to a specified share in the phosphorus emission cap (see expression 2 in box 4.1). That is, the permit entitles the owner to a percentage of the long term, average annual assimilative capacity of the relevant river. The phosphorus 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 farmers can implement abatement actions. Otherwise farmers 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 farmers 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.

In the context of a Northern Victorian river, farmers may vary their emissions in the long term by, for example, altering their mix of livestock, use of fertilisers or quantity of feed (sold or purchased). 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 phosphorus emissions which is beyond the control of farmers is divorced from the long term volume of emissions which, we assume, they can influence.

Since actual emissions of phosphorus produced by individual farmers cannot be measured their share of the cap must be translated into proxies. That is, measurable production inputs related to phosphorus emissions (see expression 3 in Box 3.1). The translation of the share of the phosphorus cap into measurable production inputs also describes the control farmers can exert over their emissions of phosphorus in the longer term. The only practical means by which this translation can be done is through the use of phosphorus 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 would be a nutrient budgeting model for agricultural land uses.

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

By defining emission permits in terms of processes embodied in the nutrient budgeting model the difficulty of measuring actual phosphorus 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 fertiliser type. This means that the phosphorus emission permits for a particular landholding can also be expressed in terms of the contextual characteristics of that holding as well as units of phosphorus 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 amounts of fertiliser applied to annual and perennial irrigated pasture. This allows the farmer to evaluate phosphorus emission permits in terms of the economic value of the combinations of production inputs and management practices possession of the permit allows. The inputs would be translated to give the emission equivalent of tonnes phosphorus 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 et al 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 phosphorus emission permits this means that the value farmers 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 livestock numbers and fertiliser use means that trades can be visualised in terms of familiar farm management measures which facilitates the exchange of emissions between farmers.

Third, a unit of phosphorus emissions creates different economic opportunities in different locations depending on the farming context. Conversely, a particular combination of livestock classes will require a different volume of emission permits in different contexts. Hence, any trade in emission permits between farmers requires determining the relevant changes in the production possibilities for each of the farmers. 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 phosphorus 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 numbers of livestock 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 stock numbers, fertiliser applied, 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 Department of Sustainability and Environment 2004).

A disadvantage of using a nutrient budgeting model to estimate emissions is the scope that it offers for litigation. As emission estimates are based on an imputed rate of emissions rather than actual emissions the imputation process embodied in the model may be subject to legal challenge.

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 phosphorus budget model, the permits are defined, and the market operates largely independently of actual phosphorus emissions in the short term.

This does not mean the market in emission permits is unrelated to actual emissions of phosphorus and phosphorus concentrations in rivers. As new knowledge is acquired about the relationship between the contextual characteristics of agriculture and emissions then the phosphorus 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 phosphorus and the phosphorus load in rivers through a market in phosphorus disposal permits.

4.3 Trading rules for phosphorus emission permits

Trading rules should be simple and enhance the managerial flexibility of permit holders (Stavins 2001). We suggest trading in phosphorus 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 farmers. For example, the establishment of a central register would facilitate enforcement of the conditions attached to ownership of permits. That is, purchasers of emission permits arrange matching contracts for disposal of their phosphorus.

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 mix and numbers of livestock, use of fertilisers, the quality of feed (sold or purchased) and management practices as well as shares in the emission cap. Consequently, when a trade is negotiated between farmers, the limits on these characteristics must be adjusted correspondingly for both farmers. 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 phosphorus emission permits would require matching adjustments in the contracts both farmers have arranged for the disposal of their emissions.

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

A change in the parameters and relationships in the phosphorus budgeting model means the relationships between proxies such as areas of crop and pastures and estimates of phosphorus emissions will change. This has two implications. One implication is that, for some farmers, the estimated rate of emissions based on the contextual characteristics of their properties will differ from their share of the phosphorus emissions cap. This means that at least some farmers are likely to have too small a share of the cap to cover their newly estimated rate of emissions. Other farmers are likely to have a share of the cap in excess of their newly estimated rate of emissions. Farmers may reconcile the difference between their permit holdings and their revised emission estimates by either buying, selling or leasing permits, or by changing land use.

The second implication of a change in the relationships between contextual characteristics and emissions of phosphorus as predicted by the phosphorus budgeting model is that the total of the emissions estimates made with the model may differ from the cap for phosphorus 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 the problem as to how emission permits should be adjusted in aggregate to match direct, or indirect, changes in the phosphorus 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 phosphorus budgeting model is revised. This concept is similar in principle to the annual revisions made to water allocations and the total allowable catch in fisheries (Guerin 2003). We believe this method is impractical in the case of phosphorus emission permits because such revisions would place unrealistic demands on farmers to alter their land use in order to accommodate changes in the cap.

Alternatively, the issue as to how to adjust phosphorus emission permits in aggregate to match direct or indirect changes in the phosphorus 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 farmers 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 phosphorus budgeting model or the emissions cap could introduce a significant element of uncertainty into the emission permits market, both for farmers 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 phosphorus budgeting model is updated infrequently and the likelihood of substantial changes in the relationships between proxies and estimates of emissions is small. In this instance, farmers 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 owners of permits to limit their financial risk should they have to purchase additional permits following a change in emission estimates.

Options allow farmers 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 phosphorus 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.

4.4 Phosphorus disposal cap and phosphorus disposal permits

The market in emission permits may be linked to actual emissions of phosphorus and phosphorus loads in rivers through a market in phosphorus disposal permits.

Phosphorus disposal permits are shares in the actual assimilative capacity of rivers over a specified period of time (see Box 4.2). Hence, the 'cap' for phosphorus disposal permits is the actual capacity of rivers to assimilate phosphorus over a specific period. Since the capacity of rivers to absorb phosphorus will vary over time depending on water flow and phosphorus loads from other sources, the cap on phosphorus disposals is a 'variable' cap that changes over time depending on conditions in the rivers.

Provided the 'cap' for phosphorus emission permits matches the long term average of the 'cap' for phosphorus disposal permits, the volume of phosphorus emissions from farmers should match the capacity of the rivers to assimilate phosphorus in the long run (expression 6 in Box 4.2).

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

SEC is the phosphorus emissions cap
SDC_t is the phosphorus disposal cap for period t
D_j is the phosphorus disposal permit allocated to landholder J
k_j is the percentage of the 'cap' allocated to landholder J
$\hat{c}$ is the maximum phosphorus concentration permitted in the river
c_t is the phosphorus 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 phosphorus 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 phosphorus 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 phosphorus emissions cap (SEC) given earlier by expression (1) in box 4.1. In other words, the average phosphorus disposal cap will approximate the phosphorus emissions cap in the long run.

The phosphorus 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 4.2 Algebraic expression for the phosphorus disposal 'cap' and permits

For this arrangement to succeed a condition of ownership for a phosphorus emission permit is that the owner enters 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 of phosphorus disposal permits is that the owners have a demonstrated capacity to store phosphorus and discharge it at will. This condition could be fulfilled by landholders with drainage diversion rights and purpose built storages.

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 nutrients within the landscape and then disposing of it when suitable capacity to assimilative them becomes available in the river is not new. The sub-surface drainage programs in North Central and the Goulburn Broken operate on the premise that phosphorus 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 phosphorus storage and disposal. The disposal permits also create a direct relationship between the emission and disposal of phosphorus.

Theoretically, this flexibility will allow the equating of the marginal costs of abatement across the scarce assimilative capacity of the river, drainage diversions, and purpose built storages.

4.5 Trading rules for phosphorus disposal permits

Trading in phosphorus disposal permits appears to be a much simpler affair than trading in phosphorus 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 phosphorus disposal permits can occur between market participants at anytime and throughout the region.

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 phosphorus flows from the regional drainage network.

Trades in phosphorus disposal permits between different reaches in a river 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 contracts for disposal of phosphorus emissions from a drainage network are shared between two or more owners of phosphorus 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 phosphorus disposal.

The contracts for disposal describe the relative shares in phosphorus 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 phosphorus emissions will require adjustments to allow for any upstream releases for disposal purposes. This means that owners of phosphorus disposal permits would be required to monitor phosphorus concentrations and flow rates in the drainage network at the point of extraction when diverting drainage flows, as well as concentration and flow rates at the storage release point.

Variations in the phosphorus disposal cap due to fluctuations in river flow and phosphorus 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 phosphorus, futures and options in contracts for disposal rights may be the most practical way of managing these variations.

4.6 Measurement of emissions

A fundamental difficulty in designing cap and trade markets in nutrient emissions from diffuse sources such as agriculture is the inability to measure emissions from individual properties. This difficulty is compounded in the case of phosphorus by the prohibitive cost of monitoring phosphorus concentrations in rivers on a continuous basis. Measurement of phosphorus concentrations involves a costly process of sample collection and laboratory analysis. This renders even regular monitoring of phosphorus concentrations at a number of sites on in a river an expensive proposition.

We have avoided the problem of measuring individual emissions by defining emission permits as shares in the capacity of rivers to assimilate phosphorus in the long term and by using nutrient budgeting models to estimate the long term emissions of individual farmers.

Given the relatively high cost of monitoring phosphorus concentrations in rivers we suggest the assimilative capacity of rivers be estimated on the basis of weekly (or even monthly) measurements. If concentrations are relatively stable over periods of a week or more then the capacity of rivers to assimilate phosphorus in a particular week can be estimated by combining the weekly concentration measure with measurements of water flow. On the other hand, if concentrations are relatively variable but phosphorus loads are relatively stable over periods of a week, then the capacity of rivers to assimilate phosphorus in a particular week can be estimated by combining the weekly load measure with measurements of water flow.

The relatively high cost of measuring phosphorus concentrations does suggest the measurement of concentrations in disposal infrastructure may be particularly expensive if measurements needed to be taken frequently.

4.7 Accumulation and activation of phosphorus

A characteristic feature of the transport of phosphorus in the environment is that phosphorus primarily leaves irrigated dairy farms attached to sediment in run-off. Consequently, as sediment collects in the beds of drains and rivers phosphorus can accumulate. Given suitable conditions the accumulated phosphorus can subsequently 'reactivate' and become soluble, thereby changing the concentration of phosphorus in the drain or river independently of actual phosphorus emissions. Hence the concentration of phosphorus in a drain or river need not be directly correlated with actual emissions in the short term. This has two implications for the operation of the market in disposal permits.

The potential for phosphorus accumulated in sediments to reactivate will influence the pattern of phosphorus emissions over time in drains. This may be a factor that needs to be considered in the design of infrastructure for collecting and storing phosphorus emissions.

The potential for phosphorus that has accumulated in river sediments to reactivate will also influence the capacity of rivers to assimilate phosphorus in the short term – though not in the long term. Consequently, reactivation will limit the amount of phosphorus discharged by owners of disposal permits in the short term. Hence, the reactivation of phosphorus in river sediments may also be a factor that needs to be considered in the design of infrastructure for storing phosphorus emissions.

Since emission permits are defined as the average of emissions in the long term the accumulation and reactivation of phosphorus should not affect the operation of the market in emission permits.

5. Monitoring and compliance

5.1 Monitoring of compliance

Consistency requires that compliance with emission permit conditions would be evaluated in terms of the way in which the agricultural inputs that serve as proxies for emissions are specified in the nutrient budgeting model.

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 phosphorus disposal permits would require the installation of flow and phosphorus concentration meters on the outlets of storages.

5.2 Penalties for illegal emissions

Farmers 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 farmers 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 farmer will gain from phosphorus 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 farmers 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. In such circumstances, establishing a market in emission permits is problematic as the right to discharge is no longer exclusive to those in possession of emission permits.

6. 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. Establishing and enforcing water quality standards by constraining those activities that generate phosphorus emissions involves the restructuring of rights and obligations of individuals and organisations, and redistributing wealth as a consequence. This restructuring and redistribution occurs irrespective of the policy instrument that is used to achieve the standards – regulation, emission charges, incentives or markets in emission permits. The instrument that is used will influence the precise nature of the new structure of rights and the resulting redistribution of wealth. Consequently, the issues that are canvassed in the following discussion apply whatever instrument is used to establish and enforce water quality standards.

The distribution of gains and losses among landholders of establishing a cap and trade market in phosphorus emissions is determined by the initial allocation of permits among landholders in conjunction with the standard set for water quality. Our aim of this chapter is to contribute to the discussions on the allocation of property rights by highlighting the implications of different methods of allocating permits.

6.1 Distribution of gains and losses

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

The distribution of adjustment costs between farmers and the rest of the community is also influenced by the procedure employed to distribute emission permits. Broadly speaking, permits may be allocated by sale or by gift.

6.1.1 *Allocation of emission permits by sale*

The allocation of permits by sale requires farmers to purchase permits to cover their emissions, usually through some form of auction or tender process. This approach to allocating permits may appear attractive to many as an application of the 'polluter pays principle'. The application of this principle deserves careful consideration for three reasons.

First, farmers will have experienced a diminution in their rights and an associated loss of wealth simply because of the loss of their previously unrestricted right to discharge phosphorous. This is because the restriction of their right to discharge phosphorus translates into either restrictions on their land use and income, increased production costs entailed in implementing abatement measures, or both. That is, farmers must bear the costs of either implementing abatement measures or else bear losses associated with scaling down, changing or closing enterprises. Many in the community may consider it unfair for farmers to have to purchase their initial endowment of emission permits as well as bearing these costs and losses.

Second, establishing standards for water quality places a constraint on phosphorus emissions in a catchment. That is, standards set a limit or cap to emissions in the catchment. In establishing a standard for water quality the community, at least in principle, sanctions a restricted volume of phosphorus emissions. In other words, the water quality standard defines the volume of emissions that are deemed acceptable by the community. Consequently, because farmers are discharging phosphorous within the cap they have the sanction of the community. Creating a legal right to discharge phosphorus within the constraints of the cap means the term 'polluter' – with its reprehensible connotations - is not an accurate way to describe the status of farmers as dischargers of phosphorus. Hence, the validity of applying the polluter pays principle is questionable in this context.

Third, for emission rights to be valuable the volume of emission permits available for purchase must be less than the current or anticipated rate of emissions in aggregate. This means that at least some farmers must be in a position to immediately reduce emissions as not all farmers will be able to purchase emissions permits. As noted earlier, the limited control farmers can exert over emissions of phosphorus effectively prevents them from substantially adjusting their emission rate in the short term without making highly disruptive changes in their land management. Consequently, allocating emission permits by sale becomes problematic if the allocating authority wishes to avoid imposing serious economic losses on farmers.

However, the sale of emission permits may be appropriate when the number of emission permits is being expanded. This may be appropriate if the initial allocation was found to be too restricted and additional permits were made available in confidence the water quality standard would not be breached.

We do suggest, however, that landholders be invited to tender for phosphorus disposal permits. Landholders submitting tenders would need to demonstrate a capacity to develop the infrastructure for harvesting and storing drainage flows containing phosphorus from the regional drainage network. We believe phosphorus discharge permits should be allocated by sale because these permits create new rights for landholders to discharge phosphorus into rivers in the catchment as opposed to emission permits that formalise and restrict the existing rights of farmers to discharge phosphorus.

The alternative to selling emission permits is to gift them to farmers. The method used to gift emission permits is an important determinant of the way in which adjustment costs are distributed among farmers themselves. While there are many variants, there are essentially two approaches to gifting permits – gifting on the basis of historical emissions and gifting on the basis of averaging.

6.1.2 *Allocation of permits by gifting using historical emissions*

The gifting of emission permits on the basis of historical emissions, otherwise known as 'grandfathering', means that farmers are simply given emission permits equivalent to their estimated emissions over a relevant period of time prior to the establishment of the market. The granting of emission permits on the basis of historical emissions means the introduction of the market does not require farmers to make any immediate change to the management of their enterprises. Should farmers wish to increase their emissions, to intensify their operations for example, they would need to purchase additional permits.

Gifting on the basis of historical emissions is often criticised on the grounds that farmers that have reduced their emissions by implementing best practices would receive a smaller endowment of permits than farmers that have not reduced their emissions. In other words, farmers that have implemented abatement measures in the past are 'penalised' while farmers that have not taken such socially desirable actions are 'rewarded' with greater endowment of permits. The validity of this criticism depends on a number of factors.

First, this criticism may be unjustified in circumstances where emissions were not known to create problems or where emissions were known to create problems but farmers were not expected to reduce emissions.

The validity of this criticism also depends on the extent to which abatement measures are uniform in their effectiveness and efficiency. Some farmers may have been able to implement abatement measures at relatively low cost. The cost to others of implementing similar measures may have been prohibitively high. Alternatively, the measures may be ineffective in the circumstances faced by some farmers. In some cases relatively inexpensive measures may be effective whereas in other cases only relatively expensive abatement measures would be effective.

Failure to implement abatement measures in the form of best practice does not necessarily signal then, a lack of concern for the environment or a lack of willingness to behave in a socially desirable manner. The fact that a particular farmer has not adopted best practices is not, of itself, sufficient grounds for concluding that the farmer has disregarded the rights of others, and should necessarily be allocated a smaller endowment of emission rights.

The validity of this criticism is also limited if incentives were paid to support farmers to implement best practice. To the degree that farmers did not bear the full cost of implementing best practice, and possibly obtained commercial benefit from the best practice, the farmers have already been 'rewarded' for engaging in such socially desirable actions.

Allocation of permits on the basis of historical emissions does, however, raise the issue as to how the initial allocation of permits should be reduced over time to be consistent with the emissions cap. One approach is to institute proportionate reductions in the emissions each permit allows until the aggregate volume of emissions 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 farmers.

This approach does distribute the costs of adjusting to the cap unequally among farmers. Those farmers that are least able to adjust their emissions will bear a relatively greater proportion of the adjustment costs compared to farmers that are better able to adjust their emissions.

A case might be made that the community should at least partially compensate farmers for the adjustment costs they incur 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, or using public money in an incentive program or cost share program to support farmers investing in abatement measures.

An alternative approach to adjusting the initial allocation of permits is for the catchment management authority to institute a program of purchasing emission permits from farmers until the volume of emission permits remaining in the ownership of farmers 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 farmers for the benefit of the community, the community should meet the costs of adjustment.

6.1.3 *Allocation of permits by gifting using averaging*

A second possibility when gifting emission permits is to allocate the same volume of emission rights to all farmers irrespective of their historical emissions. Allocating emission rights equally among farmers may appear attractive because it provides a mechanism for compensating, to some degree, apparent differences among farmers in terms of lost opportunities. These lost opportunities may take the form of foregone future income or a decline in asset values. For example, where emissions are correlated with farm intensification some may argue that to allocate permits on the basis of historical emissions unfairly penalises those farmers that have not yet taken the opportunity to intensify their operations.

Alternatively, allocating emission rights equally among farmers may appear attractive because it provides a mechanism for compensating, to some degree, those farmers that have implemented best practices prior to the establishment of the market. The criticisms made previously on the validity of adjusting the allocation of emission permits to reward farmers that have implemented best practice apply here.

Allocating permits by averaging has two potential disadvantages. The first is that this procedure may be politically impractical. Logically, if all farmers receive an equal share of emission permits then farmers with relatively high emissions will be required to immediately implement abatement measures or obtain additional emission permits from farmers with relatively low emissions. As argued previously, farmers may have little capacity to implement abatement measures immediately. Hence, farmers with relatively high emissions may face serious economic losses. For this reason, allocating emission permits equally among farmers may not be politically feasible.

The second disadvantage relates to the distribution of adjustment costs among farmers. If all farmers are allocated the same volume of emission permits, those farmers who face relatively high costs in reducing their emissions may be required to purchase emission permits from farmers who face relatively lower costs. Consequently, this type of allocation may serve to redistribute adjustment costs among farmers in such a way as to transfer wealth from those experiencing the greatest economic disruption to those experiencing the least economic disruption.

Note that, if compensating farmers for losses in terms of foregone opportunities is considered justified, then economic theory suggests that compensation should be made in the form of direct income payments.

6.2 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 farmers and differences among farmers in the economic return to emissions. Provided there is some variation in economic returns to emissions to farmers, and some variety among them in the cost of implementing abatement measures, then trading should occur.

The greater the degree of variability among farmers 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 milk and calves and the costs of fodder and fertiliser 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 changes in these prices over time will have differential impacts on dairy enterprises, the economic value of an emission permit will differ across enterprises.

In theory this means the price that farmers are willing to pay in order to lease or purchase an additional permit will change over time in accord with changes in their economic returns. Those farmers experiencing an increase in returns may seek to acquire additional permits to take advantage of the increase. Those farmers 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 that the greater the degree of variability in abatement costs among farmers, the greater the opportunities for the exchange of permits among farmers. Much will depend on the flexibility with which farmers 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 that act as proxies for emissions and estimated emissions as embodied in the phosphorus budgeting model will prompt the exchange of permits. As discussed earlier, modifications to the phosphorus budgeting model are likely to result in changes to estimates of farmers' emissions given the combination of agricultural inputs they are allowed by their permits. Differences among farmers in the opportunity costs of taking measures to adjust emissions relative to the prices of emission permits and contracts for phosphorus disposal, are likely to encourage some farmers to dispose of a portion of their permits and to encourage other farmers to acquire permits. The greater the sensitivity of estimates of emissions to changes in the phosphorus 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 farmers. In circumstances where farmers 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 phosphorus. 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 any individuals who are landholders and are undertaking activities that discharge phosphorus must own an emission permit. Some stakeholders may not be comfortable with tradable emission permits unless the right to possess emission permits is restricted. See Schillizzi (2003) for a further discussion of the equity issues associated with market mechanisms.

6.3 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 capacity in on-farm storages relative 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 farmers and differences among farmers in the economic return to emissions.

A key issue in the establishment of the market for disposal permits is the mechanism by which farmers owning emission permits are encouraged to enter into contracts for phosphorus disposal. This is particularly important when the market is initially established, as only a few landholders will possess the infrastructure needed to satisfy the conditions for owning a disposal permit. We suggest that the disposal market be encouraged to develop by allowing farmers to own emission permits without a contract for disposal provided they pay a levy in proportion to the volume of emissions their permit allows. The rate of the levy could be increased over time thereby rendering phosphorus emissions increasingly expensive. Farmers with emission permits who have entered a contract for disposal would be exempted from the levy. Farmers 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.

With respect to the price of disposal permits, variation in economic returns to emissions to farmers and variety among farmers in the cost of implementing abatement measures, will generate differences across sub-catchments in the premiums farmers with emission permits will pay for the disposal of phosphorus. Variations across sub-catchments in the costs of disposal infrastructure, 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 phosphorus.

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 farmers 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 farmers incur when modifying their emissions by changing agricultural practices;
- Changes in the relationships between contextual characteristics and estimated emissions as embodied in the phosphorus budgeting model;
- The allocation rule used to distribute emission permits to farmers.
- 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.

6.4 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. Farmers that are allocated permits will, in effect, be freely granted the right to discharge phosphorus within the limits of the assimilative capacity of rivers in the region. We believe that 'gifting' may be defended as compensation for the curtailing farmers' 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 farmers 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 farmer sells permits, the sale must be associated with a measurable reduction in emissions in order to proceed. Hence, for the farmer 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 farmers 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 farmers to secure windfall gains will be limited.

7. Discussion

In the introduction we observed that monitoring of rivers in the Goulburn Broken catchment indicates the current approach to reducing phosphorus emissions to target levels has been successful. However, some catchment partners are concerned the target will not continue to be achieved because drainage flows are expected to increase with a return to more customary rainfall patterns. This uncertainty is placing pressure on the partners to demonstrate improved environmental performance and to create confidence that water quality targets will be met whatever the seasonal conditions in the future.

The institution of a phosphorus emissions cap and a phosphorus disposal cap provide a reasonable degree of certainty that water quality objectives will be achieved irrespective of seasonal conditions, provided appropriate resources are devoted to ensuring compliance with the conditions of permits.

The introduction of markets in phosphorus emission and disposal permits of the type we have described creates economic incentives for farmers to invest in abatement measures such as best practices. The more restrictive the cap on phosphorus disposal compared to phosphorus emissions the higher the return to owning a disposal permit and investing in disposal infrastructure such as off river storages. Hence, the creation of markets in emission and disposal permits creates incentives for private investment in structures to store and manage phosphorus emissions.

The creation of these markets may require major investment in equipment and infrastructure to measure phosphorus concentrations in rivers. Whether this investment would be worthwhile is not clear.

The creation of these markets raises four issues that we will consider here. The first concerns the need for a market in phosphorus disposal permits.

The market in emission permits provides control over aggregate emissions of phosphorus in the long term but, of itself, does not influence the timing of emissions into rivers in the short term. 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 phosphorus emissions, so as to release emissions in line with seasonal variations in the capacity of rivers to assimilate phosphorus.

The need for a market in phosphorus disposal permits depends then on how the catchment partners view success. If they view success in terms of long term indicators, such as controlling the annual load of phosphorus emissions, then a mechanism that provides control over the timing of emissions is required. Consequently, there is no requirement to establish a market in disposal permits. If this is the case then the requirement that farmers negotiate contracts for disposal of their emission is unnecessary. Penalties for failing to comply with the conditions of emission permits would need to be suitably severe (such as forfeiture of water right for example).

However, if the partners view success in terms of short-term indicators, such as controlling the concentration of phosphorus in rivers on a weekly or monthly basis, then a mechanism that provides control over the timing of emissions is required. In this case the market in disposal permits is required.

The second issue we will consider concerns the imposition of levies or charges on phosphorus emissions at the launch of the market in emission permits. The purpose of these charges is to encourage farmers to negotiate and pay a premium for the disposal of their phosphorus emissions and thereby encourage private investment in infrastructure to intercept and manage phosphorus emissions. The issue arises as to whether such charges of themselves would be sufficient to ensure the phosphorus emission targets were achieved to the satisfaction of the catchment partners.

Emission charges appear attractive as an instrument because of their apparent simplicity. Unfortunately, emission charges are often impractical in reality (Baumol and Oates 1975; Glasbergen 1992; Stavins and Whitehead 1992). The challenge with emission charges is determining the appropriate rate of charge on emissions. In the absence of detailed information on abatement costs there will be uncertainty as to the response of farmers to the charge. If the charge is set at too low a rate then environmental standards will not be met. If the charge is set at too high a rate then economic activity is unnecessarily curtailed. Consequently, the rate at which the charge is levied would need to be raised and then subsequently lowered as the administrating authority pursues an iterative path converging on a rate that generates the target level of emissions. This may entail costly adjustments and readjustments on the part of farmers in terms of production, input mix and investments in abatement technology.

Furthermore, the emission charge would require frequent revision to accommodate changes in the volume of emissions due to the expansion or contraction of farming in response to changing economic conditions, and to allow for changes in the prices of inputs used for abatement measures. The charge would also need to be revised to accommodate changes in the volume of emissions due to changes in farming technologies and abatement technologies. This need for repeated changes in the charge in order to maintain the target level of emissions is an unattractive prospect from both an administrative and political perspective.

Baumol and Oates (1975) note that another difficulty with the introduction of a charge on emissions is that such a charge may generate substantial increases in costs to farmers relative to other policy instruments. While a system of emission charges might ensure the target level of emissions is achieved at least cost to the community, the charges themselves impose a new financial burden on farmers. The evidence suggests this charge burden can be extreme (Jacobs and Casler 1979). The political acceptability of the charge might be improved somewhat if the revenue raised from the charges was used to fund public abatement programs – an approach that has been used successfully in France (Hahn 1989).

Finally, a levy or charge on phosphorus emissions in itself does not provide a mechanism for aligning the disposal of phosphorus emissions in the short-term with variations in the capacity of rivers to assimilate phosphorus. An additional mechanism, such as a market in phosphorus disposal permits, is necessary to achieve this objective.

The third issue we will discuss 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 phosphorus emission and disposal permits can operate independently of drainage diversion licences. Although the diverters are harvesting phosphorus emissions, they are simply modifying the distribution over time of emissions at the end of the drainage network in the short term. Theoretically, the average volume of phosphorus 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 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.

The final 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 phosphorus emissions.

8. Conclusion

Regional and state policy makers are increasingly interested in finding alternative policy mechanisms for managing nutrient emissions arising from agricultural activities for many reasons. One alternative, markets in nutrient 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 emissions with the seasonal flows in rivers. Importantly, cap and trade markets also offer greater surety that permanent reductions in 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 phosphorus emission and phosphorus disposal permits for irrigated agriculture for the Goulburn Broken 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. Including the practical institutional and political issues involved in the implementation of markets. Hence, in designing the markets we have tried to take into account the biophysical and institutional realities of the region in which they could be implemented.

9. References

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