Water Pricing:
An Option for Improving Water Management in Alberta

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EXECUTIVE SUMMARY

Water pricing is a policy instrument that has potential to play a greater role in managing Alberta's water resources. The introduction of a system of administered pricing for the use of water can provide incentives for its wise use and re-use. Water pricing can influence the quantity and quality of water available, as well as influencing how this water will be used. Albertans have long experience in acquiring access to resources such as natural gas and electricity based on price-per-unit transactions. In those markets, rising and falling prices are central to allocating and rationing the use of available supplies, as compared to the use of rigid systems of seniority-based water licences to allocate water.

The challenge of implementing water pricing may be similar to that for natural gas or electricity, since water's available supply and demand fluctuate constantly, and since wholesale and retail consumers depend upon reliable access to an assured supply. Water management presents an added challenge when water has multiple uses, such as providing environmental services to society at large. The effective use of water pricing can incorporate associated environmental costs or benefits into the prices that water consumers pay, causing consumers to reduce their usage of water at times or places that are environmentally important.

This paper describes the basis for a system of administered water pricing to manage Alberta's water, including consideration of the specific policy objectives to be met and the conceptual approach for setting appropriate price levels. Prerequisites for effective use of such a price system include: 1) greater use of metering and monitoring of water withdrawals and return flows; and 2) careful consideration of the values to be placed on environmental uses of both surface water and groundwater.

Novel features of the approach proposed here include 1) the pricing of storage uses as well as of the consumptive uses of water; and 2) the option to adopt a refundable or revenue-neutral financing approach that returns fee revenues to the users while preserving users' incentives to use water efficiently.

INTRODUCTION

Water pricing is a policy instrument that has potential to play a greater role in managing Alberta's water resources, especially when compared to historical and current practice. This new approach would involve the use of government-administered prices as a key mechanism for coordinating water use decisions in the province. Whether one calls them "charges," "fees," "taxes" or "levies," attaching "prices" to the use of water can provide incentives for its wise use and re-use – even if all of the collected fees are later refunded to the users. Water pricing can influence the quantities and quality of water available, as well as influencing how this water will be used.

BACKGROUND

Over the past decade, Alberta has begun to allow the re-allocation of water rights through market-based trades. Much of the attention to water management has been directed at the South Saskatchewan River Basin (Alberta Environment 2006; Bow River Basin Council 2005) where water rights trading has been permitted, but residents of other major basins and sub-basins also have growing concerns about water allocation and water management issues.

In 2003, the province's *Water for Life* strategy (Alberta Environment 2003) provided a framework for water policy and management, including identification of the potential role to be played by economic instruments such as water pricing.

Recently, there have been growing concerns about the adequacy of surface water to meet water users' needs, and more attention has been directed at the current status and future role of the province's groundwater resources. For instance, the recent report by the Council of Canadian Academies presented a case study of groundwater management in the Athabasca oil sands (Council of Canadian Academies 2009).

The current examination of water pricing as a policy tool for Alberta also coincides with numerous other recent studies of Alberta's water allocation and transfer systems, including those that look at greater use of water markets and re-definition of historical water rights and transfer processes. See for example, Alberta Water Council (2009), Alberta Water Research Institute (2009), Droitsch and Robinson (2009), and Minister's Advisory Group (2009). Internationally, two recent reports by the Organisation for Economic Co-operation and Development describe the extent to which numerous countries have adopted pricing approaches for urban water use (OECD 2010a) as well as for the agricultural sector (OECD 2010b).

The following sections establish some objectives for a new system of water pricing in Alberta, and show how system of water allocation by price might work. First, the paper looks at the benefits of measuring users' net consumption. Second, the process by which price setting occurs is considered. Third, the issue of how to handle water revenues (that can be of critical importance to any new system that would be implemented) is discussed, and some alternatives are presented. Fourth, some operational and administrative requirements to implement a water price system are then presented, followed by brief concluding remarks.

THE OBJECTIVES OF WATER PRICING

Many people have experience with governments' efforts to design schemes for pricing (or taxing) various resources. However, it is important to separate the role and effects of water prices in raising or redistributing public revenues from their effects in signaling how, when and where water is to be supplied or used. Water prices can achieve purposes other than water management, including revenue raising, cost recovery, income redistribution, and resource valuation. Often a conflict or inconsistency can arise in designing a pricing scheme to meet more than one of these purposes at the same time.

In the examination of water pricing presented here, the principal purpose of new water prices is the improved management of Alberta's water resources. According to Hanemann, "The generic problem of water is one of matching demand with supply, of ensuring that there is water of a suitable quality at the right location and the right time, and at a cost that people can afford and are willing to pay" (Hanemann 2006).

For greater clarity, the design objective for a reform of water pricing – and the criterion against which competing alternatives can be judged – is the efficiency of water resource use. In economic terms, an allocation of water resources among diverse uses is efficient if there is no alternative way to re-allocate any of that water that can make at least one person better off without making someone else worse off. That is, given the resource base and technologies available, once all of the opportunities for welfare-improving re-allocations of water have already been taken, then the resulting pattern of water supply and use is efficient.

Managing water resources in pursuit of economic efficiency is synonymous with seeking the greatest collective return to society from water use, now and over time. This may be achieved by influencing:

1. how, where and when water will be used, in which quantities and by whom, and what will be the nature of the return flows and any effects on the ambient environment;
2. how and where water is supplied, stored and conveyed, by whom and at what cost; and
3. the investments that are made now and in future to develop and protect water resources, under current environmental conditions and climate change, both with available technology and optimal investment in new technology, and with optimal risk management.

This efficiency objective for water pricing should be interpreted to include all the ways that water adds benefit or contributes to society's general welfare, even if, in practice, these amounts are not monetized currently or are difficult to evaluate. Of course, while some costs and benefits from alternative water allocations do have associated expenditure amounts and revenue flows that are easy to measure and open to audit, the numerous costs and benefits from alternative water allocations are not reflected in observable market transactions. For example, when rates of flow in a local river support a healthy sport fishery, some of this may be observed in the economic activity associated with fishing licences, sporting goods and guiding fees. These levels of activity may go up or down and may provide a basis for economic comparison of alternative water pricing schemes or allocations. Even if the sport fishery were closed in that area, proposed changes to the state of the river and its fish populations would be viewed by many residents as either beneficial or harmful. Accordingly, these differences in the river must also form part of any analysis that seeks to define the effect of policy decisions on society overall.

Changes in numerous other river attributes need to also be part of those economic comparisons when deciding which water allocations are "best." These attributes might include the scenic value of a full versus empty river channel, changes in the productivity and resilience of established aquatic ecosystems, or changes in the water quality. In many cases, methods of non-market valuation can be employed to estimate comparable dollar amounts for these "non-market" effects. In other cases, although no precise estimates may be available, the nature and expected magnitudes of these benefits and costs will still be relevant for the purposes of designing or comparing alternative pricing policies or water management regimes.

In addition to economic efficiency, other criteria that are also important to evaluation of most proposed policy reforms include their effects on fairness within society, their budgetary cost, their capacity to generate revenue (including the likelihood of cost recovery), their administrative complexity, political acceptability, and the government's constitutional and/or legal authority to implement them.

Improved water management will be highly dependent upon the volumes of water allocated to competing consumptive and non-consumptive uses at various points in time (including water use for environmental services). New pricing schemes that promote efficient resource use will necessarily be connected with changes in the volumes of water used over time. In order for new pricing to influence individual decisions about the quantities of water to use, to store, or to supply, water pricing has to be based on measured or estimated volumes of water.

Time of use, and, in some cases, differences in water quality, should also influence the price to be charged. Therefore, any proposal to use such a pricing system will depend upon the wide-scale adoption of metering and monitoring programs. The information to be collected or estimated includes a period-by-period breakdown of gross water withdrawals, and in some cases, of the volume and quality of return flows, all at the level of individual water users.[1]

In this way, an effective system of water pricing will be different from other forms of water taxes, rates or licensing fees that are not volume-dependent. Those other schemes are mainly used to allocate the cost burden among users or to generate revenues for public or private suppliers.

One might think of the move to volumetric pricing (on a comprehensive basis for all uses) as incorporating two policy steps: 1) the decision to adopt meter usage; and 2) the decision to charge a price per unit. There is evidence that the metering step on its own can promote water conservation and increase the efficiency of water use, such as when it provides conscientious users with direct feedback about their own practices relative to recommended targets and to community norms.

1 As discussed below, an implementation strategy might include an exemption for specific uses up to some specified volume, such as a metering exemption for rural residents whose monthly withdrawals are below some threshold level.

The supplemental benefit derived from pricing per unit is due to this strategy also providing direct financial incentives.

If promoting the efficiency of resource use is the principal goal of a water policy reform, then the general argument in favour of using administered water pricing is its potential ability to:

1. Allocate quantities of water demanded to their highest-valued uses and to encourage conservation;
2. Shape the spatial and temporal pattern of water use to match supply conditions;
3. Send signals about the potential gains from further investment in capacity expansion;
4. Encourage innovation and risk-taking in water resource supply and use;
5. Raise revenues for the Province's treasury or to be dedicated specifically to augmenting such activities as sustaining the environment, the resource base and water supply infrastructure; and
6. Redistribute income among market buyers and sellers in specific ways.

Some of these effects are also associated with other economic instruments, such as the trading of short-term water allocations or long-term water entitlements.[2] One of the advantages of water pricing relative to some other economic instruments is the ability to include non-market costs and benefits explicitly in the price determination process. Suppose, for example, that two irrigators agree on a market trade of this year's water. The "price" that they agree upon will reflect the value of that water to each of the traders, but might not reflect the value of any additional effect on society of trading that water. If the point of withdrawal for the traded water volume moves upstream because of the trade, then instream flow volumes might decrease below the point of withdrawal. This trade could take away benefits from recreationalists, environmentalists or others.

The alternative process of setting an administered price (the price that will apply to the new user) can explicitly reflect the value of foreseeable recreational or environmental effects. In the example above, relative to the two users' valuations of the water to be traded, an administered price could be increased to include these "social" costs of lower instream flow volumes. In the private trade, the negotiated price is lower than with this administered price, and the associated volume of water use (and of associated instream "harm") is expected to be higher.

2 For discussion of other economic instruments, see Alberta Water Council (2009), Alberta Water Research Institute (2009), Brandes *et al.* (2008), Droitsch and Robinson (2009), Horbulyk (2005) and Mansur and Olmstead (2007).

HOW WATER PRICING WOULD WORK

The process of water pricing involves announcing the prices per-unit at which users can extract or withdraw water, where those per unit prices might change according to the volumes used, and might be accompanied by a monthly recurring charge that is independent of actual usage levels. As an example, this method of pricing is already familiar to residential water users in some cities that have metered use. Each household's water bill often shows a fixed monthly fee plus some amounts that depend on the water meter readings.

This method of allocating water is sometimes referred to as "administered pricing," to distinguish it from the negotiated pricing that results from water trading processes. With water trading, such as through a water exchange, prices are also observed for water, but instead of being set by a water agency, these prices are part of the negotiated outcome that defines each transfer between two parties.

Application and Design

In order to focus on the application and design of water prices as an allocation mechanism, the explanations that follow will proceed "as if" under a new water policy, where price alone would be used to allocate the water in some or all sectors or regions. That is, in considering the role that these prices would play, let us assume that water licences and rights under Alberta's current water allocation system are not a prerequisite for any user to purchase water under this new system of allocation by price. Indeed, an important motivation for moving to such a system is to offer a route for new and existing users to gain access to more water than allocated by their current licences. Senior licensees are also afforded full access at the going price.

There are numerous available alternatives in determining how and where water pricing would apply if it were to be the principal means of water allocation. An important choice is whether to apply pricing at one or more "wholesale" levels, upstream from the end users, and/or to apply pricing to the end users in "retail" transactions, as with residential water metering. The main pricing proposal presented here encourages the mandatory application of pricing at multiple levels in the supply chain.

Consider how this might work in the case of cities, irrigation districts and individual licensees respectively. In the case of cities and towns like those who currently hold water licences under Alberta's *Water Act*, their withdrawals would now be subject to payments under a system of water pricing that applies to all water withdrawals. However, in order to capture the strong incentive effects of pricing at the end-user level, there should also be a requirement for the city or town, as licensee, to impose a system of metering and pricing on its end users. This step will expose individual users to the monetary tradeoffs associated with water conservation, with water-saving appliances, and with water-saving landscaping practices, as examples. There is a greater likelihood of behavioural change at the user level under end-user pricing than if the city's new water-fee expenditures were passed on to residents hidden somewhere inside the residential property tax system.

Under the property tax alternative, there is no direct and observable linkage between users' water usage and their payments. Since some towns and cities already follow the practice of metering and pricing service to end-users of water, the necessary changes for them might be limited to passing on to users the new and additional cost of water prices paid by the city for its own supply.

A further mandated step in the cities' reform process might require the cities to formalize their budgeting for their own use of water – that is, when local government agencies are the end users. Once again, explicit scrutiny of these dollar amounts can serve as a strong impetus for water conservation. Currently, a significant portion of the water that some (metered) cities extract from water sources does not end up generating revenue by passing through the meters of existing customers. This "non-revenue" water may be allocated to such planned uses as firefighting, street cleaning, parks and recreation, swimming pools, golf courses, city facilities, back-flushing of water treatment processes, and so on. Some parts of this usage may be unintentional, such as water loss through leakages, water main breakage, inaccurate metering and theft. Exposing all of these water amounts to the same budgetary discipline as applies to the cities' other expenditures on utilities and supplies can provide an important opportunity to rationalize use of this water.

In the case of Alberta's irrigation districts, a key change would be the imposition of volumetric pricing on all end users of the water consumed by each district – the largest of which would be the irrigators. However, within the large geographic areas that are supplied by some districts' water conveyancing works, one will also find the wide range of water uses and users that are also present in most town and cities. As in the case of cities, the imposition of these pricing disciplines will provide strong signals to end users about the value of water conservation, as well as forcing the irrigation district to examine its own internal practices and uses of water.

Some districts have historically been more proactive than others in making investments to reduce water losses in their own water storage, conveyance and other operations. A new system of pricing can facilitate, if not necessitate, a careful look at how much of the historical water losses and potential water savings are under the control of individual irrigation district water users (as irrigators) and how much of these losses will require collective action affecting each district's common facilities and operations.

Finally, there are other users, who are not cities or irrigation districts – such as those who currently hold their own water licences. Perhaps they are small users who withdraw surface water or groundwater volumes that are low enough to be exempt from licensing. These users should also be expected to pay for water under a new pricing scheme, and on the same basis as other users. Bear in mind, the per-unit price charged for groundwater access in a confined local aquifer may be considerably different from the price charged for water withdrawals from a river that is currently highly utilized. In each case, mandatory exposure of each user to a system of metering, monitoring and pricing is a key step to encouraging changes in water use behaviour.

Precedents

The idea that a higher level of government, such as the Province of Alberta, should seek to improve water management by imposing new pricing practices on lower jurisdictions does find precedent elsewhere. For example, Article 9 of the *European Water Framework Directive* (European Parliament 2000; Chave 2001) mandates that member states will use water pricing to promote efficiency of water resource use following some specified lead-in period. Perhaps more importantly, this Directive provides a set of principles that water pricing schemes must follow when setting the price that end-users will pay for that water. As an example, the price setting process must include consideration of the environmental and resource costs that emanate from water withdrawals.

The Province of Ontario passed legislation in 2002 that would compel municipal and other jurisdictions in that province to follow certain principles and practices for water rate setting. As of June 2010, the *Ontario Sustainable Water and Sewage Systems Act* had received Royal Assent, but had never been brought into force. In 2007, Ontario decided to impose a new volumetric fee on water withdrawals by large industrial and commercial users in selected industries, provided their withdrawal rates exceed 50 cubic meters per day. The prescribed price is $3.71 per million litres of water, based on gross withdrawal volumes, with collection starting in 2009. This measure has been criticized by Ontario's Environmental Commissioner for its low coverage of water-using sectors and for being "… unlikely to create any real economic incentive for conservation – just a penny will buy almost three cubic meters of water" (Environmental Commissioner of Ontario 2008).

Pricing Net versus Gross Water Withdrawals

An important feature of the principal approach to water pricing presented here is its treatment of the distinction between gross consumption volumes and net consumption volumes. Specifically, the system of water pricing described here seeks to price the volume of water use on the basis of net consumption. Equivalently, whatever prices are to be charged per unit of gross consumption, these users will earn a credit or rebate for that portion of the water that is returned to the same watercourse. Let us briefly examine this distinction between pricing gross consumption and net consumption.

For most water users, some significant portion of the gross water withdrawals will return to the same hydrologic system for later use by other users. In the case of some cooling processes, 100% of the water returns to the water body from which it was taken, at or near the point of withdrawal. In urban uses, the percentage of wastewater return flows is high – perhaps 90%. For residential users, the share of return flows seems to have strong seasonal variation. Many outdoor water uses occur in summer with potentially high rates of evaporative loss. Water used outdoors is not recaptured by the wastewater treatment system, and only some small fraction of it may infiltrate to rejoin surface water or groundwater bodies.

Other water users (e.g., industry and agriculture) have return flows that are dictated, in many cases, by their choices of installed technology and by the way that technology is being operated. What is important for the water allocation process is to recognize that the magnitude of return flows (relative to gross withdrawals) can and will change across users, and that many users can alter the volume of return flows in response to changing economic circumstances. For example, an irrigator who is concerned about water scarcity may have the option of reducing conveyance losses (e.g., by lining canals) thereby decreasing the relative magnitude of return flows from canal seepage for a given amount of gross withdrawals.

The scarce resource to be allocated by pricing is the available water in a given watercourse. Using "net consumption" as the measure of volume to be allocated by price is the measure that most directly relates the effects of individual water use decisions to the magnitude of the available supply.[3] If diverse users purchase quantities of water at the same price, the decision to account for their collective usage based on net consumption will greatly facilitate the management of water resources at the watershed level, including the process of setting prices that allocate water efficiently.

Pricing Water Storage

Water storage can have either beneficial or harmful effects on other uses of a water system depending upon the times and places that water is removed from and returned to the system. The use of water to fill storage reservoirs for tomorrow can be a competing allocation for scarce water today, and these withdrawals should be subject to pricing on the same basis as all others. Although the recommendation to price only the net withdrawals of water could exempt some short-term uses that return all of the withdrawn water with only a short time delay, water stored for longer time periods may experience timing-related changes in its per-unit value.

The pricing practice recommended here is to charge for water withdrawals at the prevailing price at the time the water goes into storage. A credit for return flows should be granted based on the per-unit price in the period the water is returned from storage. Precipitation events and evaporative losses from some storage facilities may register them as net suppliers or net consumers of water in some seasons of the year.

The intended effect of this aspect of water pricing implementation is to offer a positive price incentive for storage practices that move water from low-valued to high-valued time periods, since the per-unit return credits will exceed the per-unit water prices paid. Conversely, storage activities that compete for water when it is high in value and return it when it is low in value will be penalized and discouraged by this pricing system.

3 The use of pricing based on net consumption implies that the use of water for cooling purposes in a system that avoids evaporative water losses will be free for these users when the quantity of (net) usage is zero. As at present, some system of permits and monitoring might still be required. This can ensure that the volume of gross water withdrawals will not cause harm to the environment or to other users, even where there is complete return of the extracted volumes.

HOW TO SET THE PRICE LEVELS

The basic idea behind administered water pricing is that the announced price level becomes an instrument by which the volume of water use can be controlled.[4] Recall, the efficiency of water use is promoted when the optimal quantity of water use is achieved. When taken as a large group (or on average) water users who understand and can see the connection between their respective level of water use and its per-unit price, will find ways to use less water when the per-unit price is relatively high (and use more water when the price is relatively low). Although sometimes the targeted quantity of water use might generate high revenues or low revenues, these revenues from the prices paid will be of secondary importance from the perspective of price setting and efficient water use. Attention should focus on using price levels to achieve the optimal volumes of water use.

A simple description of the optimal or targeted volume of water to sell is: the level at which, for the last unit sold, all of the costs to society from selling that unit equal all of the benefits to be gained from its use. Almost always, these costs and benefits from water use vary according to the specific volumes of water sold or purchased. Thus, for the final unit of water used, if there were to be either more costs than benefits (or more benefits than costs) this would be a clear sign that some other level of water use can bring more value in total and that some other level of water use should be targeted instead.

The role of administered prices, in this case, is to send a clear signal – in the form of a price per unit of net consumption – to all potential purchasers. The signal informs potential users of the collective cost to all of society from anyone using the next unit of water that is to be offered for sale. Those users who can generate more gain or benefit from using water at this price now will voluntarily pay the asking price, whereas those who would like to use the water, but not quite so keenly, will decline. In practice, many regular customers will purchase some water in each market period, and will use the price signal as a means to decide how much water to purchase each period. Thus, the administered pricing process announces a price based on costs, and individual users make water quantity choices based on their own information about the expected benefits from their intended water uses.

Unlike the case of some competing proposals for water policy reform, there is no specific ranking of priorities of uses. If someone is not willing to pay a relatively high price to use water for landscaping purposes, but another user will pay that price for irrigation, then the water goes to irrigation, without any specific attempt to categorize "irrigation" as a higher- or lower-valued use compared to "landscaping."

Consider two situations, one with relatively abundant water to allocate and the other with relatively scarce water. Suppose we are thinking of the price of water to be charged at source, without any expenses to be incurred prior to this point of sale for storage, conveyancing or treatment. In the case of relative water abundance, the estimates and calculations to be made by the price setter involve determining the cost of allowing the next unit of water to be drawn from the watercourse. It involves answering the question: "What dollar value do we give up as a society if we let that water be taken, here and now?

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4 For more detailed treatments of water pricing theory and practice see: Ayoo and Horbulyk (2008), Dinar and Saleth (2005), Griffin (2006), Olmstead and Stavins (2009), Tsur (2009) and Young and McColl (2007).

In some cases, the answer will be practically zero, since the water is relatively abundant and will flow away to Saskatchewan, Montana or the NWT if no Albertans choose to purchase it. In other cases, there may be an option to store more of this water, either in a storage structure or in an interconnected aquifer, in which case part of the cost of using it now is the foregone value of using it later. Another type of cost could include costs to the environment from reducing flow volumes or water levels from this water body.

What amount of money would society be willing to pay to see that extra acre-foot or cubic decameter of water stay in that lake or river now, thereby contributing to ecosystem and environmental productivity and function? If there are scenic values or noticeable effects on water quality, these costs should also be relevant. Where the prospective sale of more water is being contemplated, the price-setting process is based on identifying and adding up each of these sub-component costs, since each type of effect will be felt if the water is withdrawn by a purchaser. One implication of this pricing approach is that, all else being equal, the price will be higher in those locations that place a high value on instream flows directly downstream, whereas the price will be lower where instream flow values downstream are insignificant.

In the alternate situation with water that is relatively scarce, the prices to be charged will likely be highest, since for most of the costs already identified, the dollar value will trend successively higher in times of water scarcity. That is, the damage caused or cost incurred by the withdrawal of another acre-foot of net consumption is likely to be higher for a river in low flow compared to a river nearing flood stage.

A large challenge in this price-setting process is that at some point, there may simply be no more water available at any price. Consider this contrast: in times with abundant water, price setting helps to decide both how much water will be withdrawn, and who will get to use it. In times of relative scarcity (combined with high demand), there is no question that all of the available water will be used, and the only role of pricing is to allocate it among competing buyers. In this situation of "scarcity pricing," optimal price setting will resemble an auction.

Moving from wholesale to retail levels of water pricing, many cities and municipalities have already developed systems of price setting that fully reflect the capital and operating costs incurred. For them, the challenge will be to also include in their pricing mechanisms the new wholesale prices that they will also be paying as part of their cost of doing business. Nationwide, there has been some concern that a number of jurisdictions do not price their municipal water resources appropriately. In some cases, through their unwillingness to fund infrastructure replacement, these groups are able to game the fiscal system, and to set themselves up as most needy or most worthy of special grants from senior governments to address failing infrastructure or growing needs. The unintended effects of such funding might include insufficient attention to infrastructure maintenance and associated service risks to users. In other cases, the unintended effect is the overprovision of expensive capacity. That is, since there is insufficient political will to charge prices that will have a proper rationing effect – matching marginal costs and benefits – the volumes that are supplied are too large compared to the optimum. In such cases the provided infrastructure capacity is significantly more expensive to build and maintain. For more on these points see Renzetti (2009) and Water Strategy Expert Panel (2005).

Since both the supply of water and the demand for its use are dependent upon time, location and water quality, the challenge is to set prices that will allocate the available supply considering these and other characteristics. The expected outcome of the process will be water prices that apply to specific bodies of water, be they lakes, aquifers or clearly defined sections or sub-reaches of flowing rivers. Almost certainly, there will be seasonal variation in these prices, and in practice the prices could be designed to vary hourly, daily or weekly. For much of the water to be allocated, water quality concerns may not affect its value for intended uses. In those cases where the value of water quality *is* important to diverse users, this attribute could also be reflected in the structure of water prices. What should become clear is that users in diverse locations should expect to pay prices for water that are based on their local situation, and which might not be very similar at all to the prices paid elsewhere in the province. Among other consequences of such a policy is to encourage water-using firms to locate where water supplies are relatively cheaper during the period of the year when they use the most water.

The simplest cases of water pricing are those where the hydrology of the water source is well known, and where there is a basis for characterizing the amounts of water that are available for allocation in each period. The task is also made easier if the characteristics of water users and aggregate water demand are also well understood. Allocating the monthly water withdrawals from a small lake or aquifer might fit this category, provided there is a clear understanding of the levels and timing of recharge flows to each water source.

The opposite situation, where the application of water pricing is more challenging, might include areas where groundwater is under the influence of surface water in a manner that makes sustainable supplies hard to estimate. Regions with highly variable rates of surface water flow, variable weather (precipitation, evaporation, freezing-thawing cycles) and highly variable water demand will make water pricing more difficult to implement, just as, in practice, they increase the difficulty of almost all other water management efforts.

Numerous authors on this topic have cautioned that the precise determination of ideal price levels for an effective and wide-spread system of administered water pricing would be challenging – presenting administrators with an unrealistic goal. All the same, they concede that the approach can be introduced in smaller, less ambitious steps that might be accomplished more readily (Olmstead and Stavins, 2009; OECD, 2010a).

The notion of implementing such pricing schemes may be hard to visualize for water resources, but there is an opportunity to learn from the successful evolution of pricing practices for other resources. Few Albertans would be willing to jeopardize their access to electricity or home heating fuels during harsh winter weather, or to be exposed to exorbitant retail prices for these utilities, yet these are commodities whose provision to consumers is largely determined by a series of frequently changing pricing decisions.

The allocation of electricity at wholesale and retail levels by use of pricing schemes has become quite commonplace. These markets might be illustrative for water allocation, since in some situations, electricity and water share the characteristics of not being storable, and of being limited in absolute supply when and where needed. Similarly, natural gas markets shed some light on situations where there may be enough of the resource in total, but where there may be a limited capacity to move it to the point where it is most needed, due to, for example, restrictive capacity constraints in either pipelines or river channels.

One innovation from these markets is the sale of different units of the commodity with different degrees of supply reliability. Even in some cases where electricity has been sold essentially on spot markets (without elaborate multi-period contracts), some consumers have been offered lower rates in exchange for being classed as "interruptible" on short notice. This practice provides a greater degree of reliability of service to those customers who are willing to pay full prices. It reduces the likelihood that any (full) paying customers will ever be turned away due to short supply. Gas markets have provided the innovation of pricing the use of scarce pipeline capacity distinct from the commodity itself, so that in times when the ability to access the commodity at specific locations is constrained, markets can play a further role in allocating final delivery and consumption.

WHAT TO DO WITH WATER REVENUES

Perhaps the largest popular concern or political drawback to the use of allocation by pricing is the large amount of revenues that might be withdrawn from the consuming public. Not only may there be there an understandable reluctance on the part of residents to give up too much more of their disposable income in support of improved water management, there can be other unintended effects as well. For example, suppose that some watersheds or provinces charge prices that fully reflect all social costs of capital and operations, including non-market costs of environmental harms, and that other regions do not. It can quickly become apparent that businesses in the high-priced jurisdiction will be disadvantaged in trade relative to the other jurisdictions.[5]

Fortunately, provided that water users actually pay the full cost for the last units of water that are withdrawn, these users will have incentive to choose the optimal amount of water each period. Importantly, the full set of revenues collected each period does not have to be retained by government or by private water agencies. These collected revenues could be returned to the user community, provided that these users still face the correct incentives (price per unit) not to over-consume.

The notion of refundable user fees has received considerable attention in a number of environmental and resource applications, and, in principle, could be implemented at both the wholesale and retail levels. Collinge (1994) discusses the idea for residential water rates, whereas Sterner (2003) reviews broader applicability of this practice. Gersbach and Requate (2004) explore conditions under which various refund schemes promote or deter efficient behaviour by participating firms. Bernard *et al.* (2007) explore the operation of refundability when it is made to apply to some firms but where other firms pay no fees at all. Kolstad (2009) explores refundability of revenues raised through tradable permit schemes.

5 In terms of economic efficiency, broadly defined to include all non-market effects, Albertans would be collectively better off by not exporting goods at prices below full cost if those lower prices largely benefit customers elsewhere.

Consider the case of residential water use where the historical pricing system consists of a monthly fixed fee, plus a per-unit charge on all amounts used. When a city is faced with a new "wholesale" water charge per-unit of withdrawals, the city is likely to pass this straight through to its customers on a per-unit basis. If the sole purpose of a new wholesale pricing scheme were to allocate the optimal amount of water among users, and not to raise revenues, then this extra revenue is not necessary to the effective operation of the allocation-by-pricing mechanism. In this case, householders could be given a credible commitment that the new fee would be "revenue neutral" when aggregated at the city level. To make this operational, the city could be allowed to use all of the incremental payments (for the wholesale water price) to reduce the monthly fixed-fee portion of each account holder's water bill. In some months or situations, some householders could even receive a fixed subsidy, such as when the rebate amounts exceed the usual monthly fixed fee. Importantly, high water users would continue to pay more per month based on the amounts they actually consume. The incentive to conserve water would be preserved since each water user still faces a per-unit charge that reflects the full cost of using water relative to leaving it at source. With full refundability, the new fees place no financial burden on the average household.

The implementation of a fair and easy-to-explain rebate system that could work across all water-using sectors in a region at the wholesale and retail levels might take some careful thought and design. In principle, there is no reason that water pricing has to be seen as a tax, synonymous with revenue collection, since refundability of revenues is a policy option.

When discussing new collected revenues, some groups have seized upon the potential role that these funds could play if only they were devoted to specific causes related to water and the environment. Although water pricing does create such a possibility, the decision *not* to make the pricing system be revenue-neutral is essentially a positive resource taxation decision. Viewed in that light, the associated debate about how to best to use new resource tax revenues is also a separable matter of public policy – one that is not necessarily linked to the decision to use water pricing as a management tool.

OPERATIONAL REQUIREMENTS TO MANAGE WATER USE WITH PRICES

The foremost operational requirement that any agency would face in allocating all of its water by pricing is the determination of how much is for sale in each time interval in each place. An effective pricing strategy would benefit from accurate predictions of water supply and of storage and diversion possibilities. In the case of Alberta, these estimates would depend upon considerable information about groundwater and surface water hydrology and climate, but would also require careful consideration, if not resolution, of appropriate valuations of instream flow volumes on a reach-by-reach basis.

For each pricing zone that is created, there will be a need to estimate the relationship between the volumes of water used in each period and the full set of social costs from successive volumes of withdrawn water. These so-called social marginal cost schedules for water use will provide the values necessary to quote prices that effectively allocate the amounts of water that are available in each marketing period. The reliance of these cost calculations on a number of non-market effects will likely create a need for new economic data collection and statistical studies to support the estimated values (Young 2005).

Similarly, as explained by Olmstead and Stavins (2009), policymakers would need to learn more about the specific short-term and long-term responses of each group of water users to changes in water price. These responses are typically estimated by economists as short-run and long-run own-price elasticities of demand. These values describe the percentage rate at which water usage levels fall in response to each percentage by which its price increases. Elasticity estimates are important to choosing prices that will allocate available supplies, and to predicting water revenues. Since the users' actual response behaviours may be sensitive to such diverse influences as income levels and local weather, accurate numerical estimates will depend on analysis of regional data. Numerous published estimates are available from other locations, but their use may introduce considerable unpredictability about local users' responses to any new pricing regime.

In prioritizing the work to be done, clearly the most significant categories of costs and benefits in each region should be estimated first. Through the methods of "benefits transfer," it is sometimes possible to recalibrate or to update the cost schedules derived in one region to apply to other regions, such as by making corresponding adjustments in related variables such as population, income, and so on.

The need for low-cost metering technology to measure volumes and times of use has already been mentioned. Almost certainly, metering systems would have to be supported by other monitoring and enforcement programs to deter water users from illegally circumventing these allocation systems. One approach, in a lead-in phase, may be to allow for some expected or average volume of use (or of expected return flows) that is reasonably fair to those who remain unmetered. The choice of these volumes should provide a clear onus and incentive on these users to invest in actual recording and reporting equipment whenever this practice appears warranted for the costs involved.

Although effective water management already requires some understanding and measurement of return flows, this is another area that would need more attention and resources to facilitate a move to pricing on the basis of net consumption. Since users are essentially getting a full credit for their return flows, and since the nature of these return flows is vulnerable to manipulation over time, some monitoring or metering would also be needed here. Especially in the agricultural sector, some other jurisdictions have placed regulatory importance on the magnitude and quality of return flows, and may already be employing systems that perform this function at relatively low cost.

ADMINISTRATIVE REQUIREMENTS TO ENABLE WATER PRICING

There are a number of other issues that can effect how well a new pricing system could be implemented and accepted by the public at large. Some of these might be considered issues of policy, jurisdiction, or administration.

1. It is not clear how to allocate water to federal government uses and to First Nations under a system of pricing that would be operated by a province. One approach is to consider their allocations to be outside of the pricing system, so that the amounts of water to be allocated by price from any source in any region will be estimated net of these outside users' net consumption.
2. The segmentation of water sources into separate regional pricing zones will involve a tradeoff. There will be greater data and administration costs if there are more pricing zones, but there will also be greater social benefits from efficiency of resource use when local water and user conditions are more accurately reflected in the water supplies and allocations. The intended frequency of price changes is an important choice for programs administrators, and is tied to the ability of water users to stay informed of the most current prices in their areas and to respond to changes as needed.
3. For price signals to perform their role in leading diverse water users to the optimal quantities of water use requires considerable sharing of information to those users. For some decisions at the householder level (e.g., the amount of natural gas heating to use each month), the current practice for many utilities is to provide rate information to householders *after* the consumption has occurred. The householder's bill shows how per-unit rates may have fluctuated during the previous consumption period. Even if relatively few households would have known those rates in making their day-to-day gas consumption decisions, this information might guide their choices about appliance selection and thermostat settings. At the industrial scale, the operator of a hydroelectric facility or an irrigation district that is using large volumes of water would almost certainly be in a position to respond to real-time pricing information delivered electronically. Effective operation of the pricing system needs this information to be shared, and there may be considerable flexibility in how to undertake this.
4. Depending upon how clearly the pricing system can be designed and explained to users, there is likely to be some further gain from providing as much openness and transparency as possible with respect to the types of formulas, estimates and calculations that are to be used to set regional prices. There may well remain lingering concerns that some users or regions are being favoured or penalized relative to others in the prices each faces. As with, for example, utility pricing, there may be calls from users for routes to appeal price levels through the courts or through other oversight agencies.

5. Individual water users in each region may place considerably different levels of importance on price stability or price certainty. Where this is an important feature to users, it may be possible to create ways to re-assign the inherent market risk in such a pricing system from those who cannot tolerate risk to those who can. The creation of interruptible rates is one example, but there may be numerous pricing strategies, contracts or other ancillary products that can reallocate this risk in ways that benefit all users. It is clear from privatized gas and electricity markets in Canada, among others, that some consumers are willing to pay a price premium to a supplier or to a market intermediary to lock in a variable-term price guarantee rather than to contend with a higher "spot" price if one should emerge. It is conceivable that water pricing could also be augmented in this way if there is market demand for it.

CONCLUDING REMARKS

Providing a means for Alberta's water to move to its highest and best uses, broadly defined to include environmental and instream uses, is a key step in increasing the benefits that all Albertans gain from this increasingly scarce natural resource. The use of a new system of water pricing for both surface water and groundwater is one promising means to reach that objective. There are a number of important prerequisites to realizing these water outcomes, and these include careful attention to metering and monitoring, as well as to valuation of environmental and non-consumptive uses. Novel features of the approach proposed here include: 1) the pricing of storage uses as well as of consumptive uses; and 2) the option to adopt a refundable or revenue-neutral financing approach that returns fee revenues to the users.

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