Economic instruments for water management: selected Australian and Canadian case studies, and issues for application in Canada

Amy Mannix & Vic Adamowicz

University of Alberta

October 2011

SP | Sustainable Prosperity

STATE OF KNOWLEDGE REPORT

Sustainable Prosperity is a national research and policy network based at the University of Ottawa.

SP focuses on market-based approaches to build a stronger, greener, more competitive economy. It brings together business, policy and academic leaders to help innovative ideas inform policy development.

Please note that the conclusions and opinions reflected in this document do not necessarily reflect the views of SP as an organization. This report was completed in May 2010.

Sustainable Prosperity
c/o University of Ottawa
555 King Edward Ave
Ottawa, ON K1N 6N5
www.sustainableprosperity.ca

Abstract

Where carefully designed and implemented, economic instruments provide an ability to minimise the costs of conservation policies and may encourage economic gains. These possibilities apply in the cases of water conservation and water quality management, even for countries of relative water abundance such as Canada.

While water is abundant overall, within Canada there are regions that have the potential to experience water scarcity. Often this scarcity is inter-temporal in nature, that occurs when the seasonal pattern of water demands do not match the pattern of natural flow. Examples of inter-temporal scarcity issues relate to water extraction in river systems where flows are not regulated by dams or other structures, and the release of stored water for hydroelectric generation. In comparison to water quantity, water quality in Canada is perhaps of greater concern, though this in turn suggests a possible increased opportunity for economic instruments to lead to economic gains (where "gains" are defined in a broad sense, encompassing both monetary and non-monetary values).

This report presents the current state of knowledge for economic instruments applied to water management by detailing several case studies within the topics of urban water supply, basin water allocation (Lower Athabasca and the South Saskatchewan River basins in Alberta), and water quality management (South Nation River basin in Ontario). The case studies demonstrate that economic instruments are in their formative stages in Canada, with challenges among those either implemented or in the process of continuing implementation. Alongside the Canadian cases are examples that have been adopted within a country of comparatively high water scarcity and water quality concerns, Australia (Murray-Darling Basin, Hunter River Salinity Trading Scheme). Notwithstanding the key differences in the

physical environment, these Australian examples may serve to assist those interested in Canadian water management by illustrating a "learning by doing" approach in systematically identifying and addressing environmental and economic concerns.

The participatory style of governance for water management in Canada creates special challenges in the design and adoption of sophisticated policy instruments for water such as efficient pricing and markets. Collaborative efforts that recognise the benefits of technical input in ensuring efficiency and equity outcomes will be the key to the success of economic instruments in practice.

Table of Contents

Abstract ___ *iii*

Introduction ___ *1*

1.1 Structure of report ___ 4

The role of economic instruments for water management ___ *5*

Economic instruments for urban water supply ___ *7*

2.1 Introduction and design issues ___ 7

2.2 Urban water supply in Canada ___ 8

2.3 Urban water reforms in Australia ___ 11

Economic instruments for basin water allocation ___ *19*

3.1 Introduction and design issues ___ 19

3.2 Basin water allocations in Alberta ___ 20

3.2.1 South Saskatchewan River Basin ___ 20

3.2.2 Lower Athabasca River Basin ___ 27

3.3 Murray-Darling Basin in Victoria, Australia ___ 33

Economic instruments for water quality control ___ *47*

4.1 Introduction and design issues ___ 47

4.2 Offsets for water quality control in the South Nation basin ___ 48

4.3 Hunter River Salinity Trading Scheme ___ 50

Opportunities and challenges for implementation ___ *60*

Summary of key findings ___ *68*

Bibliography ___ *70*

5.1 Cited references ___ 70

5.2 Selected cited references by topic ___ 84

5.2.1 Urban water supply ___ 84

5.2.2 Basin water allocation ___ 85

5.2.3 Water quality ___ 90

Appendix A OECD (2004) recommendations ___ *93*

Appendix B Basic theory and literature review ___ *94*

B.1 Optimal water allocation ___ 94

B.2 Selection and design of economic instruments ___ 96

Appendix C Background explanatory factors ___ *104*

C.1 Climatic variability and demand characteristics ___ 104

C.2 Political economy ___ 105

List of Tables

- *Table 4-1 Characteristics of expansionary and mature phases of water economies (Randall, 1981) 37*
- *Table 5-1 River flow specifications and salinity goal in the Hunter River Salinity Trading Scheme 54*
- *Table 6-1 Barriers and lessons learned for economic instruments applied to water management (adapted from Marbek Resource Consultants and Renzetti [2005]) 65*
- *Table 8-1 Rights to the environment and selection of policy instruments (Sterner and Höglund Isaksson, 2006:96) 99*
- *Table 8-2 Normative criteria in democratic theory (Ferree et al., 2002:316) 107*
- *Table 8-3 Example statement of values and principles (Source: Murray-Darling Basin Ministerial Council [2001]). Note the principles of efficiency, full accounting and informed decision-making (the statement emphasizes participation related to the multi-state governance of the basin at that time). 108*

List of Figures

- *Figure 1-1 Water use and availability by drainage region (Statistics Canada, 2009:74) 2*
- *Figure 3-1 A potential reform menu for urban water supply in Australia (Productivity Commission, 2008:XXIII) 13*
- *Figure 3-2 Water pricing principles within the Water Industry Regulatory Order (clause 14(1)) for the State of Victoria (Essential Services Commission, 2007:8) 16*
- *Figure 3-3 Conceptual diagram of two part tariff for urban water supply, where usage charge equals marginal cost (IPART, 2008:5) 17*
- *Figure 4-1 Licensed water-use by oil sands industry from the Athabasca River (14.01 m^3/s) as a proportion of monthly statistics of flow (monthly maximum, average, median and minimum flow) below Fort McMurray, 1958 to 2004 .... 28*
- *Figure 4-2 Comparison of net cost savings of options, $ M, relative to assumed production losses in the event of water restrictions under Phase 1 of the Lower Athabasca Water Management Framework (Mannix, 2009) 31*
- *Figure 4-3 The Murray-Darling Basin (Source: Murray Darling Basin Association) 36*

- *Figure 4-4 Steps in determining the seasonal share (water allocation) in the Goulburn-Murray System in northern Victoria, Australia (Source: Goulburn-Murray Water).* ... 39
- *Figure 4-5 Water trading zones in Northern Victoria (Source: Victorian Department of Natural Resources and Environment, 2002)* ... 40
- *Figure 4-6 Seasonal water allocation and market price (in 2009 Australian dollars) for temporary transfers in the Goulburn Irrigation Area, Victoria, Australia, 1998 to 2009* ... 45
- *Figure 4-7 Seasonal water allocation and volume traded (ML/month) for temporary transfers in the Goulburn Irrigation Area, Victoria, Australia, 2002 to 2009* ... 45
- *Figure 4-8 Seasonal water allocation and the proportion of seasonal allocation transferred, by month, for temporary transfers in the Goulburn Irrigation Area, Victoria, Australia, 2002 to 2009* ... 46
- *Figure 5-1 Conceptual diagram of the river salinity – flow relationship in the Hunter River during high flow events (Smith, 2003:3)* ... 52
- *Figure 5-2 Scheme performance for 2007-2008 for the Hunter River at Singleton (Department of Environment and Climate Change NSW, 2009:3)* ... 52
- *Figure 5-3 Monthly mean salinity concentration (EC) at Singleton, 1980 to 2002 (Smith, 2003a:7)* ... 58
- *Figure 8-1 Hypothetical depiction of marginal social benefits and costs of water extraction, and optimal level of water allocation (Q*)* ... 95
- *Figure 8-2 Illustrative (hypothetical) example of relationship between shortfall of supply and demand for water in an unregulated river system with a weekly variable cap on water extraction* ... 95

Introduction

Second only to the United States, Canadians are among the highest water users in the world with an average water-use that is almost 70 per cent higher than the OECD average (Statistics Canada [2003], OECD [2008]). One might question the importance of this fact given the sheer physical abundance of water. Water *is* plentiful in Canada, for example:

- Canada has the greatest volume of water resources, both in total and renewable terms, among OECD countries (OECD, 2008)
- On an annual basis, Canada's rivers discharge 7 per cent (105 000 m^3/s) of the world's renewable water supply (Environment Canada)
- Canada has the largest wetland area in the world (Environment Canada)
- Freshwater withdrawals are in the order of 1.5 per cent of the available resource (OECD, 2004).

Although water is generally in abundance, there are regions within Canada – particularly in the Prairies – that have the potential to experience water scarcity among competing annual demands (Figure 1-1). A more common form of water scarcity is inter-temporal in nature, arising when the seasonal pattern of water demands do not synchronise with the pattern of natural flow. The issue of seasonal differences between demand and supply arises in the case of water extraction from the Athabasca River by oil-sands industry (Mannix et al. [2010], Phase 2 Framework Committee [2010]). Hydroelectricity generation produced by storing water (as opposed to run-of-river operations) may cause similar issues. Canada is the world's largest producer of hydroelectricity (Environment Canada), and in some cases this production has drastically altered the pattern of streamflows and in-stream ecology – including within Banff National Park and adjacent conservation areas (Schindler [2000], Schindler and Donahue [2005]).

Whether absolute or inter-temporal in nature, water scarcity in Canada is exacerbated by pricing policies which understate both the physical supply costs and the underlying economic costs of water (Renzetti, 2009). Even in areas where water is in abundance, the under-pricing of water and wastewater services has the perverse effect of creating unnecessary costs. These costs are due to the enhanced services and capacity of infrastructure needed to accommodate excessive water-use.

Figure 1-1 Water use and availability by drainage region (Statistics Canada, 2009:74)

Compared to water quantity issues, water quality in Canada is perhaps of greater concern. This includes the eutrophication of water bodies associated with excess nutrient inputs from agricultural lands and urban wastewater, as faced by Lake Winnipeg (Bourne et al. [2002], Hesslein et al. [2007], Chambers et al. [2001], Environment Canada [b]). Along with addressing issues of water quantity and wasteful use, economic instruments in the form of prices, markets, or similar forms or combinations, could have the potential to improve the water quality of river basins while minimising overall costs (pending empirical research).

The lack of economic instruments for water management and the under-pricing of water in Canada have been recognised for some time.

> "It is disheartening to realise that many of the arguments regarding the costs of mispricing water and the need to rationalize those prices were made as long ago as 1985"
>
> Renzetti, 2009:16

> "In a country where the public often regards water as a limitless resource and a gift of nature, the notion that water is also an economic good with social and ecological functions is not yet readily accepted. Therefore, *water management often lacks an economic information and analytic base*. Many price signals are inappropriate and *subsidisation* is pervasive…
>
> Little progress has been made to date in implementing the user pays principle, although it features in various provincial policies and is the "headline" strategy in the 1987 Federal Water Policy."
>
> OECD, 2004:70-71 (author's emphasis)[1]

[1] Refer to Appendix A for a full list of OECD (2004) recommendations for water management in Canada.

While there may be a lack of familiarity with economic instruments for water management, which this report attempts to address, clearly there are other factors of influence particular to the Canadian policy environment.

1.1 Structure of report

This report describes the potential uses of economic instruments applied to water quantity and quality issues, aimed at those with an interest in Canadian water policy.

A description of the importance of economic instruments is first provided in Section 2. The main contribution of this report then follows, in the form of an overview of selected cases of economic instruments in Canada (either implemented or under research) each presented alongside a detailed description of selected Australian case studies that address similar issues. Specific topics addressed are urban water supply (Section 3), basin water allocation (Section 4), and water quality (Section 5). The selection of Australian case studies is due to the author's direct experiences and familiarity, though more importantly due to the innovative nature of these cases in terms of the application of economic instruments. From the case studies, readers are encouraged to understand the economic issues related to water management, to become familiar with current activities that attempt to address these issues, and to consider future possibilities given the findings and developments made elsewhere. The opportunities and challenges for the application of economic instruments for water management in Canada are then described toward the end of the document (Section 6), followed by concluding remarks (Section 7).

The role of economic instruments for water management

> "Increasing the use of economic instruments [in Canada] is a *matter of urgency* in view of the need for affordable solutions and appropriate cost sharing to reduce environmental degradation"
>
> OECD, 2004:125 (author's emphasis)

> "Subsidised irrigation water and infrastructure [in Canada] do not facilitate the conservation of water resources and promotion of the efficient allocation of water between farming and other uses"
>
> OECD, 2008b:251

> "The available evidence demonstrates strongly that Canadian water agency cost-accounting and pricing-rules are inefficient. Costs are understated, and prices fail to reflect marginal costs, leading to excess consumption, overextended and undermaintained infrastructure, and stifled innovation" Renzetti, 2009:13

Economic instruments for water management are able to be designed to fit particular policy goals and market characteristics, and so come in a wide range of forms. In general, economic instruments may be price-based, or quantity-based, or some hybrid combination (Appendix B.2). A common goal of all economic instruments is economic efficiency, or – at least – cost-effectiveness, within the bounds of the policy issue to be addressed. The underlying philosophy in the choice to use economic instruments is utilitarian; that is, the basic goal is to maximise the values associated with water and its use, including the value of environmental goods and services as well as intrinsic (non-use) values, to the extent that these can be estimated. Rather than altering efficiency outcomes, other goals such as equity are likely to be best accommodated by layering an additional policy that is designed to specifically address the equity issue (e.g., rebates specific to low-income households)[2].

Economic instruments are one tool within a range of available approaches (e.g. command-and-control standards, voluntary agreements, and education methods) that may be used to reach target environmental outcomes such as water conservation goals. Economic instruments are a complement – not a substitute – to environmental regulation by assisting the management of environmental impacts on a cumulative rather than an individual basis. Compared to other methods, a clear advantage of economic instruments is that these provide the incentive for water users (or polluters, where applied to water quality) to make trade-offs by determining the net worth of water-using activities, and whether to change their behaviour so that the societal costs of water use do not exceed the value obtained from water use – a value that in general is best known by the user. The incentives to change behaviour from the use of economic instruments includes the incentive to invest (up to an efficient level) in technology improvements that may lead to increased water conservation.

The design of an economic instrument determines the costs that are faced by each water user. These costs may be designed to reflect the operation costs of providing water supply and treatment services, or may go one step further by also reflecting the costs associated with the forgone opportunity of using water for alternative uses (e.g. preserving in-stream ecology) and, in the case of water supply and wastewater treatment services, the forgone opportunity of using infrastructure funds to finance other public projects.

Naturally, the choice in using economic instruments should consider whether the total benefits outweigh the total costs, taking into account initial and ongoing costs (e.g. monitoring and administration) in comparison to alternative policy instruments.

---

[2] Refer to Appendix B.2 for a short literature review regarding the need for separate policy instruments to address each separate policy goal.

Economic instruments for urban water supply

2.1 Introduction and design issues

Urban water supply is generally defined as the water supply within municipal boundaries, that includes water supply to households as well as commercial and industrial properties.

As with other economic instruments, the basic aim is to ensure that appropriate price signals are given so that water users are encouraged to conserve water to an efficient level; that is, prices reflect the physical costs of water supply as well as the opportunity costs, including the potential to use water for alternative purposes. Without such incentives, users are not encouraged to make consumption choices that maximise the overall value obtained from the water resource, nor to ensure an efficient level of investment in technology and innovation for water-using activities.

The physical costs of water supply include water treatment and pumping, as well as costs related to the capacity profile of the pipeline distribution network and provision for replacing assets once their useable life has expired. The opportunity costs of supplying water for municipal purposes include the value of preserving in-stream flows and water quality impacts following wastewater disposal. These costs may vary with the timing of diversions and return flows, though the seasonality of downstream costs in the case of concentrated wastewater discharge may be reduced by the storage and release of basin inflows for wastewater assimilation. If water is scarce to the point of competing uses (e.g. agriculture, industrial) then the marginal benefits of the next most profitable activity would also form part of the opportunity costs of urban water supply.

The institutional design of water supply and treatment entities is highly important for creating the conditions that promote their efficient operation, acceptable service provision (e.g. related to minimisation of supply interruptions or sewerage blockages), environmental regulation (e.g. sewage overflow events, wastewater quality), and technological innovation (e.g. development of alternative supply sources, or optimisation of infrastructure networks). Similar to gas or electricity networks, urban water supply is an example of a natural monopoly as it is most efficient for there to be only one system of pipes that supplies each customer. Regardless of who supplies water (whether carried out by municipalities or government, a corporatized government entity, or otherwise), natural monopolies are subject to economic risks for which risk management strategies are required. Ideally, such strategies include the independent oversight of urban water supply backed by well-designed regulations to ensure operations are carried out in the public interest – that is, that operations are handled efficiently, prices are set fairly, and services are adequately maintained[3]. For determining a water pricing policy, it is recommended that the policy analyst carefully consider the incentives of the water supply entity for keeping prices in check both before and after a move to a user pays model, particularly with regards to wages and municipal rates.

The OECD (2010) provide a recent review of the issues for water pricing and policy challenges, including implementation issues and a rationale for second-best solutions in cases where water meters are not present.

2.2 Urban water supply in Canada

Two recent Canadian commentaries (Renzetti [2009], Coad [2009]) and an earlier international review (OECD, 2004) describe a state of affairs in which Canada by and large has not adopted water pricing practices to ensure sufficient water conservation and the sustainable upkeep of water and wastewater infrastructure.

[3] For example, England and Wales use the services of The Water Services Regulation Authority (Ofwat, http://www.ofwat.gov.uk/).

Prices are "remarkably low by international standards" (Renzetti, 2009:6), with most Canadians paying less than $0.02/litre (including both fixed and variable costs) for water and wastewater services (Coad, 2009). A recent survey of Canadian municipalities revealed that the concept of full-cost accounting "is often ignored" in pricing water and wastewater services, and that there is widespread confusion on what costs ought to be accounted for within prices – particularly with respect to long-term budgetary planning (Coad, 2009:19). Consideration of the range of service costs, including replacement cost, expansion cost, and operating cost, "is not as commonly used as one might expect", though there are several exceptions among larger cities, in particular Toronto (Coad, 2009:13). The available information indicates that prices only recover around 70 per cent of recorded expenditures, which in turn do not incorporate the full range of costs (Renzetti, 2009); for example, recorded expenditures of the regional municipality of Niagara were found to underestimate costs by in the order of 16 to 55 per cent (Renzetti and Kushner, 2004). To improve pricing practices in Canada, key recommendations by Renzetti (2009) include:

- Expanding the use of water meters
- Ensuring that water prices reflect all associated costs, and
- Peak pricing in summer in accordance with marginal costs.

Institutional design is an important precursor for creating the conditions that ensure prices are set appropriately. In most municipalities of Canada, the current process of funding water and wastewater services involves municipalities (either directly or indirectly) in revenue and investment decisions (Coad, 2009). The typical funding model is vastly different to that of other essential utility services (namely electricity and natural gas), whereby water and wastewater services are financed from a range of sources including municipal taxes, provincial or federal grants, developer fees (for new expansions), and user fees and service charges (Coad, 2009). Grants tend to be sporadic and supplied without condition for planning reform. This in turn has the perverse effect of generating over-designed, expensive assets while condoning poor planning and investment practices (Coad [2009], Renzetti [2009]).

The inefficiencies in Canada's provision of water and wastewater services are seemingly endemic:

> "Some of the simplest analytical solutions have not been implemented, have been partly implemented, or do not have clearly defined target outcomes. The barriers do not appear to be conceptual or analytical, but are most likely social, political, or cultural."
>
> (Coad, 2009:23)

An attitude among Canadians of an entitlement to water may have contributed to the inertia in adopting a user pays model (Coad, 2009:25). Access to water is commonly discussed in terms of human rights, yet concerns of equity may be overstated. Canadians are exposed to some of the lowest water tariffs among OECD countries in terms of share of disposable income (an average of 1.2 per cent) for the lowest decile of the population, and share of average net disposable income (0.3 per cent) (OECD, 2010). In surveying Canadian municipalities, Coad (2009:23) found "no evidence" of financial hardship in those areas that had adopted cost-based rates.

The planning capacity of water service providers, combined with the extensive labour needs of a participatory-style decision model, are also likely to be explanatory factors. In Alberta, there is a proposal for water-related infrastructure grants to be conditional upon the preparation of plans to undertake water conservation activities (known as Conservation, Efficiency and Productivity [CEP] plans [Alberta Water Council, 2008]). Concerns of inequities have been raised, however, due to the perceived greater burden on smaller-sized municipalities to undertake planning activities, along with excessive costs (Alberta Water Council, 2010). Even for Alberta's larger urban sector, conservation planning has required "upwards of 3000 hours of volunteer time", though this tax on human resources is apparently unavoidable:

> "...the amount of time required to engage members, create buy-in, and develop and approve the plans is substantial – particularly where there is a large sector membership...Engagement in the plan-development phase is critical to ensuring engagement during the implementation phase. Sector-members will generally resist implementing plans to which they have not had meaningful input."
>
> (Alberta Water Council, 2010:9)

The process of implementation is clearly an important factor that affects the costs relative to the benefits of water management activities, that depends in part on the socio-political context (e.g., refer to Appendix C.2).

2.3 Urban water reforms in Australia

In the majority of cases in Australia, the price of water that is charged to customers in urban areas covers the full costs of providing the water supply based on long-run marginal costs (Productivity Commission, 2008). This includes provision for future asset replacement and a rate of return on assets. Pricing reforms of this nature were completed largely in the 1990s by state-owned utilities as part of a range of national reforms that aimed to improve the competitiveness of the Australian economy (Productivity Commission, 2008). Water prices are set based on financial costs, rather than in response to market signals, and progressive levels of compulsory restrictions are invoked in response to water scarcity.

The Australian pricing structure combined with quantity controls is of concern to economists given that it may not adequately reflect the economic cost of water to customers – including environmental and other costs associated with water scarcity – nor differentiate between customers who differ in their value of water used for discretionary purposes when water is scarce. Water prices that are based on financial rather than economic costs increase the potential for unwise investment choices. A financial pricing structure is unlikely to provide sufficient incentives for investment in water-saving technology and supply augmentation, nor behavioural change by households and firms, and does not provide sufficient incentives to urban water suppliers to consider alternative, cost-effective means of augmenting supply (Productivity Commission, 2008). While there are economic barriers to markets for urban water and sufficient competition due to natural monopoly aspects, the challenges for the reform of this sector is similar to those for the provision of telecommunications, rail, electricity and natural gas services (Productivity Commission, 2008).

The potential reform options for urban water supply in comparison to the current centralised model (Figure 3-1) were considered in a scoping report by the Productivity Commission (2008), an independent economic advisor of the Australian government[4]. While detailed investigation of each option is necessary, and their implementation may require gradual change in some cases, the Commission envisions the possibility of "a competitive urban water market (with appropriate regulation of monopoly elements of the supply chain) involving many retailers and wholesalers with different price-service-security offerings" (Productivity Commission, 2008:xxiv). Some reforms have already occurred, for example in Sydney and Melbourne, government water supply corporations have been separated into wholesale and retail entities, wholesale and retail prices are independently regulated, and Melbourne has recently transferred water from a rural northern basin to augment its water supply and service urban growth. Additional reforms (Figure 3-1) may not only allow efficient choices to be made at the consumer level, but could reduce the overall costs of water supply provision by

[4] For further information on this organisation, refer to the quick guide (Productivity Commission, 2008a) and history (Productivity Commission, 2003) publications of the Commission. The broad political influence of the organisation is discussed in Banks (2005).

reducing the likelihood of poor investment decisions at the expense of users and taxpayers (Productivity Commission, 2008). In hindsight, the use of more effective institutional models for urban water supply may have assisted in avoiding recent decisions to augment the supply of several large cities using desalination technology, the decision and timing for which appears to have been made at an inordinate expense to Australian taxpayers (Grafton et al., 2008).

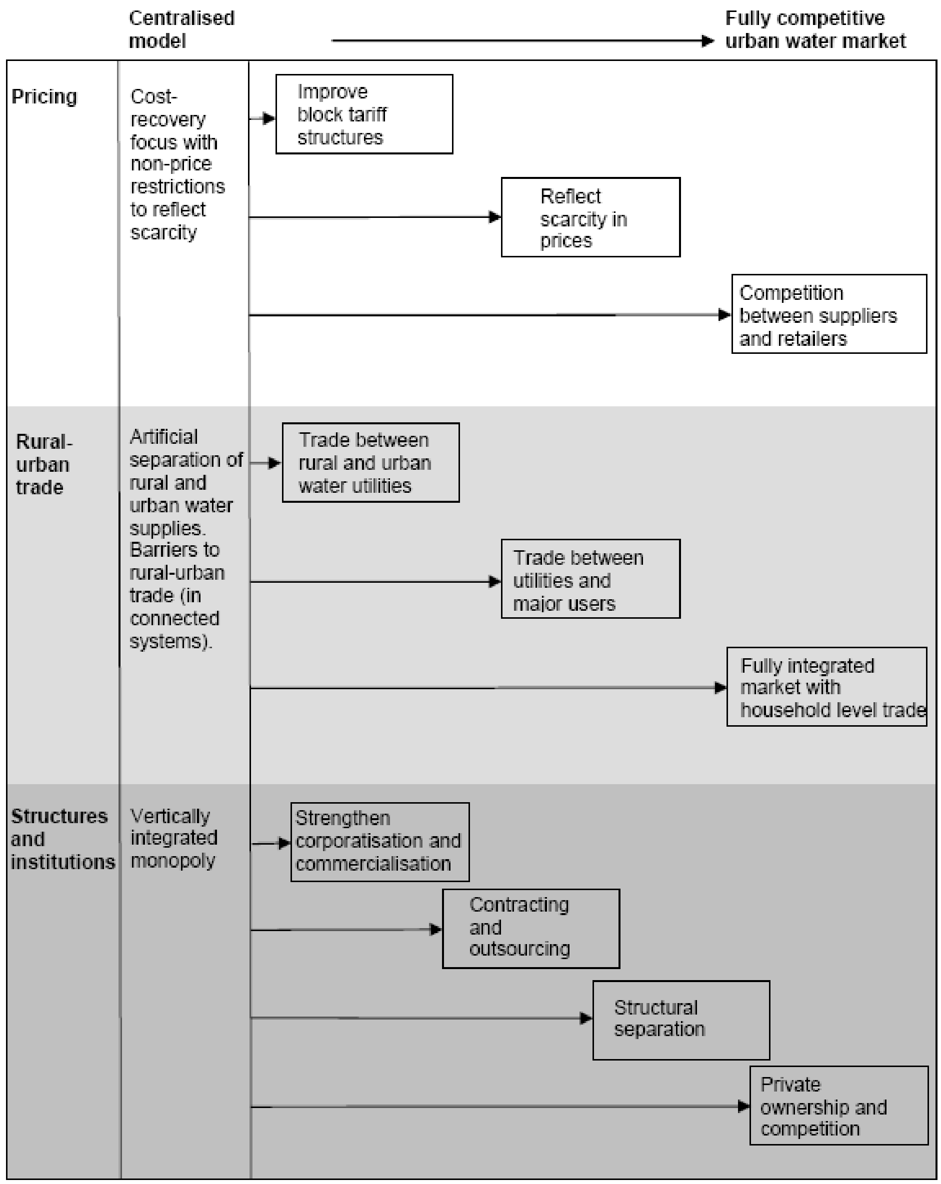

Figure 3-1 A potential reform menu for urban water supply in Australia (Productivity Commission, 2008:XXIII)

Scarcity pricing is a new option that has received some initial consideration by the independent regulators of water prices in New South Wales and Victoria, known (in respective order) as the Independent Pricing and Regulatory Tribunal (IPART) and the Essential Services Commission (ESC). In the near term, IPART (2009) recognises the potential for scarcity pricing to be used between the wholesale (Sydney Catchment Authority) and retail (Sydney Water) urban water supply entities. This potential could be in the form of wholesale prices that reflect the scarcity value of water held in storage along with the costs of water capture, storage and supply (IPART, 2009). Such prices would provide a signal to retailers of when to invest in water conservation and instigate demand management actions, and would encourage innovation in supply while also allowing new water suppliers to enter the wholesale market (IPART, 2009). The value assigned to water scarcity would need to be set independently by the regulator, using a formula that sets prices which vary inversely with dam levels and that depends on factors such as “the adequacy of existing water storage infrastructure, the cost of augmenting water supplies and the importance that society places on not running out of essential water” (IPART, 2009:133).

At the retail level, IPART (2009) considers scarcity pricing to have the potential to complement water restrictions rather than to replace restrictions. This limitation is due to indications of a low response by consumers to price fluctuations (IPART [2003], Grafton and Ward [2007] and Warner [1996] in IPART [2009]) and the apparent high degree of public support for ongoing compulsory restrictions (IPART, 2009). Price fluctuations may be high: an initial study of scarcity pricing in Sydney indicates that price increases of between 62 per cent and 143 per cent are needed to achieve the same residential demand as that achieved under Level 3 water restrictions (O’Dea and Cooper, 2008); though price fluctuation in itself is not of concern from an economic perspective given its function of balancing short-run supply with demand (Grafton and Kompas, 2007). An additional issue is the desire for price changes to target only discretionary levels of water use, which in turn may be difficult to set and administer given variations in household size and shared metering arrangements for some customers (e.g. apartment buildings).

In Victoria, scarcity pricing to balance short-run marginal costs has received cursory consideration within a recent review of water tariff structures (Essential Services Commission, 2007). An initial position is that innovative pricing models are encouraged if these meet certain decision principles (Figure 3-2), and provided implementation issues can be overcome (Essential Services Commission, 2007). Such pricing would reflect the opportunity cost of water in storage, that in turn is based on the option value of conserving stored water for the future and deferring or avoiding the costs associated with finding additional water supplies and/or water restrictions (Essential Services Commission, 2007). Scarcity pricing could be used as a substitute for water restrictions to some extent, and so would reduce the efficiency costs of restrictions (Essential Services Commission, 2007) that nationwide appear to be in the order of several billion dollars (Productivity Commission, 2008). Given price increases may be highly variable, non-price measures e.g. restrictions and education, may be “more effective than high prices in changing consumer behaviour in the short term”, and there may be additional issues with regards to consumer understanding, the high costs for consumers in monitoring prices, and administrative costs of implementation (Essential Services Commission, 2007:64).

The Essential Services Commission of Victoria is to be satisfied that prices are set so as to:

(i) Provide for a sustainable revenue stream to the regulated entity that nonetheless does not reflect monopoly rents and or inefficient expenditure by the regulated entity;

(ii) Allow the regulated entity to recover its operational, maintenance and administrative costs

(iii) Allow the regulated entity to recover its expenditure on renewing and rehabilitating existing assets

(iv) Allow the regulated entity to recover:

- **a.** a rate of return on assets as at 1 July 2004 that are valued in a manner determined by, or at an amount otherwise specified by, the Minister at any time before 1 July 2004
- **b.** all costs associated with existing debt incurred to finance expenditure prior to 1 July 2006, in a manner determined by the Minister at any time before 1 July 2006

(v) Allow the regulated entity to recover a rate of return on investments made after 1 July 2004 to augment existing assets or construct new assets

(vi) Provide incentives for the sustainable use of Victoria's water resources by providing appropriate signals to water users about:

- **a.** The costs of providing services, including costs associated with future supplies and periods of peak demands and or restricted supply; and
- **b.** Choices regarding alternative supplies for different purposes.

(vii) Take into account the interests of customers of the regulated entity, including low income and vulnerable customers

(viii) Provide the regulated entity with incentives to pursue efficiency improvements and to promote the sustainable use of Victoria's water resources; and

(ix) Enable customers or potential customers of the regulated entity to readily understand the prices charged by the regulated entity for prescribed services, or the manner in which such prices are to be calculated or otherwise determined.

Figure 3-2 Water pricing principles within the Water Industry Regulatory Order (clause 14(1)) for the State of Victoria (Essential Services Commission, 2007:8)

It is generally accepted that the most efficient pricing structure for urban water supply is a two-part tariff, consisting of a single volumetric price that reflects the marginal cost of water use, and a fixed service charge to recover the fixed costs of supply (e.g., $P_{MC\ fc}$ at point c in Figure 3-3). Scarcity prices that only target the discretionary water-use of households, and not water use which is considered essential, would result in volumetric prices that exhibit an inclining block tariff rather than a single volumetric price. In general, an inclining block tariff is *not* considered efficient due to cross-subsidisation between the two defined levels of water use (Productivity Commission, 2008). While it may not be optimal from an economic perspective, an inclining block tariff was introduced in 2005 to individually-metered residential customers in Sydney due to a range of reasons that included the potential to reduce demand (IPART [2004] in O'Dea and Cooper [2008]). However, the use of inclining block tariffs in Sydney and Melbourne while water restrictions were in effect has been shown to have had only a minor impact on total demand (O'Dea and Cooper [2008], City West Water [2007a] in Essential Services Commission [2007]).

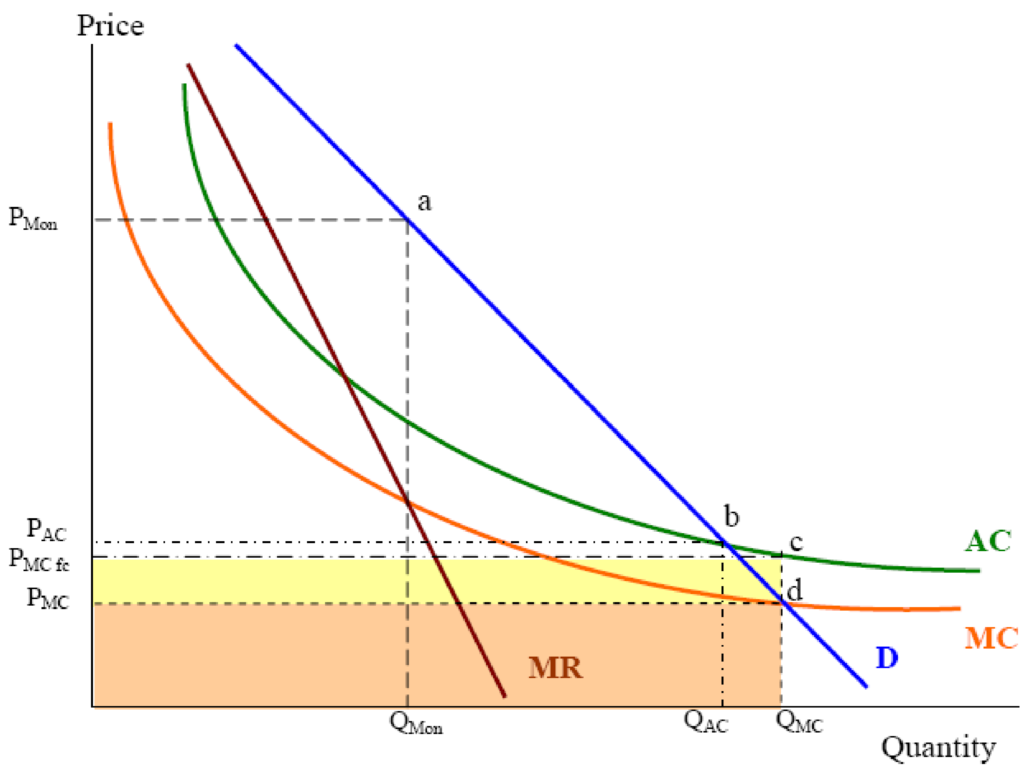

Figure 3-3 Conceptual diagram of two part tariff for urban water supply, where usage charge equals marginal cost (IPART, 2008:5)

The treatment of equity concerns for urban water supply is subject to ongoing debate in Australia. The use of inclining block tariffs as a means to target only discretionary water-use has been questioned given this creates the expense of reduced water-use efficiency, when social concerns may be better addressed by taxation or welfare arrangements (e.g., relief from fixed charges for water supply) that specifically target low-income customers rather than applying to all customers (Productivity Commission, 2008). On this matter, it has been questioned why water is subject to special policy treatment on the grounds of its fundamental human needs status, when markets and pricing approaches are commonplace for many other goods and services of a similarly essential nature, such as food, accommodation, and heating (Productivity Commission, 2008)[5]. Although prices during times of shortage may rise by more than 50 per cent under a scarcity pricing regime (Grafton and Kompas, 2007), the overall impact on low-income households may only be minor. A survey across all states and territories in 2003-04 indicated that for the 20 per cent of households with the lowest gross incomes, average weekly spending on water and sewerage charges ranged from 0.19 per cent in Tasmania to 1.4 per cent in the Australian Capital Territory (ABS, in Productivity Commission, 2008). Further, while restriction policies that affect all may be seemingly equitable, the use of prices rather than restrictions could likewise be deemed fair from the point of view that the valuation of impacts would be equally distributed across all consumers. For example, it could be argued that restriction policies unfairly target those households that prefer to limit their indoor water-use in favour of garden use, and that garden users may unfairly suffer a greater perceived loss due to water restrictions compared to those households that use large quantities for indoor use (Productivity Commission, 2008).

[5] A short literature review of the potential economic and institutional reasons for preferring quantity versus price controls in the provision of water is provided by Byrnes et al. (2006).

Economic instruments for basin water allocation

3.1 Introduction and design issues

Economic instruments for basin water allocation are only likely to be adopted in areas where water is sufficiently scarce (refer to Figure 1-1), which typically coincides with regions where the total water demand is dominated by agriculture (e.g., see Alberta Environment [2007]). As such, economic instruments by necessity must include the irrigated agriculture sector[6].

Similar to urban water supply, the design of an economic instrument for basin water allocation should ensure that water users are aware of the opportunity costs of their water use, including the forgone opportunity of transferring water to elsewhere. Water prices are a possible method to convey incentives that promote economic efficiency; however estimating prices that enable efficiency will be subject to information constraints. Water markets allow the "invisible hand" to determine the appropriate level of incentives, as expressed by market prices[7]. The design choices of a market include the method of accounting for environmental demands along different river reaches (e.g. see Bjornlund [2010]), and the treatment of different water-use sectors including municipal uses.

A market in itself will not guarantee that the allocation of licensed water-use will be efficient. Risk management is required to mitigate the range of potential sources of market failure; if these cannot be adequately dealt with, then markets may not be suitable and other forms of policy instruments may perform better. For example, if there are only a small number of water users,

[6] As previously, water-use efficiency in relation to agriculture is based on the concept of economic efficiency, which is distinctly different to the concept of irrigation efficiency. For example, if water is in high demand, it may be economically efficient to reduce irrigation levels and in turn restrict plant growth to obtain the maximum economic value from the water available.

[7] There are differences in the efficiency outcomes of prices and markets – for example, in cases of uncertainty in benefits and costs, and exogeneous technology change (refer to Appendix B.2).

or licences are not similarly specified, then there is the risk that a water market will be thin and/or unbalanced, leading to fewer trades and less efficient water-use than otherwise. Underlying subsidies may also be an important factor. Similar to urban water supply systems (Section 3.1), the use of full-cost accounting for irrigation districts requires the inclusion of the long-run replacement costs of supply assets including headworks (dams located in the upper catchments operated for irrigation supply purposes), whose costs may comprise a sizeable portion of the full costs of supply within an irrigation district.

3.2 Basin water allocations in Alberta

3.2.1 South Saskatchewan River Basin

Under Alberta's *Water Act (1996)*, water licences may be transferred (i.e., exchanged between a willing buyer and a willing seller) where transfers are enabled under an approved water management plan. The South Saskatchewan Water Management Plan was approved in 2006 and provides the ability for water transfers in the South Saskatchewan River basin (Alberta Environment, 2006). Since this time, a small number of transfers have occurred, though an active and open market in the form of many buyers and sellers has not developed – even though new water licences are no longer available from the government. This lack of market development does not appear to be due to an absence of potential buyers, but rather an absence of potential sellers. Apart from a lack of market activity, there are other important factors that risk the overall efficiency of a market solution applied to the South Saskatchewan River basin.

Sources of market failure for the transfer of licensed water-use include the complex licensing and transfer arrangements in Alberta, and difficulties in accessing information. During times of water scarcity, licensees are allocated water under the prioritised system of "first in time, first in right". That is, allocation is in order of the licensed date of priority (based on the submission date of the original licence application), and those holding a water licence with an earlier date are able to obtain their full licensed volume (subject to licence terms and conditions) before the next in order is granted access[8]. The heterogeneity of licences and their associated water supply risk may not be well understood by licensees, and valuation is difficult as there have been few trades to date with no requirement for price disclosure. There is no guarantee that a sale will go ahead once buyers and sellers have been located as transfers may only be approved if there are no adverse effects to other users or the environment (*Water Act*, s.82(3)). These information issues are confounded by uncertainty regarding use rights. This includes the return or discharge of the non-consumptive portion of licensed allocations, the obligation for which may be unclear within the terms of licences (Alberta Water Council, 2010).

Rights are also unclear in relation to stored water in the upper catchments, whether operated by government or by private firm for hydroelectricity purposes. The operation of storage alters the inter-temporal pattern of flow and so can have major impacts on the water supply of downstream licensees and the aquatic habitat. Some storage areas, particularly those that are privately operated, may not have an operation plan in place that would otherwise seek to balance the needs of competing uses, such as those of water supply, flood protection, environmental impacts, wastewater assimilation, and hydroelectricity generation. In the case of the Bow River sub-basin, hydroelectric generation in the upper catchment area has dramatically altered the diurnal pattern of flow and moderately altered the seasonal pattern of flow, with corresponding ecological impacts[9].

[8] In contrast, parts of the Australian Murray-Darling Basin (Section 4.3) uses a shared or proportional system of allocation, in which licence shares are granted an equal proportion of the stock of water available that is held in upstream dams.

[9] Schindler and Donahue (2005:21) describe that the flows in the upper Bow River, between the Cascade River and the Bearspaw Dam, "fluctuate rapidly, sometimes several times a day, to

Market imbalance and restrictive governance arrangements are further potential sources of market failure. The majority (84 per cent) of licensed water-use in the South Saskatchewan basin is allocated to the irrigated agricultural sector (Alberta Environment, 2007). Irrigation allocations are predominantly in the form of large, senior licences held by irrigation districts that foster market imbalance and the potential for inefficiencies due to uncompetitive behaviour on the part of senior licensees. The lack of potential sellers among the irrigation districts is a function of the *Irrigation Districts Act* (revised in 1999). Licences are held by the district – not individual irrigators within the district – and a transfer of licensed water-use requires the support of 50 per cent of irrigation district members via a plebiscite[10]. The requirement is similar for the expansion of an irrigation district beyond its current limits. In both cases, there are weak incentives for district members to support a motion to either sell water or expand in area, as each member does not directly receive the proceeds from either decision but may perceive a loss in the security of their water supply[11]. Similar issues also arise from the behaviour of other major licensees. The City of Calgary holds several licences and uses less than half its licensed volume, and is actively seeking to reduce the average water consumption of its citizens (City of Calgary, 2008). The City has not sold its excess licences though has been involved in the preparation of scoping studies for commercial agreements to

---

facilitate adjustments in electricity supply to changing demands…this makes the reach fairly inhospitable as habitat for riparian animals and fish". In addition to upstream impacts, hydroelectric generation provides indirect benefits from the winter dilution of wastewater discharged by the City of Calgary, as well as the potential for water quality impacts due to the attenuation of high flows in summer (linked to excessive macrophyte growth [Sosiak, 2002] that in turn reduces the availability of dissolved oxygen to sustain other forms of aquatic life).

[10] Within a district, water access is linked to land ownership, and water transfers within a district may only occur via the transfer of "assessed acres" between one farm to another.

[11] Nicol et al. (2008) report that concern for water availability during times of drought is stated by irrigators as a key reason for adopting improved irrigation technologies and management practices.

supply water to nearby areas (Calgary Regional Partnership, 2007), indicating either highly risk averse behaviour and/or a reluctance or inability to dissipate market power by the separation of water allocation from water supply. These examples suggest that there are significant impediments to economic development related to water use in the basin, while also raising concerns regarding equity.

The behaviour of senior licensees may in part be explained by the treatment of unused water allocations. The *Water Act* allows for the cancellation of unused licences (s.55(1)(f)), and the transfer of unused portions of licences is generally not permitted given the potential for adverse effects[12]. In practice, the threat of licence cancellation encourages greater water-use within existing licences, as confirmed by the following statements:

> "As an irrigation district, we are concerned that [outside interests] are following irrigation district water licences and diversions very closely and we suspect that if current irrigation water licences are not utilised to their potential, they may eventually be in jeopardy.
>
> By the LNID [Lethbridge Northern Irrigation District] expanding its irrigation limits, it is showing the government regulators that the LNID fully intends to be using its current licensed withdrawal amounts."
>
> Lethbridge Northern Irrigation District (2010:10)

> "The Board is very serious about [expansion] and would like to start the process…The reason for [expansion] is that we have become much more efficient as an irrigation district with all the pipelines we have installed, and water users have become so much more efficient with all the low pressure pivots they have bought…Government is inclined to think more with the "use it or lose it'" approach. We think we should

[12] This requirement raises inconsistencies as a transfer of licensed water-use, by definition, is only possible if the water would not otherwise be used by the original licensee.

use it…the demand [for new irrigation acres via district expansion] is two or three times the supply."

Bow River Irrigation District (2009:5)

There is considerable scope within existing licences for increased water-use similar to the above examples [13]. Apart from the perceived threat of licence cancellation, a water market signals a shadow value for licensed water-use that was previously unapparent, and so may similarly encourage increases in water use.

The potential for greater use of existing licences in turn increases the (likely unanticipated) risk of water restriction of junior licensees, and/or reduces the availability of flow that would otherwise remain in-stream to sustain environmental values and to meet the downstream flow commitments with the province of Saskatchewan. These impacts are not fully protected or planned for under existing governance arrangements. The South Saskatchewan Water Management Plan (Alberta Environment, 2006) sets a water conservation objective of 45 per cent, representing the target proportion of the natural flow to remain in-stream for environmental purposes. This target is aspirational in nature and is not enforceable, though its achievement in practice generally requires that actual water-use is held constant (or reduced) in water scarce zones of the basin. Enforcement of environmental impacts is possible, however, on an individual licensee basis via licence terms that limit diversions according to in-stream flow conditions (referred to as "in-stream objectives"), though these are not consistently specified due to entrenched rights (Alberta Environment, 2003)[14], the level

[13] In 2005, actual water-use in the basin was 56 per cent of licensed water-use (Alberta Environment, 2007).

[14] The entrenched nature of rights may be more perceived than actual. While licence terms vary depending on their date of issue, many enable their adjustment in response to changing social and/or environmental circumstances (including those of senior licences e.g., the Eastern and Western irrigation districts).

of protection is generally significantly lower than the water conservation objective[15], and the method itself is a further source of licence heterogeneity. The combination of in-stream objectives and full licensed water-use within existing licences has the potential to create frequent water restrictions in the South Saskatchewan basin (Alberta Environment, 2003). For example, if in-stream objectives are actively enforced and there is sufficient demand to fully utilise existing licences, water balance modelling indicates that junior allocations and commitments in the Bow River sub-basin would be subject to "frequent, substantial deficits", in-stream objectives "are frequently not met" or are frequently reduced to threshold levels in the Bow River sub-basin, while junior allocations in the Oldman River sub-basin would have "frequent, substantial deficits" (Alberta Environment, 2003:17-18).

In addition to economic concerns regarding market inactivity, the status of unused allocations, and the level of protection of junior rights and environmental values, there is also doubt as to whether a market is capable of efficient outcomes given that the full costs of the system are not recovered from users. Irrigation districts have similar issues to urban water supply (Section 3) in terms of a lack of metering of individual water-users and the recovery of all costs from users to enable the sustainable upkeep of existing infrastructure. Farmers within an irrigation district in southern Alberta are charged a flat-rate for water and are subject to an upper limit on water usage per acre. The largest irrigation district in Alberta in terms of water licence held and volume supplied, the Eastern Irrigation District[16], is a lone

[15] An extreme example is the senior licence (1903 priority) of the Eastern Irrigation District, that enables water to be diverted for use when flows are as low as 2.83 m^3/s along the lower reach of the Bow River (Alberta Environment, 2003). Note that this rate is one-fourteenth (1/14) the instream objective applicable to nearby downstream licensees (Alberta Environment, 2003).

[16] The Eastern Irrigation District supplied 257 500 acre feet or approximately 320 gigalitres to irrigated farms and diverted a total of 409 400 acre feet in 2008, with a gross water licence allocation of 762 000 acre feet. To provide perspective, the total volume diverted by the Eastern Irrigation District in 2008 is approximately 15 per cent greater than all existing and approved surface water licences held by oil sands operations in the Athabasca basin (Mannix et al., 2010).

exception as it has provided water at no cost to irrigators since 2003 due to revenues received from oil and gas activities (Government of Alberta [2009], Eastern Irrigation District [2008]). The cost of infrastructure renewal in all irrigation districts is highly subsidised, with government paying 75 per cent of costs under the Irrigation Rehabilitation Program (Government of Alberta, 2010)[17]. Given that the full costs of the water supply are not passed on to irrigators, the financial incentives for an irrigator to conserve water primarily arise from the costs of power for pumping water[18]. The effect of subsidies for irrigation district infrastructure results in greater irrigation demand than otherwise, and a reduced willingness to sell licensed water-use.

The Eastern Irrigation District receives water diverted from the Bow River that has an average annual flow much lower than that of the Athabasca River (Alberta Environment, 2007).

Note also that the St Mary Irrigation District is larger than the Eastern Irrigation District on an areal basis, though has a much lower water usage. Interestingly, this district charges the highest annual water rates in Alberta (Government of Alberta, 2009) that may include charges for infrastructure replacement given that the amortisation of assets are listed within its financial reports (Meyers Norris Penny, 2009).

[17] The government's contribution was originally and continues to be explained to be based on the indirect economic benefits of irrigation – i.e., the economic multiplier effects of irrigation activity (Rogers [1966] in Irrigation Water Management Study Committee [2002], Freeman [1994] in Ring [2006]). Such justification is questionable from an economic perspective (e.g. refer to Marsden Jacob Associates, 2005) as it assumes that there are ample labour and capital at the provincial level, and is unlikely to have taken into account the indirect economic costs (i.e., opportunity costs of financing alternative projects, including [to be even-handed] their associated multipliers) such that the net indirect economic benefits are likely to be significantly lower than claimed. The cost-sharing justification is likely also out of date given more recent estimates of the economic contribution of irrigation to the economy (e.g. Irrigation Water Management Study Committee, 2002). Note that the Eastern Irrigation District, which provides water at no cost to irrigators, received $5.6 million under the Irrigation Rehabilitation Program in 2008, and has approximately 25 per cent of its infrastructure yet to be upgraded (Government of Alberta, 2009). Since its inception in 1969, the Government of Alberta has contributed $750 million to the Irrigation Rehabilitation Program, an additional $175 million has been provided by irrigators (Swihart, 2010).

[18] A survey of farmers reveals that the decision to invest in on-farm infrastructure that may in turn lead to water conservation is largely based on profit concerns, including improved crop yield or quality, or to reduce the costs of energy or labour, with water conservation in itself being of incidental importance (Nicol et al., 2008).

Subsidies for on-farm irrigation infrastructure may also lead to increased irrigation demands rather than the net conservation of water (Nicol et al., 2008) in cases where districts are able to expand and/or utilise licensed water-use that was previously earmarked as return flow[19]. Ultimately, such subsidies may in part be paid for by potential buyers of licences (e.g., municipalities without sufficient water licences) due to higher prices, with less transfers occurring than otherwise. This suggests a reduced economic value of water use compared to a case in which subsidies are no longer provided.

3.2.2 Lower Athabasca River Basin

The stakes for water management in Canada are perhaps nowhere higher than in the oil sands. In the lower Athabasca River basin of northern Alberta, significant planning has been carried out to set aside a minimum proportion of the in-stream flow from the available water supply of the oil-sands industry. Limits on the extraction of surface water by industry are set as part of Phase 1 of the Lower Athabasca Water Management Framework (Alberta Environment and Fisheries and Oceans Canada, 2007)[20]. These limits are designed to reduce water availability when the in-stream flow is low in comparison to the historic record. The design of an economic instrument to manage water conservation in the oil sands should ideally reflect the water demand and supply situation that is unique to the lower Athabasca region. This situation is described below based on a recent analysis by Mannix (2009)[21].

[19] The greatest potential for water conservation is unlikely to be from further investment in expensive on-farm infrastructure, but from relatively inexpensive improvements in water management practices such as soil monitoring and automated irrigation (Nicol et al., 2008).

[20] Phase 2 is due to be released later in 2010.

[21] Analysis carried out as part of MSc thesis, supervised by C. Dridi and W. L. Adamowicz. See also Mannix et al. (2010) for summary statistics of the availability of water supply.

Unlike basins in southern Alberta that have on-stream dams that regulate flow, the seasonal pattern of flow in the Athabasca River is reasonably natural, and the in-stream ecology is most susceptible to water extractions when flows are at their lowest during winter (Phase 2 Framework Committee, 2010). Relative to the implied 55 per cent water-use target of the South Saskatchewan River basin (Alberta Environment, 2006), the approved average licensed water-use of oil sands operations is low compared to the range in seasonal flow of the Athabasca River – particularly during summer (Figure 4-1)[22].

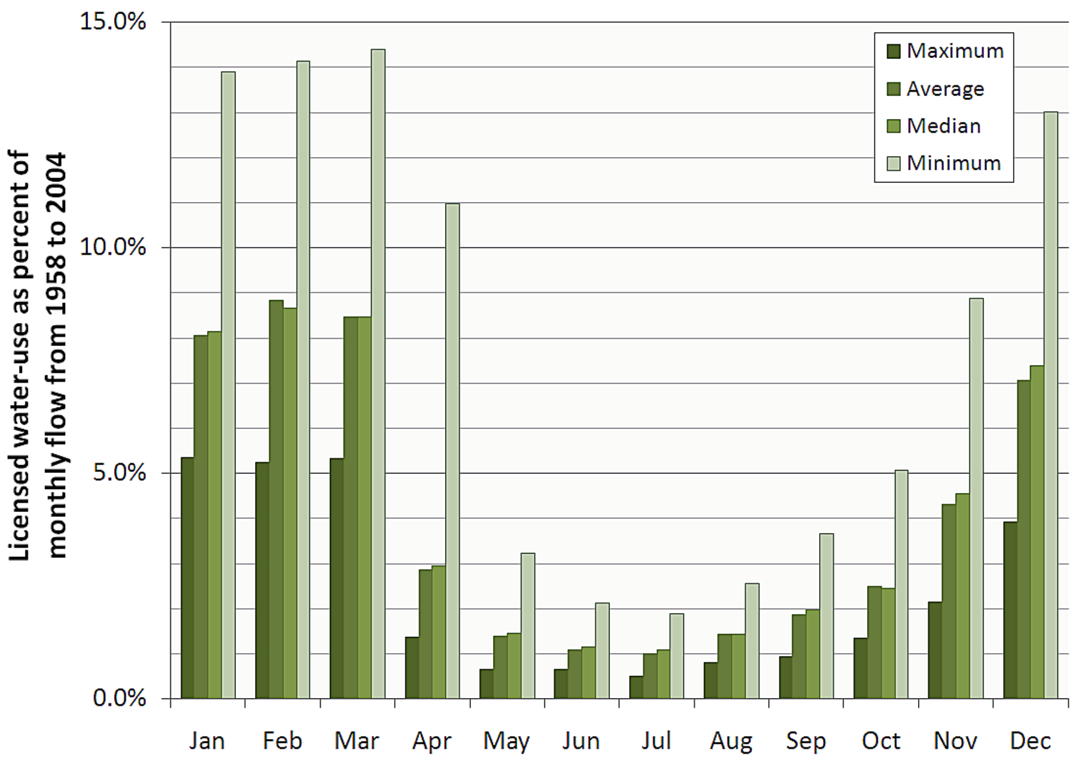

Figure 4-1 Licensed water-use by oil sands industry from the Athabasca River (14.01 m^3/s) as a proportion of monthly statistics of flow (monthly maximum, average, median and minimum flow) below Fort McMurray, 1958 to 2004

[22] Note that there would be differences in environmental values and the potential environmental responses to water conservation between the Athabasca River and the South Saskatchewan River basins; combined with water demand factors this would result in different targets for water conservation (if set based on economic efficiency) between the two basins.

Although there is not an approved water management plan in the Athabasca River basin and so permanent water transfers are not available, temporary agreements to assign water among licensees are available under the *Water Act* (s.33). These agreements have been used by the oil-sands industry for the first seasons of implementation of the water management framework. Each agreement to assign water is prepared in advance of the winter, low-flow period and outlines the allocation of water among firms in case of water scarcity. In practice, the agreements have allocated water that would not otherwise be used by senior licensees, with the expectation that junior operators will mitigate their supply risk by constructing off-stream storage (Athabasca Regional Issues Working Group, 2007).

Using the limits of the Phase 1 framework, and assuming a base case of a 10 per cent reduction in the historic weekly flow, it was found that industrial water demands would need to be above 7.5 m^3/s before shortfalls may occur. This is approximately double the average water-use in 2008 of 3.6 m^3/s (pers. comm., Alberta Environment). As water restrictions appear unlikely in the short term, a future water demand scenario[23] was used to consider the potential costs of water restrictions to the oil sands industry, and options to reduce these costs. The options were assessed relative to the usual policy of water allocation in order of licence seniority.

The options analysed were:

- A **market-based policy option** that directs water to those operations that use the least amount of river water to produce a barrel of oil. This option may be in the form of water trade assuming perfect competition, or an efficient pricing mechanism.

[23] Future demand scenario based on a medium-term (e.g., 2020) demand of 12.2 m^3/s, combined with a 10 per cent reduction in background flows.

- A shared **off-stream storage** that enables a constant water supply to industry by storing water when river water is in surplus (i.e., when river extractions are not restricted by the Phase 1 framework).
- Recovery of wastewater stored in mature-fine tailings via **tailings consolidation** technology, combined with increased water recycling (using reverse osmosis water treatment) so that the demands for river water are reduced.
- **Combinations of the above** options i.e., the policy option combined with either technology option (storage, or consolidated tailings and increased recycling).

The analysis assumed that water shortages would reduce oil production in the same proportion as the degree of restriction (i.e., linear demands). Based on this assumption, all options analysed were found to reduce the costs of water restrictions (Figure 4-2). Overall it was found that a combined policy-technology approach would encourage cost minimisation and provide ongoing incentives to optimise water-use efficiency. Storage was estimated to be the most cost-effective as it can be sized to avoid costly interruptions in oil production. It also creates more efficient water-use by timing water extraction to coincide with periods when environmental impacts are lower. However, storage does not provide ongoing incentives to increase water-use efficiency in the sense of lowering the average volume of river water that is required to produce a barrel of oil. This is because there are few costs faced by industry (e.g. in the form of shadow costs) if an off-stream storage is filled during times when there is surplus flow.

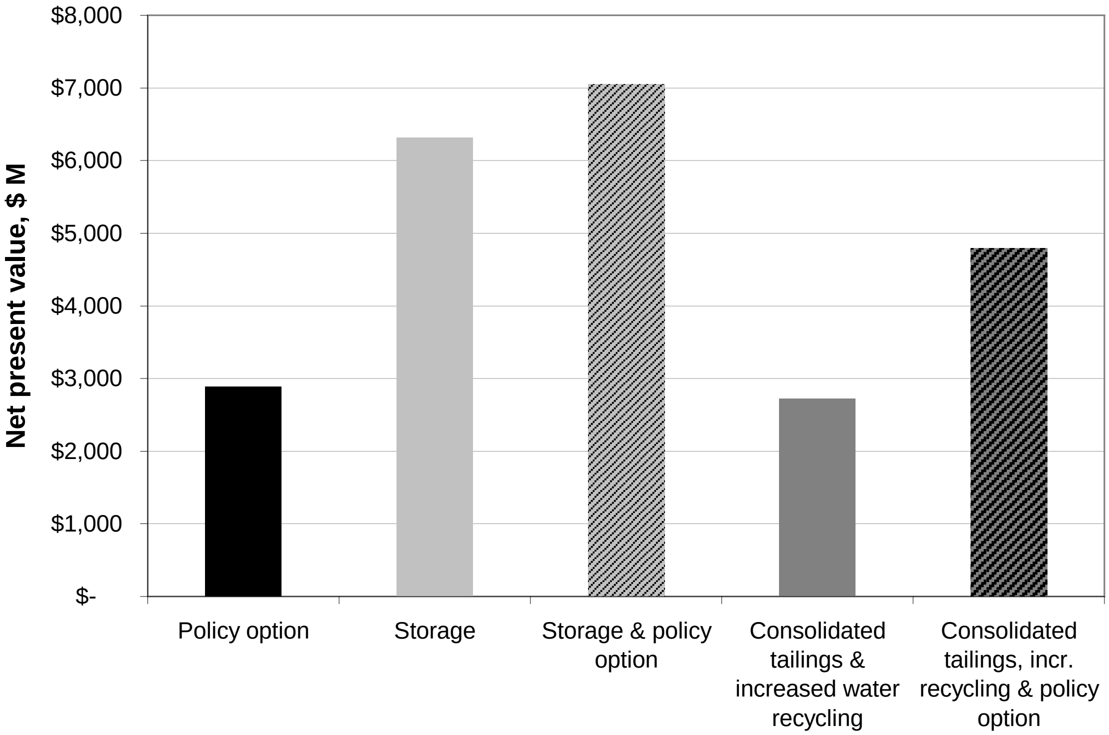

Figure 4-2 Comparison of net cost savings of options, $ M, relative to assumed production losses in the event of water restrictions under Phase 1 of the Lower Athabasca Water Management Framework (Mannix, 2009)

As for the results of other options, enabling water transfers would assist in reallocating water during times of restriction to its most productive use, but may not induce increases in water-use efficiency at other times. An alternative would be to impose a charge on water extractions, possibly in conjunction with the refunding of collected fees (to be more amenable to industry). For example, a refund can be designed to reward oil-sands operators that use the least amount of river water to produce a barrel of oil, though this in turn may reduce the willingness of industry to share information and experiences (especially in relation to indistinct technology that is not covered by patents)[24]. Similar to water transfers, if a market-based policy option in the form of a pricing with refund system is only designed to address the temporary water scarcities that arise as a result of

[24] The sharing of information among firms may be particularly important in the oil sands given the unique nature of the resource and the technology used for its extraction.

the framework, then this does not provide an incentive to increase water-use efficiency at other times. To provide incentives that reflect the environmental costs of river water extraction across all periods, prices for water could be set which fluctuate according to the conditions of the framework (e.g., greater costs for water extraction during “red” flow conditions, mid-range costs for “yellow” flow conditions, and lower costs for “green” flow conditions), with congestion pricing or reliance on licensed quantities when there is insufficient water supply to meet all demands.

Recent developments suggest that some of the options may already be in progress. Several junior licensees plan to construct private on-site storage (AECOM, Imperial Oil [2006]), and recent tailings regulation (ERCB, 2009) may encourage greater water re-use, possibly involving consolidated tailings or similar technology. Phase 2 of the water management framework is expected to be announced later in 2010. For Phase 2, industry stakeholders have indicated their preference to continue with annual agreements to assign water, and that temporary transfers be allowed (Phase 2 Framework Committee, 2010). Even if both of these industry preferences are accepted, there may still be unfulfilled opportunities for reducing the costs of water restrictions due to market imbalance (few senior licensees), a lack of market disclosure in terms of prices and volumes either transferred or assigned, and barriers to the entry of new firms. Due to the high stakes, the opportunity costs of a revised water conservation policy require careful consideration. An important reminder is that if there is a desire to achieve economic efficiency, then the marginal costs to industry of an additional unit of conserved water should be similar in value to the marginal social benefits of an additional unit of in-stream flow.

3.3 Murray-Darling Basin in Victoria, Australia

The majority of Australia's irrigated agricultural production (and water use in general) occurs in the Murray-Darling Basin, which has an area similar in size to Canada's province of Ontario. The Murray-Darling Basin overlies four states: Queensland, New South Wales, Victoria, and South Australia; and one territory: the Australian Capital Territory (Figure 4-3). The southern bank of the River Murray designates the State border between Victoria and New South Wales. Under the River Murray Waters Agreement (1915), the rights to water are apportioned to the states as follows:

- Flows at Albury, the first major town from an upstream to downstream direction along the River Murray, are shared equally between New South Wales and Victoria
- Tributaries downstream of Albury to the River Murray are controlled by the state in which the tributary lies
- Victoria and New South Wales are to supply a minimum quantity of water to South Australia[25].

While water management has evolved separately in each state and territory of the basin, and so each has variations in terms of how water entitlements are specified, differences may be lessened in the future given that the responsibility for water governance was ceded from state governments to the federal government in 2004 under the National Water Initiative[26].

Similar to water quantity, the responsibility for ensuring adequate water *quality* in the Murray-Darling Basin is shared between the state governments of the basin, though ultimate responsibility was transferred to the federal

---

[25] Given this minimum quantity, water allocation to South Australia could be considered to have a basis of prior appropriation rather than riparian rights (Quiggan, 2001), and so has some similarity with water rights arrangements in the western regions of North America.

[26] Subject to legal challenge involving the State Government of Victoria at the time of writing.

government in 2008 (*Water Act 2007*). As first described in the 1988 Salinity and Drainage Strategy (Murray-Darling Basin Ministerial Council, 1988), a target upper concentration for river salinity (to be achieved 95 per cent of the time under defined benchmark conditions) is set at 800 EC (μS/cm). This target is based on an objective to improve water quality for all beneficial uses, including water use for agriculture, the environment, municipalities, industry and recreation. The target salinity concentration is measured in the River Murray at the downstream town of Morgan, in South Australia, which is located just upstream of the pipeline off-takes for the water supply to the state capital of Adelaide. A key element of the original Salinity and Drainage Strategy was a cap on the salinity impacts of new actions by New South Wales and Victoria at 1988 levels i.e., actions that have a salinity impact must be offset so that the total salinity impacts attributable to each State are maintained at or below their salinity impact as at 1st January 1988. South Australia is also responsible for its own salinity impacts as at 1st January 1988, while Queensland is held accountable for salinity impacts as at 1st January 2000. Each state monitors and reports annually on their progress in meeting these targets, including the maintenance of the "A" Register that lists the salt disposal entitlements or salinity impact credits applicable to each state (equal to the surplus salinity concentrations below that of the 1988 cap). The Basin Salinity Management Strategy 2001-2015 (Murray-Darling Basin Ministerial Council, 2001) includes additional accountabilities by State governments in the form of a "B" Register to track progress in meeting salinity impacts associated with historic developments (referred to as "legacy of history" impacts).

The historic evolution of water management in the Murray-Darling Basin in terms of water allocation and economic considerations is described by Quiggan (2001). Since the late 1980s, the water economy of the Murray-Darling Basin can be considered to have largely completed the transition from an expansionary phase to a mature phase (Quiggan, 2001) – both of which are described in general terms in Table 4-1 (from Randall [1981]). Such transitions may be accompanied by the persistence of policies introduced during the earlier, expansionary phase, including subsidies for water use (Quiggan, 2001). Though rural water users in the Murray-Darling Basin are charged the full infrastructure costs of water delivery, including the costs of operation, maintenance, administration, tax and interest (covering both irrigation district infrastructure and headworks)[27], subsidies still persist and economic benefits could be derived from further reforms – such as introducing charges to rural water-users for a return on assets (as done for the urban sector), and allowing water to be transferred between rural and urban water-users (Productivity Commission, 2008).

[27] Refer to Parker and Speed (2010) for a description of agricultural water pricing in Australia, including methodology, the levels of cost recovery across the various irrigation areas, and challenges and lessons learned on regulation and micro-economic reform.

Figure 4-3 The Murray-Darling Basin (Source: Murray Darling Basin Association[28])

[28] http://kids.mdbc.gov.au/__data/page/75/Basin_Map.pdf (accessed 27/8/09)

Table 4-1 Characteristics of expansionary and mature phases of water economies (Randall, 1981)

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

With recognition of the potential for new licences to increase water scarcity and further impact river health[29], surface-water extractions in the Murray-Darling Basin were subject to an interim cap in 1995 and were permanently capped in 1997 [30]. The cap restricts water use in each season based on the water diversions that would have occurred at the 1993-1994 level of development (including infrastructure and management rules), and so the

[29] Illustrated by a basin-wide audit of water use (Murray-Darling Basin Ministerial Council, 1995).

[30] Following an independent review of related implementation and equity issues (Independent Audit Group, 1996).

cap varies depending on the seasonal climate and hydrology[31]. Other prominent features of the basin from an economic perspective include the water share announcement regime, water entitlement specification, and the facilitation of an active water market. The remainder of this case study discusses these features with a focus on recent developments in Victoria[32].

Unlike water allocations in the western regions of North America, which are commonly based on a prioritised system of first-in-time first-in-right, the management of allocations in the Murray-Darling Basin (MDB) is predominately based on a *shared* system of allocation, within which different classes of licences (grouped by water supply risk) have developed[33]. Possible contextual factors related to the development of this shared system include a basis of riparian rights in Victoria and New South Wales, the history of irrigation development[34], the extreme variability of the hydrology (McMahon et al., 1987), Australian governance norms (e.g., top-down management) and egalitarian social preferences (see also Appendix C.2). Similar to other systems, licences for water use in Victoria may be specified in terms of an annual volume (subject to an announced share), and may include restrictions on the timing of use e.g., irrigation districts do not supply water during the winter period. The shared element of the system applies to licensed volumes for irrigation purposes in certain areas, which are subject

---

[31] See Schedule F, Murray-Darling Basin Agreement for further details: http://www2.mdbc.gov.au/__data/page/86/Schedule_F_MDBA.pdf (accessed 4/12/2009).

[32] For a more detailed description of rural water-use in Australia and the role of markets, including a review of policies to address third-party impacts such as storage carryover, refer to Productivity Commission (2006). Young (2010) provides a summary of lessons learned from the reform of agricultural water-use in Australia.

[33] See Productivity Commission (2003a) for a detailed summary of water rights in Australia with comparisons to selected international case studies.

[34] Irrigation development occurred with an emphasis on supply-side management and settlement schemes in irrigation districts, including for retired soldiers, with development driven by government rather than private investment. Refer to Barr (2005:82) for a brief description of the history of irrigation in Victoria.

to an applicable share depending on the type of licence (e.g. high security or low security) and the seasonal conditions relevant to the supply location of the licence (Figure 4-4). In northern Victoria, water licences are grouped into various segments and districts of the basin (Figure 4-5), which each have separate share announcements based on flow variability and the total volume of licences held. Two classes of water entitlements are available: (i) a high-security licence, specified in the Goulburn system as being able to be supplied in full in 97 years out of 100 [35], and (ii) a low-security licence, available in years when the water supply is relatively plentiful.

Basic steps for determining the share of water available to licensees

1. Determine the volume of water available for allocation, equal to:

Volume held in storage

less Upfront commitments, including losses (e.g. seepage and evaporation) associated with water storage and delivery, supply to urban licences, environmental flows, and storage carryover where permitted.

2. Divide the total volume of water available (step 1) by the total volume of irrigation licences that are supplied by the system.

Expressed as a percentage, this is the seasonal water allocation. The percent share is applied to the licensed volume of each licence in order to determine the volume available for actual use in that season.

For example, under a share announcement of 80 per cent, a licensee holding a 100 ML water licence would only be permitted to divert 80 ML in that season.

3. Announce the share allocation.

4. Reassess the share allocation during regular intervals. (The share announcement will likely increase during the season as a result of rainfall-runoff events within the storage catchments.)

Figure 4-4 Steps in determining the seasonal share (water allocation) in the Goulburn-Murray System in northern Victoria, Australia (Source: Goulburn-Murray Water).

[35] See Goulburn-Murray Water website: http://www.g-mwater.com.au/water-resources/allocations/how-seasonal-allocations-work/security_of_supply (accessed 13/12/2009)

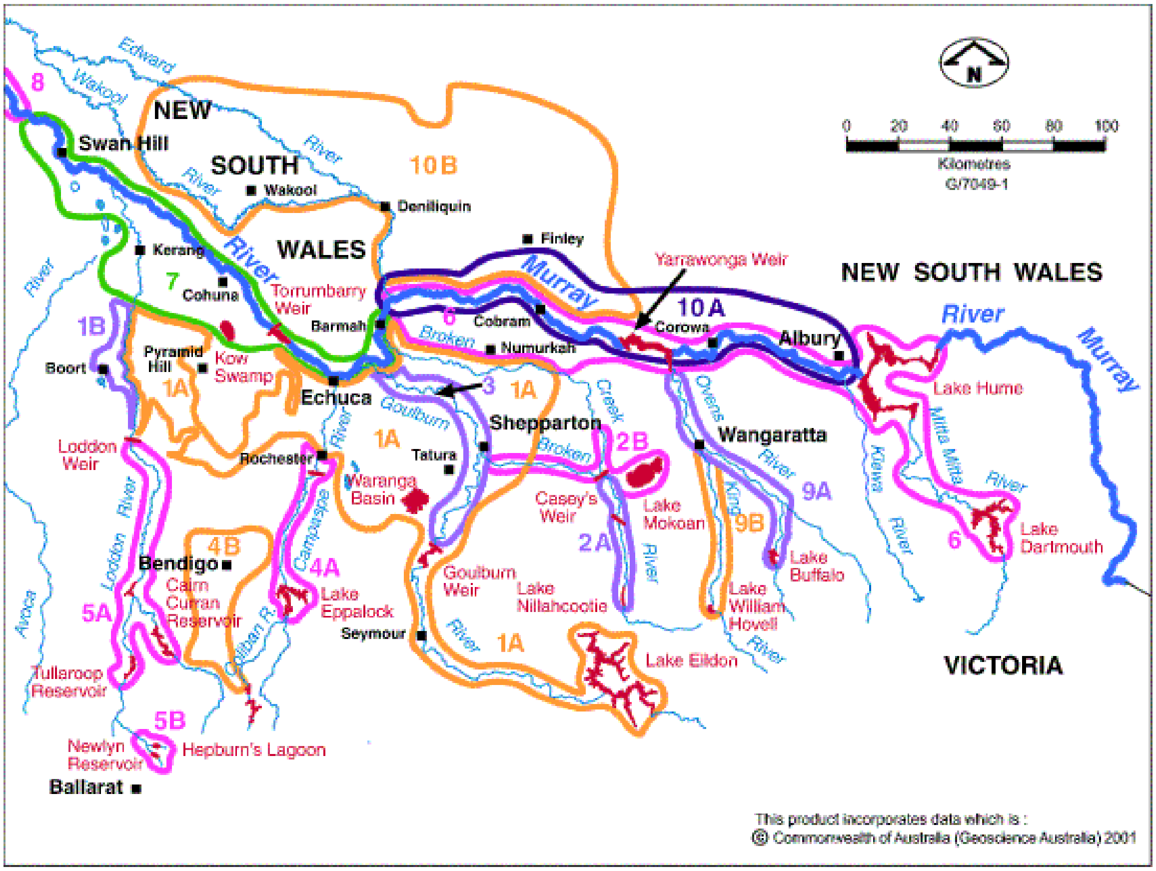

Figure 4-5 Water trading zones in Northern Victoria (Source: Victorian Department of Natural Resources and Environment, 2002[36])

Compared to water allocation based on either the prior appropriation or prior allocation systems, water trade occurring under a shared system of allocation is prone to third-party effects; recent developments in the specification of licences in Victoria have followed from the identification and assessment of significant third-party impacts[37]. Water trade in northern Victoria has largely occurred in a downstream direction, which in previous

[36] http://www.watermove.com.au/tradingzoneprofile.asp?trdng_zone_id=1 (accessed 2007)

[37] Randall (1981) provided an early prediction of many of the third-party effects of water trade that have since eventuated.

years resulted in a switch in the location of the water source[38], which in turn altered the water security of licences (that are specified differently in each system) and risked exceeding the delivery capacity of the new source during peak demand periods. Transfers between different source locations are now managed by specifying licences according to a common framework[39], tagging water entitlements as belonging to their original source of supply, and separating water shares from delivery shares (see below), so that the overall water availability to licences and water access is controlled within a more stable property rights framework. For transfers between regulated and unregulated systems, there are trading ratios (based on estimated water losses) and limitations on upstream transfers in effect that similarly ensure that the system maintains its reliability of supply and is accountable from a hydrologic perspective.

Even with these controls, significant third party impacts linked to the cap and trade system have continued to occur. The previous lack of property rights in northern Victoria for the carryover of stored water between seasons (due to a centralised storage policy), combined with the development of an interregional water market that increases the incentives for water use within the current season, has led to a reduction in stored water and thus an erosion in the reliability of supply – so much so that economic losses from interregional water trade are estimated to exceed gains (Brennan, 2008). The introduction of a limited ability to carryover storage[40] is expected to somewhat alleviate this impact (Brennan, 2008). Insufficient planning

[38] Water trade has occurred typically from the Goulburn (1A) system to the downstream Murray system (8), as shown in Figure 4-5.

[39] This includes the separate specification of a tradeable low-security water right, that was previously allocated as discretionary “sales” water to those holding permanent water entitlements in the Goulburn-Murray system.

[40] Details of carryover rules are available from Goulburn-Murray Water (2007) and Goulburn-Murray Water (2009).

controls associated with the conjunctive use of surface and groundwater resources have also created unforeseen impacts. In concept, surface water and groundwater resources may be up to 100 per cent interchangeable albeit with significant time lags in the case of groundwater (Evans, 2007). The setting of a basin cap on surface-water supplies without sufficient control of groundwater resources has inadvertently led to a double counting of water resources that in turn undermines the overall risk to water supplies (Evans, 2007).

The potential third-party impacts of water trade, including those arising from supply capacity constraints and abandoned irrigation district infrastructure (Heaney et al. [2006], Roper et al. [2006]), were contributing factors for the "unbundling" of water licences in Victoria in mid-2007. The unbundling process clarified the entitlements associated with water licences into the following three components:

- A **water share**, which may be either a high-reliability or a low-reliability share. A water share is linked to the announcement of seasonal allocations, which together specify the amount of water available for diversion during a season.
- A **delivery share**, which provides a share of the available capacity of the water delivery network and is linked to the location of the water diversion. The delivery share obligates the holder to contribute to the operation and maintenance of the delivery system.
- A site **water-use licence**, that is attached to land and outlines site-use conditions, limits and responsibilities, such as those related to groundwater infiltration, drainage disposal, land and water salinisation, biodiversity, and other schemes designed to minimise the cumulative environmental impacts of water use.

The recent changes in the specification of licences in Victoria have been accompanied by changes in legislation designed to evenly spread the risks of climate change or other long-term impacts on water availability (including bushfires) between licensees and the environment (*Water Act 1989* no. 80, s. 22B-22J). These changes allow the State Government to adjust the amount of water available (as part of the determination of water shares) every 15 years, without compensation, if warranted based on the results of an open review process that involves expert assessment.

Other policy developments linked to enabling water transfers include efforts to encourage interregional transfers[41] and minimise transaction costs. This includes the provision of market information with the use of internet trading[42], and reduced waiting periods for administrative approvals. Under the federal *Water Act 2007*, the Australian Competition and Consumer Commission (ACCC) is responsible for providing advice on water market and rural water delivery fees in the Murray-Darling Basin, as well as for monitoring compliance and enforcement[43]. Plans are also underway to develop a national water register and exchange[44]. Apart from basic water transfers, the market appears to have sufficiently matured to enable other transfer mechanisms such as the use of option contracts (Bjornlund and Rossini, 2008). Option contracts that activate when the seasonal water availability drops below a specified level have assisted in recent transfers between perennial and annual crop farmers (pers. comm., Stuart Whitten, 27/11/2009), and have been considered as a concept for environmental flow provision (Hafi et al., 2005) and more generally in terms of a futures market (SFE Corporation Limited, 2005).

---

[41] The estimated economic benefits of removing barriers to intra and inter-regional water trade in the Murray-Darling Basin are described by Peterson et al. (2005) and Qureshi et al. (2006).

[42] Watermove (www.watermove.com.au) is the platform for water trade in northern Victoria.

[43] Refer to the ACCC website (www.accc.gov.au) for updates.

[44] http://www.climatechange.gov.au/en/minister/wong/2009/media-releases/November/mr20091109.aspx (accessed 1 December 2009)

Water trading has been active in Victoria since the mid-1990s (Department of Natural Resources and Environment, 2001) and has assisted in the transformation of regional economies – both in Victoria and elsewhere in the Murray-Darling Basin (Bureau of Transport and Regional Economics, 2003). The considerable efforts undertaken to create functioning water markets have generated substantial gains: during the recent prolonged and severe drought, when end-of-season water shares in northern Victoria were in the order of 30 per cent, participation in the water market has managed to prevent the widespread loss of high-value horticultural crops that might otherwise have led to dire flow-on impacts to regional economies (pers. comm., Stuart Whitten, 27/11/2009). The ability of the market to allocate water to relatively high-value crops when water is scarce is indicated by the historically high prices for water obtained during times of low seasonal allocation (Figure 4-6), and larger volumes traded when water is scarce (Figure 4-7, Figure 4-8)[45]. While severe water scarcity has been an important motivation for the recent reforms, the development of water markets and associated policies such as efficient pricing have occurred over several decades. National leadership in driving economic reform across all sectors (not only water) played a highly-important role[46].

[45] Brennan (2006), Bjornlund and Rossini (2007), and Appels et al. (2004) together provide a range of information that assists in explaining the observed water prices (Figure 4-6) and trading volumes (Figure 4-7, Figure 4-8).

[46] Significant changes to the water sector were initiated when the water supply was relatively plentiful, that followed a series of broad policy measures led by the Federal Government in the early 1990s. Banks (2005) provides a summary of the history and breadth of economic reforms over this period, with a focus on the institutional context that facilitated an informed policy-making environment.

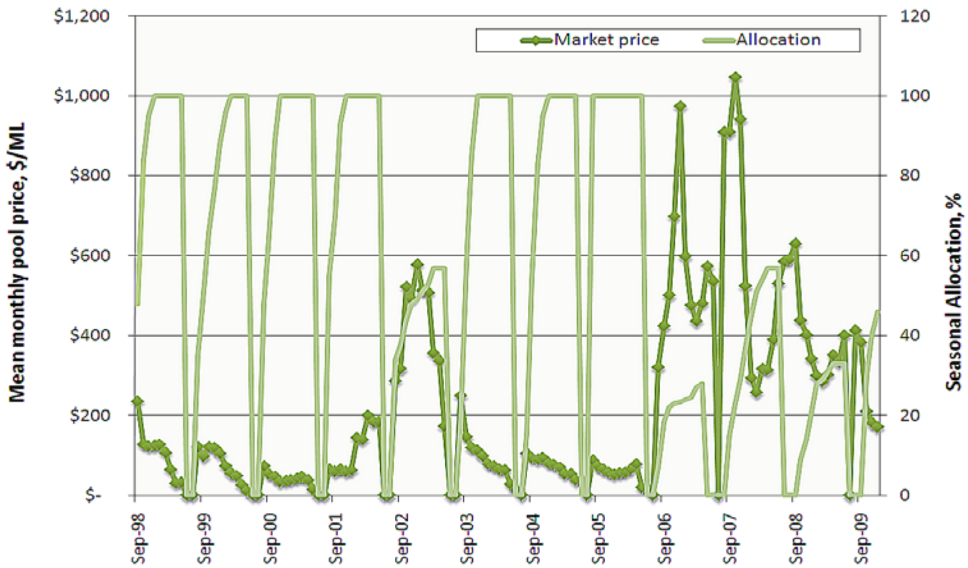

Figure 4-6 Seasonal water allocation and market price (in 2009 Australian dollars) for temporary transfers in the Goulburn Irrigation Area, Victoria, Australia, 1998 to 2009[47]

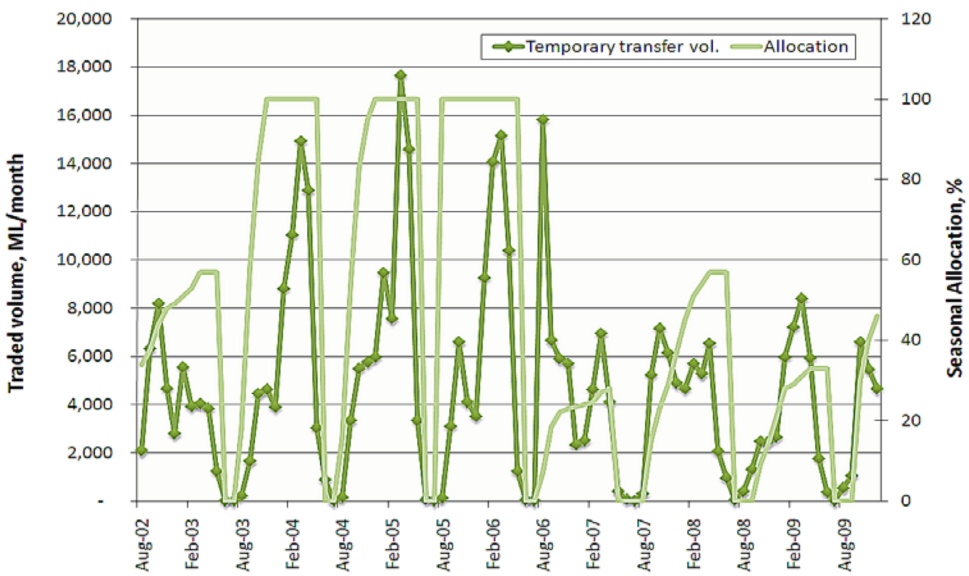

Figure 4-7 Seasonal water allocation and volume traded (ML/month) for temporary transfers in the Goulburn Irrigation Area, Victoria, Australia, 2002 to 2009[48]

---

[47] Source: Historic water prices of temporary transfers in the Goulburn region (trading zone 1A) were downloaded from Watermove (http://www.watermove.com.au/) for the period August 2002 to December 2009. Earlier water prices (from September 1998) provided by Asif Zaman of Melbourne University (pers. comm., 30/11/2006). Allocation information obtained from Henning Bjornlund (pers. comm., 3/04/2007) and the media releases of Goulburn-Murray Water (http://www.g-mwater.com.au/news/media-releases/default.asp).

[48] Source: as per Figure 4-6.

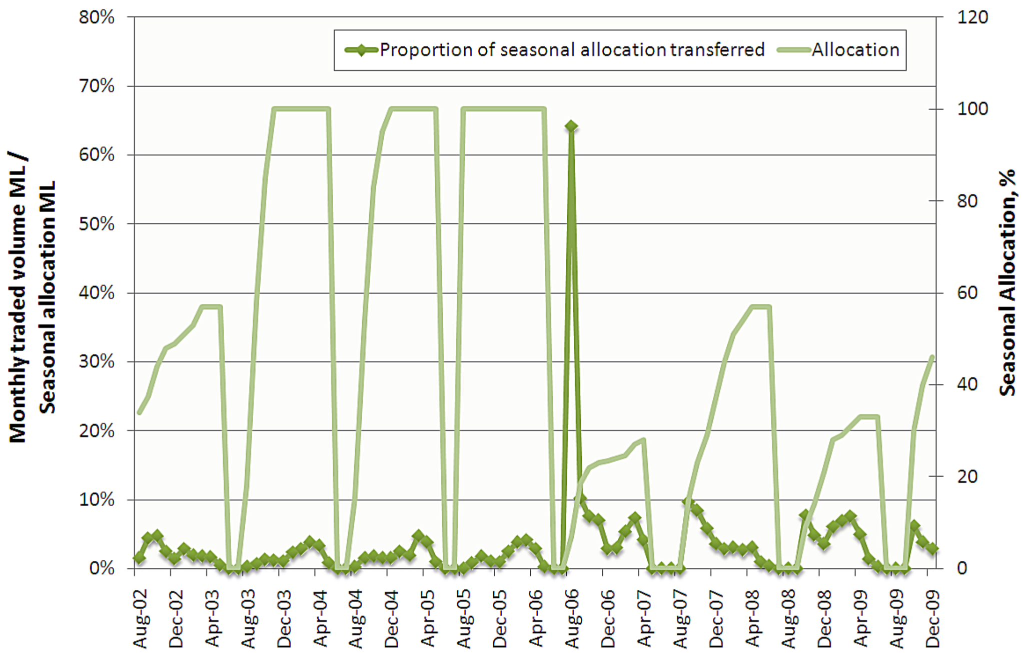

Figure 4-8 Seasonal water allocation and the proportion of seasonal allocation transferred, by month, for temporary transfers in the Goulburn Irrigation Area, Victoria, Australia, 2002 to 2009[49]

[49] Source: as per Figure 4-6. Total entitlement figures used in calculations obtained from Goulburn-Murray Water annual reports.

Economic instruments for water quality control

4.1 Introduction and design issues

As previously described, economic efficiency is the underlying aim of economic instruments for water quality control. Water quality, however, presents additional challenges for both the design and application of economic instruments.

Monitoring is typically an issue, particularly for non-point sources of pollutants (e.g. run-off from agricultural land). The physical relationships may not be sufficiently known to accurately determine cause and effect, which in turn creates difficulties for estimating the potential benefits of mitigation measures. These challenges are pronounced for water quality parameters that are not conservative and alter in chemical composition once discharged to the environment (e.g. nutrients), introducing spatial complexity and estimation difficulties. The impracticalities of monitoring water quality at a small scale may be addressed by instead monitoring activities that may indirectly lead to alterations in water quality (e.g. farming practices, such as the handling of cattle and manure management practices).

Where the total discharge of water contaminants has been capped, a water quality market may be designed based on the concept of “offsets”, whereby those who plan to undertake new activities which involve the discharge of contaminants must seek to ensure no net change in environmental outcomes by arranging for conservation measures that indirectly offset their impacts. To ensure economic efficiency and to avoid perverse incentives, acceptable offset activities should only be those that would not otherwise be carried out if there were no scheme in place, and the activities are considered to be above and beyond the normal duty of care of the scheme participant. An offset scheme may be difficult to design due to uncertainty in the environmental effectiveness of offset activities; some schemes have introduced risk factors for the calculation of the benefits of offset activities to deal with this issue.

Economic instruments are complementary to environmental regulation. A common challenge for the design of economic instruments that involve non-point source pollutants (particularly nutrients) is the limited environmental regulation of non-point elements originating from the agricultural sector. The risks associated with policy gaps with regards to the agricultural sector should be assessed when considering the introduction of economic instruments to control water quality.

4.2 Offsets for water quality control in the South Nation basin

Concentrations of phosphorus in the South Nation basin of eastern Ontario are well in excess of provincial guidelines[50], with non-point sources (e.g. agricultural lands) estimated to contribute 90 per cent of the phosphorus load (O'Grady, 2008). The provincial Ministry of Environment decided to cease issuing new permits for phosphorus discharge (point source) in the basin in 1998, such that any new developments including new municipal wastewater treatment facilities were prohibited from releasing phosphorus (permits issued prior to 1998 remain unaffected). The costs of the permit cap were reduced by the introduction of an offset scheme that enables new developments to discharge phosphorous provided that their discharge is offset by mitigation activities located elsewhere in the basin.

Under the scheme, new developments are able to purchase offsets from the South Nation Conservation Authority, who in turn issues grants to rural landowners for activities that mitigate the release of phosphorus to watercourses in the basin. Each kilogram of point source phosphorus

[50] The annual mean concentration of phosphorus in the lower reach of the watershed is 0.129 mg/L, which is more than four times the concentration of the provincial guidelines of 0.03 mg/L (O'Grady, 2008).

discharge requires four kilograms of non-point source phosphorus mitigation. The reason for this selectively high ratio is due to:

> "…the unique nature of the Total Phosphorus Management program (it is the first of its kind in Ontario), lack of knowledge on how much P is first transported, then delivered, to watercourses, and the debate on how much of the P in the water is soluble vs. particulate. The high offset ratio also allows a buffer in the event that a [offset activity] is not 100 per cent effective." (O'Grady, 2008:190)

Offset activities are carried out voluntarily by landowners who receive grants. Examples of offset activities include manure storage management, diversion of clean water runoff from barnyards, feedlots and manure storage areas, restricted access of livestock to watercourses, repair or replacement of biologically-failed septic systems, reduced tillage of crops or the use of cover crops, and the use of vegetation to filter agricultural runoff (O'Grady, 2008). The average cost of offset activities is estimated to be $400 per kg of phosphorus removed, including management and monitoring costs by the South Nation Conservation Authority (O'Grady, 2008).

The design of the scheme indicates that efficiency and equity outcomes were likely compromised by political constraints. There was initial strong opposition from the agricultural community, whom expressed the belief that point-source dischargers had been given "a licence to pollute, and that the public would perceive that farmers were the cause of the problem if they were doing all the work and getting all the grants" (O'Grady, 2008:194)[51]. The scheme has an unorthodox risk distribution, whereby those who purchase offsets are legally responsible if phosphorus targets are not met – that is, neither the South Nation Conservation Authority as the broker, nor landowners who receive grants, are liable for achieving phosphorus

[51] Note that this opinion does not appear to evenly acknowledge the sources of phosphorus in the basin.

mitigation outcomes (O'Grady, 2008). To ensure their participation, the farming community required that field inspectors be farmer representatives, and that the offset ratio be increased from the planned 2:1 ratio to the current 4:1 ratio (O'Grady, 2008). O'Grady (2008:193) reports that municipalities have paid upwards of $500,000 for phosphorus offsets, and that an advantage of the scheme, in addition to reduced costs for new dischargers, is that "it puts money in the hands of farmers".

4.3 Hunter River Salinity Trading Scheme

A relatively well-established example of point-source water quality trading is the Hunter River Salinity Trading Scheme in New South Wales, Australia[52]. The catchment area of the Hunter River contains large deposits of black coal that is mined for local use and export, and groundwater in the catchment is naturally high in salts. Surface runoff from mine sites, mine dewatering and on-site water-use that includes coal washing, along with the evaporation of cooling water by power stations, all produce saline water that is discharged (under licensed conditions) to the Hunter River. The Hunter River Salinity Trading Scheme manages the discharge of saline water from the coal mining and power supply industries based on two main objectives (NSW Water Information, 2009):

1. To minimise the impacts of saline discharges on irrigation and other water uses, and on the aquatic environment of the Hunter River catchment.

2. To minimise the overall costs to the community of saline discharges, in an equitable and flexible way while providing ongoing financial incentives to further reduce saline discharge by industry.

[52] Further details of the scheme are available on the New South Wales government websites: http://hrs1.epa.nsw.gov.au/default.html, http://www.environment.nsw.gov.au/licensing/hrsts/index.htm, and http://waterinfo.nsw.gov.au/hunter/trading.shtml (accessed 18/10/2009)

The salinity goals of the scheme, developed via community consultation, are to maintain the salinity concentration in the Hunter River to below 900 electrical conductivity (EC) units (measured in micro-Siemens per centimetre [μS/cm]) at Singleton, and below 600 EC (μS/cm) further upstream at Denman (Table 5-1).

The decision to implement a salinity trading scheme emerged from necessity, given the previous industrial licensing and regulation approach could not resolve the conflicting desires to allow further industrial growth in the upper catchment while maintaining river salinity to levels suitable for existing downstream purposes (municipal water supply, irrigated agriculture). The issuing of licences with the traditional provision that the best available technology is used, while old industrial licensees could continue to emit pollutants at relatively high levels, was found to be an expensive barrier to the entry of new operations (thus limiting economic growth) (Smith, 2003a). Industry shutdown, along with a range of engineering solutions, was considered prior to the selection of trading of salinity credits as the preferred policy (Smith, 2003). The salinity trading scheme allows discharge licences to be readily granted to new mines while maintaining river salinity concentrations to within the salinity goals of the region (Smith, 2003a).

The fundamental basis of the design and operation of the scheme is hydrology. The rules of the scheme are designed to take advantage of the natural relationship that exists between river salinity concentration and flow. Following an initial spike in salinity concentration, flood flows in the Hunter River naturally coincide with lower salinity concentrations (Figure 5-1). The scheme enables saline discharges from industry to occur when there is ample flow in the river for dilution, so that the effect on in-stream salinity concentrations is minimised. The mechanics of the scheme are perhaps best illustrated by a scheme performance chart of salinity concentration in the Hunter River over time, displayed in Figure 5-2 (at Singleton). The yellow bars depict times during the 2007-08 period in which saline discharge was allowed to occur, the red stars depict when saline discharge by industry actually occurred. Saline discharge is only enabled when the salinity in the river is predicted to be below the salinity goal and the impact of saline discharges to the river (based on an assessment of flow conditions) is minimal.

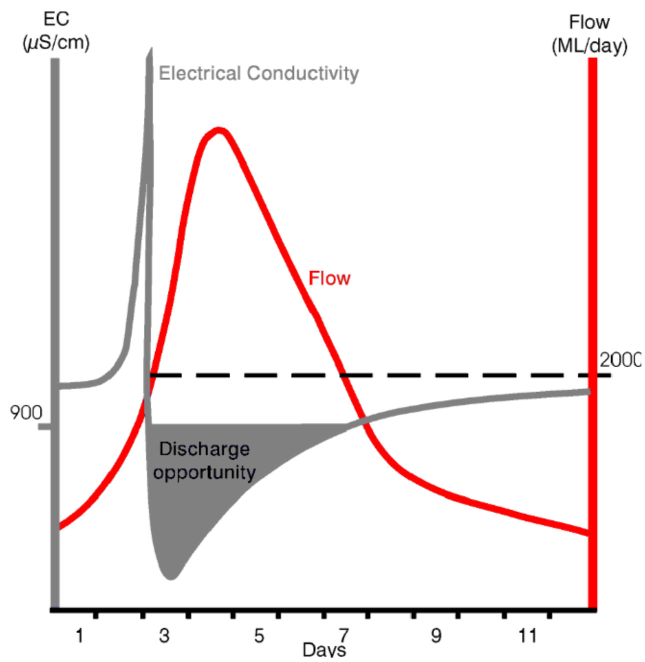

Figure 5-1 Conceptual diagram of the river salinity – flow relationship in the Hunter River during high flow events (Smith, 2003:3)

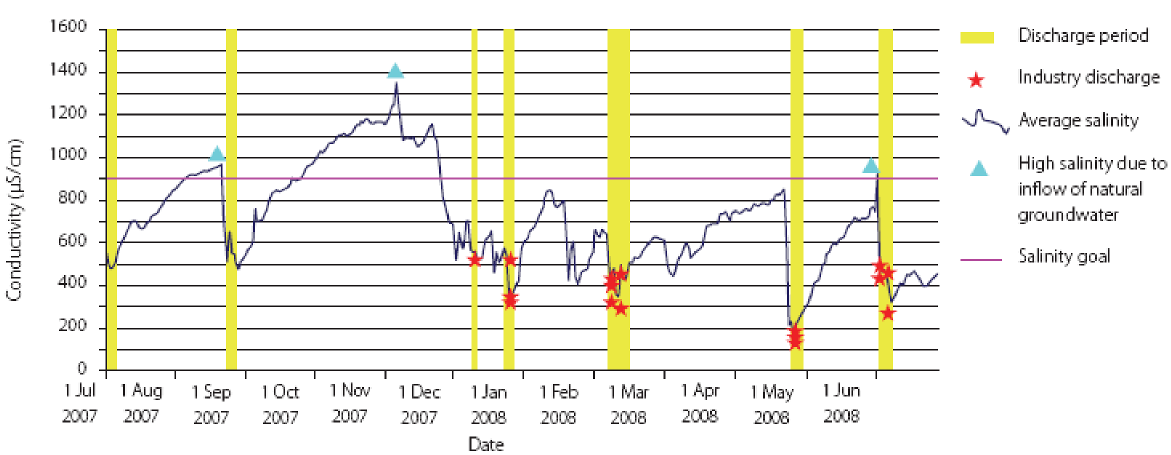

Figure 5-2 Scheme performance for 2007-2008 for the Hunter River at Singleton (Department of Environment and Climate Change NSW, 2009:3)

Hydrological assessment forms the basis for operating the scheme. Flows in the river are grouped into flow "blocks"; these are identified by their Julian date (1 to 365) followed by the year, that represent the modelled daily flow that passes by a specified location along the river (Singleton). The identification of flow blocks is a convenient method to track flow while accounting for the travel time between upstream and downstream locations. The operating rules governing the ability to discharge salt into the River depends on the predicted flow and salinity conditions for each flow block, as follows:

- When flows are low (e.g. below 2 000 ML/d at Singleton), no saline discharge is allowed.
- When flows are high (e.g. 2 000 to 10 000 ML/d at Singleton), saline discharge is allowed up to a level that maintains the river salinity to within the specified limits (e.g. 900 EC at Singleton).
- When flood conditions are declared (e.g. river flows above 10 000 ML/d at Singleton), unrestricted saline discharge can occur – though industry must co-ordinate discharges to meet salinity targets in all river sectors[53].

The flow conditions and total allowable salt discharge are predicted using a biophysical model (CAIRO) combined with continuous records of streamflow and water quality collected from 21 monitoring gauges (Smith, 2003), and weather data[54]. Blocks are rated as either low, high or flood flow. When upcoming high flow conditions are predicted, the scheme operator informs

[53] If industry discharge leads to the exceedance of salinity goals during flood flows, then the scheme's rules allow for the ability to extend the salinity credit requirements to cover flood periods (Smith, 2003a).

[54] The scheme operation is based on forecast information in order to give participants sufficient notice to arrange for wastewater discharge (licence holders in the upper-catchment need at least seven hours' notice).

participants of the total allowable salt discharge (in tonnes) by distributing a scheme register for each block of flow[55]. A factor of safety valued between 0 and 1, referred to as a sector credit factor, may also be specified along a particular river sector to ensure that salinity targets continue to be met following excess salinity credits being traded into the sector (Smith, 2003a).

Table 5-1 River flow specifications and salinity goal in the Hunter River Salinity Trading Scheme

River Sector	Low flow conditions (ML/d): no saline discharge allowed	High flow conditions (ML/d): saline discharge allowed subject to credits	Goal: upper limit of salinity concentration, EC (µS/cm)
Upper (upstream)	Less than 1 000	1 000 to 4 000	600 EC at Denman Under flood flows: 900 EC average block salinity and 1500 EC upper limit salinity at Denman
Middle	Less than 1 800	1 800 to 6 000	900 EC at confluence of Glennies Creek with the Hunter River
Lower (downstream)	Less than 2 000	2 000 to 10 000	900 EC at Singleton

Scheme participants can only discharge salt during high flow conditions if they hold discharge credits. The credits each represent a share of the total allowable discharge within each block and only apply to periods of high flow conditions. There are 1 000 credits in total which can be used whenever saline discharge is allowed. Each credit permits the holder to discharge 0.1 per cent of the total allowable discharge, multiplied by the sector credit factor if set, into a block of high flows. A credit can be used only once during

[55] Examples of the register can be found at: http://hits.nsw.gov.au/rr/rrindex.html

each block. If a participant wishes to use credits, their timing of discharge must take into consideration the travel time of flow between the point of discharge and the point of river inflow (i.e., the point at which the block is specified).

While the operation of the scheme is designed to meet the scheme's first objective of minimising salinity impacts, the specification, allocation and tradability of salinity credits incorporates design elements to enable the scheme to meet its second objective related to providing incentives that maximise economic gains within the scheme's salinity goals. Discharge credits may be obtained from a 24-hour online credit exchange, or via biannual auctions. When the scheme was first regulated in 2002, the lifespan of the credits were designed so that one-fifth (200 credits) would expire every two years, with an equal number of new credits (200) issued every two years to the highest bidder under public auction. Following the initial issue of credits, the lifespan of new credits is now 10 years (extended from the 1-2 years under the trial scheme to allow participants greater planning ability and process adjustment). During the trial scheme, the initial permits were issued free of charge based on a formula that considered environmental performance, saline water production, employment, and economic output of each scheme; these were later reissued when the scheme was formalised. The scheme's administration costs, which include river monitoring, modelling, and register and report preparation, are fully recovered from annual fees paid by discharge licence holders and credit holders (credit holders may include members of the public if they wish to purchase credits via auction). If the proceeds from each biannual auction generate a surplus above auction costs, then these are deducted from the annual costs of the scheme that would otherwise be payable by scheme participants. Auction results are publically available on the internet[56].

---

[56] Available at: http://www.environment.nsw.gov.au/licensing/hrsts/auctions.htm

The scheme operator monitors in-stream flow conditions to ensure that these align with the licence holders' reports of discharge. A particular success of the scheme has been the compliance of participants: industry operators take care to obey scheme rules, and are sensitive to public scrutiny. As part of improving transparency and accountability, industry agreed to install real-time salinity and discharge monitoring, with information available to the public (Smith, 2003a). Some industry participants have voluntarily installed web cameras that display pictures of their pipe outlets, to further demonstrate their compliance (Smith, 2003 [verbal presentation]).

The introduction of the scheme has been staged and based on continuous review and improvement, and appears to have been highly successful. A trial of the scheme began in 1995 when historic salinity levels were routinely above the salinity goals of the scheme. In the years following its introduction, river monitoring indicates a marked reduction in the frequency and severity of spikes in salinity concentration above the salinity goal (Figure 5-3). Following this success the scheme was formalised in 2002, around which time the scheme managed saline discharges from 22 coal mines and 2 power stations (Smith, 2003). Smith (2003a:8) described the key lessons learned from the Scheme as follows:

- *Clear definition of the environment goal or output of the scheme is paramount.*
- *The scheme's rules must be carefully defined so as not to undermine achievement of this goal.*
- *A regulatory framework is essential to underpin the integrity of such a scheme.*
- *Effective consultation and stakeholder involvement is important to get industry ownership of the scheme and a good level of satisfaction amongst all stakeholders.*

- *The EPA developed an on-line credit exchange facility system to ensure fast, efficient, 24-hour credit transfers. This allows participants to respond to discharge opportunities even when discharge events occur outside business hours. An unforeseen benefit of this tool has been that participants now have a better understanding of the Scheme rules.*
- *An extended pilot period was necessary to demonstrate that the Scheme would work. Based on the experience of the pilot it was possible to improve and finalise the Scheme.*
- *It was necessary to gradually remove the grandfathered entitlements of the original licence holders to enable new industry and development to participate in the Scheme. Grandfathered credits are being progressively withdrawn and reallocated by auction over 8 years.*

Other key lessons for the general design of emission trading schemes elsewhere, described by the NSW government[57], include:

- *The scheme has transformed the role of the environmental regulator and the practice of environmental regulation. Rather than the regulator dealing one-on-one with each polluter, the scheme sees a community-driven environmental goal transparently delivered by a market mechanism.*
- *Discharge privileges are explicitly based on a quantitative environmental goal, rather than available abatement technology. It is only on this new basis that environmental regulation can be sure of achieving environmental goals. Being performance-based, it also encourages individual innovation and it facilitates cooperation and resource sharing to ensure environmental goals are achieved at least cost.*
- *The scheme has proved that innovative solutions can be applied in practical ways provided communities can be encouraged to work together.*

[57] http://www.environment.nsw.gov.au/licensing/hrsts/precedence.htm (accessed 25/10/2009)

Antagonism or pessimism are not the only end-point when rivers and their communities are in trouble. The scheme has fostered mutual acceptance of differing needs, expectations and capacity to contribute within a community, and that community is itself now more fully integrated within the sustainable limits of its ecosystem.

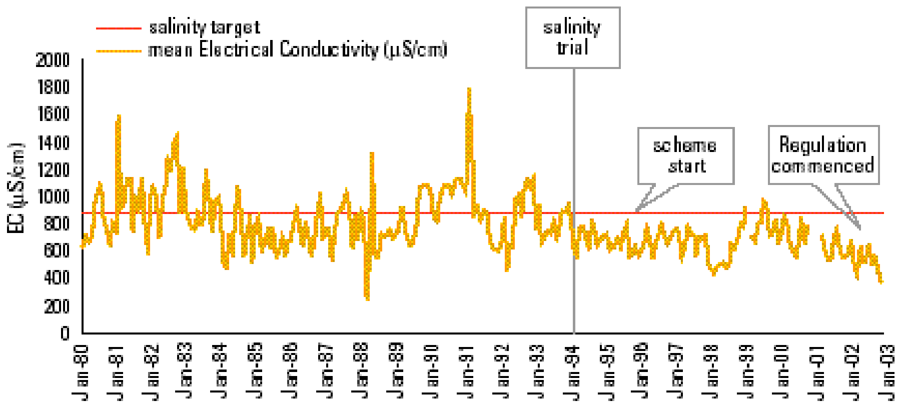

Figure 5-3 Monthly mean salinity concentration (EC) at Singleton, 1980 to 2002 (Smith, 2003a:7)

The total costs of the regulated scheme were forecast in 2001 to range from $3 million to $6 million in present value terms (5 years, 7 per cent discount rate, Australian dollars), depending on the selected flood thresholds and the ability of the discharge credits to offset costs to industry (NSW Environment Protection Authority, 2001). The benefits of the scheme relate to the downstream benefits of reduced water treatment costs, reduced infrastructure maintenance and replacement costs, and increased yields from irrigated agriculture due to improved water quality, that are collectively estimated to be in the order of $10,000 per annum per EC unit [µS/cm] of salt reduction (James [1997] in Bjornlund [2003]). Prior to the scheme, salinity levels in the river were up to double the 900 EC benchmark, and the benchmark was exceeded almost 50 per cent of the time (Bjornlund, 2003). Over the trial period of the scheme, the benchmark was exceeded less than 5 per cent of the time (Bjornlund, 2003). In addition, one of the most significant financial benefits of the scheme is the timely approval of new mines; during the scheme regulatory review, six new mines were under consideration – each with a typical annual value of production of over $300 million (NSW Environment Protection Authority, 2001).

Opportunities and challenges for implementation

The case studies illustrate how economic instruments have been applied to water management in both Canada and Australia. The differences in water supply and demand characteristics between the two countries (Appendix C.1) suggests that the concept of scarcity pricing being explored in Australia for urban water supply (Section 3.3) may be suitable for water pricing in Canada associated with hydroelectric dam operation. Likewise, the use of water trading based on a shared system of water allocation as adopted in the Murray-Darling Basin (Section 4.3) may have relevance to specific areas of Canada where water is scarce – particularly in locations where there is competition for water held in storage (though a change to proportional allocation may be subject to the political difficulties of existing entrenched rights). The design of the Hunter River scheme to control the salinity impacts of industry (Section 5.3) could inform the design of water quality instruments applied to Canadian rivers that receive pollutant loads from point sources such as municipalities and industry. Creative designs to manage water quality might also incorporate the wastewater assimilation and ecosystem impacts of flow fluctuations due to hydroelectricity generation (where relevant).

Apart from physical differences, differences in socio-political context are also important for determining the potential to adopt the techniques used elsewhere. As may be apparent from the case studies, the top-down style of governance in Australia is such that outcomes-based decision making underpinned by technical information is encouraged (Appendix C.2), and there is familiarity with economic concepts given widespread economic reforms that commenced in the 1980s (Banks, 2005). Decisions tend to be made either independently under the authority of elected representatives, or collectively via majority vote, based on an underlying principle of proportional representation that does not rely on consensus (Appendix C.2). Independent economic regulators have a predominant role in Australia in ensuring economic performance (e.g., via the identification and removal of significant sources of market failure). There has also been considerable "learning by doing" in the adoption of economic instruments.

In examining the potential application of the Australian case studies, it is of note that there are fundamental differences in the norms for decision-making and governance in Canada (Appendix C.2). There is less familiarity and apparent political support for the concept of economic reform, and there is less reliance on economic regulatory bodies, thus there will likely be differences in the ease and potential effectiveness of the implementation of economic instruments. Of particular importance is the rise of pluralism and the shift (since around 1980) to a participatory, bottom-up style of governance across North America (Maxwell and Randall [1989], Howlett and Lindquist [2004])[58] that has important social and economic implications. For example, the economic risks of a fragmented socio-political structure include a collective inability to adopt worthwhile policies, known as the Isolation Paradox (e.g., Randall [1997]), and related issues of slow and undefined processes for decision making (i.e., high costs for policy formation akin to transaction costs and risks of increased uncertainty), entrenched rights (e.g.,

[58] Howlett and Lindquist (2004) explain that the increasing complexity of the Canadian policy environment post-1980 appears to have resulted in a major shift in policy analytical styles within government, from the former use of rational methods within a top-down governance model, to one focused on process-related skills within a decentralised governance context. This complexity includes "the rise of special interest groups, think tanks, citizens, and international actors" that have influenced agendas and policy setting (Howlett and Lindquist, 2005:102). The loss of autonomy of departments and agencies in turn suggests a reduced ability to carry out activities in an operational manner, including a reduced ability to ensure that underlying policy goals will eventually be achieved. Important events include the devolution of decision authority in the mid-1990s between federal, provincial and local governments (linked to issues of national unity) and the downsizing of policy capacity within government departments; changing relations with Aboriginal communities, whom "increasingly seek…self-government, including, at the very least, co-management of natural resources" (Notzke [1994] in Howlett and Lindquist [2004:238]); and the enhanced role of litigation related to US influences and the Charter of Rights and Freedoms (Howlett and Lindquist, 2004).

property or use rights), and strategic behaviour[59]. Pluralism is also of practical importance in determining the types of economic instruments available. If water management decisions are contingent upon the agreement of water users, then this implies that the rights to the water resource primarily rest with water users rather than society as a whole. In these circumstances, economic instruments that involve government payments to water users (in the form of subsidies or otherwise) are likely to be the most politically-feasible alternative (refer to Table 8-1, Appendix B.2).

To overcome the isolation paradox of a pluralistic society within the bounds of participative governance, Randall (1997:35) suggests the following process:

1. **Develop problem-scale solutions** within a framework of national laws and policies (including national policies designed to avoid "race-to-the-bottom" environmental outcomes).

2. **Establish a long-term process** involving all legitimate interests. This requires that participants themselves work out solutions to the problems, incorporating concepts of learning-by-doing.

3. **Establish a shared vision**, by defining goals at the community level and their underlying values.

---

[59] As observed by Randall (1997:34), "the current property rights movement [under participative governance] is not really about protecting existing property rights, but about extending them in ways quite inconsistent with recent political history: broadening the conditions under which property owners may demand compensation for private losses due to regulation in the public interest, and reversing the quarter-century-old principle of "polluter [or resource user] pays."" This appears to be evident in Alberta, where licence terms may enable their amendment in response to changing social and/or environmental circumstances (including senior licences, such as those held by the Eastern and Western irrigation districts), yet this ability is seldom – if ever – mentioned and indeed has been actively challenged. A long-standing dispute regarding a 1963 amendment to a licence of the Western Irrigation District (that effectively reallocated surplus water to new users post-1963) was settled out of court in 2008, reportedly at a cost to the Government of Alberta of $85 million (D'Aliesio, 2008).

4. **Use all tools for achieving consensus**, including deliberation, persuasion, and negotiation, bearing in mind that "it pays to proceed cautiously…[as] it is not uncommon for parties to proclaim a secure status quo or default position that may in fact be quite shaky, or to exaggerate the costs and adverse employment impacts of proposed environmental policies" (Randall, 1997:35).

Others, too, advise to proceed with caution. On the topic of policy fit for solutions adopted elsewhere, Bjornlund et al. (2007:140) provides the following helpful advice:

> "…basing the development of economic instruments on experience gained elsewhere will be challenging because experience is limited, and is unique to local conditions. Outcomes of the application of economic instruments can be positive but they also can be unexpected and undesirable, and some initiatives come with large set-up costs. Given these considerations, the government should not approach the development and implementation of economic instruments without further research into developing tools that clearly illustrate the costs and benefits of such instruments, based on local conditions. Design and implementation should be approached cautiously and be based on a thorough understanding of their impacts and water users' likely management responses to their introduction."

While the above comments were made in relation to water management in the South Saskatchewan basin, the advice likely applies more broadly – including for water pricing. As mentioned in the case studies, the reform of water prices in Australia was coupled with alterations to the institutional design of water suppliers along with labour market reforms. In the Canadian context, carrying out water pricing reform independent of other measures may risk unexpected consequences, and so a general equilibrium mindset is necessary for considering all benefits and costs. For example, promoting the shift from a municipal rates basis to a user pays model comes with the implicit assumptions that the process for setting household rates is transparent and accountable, so that municipal rates will be adjusted accordingly, and that there is no change in the incentives that regulate prices, including the input price of labour. If these assumptions are not applicable, then the policy analyst is advised to weigh the benefits of a user pays model with the risk of additional household taxation and/or market imbalance. Political leadership on whether to proceed based on the likelihood of broader reforms may be necessary in this context.

Marbek Resource Consultants and Renzetti (2005) provide a practical review of issues regarding the application of economic instruments to water management in Canada. A possible first barrier to overcome is the "cultural, social and even spiritual importance that many Canadians assign to water" that poses a particular challenge for the acceptability of economic instruments (Marbek Resource Consultants and Renzetti, 2005:40). Other key barriers noted by the review were administrative capacity, transparency (e.g., to demonstrate that "tax grabs" under water pricing have been avoided), and the equitable application of instruments via the inclusion of all impacts. The study analysed the status of economic instruments at the provincial level, including a description of barriers and lessons learned (Table 6-1).

Table 6-1 Barriers and lessons learned for economic instruments applied to water management (adapted from Marbek Resource Consultants and Renzetti [2005][60])

Province	Barriers and lessons learned
British Columbia	Public perception of the value of water is expected to be a strong determinant in the effectiveness of economic instruments.
Manitoba	The public has a tendency to view economic instruments as just another tax and thus are resistant to their adoption. As demonstrated by environmental levies for drinking cartons and cans, economic instruments are more easily adopted when revenues are earmarked in a specific fund for protection and conservation efforts.
New Brunswick	The development of economic instruments requires consideration of equity, as well as understanding the state of the resource and the costs associated with its delivery. Time requirements are an issue.
Newfoundland and Labrador	The involvement of all stakeholders in developing a system to protect and conserve water resources is a priority. Legislation includes an ability to implement economic instruments.
Nova Scotia	Charges that do not reflect the true cost of water use are not effective in reducing consumption. Targeting all water users is seen by the public and stakeholders as the most equitable approach. A major problem is the lack of monitoring and reporting on water use by users; few have fulfilled their self-reporting requirements and monitoring has been lacking. Economic instruments may be easier to adopt given the long-standing history of water fees in the province.
Ontario	Important to gaining support for water abstraction charges is the targeting of all commercial and industrial users. Involvement of all potential stakeholders in the process is a crucial enabling factor for economic instruments. Trading and other economic instruments complement but do not replace the more traditional government regulatory process. In terms of the South Nation basin water quality trading program, clearly defined water quality enhancement goals and targets were found to be essential, as is a good understanding of both point and non-point sources of pollution and their contributions to the phosphorous loading. A written management agreement between the point source discharger and the body responsible for administering the trading program is important.

[60] Alberta was not included in the case studies.

Province	Barriers and lessons learned
Prince Edward Island	While the province recognises the need for economic instruments, the difficulties lie partly in the fact that the public does not believe there is a water supply problem.
Quebec	Lengthy policy delays indicate the need to plan for a long time frame in the development of economic instruments, partly due to the number of stakeholders. The initial focus on a single industry increased the consultation time. Discussions with the bottling sector contributed to the delay in implementation and an adjustment to the targeted sectors. As a result, the government changed focus to include all water users in the proposed instrument.
Saskatchewan	The involvement of stakeholders is an important part of the development and implementation of water conservation planning and economic instruments. Full metering is an advantage when considering economic instruments for water as it allows proper assessment of current use, the setting of targets, and the assessment of the level of the charge to be implemented to reach the targets.

As listed in Table 6-1, the representatives of several provinces expressed the need to include all stakeholders in the consultation process. This participatory approach has the advantage of generating the legitimacy and buy-in required for effective implementation (pers. comm., M. Howlett). It is imperative to note, however, that if consultation is used to directly determine the design of economic instruments, this in turn creates a high risk of compromising efficiency outcomes and may not necessarily lead to acceptable equity outcomes (Appendix C.2). Ideally, this issue may be overcome by focusing public consultations on informing the key outcomes and bounds for the environmental policy, and to gather information on demand characteristics, while the design of the economic instrument is delegated to a team of technical experts, preferably within an independent institutional setting[61]. This solution may be difficult to achieve in practice

[61] The use of independent institutions should enable the design to be focused on efficiency, as well as providing conditions that promote the critical examination of instrument performance following implementation, and redesign where necessary. Examples of independent review and adaptation of instrument design are provided in the Australian case studies. In the case of salinity

due to political constraints (in which case, the process suggested by Randall [1997] may be more appropriate), though public relations may be improved by open communication and the design of targeted measures that address equity concerns and the potential resistance of key groups (e.g., policies designed to facilitate structural adjustment [Bjornlund, 2010])[62].

Finally, while price and quantity-based instruments can theoretically achieve similar outcomes, this is unlikely to be the case in practice. If stakeholder consultation by necessity must include stakeholder input in instrument design, then price-based instruments may be the lower-risk option[63]. Price-based instruments are more transparent in identifying fee structures and differences across stakeholder groups, and so would presumably lead to more acceptable equity outcomes, while also providing greater efficiency gains in cases where the water supply is relatively plentiful[64]. The usual drawbacks of price-based instruments can be addressed by the careful design of institutions to reduce the market power influences of service providers, and the use of a backstop quantity-based instrument (i.e., a hybrid price-quantity instrument) if necessary. Further, while both quantity and price-based instruments require monitoring and enforcement, the consequences of administrative lapses are less in the case of prices (Nordhaus, 2007).

---

management in the Murray-Darling Basin, the Murray-Darling Basin Commission regularly sought the advice of an expert-based Independent Audit Group. The reports of this group are publically available (e.g. Murray-Darling Basin Ministerial Council, 2008).

[62] Strong initial resistance to economic instruments is to be expected, particularly among heavy water users with relatively low water productivity. For example, Bjornlund et al. [2007] describe the variable though overall low level of support for economic instruments based on a survey of irrigated agriculture representatives in southern Alberta.

[63] This paragraph generally refers to basin water allocation issues. Price-based instruments are a practical necessity for urban water supply, as even if the functions of water allocation and delivery are separated, transaction costs would be reduced by the urban water supplier acting on behalf of households and other low water-use customers.

[64] Refer to Weitzman (1974) mentioned in Appendix B.

Summary of key findings

Economic instruments for water management in Canada are in their formative stages, with challenges among those either implemented or in the process of continuing implementation. The case studies taken from Australia provide reasonable success stories. These also faced challenges in their formation and ongoing implementation, though were supported by systematic governance structures designed to ensure ongoing progress and economic reform, within a decision-making environment in which technical information is relied upon. The physical extremities of water scarcity and water quality concerns are other influential factors that prompted the decisive approach displayed in these examples.

Canada has ample water supplies in comparison to most other countries though is not without water scarcity on a regional level, and there may be opportunities for greater water conservation and water quality protection coupled with economic gains. If economic instruments are to be adopted for water management, a key challenge will be balancing the perceptions of political acceptability and the desires of stakeholders with the primary need to ensure that risk factors are avoided so that economic instruments indeed demonstrate benefits that are greater than costs. In practice, price-based economic instruments have the potential to present lower design and implementation risks compared to quantity-based instruments, though care will be needed to materially address public concerns regarding equity impacts and the prudent management of public funds.

While economic instruments have not been readily adopted in the water sector in Canada, there are examples of the emergence of such instruments (e.g. water trading in Alberta). Economic instruments may be more readily embraced when other jurisdictions provide evidence of their success and insights into key policy features that are required for success. The Australian case studies serve to provide such “lessons learned”. These include:

- Clear, quantitative, measurable and achievable environmental objectives.
- Clearly defined rights for water use, combined with monitoring and enforcement.
- Incorporating technical information and expertise into decision-making.
- The use of independent organisations to carry out technical roles.
- Developing and maintaining capacity among regulators and industry sectors to construct and implement economic approaches.
- Transparent processes and mechanisms.

Bibliography

5.1 Cited references

AECOM. *Horizon Oils Sands Project - Water Supply and Water System*. Website. Available at: <http://www.uma.aecom.com/MarketsAndServices/46/08/index.html> (accessed 12/07/2009)

Alberta Environment. 1987. *Licence to divert and use water. Pursuant to the Water Resources Act. Suncor Inc. File No. 11403.* Priority No. 1965-05-06-01, 1979-04-10-01. Date of issue: 1987-06-08. Available from: <http://envext02.env.gov.ab.ca/pls/xedp_apv/avwp_avwh1000_02.actionquery> (accessed 27/3/2008)

Alberta Environment. 2003. *South Saskatchewan River Basin Water Management Plan Phase 2: Scenario Modelling Results Part 1*. Calgary.

Alberta Environment. 2006. *Approved Water Management Plan for the South Saskatchewan River Basin (Alberta).* Available at: <http://environment.alberta.ca/1725.html> (accessed 22/3/2010)

Alberta Environment. 2007. *Current and Future Water Use in Alberta*. Consultant report prepared by AMEC Earth & Environmental Services for Alberta Environment. Edmonton. Available at: <http://www.waterforlife.gov.ab.ca/watershed/current-future_water_use.html> (accessed 7/12/2007)

Alberta Environment and Fisheries and Oceans Canada. 2007. *Water Management Framework: Instream Flow Needs and Water Management System for the Lower Athabasca River*. Available at: <http://www3.gov.ab.ca/env/water/Management/Athabasca_RWMF/pubs/Athabasca_RWMF_Technical.pdf> (accessed 31/5/2007)

Alberta Water Council. 2008. *Recommendations for Water Conservation, Efficiency and Productivity Sector Planning*. Available at: <http://www.albertawatercouncil.ca/Portals/0/pdfs/CEP per cent20Sector per cent20Plan per cent20Final per cent20Report.pdf> (accessed 22/04/2010)

Alberta Water Council. 2010. *What we've learned about Water Conservation, Efficiency and Productivity Sector Planning.* Draft Version 3, March 10. Available at: <http://www.albertawatercouncil.ca/Projects/WaterConservationEfficiencyandProductivity/tabid/115/Default.aspx> (accessed 21/04/2010)

Appels, D., Douglas, R., and Dwyer, G. 2004. *Responsiveness of water demand: A focus on the southern Murray-Darling Basin.* Productivity Commission, Melbourne, Australia.

Athabasca Regional Issues Working Group. 2007. *Oil Sands Mining Water Management Agreement for the 2007-2008 Winter Period*. Letter correspondence addressed to Jay Nagendran, Alberta Environment and Bob Lambe, Fisheries and Oceans Canada. 7th December 2007.

Banks, G. 2005. *Structural Reform Australian-Style: Lessons for Others?* Presentation to the IMF, World Bank and OECD. Productivity Commission, May. Available at: <http://www.pc.gov.au/speeches/cs20050601> (accessed 28/12/2009)

Barr, N. 2005. *The changing social landscape of rural Victoria*. State of Victoria, Department of Primary Industries. Available at: <http://sites.google.com/site/ruralsociallandscapes/report-repository> (accessed 13/04/2010)

Bjornlund, H. 2003. *Market experiences with natural and environmental resources (other than water). Lessons for the next generation of water market policies.* Draft Final Report. Section 1. ARC-SPIRT project: Elements of the next generation of water market policies, which are socially equitable and ecologically sustainable within rural communities. June-July, 2003.

Bjornlund, H. 2010. *The Competition for Water: Striking a Balance among Social, Environmental and Economic Needs*. Commentary no. 302. C.D. Howe Institute, Toronto. Available at: <http://www.cdhowe.org/pdf/commentary_302.pdf> (accessed 5/04/2010)

Bjornlund, H., Nicol, L. and K.K. Klein. 2007. Challenges in implementing economic instruments to manage irrigation water on farms in southern Alberta. *Agricultural Water Management*, 92(3):131-141.

Bjornlund, H. and P. Rossini. 2007. Fundamentals Determining Prices in the Market for Water Entitlements: An Australian Case Study. *Water Resources Development*, 23(3):537-553.

Bjornlund, H. and P. Rossini. 2008. *Are the fundamentals emerging for more sophisticated water market instruments?* Proceedings from the 14th Annual Conference of the Pacific Rim Real Estate Society, Kuala Lumpur, Malaysia, January. Available at: <http://www.prres.net>

Bourne, A., Armstrong, N. and G. Jones. 2002. *A preliminary estimate of total nitrogen and total phosphorus loading to streams in Manitoba, Canada*. Water Quality Management Section. Manitoba Conservation Report No. 2002-04. Available at: <http://www.gov.mb.ca/waterstewardship/reports/quality/nutrient_loading_report_2002-04_november_2002.pdf> (accessed 16/04/2010)

Bow River Irrigation District. 2009. *2009 Financial Statement and Annual Report*. Available at: <http://www.brid.ab.ca/files/2009-AnnualReport.pdf> (accessed 11/04/2010)

Brennan, D. 2006. Water policy reform in Australia: lessons from the Victorian seasonal water market. *The Australian Journal of Agricultural and Resource Economics*, 50:403-423.

Brennan, D. 2008. Missing markets for storage and the potential economic cost of expanding the spatial scope of water trade. *The Australian Journal of Agricultural and Resource Economics*, 52:471-485.

Bureau of Transport and Regional Economics. 2003. *Investment Trends in the Lower Murray-Darling Basin*. Working Paper no. 58. Department of Transport and Regional Services, Commonwealth of Australia. Available at: <http://www.bitre.gov.au/publications/05/Files/wp58.pdf> (accessed 27/12/2009)

Byrnes, J., Crase, L. and B. Dollery. 2006. Regulation versus pricing in urban water policy: the case of the Australian National Water Initiative. *The Australian Journal of Agricultural and Resource Economics*, 50:437-449.

Calgary Regional Partnership. 2007. *Planning and Technical Study on Water & Wastewater Servicing in the Calgary Region: Summary Report (Revision 1)*. Consultant report prepared by CH2M Hill. Calgary, Alberta.

Chambers, P.A., Guy, M., Roberts, E.S., Charlton, M.N., Kent, R., Gagnon, C., Grove, G. and N. Foster. 2001. *Nutrients and their impact on the Canadian environment*. Agriculture and Agri-Food Canada, Environment Canada, Fisheries and Oceans Canada, Health Canada and Natural Resources Canada.

City of Calgary. 2008. *Water Efficiency Report 2008*. Available at: <http://www.calgary.ca/docgallery/bu/water_services/conservation/2008_water_efficiency_report.pdf> (accessed 6/4/2010)

Coad, L. 2009. *CanCompete: Improving Infrastructure Management – Municipal Investments in Water and Wastewater Infrastructure*. The Conference Board of Canada.

D'Aliesio, R. 2008. Fund to settle water rift hits $85M. *Calgary Herald*, March 17. Available at: <http://www.canada.com/calgaryherald/news/story.html?id=8cd3143f-ce9b-44e7-863a-1326f3a27999&k=12737> (accessed 18/05/2010)

Department of Environment and Climate Change NSW. 2009. *The Hunter River Salinity Trading Scheme: 2007-08 performance*. DECC 2009/368. Sydney. Available at: <http://www.environment.nsw.gov.au/resources/licensing/hrsts/09368hrsts0708.pdf> (accessed 25/10/2009)

Department of Natural Resources and Environment. 2001*. The value of water: A guide to water trading in Victoria.* Melbourne.

Eastern Irrigation District. 2008. *2008 Annual Report*. Brooks, Alberta. Available from: http://www.eid.ab.ca/PDF/Board/Annual_Report_EID_2008.pdf (accessed 5/04/2010)

Environment Canada. *Quickfacts*. Website. Available at: <http://www.ec.gc.ca/eau-water/default.asp?lang=En&n=11A8CA33-1> (accessed 13/03/2010)

Environment Canada. b. *Cleaning up Lake Winnipeg: Part of the Government of Canada's Action Plan for Clean Water*. Website. Available at: <http://www.ec.gc.ca/paae-apcw/default.asp?lang=En&n=61284017-1> (accessed 14/03/2010)

ERCB. 2009. *Directive 074: Tailings Performance Criteria and Requirements for Oil Sands Mining Schemes*. Energy Resources Conservation Board, Calgary.

Essential Services Commission. 2007. *Water Tariff Structures Review Final Report*. December. Available at: <http://www.esc.vic.gov.au/NR/rdonlyres/84C8B4DB-32AB-4B21-ADC7-FD8E2B5F0E17/0/RPT_WaterTariffStructuresReviewFinalReport20071220.pdf> (accessed 3/11/2009)

Evans, R. 2007. *The Effects of Groundwater Pumping on Stream Flow in Australia. Technical Report*. Sinclair Knight Merz. Land and Water Australia, Australian Government, Canberra. Available at: <http://nlwra.gov.au/files/products/innovation/pr071283/pr071283.pdf> (accessed 28/04/2010)

Ferree M.M., Gamson, W.A., Gerhards, J. and D. Rucht. 2002. Four Models of the Public Sphere in Modern Democracies. *Theory and Society*, 31(3):289-324.

Fischer, C. and R. G. Newell. 2007. *Environmental and Technology Policies for Climate Mitigation.* Discussion Paper. April 2004; revised February 2007. Resources for the Future, Washington DC.

Gersbach, H. and T. Requate. 2004. Emission taxes and optimal refunding schemes. *Journal of Public Economics*, 88:713-725.

Goulburn-Murray Water. *How Do Seasonal Allocations Work?* Website. Available at: <http://www.g-mwater.com.au/water-resources/allocations/how-seasonal-allocations-work> (accessed 13/12/2009)

Goulburn-Murray Water. 2007. *Carryover Information Sheet.* Website. Available at: <http://www.g-mwater.com.au/news/media-releases/media-releases-2007/carryover_information_sheet.html> (accessed 03/01/2010)

Goulburn-Murray Water. 2009. *Carryover Checklist to assist G-MW customers plan for 2009/10.* Website. Available at: <http://www.g-mwater.com.au/news/media-releases/media-releases-2008/mr_carryover_checklist_to_assist_g-mw_customers_plan_for_200910_.html> (accessed 3/01/2010)

Government of Alberta. 2009. *Alberta Irrigation Information: Facts and Figures for the Year 2008*. Water Resources Branch, Irrigation and Farm Water Division, Alberta Agriculture and Rural Development, Lethbridge. Available at: <http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/irr7401/$FILE/AltaIrrigInfo2008web.pdf> (accessed 17/04/2010)

Government of Alberta. 2010. *Irrigation Rehabilitation Program. 2008/2009. Status Report.* Irrigation Secretariat, Government of Alberta Agriculture and Rural Development, Alberta. Available at: <http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/irr13038> (accessed 22/03/2010)

Grafton, R. Q., and T. Kompas, T. 2007. Pricing Sydney water. *The Australian Journal of Agricultural and Resource Economics*, 51:227-241.

Grafton, R. Q., Kompas, T. and M. Ward. 2008. *Public Submission on 'Draft Scoping Requirements' of the Environment Effects Statement for the Wonthaggi Desalination Plant*. 13 March. Submission to Department of Planning and Community Development, Victoria. Available at: <http://www.theage.com.au/ed_docs/desal.pdf> (accessed 14/11/2009)

Hafi, A., Beare, S., Heaney, A. and S. Page. 2005. *Water Options for Environmental Flows*. ABARE *e*Report 05.12. Prepared for the Natural Resource Management Division, Australian Government Department of Agriculture, Fisheries and Forestry, Canberra.

Heaney, A., Dwyer, G., Beare, S., Peterson, D. and L. Pechey. 2006. Third-party effects of water trading and potential policy responses. *The Australian Journal of Agricultural and Resource Economics*, 50:277-293.

Hesslein, R., Stainton, M., Page, S. and G. McCullough. 2007. Modelling Lake Winnipeg Nutrient Concentrations. *Research and Education in an International Watershed:*

Implications for Decision-Making. Third International Water Conference, International Water Institute, March 14, Grand Forks. Available at: <http://www.internationalwaterinstitute.org/forms/IWI2007/1B2 per cent20Climate per cent20Change, per cent20Runoff, per cent20and per cent20Lake per cent20Winnipeg, per cent20Eutrophication per cent20Part per cent202.pdf> (accessed 16/04/2010)

Höglund Isaksson, L. 2005. Abatement Costs in Response to the Swedish Charge on Nitrogen Oxide Emissions. *Journal of Environmental Economics and Management,* 50:102-120.

Howlett, M. and E. Lindquist. 2004. Policy Analysis and Governance: Analytical and Policy Styles in Canada. *Journal of Comparative Policy Analysis*, 6(3):225-249.

Howlett, M. and E. Lindquist. 2005. Beyond Formal Policy Analysis: Governance Context and Analytical Styles in Canada. *Policy Analysis in Canada: The State of the Art*. Toronto University Press, Toronto.

Imperial Oil. 2006. *Kearl Oil Sands. Water Use Management*. Website. Available from: <http://www.imperialoil.ca/Canada-English/ThisIs/Operations/TI_O_Kearl_wateruse.asp> (accessed 12/07/2009)

Independent Audit Group. 1996. *Setting the Cap*. Murray-Darling Basin Ministerial Council, Canberra.

IPART. 2009. *Review of Prices for the Sydney Catchment Authority from 1 July 2009 to 30 June 2012: Water – Determination and Final Report*. Independent Pricing and Regulatory Tribunal of New South Wales. Available at: <http://www.ipart.nsw.gov.au/files/Water per cent20scarcity per cent20- per cent20Does per cent20it per cent20exist per cent20and per cent20can per cent20price per cent20help per cent20solve per cent20the per cent20problem per cent20- per cent20Working per cent20Paper per cent20January per cent202008.PDF> (accessed 1/11/2009)

Irrigation Water Management Study Committee. 2002. South Saskatchewan River Basin: Irrigation in the 21st Century. Volume 2: Irrigation Development. Alberta Irrigation Projects Association. Lethbridge, Alberta.

Available at: http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/irr4421 (accessed 12th June 2011)

Jaffe, A. B., Newell, R. G., and R. N. Stavins. 2005. A tale of two market failures: Technology and environmental policy. *Ecological Economics*, 54:164-174.

James, D. 1997. *Economic Incentives – Australian Experience with Economic Instruments to Environmental Management*. Environment Australia, Canberra.

Lethbridge Northern Irrigation District. 2010. *Proposed Irrigation Expansion Information Package: Plebiscite Vote March 23, 2010.*

Mannix, A.E. 2009. *Analysis of the cost effectiveness of alternative policies and technologies to manage water extractions by the oil sands sector along the lower Athabasca River*. MSc thesis (unpublished). Department of Rural Economy, University of Alberta. Edmonton.

Mannix, A. E., Dridi, C. and W. L. Adamowicz. 2010. Water Availability in the Oil Sands under Projections of Increasing Demands and a Changing Climate: An Assessment of the Lower Athabasca Water Management Framework. *Canadian Water Resources Journal*, 35(1):29-52.

Marbek Resource Consultants and Renzetti, S. 2005. *Analysis of Economic Instruments for Water Conservation*. Submitted to Canadian Council of Ministers of the Environment, Water Conservation and Economics Task Group. Available at: <http://www.ccme.ca/assets/pdf/ei_marbek_final_rpt_e.pdf> (accessed 5/04/2010)

Marsden Jacobs Associates. *Frameworks for economic impact analysis and benefit-cost analysis*. Report prepared for Economic Regulation Authority, Western Australia. Available at: <http://www.era.wa.gov.au/cproot/2975/2/Frameworks_for_economic_analysis_and_benefit_cost_analysis.pdf> (accessed 22/3/2010)

Maxwell, J.A. and A. Randall. 1989. Ecological Economic Modeling in a Pluralistic, Participatory Society. *Ecological Economics*, 1:233-249.

McMahon, T.A., Finlayson, B.L., Haines, A., and R. Srikanthan. 1987. Runoff variability: a global perspective. In Solomon, S.I., Beran, M. and W. Hogg (eds). *The Influence of Climate Change and Climatic Variability on the Hydrologic Regime and Water Resources*. Proceedings of the Vancouver Symposium organised by IAHS International Commissions on Surface Water, on Groundwater, and on Water Resources Systems, 9-22 August 1987. International Association of Hydrological Sciences, IAHS Publication No. 168. Wallingford, U.K.

Meyers Norris Penny. 2008. *Consolidated Financial Statements: St. Mary River Irrigation District*. Available at: <http://www.smrid.ab.ca/smrid/2008 per cent20SMRID per cent20Financial per cent20statment.pdf> (accessed 5/04/2010)

Mundell, R. A. 1960. The Monetary Dynamics of International Adjustment under Fixed and Flexible Exchange Rates. *Quarterly Journal of Economics*, 84:227-257.

Mundell, R. A. 1968. *International Economics*. Macmillan. New York. Available from: <http://www.columbia.edu/~ram15/ie/ietoc.html> (accessed 15/1/2009)

Murray-Darling Basin Ministerial Council. 1988. *Draft Salinity and Drainage Strategy. Discussion Paper no. 1*.

Murray-Darling Basin Ministerial Council. 1995. *An Audit of Water Use in the Murray-Darling Basin*. Canberra.

Murray-Darling Basin Ministerial Council. 2001. *Basin Salinity Management Strategy 2001-2015*.

Murray-Darling Basin Ministerial Council. 2008. *Report of the Independent Audit Group for Salinity 2006-2007*. Murray-Darling Basin Commission, Canberra. Available at: <http://publications.mdbc.gov.au/download/MDBC per cent2012726 per cent20BSMS per cent20IAG per cent20FA1.pdf> (accessed 6/4/2010)

Nicol, L., Bjornlund, H. and Klein, K. 2008. Improved technologies and management practices in irrigation – implications for water savings in Southern Alberta. *Canadian Water Resources Journal*, 33(3): 283-294.

Nordhaus, W. D. 2007. To Tax or Not to Tax: Alternative Approaches to Slowing Global Warming. *Review of Environmental Economics and Policy*, 1(1):26-44.

NSW Environment Protection Authority. 2001. *Proposed Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2001. Regulatory Impact Statement.* EPA 2001/19. Sydney. Available at: <http://www.environment.nsw.gov.au/resources/licensing/hrsts/hrstsris.pdf> (accessed 25/10/2009)

NSW Water Information. 2009. *Hunter Salinity Trading Scheme*. New South Wales Government website. Last updated 28 July 2009. <http://waterinfo.nsw.gov.au/hunter/trading.shtml> (accessed 25/10/2009)

O'Dea, G. and J. Cooper. 2008. *Water Scarcity: Does it exist and can price help solve the problem?* Water – Working Paper. January. Independent Pricing and Regulatory Tribunal of New South Wales. Available at: <http://www.ipart.nsw.gov.au/files/Water per cent20scarcity per cent20- per cent20Does per cent20it per cent20exist per cent20and per cent20can per cent20price per cent20help per cent20solve per cent20the per cent20problem per cent20- per cent20Working per cent20Paper per cent20January per cent202008.PDF> (accessed 1/11/2009)

OECD. 2004. *OECD Environmental Performance Reviews: Canada*. Paris, France.

OECD. 2008. *OECD Environmental Data. Compendium 2006-2008. Inland Waters*. Paris, France.

OECD. 2008b. *Environmental Performance of Agriculture in OECD countries since 1990*. (Canada Country Section.) Paris, France.

OECD. 2010. *Pricing Water Resources and Water and Sanitation Services*. Paris, France.

O'Grady, D. 2008. Point to non-point phosphorus trading in the South Nation River watershed. In: *WIT Transactions on Ecology and the Environment, Vol. 108: Environmental Economics and Investment Assessment II*. Wessex Institute of Technology Press, UK.

Parker, S. and Speed, S. 2010. *Agricultural Water Pricing: Australia*. Background report for OECD study: Sustainable Management of Water Resources in Agriculture.

Organisation for Economic Co-operation and Development (OECD). Available at: <http://www.oecd.org/document/55/0,3343,en_2649_37401_44753399_1_1_1_1,00.html> (accessed 14/04/2010)

Parry, I. W. H. and W. A. Pizer. 2007. Combating Global Warming. Is taxation or cap-and-trade the better strategy for reducing greenhouse emissions. *Regulation*. Fall 2007. Resources for the Future, Washington DC.

Peterson, D., Dwyer, G., Appels, D., and Fry, J. 2005. Water trade in the southern Murray-Darling Basin, *Economic Record*, 81: 115-127.

Pezzey, J. 1992. The symmetry between controlling pollution by price and controlling it by quantity. *Canadian Journal of Economics*, 4:983-999.

Phase 2 Framework Committee. 2010. *Phase 2 Framework Committee Report*. Prepared by Compass Resource Management and Solander Ecological Research. Cumulative Effects Management Association. Available at: <http://www.cemaonline.ca/> (accessed 14/3/2010)

Pindyck, R. S. 2007. Uncertainty in Environmental Economics. *Review of Environmental Economics and Policy*, 1(1):45-65.

Productivity Commission. 2003. *From industry assistance to productivity: 30 years of 'the Commission'*. Productivity Commission, Canberra.

Productivity Commission. 2003a. *Water rights arrangements in Australia and overseas*. Commission Research Paper. Productivity Commission, Melbourne.

Productivity Commission. 2006. *Rural water use and the environment: The role of market mechanisms*. Research Report. Productivity Commission, Melbourne.

Productivity Commission. 2008. *Towards Urban Water Reform: A Discussion Paper*. Productivity Commission Research Paper. Melbourne. Available at: <http://www.pc.gov.au/research/commissionresearch/urbanwaterreform> (accessed 1/11/2009)

Productivity Commission. 2008a. *A Quick Guide to the Productivity Commission*. Available at: <http://www.pc.gov.au/__data/assets/pdf_file/0005/64679/quick-guide-2008.pdf> (accessed 4/05/2010)

Ring, L. 2006. Irrigation Infrastructure Rehabilitation in Alberta; 38 Years of Government/Industry Cooperation. Paper no. 06-143. Paper presented at The Canadian Society for Bioengineering 2006 Annual Conference, July 16-19th. Edmonton, Alberta.

Quiggan, J. 2001. Environmental economics and the Murray-Darling river system. *The Australian Journal of Agricultural and Resource Economics*, 45(1):67-94.

Qureshi, M.E., Proctor, W., and Kirby, M. 2006. *Economic assessment of water trade restrictions in the Murray-Darling basin*. Paper presentation at the International Conference on Regional and Urban Modelling, Global Economic Modelling Network, Free University of Brussels, 1-2 June.

Randall, A. 1981. Property Entitlements and Pricing Policies for a Maturing Water Economy. *The Australian Journal of Agricultural Economics*, 25(3):195-220.

Randall, A. 1997. Ecological Policies for an Age of Political and Social Fragmentation. *Research in Human Ecology*, 4(1):31-36.

Renzetti, S. 2009. *Wave of the Future: The Case for Smarter Water Policy*. Commentary no. 281. C.D. Howe Institute. Toronto.

Renzetti, S. and J. Kushner. 2004. Full Cost Accounting for Water Supply and Sewage Treatment: Concepts and Case Application. *Canadian Water Resources Journal*, 29(1):13-22.

Roberts, M. J. and M. Spence. 1976. Effluent charges and licenses under uncertainty. *Journal of Public Economics*, 5:193-208.

Roper, H., Sayers, C., and Smith, A. 2006. *Stranded irrigation assets*. Productivity Commission, Melbourne, Australia.

Schindler, D.W. 2000. Aquatic Problems Caused by Human Activities in Banff National Park, Alberta, Canada. *Ambio* 29(7):401-407.

Schindler, D.W. and W.F. Donahue. 2005. A Case Study of the Saskatchewan River System. *Rosenburg Conference on Managing Upland Watersheds in an Era of Global Change*. Banff, Alberta. 6-11 September 2005. Available at: <http://rosenberg.ucanr.org/documents/Rosenberg-schindlercanada.pdf> (accessed 3/04/10)

SFE Corporation Limited. 2005. *Establishing a futures market in water availability risk*. Discussion Paper. July. Sydney.

Smith, S.A.Y. 2003. Hunter River Salinity Trading Scheme. Presentation to AARES 2003 National Symposium, *Market-Based Tools for Environmental Management*, Canberra, September 2-3, 2003.

Smith, S.A.Y. 2003a. What have we learned from The Hunter River Salinity Trading Scheme? NSW Environment Protection Authority. Paper accompanying presentation to AARES 2003 National Symposium, *Market-Based Tools for Environmental Management*, Canberra, September 2-3, 2003.

Sosiak, A. 2002. Long-term response of periphyton and macrophytes to reduced municipal nutrient loading to the Bow River (Alberta, Canada). *Canadian Journal of Fisheries and Aquatic Sciences*, 59:987-1001.

Statistics Canada. 2003. *Human Activity and the Environment. Annual Statistics 2003*. Catalogue no. 16-201-XIE. Environmental Accounts and Statistics Division. Ottawa.

Statistics Canada. 2009. *Human Activity and the Environment. Annual Statistics 2009*. Catalogue no. 16-201-X. Environmental Accounts and Statistics Division. Ottawa.

Stavins, R. N. 2003. Experience with Market-Based Environmental Policy Instruments. Ch. 9. pp 355-435. In: Maler, K. and J. R. Vincent (eds.) *Handbook of Environmental Economics. Volume 1. Environmental Degradation and Institutional Responses*. North-Holland, The Netherlands.

Stavins, R. N. and B. W. Whitehead. 1992. Pollution charges for environmental protection: a policy link between energy and environment. *Annual Review of Energy and the Environment*, 17:187-210.

Sterner, T. 2003. *Policy Instruments for Environmental and Natural Resource Management*. Resources for the Future, Washington.

Sterner, T. and L. H. Isaksson. 2006. Refunded emission payments theory, distribution of costs, and Swedish experience of NO_x abatement. *Ecological Economics*, 57:93-106.

Swihart, R. 2010. Roger Hohm Focusing on One Job. *Lethbridge Herald*, May 21(A11).

Tinbergen, J. 1952. *On the Theory of Economic Policy*. North-Holland.

Weitzman, M. L. 1974. Prices vs. Quantities. *The Review of Economic Studies*, 41(4):477-491.

Young, M. 2008. *The Role of Government and Markets in Water Reform: Learning from Australia*. Presentation to Department of Rural Economy, University of Alberta. 28th November 2008. Available from: <http://www.myoung.net.au/water/talks/Alberta_University_081128b.ppt> (accessed 13/1/2009)

Young, M.D. 2010. *Environmental Effectiveness and Economic Efficiency of Water Use in Agriculture: The Experience of and Lessons from the Australian Water Reform Programme*. Background report for OECD study: Sustainable Management of Water Resources in Agriculture. Organisation for Economic Co-operation and Development (OECD). Available at: <http://www.oecd.org/document/55/0,3343,en_2649_37401_44753399_1_1_1_1,00.html> (accessed 14/04/2010)

Young, M. and J. McColl. 2005. Defining Tradeable Water Entitlements and Allocations: A Robust System. *Canadian Water Resources Journal*, 30(1):65-72.

5.2 Selected cited references by topic

5.2.1 Urban water supply

Byrnes, J., Crase, L. and B. Dollery. 2006. Regulation versus pricing in urban water policy: the case of the Australian National Water Initiative. *The Australian Journal of Agricultural and Resource Economics*, 50:437-449.

Essential Services Commission. 2007. *Water Tariff Structures Review Final Report*. December. Available at: <http://www.esc.vic.gov.au/NR/rdonlyres/84C8B4DB-32AB-4B21-ADC7-FD8E2B5F0E17/0/RPT_WaterTariffStructuresReviewFinalReport20071220.pdf> (accessed 3/11/2009)

Grafton, R. Q., and T. Kompas, T. 2007. Pricing Sydney water. *The Australian Journal of Agricultural and Resource Economics*, 51:227-241.

IPART. 2009. *Review of Prices for the Sydney Catchment Authority from 1 July 2009 to 30 June 2012: Water – Determination and Final Report*. Independent Pricing and Regulatory Tribunal of New South Wales. Available at: <http://www.ipart.nsw.gov.au/files/Water per cent20scarcity per cent20-per cent20Does per cent20it per cent20exist per cent20and per cent20can per cent20price per cent20help per cent20solve per cent20the per cent20problem per cent20- per cent20Working per cent20Paper per cent20January per cent202008.PDF> (accessed 1/11/2009)

Marbek Resource Consultants and Renzetti, S. 2005. *Analysis of Economic Instruments for Water Conservation*. Submitted to Canadian Council of Ministers of the Environment, Water Conservation and Economics Task Group. Available at: <http://www.ccme.ca/assets/pdf/ei_marbek_final_rpt_e.pdf> (accessed 5/04/2010)

O'Dea, G. and J. Cooper. 2008. *Water Scarcity: Does it exist and can price help solve the problem?* Water – Working Paper. January. Independent Pricing and

Regulatory Tribunal of New South Wales. Available at: <http://www.ipart.nsw.gov.au/files/Water per cent20scarcity per cent20- per cent20Does per cent20it per cent20exist per cent20and per cent20can per cent20price per cent20help per cent20solve per cent20the per cent20problem per cent20- per cent20Working per cent20Paper per cent20January per cent202008.PDF> (accessed 1/11/2009)

OECD. 2004. *OECD Environmental Performance Reviews: Canada*. Paris, France.

OECD. 2010. *Pricing Water Resources and Water and Sanitation Services*. Paris, France.

Productivity Commission. 2008. *Towards Urban Water Reform: A Discussion Paper*. Productivity Commission Research Paper. Melbourne. Available at: <http://www.pc.gov.au/research/commissionresearch/urbanwaterreform> (accessed 1/11/2009)

Renzetti, S. 2009. *Wave of the Future: The Case for Smarter Water Policy*. Commentary no. 281. C.D. Howe Institute. Toronto.

Renzetti, S. and J. Kushner. 2004. Full Cost Accounting for Water Supply and Sewage Treatment: Concepts and Case Application. *Canadian Water Resources Journal*, 29(1):13-22.

5.2.2 Basin water allocation

Alberta Environment. 2003. *South Saskatchewan River Basin Water Management Plan Phase 2: Scenario Modelling Results Part 1*. Calgary.

Alberta Environment. 2006. *Approved Water Management Plan for the South Saskatchewan River Basin (Alberta).* Available at: <http://environment.alberta.ca/1725.html> (accessed 22/3/2010)

Alberta Environment. 2007. *Current and Future Water Use in Alberta*. Consultant report prepared by AMEC Earth & Environmental Services for

Alberta Environment. Edmonton. Available at: <http://www.waterforlife.gov.ab.ca/watershed/current-future_water_use.html> (accessed 7/12/2007)

Alberta Environment and Fisheries and Oceans Canada. 2007. *Water Management Framework: Instream Flow Needs and Water Management System for the Lower Athabasca River*. Available at: <http://www3.gov.ab.ca/env/water/Management/Athabasca_RWMF/pubs/Athabasca_RWMF_Technical.pdf> (accessed 31/5/2007)

Appels, D., Douglas, R., and Dwyer, G. 2004. *Responsiveness of water demand: A focus on the southern Murray-Darling Basin.* Productivity Commission, Melbourne, Australia.

Bjornlund, H. 2010. *The Competition for Water: Striking a Balance among Social, Environmental and Economic Needs*. Commentary no. 302. C.D. Howe Institute, Toronto. Available at: <http://www.cdhowe.org/pdf/commentary_302.pdf> (accessed 5/04/2010)

Bjornlund, H., Nicol, L. and K.K. Klein. 2007. Challenges in implementing economic instruments to manage irrigation water on farms in southern Alberta. *Agricultural Water Management*, 92(3):131-141.

Bjornlund, H. and P. Rossini. 2007. Fundamentals Determining Prices in the Market for Water Entitlements: An Australian Case Study. *Water Resources Development*, 23(3):537-553.

Bjornlund, H. and P. Rossini. 2008. *Are the fundamentals emerging for more sophisticated water market instruments?* Proceedings from the 14th Annual Conference of the Pacific Rim Real Estate Society, Kuala Lumpur, Malaysia, January. Available at: <http://www.prres.net>

Brennan, D. 2006. Water policy reform in Australia: lessons from the Victorian seasonal water market. *The Australian Journal of Agricultural and Resource Economics*, 50:403-423.

Brennan, D. 2008. Missing markets for storage and the potential economic cost of expanding the spatial scope of water trade. *The Australian Journal of Agricultural and Resource Economics*, 52:471-485.

Bureau of Transport and Regional Economics. 2003. *Investment Trends in the Lower Murray-Darling Basin*. Working Paper no. 58. Department of Transport and Regional Services, Commonwealth of Australia. Available at: <http://www.bitre.gov.au/publications/05/Files/wp58.pdf> (accessed 27/12/2009)

Department of Natural Resources and Environment. 2001*. The value of water: A guide to water trading in Victoria.* Melbourne.

Evans, R. 2007. *The Effects of Groundwater Pumping on Stream Flow in Australia. Technical Report*. Sinclair Knight Merz. Land and Water Australia, Australian Government, Canberra. Available at: <http://nlwra.gov.au/files/products/innovation/pr071283/pr071283.pdf> (accessed 28/04/2010)

Goulburn-Murray Water. *How Do Seasonal Allocations Work?* Website. Available at: <http://www.g-mwater.com.au/water-resources/allocations/how-seasonal-allocations-work> (accessed 13/12/2009)

Goulburn-Murray Water. 2009. *Carryover Checklist to assist G-MW customers plan for 2009/10.* Website. Available at: <http://www.g-mwater.com.au/news/media-releases/media-releases-2008/mr_carryover_checklist_to_assist_g-mw_customers_plan_for_200910_.html> (accessed 3/01/2010)

Government of Alberta. 2009. *Alberta Irrigation Information: Facts and Figures for the Year 2008*. Water Resources Branch, Irrigation and Farm Water Division, Alberta Agriculture and Rural Development, Lethbridge. Available at:

<http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/irr7401/$FILE/AltaIrrigInfo2008web.pdf> (accessed 17/04/2010)

Hafi, A., Beare, S., Heaney, A. and S. Page. 2005. *Water Options for Environmental Flows*. ABARE *e*Report 05.12. Prepared for the Natural Resource Management Division, Australian Government Department of Agriculture, Fisheries and Forestry, Canberra.

Heaney, A., Dwyer, G., Beare, S., Peterson, D. and L. Pechey. 2006. Third-party effects of water trading and potential policy responses. *The Australian Journal of Agricultural and Resource Economics*, 50:277-293.

Independent Audit Group. 1996. *Setting the Cap*. Murray-Darling Basin Ministerial Council, Canberra.

Mannix, A.E. 2009. *Analysis of the cost effectiveness of alternative policies and technologies to manage water extractions by the oil sands sector along the lower Athabasca River*. MSc thesis (unpublished). Department of Rural Economy, University of Alberta. Edmonton.

Mannix, A. E., Dridi, C. and W. L. Adamowicz. 2010. Water Availability in the Oil Sands under Projections of Increasing Demands and a Changing Climate: An Assessment of the Lower Athabasca Water Management Framework. *Canadian Water Resources Journal*, 35(1):29-52.

Marbek Resource Consultants and Renzetti, S. 2005. *Analysis of Economic Instruments for Water Conservation*. Submitted to Canadian Council of Ministers of the Environment, Water Conservation and Economics Task Group. Available at: <http://www.ccme.ca/assets/pdf/ei_marbek_final_rpt_e.pdf> (accessed 5/04/2010)

Murray-Darling Basin Ministerial Council. 1995. *An Audit of Water Use in the Murray-Darling Basin*. Canberra.

Nicol, L., Bjornlund, H. and Klein, K. 2008. Improved technologies and management practices in irrigation – implications for water savings in Southern Alberta. *Canadian Water Resources Journal*, 33(3): 283-294.

Parker, S. and Speed, S. 2010. *Agricultural Water Pricing: Australia*. Background report for OECD study: Sustainable Management of Water Resources in Agriculture. Organisation for Economic Co-operation and Development (OECD). Available at: <http://www.oecd.org/document/55/0,3343,en_2649_37401_44753399_1_1_1_1,00.html> (accessed 14/04/2010)

Peterson, D., Dwyer, G., Appels, D., and Fry, J. 2005. Water trade in the southern Murray-Darling Basin, *Economic Record*, 81: 115-127.

Phase 2 Framework Committee. 2010. *Phase 2 Framework Committee Report*. Prepared by Compass Resource Management and Solander Ecological Research. Cumulative Effects Management Association. Available at: <http://www.cemaonline.ca/> (accessed 14/3/2010)

Productivity Commission. 2003. *Water rights arrangements in Australia and overseas*. Commission Research Paper. Productivity Commission, Melbourne.

Productivity Commission. 2006. *Rural water use and the environment: The role of market mechanisms*. Research Report. Productivity Commission, Melbourne.

Quiggan, J. 2001. Environmental economics and the Murray-Darling river system. *The Australian Journal of Agricultural and Resource Economics*, 45(1):67-94.

Qureshi, M.E., Proctor, W., and Kirby, M. 2006. *Economic assessment of water trade restrictions in the Murray-Darling basin*. Paper presentation at the International Conference on Regional and Urban Modelling, Global Economic Modelling Network, Free University of Brussels, 1-2 June.

Randall, A. 1981. Property Entitlements and Pricing Policies for a Maturing Water Economy. *The Australian Journal of Agricultural Economics*, 25(3):195-220.

Roper, H., Sayers, C., and Smith, A. 2006. *Stranded irrigation assets*. Productivity Commission, Melbourne, Australia.

SFE Corporation Limited. 2005. *Establishing a futures market in water availability risk*. Discussion Paper. July. Sydney.

Young, M. 2008. *The Role of Government and Markets in Water Reform: Learning from Australia*. Presentation to Department of Rural Economy, University of Alberta. 28th November 2008. Available from: <http://www.myoung.net.au/water/talks/Alberta_University_081128b.ppt> (accessed 13/1/2009)

Young, M.D. 2010. *Environmental Effectiveness and Economic Efficiency of Water Use in Agriculture: The Experience of and Lessons from the Australian Water Reform Programme*. Background report for OECD study: Sustainable Management of Water Resources in Agriculture. Organisation for Economic Co-operation and Development (OECD). Available at: <http://www.oecd.org/document/55/0,3343,en_2649_37401_44753399_1_1_1_1,00.html> (accessed 14/04/2010)

Young, M. and J. McColl. 2005. Defining Tradeable Water Entitlements and Allocations: A Robust System. *Canadian Water Resources Journal*, 30(1):65-72.

5.2.3 Water quality

Chambers, P.A., Guy, M., Roberts, E.S., Charlton, M.N., Kent, R., Gagnon, C., Grove, G. and N. Foster. 2001. *Nutrients and their impact on the Canadian environment*. Agriculture and Agri-Food Canada, Environment Canada, Fisheries and Oceans Canada, Health Canada and Natural Resources Canada.

Department of Environment and Climate Change NSW. 2009. *The Hunter River Salinity Trading Scheme: 2007-08 performance*. DECC 2009/368. Sydney. Available at: <http://www.environment.nsw.gov.au/resources/licensing/hrsts/09368hrsts0708.pdf> (accessed 25/10/2009)

NSW Environment Protection Authority. 2001. *Proposed Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2001. Regulatory Impact Statement.* EPA 2001/19. Sydney. Available at: <http://www.environment.nsw.gov.au/resources/licensing/hrsts/hrstsris.pdf> (accessed 25/10/2009)

NSW Water Information. 2009. *Hunter Salinity Trading Scheme*. New South Wales Government website. Last updated 28 July 2009. <http://waterinfo.nsw.gov.au/hunter/trading.shtml> (accessed 25/10/2009)

O'Dea, G. and J. Cooper. 2008. *Water Scarcity: Does it exist and can price help solve the problem?* Water – Working Paper. January. Independent Pricing and Regulatory Tribunal of New South Wales. Available at: <http://www.ipart.nsw.gov.au/files/Water per cent20scarcity per cent20- per cent20Does per cent20it per cent20exist per cent20and per cent20can per cent20price per cent20help per cent20solve per cent20the per cent20problem per cent20- per cent20Working per cent20Paper per cent20January per cent202008.PDF> (accessed 1/11/2009)

Smith, S.A.Y. 2003. Hunter River Salinity Trading Scheme. Presentation to AARES 2003 National Symposium, *Market-Based Tools for Environmental Management*, Canberra, September 2-3, 2003.

Smith, S.A.Y. 2003a. What have we learned from The Hunter River Salinity Trading Scheme? NSW Environment Protection Authority. Paper accompanying presentation to AARES 2003 National Symposium, *Market-Based Tools for Environmental Management*, Canberra, September 2-3, 2003.

Appendix A OECD (2004) recommendations

OECD Environmental Performance Review, Canada (2004:52)

Recommendations for Water Management in Canada:

- Firmly implement water management policies, including *provincial water strategies* (e.g. basin management, ecosystem approach, stakeholder participation) and enforcement of regulations (e.g. inspections, sanctions); accelerate the development of integrated water resource management and water efficiency plans;
- Improve *efficiency in the delivery of water and waste water services*, through improved *governance* (e.g. consolidation of operators, quality assurance, accountability mechanisms), improved *supply management* (e.g. source-to-tap approaches for municipal drinking water systems, protection of rural water supply wells against contamination, maintenance and renewal of municipal water-related infrastructure) and *demand management* (e.g. water metering, technical measures, use of economic instruments, appropriate pricing levels and structures);
- Speed up the access to *water supply and sanitation infrastructure* for all Canadians;
- Review systematically *subsidies for water supply and treatment* infrastructure and *water pricing* practices, aiming at cost-effectiveness and long-term financing in the maintenance and upgrading of facilities; review *subsidies for flood and drought* control projects in terms of their long-term impact on risk; progressively move to *full-cost pricing* while taking account of social factors and the needs of First Nation and Inuit communities;
- Continue to promote reduction of water use and releases of water effluents from large as well as small and medium *enterprises*;
- Ensure that the environmental intentions of the *Agricultural Policy Framework* are firmly translated into actions and environmental results (e.g. with respect to nutrients, pesticides, irrigation);
- Improve the *information and knowledge base* for water management, including i) harmonised and up-to-date monitoring of ambient water quality; ii) better data on expenditure, prices and financing; and iii) further analysis of micro-economic conditions facing key water users.

Appendix B Basic theory and literature review

B.1 Optimal water allocation

In theory, a socially optimal allocation of water will occur when the marginal social benefits (MSB) of water extraction equal its marginal social costs (MSC). In this valuation context, the term “social” broadly refers to all use and non-use values (environmental, social and economic) arising from water extraction. For example, in the case of the lower Athabasca River (Section 4.2.2), social benefits include the economic benefits of production arising from industrial water-use. Social costs include those associated with the impacts of water extraction to the downstream environment, including those related to water quality. Figure 8-1 provides a hypothetical illustration of the relationship between the marginal social benefits and costs of water extraction, and the optimal level of water allocation. In cases where a physical limit is set on total water extraction over a period, the supply curve may be considered to be vertical (e.g., Figure 8-2).

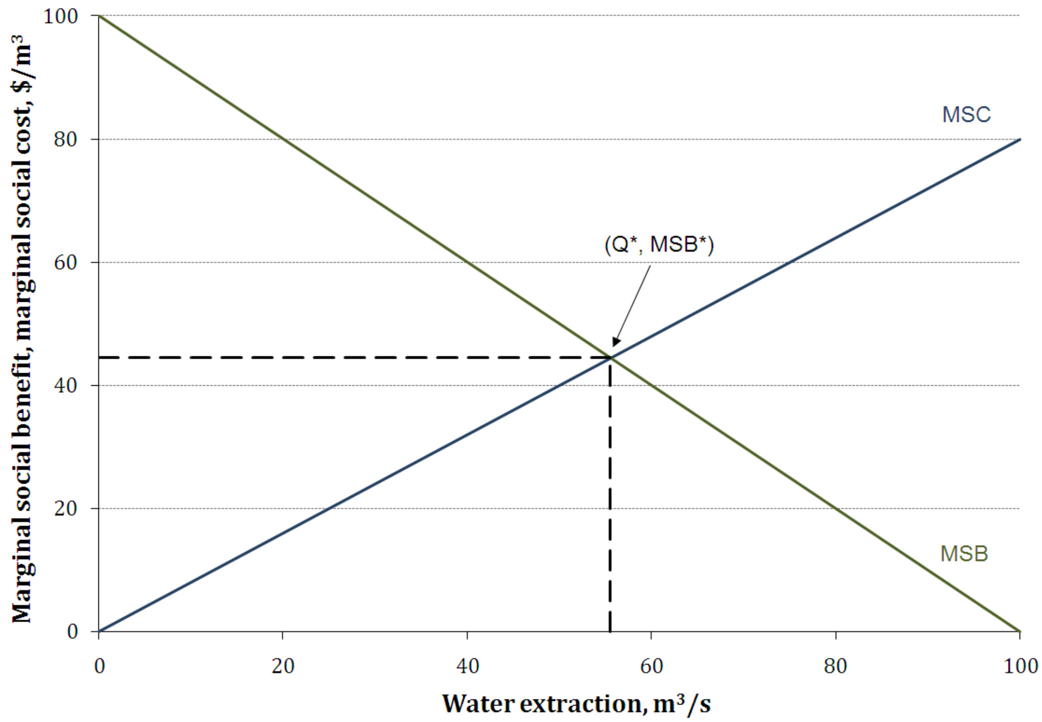

Figure 8-1 Hypothetical depiction of marginal social benefits and costs of water extraction, and optimal level of water allocation (Q*)

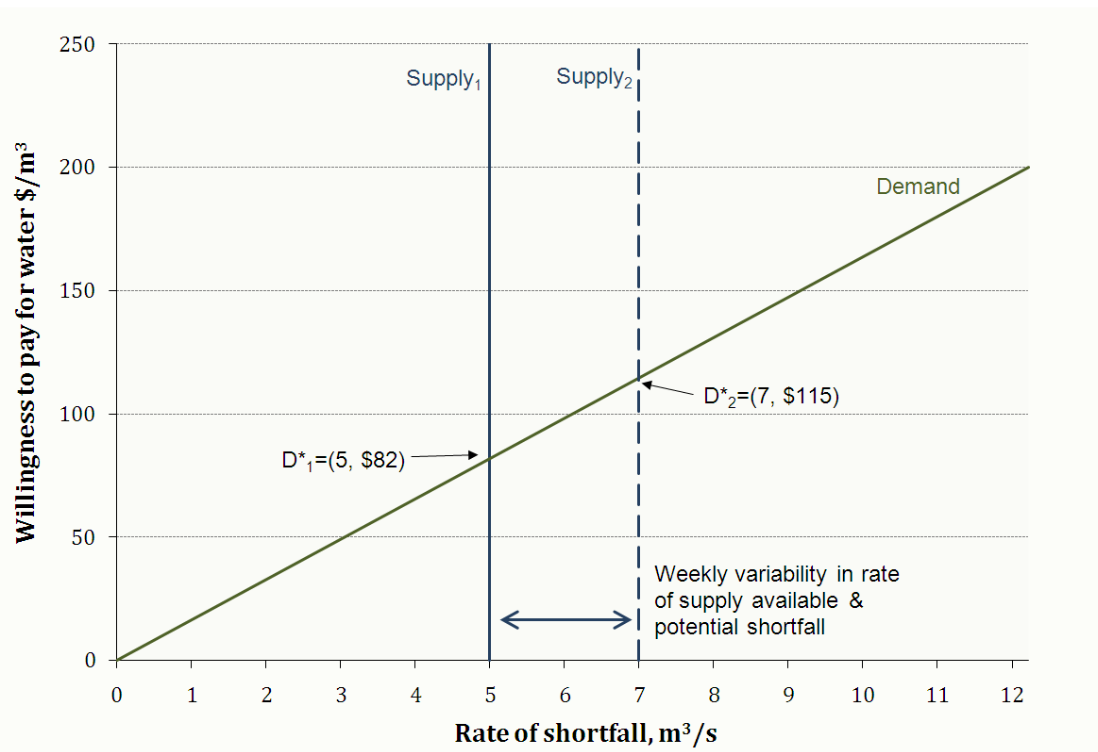

Figure 8-2 Illustrative (hypothetical) example of relationship between shortfall of supply and demand for water in an unregulated river system with a weekly variable cap on water extraction

B.2 Selection and design of economic instruments

For the design of markets to manage water allocations, Young and McColl (2005) highlight the importance of selecting a separate policy instrument to address each policy goal (see also Young [2008]). Their advice is based on Tinbergen's principle – that is, that the number of policy instruments must at least number the independent targets to be attained to enable a particular outcome to be achieved (Tinbergen, 1952), accompanied by Mundell's principle of effective market classification (Mundell, 1960), which advises that "policies should be paired with the objectives on which they have the most influence" (Mundell, 1968:239) to enable a dynamic system to be steered directly toward a stable solution. Thus, if there are several goals that are not independent (e.g. cost-effectiveness in meeting water restrictions, and increased water-use efficiency) then more than one policy instrument may be necessary.

A fundamental consideration for the design of economic instruments is whether to employ a price-based or quantity-based instrument (or a hybrid of some form). For example, in the case of the lower Athabasca River basin (Section 4.2.2), the water management framework (Phase 1) effectively caps quantity across different ranges of the flow duration curve calculated for each week of the year, however in theory it is possible that a price instrument may achieve the same quantity outcome. In cases where the quantity limit may not be reached, a price instrument has the advantage that it retains the potential to reflect the shadow value of water use.

Weitzman (1974) explains the relative advantages of each type of instrument for regulating the production of a single good (e.g. an environmental good), and for regulating the production of either multiple goods or a single good produced by multiple entities, in cases where there is uncertainty in the benefits and costs of production. A key finding was that the relative non-linearity of benefits versus costs influences the risk associated with the selection of either instrument (Weitzman, 1974). Summarised by Nordhaus (2007:37), "if costs are highly nonlinear compared to benefits, then price-type regulation is more efficient; conversely, if the benefits are highly nonlinear while the costs are close to linear, then quantity-type regulation is more efficient". It was also found that with more firms producing similar output there is a greater advantage of using price instruments rather than quantities (Weitzman, 1974).

In addition to the choice of instrument, uncertainties related to the benefits and costs of water conservation are particularly important in determining the optimal level of environmental protection. If the loss of environmental values is irreversible, there is an option value associated with the uncertainty of benefits to future generations - indicating that the level of protection should be set higher than otherwise (Pindyck, 2007). Conversely, improvements in water-use efficiency are likely to require investment in long-term changes to industry operations. The presence of irreversible sunk costs, when benefits are uncertain, indicates that the level of conservation should be set lower than otherwise (Pindyck, 2007).

Other policy factors may also influence instrument selection. Public acceptability is likely to be higher for systems designed to reduce an environmental harm in a cost-effective manner, compared to those schemes that allow the (cost-effective) maintenance of present levels of an environmentally harmful activity (Stavins, 2003). If the instrument generates revenues for government, such as in the case of a charge for water extraction, how the revenue is used (e.g. increased public spending or reducing other taxes) may affect the overall merit of the policy when indirect or general equilibrium impacts are taken into account (Sterner [2003], Fischer and Newell [2007]).

The optimal setting of prices for price-based instruments may be difficult. For efficiency, prices should be set on an annual basis such that the marginal costs of abatement, e.g. reduced water extraction, should equal the present value of marginal damages, e.g. arising from water use (Parry and Pizer, 2007). As optimal prices may be difficult to determine due to seasonal factors, a quantity instrument may be more precise and easier to develop in practice (Sterner, 2003).

The number of market participants is particularly important in the case of quantity-based instruments. Quantity-based instruments create artificial scarcities, monopolies, or rents, and are more susceptible to corrupt activities than price-based instruments - even in developed countries (Nordhaus, 2007). With few market participants, thin markets may result in significant market distortion, very limited trading, and strategic behaviour by firms (Sterner, 2003). Price-based instruments fix prices and provide certainty to firms, whereas trading systems may produce volatile prices for licences, which in turn may lead to reduced investment in abatement technology and additional costs for risk-averse firms (Parry and Pizer, 2007). Price volatility may be a particular issue for short-term water trading in an unregulated river basin, given unpredictable flow, fixed licensed water-use, and inelastic demand in the short run.

Hybrid schemes provide a method for dealing with the shortcomings of price-based and quantity-based instruments. In cases of increasing marginal damages, hybrid instruments are particularly attractive where marginal damages have wide variation across the range of total environmental harm (in the case of the Athabasca River, this may be associated with the range in the proportion of water extracted) and have significant uncertainty (Roberts and Spence, 1976). Licences can be used to avoid a high level of environmental harm, while charges provide an ongoing incentive to reduce environmental harm and may provide a greater level of abatement (e.g. water conservation) than that required by licences in the case where abatement costs are low (Roberts and Spence, 1976). One particular form of hybrid scheme allows licences to be traded and imposes a fixed penalty when water extraction is greater than licence conditions; the fixed penalty protects participants against volatile market prices (Roberts and Spence, 1976).

Sterner and Höglund Isaksson (2006) highlight the symmetry between price and quantity-based instruments and advise that the choices available for instrument selection depend on the property rights to the natural resource (Table 8-1). For example, in the case of water licences in Alberta, existing water users have prior rights although the degree of ownership is not entirely clear. Water trade is allowed subject to approval, however licences that are not actively used may be cancelled. In the case of industrial water-use along the lower Athabasca River, for example, licences may be amended to ensure "the most beneficial use of the water in the public interest" (e.g., Alberta Environment [1987]), and if so this in turn may lead to compensation under the *Water Act* (*s158*). The quantity instruments available (Table 8-1) are well established. Price instruments for an intermediate rights situation are fairly novel in practice, and are discussed in more detail below.

Table 8-1 Rights to the environment and selection of policy instruments (Sterner and Höglund Isaksson, 2006:96)

Holder of ownership rights to the environment	**Type of instrument**	
	Quantity	**Price**
Society	Auctioned Permits	Tax
Intermediate (State grants rights in proportion to output)	Permits output allocated to cover some share of permits needed	Total or partial refunding of charges i.e. Refunded Emission Payment (REP)
Intermediate (Firms have some "prior appropriation" rights)	Grandfathered permits to cover some share of permits needed	Tax-subsidy i.e. Tax with Allowances (TWA)
Polluter	Free permits with buyback from state to correspond with abatement	Pure subsidy

One price instrument that may be applicable in the case of intermediate rights to the environment is a tax with allowance or charge-subsidy scheme (Table 8-1). This type of instrument sets a baseline right to each firm for the resource. If the effluent level (or, in this case, water extraction) of a firm is above the baseline then a charge is imposed, if instead it is below the baseline then a fixed payment is provided (Mumy [1980] in Pezzey [1992]). New firms have no baseline rights, and pay for their entire consumption. Pezzey (1992) demonstrates that this scheme creates the same outcomes as a tax, and is symmetric to a permit market in which permits are initially allocated (e.g. grandfathered) and government either rents permits back or offers additional permits depending on the optimal level of effluent (or water extraction).

The alternative price instrument applicable in cases of intermediate rights is the refunded emission payment scheme. In Sweden, a refunded emission payment scheme exists to regulate the emission of nitrogen oxides (NO_x) from large industry. Described by Sterner and Höglund Isaksson (2006), the Swedish scheme sets an unusually high charge for emission of nitrogen oxides with the revenues collected then refunded in proportion to output (based on a measure of energy produced by each firm). The choice of scheme was influenced by the variance in abatement costs among polluters, familiarity in the use of charges rather than tradeable permits among policymakers, and practical issues including the high costs of monitoring (that restricted the scheme to 200 large polluters) and polluter resistance (Höglund Isaksson [2005], Sterner and Höglund Isaksson [2006]). Refunded payments are likely to be more politically attractive for managing water extractions. Compared to a tax with allowance, the refunded emission payment does not assume a baseline level of rights, and so may be relatively favourable for new firms (Sterner and Höglund Isaksson, 2006). Over a five year period of implementation it was found that technology improvement had reduced abatement costs for the Swedish firms, with many of the abatement activities carried out at very low to zero cost (Höglund Isaksson, 2005).

Refunded emission payments are variable rather than fixed (i.e., net payment depends on performance in relation to the refund measure and that of other scheme participants), and do not provide the same outcomes as a pure charge or tax with allowance scheme. In theory, under perfect competition any degree of refunding would lead to distortions as a higher level of output than otherwise is encouraged by the refund (Gersbach and Requate, 2004). Imperfect competition may also result in suboptimal outcomes, with weaker incentives for abatement in the case of low competition or oligopolies with large output shares (Sterner and Höglund Isaksson, 2006). In addition to sufficient competition, to achieve an equivalent outcome as a Pigouvian tax the scheme requires technology development to be external to the targeted plants (i.e., exogenous), otherwise there is a risk of reduced innovation - particularly in cases of indistinct technology that is unable to be protected by patents, such as learning from other's experiences (Höglund Isaksson, 2005).

The provision of incentives for technological progress (innovation and adoption) differ depending on policy instrument selection (e.g. Fischer and Newell, 2007), and the effect of technological progress on market outcomes in turn differs depending on the policy instrument. If environmental charges (e.g. water prices) are constant, then exogenous technological progress produces a higher than optimal level of abatement; whereas if the policy of an environmental cap (e.g. associated with water trade) is constant, then exogenous technological progress will result in a less than optimal level of abatement and a fall in the market price of licences (Sterner [2003], Stavins and Whitehead [1992]). Which method produces the greatest loss is an empirical matter, although if damages are estimated to increase with time, e.g. with increased population, income, and/or knowledge, then a price-based instrument is preferable (Sterner, 2003).

Private investment in research and development may lead to benefits to others when information is shared, yet this benefit may be external to the investment decision and the knowledge gained may not be publicly disseminated. Jaffe et al. (2005) discuss the relationship between market failures associated with innovation and diffusion of new technologies (leading to market under-provision), and activities that create environmental externalities (leading to market over-provision, e.g. in-stream flow impacts). A lack of investment in new, environmentally-beneficial technology may be due to a weak environmental policy, positive knowledge and adoption spillovers, or incomplete information (Jaffe et al., 2005). To deal with both forms of market failure (i.e., environment and technology), environmental regulation should be the main policy focus, while taking care to avoid policies that favour a particular technology at the expense of further innovation (Jaffe et al., 2005). To provide incentives for technology, public-private partnerships that allow market forces to influence the choice of technology may be particularly effective (Jaffe et al., 2005).

An applied study that ties the analysis of market-based instruments and incentives for new technology is provided by Fischer and Newell (2007). They model the effects of six policies designed to reduce the greenhouse gas emissions of a perfectly competitive energy sector. The policies assessed included a production subsidy for implementation of a new technology, and subsidies for research and development. They found that while emissions pricing provided the primary incentive to reduce emissions, an optimum (and much cheaper) portfolio consisted of three policies to address three externalities: (i) emissions, addressed by emissions pricing, (ii) research and development spillovers, addressed by an R&D subsidy, and (iii) learning spillovers, addressed by a subsidy for production that uses new technology (in this case, a renewable generation subsidy). The R&D subsidy was found to be a “no regrets” policy (Fischer and Newell, 2007:40) that outperformed the emissions pricing option when very low levels of abatement were required.

Appendix C Background explanatory factors

Two key background factors are discussed below to assist in understanding the context for the case studies in both Canada and Australia.

C.1 Climatic variability and demand characteristics

The variability of water supplies in Australia is worthy of special mention; along with southern Africa, the continent of Australia has the most variable precipitation pattern in the world (McMahon et al, 1987). Multi-year dry periods followed by floods are common, and in many regions it is natural for small to mid-sized rivers to cease flow during the height of summer or the dry season[65]. The extreme variability of water supplies, combined with a pattern of water demand that tends to peak when natural flows are at their lowest, creates a situation in which both urban and rural developments are typically reliant on large dams to assure an adequate water supply, and the opportunity costs of water use are often readily apparent. Treated wastewater effluent is usually discharged to land for evaporative disposal (e.g. irrigated woodlots, irrigated agriculture) or sea, so that urban water supply represents a net loss in river flow once water is diverted for urban use, and direct impacts on in-stream water quality are avoided.

Canadian water supply and demand characteristics tend to be at the opposite end of the spectrum. In most regions of Canada there is year-round access to relatively abundant supplies of water, including during the winter, low-flow period when water is covered by ice. The snowpack may act as a natural store of water, particularly in areas of higher altitude (e.g. the Canadian Rockies). The natural period for high river flow occurs following snowmelt and generally coincides with a period when water demands are high in

[65] The natural, periodic cessation of flow occurs even for very large river systems in Australia. Though the River Murray has a substantial catchment area (1 061 469 km^2), the river may have periodically ran dry during at least five periods in the 20th century if it were not for flow regulation structures such as dams, weirs and locks (Murray Darling Basin Authority website).

volume. While absolute water scarcity is relatively uncommon, one of the most obvious impacts on natural flow variability and corresponding ecosystem health occurs from the operation of dams for hydroelectricity generation (Schindler [2000], Schindler and Donahue [2005]). Apart from water supply, watercourses are also used to discharge wastewater from municipalities and industry. This discharge may be problematic for maintaining in-stream water quality concentrations to within guidelines for aquatic health, particularly during winter when the natural flow may be insufficient for dilution.

C.2 Political economy

As previously mentioned, the basis of economics is a *utilitarian* philosophy – that is, that decisions are deemed worthwhile when benefits are greater than costs. The basic approach is to set target outcomes to maximise economic efficiency, while addressing equity concerns via the use of separate policies (refer to Appendix B.2). The extent to which a utilitarian philosophy – as applied to a broad base (not at the individual level) – is adopted and/or accepted by citizens, combined with norms for decision making, will influence how economic instruments will be designed in practice, their ease of implementation including monitoring and enforcement, and the overall ability of economic instruments to minimise costs and increase efficiency. Ideally, the development of an economic instrument is handled by a skilled team of technicians (combining expertise in economics, hydrology, and sociology) that have been assigned the responsibility to carry out instrument design and implementation.

The above philosophy and approach is in contrast to the partisan nature of decision making in Canada, where stakeholder negotiations are central to the decision-making process. As part of this process, stakeholder advisory groups are commonly formed, often with a requirement that decisions be reached by consensus among all parties. If all stakeholders stand to gain from the proposed policy change then consensus is assured. However, similar to many decisions involving economic reform, environmental policy decisions tend to involve situations where policy gains are attributable to the broader public (e.g. improved water quality) at the expense of identifiable stakeholders (e.g. industry and agricultural enterprises that discharge pollutants). During stakeholder negotiations, the notion of making trade-offs so that costs are accepted in order to realise benefits may create a stalemate, as the distribution of costs and benefits would likely differ among parties, and there may not be an ability for the group to directly influence equity outcomes – particularly if the policy's benefits are widely dispersed. In broad terms, this process of policy design by negotiation creates a situation in which equity is inseparable from efficiency outcomes, technical information is of secondary importance, and the equity of key stakeholders is afforded the greater emphasis.

Further information on characterising public discourse and the decision-making process may be gleaned from Ferree et al. (2002), who describe four distinct models within modern democracies (Table 8-2). Canada appears to characterise a Constructionist form of democracy, whereas Australia is an example of a Representative Liberal democracy (for example, see Table 8-3). The different models of decision-making have important ramifications for the design and implementation of economic instruments.

Table 8-2 Normative criteria in democratic theory (Ferree et al., 2002:316)

Theory types	Criteria for a good democratic public discourse*			
	Who **participates**	**In *what* sort of process**	***How*** **ideas should be presented**	***Outcome*** **of relation between discourse and decision-making**
Representative liberal	*Elite dominance* *Expertise* *Proportionality*	Free market-place of ideas Transparency	Detachment Civility	Closure
Participatory liberal	Popular inclusion	*Empowerment*	Range of styles	Avoidance of imposed closure
Discursive	Popular inclusion	Deliberative	*Dialogue* *Mutual respect* *Civility*	Avoidance of premature, non-consensus-based closure
Constructionist	Popular inclusion	Empowerment Recognition	Narrative Creativity	*Avoidance of exclusionary closure* *Expansion of the political community*

*Priority concerns presented in italics.

Note: the authors use Germany as an example of a Representative Liberal model, and the United States as an example of a Participatory Liberal model.

Table 8-3 Example statement of values and principles (Source: Murray-Darling Basin Ministerial Council [2001]). Note the principles of efficiency, full accounting and informed decision-making (the statement emphasizes participation related to the multi-state governance of the basin at that time).

Integrated catchment management in the Murray–Darling Basin

A process through which people can develop a vision, agree on shared values and behaviours, make informed decisions and act together to manage the natural resources of their catchment: their decisions on the use of land, water and other environmental resources are made by considering the effect of that use on all those resources and on all people within the catchment.

Our values

We agree to work together, and ensure that our behaviour reflects the following values.

Courage

- We will take a visionary approach, provide leadership and be prepared to make difficult decisions.

Inclusiveness

- We will build relationships based on trust and sharing, considering the needs of future generations, and working together in a true partnership.
- We will engage all partners, including Indigenous communities, and ensure that partners have the capacity to be fully engaged.

Commitment

- We will act with passion and decisiveness, taking the long-term view and aiming for stability in decision-making.
- We will take a Basin perspective and a non-partisan approach to Basin management.

Respect and honesty

- We will respect different views, respect each other and acknowledge the reality of each other's situation.
- We will act with integrity, openness and honesty, be fair and credible, and share knowledge and information.
- We will use resources equitably and respect the environment.

Flexibility

- We will accept reform where it is needed, be willing to change, and continuously improve our actions through a learning approach.

Practicability

- We will choose practicable, long-term outcomes and select viable solutions to achieve these outcomes.

Mutual obligation

- We will share responsibility and accountability, and act responsibly, with fairness and justice.
- We will support each other through necessary change.

Our principles

We agree, in a spirit of partnership, to use the following principles to guide our actions.

Integration

- We will manage catchments holistically; that is, decisions on the use of land, water and other environmental resources are made by considering the effect of that use on all those resources and on all people within the catchment.

Accountability

- We will assign responsibilities and accountabilities.
- We will manage resources wisely, being accountable and reporting to our partners.

Transparency

- We will clarify the outcomes sought.
- We will be open about how to achieve outcomes and what is expected from each partner.

Effectiveness

- We will act to achieve agreed outcomes.
- We will learn from our successes and failures and continuously improve our actions.

Efficiency

- We will maximise the benefits and minimise the costs of actions.

Full accounting

- We will take account of the full range of costs and benefits, including economic, environmental, social and off-site costs and benefits.

Informed decision-making

- We will make decisions at the most appropriate scale.
- We will make decisions on the best available information, and continuously improve knowledge.
- We will support the involvement of Indigenous people in decision-making, understanding the value of this involvement, and respecting the living knowledge of Indigenous people.

Learning approach

- We will learn from our failures and successes.
- We will learn from each other.