Essays on Water Allocation in New Zealand: The Way Forward

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October 2005

Acknowledgements

We are grateful for helpful comments from Graeme Guthrie and Glenn Boyle, and for the support and assistance from colleagues at the New Zealand Institute for the Study of Competition and Regulation (ISCR). This book has also benefited from participants' comments at seminars to Meridian Energy, Wellington Regional Council and various ISCR public seminars. Thanks also to Tony Gray from Environment Canterbury and M-Co New Zealand for providing us with data. Any remaining errors or omissions are the responsibility of the authors.

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Chapter 1

Introduction

Water is one of the most important resources in a healthy and well-functioning economy. In addition to its direct role in sustaining life - for human, plant and animal populations - water is a crucial input in agricultural and industrial production, as well as electricity generation. Water also supports a wide range of recreational activities and often has significant existence, cultural and amenity value. Despite its fundamental importance, many of the current approaches for allocating water resources, in New Zealand and elsewhere in the world, are typically based upon a legacy of abundant water supplies. However, increasing populations and incomes have placed a growing demand on limited water resources, and will continue to do so in the future. In New Zealand, for example, the National Institute of Water and Atmospheric Research has estimated that in the next 50 years rainfall will be less than in the past while demand for irrigation water will increase rapidly (NIWA, 2003). Many current water allocation approaches fall short in dealing with such changes, which often results in water being allocated in a highly inefficient manner.

Inefficiencies in water allocation, or indeed the allocation of any scarce resource, occur when the resource is allocated to those users who do not necessarily generate the most value for society in their use of the resource. Thus, the resource could be reallocated to other more highly valued uses and thereby achieve a more efficient allocation. Inefficiencies can also occur in the use of the resource. For example, when water is wasted excess water is being used without benefit. With the increased scarcity of water resources comes a growing need to reduce such inefficiencies and ensure water is used wisely.[1]

In New Zealand, the strain on water resources is already evident. In 1994, for example, Auckland was hit by a severe water crisis, due to a prolonged drought. Significant (and urgent) conservation measures were required by both business and household water users. The crisis led to investment in the Waikato pipeline to transport water from the Waikato River to supplement Auckland's existing supplies,[2] and the introduction of water meters and usage based pricing in many households. Droughts have also had a significant adverse impact on water users in the South Island, with water shortages in Marlborough affecting many farms and vineyards in 2001, and low inflows into the southern hydro lakes affecting the generation of electricity in 2001 and 2003. Competition between water users is also becoming more apparent, with examples including competition for water from the Waitaki River in South Canterbury, and the Wairau River in Marlborough. Demand for water for hydro-generation, irrigation and in-stream purposes (such as environmental and recreational uses) is fueling the conflict between existing and potential water users in these areas.

While such challenges in the allocation of scarce water resources are not limited to New Zealand, other countries are developing methods of managing

[1] In Appendix A we provide a more comprehensive description of the standard economic concept of efficiency, and argue why the current system for water allocation in New Zealand does not achieve a high level of efficiency.

[2] Auckland's main water supply sources prior to the Waikato pipeline were dams in the nearby Hunua and Waitakere ranges.

these challenges, which reflect an increasing awareness of the need to allocate water efficiently in a manner that addresses its growing scarcity. There has been a move towards creating systems based on clearly defined property rights providing entitlements to water. Property rights enable exchange between low and high valued uses, permitting water users and suppliers themselves to make decisions on the relative value of water in competing uses and hence where it is most efficiently allocated. In some countries, such voluntary exchange has enabled water to be allocated to its most highly valued use, and provided incentives for water users to minimise water wastage. In this book we consider the tradeable property rights framework as a method of allocating water. Our objectives are to explain why such an approach can improve aspects of New Zealand's current water allocation framework, to establish the appropriate set of institutional arrangements for a tradeable rights framework to operate effectively, and to examine what may influence the value of tradeable water rights.

Part I of this study (Chapters 2, 3, 4 and 5) considers institutional arrangements for water allocation. In Chapter 2 we outline the current framework for water allocation in New Zealand. This is based on an administrative procedure defined through legislation by the Resource Management Act 1991, and has a number of shortcomings when faced with the growing demand for water resources. Among the shortcomings are that most water is allocated on a first-in first-served basis and exchange of water rights is difficult. This leads to significant inefficiencies in that water is not going to those users that value it the most unless, by chance, those users are first-in. There are also a number of barriers to the trading of water rights. This means that, once allocated, it is difficult to reallocate water to meet changing societal values and difficult for new water users to obtain water on fully allocated resources.

To address these issues, we review the frameworks for water allocation in a number of other countries in Chapter 3. We look at a range of countries, including those that have arid climates and thus have traditionally had significant scarcity of water, and others that have recently reformed their water allocation frameworks to move towards a framework based on tradeable rights. From their experiences we develop some simple lessons for New Zealand. These lessons suggest that creating secure and tradeable property rights to water, and reducing barriers to trade in these rights, can result in efficient water allocation amongst the increasing number of competing users.

The experiences of other countries also shows that having tradeable water rights is not the perfect solution in itself. While such a framework can generate significant benefits over alternative administrative allocation frameworks, it needs the right set of institutional arrangements in place to foster and encourage trade. To determine these arrangements, we consider not only the experiences with tradeable water rights outlined in Chapter 3, but also the experiences in tradeable rights frameworks for other scarce resources.

Thus, in Chapter 4, we outline the institutional arrangements for the tradeable fishing quota framework in New Zealand, and the tradeable sulphur dioxide allowances framework in the United States. We find that these frameworks are both considered to be relatively successful in comparison to alternative administrative approaches to resource allocation. The analysis of these frameworks shows the nature of the institutional arrangements that need to be put in place to ensure that trading achieves a more efficient allocation of the resource.

In Chapter 5 we collate the analyses of tradeable rights frameworks in water from Chapter 3, and fisheries and air pollution from Chapter 4 to highlight desirable institutional arrangements for a tradeable water rights framework in New Zealand. We show that, to encourage trade and foster efficiency, a tradeable rights framework requires (among other things) well-defined rights and allocation limits, an effective administrative environment, and mechanisms to enhance the smooth flow of information.

One of the important aspects of information flows is that market participants have information on the value of water property rights. Hence in Part II (Chapters 6 and 7) we outline approaches for estimating the value of water rights and determine how different features of water rights affect their value. Chapter 6 considers the value of water rights that allow for the extraction of water from a resource, while Chapter 7 values water storage rights. In the same way as values and valuation methodologies are important in the financial markets, determining the value of a water right is a crucial aspect of water rights trading. In many cases, a market for water rights may be thin, being dominated by bilateral decentralised trading between participants. In such cases, assessing the value of water rights outside of market forces may have significant importance. Moreover, as water is often used as an input into a production process (for example, for irrigation of crops or generation of electricity), its value as a property right is important for firm decision-making.

The ideas we develop in this book are likely to have implications for the water sector in New Zealand. Firstly, we argue, based on economic theory and the experience of other countries, that a tradeable property rights approach is likely to be beneficial in dealing with the allocation of increasingly scarce water resources in New Zealand. The analysis of other countries and of successful tradeable rights frameworks in fisheries and air pollution control, also suggests a number of important institutional arrangements are required for ensuring such a system works effectively. Finally, we also show how the characteristics of water rights affect their value. Our intention is to provide a broad insight into the underlying economics of water allocation and the implications that this has for water resource management in New Zealand.

Part I: Modern Institutional Arrangements for Water Allocation

Chapter 2

Water Allocation in New Zealand

2.1 Introduction

New Zealand is relatively well endowed with rainfall and water resources in comparison to other countries. Despite this, increasing demand and competition for water from in-stream and consumptive users, and an uneven distribution of rainfall and other water sources, are putting an increasing strain on New Zealand's water resources. The current framework for water allocation in New Zealand does not adequately address this growing demand. In this chapter we outline New Zealand's current water allocation framework and highlight some of its problems that need to be addressed.

The key aspects that we focus on in this chapter are the defining elements for the operation of any resource allocation regime: property rights and institutional arrangements. In terms of water, a property right is a claim to the use of water and the benefits that accrue from its use.[1] Such a claim is usually protected by the state or legal system. Institutional arrange-

[1]See Appendix B for the basic economic theory of property rights.

ments are the rules and social institutions that are formed to manage and allocate resources. They may be markets, where buyers and sellers interact through decentralised decision-making to allocate resources based on a pre-specified market design; government institutions, with either nationwide or local decision-making; private entity institutions operating according to the appropriate legal arrangements; or various combinations of these and other types of rules and institutions. Property rights regimes require the institutions of enforcement and monitoring and trading. Whether these are special or rely on general canons of law depends upon the resource. The key point is that property rights and institutional arrangements are complementary and vital to the functioning of an effective water allocation system.

In this chapter we first briefly outline the sources and uses of water in New Zealand (Section 2.2). We then explain the current legislative framework for water allocation in Section 2.3, and outline the important aspects relating to property rights and institutional arrangements in this framework in Section 2.4. Section 2.5 highlights some of the main issues with the current water allocation framework in New Zealand, and we provide some concluding comments in Section 2.6.

2.2 Sources and Uses of Water

New Zealand's water environment is fed by abundant rainfall, with the total amount of precipitation estimated as anywhere between 300 billion and 600 billion cubic metres per year (Ministry for the Environment, 1997). However, this rainfall is not evenly spread, geographically or throughout the year. Some areas are particularly dry, such as Central Otago, which is a rain shadow area and has an average yearly rainfall of only 350mm. Other areas receive substantial rainfall, for example Westland, which has an average rainfall of more than 6000mm per year. Moreover, many areas are subject to significant intertemporal rainfall variations between seasons and between years, resulting in droughts and water shortages in some periods, and flooding in others.

Rainfall collects in both surface waters (such as streams, rivers, lakes and wetlands) and groundwater deposits. New Zealand has around 70 major rivers, over 770 lakes, a huge number of streams and numerous underground aquifers. These include a number of relatively small catchments that have little or no connection to other catchments.[2] New Zealand draws its water from both surface water and groundwater resources. Rivers and lakes provide about 60 percent of the water consumed, with the remainder provided by groundwater sources (Ministry for the Environment, 1997).

Water is used for a number of competing activities in New Zealand. The largest volume of water used is for non-consumptive hydro-electric generation purposes, with over 100 billion cubic metres per year flowing through hydro station turbines to meet the country's electricity needs (Statistics New Zealand, 2002). Other in-stream uses of water include recreational and environmental uses (such as the preservation and sustenance of aquatic life, flora and fauna). A number of lakes, rivers and wetlands are also preserved for conservation, often because of their location in national parks. Consumptive uses of water include irrigation, livestock consumption, household consumption and industrial use. Excluding hydro-electric generation, water use for such activities is close to 2 billion cubic metres per year. Water for irrigation purposes is by far the largest of these consumptive uses. Some estimates have put irrigation water at around 57 percent of total consumptive water use (Statistics New Zealand, 2002). Others, such as an analysis of resource

[2] This is in contrast to many examples in other countries, such as Australia and the Western United States, where large rivers with a significant catchment area are more common.

consents to use water (excluding hydro-electric generation) by Lincoln Environmental (2000), estimate that as much as 77 percent of water allocated is for irrigation purposes.

2.3 The Legislative Framework

The main legislation governing the allocation of water in New Zealand, and in fact all natural and physical resources, is the Resource Management Act 1991 (RMA). The RMA came into force on 1 October 1991. Before then, numerous statutes and regulations relating to the environment existed. The RMA set out to integrate these into one major piece of legislation.[3] It created a framework for decentralised decision-making: that is, in this case, decision-making at the local government level rather than the central government level. This was based on a key premise in a report by the World Commission on Environment and Development (1987): that resource allocation decisions are best made at the level closest to the resource, by those who bear the consequences.[4] A key advantage of this decentralised approach over centralised resource allocation is that there is no need to achieve a national consensus on allocation, which would obviously be difficult given the variety of competing interest groups. Rather, decentralised decision-making can take into account the needs and preferences of smaller, local groups, individual demands and suppliers (Hawke, 2003).

The key part of the RMA for resource allocation is Part 2, which defines the overall purpose of the RMA as: "to promote the sustainable management

[3]Prior to the RMA, the main legislation governing water allocation was the Water and Soil Conservation Act 1967 and the Town and Country Planning Act 1977.

[4]In the next chapter we conclude, however, that decision-making for the allocation of water resources is best made at an even more decentralised level than local government, that is, by actual water users. This is in accord with the premise noted by the World Commission on Environment and Development, as actual water users are even more likely to bear the consequences of resource allocation decisions than local government.

of natural and physical resources" (Part 2, section 5). As defined in the RMA, sustainable management means managing natural and physical resources to provide for current needs while:

> "(a) Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and
>
> (b) Safeguarding the life supporting capacity of air, water, soil, and ecosystems; and
>
> (c) Avoiding, remedying or mitigating any adverse effects of activities on the environment" (Part 2, section 5).

Essentially the RMA focuses on the effects of activities (as opposed to the activities themselves) and ways to reduce or eliminate any of these effects that may harm the environment.

Along with the purpose of the RMA, the other key part of the Act is the identification of some important principles for decision-makers to use when making decisions under the Act (Part 2, sections 6 to 8). These principles are:

- Matters of national importance: such as the protection of the natural character of the environment, and the protection of natural features and landscapes.
- Other matters: included here are a number of distinct issues such as the exercise of guardianship over an area by tangata whenua, the efficient use of a resource and the recognition and protection of heritage values.
- Principles of the Treaty of Waitangi.[5]

[5] In terms of the RMA, one of the main principles of the Treaty of Waitangi is a duty to consult with Maori on resource management decisions (Parliamentary Commissioner for the Environment, 1998).

Decisions on whether or not to authorise a particular activity must "recognise and provide for" matters of national importance, but must only have "particular regard" to other matters and "take into account" the principles of the Treaty. Thus, while matters of national importance are to be considered secondary to the overall purpose of the RMA, they are given greater weight than other matters and Treaty principles (Milne and Mooar, 2002).

At the national policy level, the responsibility for administering and managing the RMA lies with the Ministry for the Environment. The Department of Conservation also has a role at this level, although only relating to New Zealand's coastal water environment. The main role of decision-making under the RMA, particularly with regard to water allocation, is played by the 12 regional councils and 4 unitary authorities[6] (hereafter collectively termed councils). The councils were developed with the role of water management in mind, as their boundaries are broadly defined in terms of the major water catchments.

The RMA effectively requires a strategic planning approach to water allocation. It provides councils with a number of tools to use for water allocation and management, namely: plans and policy statements, resource consents, and enforcement mechanisms.

Plans and policy statements are issued in a hierarchical fashion, where those at the lower level must be consistent with those higher in the hierarchy. At the highest level, the RMA allows the Minister for the Environment to issue national policy statements and national environmental standards, relating to matters of national significance. However, since the inception of the RMA there has been little use of these in relation to water resources. At the next level are regional policy statements, which all councils must pre-

[6] Unitary authorities exist in areas where there are no regional councils and are endowed with the responsibilities of both a regional council and a local district or city council in the particular region.

pare. Regional policy statements present an overview of all the natural and physical resource issues in the region. Next, councils may prepare regional plans (although the RMA does not require these as a necessity) and most councils do. A regional plan describes the objectives, policies and methods used to manage the region's resources. Regional plans must be consistent with regional policy statements. At the lowest level are district plans, which district and city councils must prepare. Like regional plans, these detail the objectives, policies and methods used to address resource management issues for the particular district or city.

Along with plans and policy statements, the RMA provides councils with both enforcement mechanisms and resource consents to guide regional resource management. Enforcement mechanisms include abatement and infringement notices that can be issued to ensure a specific action is addressed and complies with the RMA. However, the main tools used by councils in resource management are resource consents. Resource consents are required to use or develop a resource or undertake an activity that has an effect on the environment. The consent means that the activity can proceed provided any adverse effects on the environment are avoided, remedied or mitigated.

Whether or not a resource consent is required for a particular activity will be specified in the appropriate council's regional plan. This is done by classifying an activity into one of five categories: permitted, controlled, discretionary, non-complying or prohibited.[7] For example, many councils classify the taking of small amounts of water (generally around 10 to 20 cubic metres per day) as a permitted activity that does not require a re-

[7] A permitted activity may be undertaken without a resource consent; a controlled activity requires a resource consent, which the council cannot decline, but it can impose conditions on the activity; a discretionary activity requires a resource consent which the council can decline or impose conditions on; a non-complying activity does not comply with standards in the council's regional plan but the council may grant a consent; and a prohibited activity may not be undertaken and no resource consent will be granted.

source consent. Taking amounts above this threshold is often classified as a discretionary activity that requires a resource consent.

Applying for a resource consent is a complex process that has been criticised by some as being too time-consuming, with consents being "bogged down in objections" (Kerr, 2002).[8] For an applicant, the application process includes consultation with council staff and affected or interested parties, preparing an assessment of environmental effects,[9] and preparing an application detailing the proposed activity. Once the council receives the application they may decide to publicly notify the consent. The public are then able to make submissions and objections on the consent and a hearing is often held by the council to resolve any issues arising.[10] A decision on the consent is usually made by the hearings panel. After the decision is made, the applicant (or an objector to the application) may lodge an appeal with the Environment Court if they are unhappy with the decision or the conditions attached to the decision.

The Resource Management Amendment Act 2003 implemented changes intended to (among other things) reduce costs and delays in obtaining a resource consent under the Act. Among the changes was an alteration to the notification process for activities with only minor adverse effects. In these cases, complete public notification is now not necessary and only those parties that are directly affected must be notified. Also changed is the test used by councils to determine whether the effects of an activity are minor or whether a person is adversely affected.[11] Prior to the amendments it was

[8] See Trow (2003) for some further criticism of the process being slowed by objections.

[9] An assessment of environmental effects identifies any actual or potential effects of the activity on the environment, and the ways in which the applicant will avoid, remedy or mitigate these effects.

[10] The public is widely defined: section 96 of the RMA states that *anyone* can make a submission on a publicly notified consent. However, an unfounded submission may not always be in a party's best interests, as costs can be awarded against a party if the submission proceeds to the Environment Court.

[11] This is known as the 'permitted baseline' test.

mandatory for councils to disregard an adverse effect of an activity if their regional plan permits other activities with that same effect. The changes to the Act allow these effects to be considered on a case-by-case basis and councils may choose to disregard them, but it is not mandatory.

2.4 Property Rights and Institutional Arrangements

A resource consent to use water entitles the holder to derive benefits from that use. In this way, resource consents are property rights to water (water rights), following the definition of property rights in Appendix B. A water right in New Zealand is typically defined by specifying the volume of water the holder is entitled to (often measured in litres per second or cubic metres per day), the site that the water is to be taken from, and the specific use that the water is to be put to. The RMA restricts the duration of water rights to a maximum of 35 years before renewal is required, although in practice most councils renew water rights at 5 to 15 year intervals (Lincoln Environmental, 2000). Rights may also be cancelled if they have not been exercised over the preceding 5 years.

The definition of water rights also allows them to be exchanged between water users, although only to a limited extent. Section 136 of the RMA specifies that all or part of a water right may be traded to another user within the same catchment, aquifer or geothermal field. Furthermore, the trade must be provided for in the regional plan and approved by the appropriate regional council. While some councils do provide for the trading of water rights in their regional plans, to date there has been very little trading (Lincoln Environmental, 2000).

The granting of a water right does not provide the holder with a guarantee that water will always be available, and councils have various methods for dealing with water shortages that often involve reductions in the amount of water available to rights holders. These methods include proportional cutbacks in water extractions as river flows drop below certain levels, rostering arrangements between water users, and giving some users priority over others. For example, the Hawkes Bay Regional Council gives priority to domestic water, stock water and fire fighting needs while other water users may have their takes reduced or even stopped all together in periods of water scarcity (Hawkes Bay Regional Council, 2000). Similar schemes are common among other councils.

As noted above, the key organisational players in the allocation of water rights are regional councils and unitary authorities.[12] Rights are allocated by councils through an administrative process legislated by the RMA. The first step in the allocation of any water from a resource is the preparation of regional plans. As noted earlier, councils use plans to set out objectives, policies and methods relating to water allocation, which guide the issuance of water rights. Methods in regional plans used to aid water allocation decisions include the setting of minimum flows for surface water and minimum levels for groundwater. These are set to protect environmental factors such as fish habitats and natural character, and to ensure adequate provision of water for recreational opportunities. Regional plans specify other important factors such as allocation limits (how much water can actually be taken from a resource), how water is rationed in periods of scarcity and the ability to trade water rights in the region.

Organisations or individuals wanting to take, use, dam or divert water apply to the council in their region for a water right (unless the proposed

[12]Councils are also responsible for water resource management, including monitoring the state of their region's water resources, such as river flows and lake levels.

activity is a permitted activity as described earlier, in which case a water right is not required). An application is analysed to ensure compliance with the information set out in the regional plan (if such a plan exists), such as ensuring minimum flows and allocation limits are not breached. The assessment of environmental effects provided by the applicant is also analysed to ensure any adverse effects on the environment are avoided, remedied or mitigated. Councils undertake a consultation and decision-making process to assess an application for a water right. However for resources that are not fully or over-allocated, rights are generally issued on a first-in first-served basis. While not explicitly stated in the RMA, first-in first-served is effectively the only mechanism available for water allocation.[13] Most councils can, and do also consider efficiency in making allocation decisions, although this only extends to the technical efficiency of individual takes rather than the allocative efficiency of the resource allocation (Lincoln Environmental, 2001a) or the relative efficiency of competing users.

Councils have varying approaches for dealing with an over or fully allocated resource. If a water resource is fully allocated some councils operate a waiting list approach, where the applicant will wait to gain an allocation of water if it becomes available. For example, Tasman District Council (a unitary authority) operates an informal, unadvertised waiting list for fully allocated resources (Lincoln Environmental, 2000). However, many resources do become over-allocated, and this suggests councils continue to allocate water first-in first-served even on fully allocated resources.[14] If a water resource is over-allocated to the point where action is required, most councils will use some type of rationing scheme where existing consents are reviewed

[13] The Courts have endorsed the first-in first-served approach as that which was intended by Parliament in passing the RMA. See Fleetwing Farms Ltd v Marlborough District Council (1997), 3 NZLR 257.

[14] See, for example, McLellan (1998) for an indication of New Zealand water resources that are fully or over-allocated.

and adjusted to reduce allocations. It is often the case that a resource is over-allocated but not all water rights are being continuously exercised, thus taking some pressure off the resource. Nonetheless, this situation is undesirable as the potential for over-use still remains.

2.5 Issues with the Current Arrangements

Despite New Zealand's relative abundance of water compared with other countries, there are some significant issues with the current arrangements for water allocation. Drawing on the outline of New Zealand's current property right and institutional arrangements in the previous sections, and problems identified in reports by CS First Boston (1995) and Lincoln Environmental (2001a), the following list identifies some key issues with the current arrangements:

- The first-in first-served approach is an ineffective way of allocating water from a resource in periods of excess demand. Furthermore, there is limited trading of water rights to reallocate water, which often results in water rights being assigned to low-value uses at the expense of high-value uses. Particular aspects of the current system, such as defining water rights by use, restrict such voluntary exchange.

- Uncertainty in water flows is unavoidable, however steps can be taken to provide more certainty in supply for water users. New Zealand's water allocation arrangements do not often take such steps and therefore compromise both short-term and long-term supply reliability.

- There are issues with the RMA regarding the time delays resulting from the consultation process, which can add significant costs to, or even prevent altogether, major water-intensive investments.

These issues are explained in more detail in the following sections. Alternative arrangements that could help resolve some of these problems are outlined in later chapters.

2.5.1 First-In First-Served and Limited Trading of Water

First-in first-served is often criticised as being an ineffective approach to water allocation.[15] However this criticism needs to be qualified. Under excess supply conditions, first-in first-served is a suitable approach to the allocation of water. The RMA ensures that first-in first-served is bounded by conditions that ensure efficiency of use and the minimisation of adverse environmental impacts. Thus, when water resources are in ample supply, this approach ensures all who value water and who are able to use water in an efficient and environmentally friendly manner are able to gain access to that water.

It is when demand exceeds supply and resources become fully allocated that the first-in first-served approach is inefficient. When water users are competing for the same water, an efficient allocation framework ensures water is allocated to those uses that are the most highly valued by society. The first-in first-served approach, however, provides no efficiency criteria for a council to use in making decisions over competing water uses. This will inevitably lead to water rights being granted to a particular use at the expense of other uses that have a higher value to society, unless by coincidence higher valued uses are first-in. Moreover, the societal value of water in particular uses can change (over both short-term and long-term horizons), but the first-in first-served approach is too rigid to allow reallocation to meet such changes.

The first-in first-served approach would not be so flawed under excess demand if a mechanism for exchanging water rights existed so that water

[15] See for example Lincoln Environmental (2001a, p.9).

could be reallocated to higher value uses. As noted earlier, the RMA does allow water rights to be traded between users, and some councils also allow it in their regional plans. However, limited trading of water actually occurs. Research by Lincoln Environmental (2001b) found that, although a survey of water users showed 74 percent were in favour of water being transferred between users, significant barriers to transfer suggest little water will actually be traded. These barriers include infrastructure costs (such as the transfer of water to unirrigated land requiring significant investment in infrastructure), uncertainty over future water and land use, a lack of information on where there is additional water, and the general view (mainly amongst irrigators) that water is directly tied to the land it is used on. In addition, a key barrier is the way water rights are actually defined. A water right in New Zealand restricts the water to a particular use, making it difficult for trading to occur across alternative uses. Moreover, the lack of an upper allocation limit on many New Zealand water resources means that there is often no need to trade water rights when one can simply be obtained through the normal administrative procedure.

The benefits of establishing tradeable water rights to facilitate trading in water have been well documented by many authors.[16] These benefits include:

- Achieving allocative efficiency by moving water from uses that have a low value to society to uses that are valued more highly.
- Encouraging efficient use of water by providing users with incentives to sell unused water.
- Removing political favouritism in making allocation decisions.
- Delaying possibly expensive new infrastructure to increase water supply

[16] See for example Simpson (1994), Holden and Thobani (1996), Thobani (1997) and Dinar, Rosegrant and Meinzen-Dick (1997).

by allowing extra water to be purchased.

- Encouraging investment in projects that are water intensive.
- Providing a mechanism for potential water users to obtain water from fully allocated resources.

These benefits are not always readily apparent where tradeable rights exist in other countries. Often cited disadvantages with tradeable water rights frameworks include: the potential for monopolies to form by one user buying up all water rights; externalities may be imposed on third parties who utilise return flows which are subsequently sold;[17] transaction and institutional set-up costs can be high; and there are often difficulties in rigorously defining property rights for water when it has public good elements. Institutional arrangements that may diminish or eliminate these disadvantages are discussed in Chapter 5.

2.5.2 Certainty of Supply

Providing for efficiency is important, but it must be coupled with well-defined and secure water rights, with a high degree of certainty in water supply. Ensuring water users have certainty in supply is important as it allows them to make investment decisions based on their expectations of continued access to water. Ensuring certainty of supply has two dimensions: ensuring certainty of long-term supply through the preservation of property rights; and ensuring certainty of short-term supply by appropriately dealing with the variability of flows. While we have argued above that the current water allocation framework in New Zealand is inefficient, in its current state it

[17]For example, suppose an upstream user on a river extracts 50m^3 of water per day but returns 20m^3/day, and a downstream user extracts the entire amount returned, 20m^3/day. If the upstream user's water right was sold, a new user may extract the full 50m^3/day and return nothing, thereby affecting the water available for the downstream user. See Appendix C for a more detailed description of the problem and possible solutions.

would also not meet certainty of supply conditions even if it were to provide an efficient exchange mechanism.

Consider first the long-term certainty of water supply. Research by Lincoln Environmental (2001a) has indicated that existing water rights holders are concerned that the granting of subsequent consents may affect the availability and reliability of their existing water supply. While the RMA provides no legal protection for existing property rights, Milne and Mooar (2002) note that a regional council or the Environment Court are unlikely to grant a water right that affects the profitability of an existing user's water right.

However, this does not prevent conditions on existing water rights being altered upon renewal. As noted above, most councils renew water rights at 5 to 15 year intervals. This short duration and uncertainty over whether conditions will change on renewal can cause users to delay or restrict investment in water intensive uses. McLellan (1998) notes that if a water right in New Zealand is exercised appropriately it is likely to be renewed and so effectively has an unlimited time-limit, however alteration of consent conditions upon renewal generates significant uncertainty as to the long-term reliability of supply.

The lack of long-term protection of existing property rights has been clearly shown by the special legislation recently introduced for the Waitaki catchment.[18] The Government used its powers under section 140 of the RMA to call in all new applications for water from the Waitaki catchment and developed a framework outside (although consistent with) the RMA to deal with water allocation in the catchment. However the framework does not provide any protection of existing water rights and risks altering

[18] In 2004 the Government passed the Resource Management (Waitaki Catchment) Amendment Act to deal with competing claims for water on that catchment. See Counsell and Evans (2004) for further explanation of the Act and where it differs from more economically efficient arrangements.

conditions on these rights in a way that could significantly reduce the value and performance of existing investments.

New Zealand's current water allocation system also creates some uncertainty of supply in the short-term. It was noted earlier that, although a water right gives no guarantee as to the short-term availability of water, councils do implement systems to deal with flow variability. However these systems are only implemented on an ad hoc basis and there is nothing in the legislation to create a consistent system nationwide. Moreover, some systems (such as rationing) can potentially become excessively administrative, which may lead to certainty of supply for low-valued, but politically strong water users over alternative higher-valued uses. Other systems - such as defining priorities for domestic, stock water and fire fighting purposes only - do not allow other users to obtain higher priorities and create the certainty of supply they desire. While water users should be aware that flow variability prevents water from being continuously available, transparent systems do need to be in place to minimise the impact of this variability and create incentives for investment by water users.

2.5.3 RMA Issues

As noted earlier, it is often argued that a major issue with the RMA is the consultation process on planning documents and resource consents is too drawn out. This may have adverse effects such as imposing additional costs on investment projects, delaying investment, or even preventing potential projects altogether. On the other hand, a lack of consultation with affected parties on environmental issues is likely to be inefficient as it limits the procedural rights of these parties. Furthermore, recent statistics show that in the year to 30 June 2004, 77 percent of all resource consents were processed within statutory time limits and 56 percent of publicly notified consents were processed within these limits (Ministry for the Environment, 2005).

The process of rigorous consultation with affected parties is not confined to New Zealand. In many of the western states in the United States the potential transfer of a water right involves a similar process of consultation and negotiation with affected parties, hearings and even court action to resolve longstanding conflicts. Hence the transfer process can involve significant transaction costs. However, Colby (1995) presents an argument to suggest that the presence of these costs does not necessarily lead to inefficiencies. Colby argues that the ability to impose transaction costs through the threat of a long costly legal battle gives potential water users an incentive to negotiate with affected parties and reach a settlement. Hence a more efficient reallocation of water may occur as the social costs and externalities to affected parties are taken into account when they otherwise may not be.

The argument applies equally to the New Zealand context. The RMA imposes significant transaction costs on a potential water user in their application for a water right. The possible costs of the application becoming drawn out and proceeding to a hearing or the Environment Court may give the potential user an incentive to consider the views of third parties.[19] If the views of third parties are considered then the water allocation may be more efficient in the sense that more complete costs to society are taken into account. The conclusion here is that a protracted consultation process, or at least the threat of a protracted one, can also have advantages. Resolving the issue is not as simple as reducing third party objections, but reducing unwarranted objections does have some merit. The recent RMA amendments have gone some way towards addressing this. We will not address this issue

[19]This was exactly the case with a replacement sewerage treatment plant recently built in Auckland. Cumming (2004) notes that consultation with affected parties, rather than expensive litigation through the Environment Court, actually resulted in an improved design and a more socially acceptable outcome from the project.

any further in this study, as our focus is on the other issues of protection and trading of property rights to water.

2.6 Conclusions

Although rainfall and water resources are plentiful in New Zealand, these are not evenly spread over time or space. Coupled with a multitude of competing users of water resources, this makes the issue of the efficient allocation of water an important one. The current arrangements for water allocation in New Zealand are based around the legislative framework provided by the Resource Management Act. The Act requires a planning approach to the allocation of water. In practice, the only approach available to most councils is to allocate water on a use-specific first-in first-served basis, despite the amount of planning and consultation that goes in to the allocation process. While the first-in first-served approach works well when there is an excess supply of water, it is inefficient at allocating water between competing users and uses when demand exceeds supply. Further deficiencies in New Zealand's current arrangements for water allocation include limited trading of water rights and a lack of long-term and short-term security of supply. We would argue from this analysis that there is a strong case for consideration of alternative arrangements for water allocation in New Zealand. In the next chapter, we outline the experiences in water allocation in a number of other countries, with a view to assessing such alternative arrangements for New Zealand.

Chapter 3

Lessons from Other Countries' Experiences in Water Allocation

3.1 Introduction

Traditional water allocation systems in many countries have focused on riparian and administrative allocation of water resources.[1] However more recently, governments in other countries have been moving towards more economically efficient arrangements to account for the growing scarcity of water resources under increased demand. These arrangements typically create well-defined property rights to water and allow tradability of rights across uses. There is also a move to developing institutional arrangements that lower transaction costs and facilitate trading in water rights.

In this chapter we outline the experiences of a number of countries. A range of countries is considered. Some (Australia, Mexico and Chile) have

[1] See Scott and Coustalin (1995) for a thorough review of the evolution of water rights in England, the United States, Canada and Australia dating as far back as the eleventh century.

recently reformed their water sectors and implemented new methods to deal with water allocation. Chile is also useful to consider as, like New Zealand, a significant proportion of its water use is for hydro-electric generation. Other countries (England and Wales) are currently working towards reforming allocation mechanisms in their water sectors. Some (Australia and Colorado, U.S.A) have significant scarcity of water and so developing efficient arrangements to manage that scarcity is a high priority for them.

In Section 3.2 we outline the arrangements for water allocation in these countries. Looking at these arrangements highlights ways in which efficient allocation mechanisms can be created to deal with the issues identified for New Zealand in the previous chapter. Thus, in Section 3.3 we establish lessons for New Zealand from the experiences of other countries, and tie these lessons in with the issues highlighted in Chapter 2. Section 3.4 presents some conclusions.

3.2 Water Allocation Experiences in Other Countries

3.2.1 England and Wales

The government, through the Environment Agency (EA), manages water allocation in England and Wales. Property rights to take water are defined by an abstraction license. Water users wishing to take water from a resource submit a formal application to the EA for an abstraction license, giving the right to take water from a specific source at a specific rate. The framework for defining and allocating these licenses has recently changed with the passing of the Water Act 2003. Under the previous legislation, licenses specified the land that the water was to be used on (except when the water was for the public water supply). Potential water users applying for a license had to either occupy the land associated with the water use, or have a right to access it. The majority of licenses were also defined with an indefinite time-limit and were not required to be renewed.

The allocation of licenses under the old system was done by an administrative process with similar features to the system used in New Zealand. In making an application for a license, the applicant was often required to assess the impact on the environment of the water taking and publicly notify the intent to take water. Interested or affected parties could make submissions to the EA. In deciding whether to grant an abstraction license, the main issues the EA would take into account were: water availability, effects on the environment, the rights of existing water users, public objections, the applicant's need for the water and the impact on stream flows (DEFRA, 1998). While there was scope for trading of water licenses, very little trading actually occurred.[2]

While many of the features of this system have been retained (such as the emphasis on public consultation), the Water Act 2003 implements a number of changes. A key feature of the way water rights are to be defined under the new system is the time-limitations placed on licenses. The time-limit on most new licenses is now set at 12 years before renewal is required. License holders also have a 'presumption of renewal' where licenses are likely to be renewed provided conditions of environmental sustainability, continued justification of the use of water and efficient use of the water are met. The renewal strategy is handled by another new initiative (although not one implemented by the Water Act) called Catchment Abstraction Management Strategies (CAMS). A CAMS for a catchment is a strategy to manage water use at the catchment

[2]A key reason for the lack of trading was the requirement for most traded licenses to be tied to the particular land they are used on (Risk and Policy Analysts Ltd, 2000).

level. It is a plan developed by consultation that lays the foundations for dealing with new or revised licenses on a catchment. CAMS provide a means for determining how close a catchment is to full allocation (and hence to a situation of excess demand).

The Water Act also includes measures designed to simplify the process and reduce the transaction costs of license application and license trading. The Act aims to facilitate more trading and allow a more market-based allocation system to develop. For example, the Act removes the requirement for licenses to state the land they will be used on. This ensures that there is no restriction on where a license can be transferred to. Licenses may be purchased on either a temporary or permanent basis with approval from the EA. The CAMS process is likely to further facilitate trading of water licenses by identifying fully allocated resources and water availability.

3.2.2 Australia

Australia is currently in the midst of a period of significant reform of its water sector. Reform began in some areas over the 1980s and 1990s but became more firmly grounded in 1994 when the Council of Australian Governments (COAG - consisting of the Prime Minister, state Premiers, territory Chief Ministers and the President of the Australian Local Government Association) agreed to a framework for water reform at the national level. The framework consisted of a number of directives that states and territories were required to follow in the reform of their water sectors.

The primary responsibility for implementing the reforms lies with the state and territory governments. The key elements of the reforms are:

- Pricing: pricing must be based on usage-based pricing, full cost recovery and making any cross-subsidies transparent.

- Water allocation: clear allocation systems are to be established, including separating water licenses from land, and allocating water to the environment.
- Trading: trading of water licenses must be made possible.
- Institutional reform: the roles of water service provision must be clearly separated from those of regulation and resource management.

As state and territory governments progressively implement the reforms, water allocation is moving towards a mix of administrative and market-based methods. A state/territory government department is responsible for issuing property rights to water (licenses) to potential water users. The reforms have ensured that water licenses are clearly separate from land. They are typically defined by the volume of water that can be taken and in many cases have a 5 to 15 year tenure before renewal.

The appropriate state or territory government department issues licenses through an administrative approach. This involves using plans to set out (among other things) minimum flows for environmental purposes, reallocation rules in times of low flow and rules for the trading of water licenses (such as the requirement that transfers do not have an adverse effect on third parties). Licenses are then allocated by an administrative process involving application, assessment and notification similar to those previously described for New Zealand, England and Wales. Most states in Australia adopt a catchment management approach similar to the CAMS in England and Wales. For example, in Queensland, Water Resource Plans are prepared for each catchment. These plans develop methods of consultation and modelling to determine the best way to allocate water between competing users. They also provide information on how close the catchment is to reaching full allocation.

Once allocated, trading of licenses is also possible. Although markets for the trading of water licenses have existed in some areas since the early 1980s, the COAG reforms have ensured all states and territories now use water markets to facilitate trading. In the case of New South Wales, an embargo on issuing new licenses means administrative allocation is largely redundant on many fully allocated resources, and the only way to obtain a water license is by trading with another user (DLWC, 1997). Trades can be instigated by methods such as independent buyer-seller contact, or via centralised trading platforms. Examples of the latter include Water Exchange (www.waterexchange.com.au) operating across all states, and Watermove (www.watermove.com.au) operating in Victorian water markets.

Although trade in water markets is increasing in parts of Australia, the markets are considered by some to be quite thin in terms of the number of trades (Pigram, 1999; High Level Steering Group on Water, 1999).[3] Another problem with the creation of water markets is that the exercise of 'sleeper' licenses (previously unused water licenses) or 'dozer' licences (previously occasionally used licences) can have a negative impact on the environment through increased water taking (McKay and Bjornlund, 2001).

The problem of sleeper or dozer licences is solely the result of an initial over-allocation. The exercise of sleeper or dozer rights in a tradeable rights framework will not be harmful if the water available under those rights lies within the specified upper allocation limit. However if this limit is lower than the amount of water originally (over) allocated, then the exercise of sleeper and dozer rights pushes total water use above this limit. In general, therefore, the issue is one of how to reduce existing allocations when an upper allocation limit is set that does not cover all existing allocations. In this sense, the problem of sleeper and dozer rights is similar to another problem affecting

[3] The issue of thin markets is addressed later in the chapter.

Australia's implementation of tradeable water rights: how to reduce existing allocations when new information becomes available that implies a reduction in the allocation limit.

There was considerable recent debate over this issue in Australia, resulting in COAG's 2004 National Water Initiative setting out a framework for how water users will be compensated for a reduction in their water allocations. The outcome for Australian water users was that water users will not be compensated for the first 3 percent reduction in water allocation. Compensation payments for reductions between 3 percent and 6 percent in water allocations will be shared between state/territory and federal governments one-thirds and two-thirds respectively, while compensation for reductions greater than 6 percent will be shared equally between state/territory and federal governments.

Despite some problems, water markets in Australia have shown significant benefits, including the movement of water from low valued to high valued crops and to irrigators with more efficient irrigation technology (McKay and Bjornlund, 2001). This has led to further flow-on benefits such as a reduction in polluted irrigation run-off draining back into waterways. Moreover, as Bjornlund (2002) notes, Australian water markets are maturing[4] and are beginning to generate more efficient outcomes. Water markets in Australia are now actively promoted and the use of brokerage and other similar information services is becoming widely established.

3.2.3 Colorado

Much of Colorado is in a drier region of the United States and as a result has a long history of developing efficient methods to deal with the allocation

[4]According to Bjornlund (2002), the main indicators of a mature water market include less price dispersion, easing of trade restrictions and an increase in market activity.

of its scarce water resources. Water rights in Colorado are defined by the doctrine of prior appropriation, which rests upon the principle of 'first in time, first in right'. The first user in time to obtain a water right from a particular water resource is the senior right holder for that resource. In periods of water shortage, senior right holders are given first priority to ensure their allocation is satisfied and more recent, junior, right holders will have their allocation reduced. Water rights do not have any time limit, and some priorities on major streams date back as far as the 1850's.

Allocation of water rights in most of Colorado is done administratively through the judicial system, although market mechanisms do exist to facilitate trading of rights. In order to obtain a right to take or divert water in Colorado, a potential water user submits an application to a district water court and the application is publicly notified. Objections are heard by the water court before they make the final decision on the granting of the right. This decision is based on recommendations by a state engineer in accordance with the applicable water laws of the state. A beneficial use provision also defines water rights: once granted, a water user must prove that their water allocation is being put to beneficial use or they risk having their water right revoked.[5]

To trade a water right an application is made to the water court.[6] The trade will be publicly notified and a hearing often results. Where there are effects on third parties that the court deems to be of concern, the court will determine the appropriate remedies or compensation. If there are no objections to the trade and it is considered reasonable, the court typically

[5]Whether a particular use is deemed 'beneficial' is determined in Colorado state legislation. For example, it was not until 2002 that recreation was officially deemed to be a beneficial use of water.

[6]A trade that does not change the use or point of diversion of the water, or does not have an effect on third parties, can often be done without court approval (Simpson and Ringskog, 1997).

grants the trade. Despite the high transaction costs associated with water rights trading, trades often occur and are not just confined to recent years. For example, Colby (1995) notes that an average of 70 trades were approved each year over 1975-1984 in Colorado.

In one part of Colorado water allocation mechanisms differ slightly from the rest of the State. A different mechanism applies for water from the Colorado-Big Thompson (C-BT) project, a major water supply scheme in northeastern Colorado. Allocation of all water from the C-BT project is the responsibility of the Northern Colorado Water Conservancy District. Water from the project is used to supplement the existing supplies that users obtain from other sources in Colorado. The key feature of water allocation from this project is that trading of water rights (termed 'allotments') is widely used to reallocate water.

The initial allocation of water allotments was made in 1959 at no charge to users and was based on a potential user's future needs and ability to make beneficial use of the water. Each year, the Board of Directors of the District decides how much water is available and establishes a quota to be made available for the following year. Since water from the C-BT project is supplemental water and significant quantities of C-BT water can be stored, the quota will be higher in drier years when water from other sources is scarce. A water user's allotment will be adjusted in proportion to changes in the quota.

These annual quota changes do not have an adverse impact on users, as holders of water allotments are able to make both temporary and permanent trades of water. For temporary trades, the two parties (the buyer and seller) agree on a rental price and notify the District simply by sending them the relevant details of the trade. Upon verification the water is credited from the seller's account and debited to the buyer's account. No administrative approval of the trade is required and the District does not charge any administration fees. The process for a permanent trade of a water allotment is also reasonably straightforward. After the two parties have agreed on a price, an application for trade is made to the District along with a small administration fee. The application is reviewed to ensure it complies with the District's policies and procedures, and if approved by the Board of Directors of the District, the trade is allowed to proceed. Trades are instigated by a variety of methods including brokers, newspaper advertisements and direct contact.

As a result of the market, there has been significant transfer of water resources from low-valued (mainly agricultural) uses to higher-valued (industrial and urban) uses (Kemper and Simpson, 1999). These authors also note that the water market has led to the tendency among farmers to improve the efficiency of their irrigation practices and employ water conservation techniques.

A key feature of the institutional arrangements for the C-BT project is the existence of 'ditch companies'. Ditch companies are farmer-owned collectives that run irrigation schemes and have the important task of internally distributing and managing water allotments from the project. As Kemper and Simpson (1999, p.30) note, "their existence greatly facilitates the transactions taking place in the market".

3.2.4 Mexico

Mexico has recently undergone a significant period of water reform following the implementation of its National Water Law in 1992. The law decentralised water resource management and instigated a market-based system to allow for the transfer of water rights (termed 'concessions' in Mexico). The responsibility for implementing the reforms and granting water concessions lies with the government's National Water Commission (CNA). The water law also transferred the responsibility for operation and maintenance of water supply schemes (particularly for irrigation schemes) from the CNA to resource-specific Water User Associations (WUAs).

Under the water law, the initial allocation of water concessions was based on historical use, with concessions granted to individuals, WUAs[7] and public or private water utilities (who supply water to urban and industrial users). CNA approval is required for a new or renewed concession and holders are charged a fee based on the volume of water delivered to cover the management, planning and administration roles of the CNA.[8] Concessions are defined volumetrically but in times of scarcity the CNA may impose reductions on some water users. These reductions are not always proportional or based on well-defined priorities across users, but rather are often based on CNA command-and-control decision-making.[9] Concessions have varying time-limits of between 5 and 50 years although, according to Thobani (1997), the typical maturity is 30 years.

Concession holders may temporarily or permanently transfer their water concession. In many cases a transfer between irrigators can be managed by the appropriate WUA, with the transfer only requiring notification to a public registry of water concessions. However, if a transfer is outside a particular river basin, to another water use sector or has an effect on a third party, the transfer requires approval from the CNA.

[7]Once water is allocated to WUAs, they may make their own decisions on how their water is allocated. WUAs typically allocate water by either a rotation system on a prearranged schedule or an arranged demand system where farmers make daily requests for water (Hearne and Trava, 1997).

[8]Agricultural users are exempt from this fee.

[9]For example, Hearne and Trava (1997) document a case in one region of Mexico where, in the drought of 1995-1996, the CNA mandated that only cotton crops were able to use irrigation water. Hearne and Trava cite similar cases in Mexico of centralised decision-making to allocate water in drought situations at the expense of more efficient market-based approaches.

The water market implemented in Mexico is reasonably new and, as noted above, the CNA still maintains a significant role in the allocation of water which may be restricting trading. Kemper and Olson (2000) note that although markets are functioning in Mexico, there have not been a large number of water transfers. They suggest that the mechanisms to support the proper functioning of market transfers are still being set up, particularly the establishment of a complete public register of water concessions. Such a register assists with the monitoring of water resources and ensures the concessions system is managed transparently. Nonetheless, there have been some benefits from water markets in Mexico. For example, Thobani (1997) describes how reallocation has occurred by some small farmers reducing their high levels of debt by selling water rights to higher valued uses, without having to also sell the land they own. Simpson and Ringskog (1997) anticipate that as acceptance of market instruments increases, and demand for water resources rises (with a corresponding improvement in the institutional arrangements of the water market), there will be much greater use of the market to facilitate transfers of water concessions.

3.2.5 Chile

Water markets have been used in Chile for the allocation of water for a considerable time, although the defining legislation occurred in 1981 with the passing of the Water Code, which formalised a market for water rights. The Water Code created tradeable water rights that are clearly separate from land. Rights are granted free of charge by the General Directorate of Water (DGA), a division within the Ministry of Public Works. Water users wishing to obtain new or unallocated water rights apply to the DGA. If there are enough water rights to satisfy the demand, the rights are allocated as required free of charge.[10] If there are competing demands for water rights they are allocated to the highest bidder by auction. Water rights have no time-limit, and the DGA cannot cancel them once they have been granted. Rights holders also have no obligation to put their water to beneficial use. Rights holders may freely sell, mortgage, or lease water rights for any purpose, at a price negotiated between the parties to the transfer. Regardless of the nature of the transfer (and who it may affect), it does not require approval from the DGA. The only avenue for a third party to protest as to being adversely affected by a water trade is through the courts, who often lack technical expertise, and this can involve significant transaction costs (Bauer, 1997).

Like Colorado, Chile uses a priority system to ensure the reliability of supply. Water rights are designated as either permanent or contingent. Permanent rights allow the extraction of water without restrictions, except during times of low flow. Contingent rights are a lower priority and can only be exercised if there is excess water available from a resource once the requirements of permanent rights holders have been met. While water rights in Chile are required to be specified by the volume of flow per unit of time, rights within priority groups will be defined proportionately as a share of the river flow if the amount of water available is not enough to meet all the volumetric rights. Thus, in periods of low flow, contingent rights will be superseded by permanent rights, with rights holders of the latter group having their shares of a water resource reduced proportionally. Some rights, however, are designated as even higher priority than permanent rights (for example, water companies serving urban communities) and are not reduced

[10] To determine water availability the DGA should ideally prepare planning documents as in Australia, England and Wales. However, prior to 1999 this planning was very limited. The National Water Resources Policy was introduced in 1999 to improve this planning and solve other problems with the allocation framework (see Productivity Commission, 2003, Annex J).

in times of scarcity. Rights may also be designated consumptive (where the holder has no obligation to return any water) or non-consumptive where the entire allocation must be returned to the water resource - such as in the case of hydro-electric generation.

A key feature of the institutional arrangements for water allocation in Chile is the existence of water user associations that are owned and operated by their members. There are more than 300,000 water users in Chile and these are grouped into around 4,000 user associations (Simpson and Ringskog, 1997). These associations are often set up to serve irrigators but there are also a number that administer all the water users for a common water resource. Water user associations have the important role of managing and maintaining the infrastructure with which to deliver water to their members.

The decision-making role of government in Chile's water allocation system is negligible, with allocation based on market instruments such as transfers and auctions. Opinion is divided on whether the Chilean allocation framework has been a success. Simpson and Ringskog (1997) argue that the market-based approach has generally been a success, and Hearne and Easter (1995) showed that there are substantial gains-from-trade in some areas of Chile where market transactions are common. However, Bauer (1997) argues that the empirical evidence on the success of water markets in Chile is mixed. He suggests that a number of factors are limiting trading in water rights in many areas of Chile and causing conflicts between water users, such as:

- Poor infrastructure that makes it difficult to implement physical water transfers.
- An uncoordinated and poor system of recording rights and transfers.
- The belief that water should not be treated as a commodity.
- Confusing price signals.

Nonetheless, Bauer does agree that there are some strengths in the Chilean system and there are lessons that can be learnt from the areas where Chile goes wrong. The following section collates these strengths and those of other countries to discern the lessons New Zealand can learn from their experiences.

3.3 Lessons from Other Countries' Experiences

There are a number of areas where New Zealand can learn from the way other countries approach the allocation of their water resources. These can be broadly summarised into three categories: well-defined and secure property rights to water, dealing with flow variability, and tradability of water rights with institutional arrangements that encourage efficiency. These categories fit broadly with some of the problem areas identified for New Zealand in Chapter 2. Hence looking at how other countries have dealt with similar issues gives rise to possible alternative arrangements for water allocation in New Zealand.

3.3.1 Well-Defined and Secure Water Rights

An important lesson for New Zealand is ensuring water rights are well-defined. The actual terms of a water right are important, as the case of Chile reveals. Defining rights for hydro-generators as non-consumptive, where all water must be returned to the river for downstream users, has led to significant conflict between hydro-generators and downstream irrigators in Chile. As Bauer (1998) notes, conflict has emerged over whether or not non-consumptive rights allow hydro-generators to store and release water when it is appropriate. Difficulties arise because the optimal timing of storage and release by hydro-generators is not necessarily linked with the optimal timing of water extraction by downstream irrigators, who use the water released by hydro-generators. Rights are effectively defined in such a way as to give different users (the hydro-generators and downstream irrigators) rights to the same water. While no country that we aware of has implemented a system that accounts for this problem, a possible solution, initially proposed by Scott and Coustalin (1995), is to endow the rights to return flows with the user who generates them, in this case the hydro-generator. This means that downstream users cannot also hold a right to that same water, unless it is granted through negotiation with the hydro-generator. Further details of this approach are outlined in Appendix C.

Arrangements in other countries also typically ensure that rights are defined to provide for their long-term security, the lack of which is a problem that was highlighted earlier for New Zealand. An indefinite time-limit on a water right, such as is used in Chile and Colorado, is ideal in terms of ensuring the user will have continued access to water. This provides the right incentives for water users to make long-term investments. However, experience suggests indefinite time-limits may be socially undesirable. For example, in England and Wales there was widespread support for a move to time-limiting all water rights under the new legislation introduced (DEFRA, 1999). If water rights are to be time-limited, then as a minimum requirement they should have a significant duration that allows water users to make long-term investments. If water rights are made tradeable, then renewal is not required for rights to be reallocated between users or uses. Therefore, the only real need for renewal of rights is to reconsider the capacity of a catchment (and possibly allocate more or less water to the environment) or address the effects of inefficient or un-environmental uses. Even the latter may not be required as tradeable rights will allow water to be moved away from inefficient water users, but in any case such users should not be granted rights in the first place.

Despite a relatively short duration of water rights in England and Wales of 12 years (which would be too short for many investments), rights holders can presume they will be renewed provided some specific conditions are met.[11] This provides water users with some certainty upon renewal. Providing protection for existing water rights holders and ensuring some degree of certainty upon renewal are important lessons in ensuring long-term security of water rights for New Zealand.

3.3.2 Dealing with Flow Variability

Unlike land, water is not a fixed resource that can be divided by volume between users. Water flows in rivers and water levels in aquifers are variable, and this variability is often large. One method of dealing with this variability that is used in many countries is a priority system. Such a system is most notably used in Colorado (and some of the other western states in the United States) although other countries often designate public water supplies as a priority use. The system is also used in New Zealand with some regional councils defining priority water rights, although this typically only applies to public water supply users and does not allow other water users to gain a high priority water right.

A priority system allows water users to manage their risk. For example, water users who regularly need a specific volume of water (for example for public water supply or feeding livestock) bear a high level of risk if they were not to obtain their desired water allocation. Such users can manage

[11] Two of the conditions on water rights renewal in England and Wales (continued justification of need and efficient use of water) would more likely be met under a tradeable water rights framework. Water would be exchanged to those users who value it the most, and therefore could justify the need, and there would be incentives for efficient use through less wastage.

this risk by obtaining a high priority water right. Equivalently, low risk users can tolerate a water right that is of a much lower priority and does not necessarily guarantee them their desired water allocation all of the time. Where tradeable water rights exist, users are able to purchase a portfolio of water rights of different priorities to suit their desired risk level.

An alternative system to manage flow variability is to define rights as a proportion of total flows, rather than volumetrically. In this way all users have their allocations changed in proportion with changes in flows. Examples of proportionate systems include the allocation within priority groupings in Chile and the entire system used for water from the C-BT project in Northern Colorado. An allotment in Northern Colorado entitles the holder to a share of 1/310,000th of the total water allocated from the C-BT project each year. This share changes each year with changes in the total water allocated. Since water trading is relatively straightforward in the District the system is efficient, as users can trade to offset any changes in the amount of water they are allocated.

The relative advantages and disadvantages of the priority and proportional systems are addressed by Howe, Schurmeier and Shaw (1986). Priority rights have the advantage of allowing different degrees of supply reliability to be purchased, whereas extra shares of rights need to be held to achieve the same degree of reliability in a proportionate system.[12] On the other hand, Howe *et al.* (1986) argue that priority rights are non-homogeneous, making it difficult to organise water markets. They suggest the homogenous nature of proportional rights allows markets to operate more efficiently.

While heterogenous products may make centralised markets difficult to organise,[13] they do not hinder the organisation of a decentralised market

[12] This can be inefficient as, at times, the extra shares may be unused and thus are not always in their highest value use.

[13] A centralised market has a specific institutional arrangement to coordinate buyer and

where buyers and sellers instigate bilateral trades with each other.[14] Indeed, the relatively thin markets that are likely to result in New Zealand with tradeable water rights (see Section 3.3.3) will be more conducive to bilateral, decentralised trades. Moreover, the heterogeneity of priority rights in many parts of the United States (which the arguments of Howe *et al.* (1986) are based on) is significant, as different priorities exist for every different date that a water right is obtained on. A more effective approach in New Zealand's case may be to define only a small number of different priorities which may be allocated to users and traded between them.[15] A proportional system could then be used to allocate water within each priority group.

3.3.3 Tradability of Water Rights

We noted earlier how restricting water rights to a particular use and not developing the right institutional arrangements has limited the trading of rights in New Zealand, even though trading is allowed in the legislation. The analysis of the experiences of other countries shows that many of them are moving towards ensuring water rights are tradeable and arrangements are in place to facilitate the voluntary exchange of water. This experience has brought many of the benefits that theory suggests tradeable rights will generate, such as water moving to its highest valued use and water users improving the efficiency of their water use, particularly evident from the literature cited earlier for Australia, Colorado and Chile. However, facilitating trading may not always result in desirable outcomes. As Thobani (1997, p.177) notes: "tradable water rights are not a panacea, and an effective system is not easy

seller interaction and determine market-clearing prices.

[14]Counsell and Evans (2003) provide the example of electricity markets where long-term hedge contracts, that are heterogenous products of different time-lengths and allow the purchase of electricity at different locations, are traded through bilateral decentralised trades by market participants.

[15]This is similar to the system used by Environment Canterbury on the Waimakariri River, where 'A' and 'B' water rights are allocated to users, with 'A' rights having priority.

to introduce." Problems faced overseas are common, particulary, as noted earlier, in Chile. Nonetheless, many of these problems can be addressed by specifying well-defined property rights to water and creating efficient institutional arrangements to administer rights and enable trading.

It is important to establish what these arrangements actually are. There are a number of requirements for effective tradeable water rights systems that can be discerned from both economic theory and the arrangements of other countries. Some important requirements are:

- Water rights defined to be clearly separate from land and tradeable across uses and locations. In the New Zealand case, this would include ensuring rights are not defined to apply only to a specific use.
- An effective legal framework for the protection and enforcement of rights, including a public register of rights and transfers.
- Actively encouraging trading and facilitating the exchange of information on water availability and values, for example through water brokers or water users groups.
- A method to deal with return flow issues and third party externalities, whereby trading of water rights to upstream users has a detrimental effect on the return flows downstream (see Appendix C).
- A planning approach to identify on an ongoing basis when resources are reaching full allocation.

The key lesson that New Zealand can take from other countries' experiences in tradeable water rights systems is that such systems are likely to generate better outcomes and resolve some of the shortcomings of the current allocation system, particularly if a number of pitfalls are avoided. We outline desirable institutional arrangements for the operation of an efficient tradeable water rights framework in more detail in Chapter 5.

One final issue to consider in relation to tradeable water rights is the issue of 'thin' markets. Many authors note that a disadvantage of water markets overseas is that they are often thin, whereby the volume of trading is typically very low.[16] However, thin markets are still likely to generate benefits in comparison to no market. Howe *et al.* (1986) note that the amount of water traded is unlikely to be large and efficiency gains will still be realised with only a small "tradable margin" of water changing hands. Indeed, the characteristics of New Zealand, with only a small population and a large number of small and distinct water resources, are likely to lead to thin markets. With only a small number of buyers and sellers, bilateral transactions between water users are likely to be the predominate form of market transfer.

3.4 Conclusions

In Chapter 2 we outlined issues with the current arrangements for water allocation in New Zealand, such as an overly administrative approach with little flexibility for the exchange of water between users, and a lack of short and long-term security in property rights to water. A number of other countries have experienced similar problems in their water sectors for many years. In this chapter we have shown how these countries have developed other methods for the allocation of their scarce water resources (or at least have made progress in reforming these methods). The right framework for water

[16]See for example Pigram (1999, p.8): "Despite the incremental easing of restrictions over trade in water rights, the water market [in Australia] is essentially thin"; and Bauer (1997, p. 643): "[transfers of water rights in Chile] involve a very small percentage of water users and relatively little reallocation of resources, and the resulting markets are fairly inactive".

allocation in New Zealand will not be found by exactly replicating their experiences, as New Zealand's water environment has its own distinct features that limit the application of a universal model. However, New Zealand can go some way towards developing the appropriate framework by learning from the experiences of other countries, particularly in the areas of defining water rights to ensure long-term security in supply, dealing with flow variability, and allowing market-based allocation systems to develop and prosper.

While the experiences of other countries highlighted in this chapter certainly assists in establishing desirable arrangements for water allocation in New Zealand, we may also turn to the allocation arrangements of other environmental resources for such assistance. Indeed, where a tradeable water rights framework for New Zealand is concerned, it is helpful to look at the arrangements in tradeable rights frameworks in other resources. This is the approach taken in the next chapter, where we review tradeable rights frameworks in fisheries and air pollution, thus complementing the water rights frameworks described in this chapter to gain a broader view of an efficient water allocation framework for New Zealand.

Chapter 4

Tradeable Rights Frameworks for Fisheries Resources and Pollution Control

4.1 Introduction

In Chapter 3 we highlighted the benefits that can result from having tradeable water rights. These benefits do not only result from applying a tradeable rights framework to water. Indeed, the theory on tradeable rights is well-developed and applies equally to other scarce resources.[1] The basic concept of this theory is that allowing resource users to trade rights between them leads to those rights moving to those users who value them the most. This encourages efficiency in resource allocation, a requirement that becomes particularly important as the scarcity of the resource increases. As we have shown for the case of water, tradeable rights also generate other benefits such as encouraging efficiency in the use of the resource itself and removing the need for difficult (and inevitably suboptimal) allocation decisions to be

[1]Tietenberg (2002a) provides extensive discussion of the theory of tradeable rights applied to various environmental problems.

made by an administrative body.

Tradeable rights frameworks are increasingly being used for other resources to capture some of these benefits. Table D.1 in Appendix D provides details of a number of countries where tradeable rights are applied. For example, New Zealand, and a small number of other countries, have established tradeable fishing quotas for managing their fisheries resources.[2] Tradeable rights have also been used as an innovative approach to reduce air pollution. In this case, the resource is air and rather than providing an entitlement to use air, a property right provides an entitlement to pollute air. Examples of these frameworks include tradeable rights to reduce sulphur dioxide emissions in the United States,[3] and to reduce carbon dioxide emissions globally.[4] Tradeable rights were also used as a means of reducing the lead content in petrol in the United States in the early 1980's.[5] Tradeable 'Green Certificates' have recently been introduced in some European countries (for example Italy, the United Kingdom and the Netherlands) as a means of encouraging renewable energy generation.[6] The tradeable rights framework has also been suggested for slightly more obscure applications such as deer hunting in the Scottish Highlands (MacMillan, 2004) and the allocation of orbital space for satellites in outer space (Scheraga, 1987).

In this chapter we review two applications of the tradeable rights framework for resources other than water, namely tradeable fishing quotas and tradeable rights for sulphur dioxide emissions. We choose the fishing quota

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[2]For literature reviewing the New Zealand framework, see for example Newell, Sanchirico and Kerr (2002) and other references cited later in this chapter.

[3]See for example Joskow and Schmalensee (1998) and references cited later in this chapter.

[4]For a summary of the framework for carbon dioxide emissions rights trading see Barrett (1998).

[5]Kerr and Mare, (1998) provide an outline of the tradeable lead permits programme in the United States.

[6]See Nielsen and Jeppensen (2003) and other related articles in Volume 31(1) of *Energy Policy*.

framework for New Zealand as it is an example of the application of the tradeable rights approach in this country, which has been operating for some time. Section 4.2 describes how the framework for tradeable commercial fishing quotas in New Zealand works, and looks at whether the framework is considered successful. We review the tradeable sulphur dioxide emissions framework in the United States as it is an example of the innovative use of tradeable rights to address pollution concerns, and has also been operating for a long enough time to provide meaningful analysis. In Section 4.3, we outline this framework and survey the literature assessing this framework. In Section 4.4 the key institutional arrangements of these two frameworks are highlighted, with a view towards describing the desirable institutional arrangements for a tradeable water rights framework (which will be done in Chapter 5). Concluding comments are provided in Section 4.5.

4.2 Tradeable Fishing Quotas in New Zealand

Fisheries resources are a perfect example of how unregulated access of a common pool resource can lead to a race to exploit the resource and a consequent depletion of the resource stock. The gains from fishing are captured entirely by each individual fisher, while the losses (from a depletion in the fish stocks) are spread over all fishers. The result is Hardin's (1968) 'tragedy of the commons', where the pursuit of individual self-interest leads to a serious depletion of the common resource. Such a depletion is clearly apparent in worldwide fisheries resources, with approximately 18 percent of stocks or species groups overexploited and a further 10 percent significantly depleted or recovering from depletion (FAO, 2002).[7]

Many economists have advocated the use of a tradeable rights framework

[7] An excellent analysis of the severely depleted state of many of the world's fisheries resources, and the implications this has for our food supply, can be found in Clover (2004).

for the allocation of fisheries resources.[8] Such a framework places a cap on the total amount of fish that can be caught, and allocates quota to fishers up to that cap. These quota are tradeable, allowing economic efficiency to be enhanced by allocating to those who can add the most value, while preventing over-exploitation through the imposition of the cap. New Zealand and Iceland are the countries that are most commonly studied for their experience with tradeable fishing quotas, although others such as the United States, Canada, United Kingdom and Australia have all experimented with such an approach (Yandle and Dewees, 2003).[9] In the following sections we outline the institutional arrangements for the New Zealand framework of tradeable fishing quotas, and survey the literature assessing the framework.

4.2.1 Institutional Arrangements

In 1986, New Zealand became one of the first countries to introduce a system of tradeable fishing quotas. Previously, fisheries management was based on a consultation and planning process with regulatory control of inputs (such as vessel numbers). However, a situation of over-fishing (leading to depletion of the fisheries resource) and over-capitalisation created what has been termed a "panic phase" (Hughey, Cullen and Kerr, 2000). In 1986 the Fisheries Amendment Act established the Quota Management System of tradeable fisheries property rights, known as Individual Transferable Quotas (ITQs). While the framework has been refined over the intervening years, its basic institutional arrangements are relatively unchanged.

The starting point for the tradeable fishing quota framework is the setting

[8]Early literature identifying the tragedy of the commons in fisheries resources and suggesting the private property rights approach as a more efficient framework include Gordon (1954) and Scott (1955).

[9]New Zealand and Iceland have implemented tradeable quotas across most species and locations, while other countries have only implemented similar systems for particular species or locations (see Table D.1 in Appendix D).

of a total allowable catch (TAC) by the Ministry of Fisheries (Mfish). This is set for each fish stock using a biological assessment and a consultation process to determine the maximum sustainable yield of each fish stock. Some of the TAC for a fish stock may be allocated to recreational, customary (Maori) and other non-commercial fishing uses. The remaining amount available for commercial fisheries is known as the total allowable commercial catch (TACC).

Given the TACC, commercial fishers hold ITQs entitling them to a specific catch amount. ITQs were originally allocated to fishers on the basis of historical usage, using each fisher's average catch over two of the three years 1981, 1982 and 1983. ITQs are defined by species, and for a specific fishing zone. They were initially defined by volume, specifying a fixed tonnage that could be caught by the quota holder on an annual basis, in perpetuity. This was later changed so that ITQs were defined proportionately, as a percentage share of the TACC.[10]

ITQs therefore provide a perpetual right to a specified share of the fishing resource for a given species and location. Each year Mfish determines the TACC for each species (in kilograms). There are 100 million ITQ shares for each species, so dividing the TACC by 100 million yields the weight for one share of the species for that particular fishing year. The number of shares held by a fisher determines that fisher's Annual Catch Entitlement (ACE).[11] A fisher may transfer all or any portion of the ACE at a negotiated price, which amounts to a temporary lease of the fisher's right for the fishing year. Alternatively, a fisher may permanently transfer the ITQ share to another

[10]The key reason for this change was that, with volumetric ITQs, the government had to enter the market and purchase quotas from existing holders if it wanted to reduce the TAC or TACC. Faced with the high costs associated with this, the government switched to proportional ITQs in 1990 (Newell *et al.* 2002).

[11]For example, suppose the TACC for Hoki is set at 250,000,000kg for a fishing year. One quota share is therefore equal to 2.5kg (by dividing by 100 million). A fisher holding 40,000 shares generates 100,000kg of ACE. (Example taken from www.fishserve.co.nz).

fisher, entitling the new holder to the perpetual stream of ACEs.

Trades between individuals or small companies owning ITQs are generally instigated through brokers. Larger companies will often instigate bilateral trades with other larger companies (Newell *et al.*, 2002). Trades are advertised in magazines, newspapers and on the Internet. No approval is required for a trade, although the details must be reported to Mfish for the trade to be effectual. Mfish maintains a searchable public register of all the relevant details of ownership and trading of ITQs for each fish stock.

The ITQ market also includes specific mechanisms for the monitoring and enforcement of fishing rights. The Fisheries Act (1996) requires quota holders and other parties in the fishing industry (for example, vessel owners and fish purchasers) to keep detailed records. As Newell *et al.* (2002, p.10) note, this creates a mechanism with which to "track the flow of fish from a vessel to a licensed fish receiver (on land) through to export records". The 1996 Fisheries Act also allows Mfish to place 'observers' on-board fishing vessels to provide more detailed observation and monitoring.

Enforcement of rights and obligations is provided through a range of penalties detailed in the Fisheries Act. Penalties range from a fine of up to $5,000 for contravening prohibited or restricted fishing methods, to up to 5 years imprisonment or a fine up to $250,000 for offenses such as making a false or misleading statement.

A number of stakeholder organisations have also been formed in the industry, to facilitate the operations of the market. Batstone and Sharp (1999) note that, by 1997, 21 such organisations had been formed, with their roles including quota management, research and TACC negotiation. Hughey *et al.* (2000) identify a number of positive outcomes that have resulted from the formation of stakeholder groups, including the ability to manage quota allocation within the group (for example, by rotational harvesting) and the ability to develop their own self-policing rules.

4.2.2 Assessment of the ITQ Framework

In relation to Iceland, the only other country having a similar long experience with ITQ markets in fisheries (having implemented such a system in 1979), New Zealand is usually considered to be the "success story" (Yandle and Dewees, 2003, p.4).[12] A number of studies have assessed the effectiveness of the system in New Zealand, and they highlight a number of positive outcomes. For example, Yandle and Dewees (2003) consider surveys of Auckland fishers in 1987, 1995 and 1999. Overall there was broad agreement from survey participants that the industry is better off with tradeable quota shares, and that the framework preserves fish stocks.

Newell *et al.* (2002) take a more empirical approach to assessing the New Zealand framework. The authors use data from 15 years of transactions across 33 species to analyse ITQ markets. They find that there are a sufficient number of quota owners and a large number of both temporary and permanent trades to generate efficiency gains.[13] Moreover, in the markets for most species the degree of price dispersion has fallen since the introduction of the framework and is comparable to that of other well-functioning markets. These authors also use econometric analysis to show that market prices are in line with fundamentals such as fish prices, quota demand, costs and ecological uncertainty. Overall, Newell *et al.* (2002, p.33) believe that the empirical evidence "suggests a reasonable level of economic sophistication

[12] Runolfsson and Arnason (1997) outline some of the weaknesses with the ITQ system in Iceland. These include reduced efficiency as quota holdings are restricted only to the owners of fishing vessels and thus cannot necessarily be allocated to other non-owners who may value the quota more highly; and uncertainty over the duration and exclusivity of ITQs, due to legislation specifying that the fish stocks remain the common property of the Icelandic people.

[13] According to Newell *et al.* (2002), the annual average number of transactions (using data up to the end of the 1998 fishing year), was 8,700 temporary leases of quota and 2,000 permanent sales.

in these markets, implying that market-based quota are potentially effective instruments for efficient fisheries management".

Other authors also outline the benefits of the ITQ markets, but note that there are areas where the markets are not as effective as they could be. In the Yandle and Dewees (2003) survey, some participants expressed concern as to the complexity of the system and the high barriers to entry. Batstone and Sharp (1999) argue that, while tradeable quota shares are certainly an improvement over the old regulatory approach to fisheries management, it is unlikely that the framework is economically efficient. The authors argue that this is because the framework does not provide a mechanism for the allocation of the resource amongst non-commercial fishers (for example, recreational fishers).

This is also an issue raised in the more critical review of Rennie (1998). However, it is entirely possible for recreational fishers, either individually or as a group, to purchase fishing quota and effectively remove it from the commercial market to be used for recreational purposes. This approach can also be applied to the use of water for recreational or environmental purposes. We discuss this in the next chapter.

Another of Rennie's (1998) main criticisms of the ITQ framework relates to reductions in the TACC. To actually implement a reduced TACC in any year requires considerable scientific certainty, but commercial fishers often challenge the scientific basis of TACC reductions to stall their implementation. To provide a counterargument, this perceived disadvantage with the market-based system in fishing quotas is based on a comparison with a first-best alternative that might not necessarily be achievable. As Demsetz (1969) argues, an approach where real alternative arrangements are compared to determine which best solves economic problems is preferable to comparing an existing "imperfect" arrangement with an idealised alternative. Indeed, administrative decision-making under a regulatory approach to fisheries resources would also be subject to challenges on the scientific basis of decision-making. Thus, this criticism of Rennie's hold equally true for other alternative, and achievable, frameworks.

Rennie (1998) also argues that perpetual ITQs inhibit flexibility in the system, in that new industries are unable to develop in areas where perpetual harvesting rights exist. He cites as an example the case of the high-value whale watching industry in Kaikoura, which may not have eventuated had ITQs for whales been established when whaling was a more socially acceptable industry. However, Rennie's argument neglects the fact that the value of a particular industry to society will be reflected in its market price. Therefore, as whaling becomes socially unacceptable, the price of whale meat would fall and thereby reduce the viability of whale harvesting. On the other hand, as whale watching becomes more socially demanded, the price that whale watchers would be prepared to pay for this activity would increase, making this industry more viable. Even with perpetual whaling rights, whale harvesters would still cut their losses and exit the industry if whaling were no longer viable. Thus, perpetual rights in no way inhibit the ability of new industries to develop in harvested areas, particularly if whale catchers can sell their ITQ to whale watchers.

In sum, the assessments of New Zealand's tradeable fishing quota framework are positive. The literature suggests that the market is relatively efficient and is considered an improvement over alternative approaches based more on command-and-control regulation.

4.3 Tradeable Emissions Rights in the U.S

In recent years, tradeable property right frameworks have become more widely accepted as a mechanism with which to achieve pollution targets and address serious environmental problems. Examples include tradeable permits for the emission of sulphur dioxide (SO_2) in the United States, a key cause of acid rain; and the global tradeable carbon credits programme implemented via the Kyoto Protocol, designed to reduce the incidence of carbon dioxide in the atmosphere (which contributes to global climate change). The following sections explore the institutional arrangements for the U.S. tradeable SO_2 permits framework, and provide a review of the literature assessing this framework.

4.3.1 Institutional Arrangements

SO_2 and nitrogen oxide (NO_X) are the main causes of acid rain in the United States. SO_2 is produced predominately by coal-burning electricity generators, and high concentrations of SO_2 have led to acid rain problems in parts of North America, notably northeast United States and southeast Canada (Joskow and Schmalensee, 1998). While legislative attempts have been made to address this problem, they were largely based on command-and-control regulations. In 1990, however, the United States introduced legislation establishing tradeable SO_2 emissions permits (termed 'allowances' in the United States) as a market-based means by which to reduce SO_2 emissions.

The SO_2 trading framework is administered by the Environmental Protection Agency (EPA) and split over two phases. In a similar manner to the fishing quota system, the EPA places a fixed cap on the total amount of SO_2 in each phase. In Phase I (1995-1999), the 263 dirtiest generating units in the country were allocated allowances for each year up to a maximum annual cap of 5.7 million tons of SO_2. These allowances were allocated free of charge based on a unit's share of heat input over 1985-1987. Phase II (2000 onwards) covers all generating units emitting SO_2, and allocates allowances in a similar manner up to a cap of 9.4 million tons for each year of 2000-2009, and 8.95 million tons thereafter (Joskow and Schmalensee, 1998).[14]

An allowance entitles the holder to emit one ton of SO_2 from a generating unit, and is defined by its 'vintage': the year in which it is first able to be used. At the end of each year, the generator must provide the EPA with sufficient allowances to cover each of its units' total emissions for that year. A generator may bank excess allowances for use in a later year, and may freely trade allowances with any other generator at any other location in the United States. No pre-trade approval is required and trades are generally instigated through brokers or by private bilateral arrangements (Joskow, Schmalensee and Bailey, 1998).

The EPA maintains a public register of allowances known as the Allowance Tracking System. This system records the ownership details of allowances and details of allowance trades and banked allowances. The system is freely searchable via the EPA website. The EPA also undertakes the roles of monitoring and enforcement in the tradeable allowances framework. Generators are required by law to install emissions monitors and report their emissions to the EPA. Financial penalties apply if a unit exceeds the emissions covered by its annual allowances (Joskow, Schmalensee and Bailey, 1998).

In addition to allowing tradability of allowances, the EPA runs an annual auction of allowances, the purpose of which is to facilitate trading. This auction was originally established in response to concerns that active trading

[14]Despite the initial allocations following specific rules, Joskow and Schmalensee (1998) argue that the actual allocations were significantly influenced by interest group pressure for rent-seeking opportunities.

would not occur in the absence of a centralised trading facility (Joskow and Schmalensee, 1998). The EPA holds back approximately 2.8 percent of the allocated allowances for each year, and runs an annual auction for these allowances. The revenues gained from the auction are returned to generators in proportion to their allowances held back for the auction.

4.3.2 Assessment of the SO_2 Allowances Framework

A key aim of the tradeable SO_2 allowances framework in the United States was to reduce emissions to about half their 1980 level in the long-run (Carlson, Burtraw, Cropper and Palmer, 2000). In theory, a tradeable allowances framework allows for emissions reductions to be realised (through the imposition of the emissions cap) while providing the flexibility for the most efficient allocation of emissions amongst electricity generators. Generators have incentives to reduce emissions and sell off excess allowances.[15] In the economics literature, the success (or otherwise) of the framework is generally evaluated in one of three ways: determining if emissions reductions have been achieved, evaluating the efficiency of the market, or determining if cost savings have been achieved.

It is a relatively undisputed point that SO_2 emissions have dropped since the implementation of the tradeable allowances framework. Schmalensee *et al.* (1998) show that emissions dropped sharply in both 1995 and 1996, the first two years of Phase I of the framework. The authors also show that actual emissions in this period were below counterfactual emissions, estimated as if the tradeable emissions framework was not in place. More recent data on actual SO_2 emissions are provided by EPA (2002), showing that emissions

[15] The two main approaches used to reduce SO_2 emissions are fuel switching and scrubbing. Fuel switching involves switching to coal with a lower sulphur content, while scrubbing involves installing facilities that reduce SO_2 emitted into the atmosphere (Schmalensee, Joskow, Ellerman, Montero and Bailey, 1998).

in 2001 have fallen by just over 30 percent from 1990 levels. The EPA also projects annual human health benefits from emissions reductions to exceed U.S.$50 billion in 2010. Burtraw and Mansur (1999) estimate health benefits with tradeable emissions allowances at around U.S.$125 million in 2005 compared to a scenario with the same cap on emissions but no trading.

Similar to the review of analyses of fishing quota markets given above, many authors assess the efficiency of the SO_2 allowances market and use this as an indication of the success of the framework. Schmalensee *et al.* (1998) argue that a large increase in trading volumes over the initial years of Phase I shows the market was becoming more efficient. Joskow, Schmalensee and Bailey (1998, p.676) compare price indexes compiled by three different brokers from private bilateral trades made by the brokers' clients, with market-clearing prices at annual allowance auctions. They conclude that "the close alignment of prices quoted from several independent sources strongly suggests the emergence of a relatively efficient market". The authors also add that falling commission costs and bid-ask spreads further confirm the emergence of an efficient market.

Turning now to cost savings, most authors suggest the tradeable allowances framework has generated significant emission abatement cost savings when compared with estimated costs from alternative command-and-control frameworks. For example, Stavins (1998) estimates that cost savings of up to U.S.$1 billion have been achieved annually. Schmalensee *et al.* (1998) estimate that the tradability of allowances compared with the same allocation of allowances but no tradability saved between U.S.$225 and U.S.$375 million per year in abatement costs.

While Carlson *et al.* (2000) agree that abatement costs are lower under the tradeable allowances framework than under command-and-control, they consider whether the allowances framework actually achieved the least-cost solution. The authors estimate marginal abatement cost functions and determine that actual cost savings were greater than those that could have actually been realised. Despite this, they believe that as market familiarity increases, so too will the volume of trading which will result in full cost savings becoming realised. Moreover, the arguments of Demsetz (1969) apply again, in that the success of the framework should not be measured against idealised (and potentially unachievable) alternatives.

Overall the consensus in the literature is that the tradeable SO_2 allowances framework has worked well. However, as Schmalensee *et al.* (1998, p.67) note, any tradeable rights framework can produce surprises and can take time to develop, and they are not "a magic tool that can solve any environmental problem at negligible cost".

4.4 Key Features of the Frameworks

The tradeable rights frameworks for fishing quotas and SO_2 allowances have a number of similar features. The broad approach taken by both frameworks is what has become known in the United States as a 'cap and trade' approach: an upper limit or cap is set on the total resource use and hence on the total number of property rights to be allocated, and these rights can be traded between resource users to achieve the most efficient allocation of the resource. More specific institutional arrangements of both frameworks are also very similar, such as the way property rights are defined and allocated, the rules for trading rights, monitoring and enforcement provisions, and mechanisms to enhance information flows. The following sections summarise these features with a view towards determining the appropriate institutional arrangements for a tradeable water rights framework.

4.4.1 Defining and Allocating Property Rights

In both the fishing quota and SO_2 allowance frameworks, property rights are well-defined by ensuring that they specify exactly what the holder of a quota or allowance is entitled to. Moreover, once a right is allocated it provides a perpetual entitlement either to a share of the fishing resource or to emit SO_2 in the respective frameworks. Investments in both the industries that these rights apply to can be significant (for example, investing in a commercial fishing fleet, or investing in an SO_2 scrubber to reduce emissions), and perpetual rights provide holders with certainty over a long enough time-frame to recoup the costs of their investment.

The initial allocation of rights in both frameworks is based on historical usage. This provides protection for existing property rights and investments that have already been established prior to the introduction of the framework. Indeed, as Moran (2003, p.5) notes, to eliminate or alter any type of property right without compensation can cause "deep-seated damage to the incentive system on which society's prosperity is founded".

An alternative initial allocation procedure would be to auction property rights and allocate rights to the highest bidder. However, such an approach provides no protection for those who have historically utilised the resource and invested accordingly. Moreover, trading of property rights after the initial allocation will ensure the efficient allocation of property rights, so that the initial allocation of rights is largely irrelevant.[16]

[16]Lyon (1986) provides a more rigorous argument for this, concluding that the efficiency properties of auctioning tradeable rights will, in the long-run, approach those of a framework based on free initial allocation followed by competitive trading.

4.4.2 Trading of Rights

Property rights for commercial fishing in New Zealand and SO_2 emissions in the United States can be readily traded between users without prior approval. In the SO_2 allowance framework, there are no restrictions on trading allowances to other locations or generating units. In New Zealand the trading of fishing quotas is restricted by species and location. Due to the characteristics of the fishing industry, it would be difficult to allow a quota for one species and location to be bought be a water user wanting to apply that quota to another species and location.[17] Nonetheless, this does not prevent the trading of a quota for one species and location with a quota for a different species and/or location (which may include a monetary payment for the difference in value between the two quotas).

Aside from the annual auctions held for a small portion of SO_2 allowances, neither framework has a centralised trading platform to instigate trades. With centralised trading, a specific institutional arrangement is set up to bring together buyers and sellers, and establish trades and market-clearing prices. However, both the fishing quota and SO_2 allowances frameworks operate predominately through bilateral decentralised trades between market participants. The lack of a centralised trading platform in both cases does not seem to be a major impediment to trade since, as discussed above, both frameworks have sufficient trading volumes and are considered to be operating relatively efficiently.

[17] To enable such trade across species or locations would require the setting of a single cap on the entire fish population for all species. Such a cap will not capture the different characteristics that different fish species have (such as populations and population growth rates) and may therefore not adequately address over-exploitation.

4.4.3 Monitoring and Enforcement

Both of the tradeable rights frameworks analysed have comprehensive monitoring regimes in place, which monitor compliance with the rules of the framework. They also specify stringent financial penalties for any breach of the rules of the framework. In both cases, the monitoring arrangements require self-monitoring and reporting by property right holders, with an overseeing role undertaken by an administrative body.

While implementing monitoring and enforcement arrangements in a tradeable rights framework may be costly, such arrangements are an essential part of the framework as they provide protection of property rights and ensure that entitlements are not exceeded. Self-monitoring may raise compliance costs for rights holders, but in the long-run, efficiency gains from tradeable rights are likely to outweigh these costs. Moreover, the alternative of command-and-control regulation would also require monitoring and enforcement arrangements to operate effectively. Thus, any increase in costs from moving to a tradeable rights framework may only be from the lack of such arrangements in place in the existing framework.

4.4.4 Information Exchange

For tradeable rights frameworks to work effectively, information (such as where rights are available to buy and sell, and the value of property rights) needs to flow smoothly between market participants. Both the fishing quota and SO_2 allowance frameworks have specific institutional arrangements to facilitate the flow of information.

Firstly, both frameworks have a searchable public register recording the full details of property rights and their trades. This ensures the framework is transparent and reduces information asymmetries by providing a mechanism by which any potential or existing right holder can obtain the exact details of a right. Brokers have also established themselves in the fishing quota and SO_2 allowance markets, and their presence would facilitate trading and information exchange. Finally, information flows and trading are also enhanced in the fishing quota framework by the existence of stakeholder groups.

4.4.5 Recreational or Environmental Uses

We highlighted earlier that there is potential in New Zealand's tradeable fishing quota framework for recreational fishers to group together and purchase quota for non-commercial fishing opportunities. Similar approaches have occurred in the U.S. tradeable SO_2 allowance framework. For instance, Joskow, Schmalensee and Bailey (1998) cite examples of environmental groups bidding for (and obtaining) SO_2 allowances at the EPA's annual auctions, and retiring these allowances to reduce overall SO_2 emissions. Organisations such as the Clean Air Conservancy and the Acid Rain Retirement Fund have established themselves as non-profit organisations with the express purpose of buying and retiring SO_2 allowances. Allowing for such purchases in a tradeable rights framework ensures that environmental and recreational groups are represented in the framework, and enhances its overall allocative efficiency.

The difficulties with the purchase of tradeable rights by recreational or environmental groups, which Buurman (2004) highlights, are in organising a large group of contributors, and the potential for non-contributors to free ride on the payments of others. Nonetheless, as Buurman (2004) notes with regard to the New Zealand fishing industry, there are existing mechanisms in place for organising large groups of people, and the involvement of the Department of Conservation may further assist in recreational purchases. Free rider behaviour can be mitigated through the imposition of a licence fee or a similar charge to recreational users. Hence, there are definite benefits to be realised in a tradeable rights framework if the appropriate arrangements can be put in place to allow recreational or environmental groups to get together and purchase rights while mitigating the potential for free rider behaviour.

4.5 Conclusions

The use of tradeable property rights has become widespread in addressing resource allocation under scarcity. Tradeable rights frameworks such as fishing quotas in New Zealand and SO_2 allowances in the United States are generally considered to be successful, and their design has implications for tradeable water rights systems. The basic approach is to set an upper limit on the resource use and specify well-defined tradeable property rights. Such an approach, as we have suggested in earlier chapters, could apply equally well for water. It is also the more specific institutional arrangements for fishing quotas and SO_2 allowances that ensure these markets operate efficiently. The next chapter draws on the ideas presented in this chapter and Chapter 3 to suggest desirable institutional arrangements for a tradeable water rights framework in New Zealand.

Chapter 5

Institutional Arrangements for Efficient Water Allocation in New Zealand

5.1 Introduction

In Chapter 3 it was noted how New Zealand's current arrangements for water allocation could be improved by creating well-defined, secure and tradeable property rights to water. Tradeable water rights frameworks are widely used in many other countries, for example in Australia, Chile and many of the western states of the United States. As noted in Chapter 3, these frameworks have brought benefits to water users and ensured scarce water resources are used where they are most valuable. Tradeable rights frameworks have also been successfully applied for the control of other scarce resources such as fisheries resources and air pollution, addressed in Chapter 4. It is apparent from these earlier chapters that tradeable rights frameworks can deliver benefits in areas where traditional administrative methods often fall short.

While some authors have suggested the possibility of capturing these benefits by using tradeable water rights frameworks in New Zealand,[1] they often do not consider the exact institutional arrangements needed for such frameworks to work well. As McMillan (2002) notes, markets do not operate efficiently in a vacuum. They need an appropriate set of rules, regulations and organisations that define and support market behaviour. Current water rights trading in New Zealand is testament to this. Although trading is allowed in the RMA and in some councils' regional plans, very little trading actually occurs. A key reason for this is that there are few other arrangements that support and encourage water trading. Factors inhibiting trading are that water rights are defined on a use basis, making it difficult to trade across uses. Rights for irrigation purposes are also typically bundled with the land they are used on, and only traded with the land when it is sold. The purpose of this chapter, therefore, is to describe desirable institutional arrangements for the operation of a tradeable water rights framework in New Zealand.

This chapter outlines these desirable institutional arrangements by drawing on economic analysis and the experience of other countries, with the latter based on the review of other countries in Chapter 3. It also draws on the institutional arrangements in the successful fishing quota and SO_2 allowance frameworks outlined in Chapter 4. We address firstly the likely role of regional councils under a tradeable rights framework in Section 5.2. This role would include determining the total amount of water available for allocation on a catchment through a planning and consultation approach, allocating water rights based on historical usage, monitoring and enforcing water rights, and approval of trading of rights. These regional council roles cover a wide range of the desirable institutional arrangements, although there are still others that are important for the successful operation of a tradeable rights framework. In Section 5.3 we outline the benefits from having a searchable

[1] See, for example, McLellan (1998) and Lincoln Environmental (2001b).

public register of water rights. Section 5.4 then describes other institutional arrangements that will facilitate the flow of information and thereby lower the costs involved in trading. We then summarise these ideas and those of earlier chapters to provide an overview of a tradeable water rights framework in Section 5.5, and present some concluding comments in Section 5.6.

5.2 The Role of Regional Councils

While tradeable water rights allow decision-making to be decentralised to the level of actual water users, this does not preclude an administrative role for regional councils in a tradeable rights framework. Indeed, regional councils are likely to have a vital role in ensuring markets operate smoothly and efficiently. Moreover, there are also likely to be benefits from the existing system where council boundaries are based around the major water catchments, since trading of water rights is likely to be relatively localised. Examples from earlier in this study of administrative roles include those played by the DGA in Chilean water markets, the Ministry of Fisheries in the New Zealand fishing quota frameworks, and the EPA in the SO_2 allowances framework in the United States. These experiences suggest four broad roles for regional councils in a tradeable rights framework which are developed further in the following sections: setting allocation limits, allocating water rights up to that limit, monitoring and enforcement of rights, and pre-trade approval of rights transfers.

5.2.1 Defining Rights Through Allocation Limits

We have already discussed some of the important requirements of well-defined water rights in Chapter 3, such as a clear specification of what may be taken, proportional or priority rights to deal with flow variability,[2] and a long enough time-limit to encourage investment. The other aspect of defining water rights that we outline here is in ensuring rights are defined through the setting of an upper allocation limit on the water use.

The tradeable rights frameworks for commercial fishing and SO_2 emissions outlined in the previous chapter are both based around the simple concept of setting an upper limit on the use of the resource and allocating tradeable rights up to that limit. The upper limit establishes scarcity of property rights to the use of the resource, which ensures that these rights have value and that the resource is not over-utilised. This in turn provides incentives for trade, thereby enhancing the efficiency of the resource allocation. In the same way, efficiency of water allocation will be enhanced by firstly establishing how much water is available to be allocated on a catchment, as is done with fish stocks. Regional councils would be well placed to undertake a planning approach to determine such allocation limits.

While many regional councils do currently set allocation limits through the preparation of catchment plans, it is not mandatory under the RMA to do so, and this has caused problems on some catchments. For example, legislation passed in 2004 to deal with growing competition for Waitaki River water noted that the lack of a catchment plan for the Waitaki compounded the problem of allocating the water amongst the large number of competing users.[3] Developing catchment plans and allocation limits through consultation and modelling is used for tradeable water rights frameworks in countries such as Australia, England and Wales, and is an absolute necessity in fostering efficient markets in water.

[2]The concept of proportional water rights links closely with the way New Zealand's fishing quota framework operates, where the total amount of the resource is defined and users obtain tradeable shares in the resource.

[3]See Counsell and Evans (2004) for further explanation of the issues surrounding the Waitaki legislation.

The setting of allocation limits is also likely to incorporate the setting of minimum flows to provide for in-stream uses. Currently in New Zealand, the RMA provides for the setting of minimum flows to protect the habitats of fish, vegetation and fauna; to provide for recreational opportunities; and to provide water for Maori cultural values. The public good nature of in-stream flows means it is important to allow minimum flows to be set administratively in a tradeable water rights framework.[4] However, it is possible in such a framework that in-stream users could supplement their existing water supplies through the purchase of water rights from consumptive users. There are a number of cases from the western United States where water rights have been purchased for in-stream purposes. Colby (1990) provides numerous examples, such as the purchase of irrigation water rights by a local county in Nevada to maintain the shoreline for fishing and boating; and the purchase of in-stream rights by the Montana Fish, Wildlife and Parks department to protect trout fisheries. The combination of regional councils setting minimum flows but also allowing in-stream rights to be purchased has the potential to enhance the efficiency of a tradeable rights framework while still providing for public good values.

The setting of allocation limits also raises the question of how to address changes in water availability and its impact on the rights of existing water users. Changes in water availability may be from natural events, such as droughts or climate change; or more artificial events, such as new scientific information on water availability in a catchment, or regulatory changes to allocation limits or minimum flows. The question then becomes who bears the risk from such changes. As we noted earlier in Chapter 3, this is a

[4] A public good is one which is nonrival (consumption by one person has no effect on the amount of the good available to be consumed by others) and nonexcludable (it is impossible to exclude others from consuming the good). A number of in-stream uses, such as various recreational activities, are public goods.

question that has recently been vigorously debated in Australia. Recall that the solution set out in COAG's 2004 National Water Initiative is for water users to be compensated for reductions in water availability due to changes in government policy, to be partially compensated for changes due to new scientific information coming to light on the capacity of a catchment, and to be uncompensated for changes to their water allocation due to drought or climate change.

A recent case in the U.S. has brought up similar issues. In 2001, the Tulare Lake Basin Water Storage District, and a number of other water users in California, brought a claim in the U.S. Court of Federal Claims for compensation from the Federal Government from water-use restrictions imposed during droughts in the early 1990s. The restrictions were set under the Endangered Species Act to protect two species of endangered fish in the Sacramento and Feathers Rivers. As a result of the restrictions, water districts and farmers in the regions faced a significant reduction in the volume of their water takes. The Plaintiffs argued that the restrictions constituted a regulatory taking of their water property rights, and they were therefore entitled to compensation. The U.S. Court of Federal Claims agreed and ordered the Federal Government to pay compensation to affected users, which was settled at U.S.$16.7 million in December 2004. As the judge noted in his ruling on the case, "the federal government is certainly free to preserve the fish; it must simply pay for the water it takes to do so".[5] Both this case and the Australian example suggest that an important aspect of a tradeable rights framework is providing a set of rules relating to compensation and changes in water availability in a catchment.

[5]United States Court of Federal Claims, *Tulare Lake Basin Water Storage District, et al v. The United States*, No. 98-101L, 30 April 2001, Opinion of Judge Wiese, p.19.

5.2.2 Allocating Initial Water Rights

We have already argued that the initial allocation of water rights in a tradeable rights framework should be based on historical usage, to provide for the protection of existing investments. Thus the role of regional councils would be to ensure all existing holders of resource consents for water have these consents recognised as tradeable water rights under the new framework.

This allocation may not necessarily exhaust the upper allocation limit set on a particular catchment. The regional council will therefore also have a role in allocating rights through an administrative procedure until this limit is reached. When excess water is available to be allocated, freely allocating rights on a first-in first-served basis remains an efficient allocation mechanism. It is only when demand for water rights exceeds supply that market transfers of rights would be the main allocation mechanism to enable water to be allocated to its highest valued use.

The initial allocation of water rights based on historical usage means that there are rents that can be captured by the holders of these rights. That is, a water user may obtain a right freely through historical usage or by first-in first-served, and later sell it for a considerable profit when demand for rights increases. While the capture of such rents may be a politically contentious point in the development of a tradeable rights framework, it does not limit the efficiency associated with well-defined, tradeable rights. Rent capture affects the incidence of returns, but from society's point of view this would not outweigh the efficiency gains from the potential to trade to the highest valued use.

In addition, the main alternative allocation mechanism of auctioning rights can be problematic. It is only applicable when there is as yet unallocated water for which demand exceeds supply. The auction approach generally allocates to the highest valued use in such circumstances.[6] To auction existing allocated rights to water would negate the associated property rights. Allocating tradeable rights on the basis of historical usage rather than auctioning is the most appropriate initial allocation mechanism for water that has already been allocated, even by customary use.

5.2.3 Monitoring and Enforcement

Regional councils currently undertake monitoring and enforcement roles in relation to water resources. However, for a tradeable water rights framework to work efficiently there is a need for a greater investment in these roles. Noncompliance in a tradeable rights framework, as Tietenberg (2002b) notes, makes it difficult to meet economic, social and environmental goals. In the absence of an effective monitoring and enforcement regime, property rights holders will lack the disincentives to over-utilise the resource, which in turn may reduce efficient trading opportunities.

Monitoring by regional councils would include the metering of water use, and the monitoring of water quality, return flows and minimum flows. This would likely require an increased investment over current monitoring provisions in these areas. For enforcement, a number of enforcement provisions are already specified in the RMA, and these could continue to apply under a tradeable rights framework. Regional councils have the power to issue notices such as enforcement orders or abatement notices, and anyone contravening such notices is liable for a penalty. While increased monitoring and enforcement for the operation of a tradeable rights framework will inevitably entail increased costs, the benefits of market efficiency are likely to outweigh these costs.

[6] Under some general assumptions, the 'standard' auction formats (ascending, descending and sealed bid) all allocate resources to the highest valued uses. See Klemperer (1999) for more details.

Moreover, tradeable water rights may provide greater incentives for decentralised self-monitoring by water users than under an administrative allocation framework. Making rights tradeable establishes an opportunity cost of water. This provides users with a financial incentive to monitor their use of water to ensure it is being used efficiently. While regional councils would not want to rely entirely on self-monitoring due to the possibility of deliberate mis-reporting, it would reduce the burden on councils and lower the costs of centralised monitoring.

5.2.4 Pre-Trade Approval

The fisheries and SO_2 frameworks described in Chapter 4 did not require any administrative approval for trades to proceed. This lowers the transaction costs of trading and thereby facilitates trades. However, the characteristics of water make it difficult in some cases for trades to proceed without having an adverse effect on a third (non-trading) party. Consider, for example, an upstream water user who returns some water to the river, which is later used by downstream users. If these return flows are sold to a location even further downstream, this affects the availability of water to the non-trading water users in between. Alternatively, adverse third party impacts may also arise if a new water user following a trade alters the quality of water returned to the river, which again can affect the water available to non-trading downstream users.

These concerns can in part be addressed by ensuring water rights are well-defined, particularly for return flows. If the rights to return flows are held by the water user who generates them, then these rights can be readily traded without undermining the rights of downstream users. Alternatively, if the rights to return flows have been legitimately purchased by downstream users, these rights cannot be sold by the water user who generates the return flows.

Since a non-trading party and a trading party cannot simultaneously hold rights to return flows, there will be no adverse effects on the non-trading party if the rights to those flows are traded downstream. Thus, trades could proceed without prior approval. We discussed this approach earlier in Chapter 3 and more details are also provided in Appendix C.

Despite this, there may still be cases in which prior approval of trades is necessary, to ensure that adverse effects on third parties are avoided. Regional council approval of trades affecting third parties could be sought, with this approval being based on the consent of the affected parties. While the process should not limit the procedural rights of these parties, it should also be relatively straightforward to ensure that transaction costs from the process are kept low. A quick and simple approval process, coupled with well-defined rights as noted above, is unlikely to significantly impede trading.

Pre-trade approval may also be necessary to prevent monopoly power in a tradeable rights framework. It is sometimes feared that establishing tradeable water rights will lead to a large water user buying up all the water rights to become a monopoly. However, the exercise of monopoly power could be constrained, as it is in many markets, by appropriate regulation through pre-trade approval. In the New Zealand fisheries ITQ framework, for example, there is a limit set on the total amount of quota any one person or company can hold. Note, however, that even with the presence of a large water user in a tradeable rights framework, it does not necessarily mean that user can exercise monopoly power. To buy up enough rights requires willing sellers, and even holding a large number of rights, as Hahn (1984) shows, the user may still not be able to influence the market price of those rights.

5.3 Registration of Water Rights

Any water allocation framework based on property rights will require specific institutional arrangements to provide each right holder with some form of registration of their entitlements under that right. The current system for water rights in New Zealand provides for their registration through a resource consent certificate held by both the water user and the regional council, which outlines the details of the water right and any conditions attached to the right. However, this system can lead to problems over the certainty of title provided by the certificate, particularly as the information on the certificate can often be incomplete. For example, in a recent Environment Court case, Meridian Energy sought a declaration of its water rights on the Waitaki River. The need for the declaration arose because Meridian held certificates of its water rights but these did not record the full details of the rights. The full details were actually recorded on the original application made for the rights. While the Court did make the declaration, the situation highlights the considerable uncertainties that can arise when records of water rights are held in the form of a certificate that may differ from other certificates or records.

To improve this system and the efficiency of water allocation in New Zealand, a single public register of water rights titles could be implemented. Such a system could be based on the Torrens Title system of property rights registration. Under the Torrens system the owner of a right has their title guaranteed by the state, with a central register containing all the relevant details of the property right. While certificates of title will also be issued, the register contains the correct details of the right. Similar systems are used for water rights in New South Wales, Queensland, Mexico and Chile. The frameworks for tradeable fishing quotas and SO_2 allowances also provide similar searchable property rights registers, and the approach is used for the registration of land titles and transfers in New Zealand.

A centralised register of water rights reduces the opportunities for fraud and misrepresentation (Young and McColl, 2002). Other benefits it would provide in a tradeable rights framework include:

- reducing information asymmetries,
- providing certainty as to the ownership of water rights and their exact entitlements,
- lowering the transaction costs of trading both through lower information gathering costs and lower administration costs,
- assisting in monitoring the state of resource allocation by providing monitoring agencies with a clear indication of the nature of rights allocations.

Moreover, a single register recording all water rights nationwide is preferable to regional or catchment-specific registers because it ensures national consistency and provides for inter-catchment transfers. Multiple registers would increase the transaction costs of rights transfers, particularly where a potential water right purchaser comes from outside the region associated with the register. The experience of Chile is evidence of this, where there are three sources of information on water rights titles: local Real Estate Title Offices, private canal associations, and the government's incomplete register held by the General Directorate of Water. Bauer (1997) notes that this creates a significant barrier to water rights trading in Chile, as it makes information costly or difficult to obtain (thus raising transaction costs). A single public registry in New Zealand could be managed at the central government level.

5.4 Enhancing Information Exchange

Developing institutions that allow information to flow freely between market participants is a crucial part in the design of any market. This is true also for allowing water to be allocated efficiently through a tradeable water rights framework. The high cost of obtaining information may be one of the reasons why so little trading of water rights occurs currently in New Zealand. The sort of information that market participants wanting to trade water rights would require includes: where water rights are available to buy or sell; the value of water rights (which may be based on past transaction information); the characteristics of a traded water right, such as how much water it entitles the holder to, the quality of the water, and the security of supply the right is subject to; and hydrological information such as current and expected future rainfall and flows.

A variety of institutional arrangements are used in other tradeable rights frameworks (including frameworks for water in other countries) to support the flow of this sort of information. Some of the main arrangements are outlined below and they could easily be applied to New Zealand to facilitate water rights trading.

5.4.1 Water Brokers

Brokers are widely used in many tradeable water rights frameworks, such as those in Australia and Colorado. Trading in fishing quotas in New Zealand and SO_2 allowances in the United States are also typically assisted by brokers. In the SO_2 allowances market, for example, around 65 percent of trades in the first five years of the allowance market involved brokers (Wojick, 2000). Brokers assume responsibility for matching buyers and sellers and often have a role in negotiating the terms of the trade. It should be noted, however, that they are not a necessity for making a trade. In the same way as land sales can be made without the assistance of a real estate agent, water users can trade water rights without a broker.

The use and existence of water brokers is likely to depend on the size and complexity of the market. On many New Zealand catchments markets for tradeable water rights are unlikely to be large, and it may not be cost effective for brokers to operate in these markets. However, there may be economies of scope generated by real estate agents also acting as water brokers. This would be particularly cost effective where trading of water rights is associated with trading of land, such as in the case of irrigation. In any case, brokers are likely to emerge where the need for them exists, but their development should be encouraged in any tradeable rights framework.

5.4.2 Administrative Services

In addition to the roles highlighted above, regional councils would also play an important role in facilitating information exchange. This can be done by supplying information on water availability and previous trades. The Internet is a valuable tool for providing this type of information service, and its use in this case would complement its existing uses by regional councils.[7] Similar information services are widely used overseas. For example, the Department of Water, Land and Biodiversity Conservation is responsible for water resource management in South Australia. It operates a public and freely available information service on its website giving details of all previous water rights trades in the State, and it allows those wishing to trade to post details on the site. In the New Zealand tradeable fishing quota framework, FishServe - a subsidiary of the New Zealand Seafood Industry Council - op-

[7]For example, many regional councils use their websites to give details of rainfall, river flows and lake levels, and any water use restrictions that apply in their area.

erates a website offering services that include searching for individual quota holdings and viewing Crown quota holdings for sale. Similar services would greatly facilitate information flows in a tradeable water rights framework.

5.4.3 Water User Groups

The formation of user groups has occurred in a number of tradeable rights frameworks. Examples include water user groups formed in Chile and Mexico, and stakeholder groups for fisheries management in New Zealand. Water user groups facilitate the flow of information by providing an outlet for water users on the same catchment to meet and exchange information. They also lower the search costs involved in trading water rights. While water user groups do exist to some extent already in New Zealand (for example, through the grouping of irrigators in large-scale irrigation schemes), encouraging their continued development and operation is likely to provide a further mechanism for information exchange in a tradeable rights framework.

5.5 An Overview of the Framework

In this section we summarise the ideas developed thus far, in this chapter and in earlier chapters, to provide an overview of a water allocation framework that encourages efficiency through tradeable water rights. Such a framework would not require significant changes to the existing system for it to operate well. Indeed, a tradeable water rights framework would fit within the current legislative framework provided by the RMA. Changes would be needed to the way water rights are defined, to allow for clearly specified perpetual rights (or at least a significant time-frame before renewal), which are defined proportionally or by priority to allow for flow variability, as we discussed in Chapter 3. The RMA would also need to make catchment planning mandatory for regional councils, to allow upper allocation limits to be set. The setting of allocation limits on all water resources would be one of the first, and vital, steps in moving to a tradeable rights framework.

Other existing provisions of the RMA already provide for an efficient water allocation framework and would only require development rather than complete modification. For example, the setting of minimum in-stream flows for environmental, recreational and cultural uses would remain an important aspect of a tradeable rights framework to ensure that water is provided for public good values. However, this would be developed to also allow in-stream users to buy and sell water rights. The existing monitoring and enforcement roles of regional councils also provide a good basis for a tradeable rights framework, although they too may need to be expanded to ensure the efficient operation of this framework.

We have suggested that, once water rights are well-defined, they be allocated to users on the basis of historical use. That is, existing resource consent holders under the current system would effectively have their consents deemed to be water rights under the new system. With significant investments often needed for the use of water (such as a hydro-dam, irrigation network, or public water supply pipelines), allocating rights in this way provides for the protection of the value of such investments. A tradeable rights framework would also require a centralised register, to provide for the registration of water rights once allocated.

Other aspects of a tradeable water rights framework could be developed outside of the RMA. The establishment of water brokers and water user groups, for example, would occur where the need for them exists. Nonetheless, central or local government encouragement and direction for such institutions would be an important aspect of the framework. Indeed, the education of water users and the provision of information relating to a tradeable rights framework would greatly enhance its efficiency.

Finally we would also note that, to a certain extent, a water market already exists in New Zealand via the electricity spot market. The electricity market provides a market price for water in hydro-generation, as the spot price at a relevant node for a hydro-generator represents the opportunity cost of using water in electricity generation. In an alternative use, the value of water on a river with hydro-generation will therefore be at least the electricity spot price less the variable cost of hydro-generation. The electricity market prices water down river chains, with the water at the top of the chain (with more power stations to pass through) being more valuable that water further down the chain. It also prices water across regions, as the lower electricity production in one region reflects greater water scarcity and hence higher water values. The key point is that the electricity market acts as an existing water market, and may inform decentralised decision-making in a more complete tradeable water rights framework.

5.6 Conclusions

Experience with tradeable rights frameworks suggests that, firstly, establishing some form of institutional arrangements is important for the successful operation of these frameworks. Evidence of this is provided by New Zealand's current arrangements for water allocation, where trading of rights is allowed but does not occur, in part due to the lack of institutional arrangements to encourage trading. For example, on many catchments in New Zealand there is no upper allocation limit set - a basic arrangement applied in standard tradeable rights frameworks. Even if a catchment is over-allocated, a water user can still obtain a water right freely through the first-in first-served process from the regional council. Thus, it makes little sense for a potential water user to obtain a water right by purchasing it from another user, when it can be obtained freely from the council.

Secondly, not only do institutional arrangements need to be present, but they also need to be designed appropriately to provide the desirable incentives and outcomes. Tietenberg (2002b) cites the case of the Dutch cutter fisheries tradeable quota market, where inadequate enforcement meant the market did not operate effectively and exploitation of the fisheries continued. Designing appropriate institutional arrangements may be difficult, but it is a necessary part of ensuring a tradeable rights framework works as desired.

In this chapter we have drawn on the institutional arrangements from tradeable rights frameworks, both for water and for other resources, to highlight desirable arrangements for water in New Zealand. These arrangements would not require a significant modification to the current water allocation arrangements. Indeed, there would still be a significant role to be played by regional councils in order to encourage and facilitate trading. Yet by ensuring these arrangements are in place more trading would occur, thereby enhancing the efficiency of water allocation in New Zealand.

We have noted that one of the important arrangements to be put in place is enhancing information flows, particularly with regard to information on the value of water. In the next two chapters we highlight approaches for determining the value of water outside of market-based mechanisms. These approaches would allow water users to determine the value of water rights when trading volumes are low, or if an administrative allocation mechanism predominates.

Part II: Valuation of Water Property Rights for Extraction and Storage

Chapter 6

Valuing Water Extraction Rights

6.1 Introduction

We have discussed in previous chapters the importance of information in ensuring tradeable rights frameworks operate efficiently. This includes ensuring that information for valuing water rights is readily available to all market participants. Knowing the value of water rights allows water users to make decisions with regard to buying or selling water rights, and their future water use and investment.

In a tradeable water rights framework, the value of a right will be set through trading, particularly when market activity is high. However, in the absence of trading or when markets are thin, it is still important for decision-makers to be able to determine the value of water rights. As we discussed in Chapter 3, markets for water rights are quite likely to be thin (although this does not necessarily constitute a problem with tradeable water rights). Moreover, as Sharp (2004, p.3) notes, there is little or no information on the value of water in New Zealand, and "there are no mechanisms in place that generate information on opportunity cost".

Notwithstanding that there are in fact mechanisms in place that provide information on the opportunity cost of water (that is, the electricity spot market: see Chapter 5), the purpose of this chapter and Chapter 7 is to examine approaches for the valuation of water rights outside of a market-based framework, thereby providing an additional approach to determining the value of water. When water rights are not traded, these approaches would indicate the values of water characteristics that should be reflected in an administrative system. These approaches to valuing water rights will not, however, duplicate rights values in markets, because such values depend on demand and supply opportunities and expectations regarding water and markets that use water.

Many previous studies have analysed the value of water in alternative uses, and comprehensive summaries of such studies can be found in Gibbons (1986) and Frederick, VandenBerg and Hanson (1996). However, these studies typically utilise static approaches for the value of a single unit of water in a particular use, and are often based on willingness to pay approaches. For example, Gibbons (1986) outlines a method known as farm crop budget analysis, one of the key approaches for estimating the value of water in irrigation. Under this approach, representative farm budgets are used to estimate the value of water by evaluating crop revenue less non-water input costs, expressed as a price per unit of water per year. This represents the maximum amount a farmer would pay for water and still cover the costs of production.

Colby (1989) argues that to derive the actual value of the water right from such static annual water values, the present value of the stream of annual values for the length of the water right must be determined. However, aside from the farm budget approach, most methods for estimating a static water value only result in a price per unit of water at a single point in time, rather than annually.[1] Moreover, where the water right allows storage, the present value approach does not account for the option premium incorporated into the value of a water right. As we will explain below, a water right may be described as an option, by analogy with financial options on share prices. This option has value and thus adds a premium to the value of the right over and above the value determined by the present value approach.

Colby (1989) does, however, suggest that there are alternative approaches to valuing an actual water right. Possible approaches are: the sales comparison approach, where the value of a water right is determined by the price that similar water rights sell at; the land differentials approach, based on a comparison of land sales with and without water rights attached; the least-cost alternative approach, where an estimate is found for the least-cost alternative to creating a water supply similar to the water right; and the income capitalisation approach, which calculates the present value of the stream of net benefits that the water right generates over time. While all of these approaches have advantages and disadvantages, the income capitalisation approach is likely to be appropriate when markets for tradeable water rights are relatively thin and water is put to a productive use that enables net benefits to the right holder to be easily determined.

In this chapter, we extend the income capitalisation approach to value water rights. We consider a right that allows for water to be taken ('extracted') from a river (a 'water extraction right') and we explain how this type of right is analogous with a financial option (Section 6.2). From this we consequently show how this right can be valued in Section 6.3. We also

[1] For example, Gibbons (1986) notes that estimating the value of water to many industrial users is often determined by the cost of treating and reusing water, based on the assumption that this will be a user's maximum willingness to pay. Such estimates only result in a value of water expressed as a price per unit.

apply some data to value this right and derive some empirical results that show how different characteristics influence its value (Section 6.4). We offer conclusions in Section 6.5. From these we conclude that it is possible to value water to a useful extent, although our examples are simplified and cannot reflect all the information that market trades would reflect.

6.2 The Concept of Option Value

A water extraction right typically provides the right to extract up to a maximum volume of water from a water resource on a regular basis (usually daily) over the lifetime of the right (that is, until the right expires or is required to be renewed). To see how the income capitalisation approach would be used to value such a water right, suppose an irrigator holds a right to extract one cubic metre (m^3) of water from a river every day for a year. Assume, for simplicity, that the contribution of $1m^3$ of water is one unit of the final output, and that this output can be sold at a price of $10. If it is assumed for the purposes of this example that the irrigator has absolute certainty that it is able to extract its $1m^3$ every day, and that the output sales price remains unchanged, then the payoff from the water right (and thus the value of the right) to the irrigator is the (present) value today of the $10 received each day for one year.

Clearly this example is unrealistic. The value of the water right is likely to be influenced by changes in the river flow which affect the amount of water the irrigator can extract. Furthermore, the selling price and the ability to produce the crop are also likely to change throughout the year. The income capitalisation approach does not reflect this decision-making under uncertainty. Recent approaches to determining the value of an asset which depends on the uncertainty in underlying variables have used the techniques of option valuation. This determines the value of an asset by analogy with financial options. A standard financial option is a financial market product giving the holder the right (but not necessarily the obligation) to buy or sell shares in a particular company's stock at a predetermined price (the "strike price") and usually on or before a predetermined date. A holder of such an option has the decision to either exercise the option or leave it to expire unexercised.

A financial option has value because of the uncertainty in the share price. The price today may change in the future, potentially resulting in a better payoff to the option holder if the option is exercised. The techniques for valuing financial options can also be applied more generally to value assets with uncertainty in underlying variables, such as in our example of an irrigation water right with underlying uncertainty in river flows and the crop sales price.[2]

The ability to value a water extraction right by analogy to financial options is a result of the interaction of water users on a river. A water user's ability to extract water is contingent on the water rights of other users and consequently the water that must be left in-stream for them. On any given day, a water user will either extract an amount of water or, if required to, leave it in-stream for other users and extract nothing. This is similar in financial options to a European call option which, if exercised, allow the holder to buy shares at a predetermined strike price and, if not exercised, will expire and return no payoff. There is therefore an implicit option in a water extraction right on any given day. The entire water right is equivalent to a series of European call options, with each expiring on a particular day.

By way of further explanation, Figure 6.1 gives a simple representation of

[2]See Dixit and Pindyck (1994) and Trigeorgis (1996) for more on option valuation in examples outside of financial options (so-called "real options").

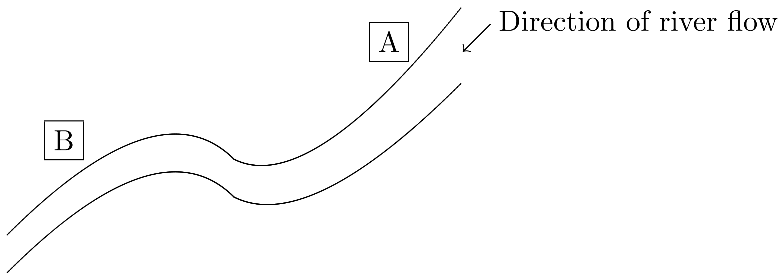
the interaction between water users on a river that allows a water extraction right to be valued using option valuation techniques. There are two water users on a river, A and B, with user B extracting water from a location downstream from A. User A has a *geographic* priority over the water, as the amount of water that B can extract depends on the amount extracted by A.[3] For example, A may be able to extract up to some amount K_A, leaving the amount available for B to extract as $W - K_A$, where W is the amount of water flowing in the river prior to any extraction.

Consider user B. This water user essentially holds a call option on all the water (W) where the 'strike price' is the volume of water foregone, set at K_A. If the flow is above K_A, B receives $W - K_A$ and A receives K_A. This may be viewed implicitly as B choosing to exercise the call option by buying all the water W from user A, but foregoing the strike price of K_A. If the flow is less than K_A, B's foregone water is more than the total water available, so the net water obtained by B would be negative and the option would not be exercised.

Turning now to User A, who will always obtain all of the water available W up to the limit K_A. Using the option analogy again, A's implicit decisions are akin to owning all the water and writing a call option against this for user B with a strike price in terms of water foregone of K_A. As mentioned above, if the river flows are less than K_A, then B's option is not exercised and A retains ownership of all the water available, which is extracted. If flows are above K_A, user B will exercise the call option and 'buy' the water from

[3] It is not always the case that an upstream user will have priority over a downstream user solely due to its geographic location. An alternative priority system is where a water user has a *regulatory* or *contractual* priority to the water, even if it is downstream of other users. In this example, B may have a contractual priority over the water, requiring A to leave a portion of the water in-stream for B's use. As explained in Chapter 3, this type of contractual priority system is used in Colorado, where the priority of water rights is based on the date they are issued (with the earliest right having a higher priority over later rights).

Figure 6.1: Interaction of water users on a river



A by foregoing the volume K_A. This interaction therefore allows the water extraction rights of A and B to be implicitly defined as options and hence be valued using option value techniques.[4]

6.3 Determining the Option Value

To determine the value of a water extraction right, we use the same techniques used to value standard financial options.[5] This is done by firstly determining the payoffs to the water user over the life of the water right (as with the income capitalisation approach described above), and placing this in the context of the interaction of water users on a river. The discounted sum of these payoffs then gives the current value of the water extraction right.

The value of the water right will therefore depend on a number of factors. Firstly, the value depends on how much water the user can extract, which will be determined by the priority ranking of the water user on the river. For example, if the water user is the lowest ("junior") priority that must leave an amount K_A in the river for other users, then that user may extract an

[4]This is a similar way to which stocks and bonds on a firm can be viewed as implicit options, and valued as such. See Ross, Westerfield and Jaffe (1993), pages 634-640.

[5]We will only give a brief description of this approach in this study, without presenting the full mathematical development. A more complete analysis can be found in Counsell (2004).

amount $W_t - K_A$, where W_t is the amount of water flowing in the river at time t prior to any extraction. If P_t is the price that the water user obtains from its product produced by one unit of water, then the payoff to the user at any time t is $\max\{P_t(W_t - K_A), 0\}$ (that is, the price multiplied by the amount extracted if the implicit call option is exercised, or zero if it is not).

Valuing the water right using option valuation techniques allows for the uncertainty in underlying variables. We use stochastic processes to model the uncertainty in river flows (W_t) and prices (P_t).[6] In particular, we assume that the uncertainty in W_t and P_t follows a mean-reverting process. That is, in the short-term the variables exhibit fluctuations, but over the long-term they revert to some mean level. This is likely to be the case for river flows because, while floods will increase river flows and droughts will decrease flows, there will be some equilibrium flow that the river reverts to in the long-run. Similarly, commodity prices tend to exhibit mean-reversion over time due to the impact of relative prices on supply (Schwartz, 1997).

Given the uncertainty in W_t and P_t, we can determine the value of a water extraction right using standard techniques of option valuation. While we will not explicitly outline these techniques here, we will present some results from such a valuation in the following section.

6.4 Data and Empirical Results

Using models developed from the concepts outlined above, we can apply some data to the models to determine the value of water extraction rights. Full details of this approach can be found in Counsell (2004), and we only present some of the main results here that show how different variables influence the

[6]The variable P_t may not be exactly the price of the commodity that the water user produces. It is used to represent the value that a unit of water generates for the user, but for simplicity we just refer to it here as the price.

value of this type of water right.

Description of the Data

In valuing a water extraction right, we require data to estimate the uncertainty in both river flows and prices. We use data from the Waimakariri River in North Canterbury for water flows. The data consist of the flow of the Waimakariri River (in cubic metres per second) recorded at the Old Highway Bridge recording station.[7] The series runs from 12am on the 1st of July 2001 to 12.30pm on the 15th of July 2003, with observations recorded at 15 minute intervals. These data allow us to estimate a stochastic process that models the mean-reversion in water flows.

For data on prices, we use electricity prices from the New Zealand wholesale electricity market. Half-hourly electricity price data from the Haywards node are used, with data ranging from 12am on 1 January 2000 to 11.30pm on 31 December 2002.[8] While the Haywards node is not associated with electricity generation on a river, the prices at all nodes across New Zealand are significantly similar for it to be used as a reference node.[9] The use of electricity price data is consistent with the holder of the water extraction right using water for electricity generation. Moreover, electricity prices are also likely to be a valid proxy for the value of water in alternative uses because, as Counsell and Evans (2004) explain, the price of electricity provides a minimum value for water on rivers with hydro-generation.

[7]The source of the data is Environment Canterbury.

[8]The source of the data is M-Co New Zealand.

[9]Guthrie and Videbeck (2003) analyse the differences in electricity prices across nodes and conclude that they show significantly similar movements.

Empirical Results

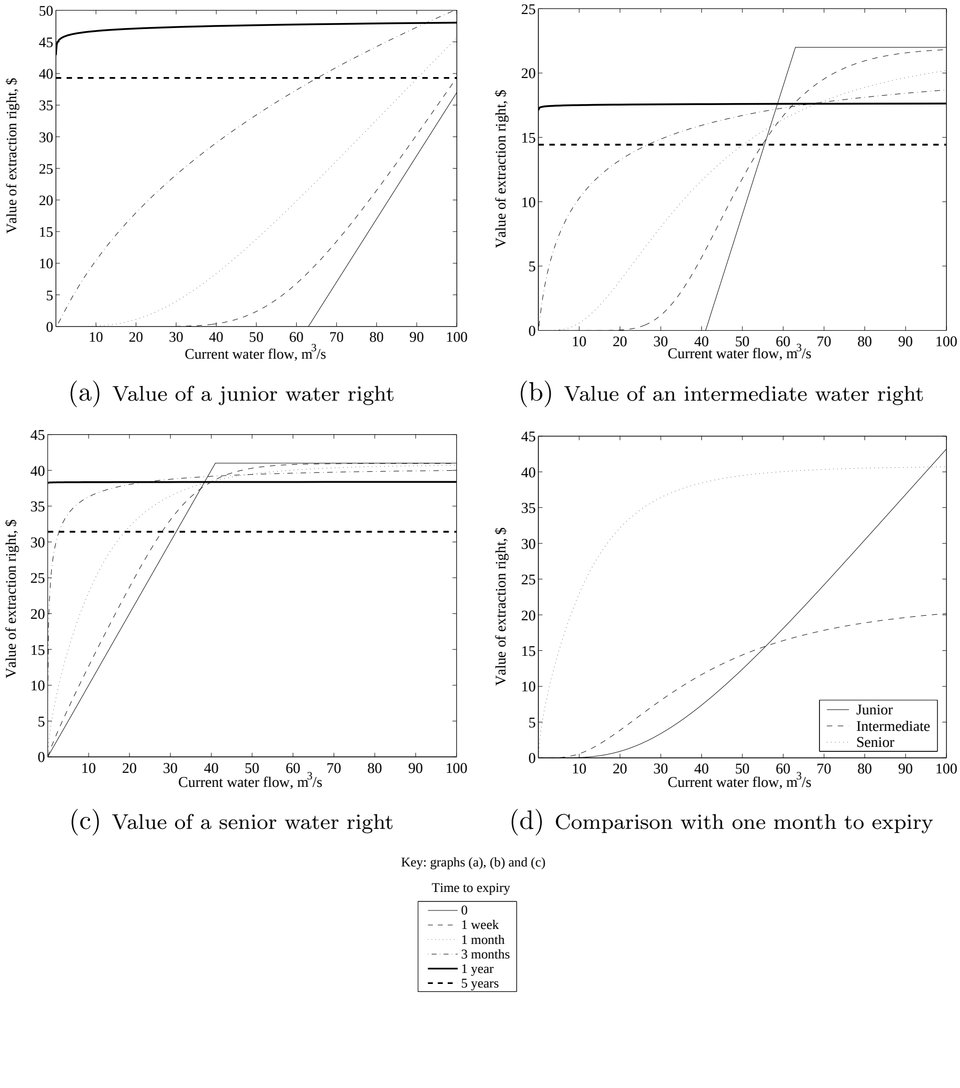
Using these data we can show what factors influence the value of a water extraction right. Firstly, we show how the current river flow (W_t) and the time that the water right has till expiry influence its value. To do this we make two simplifying assumptions: that the price (P_t) is a constant equal to one (rather than also being uncertain) and that the water right as an implicit call option can only be exercised on its expiry date. The latter assumption means that the water user has a one-off chance to extract water from a river on the expiry date of the water right. If there is water available, the user will exercise the option and extract, but (as discussed earlier) if the demands of other water users take precedence then the option will not be exercised.

We also consider three different priorities, to show how the priority of the water user influences the value of the right. We have a senior, intermediate and junior priority. The senior priority right holder has first call on the water and will extract everything that is available up to some maximum (which we set at 41m^3/s). The senior water user implicitly writes a call option for the intermediate user, with a strike price at the flow of 41m^3/s. The intermediate priority can therefore extract water once the senior priority is met, and may take up to a maximum of 63m^3/s by writing an implicit call option for the junior priority with this strike price. The junior priority may take whatever water is left over after both the senior and intermediate priorities are met.

The value of the water extraction right to the junior, intermediate and senior water right holders are plotted in Figure 6.2 (a), (b) and (c) respectively. These graphs show the value of the right against the current water flow over different expiry dates. Also shown in Figure 6.2 (d) are the junior, intermediate and senior water rights with one month to expiry on the same graph.

These graphs have three important features. Firstly, as the time to expiry

Figure 6.2: The value of water extraction rights against current flows



(a) Value of a junior water right

(b) Value of an intermediate water right

(c) Value of a senior water right

(d) Comparison with one month to expiry

increases, graphs (a), (b) and (c) show that the value of the water right becomes less responsive to the current river flow. This makes sense intuitively. If, for example, a water user cannot extract water for another year, then that user's best estimate of the flow in one year is for water flows to revert back to their long-run flow. In this case, current flows will have very little impact on future flows and hence on the value of the right.[10] If the time to expiry is relatively soon (for example, one week), the current flow has a large impact on the option value of the water right. This suggests the uncertainty in flows influences the value of a water right over only a short time horizon.

The second feature of Figure 6.2 is that the more senior the water right, the less responsive its value is to current flows and the more concave the graph of that value is. Again, this is intuitively obvious, as a senior water right holder has a lot more certainty in its ability to meet its water needs. Hence the value of its water right is relatively constant and less responsive to the current water flow.

Finally, graph (d) shows that when the water right has a short time to expiry, the value of a senior water right is significantly higher than both the intermediate and junior rights. Note however that the value of the intermediate water right is not significantly larger than the junior right. Indeed, at high flows (above approximately 55 m^3/s) with one month to expiry, the junior right becomes more valuable than the intermediate right. This is because, without an upper extraction limit for the junior right, it is possible in times of high flow that the junior right holder can extract more water than the intermediate right holder.

We can now relax the assumption that the price is constant to see how

[10]Note also that as the time to expiry increases from one year to five years, the option value of the right decreases (as shown by the five year plot below the one year plot in all cases in Figure 6.2) due to the influence of discounting the cash flows back over a longer time period.

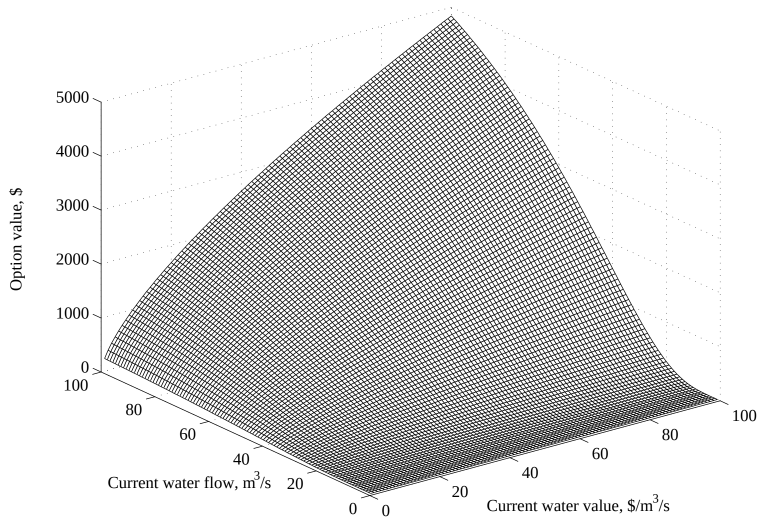
the current price influences the value of a water right. To simplify the results our attention is restricted to the intermediate right holder with a comparison of a right that can only be exercised in one month with a right that can only be exercised in one year. Figure 6.3 plots the current value of both water flow and price against the value of these water rights.

As would be expected in Figure 6.3 (a), for a given level of water flow, as the price increases so too does the value of the water right. As the time-length on the water right increases from one month to one year, Figure 6.3 (b) confirms the findings in Figure 6.2 (b): the value of the intermediate water right becomes considerably less responsive to the current flow. The value also becomes less responsive to the current price. As with water flows, this is because with a long time to expiry, it is more likely the current price will revert to its long-run level.

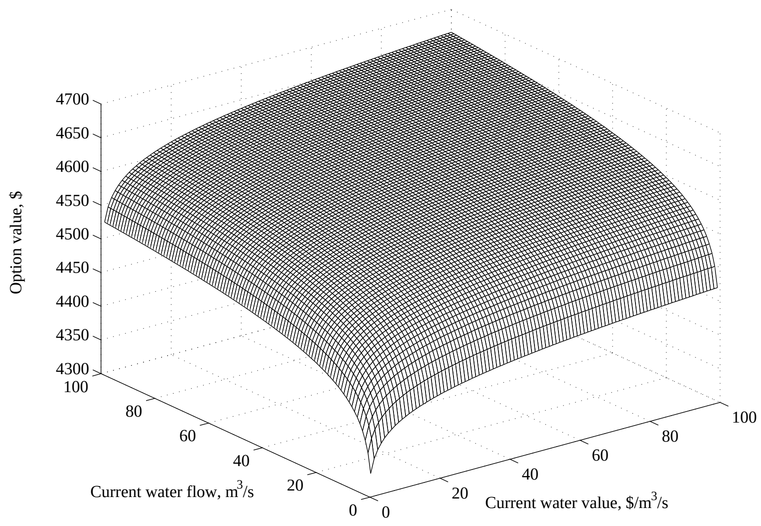
Finally, we relax the other of our initial assumptions and consider the value of a water extraction right that can be repeatedly exercised (for example, daily) up until its expiry date, although we revert to the assumption that prices are constant. Figure 6.4 (a) graphs the value of an intermediate water right that can be exercised repeatedly. The value of the water right is calculated with one month, three months and six months until expiry of the right. The graph shows a similar pattern to that of Figure 6.2 (b): as the time to expiry increases the value of the extraction right tends to flatten out over the range of W_t. The difference between Figure 6.2 (b) and Figure 6.4 (a) is that the value of the right is higher the longer that it has to expiry.

Figure 6.4 (b) shows a comparison between the junior, intermediate and senior water rights with repeated exercise and one month to expiry. Again the results are similar to the single exercise case shown in Figure 6.2 (d). This is encouraging as it suggests the results we have already presented from the single exercise case would be similar to those of the repeated exercise

Figure 6.3: The value of water extraction rights against current flows and price

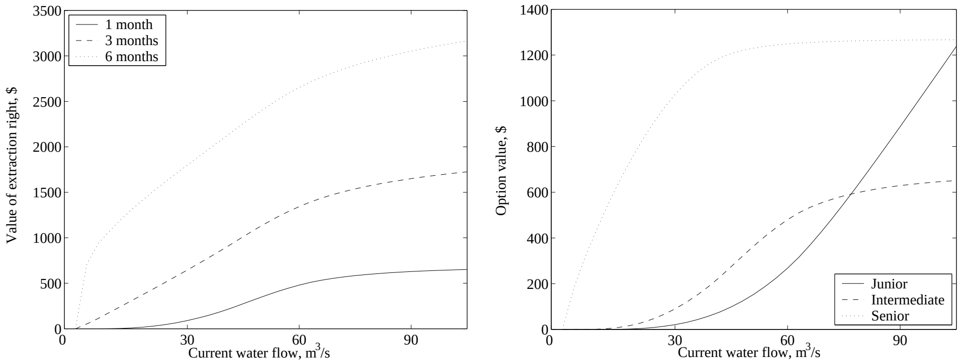


(a) One month to expiry



(b) One year to expiry

Figure 6.4: The value of water extraction rights with repeated exercise against current flows



(a) Value of an intermediate water right (b) Comparison with one month to expiry

case.

6.5 Conclusions

In this chapter we build on earlier work analysing the value of water at a point in time by considering the value of a water right entitling the holder to extract water over a period of time. Earlier research for the value of a water right, as opposed to static water values, often calculates the present value of benefits accruing to the water user from holding the water right. However, such approaches neglect the importance of the options provided to the holder of the water right. These options have value, and this value should be included in the value of the water right.

The approach to valuing water rights developed in this chapter would be useful in the absence of tradeable water rights, or when rights are tradeable but trade volumes are not large. It would also provide water users with a tool to valuing their water as a factor of production, for example to irrigators, hydro-generators or industrial water users. While the results presented in this chapter will not necessarily duplicate values that are determined through trading, they do show how the characteristics of water rights would influence such values.

Chapter 7

Valuing Water Storage Rights

7.1 Introduction

The previous chapter developed an approach to valuing a water right allowing the holder to extract water from a river. The focus of this chapter is on the value of a right to store water taken from a river. Water storage is important because it provides water users with the ability to substitute their use of water across time and thereby reduce the impact of uncertainty in variables such as river flows or the value of water to the user.

Valuing the right to store water, and to release water from storage to put it to a productive use, can be done using a similar approach to that described for water extraction rights in Chapter 6, again using an analogy with a financial option. In Section 7.2 we explain this concept, while in Section 7.3 we show how the value of the storage right is determined. As in the previous chapter, in Section 7.4 we apply some data to value a storage right and derive some empirical results that show how different characteristics influence its value. Concluding comments are provided in Section 7.5.

7.2 The Concept of Option Value

We define a water storage right as one that provides the right to store water and release water from storage. In much the same way as described in Chapter 6, the income capitalisation approach can be used to value this type of water right. The payoffs to the water user are a result of releasing water from storage and applying it to a production process. Thus the present value of the stream of these payoffs gives an estimate of the value of the water right.

However, in the case of storing water, the water user has the ability to wait, either to store water or to use stored water at a later date. A water user's decision to store water in the current period gives the user an option to put the stored water to a productive and potentially profitable use in some future period. The water user effectively holds an option to release. This option has value because, by holding onto water and not releasing it, there is a chance that prices may rise and the water user can obtain a higher price by using its water at these higher prices.

On the other hand, storage facilities generally have limited capacity. So when storing water results in a full lake or storage facility, the option of storing water in the future is lost, and may only be regained when the water is released from storage. Therefore, when the lake is not completely full, the water user has an option to store. Storing water is costly, because a water user foregoes the price that could be earned from using the water. Therefore, the option to store has value because, by holding on to water instead of storing it, there is a chance that the foregone price, and hence the cost of storage, will be lower in the future and so water can be stored at a lower price.

The concept of option value with a water storage right therefore comes from the water user's ability to wait. The option to store water is equivalent to an American call option, while the option to release water is equivalent to an American put option. An American call (put) option gives the holder the right to buy (sell) shares at the strike price at any time leading up to some expiry date in the future. Like an American call, the option to store gives the right to buy water at anytime up to the expiry date and like an American put the option to release provides the right to sell at anytime up to this date. By exercising the option to store, the water user gains an option to release. Exercising the option to release gives the water user an option to store, and so on. Thus to value a water storage right we must incorporate the value of both of these options into the value of the right. We note also that in this case the options are much more explicit than in the case of a water extraction right, in that it does not require the interaction of other water users for the options to be available.

7.3 Determining the Option Value

The value of a water storage right is determined in a similar way to a water extraction right. The discounted payoffs to the water user over the life of the water right determine the right's value. To calculate these payoffs, we suppose that the holder of a storage right (a 'storage firm') has a storage lake of a maximum capacity of 1m^3. This firm's business consists solely of storing water or releasing water from storage. That is, it is not putting water to any other use (such as irrigating crops or generating electricity). The firm holds a perpetual water right allowing it to pay $\$P_t$, the price in the current time period t, to take one cubic metre of water from the river and store it, whenever it has the ability to do so. Any water released from storage is returned to the river and may be sold to downstream users, also for the current price of $\$P_t$. It is assumed that P_t, which shall be termed the water price, is stochastic. The price process is taken to be exogenous to the firm's decisions. The storage firm can arbitrage changes in P_t across time. For example, the firm can store water when P_t is low and sell it to downstream users at a later date when P_t is high.

While we use a mean-reverting stochastic process for the uncertainty in P_t, as used in the water extraction right case, the valuation approach is easier to solve if we only allow for partial uncertainty in river flows. We suppose that the river flow is in one of two states: wet or dry. In the wet state, over some defined time interval, river flows are sufficiently high to allow the lake to be filled if it is empty. However, in the dry state, river flows are too low over the interval such that the lake cannot be filled at time t if it is empty. River flows may switch between the states of wet and dry according to pre-specified switching rates. We denote by ρ_w the average rate per year at which the state of river flows switches from the wet to the dry state. Similarly, ρ_d is the average rate at which river flows switch from the dry to the wet state. These switching rates may either be constants, or correlated with prices to allow for the impact that changes in river flows could have on prices.

The value of the storage right using this approach depends on a number of factors. The first of these is the firm's strategies at any time t of whether to store water (if the lake is empty) or release water (if the lake is full).[1] If the lake is empty, then at high prices the firm would prefer to wait and retain its option to store. If the price drops below some threshold, which we denote P_S, the firm will exercise its option to store. In contrast, with a full lake, the option to release will be retained when prices are low. When the price reaches some threshold P_R, the option to release will be exercised.

Given these strategies, we can start to see how the value of the storage

[1] For simplicity, we assume that the lake is either completely empty or completely full, and cannot be partially filled or emptied.

right may be determined. Suppose that, in the current period t, the lake is currently full and the storage firm holds an option to release. Prices will fluctuate over time but at some unknown time in the future, say time T_1, the price will increase above the threshold P_R and the firm will choose to release its water. The payoff to the firm from this action is the price it obtains by selling water to downstream users (P_{T_1}), plus the value of the option to store in the now empty lake (which we denote by the variable G). That is, the value of the option to release from the full lake (denoted F) is:

$$F(P_t) = e^{-r(T_1-t)}(G_{T_1} + P_{T_1})$$

where the exponential term allows for discounting the payoff back to time t at the risk-free interest rate (r).

Now with an empty lake, the firm will exercise its option to store at some time T_2 in the future when price decrease below the P_S threshold. If we assume for the moment that river flows will always be in the wet state (so that the lake can always be refilled if it is empty), we may therefore substitute for the term G in the above equation. The firm will gain an option to release (F) but pay the price P_{T_2} to store the water. Hence we have:

$$\begin{aligned} F(P_t) &= e^{-r(T_1-t)}P_{T_1} + e^{-r(T_1-t)}e^{-r(T_2-T_1)}(F_{T_2} - P_{T_2}) \\ &= e^{-r(T_1-t)}P_{T_1} - e^{-r(T_2-t)}P_{T_2} + e^{-r(T_2-t)}F_{T_2} \end{aligned}$$

Substitution may continue in this way for the life of the water right (which we have actually assumed is perpetual). We will obviously have to incorporate expectations as to whether river flows will be in the wet or the dry state, but it is clear that the value of the storage right depends on the initial state of the lake (full or empty), the switching rates between wet and dry river flows and the initial state of river flows, the initial water price P_t, and the optimal strategies to store and release. Based on these conditions, the value of the right is just the discounted value of the payoffs to the storage firm.[2]

7.4 Data and Empirical Results

Description of the Data

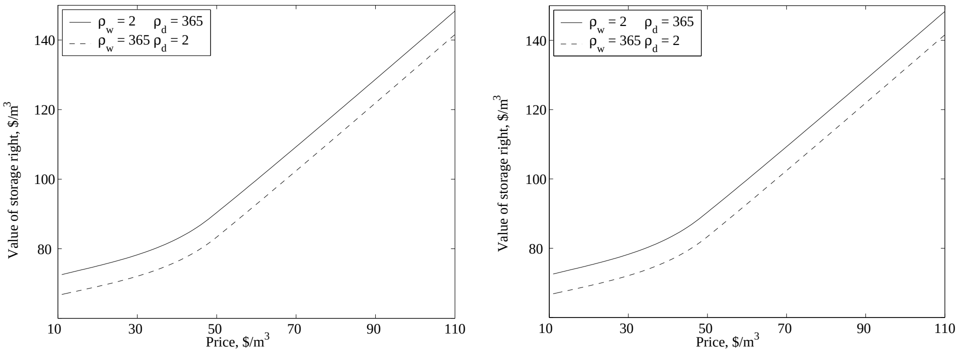
To determine the factors that influence the value of a storage right, we use the same data on electricity prices as used for a water extraction right in Chapter 6. This would be consistent with the storage firm buying water for storage at the prevailing electricity price and also selling water released from storage at the electricity price. This approach would be associated with a situation where the highest value downstream user is an electricity generator with the rights to all water upstream. If the storage firm wishes to take water out for storage, it must compensate the generator for the foregone revenue that could have been obtained from generation. Similarly, the maximum price a generator would pay for water released by the storage firm is equal to the price it can sell it for on the electricity market.

Empirical Results

We noted above that the value of the storage right depends on the a number of initial conditions: initial state of storage (a full or empty lake), the initial state of river flows (wet or dry), switching rates, store and release strategies, and the initial price. In Figure 7.1 we show the value of a storage right starting with a full lake in both the wet and dry states for different values of

[2] As in the water extraction case, a more detailed mathematical explanation of the method used to solve for the value of the water storage right can be found in Counsell (2004).

Figure 7.1: Valuing a storage right on a full lake in wet and dry states



(a) Value on a Full Lake in the Wet State (b) Value on a Full Lake in the Dry State

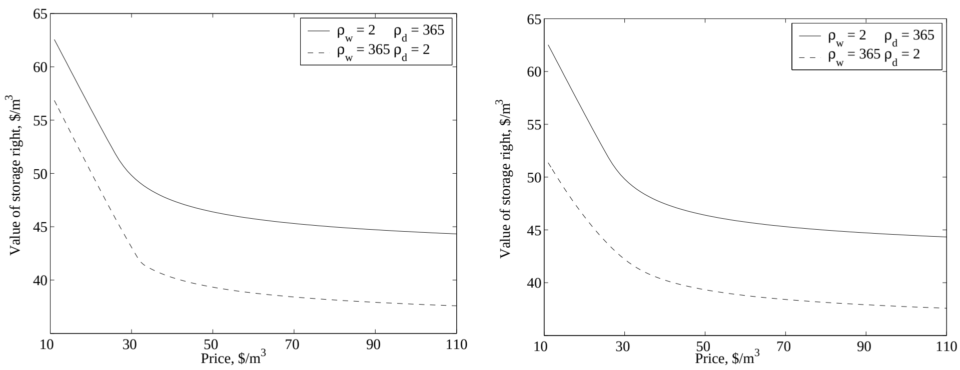
ρ_w and ρ_d.

Both graphs show that the value of the right is positively related to the current price. As prices rise it becomes more profitable for the storage firm to sell its stored water at these higher prices. Hence it becomes more likely that the firm's option to release is exercised as prices rise, and thus the value of this option also increases, which consequently increases the value of the storage right.

The second point to notice is that the value of the right is reasonably similar across both states of wet and dry. While it would be expected that the value of the right would be higher in the wet state than in the dry, the reason they are so similar may be that a perpetual right provides enough time for the payoffs to converge in the long-run.

Thirdly, as the likelihood of a switch from the wet state to the dry state increases (that is, ρ_w goes from an average switching rate of twice per year to daily) and the likelihood of a switch from the dry state to the wet state decreases (that is, ρ_d goes from an average switching rate of daily to twice per year), the graph for the value of the right on the full lake in both cases shifts down. This make sense intuitively, given that the price process is unaffected

Figure 7.2: Valuing a storage right on an empty lake in wet and dry states



(a) Value on an Empty Lake in the Wet State (b) Value on an Empty Lake in the Dry State

by the state of river flows: if it is more likely that river flows will become dry and stay dry, then the option to release on the full lake is worth less because it is less likely that the lake can be refilled.

Now consider the value of the right on an empty lake under both states for the same values of ρ_w and ρ_d, as shown in Figure 7.2. In this case, the value of the right is negatively related to the current price. As the price increases, the value of the water right starting with an empty lake decreases. The reason for this is that as the price increases it becomes less profitable for the storage firm to pay that price to store water. Consequently it becomes less likely that the firm will want to store water at such a high price. Thus, as it is less likely that the option to store is exercised, the value of this option decreases as prices rise.

Figure 7.2 also shows that, in both states of river flows, as ρ_w goes from twice per year to daily and vice versa for ρ_d, the value of the right decreases. The intuition here is that if it is more likely to become dry and stay dry, then the option to store in the empty lake is worth less (since there is a greater probability that this option will not be exercised). Note also in this case that, when $\rho_d = 2$, the value of the storage right is less when starting in the dry state than in the wet state, at least for small values of P_t. This is because when P_t is small the firm will store water, but in the case of the dry state it may be some time before the lake can be filled and therefore the long-run payoff to the firm is lower.

We discussed above the threshold prices P_S and P_R at which the storage firm will find it optimal to exercise its option to store and option to release respectively. It is therefore also informative to consider how the threshold prices change for the full and empty lakes under different values of ρ_w and ρ_d. Table 7.1 shows the threshold prices at which the option to release will be exercised on the full lake under both wet and dry states, and at which the option to store will be exercised on an empty lake in the wet state.[3] Two important features from Table 7.1 stand out:

- As ρ_w increases, with ρ_d held constant at 2, the price threshold at which both the option to store and option to release are exercised increases. This is because as ρ_w increases it is more likely that river flows will go to the dry state and stay there. Therefore, the firm will be more reluctant to release or store water if it ends up in the dry state, which pushes up the thresholds.

- As ρ_d increases, with ρ_w held constant at 2, the price threshold at which the options to store and release are exercised in the wet state decrease slightly. With ρ_d increasing it is more likely that flows will switch to the wet state and stay there. Thus, intuition would suggest that the firm would be more likely to release water from a full lake or store water in an empty lake in the wet state, which would push both the thresholds down. Note also that there is effectively a floor on how low the thresholds can go, and this is reached at \$47 for the full lake and

[3] Recall that, since the empty lake in the dry state cannot be filled, the option to store does not exist and therefore there is no threshold.

Table 7.1: Threshold prices for a water storage right

ρ_w	ρ_d	Full Lake, Wet State	Full Lake, Dry State	Empty Lake, Wet State
2	2	$48	$48	$27
12	2	$49	$49	$29
52	2	$49	$49	$31
365	2	$49	$49	$32
2	12	$47	$47	$26
2	52	$47	$47	$26
2	365	$47	$47	$26
P_t	$N\Delta P_t - P_t$	$47	$47	$26

$26 for the empty lake.[4]

- In the last row of Table 7.1 we show the thresholds when ρ_w and ρ_d are functions of P_t. We choose linear functions, with $\rho_w = P_t$ to provide a positive correlation with P_t, and $\rho_d = N\Delta P_t - P_t$ (where ΔP_t is the change in P_t and N is the maximum price we value the water right at) giving a negative correlation with P_t and a function that is symmetrical with ρ_w. Notice that the thresholds in this case are more consistent with the constant case of ρ_w being low and ρ_d being high than vice versa. This may be an indication that prices at the low end of the distribution are more prevalent.

7.5 Conclusions

The key implication of the analysis in this chapter, and in Chapter 6, is in providing an approach to valuing water rights outside of market mechanisms. The approach used allows the value of a water right to be determined either

[4]This floor is determined by the long-run water price level and the storage firm's ability to buy low and sell high. That is, the thresholds will not decrease to a point where, in the long-run, the firm cannot profit from its ability to arbitrage changes in prices.

when markets for tradeable water rights exist but are essentially thin (and therefore provide little information on values), or in the absence of a market when water is allocated administratively. Moreover, by valuing a water right as an asset on uncertain underlying variables, we incorporate any option value that the water right has. Hence, the approach is an improvement over more traditional methods of valuing water rights, such as the income capitalisation approach, which may underestimate a right's value by not incorporating an option premium.

We have also shown how changes in certain features are likely to affect the value of water extraction and storage rights. For example, in Chapter 6 we showed how a water extraction right with a longer time to expiry is likely to be more valuable than rights of shorter duration. Furthermore, longer duration rights will be less responsive to changes in the current conditions (such as water flows and prices) than rights with closer expiry dates. Rights of a higher priority will also be more valuable and less responsive to current conditions than more junior water rights.

Similarly this chapter showed that the value of a water storage right will also depend on its particular features. A water right when the storage facility is currently full will be more valuable if the current price is high, while if the storage facility is currently empty the right will be more valuable when the price is low. A storage right would also be more valuable if it is quite likely that river flows will remain high.

Many of these outcomes may seem relatively intuitive. Indeed, it would seem obvious that a water right of a long duration or high priority would be more valuable than a similar right with a shorter time to expiry or lower priority. Similarly, if it is very dry, a water right would clearly be less valuable than if there were plentiful supplies of water available. However, the empirical results do lend support to this intuition and show how other features (such as water flows and prices) affect the value of water rights.

Appendices

Appendix A

Economic Efficiency

The standard definition of economic efficiency as it applies to water resources has three different dimensions: allocative, technical and dynamic efficiency. Allocative efficiency refers to the way in which scarce water resources are allocated amongst competing users at a point in time. There are two common types of allocative efficiency. The first, and more strict version, is Pareto efficiency. This defines an allocation of resources as efficient if it is not possible to reallocate the resources in such a way as to make anyone better off without making someone else worse off. The less stringent version is Kaldor-Hicks efficiency, where an allocation is efficient if those that are made better off could compensate those that are made worse off to enable a Pareto efficient outcome.

The Pareto and Kaldor-Hicks definitions of efficiency refer to the ability to make someone better or worse off. In this sense, they consider the value of a resource allocation to society. In particular, both the Pareto and Kaldor-Hicks definitions of allocative efficiency are effectively based on allocating resources in order to maximise the total value of the allocation, including both tangible and intangible values (where the latter are common in environmental valuation). If, for example, water resources could be shifted to a use that is more highly valued, then a more allocatively efficient outcome is possible.

Technical efficiency refers to the way water is actually used, be it in a production process or by a household user. This concept of efficiency embodies the principle of water wastage. Cai, Ringler and Rosegrant (2001, p.5) describe technical efficiency for an irrigator as "the fraction of water beneficially used over water withdrawn." Indeed, for a given production process (such as a farmer producing crops or a hydro-generator producing electricity), the process would use water in a more technically efficient manner if the producer were able to produce the same amount of commodity using less water. For a household, technical efficiency is also related to reducing water wastage. A household uses water in a technically efficient manner if any and all water that comes from turning on a tap is put to beneficial use. Technical efficiency is determined by the costs and benefits of water use within firms and households. Thus, it can be viewed as internal allocative efficiency.

While allocative and technical efficiency relate to efficiency at one point in time, dynamic efficiency considers the efficiency over time. Evans, Quigley and Zhang (2000) define dynamic efficiency as the efficiency of decision-making relating to allocating resources and the production process of firms in the future. Dynamic efficiency effectively embodies both concepts of allocative and technical efficiency and can be viewed as the present value of these.

The main focus of this book is on the allocative efficiency of New Zealand's current water allocation framework. The allocation of water rights in New Zealand is based on first-in first-served and use-specific rights. When there is competition for water resources for which demand exceeds supply, the first-in first-served system does not achieve allocative efficiency because the economic and social values of a particular use are not taken into account. There is no criteria for determining if resources are allocated to their highest value use, and only by coincidence will the first-in user be the highest valued, particularly where water demand is changing rapidly. Furthermore, once water is allocated, there are barriers to trade that prevent rights being reallocated to a higher valued use. This is where creating the right institutional structure and reducing barriers to allow the exchange of rights across uses will achieve a more efficient allocation of water, as we have explained throughout this book.

Appendix B

Property Rights

A property right is a claim to the socially acceptable uses (and the stream of benefits accruing from this use) that a scarce resource can be put to by the holder of the right (Demsetz, 1998). Ownership of a property right does not necessarily require or convey ownership of the resource. For example, the right to use resources such as public roads and footpaths is available to all citizens, but ownership of such resources is vested in the Crown. In fact, ownership of a property right entitles the holder to a bundle of three separate rights: the right to use the resource, the right to exclude others from its use, and the right to transfer these rights to others (Demsetz, 1998). If property rights are well-defined, then holders will have security in their use of the resource and their ability to exclude others, plus they will have the ability to freely transfer their bundle of rights to others.

For water allocation in New Zealand, a resource consent to take or use water is typically referred to as a water 'permit'. Moreover, Section 122 of the RMA notes that a resource consent "is neither real nor personal property". In this sense, there may be some question over whether resource consents are actually water property rights. Certainly a resource consent itself is not real or personal property, and a holder of a consent does not have a property right to ownership of the actual water resource. Nonetheless, a resource consent does give the holder a right to take, use, dam or divert water. In this regard, such a resource consent is a property right in the form of a usufructuary right. Black's Law Dictionary (Garner, 1999, p.1542) defines a usufruct as "[a] right to use another's property for a time without damaging or diminishing it". Furthermore, a property right need not be explicitly called such for it to be consider a right. As Moran (2003, p.5) notes: "It is not necessary for government to formally recognize such rights for them to be present...Property rights are the rights that are generally accepted in the community, not just those that the government has so ordained". It is certainly the case that water permits in New Zealand are recognised and valuable as rights, particularly given the increasing demand for water resources. Thus, regardless of the semantics, resource consents to take, use, dam or divert water in New Zealand are indeed 'water rights'.

Property rights play a more important role when resources are scarce and there are competing users. A resource with an abundant supply will not be reliant on property rights as users can derive benefits from its use without affecting others. As resources become scarce, the nature of property rights will change. This process is evident with water resources in New Zealand, where the increased scarcity of water is causing problems in the way property rights are defined and allocated. The current arrangements for water property rights in New Zealand evolved at a time when scarcity of water was not a major issue.

When resources are scarce, the key reason for the existence of property rights is that harmful or beneficial effects from resource use may arise that have an impact on third parties. When this occurs there is an externality. Property rights exist to internalise externalities by allowing those directly involved in resource use to bear the full consequences of their use (Demsetz, 1967).

However, if property rights are not defined and enforced correctly they may still generate externalities. These may arise if the transaction costs involved in defining, transferring and enforcing property rights are high (Furubotn and Pejovich, 1972). With high transaction costs, resource users do not take into account the costs and benefits to third parties. This is apparent with water resources in New Zealand. The first-in first-served allocation of water with limited transfer of water rights generates an externality in that water is not allocated to the highest valued uses. This is due to the high transaction costs associated with trading. The lessons learned from the experiences of other countries described in Chapter 3 suggest that such transaction costs can be lowered by institutional arrangements, and can be low enough to allow water to move to those who value it the most.

Appendix C

Water Rights and Return Flows

It is an oft-cited disadvantage with tradeable water rights that trading can have effects on third parties through the sale of return flows. To see this, consider the following example, adapted from Holden and Thobani (1996). In Figure C.1 (a), a water user (A) extracts 50 units of water from a river that has a total of 100 units of flow.[1] User A only physically consumes 30 units, resulting in 20 units of return flows. A user downstream (B) then holds a right to extract 60 units, and it is required to leave 10 units in-stream. Consider then in Figure C.1 (b), where A sells its water right to another user (A') who consumes the entire 50 units of water leaving no return flow. It is clear that there is a problem here, as the sale affects B's extraction. B can now take only 40 units of water in order to leave 10 units in-stream.

The problem arises because two users have the rights to the same water. It is similar to a problem that often occurs between hydro-generators and downstream consumptive users. For example, Bauer (1998) gives examples in Chile of how storage and timing of releases by hydro-generators has created difficulties for downstream irrigators to satisfy their water rights. While this

[1] Obviously the river flow will vary, however for the purposes of this example it is assumed to be fixed. This assumption is not too unrealistic as the numbers used may indicate the river flow on an average day.

does not relate to the sale of water rights, the issue is the same as that given in the example above because actions by upstream users who generate return flows can undermine the rights of downstream users.

A solution to the problem of trading return flows, proposed by Holden and Thobani (1996), is to restrict user A to only trading the consumptive portion of its water right. Thus, in Figure C.1 (c), the new user (A') only holds the right to extract 30 units of water (the consumptive portion of A's water right), allowing B to take out its full allocation of 60 units and still leave 10 units in-stream.

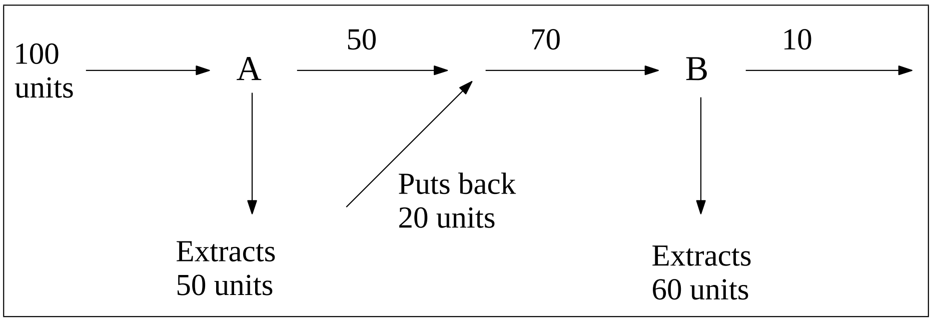
While such a system may work for countries where return flows are small, it will not work as effectively in New Zealand due to the large proportion of hydro-generation giving significant return flows. Such a system is likely to restrict trading, as hydro-generators would not be able to trade any of their non-consumptive water rights.

An alternative solution would be to endow a water user who generates return flows with the right to those flows. This creates exclusivity in water rights and eliminates the problem of two users having the rights to the same water. While downstream users can use return flows, there would be no rights that could actually be allocated to these flows. As Scott and Coustalin (1995) note, access to these return flows can be gained through bargaining and negotiation, or through the sale of rights.

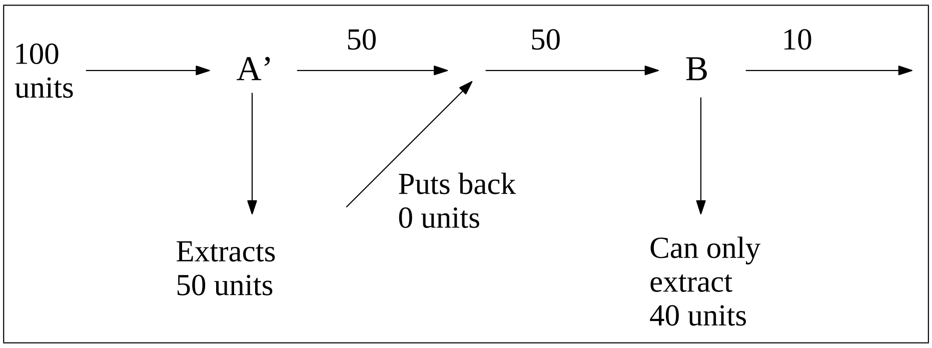
An example of this solution is shown in Figure C.1 (d), where A has the right to its 20 units of return flow, which it can readily sell. The downstream user B cannot simultaneously hold a right which utilises these flows. It can only hold a right for what is left over: 40 units. There is nothing stopping B from using the extra 20 units of return flows, but it has no legal right to them so cannot object if they are sold. This is similar to the method used in the Colorado-Big Thompson project. In this case, rights to return flows are held by the Northern Colorado Water Conservancy District. A downstream user can certainly utilise return flows but it has no legal right to those flows so must be prepared to relinquish that water if the flows are subsequently sold.

Of course if tradeable rights existed and user B did wish to obtain more water, it could buy the non-consumptive portion of A's water right. This would mean that A is only entitled to the consumptive portion of its water right of 30 units of water. In the case of a hydro-generator and a downstream user it would mean the generator has an obligation to release water to provide to the downstream user. However, it would be expected that the price charged to the downstream user for this non-consumptive portion would cover the costs to the generator of releasing water when it may not be optimal to do so from the generator's perspective. This solution may solve conflicts that often occur over the timing of hydro-generation releases for downstream users.

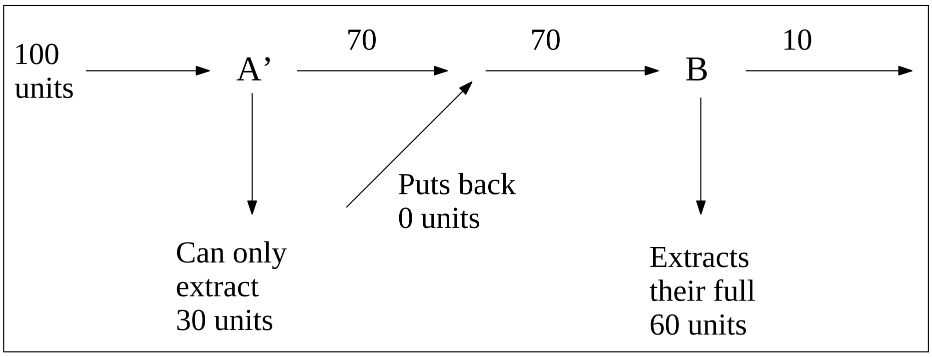
Figure C.1: Dealing with return flows under a tradeable water rights system



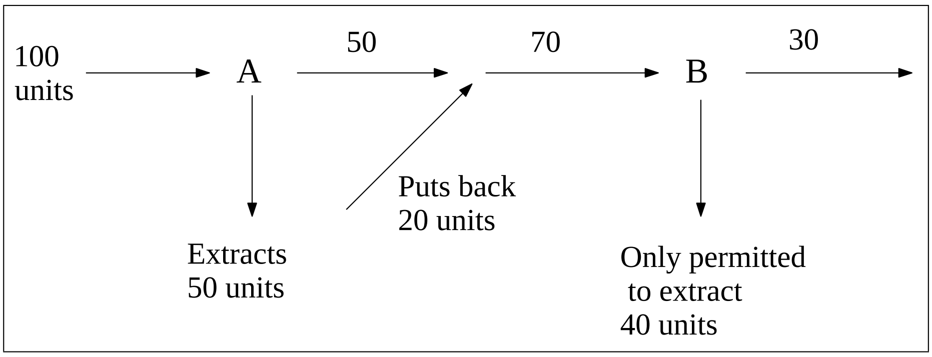
(a) Initial situation



(b) Following water trade



(c) Holden and Thobani (1996) solution



(d) Alternative solution

Appendix D

Examples of Tradeable Rights Frameworks

Table D.1: Examples of tradeable rights frameworks

Resource	Country	Starting Date	Details
Fisheries	Iceland	1979	ITQs were initially only applied to herring but were extended to all other fisheries by 1988.
	New Zealand	1986	Tradeable quotas are currently applied to a total of 33 species.
	Australia	1989	ITQs are used in the South East fishery. The framework was initially only applied to gemfish but this was extended to 15 other species in 1992.
	U.S.A	1990	ITQs were implemented for surf clam and ocean quahog, mainly around the mid-Atlantic region.
Air Pollution	U.S.A	1982	Leaded petrol: tradeable rights were established for the amount of lead per unit of petrol produced, and allocated to refineries as a means to reduce the lead content of petrol.
	U.S.A	1995	Sulphur dioxide: tradeable emissions allowances are allocated to sulphur dioxide producing electricity generators.
	Worldwide	2008	Carbon dioxide: tradeable carbon credits are to be allocated to producers of carbon dioxide (e.g. coal-burning electricity generators) and sequesters of carbon (e.g. forest owners). Among countries who have ratified the Kyoto Protocol implementing the framework are New Zealand, Canada and the United Kingdom.
Renewable Energy	Netherlands Italy United Kingdom	2001 2002 2002	These countries have all implemented systems of 'Green Certificates': tradeable rights for renewable energy generation. Consumers or electricity distribution companies buy certificates to meet specific renewable energy targets. Electricity generators can sell certificates for every unit of renewable energy generated.
Water	Colorado	c1850	Tradeable water rights have existed in Colorado since the mid-19th century when the doctrine of prior appropriation was established as a means of allocating water between competing miners, farmers and ranchers.
	Chile	1981	Tradeable water rights were formalised in the legislation through the 1981 Water Code, which significantly decentralised water resource management.
	Mexico	1992	Water rights were made tradeable with the implementation of the National Water Law in 1992.
	Australia	1994	Tradeable water rights were in use in the 1980's and 1990's in parts of New South Wales, but became more widespread following a water reform programme beginning in 1994.

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