THE ECONOMIC VALUATION OF WATER FROM THE ASHBURTON RIVER: IMPLICATIONS FOR ALLOCATION

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ABSTRACT

Recent legislative changes in New Zealand allow much greater flexibility in the procedures used by regional authorities to allocate water resources. In certain river catchments where competition for water in alternative uses is high, estimates of the economic value of water could prove useful in designing an allocation scheme. In this study two methods were used to value the water from the Ashburton River. First, a mathematical programming approach to estimate the value of water to farmers in the Ashburton catchment. This value is about $0.62 million. Second, a contingent valuation approach to estimate the value of in-stream flows of the Ashburton to the residents of the Canterbury region. This value is estimated at between $2.47 million and $5.15 million. We assess the methods and the results for implications in allocating Ashburton water between irrigators and in-stream flows.

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CHAPTER ONE

INTRODUCTION

The New Zealand economy has gone from being heavily regulated to a more market orientated, less regulated economy. Local government has been restructured and the new Regional Councils have a greater role in managing their local natural resources. As from 1 October 1991, Regional Councils are responsible for land and water management under the Resource Management Act. Prior to this Regional Councils were subject to the Soil Conservation and Rivers Control Act 1941, and the Water and Soil Conservation Act 1967.

Although some natural resource management issues will affect all regions, the significance of the issue and the method of management will vary from region to region. Water is one example of a natural resource that some regions have in abundance to meet current demand. In other regions, including Canterbury, local scarcities occur from time to time. The shortage of irrigation water for the Loburn orchards during the 1988/89 season is a recent example (Yates, 1991).

Water is the focus of this study because of the importance of water to Canterbury. With the changes that have occurred in New Zealand in recent years, there are opportunities that did not previously exist that may potentially benefit the region and assist the region in managing its resources.

This chapter briefly describes the changes that have occurred in resource management law in New Zealand, the changes in local government structure and some of the issues surrounding water in Canterbury, before outlining the organisation of this thesis.

1.1 THE RESOURCE MANAGEMENT ACT

Water management in New Zealand had been established through the Water and Soil Conservation Act 1967 and its subsequent amendments. Water rights were the fundamental tool that was being used. The Act vested the sole right to dam any river or stream, divert or take natural water, or discharge natural water or waste into any natural water, or to use any natural water in the Crown.

Regional Water Boards and Catchment Authorities were established to carry out water management for the Crown. Water rights were issued to individuals or groups that entitles to use the water within the limits specified in the right. Water rights were normally tied to land and could not be transferred to other sites, although they could be transferred with the sale of the land. It was usual for catchments to have a common expiry date so that the supply and demand for water within that catchment could be reviewed. The 1967 Act allowed for the continuation of notified existing lawful uses by granting rights in perpetuity. Traditionally, water had been allocated on a first come first served basis. This resulted in problems when demand for water outstrips supply. A common practice when seasonal flows were low was to restrict water to all users on a proportional basis (Sharp, 1988).

Bryan Bates (1988) identified several problems with water management in New Zealand. These included inflexible legislation, lack of integration between water and land use management, unclear legislation direction on cultural values, lengthy water right process, and funding.

The Resource Management Act 1991 replaced the 1967 legislation. The purpose of the Act is to promote the sustainable management of natural and physical resources. In the Act, sustainable management means managing the use, development, and protection of natural and physical resources in a way, or a rate, which enables people and communities to provide for their social, economic, and cultural wellbeing and for their health and safety 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.

The 1991 Act promotes an integrated approach to resource management. It specifically encourages the use of economic instruments to manage the use and quality of natural resources, including water, and provides regional authorities with broader powers than previously existed.

The Resource Management Act replaces the concept of "water right" with "water permit". A resource consent (a water permit is one of many differing resource consents) can be granted for a duration of up to 35 years. The Resource Management Act allows transfers of permits to occur within a catchment, if authorised by a resource management plan. Existing notified uses that were granted in perpetuity will be phased out (Resource Management Act, 1991).

The Act states that regional resource management plans should contain clear and reasonably specific sustainable management objectives or outcomes. Plans should be concerned with both ends (outcomes) and means. The means must clearly serve or enable the ends to be met. The plan must set out what state represents the desired level of sustainable management, determine the means by which the ends are to be achieved and how the system will be monitored (Mulcock, 1991).

These changes allow the Regional Councils greater flexibility in allocating its resources.

1.2 RESOURCE MANAGEMENT AND LOCAL GOVERNMENT REFORM

Local government in New Zealand was reformed in 1989. More than 600 local authorities have be reduced to 94: 13 regional councils, 74 district councils and 7 special authorities. Previously existing city, borough, district, town and country councils, catchment and regional water boards and most other special purpose authorities have been abolished (Department of Statistics, 1990).

All of New Zealand except the Chatham Islands is divided into 14 regions based on water catchment boundaries. They are governed by 13 regional councils and a district council. Gisborne Region is unique in that its district council is also the regional council for that area.

Regional councils took over many of the responsibilities performed in the past by many special purpose authorities. This includes the functions carried out by catchment boards, harbour boards, and pest and noxious plants authorities.

The regional councils will also play an important planning role through their involvement in resource management and its ability to set policy for matters which are of concern for the whole region.

In addition to the regional structure, New Zealand is divided into districts administered by either a district council or a city council. These carry out the day to day local government functions. They provide essential services such as water supply, roads, sewage disposal and rubbish collection. They also provide amenities such as parks, recreational facilities, libraries and community centres. They continue to carry out district scheme planning (Department of Statistics, 1990).

The mission of the Canterbury Regional Council is to safeguard, enhance, develop and promote the physical, social, economic and cultural environment of the Canterbury region and its people. In pursuit of this mission, the council undertakes (amongst other goals) to

a) manage wisely the resources of the region so as to yield balanced and sustainable benefits to present and future generations;
b) develop policies and plans which will protect and enhance the region's natural environment;
c) encourage, promote and monitor the economic growth and prosperity of the region;
d) undertake all activities in a cost-effective manner and with a minimum of bureaucracy (Canterbury Regional Council, 1990)

Local government now has a greater control in managing its local resources. It is envisaged that schemes such as flood protection and community irrigation schemes will not be funded to the same degree (if at all) by central government. It is expected that funding for any local project will come not from central government, but either from regional council, district council, private funding, or some combination of the above.

A close working relationship between regional councils and district councils is expected. There is some overlap in their roles in such areas as developing a region's resources. The exact nature of the relationship will develop over time and will depend on the individual councils concerned.

There is also potential conflicts between the roles of the regional council. These may occur in such areas as protecting versus developing the region's resources. This will most likely occur due to imperfect information and the different values held by individuals regarding the region's resources.

1.3 THE CANTERBURY REGION

The Canterbury region has large quantities of both surface and ground water and a history of reliance on its water resources to enhance its economic potential. Stockwater races were cut across the plains in 1870. Irrigation has played a major role in the development of the region with both community and private border dyke schemes being developed. Spray irrigation is also widely used especially on the heavier soils which have traditionally been used for cropping or dairy farming, but now increased interest is being expressed in horticultural crops (Ministry of Agricultural and Fisheries, 1980).

Over 150,000 hectares of Canterbury farmland is currently being irrigated from surface water sources, whilst ten major hydroelectricity schemes supply over 30 percent of the nation's electricity requirements (Talbot, 1991).

The rivers in Canterbury are important for recreational use. For example, the Rakaia catchment attracts over 75,000 visits per year. Activities include salmon and trout angling, jet boating, canoeing, ice skating, and picnicking. The salmon angling is considered of exceptional local and regional value, high national value and of significant international value (Bowden, 1983).

The Canterbury rivers have significant scenic and habitat values. Canterbury has many braided rivers (see Figure 1.1). A braided river consists of two or more unstable channels divided by shingle flats and islands. Channels successively divert and rejoin. Canterbury's rivers support a wide variety of wetland bird species, including three endemic birds: the wrybill plover, black-billed gull and black-fronted tern, which have specific adaptions for breeding and/or feeding on riverbeds. For example, the Rakaia River is New Zealand's most important breeding habitat for the wrybill plover, and the Ashburton River is a major habitat for the black-fronted tern and the black-billed gull (O'Donnell and Moore, 1983).

In recent times there has been conflict over water use in Canterbury. A major conflict involved the Rakaia river, regarding the value of the water for in-stream use versus out-of-stream use, mainly irrigation. This resulted in a National Water Conservation Order for the river, which came into force on 10 November 1988. The Conservation Order took over five years to resolve and the full public cost of management planning and the conservation order has ben very high, possibly as much as $3 - $4 million (Mason, 1988).

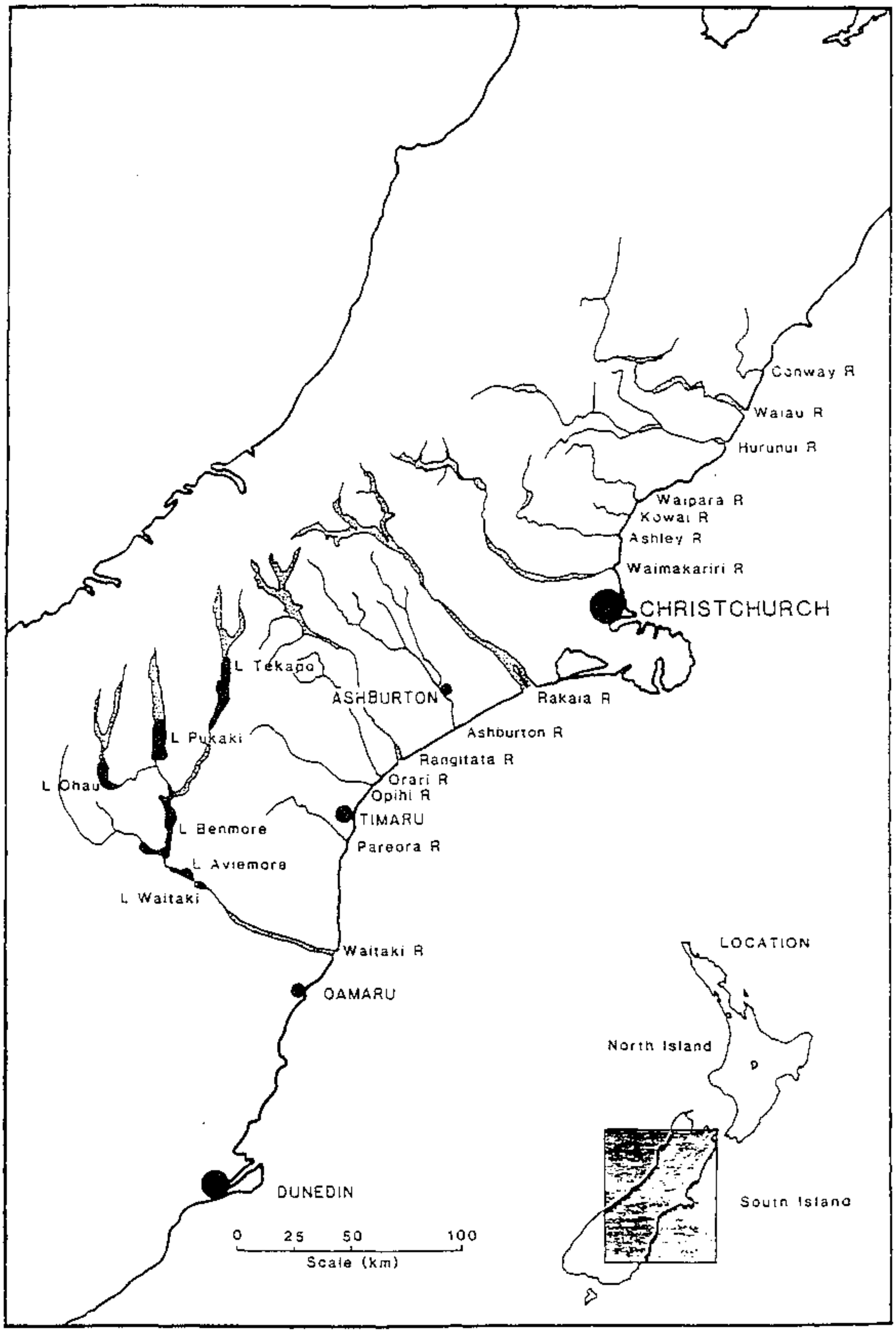
Currently, the management plan for the Ashburton River is being reviewed. The allocation of the water between in-stream and out-of-stream uses is one of the issues that will be addressed. The result of this review and the resulting allocation of water may have economic implications to the region.

The Regional Council has a vested interest in encouraging the economic growth of the region, which may be through the use of its natural resources, but it must also develop policies which will protect and enhance the region's natural environment. From the Council's viewpoint, the region's resources need to be allocated the to ensure the greatest benefit to the region. This may be different from the national interest.

1.4 ORGANISATION OF THIS THESIS

The objective of this study is to estimate the economic impact of water allocation and assess whether the recent changes that have occurred in New Zealand may be beneficial to the region and assist resources managers to more effectively manage the region's water resources. The Ashburton River will be used as a case study.

Figure 1.1 Braided Rivers in Canterbury



Source O'Donnell and Moore (1983)

CHAPTER TWO

ECONOMIC THEORY APPLIED TO WATER

The 1991 Resource Management Act encourages the efficient use of resources. The Act specifically encourages the use of economic instruments to manage the use and quality of natural resources (Resource Management Act, 1991). This chapter defines economic efficiency, describes economic theory of resource allocation as applied to water and describes methods of resource valuation.

2.1 CONDITIONS NECESSARY FOR ECONOMIC EFFICIENCY

Economic efficiency as defined by Pareto and further developed by others, including Randall (1987) involves efficiency in production, efficiency in consumption and efficiency in coordination between production and consumption. What is produced is not only dependent on resource availability and technology but also on consumer preferences.

Efficiency in production results when it is not possible to produce more output of one product without decreasing the output of another product. That is, with limited resources of a and b that are used to produce products X and Y, efficiency occurs when the rate of technical substitution (RTS) of the inputs are equal.

$$(RTS_{a,b})_X = (RTS_{a,b})_Y \qquad (2.1)$$

For efficiency in consumption, the rate of commodity substitution (RCS) between commodities must be equal for each consumer.

$$(RCS_{X,Y})_1 = (RCS_{X,Y})_2 \qquad (2.2)$$

The marginal rate at which one commodity must be sacrificed in order to increase the output of another commodity (while technology and resources are held constant), that is, the rate of product transformation (RPT), should be equal to the marginal rate of substitution between the commodities for all individuals.

$$(RCS_{X,Y})_1 = (RCS_{X,Y})_2 = (RPT_{X,Y}) \qquad (2.3)$$

Given the above conditions, a number of inefficient input combinations, commodity distributions and output mixes are eliminated. This results in many efficient solutions, each with a different resource allocation, commodity distribution and distribution of well-being. At any one of these points, Pareto-efficiency results. This is where it is impossible to make one person better off without making another worse off (Randall, 1987).

In a perfectly competitive market where there are numerous participants that are unable to influence the price, homogeneity of product, freedom of entry and exit, and perfect information (Baumol, et. al., 1988), an economy will automatically tend towards a Pareto-efficient solution. Efficient resource allocation will result when

$$(RTS_{a,b})_X = (RTS_{a,b})_Y = P_a/P_b \quad (2.4)$$

$$(RCS_{X,Y})_1 = (RCS_{X,Y})_2 = P_X/P_Y \quad (2.5)$$

$$(RCS_{X,Y})_1 = (RCS_{X,Y})_2 = (RPT_{X,Y}) = P_X/P_Y \quad (2.6)$$

where P_a is the price of a
P_b is the price of b
P_X is the price of X
P_Y is the price of Y

If perfect competition prevails, a firm's marginal revenue from the product will equal the value of the marginal product (which is equal to the price times the marginal physical product). For an input such as water, if its marginal product of a resource is not equal in all uses, there may be opportunities for an economy to benefit by reallocating some water from activities with smaller marginal returns to those with a larger marginal return, thus increasing the net value of the resource to society (Baumol, 1977).

In order to examine how these principles of economic efficiency may be applied to water, it is necessary to understand the physical properties of water and how these give rise to different economic characteristics.

2.2 THE PHYSICAL CHARACTERISTICS OF WATER

Water has the following characteristics, as noted by Young and Haveman (1985) and Randall (1982):

2.2.1 Mobility

Water tends to flow, evaporate, seep and transpire. These attributes present problems in identifying and measuring the resource. Consequently, the exclusive property rights which are the basis of an exchange economy are difficult to establish and enforce.

2.2.2 Variability in Supply

Water supply can vary across seasons, years and locations.

2.2.3 Solvent Properties

Water has a capacity for assimilating and absorbing wastes and pollutants. This requires the introduction of quality as well as quantity in the definition of use.

2.2.4 Sequential Use

A river may be tapped by many and varied entities as it flows down stream. Only rarely is water fully consumed by any particular user.

2.2.5 Complementarity of Outputs

Closely related to the previous point is that some water may be used for more than one purpose. A reservoir can store water for flood control, irrigation, power generation, municipal demands and recreation. Private ownership may capture only a part of these complementarities.

2.2.6 Bulkiness

Water is a bulky commodity, in that value per unit tends to be relatively low. Therefore, costs of transportation and storage tend to be high relative to economic value at the point of use.

2.2.7 Cultural and Social Values

Water has cultural and spiritual significance for many people.

These different physical properties and uses of water means that water exhibits unique economic characteristics. These are described in the next section.

2.3 ECONOMIC CHARACTERISTICS OF WATER

Water resources can reflect any or all of a number of economic characteristics. The relative importance of each economic characteristic depends on the particular set of water uses, location, time, and strength of demands (Gray, 1983).

2.3.1 Marketable Private Good Characteristics

A variety of water uses involve marketable private good characteristics. Private goods tend to be exclusive, so that all rewards and costs accrue to the owner, completely specified and enforced, and preferably transferable so that rights may gravitate to the highest value use (Randall, 1987).

Private goods can be sold at prices that reflect the value to the users and provide sufficient economic incentive for their production. Municipal water supply or irrigation water illustrate water uses in which water can be treated as a marketable private good, although these usually also involve the additional characteristics of a public utility.

2.3.2 Public Good (or Collective Good) Characteristics

In many uses, water provides collective benefits. Examples include in-stream uses such as recreation, flood control and aesthetic values of water. The characteristics of such goods are

a) the resource, good, or service is simultaneously available to all, and

b) they are non-consumptive uses so that one individual's use does not diminish that availability to others, within the capacity of the limits of the resource (Randall, 1987).

As nonrival and nonexclusive goods, it is difficult or impossible to define individual property rights to water and it is not feasible to sell water as a private marketable good, nor is it normally efficient to do so (Randall,1987).

Unlike private goods, where total demand is determined by the summation of quantities demanded across individuals, total demand for nonrival goods is determined by summing individual valuations. For rival goods, the intersection of demand and supply defines the market price to each consumer. For nonrival goods at the efficient quantity, marginal values are different for each individual and thus it is difficult to establish a market price (Randall, 1987).

2.3.3 Common Property Resource Characteristics

Common property resources are similar to collective goods, being simultaneously accessible to all. Unlike collective goods, common property resources are subject to the right of capture and become private property upon capture. One example is ground water. A problem with common property goods is that they can be over exploited.

2.3.4 Externality Characteristics

Externalities or third party effects involve unpriced and sometimes unrecognized effects of one individual or organisation on others. Examples involve both negative externalities of water pollution and positive externalities of water improvement.

2.3.5 Public Utility Characteristics

Some developments have high fixed costs and low incremental cost per unit of output, up to capacity output levels. Economies of scale are often evident, which lead to natural monopolies. Examples include municipal waste treatment, irrigation and hydropower. For a given water delivery system of fixed capacity, marginal delivery cost is relatively low and fairly constant until the capacity constraint is approached. Fixed costs are quite high so the average cost continues to decrease until the capacity constraint is approached. With increased demand the quantity of water demanded eventually exceeds the capacity of the system and new, larger and often more expensive delivery systems are required. Thus it is possible that the long-run marginal cost of water delivery is increasing rather than decreasing (Randall, 1982). The issues involved include pricing and other policies to encourage full utilization of capacity but avoiding expansion too early, and to handle peak loads. Polices should serve to keep down costs and provide service at low prices.

An exclusive focus on delivery systems assumes that the resource itself is free. But it is not free in either the resource cost, the opportunity cost or social costs. The value of water may be defined in terms of resource cost, opportunity cost, or social cost. Resource cost is the cost of providing the water itself; opportunity cost is the value of that water in its best alternative use; and social cost implies the correction of observed costs to take account of any unpriced adverse or beneficial effects of water supply and use. In a perfectly competitive economy that has reached an efficient equilibrium, the resource cost, opportunity cost, and social cost of water are all equal at the margin, and are all equal to the price of water (Randall, 1982).

2.4 VALUATION OF WATER THAT HAS PRIVATE GOOD CHARACTERISTICS

Given these different economic characteristics what methods exist to value water?

The valuation of water that has private good characteristics can be determined from market data. For example, irrigation water is an intermediate good used to produce agricultural products. The value of irrigation water can therefore be determined by the difference in value of the agricultural products produced with and without water, keeping all other input and market conditions the same.

Irrigation water values can be either marginal values or average values; product specific or calculated for a mixture of products; and they can be estimated for the short-run or long-run. The basic methods for estimating irrigation water values are production function analysis and farm budget analysis, which includes linear programming (Gibbons, 1986).

2.4.1 Production Function Analysis

The relationship between inputs and outputs of agricultural production can be expressed mathematically as the production function. If all other inputs are held constant, then the marginal physical productivity of water for each unit of water used can be calculated. The marginal value of each unit of water is the marginal physical product of water times the product price. This procedure relies on the assumption that applications of different amounts of water incur the same nonwater input costs (Gibbons, 1986).

2.4.2 Farm Crop Budget Analysis

In most places and for most agricultural products the actual physical productivity of water is not known. In that event, representative farm crop budgets can be used to estimate the maximum revenue share of the water input. The total product revenue less nonwater input costs leaves a residual which is the maximum amount the farmer could pay for water and still cover costs of production. Depending on whether or not fixed costs are included, such values can be short-run or long-run average values (Gibbons, 1986).

2.5 CONSUMER SURPLUS

Water also has value as a public good such as swimming, fishing, and other recreational activities. In addition, water has value which exists independently of use. These nonuse and preservation values represent the value of the natural resource left in a pristine state. As there is no market from which these values can be elicited, other methods have been devised. The methods used to value nonmarket goods arise from the concept of consumer surplus.

Consumer surplus is the total amount one would be willing to pay for a given quantity of goods, less the cost of the goods (Kerr, 1986).

The net benefit derived from consuming a good can be represented by the area under the demand curve less the actual expenditure. This is the Marshallian consumer surplus, and can be used as a measure of the welfare change given a price change as shown in Figure 2.1. The difficulty is that a price change (for example point A to B) has two effects: the consumer substitutes towards the cheaper good (point C), and the effective change in real income shifts the consumer to a alternative welfare level (point B). If the area under the demand curve represents utility, one of the factors that affects utility - namely income - is changing. Therefore, measuring Marshallian consumer surplus is not a true measure of utility (Broadway and Bruce, 1984).

Hicks proposed a refinement of Marshallian consumer surplus that removes the income effects. He defined four measures of consumer surplus (Currie, Murphy, Schmitz, 1971).

Compensating variation (CV)

This is the amount of compensation, paid or received, that will leave the consumer in the initial welfare position following the change in price if the consumer is free to buy any quantity of the commodity at the new price.

Equivalent variation (EV)

This is the amount of compensation, paid or received, that will leave the consumer in a subsequent welfare position in the absence of the price change if the consumer is free to buy any quantity of the commodity at the old price.

Compensating surplus (CS)

This is the amount of compensation, paid or received, that will leave the consumer in the initial welfare position following a change in price if the consumer is constrained to buy at the new price the quantity he would have bought at that price in the absence of compensation.

Equivalent surplus (ES)

This is the amount of compensation, paid or received, that will leave the consumer in his subsequent welfare position in the absence of a price

> change if he is constrained to buy at the old price the quantity he would have bought at that price in the absence of compensation.

These measures result in Hicksian compensating demand curves. The demand curves indicate the quantity demanded at different prices, while maintaining the consumer at a constant utility level. There will be two Hicksian compensating demand curves: one at the initial level of utility level and one at the subsequent utility level, as shown in Figure 2.2.

Figure 2.1 Consumer Surplus

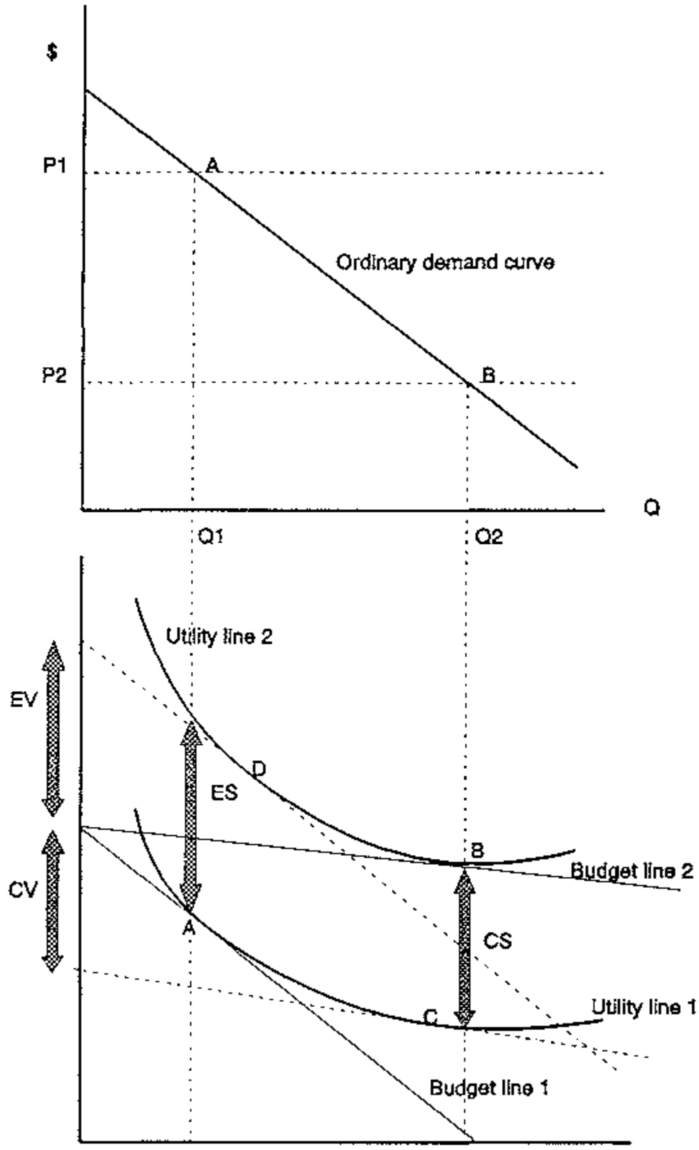
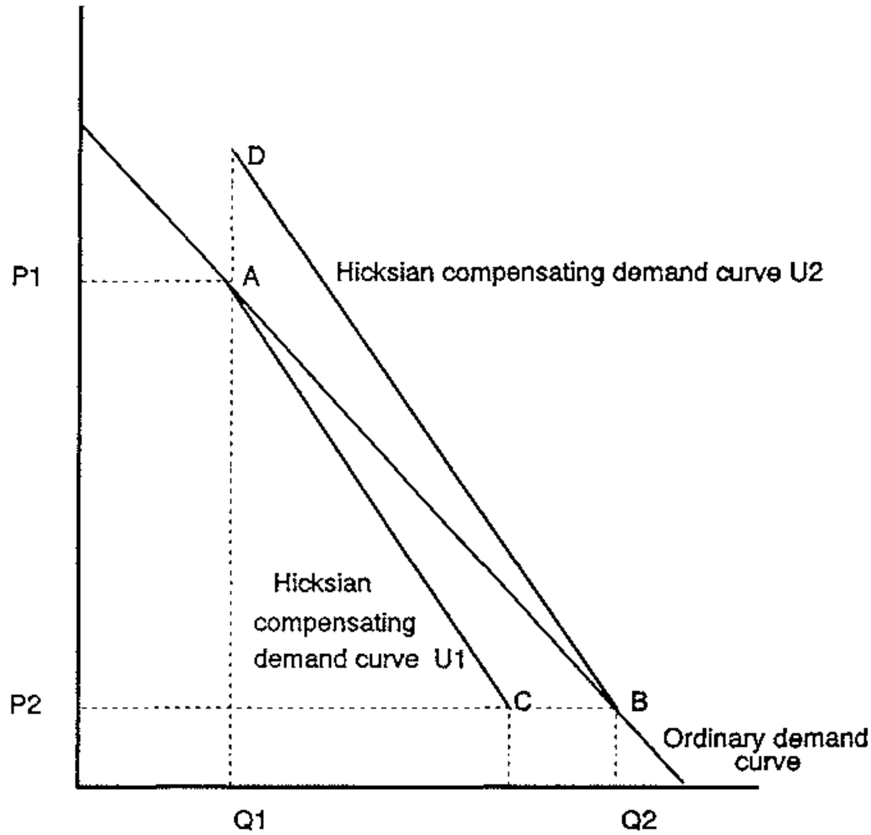


Figure 2.2 Hicksian Demand Curves



If the consumer has freedom of choice in responding to a changing economic environment, compensating and equivalent variations will measure the effect on the consumer. Compensating variation measures the gains or losses associated with taking the proposed action, and equivalent variation measures the gains and losses associated with not taking the proposed action. The compensating and equivalent surplus measures restrict the quantity of the good purchased to be either the level of the subsequent state (compensating) or the initial state (equivalent).

Which measure to use depends on the situation. If there is a quantity constraint such as whether to have a National Park or if there is a quota system in place under which consumption can only occur in discrete quantities, the consumer surplus measure is appropriate. The variation measures should be used where there is no restriction on the consumption of goods and where transaction costs do not cause a quantity adjustment (Devine, 1987).

The choice between compensating or equivalent measures depends on which state is perceived as the status quo. The compensating measure assumes that the change goes ahead and calculates the compensation to be paid or received that would leave the consumer as well off as before (Devine, 1987).

The relationship between the Hicksian measures and the Marshallian consumer surplus is dependent on the income effect of the price change and expenditure on the commodity relative to total expenditure. If the income elasticity of demand is close to zero, or expenditure on the commodity is a small percentage of total expenditure then the Marshallian consumer surplus, the compensating variation, and the equivalent variation will provide similar estimates.

In practice any of the measures can be estimated. If the demand curve can be estimated, the Marshallian consumer surplus can be calculated. The Hicksian demand curves require more work to calculate.

Consumer surplus can be aggregated over commodities and individuals. The problem in so doing is whether that the assumption of the gains (or losses) are of equal value to the individuals. It is assumed that the marginal utility of income is equal for all individuals and constant over the range of effects being considered, then the efficiency objective can be separated from matters of income distribution. If the utility of money is assumed to be different between individuals with high and low income incomes, then aggregation must address income distribution (Broadway and Bruce, 1984).

2.6 VALUE

Most decisions are not made with complete certainty. There is uncertainty of supply (for example, the availability of water), uncertainty of demand (for example, whether to go swimming or not in the future). There is also collective risk for example, all of society experiences a drought. Individual risk is when it is possible for an individual to be in one of two states such as to irrigate or not. Another factor affecting decision making is irreversibility: an environment can be destroyed with no chance of regeneration.

Because uncertainty and irreversibility affect the values of resources, several other types of value other than the value derived from immediate use. These include option value, existence value and quasi-option value.

Pearce and Turner (1990) suggest that total economic value includes actual use value plus option value plus existence value.

2.6.1 Option Value

Some consumers who do not currently purchase a commodity anticipate purchasing the commodity at some time in the future. If these consumers behave rationally, they will be willing to pay for the option to consumer the commodity in the future.

Lindsay in 1969 (see Bishop, 1982) argued that potential future users would be willing to pay more than their expected value of consumer surplus for options purchased now. This additional value over and above the expected value of consumer surplus was his concept of option value. Option value (OV) is the residue of the option price less the expected value of consumer surplus (E(CS)). Option price (OP) is the maximum amount that the consumer would be willing-to-pay now for a future option.

Option Value = Option Price - Expected Consumer Surplus.

$$OV = OP - E(CS) \tag{2.7}$$

If the option is for a dam and there are two states, wet and dry with probabilities Pw and Pd with benefits Bw and Bd

$$E(CS) = PwBw + PdBd \tag{2.8}$$

It is possible that option value can be positive or negative and under complete certainty it is zero. Graham (1981) developed a willingness-to-pay locus to demonstrate this. It describes an infinite number of combinations of payments for which the consumer would be willing to contract, contingent upon the existence of the dam, after the state of the world is known. It ensures that expected utility, when payments are made and the good is available, is equal to expected utility when no payments are made and the good is unavailable. That is, the individual is indifferent between making any of the pairs of payments and being guaranteed access and making no payments and being denied access. Four points can be identified on the locus, as shown in Figure 2.3.

a) Surplus Point (S)

   What the farmer is willing to pay in each state with a certain outcome

b) Option Price (OP)

   Lies on the 45^0 line, because it represents the maximum sure payment that the farmer is willing to make in both states

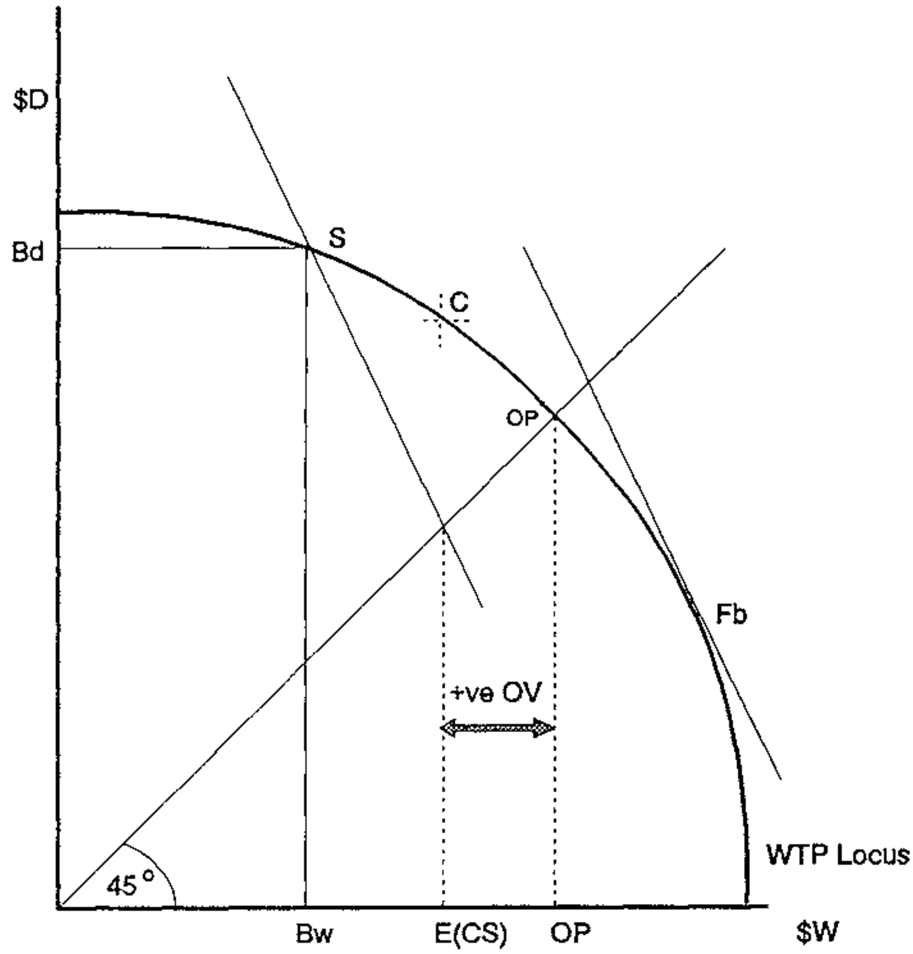
c) Certainty Point (C)

   The point on the locus which ensures an equal level of utility regardless of which state of the world actually occurs

d) Fair bet point (Fb)

   The point that maximises expected value of the benefits from the dam. The slope of the willingness-to-pay locus at this point is equal to the negative of the inverse ratio of the probabilities of the two states. This is -Pw/Pd.

Figure 2.3 Willingness-to-pay Locus



Drawing a fair bet line through S yields all payment combinations with the same expected value. Where this line intercepts the 45^0 line, payments are equal in both states and therefore also equal the expected surplus E(S). This allows the factors influencing the sign of the option value to be examined. Graham identified three possibilities.

a) Option value is positive

Option price is greater than the expected surplus so the option value is positive (as drawn above).

b) Option price is negative

The fair bet point lies to the left of the surplus point above the 45^0 reveals a negative option value.

c) Option value is ambiguous

The fair bet point lies between the 45^0 and the surplus point.

Provided the uncertainty concerning future use is an uncertainty regarding availability or supply, option value is likely to be positive.

There is some debate about which value to use in decision making. Graham (1981) argues that the option price is the appropriate measure of benefit in situations involving collective risk and expected value for individual risk. Cory and Saliba (1987) argue that the expected value of fair bet contingency contracting is the correct welfare measure of benefits to an uncertain user of a natural environment. It is a premium in the sense that it represents the maximum amount beyond expected surplus an uncertain demander would be willing to pay to ensure supply, an amount that is generated by contracting for unconstrained contingency payments and an amount that is always nonnegative.

2.6.2 Existence Value

Existence value is a value placed on an environmental good which is unrelated to any actual use or potential use of the good. For example, people value the kakapo but do not expect to derive benefit from using the bird. Pearce and Turner (1990) suggested several forms of existence value such as bequest or gift value that may be seen as ether existence value or bequest value because inheritors may make use of the bequest. This means that the distinction between option and existence value is often unclear. Stewardship could be thought of as an existence value.

2.6.3 Quasi-option Value

Quasi-option value is based upon uncertainty regarding the future availability of information upon users and values associated with resources facing possible irreversible development. Conrad (1980) indicates that quasi option value is the expected value of information gained from delaying an irreversible decision. For example, consider allowing the extinction of a species that may have future value through development (destruction) of their present habitat. The development has certain value in terms of people's willingness to pay for its outcome. There are uncertain benefits from the preservation of the habitat, but these benefits could become more certain through time as information is obtained.

Quasi option value depends as much upon reversibility as it does on irreversibility. If all the outcomes were irreversible, the information would be valueless. For the new information to be of value it must be able to be acted upon and result in an action which diminishes either the costs or damages (Cochrane and Cutler, 1990). Most environmental decisions meet this criteria. If an environment is destroyed, it is irreversible; if it is not destroyed a future option is to develop it.

If the expected growth of information is independent of the developments quasi option value will always be positive. If the information is dependant on some development this is the benefits of development, quasi option value may be negative (Freeman, 1984).

While quasi option value is definable it is unable to assist decision makers. Individual values are not identifiable because the information is unknown. If the knowledge of future states is available, it would be possible to use this directly. Quasi option values highlight the difficulty and potential error in using expected value where the possibility of new information becoming available exists. Therefore the future benefits of preservation are likely to be greater than predicted (Kerr and Sharp, 1987).

2.7 NONMARKET VALUATION TECHNIQUES

Consumer surplus is derived from the demand curve for the good. Normally the demand curve can be obtained from market data. For goods for which no markets exist, there are techniques that can provide a value on the provision of these goods.

There are two main approaches to valuing nonmarket goods: directly by asking people how much they are willing-to-pay or willing-to-accept, or indirectly by determining demand curves and then consumer surplus. The contingent valuation method is an example of direct valuation; the travel cost method and hedonic method are examples of indirect valuation.

2.7.1 Contingent Valuation Method

Contingent valuation uses economic theory and methods of survey research to elicit directly from consumers the values they place upon nonmarket goods. Survey questions are used to elicit people's preferences for nonmarket goods by finding out in monetary terms what they would be willing-to-pay (WTP) for specified improvements in them, or willing-to-accept (WTA) as compensation for no improvement or deterioration in the good. It circumvents the absence of markets by presenting consumers with hypothetical markets. The elicited values are contingent upon the particular hypothetical market described to the respondents (Mitchell and Carson, 1989).

2.7.2 Travel Cost Method

The travel cost method for estimating the demand for a site relies on the assumption that in order to enjoy the amenities provided by a recreation site, it is first necessary to travel to the site, thus incurring a cost (Freeman, 1979b).

The procedure is as follows:

a) For a given site the surrounding area is divided into zones.

b) Visitors to the site are sampled to determine their zones of origin.

c) Visitation rates per capita are calculated for each zone.

d) A travel cost measure is constructed to indicate the cost of travel from the zone of origin to the site, and return.

e) A relationship between the cost of visiting the site and the people visiting the site is estimated.

f) This estimated relationship is transformed into a demand curve by using the assumption that people will respond to an increase in access fees in the same way as they would to an increase in travel costs.

The travel cost method has the advantage of being a revealed preference method of valuation. This has the advantage that familiar types of data and analysis can be employed. It is limited in that it only measures use values for the site in its present state, therefore values such as option and existence values are not measured. Difficulties with the method include the difficulty of estimating the cost of both travelling time and time spent at the site, and the problems associated with multiple site trips. These concerns have received considerable attention (see Kerr, 1987).

2.7.3 Hedonic Pricing

Hedonic pricing recognises that some commodities have bundles of characteristics and suggests that demand depends on a commodities attributes. For example, house price may be a function of number of rooms, size of the section, desirability of the neighbourhood, and environmental qualities associated with the house such as noise levels.

Hedonic pricing recognises that home buyers are willing to pay different amounts for houses with different characteristics. The method uses statistical techniques to estimate the marginal value of the characteristics such as noise.

Hedonic pricing shares the same advantages as the travel cost method, this is, the use of observed market behaviour. This avoids any confusion between what consumers intend and what they actually do because only actual transactions are investigated.

To succeed, hedonic pricing must link the environmental resource and the price of the amenity measure being used. Another limitation of the hedonic price approach is that it underestimates the benefits when there are substantial values held by those who live outside the area for which property value data has been gathered (Fisher, 1987).

CHAPTER THREE

INSTITUTIONAL CONSIDERATIONS

Economic efficiency results when a resource such as water can move to its highest value. A market system is one way of achieving this. However, the success of such an allocation system over time (as measured by economic efficiency) may depend on several issues besides the value of water to the participants in the market. Many of these issues are institutional concerns.

This chapter first defines institutions and why these are important to water allocation. It then considers why market mechanisms could be used to allocate water, and briefly describes some examples of different markets in operation around the world. Finally, it develops criteria that may be used to assess how effective an institutional structure is at allocating a resource.

3.1 INSTITUTIONS

Institutions refers to

> "the conventions, entitlements, rules, sanctions, and incentives that define the choice domain of independent participants in our daily life." (Bromley, 1988, p.7)

Institutions also affect economic efficiency and the distribution of well-being. To quote Bromley again,

> "There is *no single policy choice* but rather an efficient policy

> choice for every possible presumed institutional setup. To select one efficient outcome is also to select one particular structure of institutional arrangements and its corresponding distribution of income. What matters is not efficiency, but *efficiency to whom*?" (Bromley, 1989, p.4)

Property rights are often used to define existing behaviours. Therefore, property rights are a policy instrument. According to Bromley (1991), property is a benefit (or income) stream, and a property right is a claim to a benefit stream that the state will agree to protect through the assignment of duty to others who may covet, or somehow interfere with the benefit stream. Property is a triadic social relation involving benefit streams rights holders, and duty bearers. Rights are a relationship between an individual (or an organisation) and others with respect to an object, rather than a relationship between an individual (or an organisation) and an object. Rights can only exist when there is a social mechanism that gives duties and binds individuals to those duties (Bromley, 1991).

Demsetz (1964) argues that property rights develop to internalize externalities when the gains of internalization become larger than the cost of internalization.

Property arrangements define which of costs might legally be ignored, and property rights legitimises those costs that are then visited on others. The issue of relevance is one of who gets those rights, and thus who will have the effective protection of the state to do as they wish. Equally important, property rights indicate who must pay whom to have their interests given effect (Bromley, 1991).

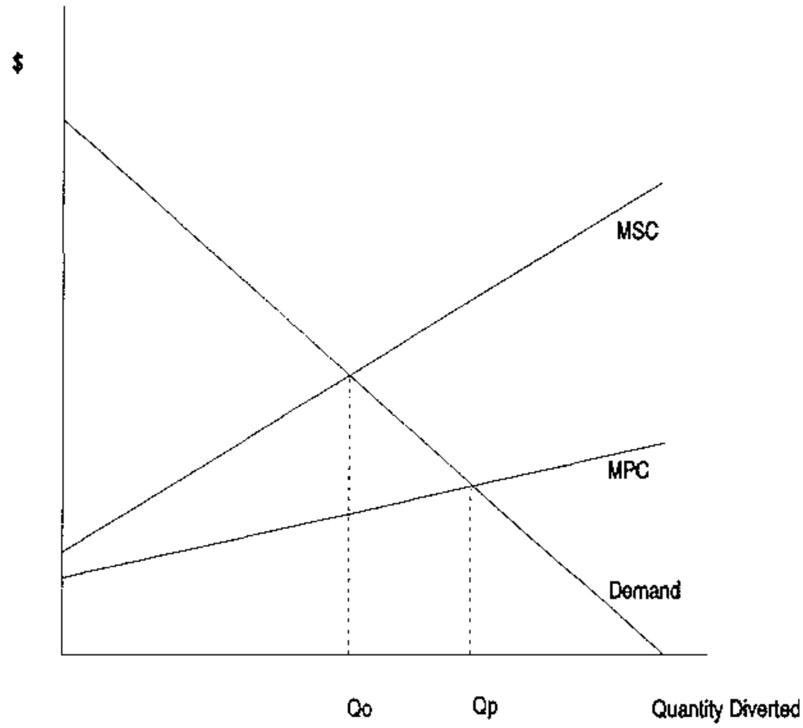
Bromley (1991) then goes on to define property arrangements in terms of rights with corresponding duties and privilege and correspondingly no rights. In the first situation, given two individuals (Alpha and Beta), if Alpha has the right he can expect Beta to behave in a certain way. Rights and duties are duals of each other. Under the alternative arrangement, if Alpha has the privilege, or presumptive right, he is free in a way that disregards the interests of Beta, and Beta has no recourse.

Externalities (or third party effects) are costs or benefits falling beyond the boundary of the decision making unit. The effect of externalities can be described in the following example. If private transactors do not have to consider in-stream values in their transactions, the amount of water diverted will be based on the costs of diverting water. Because society incurs the cost of water lost from the river, the amount of water diverted will be more than is socially optimum. The foregone in-stream benefits can be considered as an externality (see Figure 3.1).

The Coase theorem helps explain how property rights can be used to reduce third party effects. Coase (1960) argued that by internalising externalities (that is, making affected parties part of the decision process) the outcome in terms of goods and services would not differ, regardless of who held the initial property rights. The Coase theorem is based on exclusive and transferable property rights and only operates under restrictive conditions - income and transaction costs nonexistent. The Coase theorem has been criticised due to the relevance of transaction costs, equity considerations, insufficient analysis of the bargaining process, and the fact that there is often more than one person in each bargaining party, especially with public goods and the problem of free-riders (Siebert, 1981).

The Coase theorem can be illustrated with the following example. If the property rights to water belong to the in-stream user, the diverter will be willing to bargain with the in-stream user, as long as the compensation to obtain water is less than the marginal net benefit of the water. If the property rights belong to the diverter, the in-stream user will bargain with the diverter until the compensation necessary to obtain more water equals the marginal benefit of the water. The same result is obtained (Point Q in Figure 3.2 and 3.3), which is independent of the distribution of property rights.

Figure 3.1 Externality



where	Demand	=	the demand for consumptive use of water
	MPC	=	marginal private costs of diversion
	MSC	=	marginal social costs of diversion including the opportunity costs of in-stream flows

Different rights structures may result in different income effects. The party that has the initial rights determines the direction of payments between the two parties. Assuming no income effects implies that income has no effect on the supply and demand curves, but does not mean the ultimate income position of the parties is indifferent to the initial property rights (Siebert, 1981). For example, if the rights initially reside with the in-stream user and the diverter wishes to obtain water, the diverter will have to pay the in-stream user for the right to divert water, resulting in a lower income level than if the rights initially resided with the diverter.

Although the allocation is independent of the definition of property rights it is not independent of transaction costs. Transaction costs are of three types: information, bargaining or contracting, and enforcement. If marginal transaction costs differ for different endowments of property, a different allocation results. For example, if the rights belong to the in-stream user, and the diverter compensates for the use of the water, and incurs the transaction costs, his marginal benefit of the water will be the net benefit of the water less the transaction costs. The amount diverted will be less than in the absence of transaction costs (Point P in Figure 3.3). If the rights belong to the diverter, and the in-stream user incurs the transaction costs in the bargaining process, the amount diverted will be greater than without transaction costs. (Point R in Figure 3.3)

Figure 3.2 Optimal Solution in the Absence of Transaction Costs

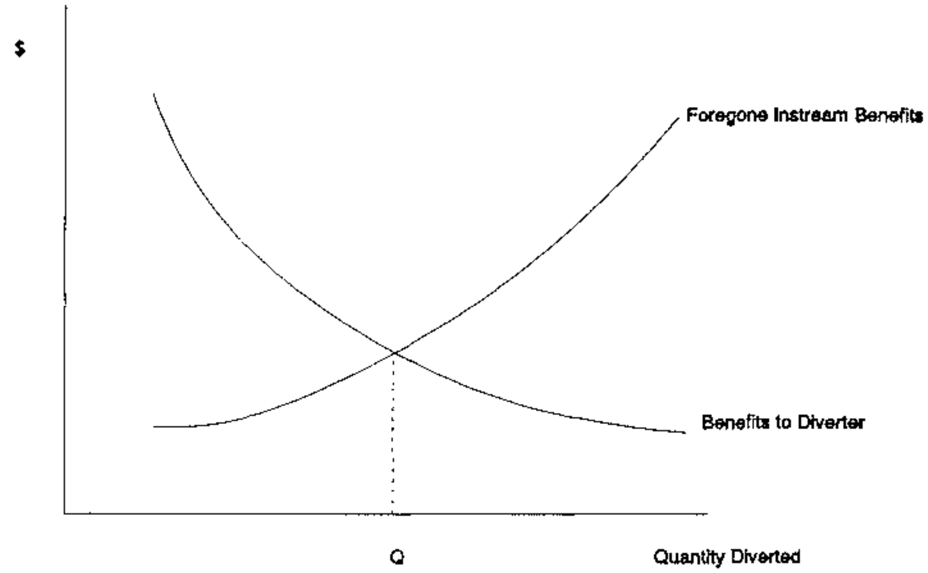
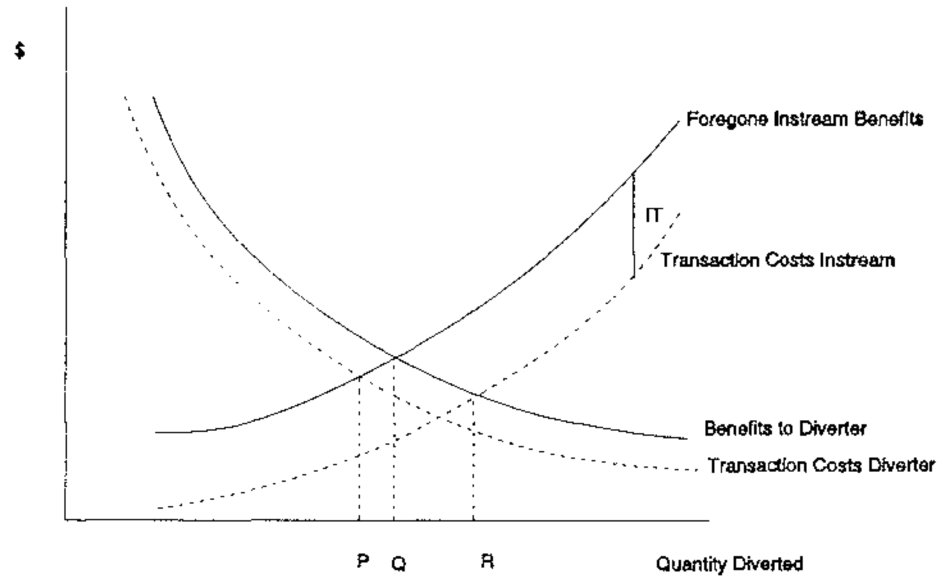


Figure 3.3 Optimal Solution when Transaction Costs Exist



In this example, it has been assumed that the in-stream users have the higher transaction costs (vertical distance IT) than the diverter, due to the fact that there are many in-stream users. Transaction costs are likely to be larger when negotiations must be initiated by a large and diffuse group of individuals rather than by a smaller group who are more vitally interested in the particular issue (Randall, 1972).

Another difficulty with many in-stream users is that, different individuals have different demand curves, while the firm has a single demand curve, individual bargaining is likely to result in permission for different amounts of abatement (Randall, 1972).

The Coase theorem does help explain the importance of property rights and the effect of transaction costs. There are several ways in which property rights can be established, and several ways in which rights might be given effect (see Table 3.1). One can have a property right that is protected by a property rule; it can be protected by a liability rule, and it can be inalienable (Bromley, 1991).

Because of implied transaction costs, some situations may best be covered by property rules while others by liability rules. This difference in transaction costs arise since, under a liability rule it is the injured party who must initiate action which will result in compensation. Under an entitlement where the injured party is protected, the active party must initiate the action to seek approval.

Table 3.1 Alternative Entitlement Rules

Rule 1 Property Rule	Alpha may not interfere with Beta without Beta's consent. Beta is protected by a property rule
Rule 2 Liability Rule	Alpha may interfere with Beta but must compensate Beta. Beta is protected by a liability rule.
Rule 3 Property Rule	Alpha may interfere with Beta and can only be stopped if Beta buys off Alpha. Alpha is protected by a property rule
Rule 4 Liability Rule	Beta may stop Alpha from interfering but must compensate Alpha. Alpha is protected by a liability rule.
Rule 5 Inalienability	Alpha may not interfere with Beta under any circumstances and no compensation is required. Beta is protected by inalienability.

Source: Bromley 1991.

How the institutional structure and definition of property rights can influence the economic value of water can be illustrated by the following examples.

3.1.1 Diversion Versus Consumptive Water Rights

For off-stream users only part of the water diverted from a stream is used consumptively that is, in a way that makes water unavailable for further use. Thus return flows from one diversion are available for re-use (Hartman and Seastone, 1970).

Water rights can be defined in terms of diverted water or consumed water. The effect of interdependencies of use and whether rights are defined in terms of consumptive rights or division rights can be seen in the following example has been adapted from Gisser and Johnson (1983). Assume three users along a river with a flow of 100 cubic meters per second available for diversion at the head of the stream. Farmer A, at the head of the stream, diverts 100 cubic meters per second, consumes 50 cubic meters per second, and returns 50 cubic meters per second to the stream. Downstream, farmer B diverts 50 cubic meters per second and returns 25 cubic meters per second, and farmer C diverts 25 cubic meters per second and returns 10 cubic meters per second. The three users divert a total of 175 cubic meters per second, a greater amount than the initial stream flow. Now assume that for each of the three users, a cubic meter per second of water has a net value of $1. If property rights are defined by the amount diverted and a buyer of water rights who planned to consume all the water he diverts was to offer farmer A $110 for the right to divert 100 cubic meters per second, farmer A would gain $10 by selling but farmers B and C would be subjected to a combined loss of $75. There would be a net loss for the entire system of $65.

With property rights based on diversion, third party impairment is likely to follow whenever transfers alter the ratio between consumptive use and diversion. Basing water rights on consumptive use rather than on diversion offers a check against third-party impairment. Therefore, a rule-of-thumb principle generally held applicable to transfers is that the amount of the transfer is restricted to the historic consumptive use (Gisser and Johnson, 1983; Hartman and Seastone, 1970).

The relevant measurement of use in a productive process is the reduction in available supply incurred from the use. Consumptive use thus becomes one of the most important factors for computing the value of the marginal product in determining allocation efficiency. However, availability of return flow depends on location of use on the stream, so that location with respect to re-use potential of return flow also becomes part of the question of efficiency. Consumptive use and re-use of return flow are clearly important considerations in determining allocative efficiency between two uses, which may have widely varying marginal product values as measured for diverted amounts (Hartman and Seastone, 1970).

3.1.2 Priority Rights Versus Proportional Rights

The two most common forms of rights are priority rights and proportional rights. Priority rights is where certain classes of rights have higher priority on the stream flow. The highest priority right has first call on the available water, and is the last individual to have his allocation restricted because of low stream flows. A proportionate right system is one in which each share permits the owner to claim a proportionate share of the water available (Howe, 1982).

The economic efficiency argument favouring priority rights is that certain users require the assurance of a highly reliable supply of water before it becomes worthwhile to invest in the production process. The disadvantage is that short-term inefficiencies due to variable supply (see Table 3.2). When shortages occur the junior right holder loses all his water before the senior right holder. The marginal value of the last unit of water given up by the junior right holder may be greater than the marginal value of the unit to the senior right holder because of diminishing marginal returns (Howe, 1982).

The value of water under a priority right system will depend on its ranking within the system. A senior right will be more valuable than a junior right.

Under a proportionate right system no right has priority over another right. Under this system, a rights owner's supply is increased by acquiring more rights. As the number of rights is increased, both the owners mean supply and the variability of that supply increases proportionately. The major disadvantage is the inefficient use or waste of the "excess water" held by the risk adverter (Howe, 1982).

Allison (1988) argues that equal sharing provides an incentive to ensure that water resources are under used. Additional rights could have a negative impact on existing rights, and therefore existing users will attempt to prevent more rights being issued. Whereas, under priority rights, additional rights will not affect existing right holders, and therefore water will be fully utilised.

Table 3.2 A Comparison of Priority and Proportionate Right Systems

	Priority Rights	Proportionate Rights
General Advantage	Different degrees of supply reliability can be purchased	Rights are homogenous, easier to establish a market
General Disadvantage	More difficult to establish a market	Differing degrees of reliability must be created by holding excess shares, with possible inefficient use of water
When users are alike	Short-run efficiencies during water shortages	Efficient allocation during shortage
When users are not alike	Prevents extreme loss to sensitive users during shortages, but generate short-term inefficiencies due to marginal products not being equal	Either excessive losses to water sensitive users during shortage or potentially inefficient use due to risk hedging
When water supply is highly variable	Protects sensitive investments, but results in some short-term inefficiencies	Makes protection of sensitive investments difficult but equates marginal values when users are alike.

Source Howe (1982)

3.2 WATER MARKETS

The above examples demonstrate how the institutional structure and definition of property rights affect the value of water. Another factor that is important is the ability of water to move to its highest value of use if economic efficiency is to be achieved. Transaction costs will also influence the final outcome.

In New Zealand the opportunity now exists under the 1991 Resource Management Act for water to be transferred. There is also pressure in New Zealand for the use of market based mechanisms to be used where appropriate. The advantages of markets as a mechanism to allocate water are:

a) water's value is recognised distinctly,
b) buyers and sellers agree to reallocation voluntarily, believing it is in their own best interests given the alternative opportunities available to them, and
c) price and other terms of transfer are negotiable by the buyer and the seller (Saliba and Bush, 1987).

Markets develop due to a mutual perception by buyers and sellers that economic gains may be captured by transferring water to a location, season, or purpose of use in which it generates higher net returns than under existing use patterns.

To maximise profits, firms will buy and use water and other inputs to minimise the costs of production and will produce items which have the highest market value.

Market prices will adjust to changes in technology, resource availability and consumer preferences, signalling production patterns to shift to whatever combination of goods and services currently has the highest market value.

By using a market system to allocate water, the problems of unsatisfied water demand or excess water supply can be resolved through voluntary responses of water right holders and prospective water users. Prices adjust to allocate water and other goods to those willing to pay the most for them so that anyone willing to pay the going price can obtain water (Saliba and Bush, 1987).

3.2.1 Conditions Necessary for a Market to Work

For a market to operate efficiently the following conditions are necessary:

Numerous participants. Each buyer and seller constitutes a small portion of the market so that their decisions have no effect on the price.

Homogeneity of product. The product bought by each purchaser is identical to that purchased by other participants. For water this would include such factors as water quality, and when the water is available. Therefore, water that was available in mid winter, could be considered a different market than water that was available at the time of greatest demand during the irrigation season.

Freedom of entry and exit. New firms desiring to enter the market face no special impediments that existing firms can avoid. Similarly, there are no barriers to firms that wish to leave.

Perfect information. Each firm is well informed about the availability of the product and their prices (Baumol, et. al., 1988). In regard to water, this includes information on the characteristics of the water right and the costs of alternative means of obtaining water (Saliba and Bush, 1987).

Information on the water right includes information on the security of both the legal and hydrological characteristics. Security of tenure does not necessarily imply security of supply. Most New Zealand rivers have variable flows and therefore supply uncertainty will remain (Sharp, 1989). In addition to the maximum allowable level of diversion, prospective buyers of water rights are concerned with the long term average expected yield, and the variability of the yield. The more secure and flexible a right is the more valuable it is (Saliba and Bush 1987)

Property, or water rights, must be completely specified, transferable and enforceable. The specification must include the privileges and restrictions, and the penalties for the violation of the right. The specification must also be exclusive and comprehensive, so that all rewards and costs accrue to the owner, and so that all attributes and uses of water that generate value can be represented by water rights. Transferability allows rights to move to their highest value. Enforceability is necessary because an unenforced right is no right at all

(Randall, 1987; Saliba, 1987).

When property rights are not totally exclusive, and third party effects exist, prices no longer convey accurate information about opportunity costs (Saliba and Bush, 1987).

The following conditions are necessary if markets are to result in an improvement in economic efficiency;

$$DB + IB_d + IB_s + NB > FDB + FIB_d + FIB_s + FNB + TC + CC \quad (3.1)$$

and

$$FDB + FIB_d + FIB_s + FNB + TC + CC < AC + (IB_d + IB_s + NB) \quad (3.2)$$

where DB = Direct Benefit of Purchaser
FDB = Foregone Direct Benefit of Seller
CC = Conveyance and storage Costs
TC = Transaction Costs
AC = Cost of Least Expensive Alternative Supply.
IB = Indirect User Benefits
FIB = Foregone Indirect User Benefits
NB = Nonuser Benefits
FNB = Foregone Nonuser Benefit
$_d$ = diversionary uses
$_s$ = in-stream uses

Equation 3.1 requires that the total benefits must exceed the total costs. This means that gains to the purchaser plus the indirect gains must exceed the total foregone benefits, both direct and indirect, and any transaction and conveyance costs.

Equation 3.2 requires that the total costs of transfer must be lower than the cost of the best alternative (Young, 1986).

A market transaction may occur if

$$DB > FDB + CC + TC \tag{3.3}$$

and

$$FDB + CC + TC < AC \tag{3.4}$$

Equation 3.3 states that the price offered by the purchaser must exceed the benefits forgone by the seller plus the conveyancing and transaction costs. Equation 3.4 requires the sum of the costs must be less than the alternative source of supply. The possibility exists that market transaction does not result in an efficient reallocation of water.

A market is biased in favour of direct benefits and costs, because a rational transactor will not look for or respond to missing information on third party effects. Moreover, third parties have no incentive to provide this information, since they are excluded from the transaction. (Nunn and Ingram, 1988)

The consequences of exclusion of third party effects from market decision making are

> "First,there is no "automatic" balancing of benefits and costs in the decision, so there is no guarantee that the transfer will result in an efficiency improvement. Second, choice, the mechanism that creates information on values, is missing for third parties; and third, transaction costs, at least those associated with litigation over third-party effects, are reduced by the exclusion of third parties from the

> transaction. If external effects are small, the exclusion of third parties may reduce costs with few ill effects; if they are large, the exclusion of third parties introduces a potential for misallocation due to lack of information and poor structuring of incentives." (Nunn and Ingram, 1988, p. 476)

Given the supply, demand and interdependency characteristics of water, transaction costs relating to the potential transaction tend to be high relative to the potential gains from the exchange (Young, 1986; Randall, 1972).

The opportunity cost criterion for efficiency requires that third party and public interests be recognised in market processes. Market prices will not reflect negative side effects of transfers unless policies require market participants to consider these impacts in their transfer negotiations. Implementation of this criterion requires policies that impose transaction costs on buyers and sellers as well as the administrative costs. Therefore, the legal framework governing market transfers is critical in determining which type of externalities are accounted for in market transactions and which are not. Protection of third party water right holders can entail high costs and can affect the level of market activity. Policies have to strike a balance between transaction costs imposed on market participants to protect third party and public interests and the benefits foregone when these interests are neglected in the market transfer process (Saliba and Bush, 1987).

3.2.2 Tradeable Water Permits

Tradeable water permits (water markets) could result in an effective pricing of water at its opportunity cost, yet proposals for tradeable water permits vary. All share characteristics that water entitlements would be legal property instruments, vested in the individual and negotiable independently of land. The various proposals differ in terms of the particular specification of rights transmitted by the entitlement and the initial distribution of entitlements. Market transfers can take many forms, depending on the legal characteristics of the water right, transactions and development costs, and the preferences of the buyer and seller. Market transfers can be divided into four basic categories: sales, leases, options and negotiated adjustments (Saliba and Bush, 1987).

a) Sales

Sales involve the permanent transfer of title including all benefits, costs, obligations and risks associated with the right.

b) Leases

Leases of water rights are temporary transfers, for varying lengths of time. Title remains with the original owner, and the benefits, costs, risks and obligations are often shared.

c) Options

Water right options are contracts signed between potential buyer and sellers, in which the terms of the contract specify the quantity, price and other conditions under which the water may be transferred. The advantage of options is their ability in allowing the buyer to know he has the option of water, when he is uncertain as to when and if he will need the water.

d) Negotiated adjustments

Negotiated adjustments do not involve transfer of rights, they are an agreement under which certain actions are undertaken which provides the buyer with increased access to water. an example is in a priority right system, where junior right holders negotiate with more senior priority appropriators to use water out of priority.

3.2.2.1 Examples of water markets

Markets for water have been discussed, particularly in the Western States of the United States of America. The need for markets has developed because in these states the demand for water is increasing and pressure exists to reallocate current supplies. Competition for water is increasing for power generation, municipal and industrial uses and for in-stream values and recreational uses. Irrigation accounts for 90 percent of the consumption and 74 percent of the withdrawals in the West (Frederick and Gibbons, 1986).

The issues of concern in developing institutional arrangements have included protection of other users and in-stream flows, transaction costs, area of origin issues, and the entitlement of the water right.

Law in the Western States of United States of America generally requires that water rights shall not be impaired by transfers. But implementation of this policy varies greatly. Procedures to protect the rights of third-party water users are a primary source of transaction costs associated with transfers. Typically, the costs of demonstrating nonimpairment are borne by the applicant for the transfer. In some states, such as Colorado, this is accomplished through a water court. In New Mexico, it is the State Engineer, and costs are shared by the applicant, the protestor and the office of the State Engineer (Saliba and Bush, 1987).

Water transfers can affect recreational, ecological and environmental values associated with in-stream flows. In-stream flows are typically year round rather than seasonal, and often extend along a stretch of a stream rather than being diverted at a single point, and are particular constraining for new water development and for water transfers (Saliba and Bush, 1987).

Area of origin issues are nonuser benefits and costs. Issues of concern when water is transferred out of a region is the possibility of a reduction in economic activity, a reduction in the region's tax base, and a loss of social infrastructure (Nunn and Ingram, 1988).

The concern over the entitlement of a water right can be illustrated with the ownership of conserved water. Water users may be able to reduce the water diverted for beneficial uses as water use patterns and technologies change over time. Water conservation technology would be adopted more readily if the water conserved could be used elsewhere or sold. Laws in United States of America vary on conserved water. California allows conserved water to be leased or sold whereas Nevada law states that a user has no right to his inefficiencies and therefore conserved water can be appropriated by others (Saliba and Bush, 1987).

In California, appropriate rights are transferable and able to be sold. The Water Resources Control Board may approve the transfer if there is no injury to other water users and it is in the public interest. The Board may authorise a trial period of less than one year if there is a possibility of injury to other water users (Saliba and Bush, 1987).

In Colorado, which has a doctrine of prior appropriation, district water courts rule on water right transfers. Litigation allows protests to be heard, and transfers are generally allowed if it can be proved that there are no adverse third party impacts. Colorado has both stream flow and reservoir rights. Stream flow rights are in terms of a maximum flow rate, and appropriators are able to withdraw water if the stream flow is at or above some specified minimum level. The more recent the right, the higher the stream flow before diversion is allowed.

Storage rights are defined in terms of volume. During any given year a right holder is allowed to fill their reservoir. The more senior the right holder fills before the junior right holders. Transfers are allowed but with native water, the courts have restricted this to the consumptive use portion.

With imported water, transfers are not subject to return flow obligations. Court proceedings are only necessary if the transfer is out of the original area or for a use not specified in the original appropriation decree.

Water companies often own the water rights and they are recognized as having the same point of diversion. Individuals own a proportional interest in the company, often as shares or stocks. Dividends are in the form of water allotments. Water is effectively traded in the form of shares, and court proceedings are only required if the transfer is outside of the company service area (Saliba and Bush, 1987).

Storage rights also exist in the State of Colorado. The Fry-Ark Project allow users to store any unused quantities of their water in the project's storage facilities, subject to space. The period of storage depends on the type of user (Saliba and Bush, 1987).

Water brokers exist within the Colorado-Big Thompson Project. Two different brokers exist. The broker can bring the interested parties together, or the broker can act as a speculator, where he buys or rents water until a buyer is found (Howe, et al, 1986b).

Tradeable water permits have several advantages, namely the ability to reflect the value of water and the flexibility of markets, but in the absence of the rigorous conditions necessary for markets to work perfectly, various institutional structures are necessary to achieve economic efficiency. The institutional structure will affect how public values are accounted for, whether the allocation mechanism is perceived as fair, and how politically attractive it is.

3.3 EVALUATING A WATER ALLOCATION SYSTEM

In evaluating how effective an institutional structure is at allocating a resource, the following criteria adapted from Baumol and Oats (1979) and Howe, et. al. (1986) could be used.

a) Dependability

How reliable is the approach in achieving its objective?

If the objective is economic efficiency, then the opportunity costs associated with water use and transfer must be accounted for by water right holders, so that their decisions are based on a complete assessment of benefits and costs. A socially responsible water allocation process must be capable of reflecting public values that may not be adequately considered by individuals.

b) Permanence

Will it endure when other issues have seized the public attention?

c) Adaptability to economic growth

Is it flexible enough to adopt to normal expansion in economic activities and population growth?

There should be flexibility, so as to allow water to be shifted in location, season and purpose of use in response to changing social and economic conditions. For this to occur, it is not necessary that all water be subject to reallocation, only that a tradeable margin exist within each major water using area.

d) Equity

Are financial advantages and burdens distributed fairly?

Water allocation process should be perceived by the public as equitable or fair. Water users should not impose uncompensated costs on other parties. Changes should be noncompulsory.

e) Incentives for maximum effort

f) Economy

Does the program achieve its results at a relatively low cost to society, or does it waste resources?

g) Political attractiveness

Is the method likely to recommend itself to legislators and to voters?

h) Minimal interference with private decisions

Does the method tell the individual exactly what to do, or does it offer the broadest scope of choices consistent with the objective with the policy? There should be security of tenure for established right holders, giving water users a basis for making long-term investment and planning decisions. Predictability of the allocation process helps water users know what to expect and to adjust gradually to changes. Prevailing requirements should be clear and not subject to unanticipated changes.

Howe, et. al., (1986) argue that markets meet the above criteria better than their likely alternatives in many situations. Protection of valid third-party interests in water is too often accomplished by outright prohibition of all transfers with adverse third party potential. Institutional innovations need to be developed which bring those interests into the negotiations, so that their losses can be compensated (Young, 1986).

CHAPTER FOUR

THE ASHBURTON CATCHMENT

The Canterbury Regional Council seeks to complete a catchment management plan for the Ashburton River by 1992. Traditionally, the river has been a primary source of stockwater and irrigation water to farms in the District and much of the water has been committed to these uses. The river also supports anadromous and freshwater fisheries, wildlife habitat and recreation. Because of the conflicting interests between continued water abstraction and in-stream uses, the management plan must address the balance between consumption and nonconsumption of flows in the Ashburton River.

This chapter provides an overview of the region and the catchment and identifies issues for economic analysis that can contribute to the management plan.

4.1 THE CANTERBURY REGION

The Ashburton River is located in mid Canterbury, on the central east coast of the South Island. It extends from the Pacific Ocean to the main divide of the Southern Alps.

Canterbury can be divided into three topographical regions: the high country, the foothills and the plains. The high country includes all land higher than 500 meters. This land lies immediately alongside and east of the main divide of the Southern Alps. The terrain is typically steep, except for undulating inland basins. There is approximately 2.3 million hectares, of which 1.2 million hectares can be farmed.

The foothills and downs contain numerous subsidiary ranges east of the high country, occupying 0.75 million hectares.

The plains lie between the foothills and the sea. They are about 193 kilometers long with a maximum width of 64 kilometers and slope from 300 meters to sea level. They occupy 0.9 million hectares and are the largest plains in New Zealand. The plains have been formed by deep beds of greywacke gravels carried east from the mountains and covered with alluvial and loessial material. The depth of this covering is very variable, from a few centimeters to over a meter. The shallow soils have free to very rapid drainage through the profile and are prone to wind erosion. The deeper soils have better water holding capacity, and some have drainage problems (Kear, et. al., 1967).

The topography has a major influence on the region. Canterbury's climate is influenced by the Alps. The climate is relatively dry. The Southern Alps form a barrier to the moist westerly winds. These are forced over the mountains to become dry northwesterly winds. Wind is particular important in Canterbury. In summer the nor'westers cause much drier conditions than temperatures and rainfall would indicate. Rainfall varies from 1200 millimeters in the high country to 500 millimeters on the coast. Rainfall tends to be evenly spread throughout the year, but is quite variable. The northwest wind combines with higher summer temperatures to cause summer drought. January and February are the warmest months with up to 20 days per year with air temperatures reaching 27-30°C. Evapotranspiration shows a marked summer peak leading to a water deficit during December to April. On average, soil moisture deficits of 42 days per year can be expected. In contrast, the winter months experience about 100 days of frosts at Ashburton (Ministry of Agriculture and Fisheries, 1986).

The water resources of the region are also influenced by the three landform regions. The region's rivers (see Figure 1.1) originate in either the high country (Rangitata, Rakaia, Waimakariri) or the foothills (Orari, Hinds, Selwyn, Ashley). The Ashburton has headwaters in both the foothills and the high country. Rivers that originate in the alpine regions are strongly influenced by snow, while rivers whose headwaters are in the foothills respond almost entirely to rain (Hayward and Ackley, 1983).

The farming systems employed in Canterbury range from extensive grazing in the high country to more intensive production on the better soils on the plains. Because of its high altitude and severe winters production from the high country is mainly fine wool and store livestock, although diversification into other enterprises such as deer farming has occurred in the last decade. The major emphasis in farming in foothills and downlands is prime lamb and cattle breeding (Ministry of Agriculture and Fisheries, 1986).

Farming systems on the plains within the Ashburton District vary from prime lamb production under dryland farming systems to intensive crop production with irrigation.

The dryland farming system is characterised by up to 50 percent of pasture growth occurring in the spring, a flexible stock policy with a stocking rate of 7-12 stock units[1] per hectare (SU/ha), early lambing (July to September) to enable lambs to be drafted before the summer dry period. Many farmers aim to have a flexible farming system that allows them to manage their farms according to the variable climatic conditions (Ministry of Agriculture and Fisheries, 1986).

With the reliability of plant growth that irrigation provides, a more diverse range of activities occur. With increased plant growth (see Figure 4.1) stocking rates can be increased and a wide range of crops can be grown that could not be successfully grown without irrigation. Crops grown include wheat, barley, peas, small seeds (clovers and grass seeds), process crops such as peas, beans and squash. Irrigation also decreases the variability in performance that occurs on dryland farms due to the climatic variation. Therefore, with irrigation, farm systems range from intensive stock enterprise to intensive crop production (Ministry of Agriculture and Fisheries, 1984).

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[1]The stock unit (SU) conversion relates the total yearly energy requirements of various classes of stock to the requirements of one 55 kilogram breeding ewe producing one lamb per annum. Stock units are conventionally calculated for the winter tally at 30 June (Fleming and Burtt, 1991).

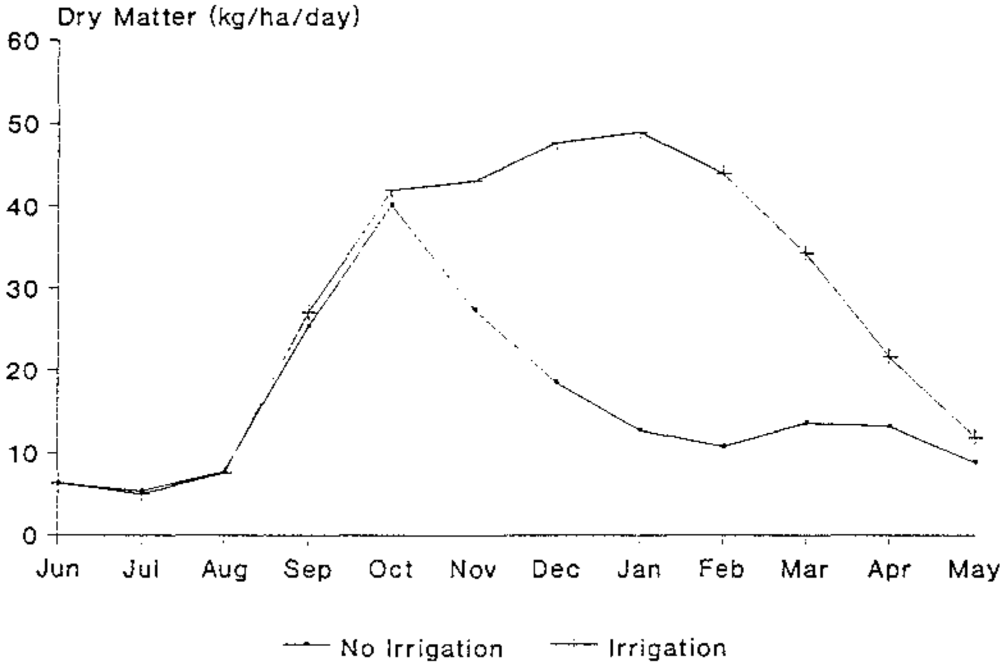
Irrigation has played a major role in the development of the region with both community and private border dyke schemes being used. Spray irrigation is also widely used especially on the heavier soils which have traditionally been used for cropping or dairy farming. Increased interest is now being expressed in horticultural crops, such as apples, by both farmers and investors (Yates, 1991).

The Levels and Redcliff Irrigation Schemes were opened in the 1930s at the same time construction began on the Rangitata Diversion Race (RDR). The Rangitata Diversion Race supplies three community irrigation schemes with 57,400 hectares able to be irrigated.

In 1982 in excess of 100,000 hectares of land in Canterbury was irrigated with water from community irrigation schemes, involving about 1600 farmers. A similar area was developed privately, although often it is spray irrigated using ground water. Another 750,000 hectares has been identified as being suitable for irrigation (Lewthwaite, 1983). Since the mid-eighties irrigation development has been static.

There are about 433,000 people living in Canterbury, the second largest population and the largest land area of any region in New Zealand. Christchurch city is the largest population centre with 286,600 residents or 66 percent of the regions population. Timaru city is the next largest centre with 27,600 residents or 6 percent of the region (New Zealand Census, 1986).

Figure 4.1 Rate of Pasture Growth



4.2 MID CANTERBURY

Mid Canterbury or the Ashburton District is bounded by the Rakaia River and the Rangitata River, the Southern Alps and the sea. The main settlement is Ashburton. The population of the District is 24,855 which accounts for 5.7 percent of the region's population. Approximately 13,900 individuals reside in the Ashburton Borough, with a further 10,900 people residing in Ashburton county (New Zealand Census, 1986). Other settlements include Methven and Rakaia. Ashburton has a major role as a servicing town for the surrounding area. Methven also supports tourism activities, such as Mount Hutt ski field, developed in the last 20 years (Duffey, et. al.,1976).

Mid Canterbury's 530,000 hectares comprise two distinct areas, the plains and the high country. Nearly half (240,000 hectares) is mountains and upland valleys. About 100,000 hectares is unfarmable rock ice and snowfields. Of the 280,000 hectares of plains, about 200,000 hectares are shallow soils of low water holding capacity and low natural fertility; 50,000 hectares are free-draining cropping soils and the remaining 30,000 hectares are deep cropping soils with some drainage impediments (Ministry of Agriculture and Fisheries, 1980).

In mid Canterbury, the Rangitata Diversion Race provides water to three schemes irrigating 57,400 hectares. The Greenstreet scheme irrigates 2,700 hectares (See Table 4.1). Another 120,000 hectares could be irrigated, of which 20,000 hectares borders the Ashburton River and its tributaries (Lewthwaite, 1983).

Table 4.1 Irrigation Schemes in the Ashburton District[a]

Scheme	Irrigable Area (hectares)
Ashburton-Lyndhurst	26,000
Greenstreet	2,700
Valetta	7,000
Mayfield-Hinds	24,400[b]
Total[c]	60,100

[a] Source Lewthwaite, 1983.
[b] Other sources (Ministry of Agriculture and Fisheries, 1980) place total area at 34,400 ha
[c] The area irrigated does not include areas privately irrigated.

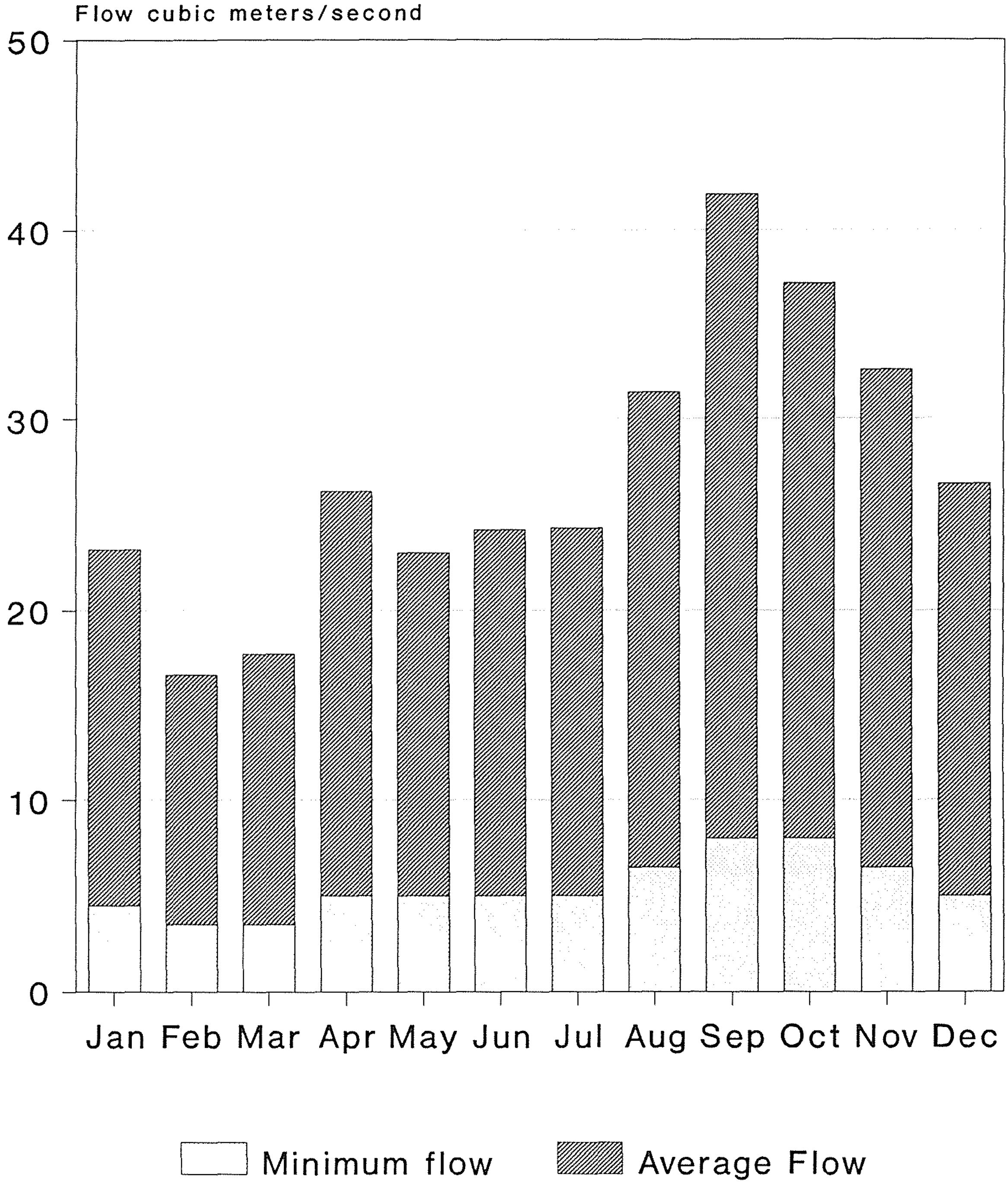
4.3 THE ASHBURTON RIVER

The Ashburton River is a relatively small braided river. It is formed of two main tributaries, the rain-fed north branch and the snow-fed south branch. The south branch, the largest of the two, rises at the Ashburton Glacier in the Arrowsmith Range. It drains half an intermountain basin containing several lakes and tarns. The South Branch has a number or tributaries including Taylors Stream, Bowyers Stream and the Stour River. It flows through a gorge before emerging onto the Canterbury plains and becoming a braided river.

The South Branch meets the North Branch approximately 2.5 kilometers west of the Ashburton township. The North Branch drains part of the Mount Hutt, Black Hill, Old Man and Alford Ranges (Gabities Porter and Partners, 1986).

Having headwaters in both the mountains and the foothills, the Ashburton streamflow is influenced by both snow and rainfall. Towards the end of September, the snow pack which has accumulated over the winter, begins to melt. The snow pack is sufficient to sustain comparatively higher flows until early January, by which time the seasonal storage of snow has been exhausted. River flows continue to recede until an annual low flow occurs during the mid February to mid April period. Figure 4.2 shows the average flow for the Ashburton River at Ashburton.

Figure 4.2 Ashburton River Flow Statistics at Ashburton



4.3.1 Water Use of the Ashburton River

Water of the Ashburton River is used for irrigation and stockwater, municipal supplies, effluent assimilation, electricity generation, wildlife and fisheries, and a wide range of recreational pursuits.

Water for domestic and industrial purposes in the townships of Ashburton and Methven total 0.274 cubic meters per second.

Over 100,000 hectares of the Ashburton District is serviced by open stockwater races. Water rights for stockwater total 9.94 cubic meters per second but average use is around 4-4.5 cubic meters per second. Irrigation abstraction water rights total about 9.59 cubic meters per second. Three quarters or 7.1 cubic meters per second, is held by the Rangitata Diversion Race as a notified use (Scarf, 1983). During periods of low flow, the abstraction levels of the Rangitata Diversion Race are voluntarily restricted to ensure that between 1 and 2 cubic meters per second was allowed to flow past the intake (Morris, 1991).

The Ashburton River has traditionally been an important recreational fishery. The river provided salmon, trout, whitebait and flounder. Work carried out by the Ministry of Agriculture and Fisheries considered the river as regionally important, and was heavily fished by local anglers. Fishing licences were held by 24 percent of the adult male population in the Ashburton Acclimatization District in 1981, which is double the figure held by the neighbouring North Canterbury

Acclimatization District, indicating the importance of fishing to the area (Eldon, et. al., 1982).

The fishery has declined in recent years because of low river flows. Salmon require a continuous flow from the headwaters to the mouth. Low flows can also isolate and reduce trout habitat. The low flows are compounded by the periodic closure of the river mouth. This is a naturally occurring phenomenon with the movement of beach sediments into the mouth. The low flow during the summer months often coincides with the salmon run upstream to their breeding grounds (Scarf, 1983).

The Ashburton River is a wetland habitat for a high number of bird species, some of which include the endemic black-fronted terns, black-billed gulls and the wrybill plover. These birds have adapted to the braided nature of Canterbury's rivers, and rely on the weed-free shingle for nesting sites and protection from predators. As such, the Ashburton River is considered as being of outstanding value to wildlife and of international importance. (O'Donnell and Moore, 1983)

The river offers a variety of recreational opportunities. In addition to fishing and bird-watching, many people enjoy boating, swimming and picnicking. There is also a 19 kilometer walkway from the township to the river mouth (Scarf, 1983).

4.3.2 Management of the River

In 1983, the South Canterbury Catchment Board recognised that with the increasing demand for irrigation water, the water resources of the Ashburton River, including groundwater, were heavily committed. Because of the conflicting interests between abstraction and the need to maintain sufficient flows throughout the river for fisheries protection, wildlife habitat and recreational use, there was an urgent need to formulate a management plan (Scarf, 1983).

According to Scarf (1983), the principle objectives of the plan were to set minimum flows for the river, to preserve the natural flow pattern and quality of the river, to establish priorities for utilisation of the resource, and to specify how the available water resources were to be allocated between in stream and out of stream users.

The Board established a monthly minimum flow level for the river. This was approximately 20 percent of the mean monthly flow. The Board indicated that at the next review in 1990, it intended to raise the established minimum flows to 30 percent of the mean monthly flow. This was based on guidelines from the United States and Canada. The Board suggested that the initial minimum flow standards could be met without placing unacceptable restrictions on existing consumptive users.

The management plan is especially important for summer and autumn period. Water in excess of the established minimum flow levels was to be shared. For the months September through to April inclusive, water in excess of the minimum flow is allocated on the following basis:

a) Above the minimum flow level and up to 7 cubic meters per second all excess is allocated to out of stream use.

b) Above the minimum flow plus 7 cubic meters per second and up to a flow equal to the minimum flow plus 13.82 cubic meters per second, excess water is shared equally between in-stream and out of stream users.

c) Above the minimum flow plus 13.82 cubic meters per second all excess is dedicated to in-stream use.

In the event of serve drought conditions resulting in low flows in the river, the order of priority of use is: domestic, stockwater, fisheries and wildlife protection, irrigation and power generation.

To assist in monitoring abstractions all abstractions in excess of 100 litres per second were to monitored with some form of metering device, as specified by the South Canterbury Catchment Board.

But the Board felt that even with this plan, water restrictions would be necessary each year, particularly during February and March. Restrictions would be placed proportionally and progressively on irrigation abstraction, to maintain the minimum stream flows specified in the plan.

The management plan recommended that means of supplementing the available water resource be investigated. Both the Ashburton County Council and the South Canterbury Catchment Board have supported the replacement of the existing inefficient open race system with a piped rural supply in the interests of improved utilisation of the Ashburton River water. Other potential plans include the enhancement of the streamflows over the critical months by damming the river near its source and impounding water over the winter and early spring months (Scarf, 1983).

Pre-feasibility studies have already been undertaken, directed towards identifying suitable ways to enhance flows. One option is a major storage reservoir before the South Branch reaches the plains (Gabites Porter and Partners, 1986).

4.4 ISSUES FOR ECONOMIC ANALYSIS

For water allocation , the Canterbury Regional Council can base the management plan for the Ashburton River on the economic efficiency of competing uses, equity and distribution considerations, or pure ecological factors.

In the current climate which promotes economic efficiency in resource management, the Regional Council may seek to place more emphasis on economic efficiency in the management plan. In this event the Council will need two important pieces of information - the value of water to abstractive users (agriculture) and the value of in-stream flows to regional residents. Once these values have been estimated, the Council could consider designing an allocation scheme that attempts, in part, to maximise the value of the river to regional residents.

Besides allocation of existing water in the Ashburton River, the Canterbury Regional Council may choose to decide if development projects to enhance or smooth the stream flows throughout the year are warranted. The Council may also decide whether technical improvements for abstractive users, which would decrease the amount of water abstracted, are warranted. In both these cases, analysis of the economic efficiency of these options would be useful to the Council; such an analysis would rely on estimates of the economic value of water for agriculture and/or in-stream flows.

CHAPTER FIVE

METHODS TO VALUE WATER

This chapter describes the methodology that is used in this thesis to determine the value of abstractive and in-stream flows of the Ashburton River. A linear programming approach is used to determine the value of irrigation water, the predominant abstractive use. A contingent valuation approach is used to determine the total value of an increase in the minimum streamflow.

5.1 LINEAR PROGRAMMING

The value of goods that have private good characteristics can be determined from market data. Irrigation is predominantly a private good, in that the benefits and costs accrue to the user. Irrigation water is an intermediately good used to produce final goods of agricultural produce. The value of irrigation water can therefore be determined by the difference in value of the agricultural produce with and without water, keeping all other input and market conditions the same (Gibbons, 1986).

A parametric linear programming approach is used to determine the marginal value of irrigation water to individual farmers, in the short run. These values are then aggregated to determine the regional value of irrigation water. This technique has been used previously (for example, see Flinn, 1969; Bernado, Whittlesey, Saxton, and Bassett, 1988; Hamilton, Whittlesey, and Halverson, 1989; Hall, Mallawaarachi, and Batterham, 1991; Jones, 1991).

Linear programming is a mathematical technique that is concerned with the determination of the optimal solution to problems (Baumol, 1977). The basic problem is one of either maximising or minimizing a function of several variables, with the variables being subject to a number of constraints. The constraints as well as the function being optimized are linear (Swanson, 1987).

Linear programming is normative in that it describes what ought to be when the objective is a particular form subject to the particular form of restraints. It is not positive, which explains phenomena as they exist (Heady and Candler, 1966). Typically the objective is to maximise profit or minimise costs, subject to a set of inequalities which provide that the total amount of resources used cannot exceed the resource supplies available. Because "straight line" relationships are employed in linear programming, the prices received and the input-output coefficients, or the amount of a resource required to produce a unit of output, are assumed to be constant (Heady and Candler, 1966).

A linear programming problem can be formulated when there exists:

a) an objective which can be quantified as in dollars of profit or cost, amount of physical input or output,

b) alternative ways or processes of obtaining this objective, and

c) restrictions which can be used in attaining the objective (Heady and Candler, 1966).

A process is a method of converting resources into output. In general, two processes are the same if they use the same resources in the same proportions to produce the same output. Therefore, if there is a change in the proportions in which resources are used or products produced, a new process must be defined. For example, for a farmer producing a crop with water as an input, if one unit of water results in one unit of crop, this is the same process as two units of water resulting in two units of crop. It is a different process if two units of water results in one and a half units of crop (Heady and Candler, 1966; Swanson, 1987).

A linear programming objective function may be to maximise total gross margin, which is equivalent to maximising net farm income (or economic profit) in the short-run evaluation where fixed costs of production are not dependent on the chosen management plan (Rae, 1977).

The programming problem is to select a combination of the processes which will maximise profits. Any program selected must be a feasible program. A feasible program is one which does not have total resource requirements exceeding the total resource supplies. There is an infinite number of feasible programs but generally only one optimum feasible program. Thus, profit must be maximised subject to the restrictions of the resource supplies and the condition that no activity level can be negative (Heady and Candler, 1966).

For example, for a given farm situation, the linear programming model to determine the maximum gross margin possible can be written as follows:

$$\max Z = \sum_{j=1}^{n} c_j X_j \tag{5.1}$$

such that

$$\sum_{j=1}^{n} a_{ij} X_j \leq b_i, \quad all\ i = 1\ to\ m \tag{5.2}$$

and

$$X_j \geq 0, \quad all\ j = 1\ \ to\ n \tag{5.3}$$

where X_j = the level of the jth farm activity, such as the acreage of wheat. n denotes the number of possible farm activities.

c_j = the forecasted gross margin of a unit of the jth activity (e.g. dollars per hectare).

a_{ij} = the quantity of the ith resource (e.g. hectares of land or millimeters of water).

b_i = the amount of the ith resource available (e.g. hectares of land or amount of water).

Z = total gross margin.

The problem is to find the farm plan (defined by a set of activity levels X_j, j = 1 to n) that has the largest possible gross margin, but does not violate any of the fixed resource constraints, or involve any negative activity levels.

A number of assumptions are implicit in the linear programming model

a) Optimisation

It is assumed that an appropriate objective function is either maximised or minimised.

b) Fixedness

At least one constraint has a nonzero right hand side coefficient.

c) Finiteness

It is assumed that there are only a finite number of activities and constraints to be considered so that a solution may be sought.

d) Determinism

All c_j, a_{ij}, and b_i coefficients in the model are assumed to be known constants.

e) Continuity

It is assumed that resources can be used and activities produced in quantities that are fractional units.

f) Homogeneity

All units of the same resource or activity are identical.

g) Additivity

The activities are assumed to be additive. When two or more are used, their total product is the sum of their individual products. That is, no interaction effects between activities occur.

h) Proportionality

The returns and resource requirements per unit of activity are constant regardless of the level of the activity.

The assumptions of additivity and proportionality together define linearity in the activities (Hazell and Norton, 1986).

The solution to the problem described above can assist the decision marker in determining which farm enterprises to select, and how much of each to produce to maximise total gross margin. Further increases in total gross margin are only possible if additional units of the fixed resources that restrict output can be obtained. If an additional unit of the fixed resource is used in a profit maximising way, then the marginal value product (shadow price) of the additional unit can be determined (Hazell and Norton, 1986).

It is possible to specify a linear programming model to determine the optimal shadow prices for the fixed resources.

Let λ_i denote the shadow price of the ith fixed resource. Then

$$\min W = \sum_{i=1}^{m} b_i \lambda_i \tag{5.4}$$

such that

$$\sum_{i=1}^{m} a_{ij} \lambda_i \geq c_j, \quad all\ j = 1\ to\ n \tag{5.5}$$

and

$$\lambda_i \geq 0 \quad all\ i = 1\ to\ m \tag{5.6}$$

This determines the shadow prices to the farm resources b_i that yield the lowest possible value W for the total endowment of the fixed resources, with the total value of the resources used by one unit of each activity X_j being equal to or greater than the gross margin c_j earned by that activity (Hazell and Norton, 1986).

This problem is mathematically closely related to the one specified in equations 5.1 to 5.3 and is the dual problem of equations 5.1 to 5.3. At optimality, the values of the two objective functions 5.1 and 5.4 are equal. Once the solution of either problem is obtained, the solution to the other is also obtained (Swanson, 1987).

5.1.1 Parametric Linear Programming

Parametric linear programming allows a series of optimum plans to be produced, for differing levels of any parameter of the problem (Rae, 1977). This technique can be used to study how a farmer who wishes to maximise returns would act with either differing amounts of availability of an input or differing prices for an input. For example the supply of water could initially be unrestricted and then slowly reduced in several steps. As water is constrained, the product that has the lowest marginal value of water would be decreased first. Thus parametric variation allows the derivation of the marginal value product (shadow price) of water over a range of available quantities.

By parametrically varying the supply of water available to the farmer, changes in the level of production and net margins can be obtained. Water is a factor of production. As the supply of water decreases or the price of water increases the farmer can adopt by using less water and thus reducing yield, substituting other inputs for water, especially improved management, changing the crop mix, or investing in improved water efficiency. Factors which influence this decision include the crop selling price, the costs of growing the crop, physical limitations of soil, climate, pest and disease especially where crop rotation is an important management technique for disease prevention, and the risk and management of growing the crop.

As the supply of water is decreased (increased) the output that provides the lowest (highest) return to water will be removed (introduced) from (to) the plan. Therefore, by determining the marginal value product of water over the range of the supply of water allows the demand curve for water to be determined (Rae, 1977).

Alternatively a water selling activity could be included in the programme. The farmer then has the option to use the water to grow crops or to sell water. By parametrically varying the price at which water could be sold enables the supply curve of water to be determined.

5.1.2 Advantages and Disadvantages of Linear Programming

Linear programming has several advantages. The approach can consider the farm as a decision unit. Most farms produce more than one enterprise and have a variety of inputs available for use. Therefore, farmers can respond in the short run by varying the inputs and/or enterprises. The model can capture this behaviour and therefore simulate the actual decision process. The technique offers flexibility, in that, a range of variables can be included and studied. The analysis does not depend on time series data and therefore new alternatives that have no historical counterpart can be studied.

A disadvantage of using a linear programming technique is that values derived are not crop values but farm values. The technique is data dependent. It is necessary to determine the coefficients before programming can begin. For example, the yield responses to differing levels of water for some new specialist crops may not be currently documented, and therefore, unable to be reliably modelled.

The above model specifications are limited in that they are based on average values and do not encompass the variation that occurs whether natural variation such as climatic conditions or price variation. In this application the objective function indicates profit maximisation, a single-period planning horizon and a certain environment (no uncertainty about yields, prices and so forth). Farmers often have multiple objectives and more complex models could be developed. However, these limitations do not invalidate the results.

The advantages of linear programming, in that it models the farm as the decision unit and that it can study the effect of changes in resource constraints, makes the technique suitable to determine the economic value of irrigation water and to study the effect of any change in the supply of irrigation water.

5.2 CONTINGENT VALUATION

To determine the economic value of in-stream flows of the Ashburton River a contingent valuation approach is used. Contingent valuation (CV) uses economic theory and methods of survey research to elicit directly from consumers the values they place upon nonmarket goods. Survey questions are used to elicit people's preferences for nonmarket goods by finding out in monetary terms what they would be willing-to-pay (WTP) for specified improvements in them, or willing-to-accept (WTA) as compensation for no improvement or deterioration in the good. It circumvents the absence of markets by presenting consumers with hypothetical markets. The elicited values are contingent upon the particular hypothetical market described to the respondents.

Respondents are presented with material which consists of three parts (Mitchell and Carson, 1989):

a) A detailed description of the good(s) being valued and the hypothetical circumstance under which it is made available to the respondent. The researcher constructs a model market in considerable detail, which is communicated to the respondent in the form of a scenario. The market is designed to be as plausible as possible. It describes the good to be valued, the baseline provision, the structure under which the good is provided, the range of available substitutes, and the method of payment.

b) Questions which elicit the respondents' willingness-to-pay for the good being valued. These questions are designed to facilitate the valuation process without themselves biasing the respondents' willingness-to-pay.

c) Questions about respondents' characteristics (for example age, income), their preferences relevant to the good, and their use of the good. This information, some of which is usually elicited preceding and some following the reading of the scenario, is used in regression equations to estimate a valuation for the good. Successful estimations use variables which theory identifies as predictive of peoples willingness-to-pay are partial evidence for reliability and validity.

The ultimate aim of a contingent valuation study is typically to obtain an accurate estimate of benefits (and sometimes costs) of a change in the level of provision of some nonmarket good. The advantage of contingent valuation is that values other than use values may be obtained for a range of goods, including those not yet provided.

5.2.1 Economic Theory of Contingent Valuation

Contingent valuation methods rely on the theory of individual demand curves. Because contingent valuation methods attempt to define consumers' demand curves they take full account of consumer surplus in estimating benefits.

The measures obtainable by contingent valuation methods can be represented in terms of the difference between two expenditure functions. Such a representation reveals that in a contingent valuation survey a respondent is being asked to determine what change in his income, coupled with the change in the level of the public good, leaves his utility level unchanged. For a discrete quantity change which can be specified in advance, contingent valuation is capable of obtaining the expected Hicksian measure without having to estimate directly any form of either the Marshallian demand curve or one of the Hicksian compensated demand curves (Mitchell and Carson, 1989). For example, a respondent could be asked how much they would be willing-to-pay for an increase in the minimum stream flow of the Ashburton River. In this situation the Hicksian compensating surplus would be determined. That is, the amount of compensation paid that will leave the respondent in his initial welfare position following the increase in the minimum stream flow.

5.2.2 Willingness-To-Pay Versus Willingness-To-Accept

Whether an elicitation question in a contingent valuation survey is phrased in terms of willingness-to-accept or willingness-to-pay depends on which Hicksian consumer surplus measure the researcher wants to obtain. The choice between willingness-to-accept or willingness-to-pay formulation is a question of property rights: does the agent have the right to sell the goods or, if he wants to enjoy it does he have to buy it? Since nonmarket goods are being dealt with the question is not easy to answer (Mitchell and Carson, 1989).

Economic theory suggests that the four measures of consumer surplus should be similar. Any differences between willingness-to-pay and willingness-to-accept focus on the income or wealth effects. Gordon and Knetsch (1979) suggest that in practice the differences between the two values are quite large. They found no support for the income effect being the complete explanation, but that the amounts of willingness-to-accept as well as willingness-to-pay positively related to household income and that income may be less of a restraint on willingness-to-pay than on willingness-to-accept. They suggested that people may underestimate their willingness-to-pay, hedging against actual payment, and overstate their willingness-to-accept to better assure that their losses are covered. Knetsch (1990) stated it as

> " instead of comparing alternative end states, people usually evaluate gains and losses in terms of changes from some reference position. And they value losses from this neutral point much more than they do gains beyond it." (p.228)

This is 'prospect theory', where the value function is steeper for losses than for gains, and therefore willingness-to-accept compensation for losses is greater than willingness-to-pay for gains. Other hypotheses put forth to explain the difference between willingness-to-pay and willingness-to-accept include:

a) Rejection of the willingness-to-accept property right. People reject the property rights implied by the willingness-to-accept format. This is often seen in surveys where there are a large number of protest bids such as "I refuse to sell".

b) The cautious consumer hypothesis. Consumers who are uncertain, who lack time to optimize their decision, or are risk averse will tend to give lower willingness-to-pay amounts and higher willingness-to-accept amounts than they would under perfect conditions. Experiments have shown that willingness-to-pay and willingness-to-accept amounts do converge as subjects gain experience in repeated trials. Normally willingness-to-accept bids reduce while willingness-to-pay amounts are quite stable. (Mitchell and Carson, 1989 quoting Brookshire Coursey and Radosevich, 1986)

c) Modifications of received economic theory. For public goods with many close substitutes, the elasticity of substitution between the public good being valued and all other goods in the economic system will be large, with the result that willingness-to-pay and willingness-to-accept should be close together. For public goods with limited substitution possibilities relative to income elasticity willingness-to-pay and willingness-to-accept can differ markedly (Hanemann, 1991).

Thus, valuing resources in terms of willingness-to-pay, which may be the easiest of options, may result in resources being undervalued. It also has implications for methods used to achieve desired policy outcomes. The effectiveness of a government policy may depend on whether it is viewed as a loss or a gain. For example, a tax to control pollution will be viewed as a loss and therefore provide a greater incentive effect than a subsidy (Knetsch, 1990).

5.2.3 The Market Scenario

A crucial difference between the indirect and direct methods is that indirect methods are based on actual behaviour where as direct questioning relies on the respondents "willingness to reveal their true preferences." The principal challenge facing the designer of a contingent valuation study is to make the scenario sufficiently understandable, plausible, and meaningful to respondents so that they can and will give valid and reliable values despite their lack of experience with one or more of the scenarios dimensions. Because contingent valuation surveys create a hypothetical market in the good they must confront the respondent with a well defined situation and elicit a circumstantial choice contingent upon the situation (Mitchell and Carson, 1989). To ensure meaningful results are obtained, Rowe and Chestnut (1982) stated that a contingent valuation scenario

> " must be informative; clearly understood; realistic by relying upon established patterns of behaviour and legal institutions; have uniform application to all respondents; and, hopefully, leave the respondent with a feeling that the situation and his responses are not only credible but important." (p. 70)

The chosen payment vehicle should have a plausible connection with the amenity it is used to value. If the vehicle does influence the willingness-to-pay amounts, it is the policy rather than the public good that is being valued. It is to be expected that responses will vary according to the information provided, since the willingness-to-pay amounts are contingent on the scenario. The hypothetical character of contingent valuation does not bias the result in any particular way, but represents a reliability problem (Mitchell and Carson, 1989).

Theoretical validity involves assessing the degree to which the findings of a study are consistent with theoretical expectations. This is most commonly measured by regressing some form of the willingness-to-pay amount on a group of independent variables believed to be theoretical determinants of a person's willingness-to-pay for the good being valued. Several studies cited by Mitchell and Carson (1989), such as Tolley and Randall's study in 1985 of air visibility, showed that the values elicited in these studies are related to the respondents' preferences in the predicted manner and is evidence of their theoretical value.

5.2.4 Techniques to Elicit Payment

There are several different contingent valuation techniques that can be used to elicit peoples willingness-to-pay (Mitchell and Carson, 1989; Cummings, et.al., 1986; Boyle and Bishop, 1988). Each is described below.

5.2.4.1 Open-ended question

After the scenario is described, respondents are questioned as to the maximum amount they are willing-to-pay for the change described in the scenario without the aid of additional information. This technique is often used in mail and phone surveys. The advantages of the method include the simplicity to administer, in that no interaction between the respondent and the surveyor is required, and therefore there is less opportunity for surveyor biases. One concern is that because people are not experienced in valuing public goods, it may be expecting too much of respondents to provide accurate values. Cummings, et. al., found that open-ended questions produced lower values than bidding games (Bishop and Heberlein, 1987)

5.2.4.2 Iterative bidding

As in all contingent valuation studies the first step is to describe the item to be valued in detail, and the hypothetical market to the respondent. A willingness-to-pay format begins with the interviewer suggesting a starting bid. If the respondent is willing-to-pay the initial bid, the interviewer records the information and raises the bid. The bid increases until the respondents are no longer willing-to-pay. A concern is that the initial bid can influence the respondent's final bid, that is, starting point biases.

There are several variations on the bidding game. Most variations are designed to minimise starting point biases. One is the bracketed bid procedure. A respondent is given a very high or very low initial price, the next price is at the opposite end of the price range as the first, such that a high-low bracket is established. Subsequent bidding narrows the high-low range until the respondent final price is obtained.

5.2.4.3 Payment-card

After explaining the scenario, respondents are handed a payment card, which may also show amounts spent on other nonmarket goods (anchors), to remind people that they do already "pay" for such goods. This is an anchored payment card and is often tailored to the respondent's income category. The anchored cards generate fewer protest bids than do other questioning formats, but may be susceptible to anchor point bias, similar to starting point bias (Boyle and Bishop, 1988).

5.2.4.4 Contingent ranking

Respondents are asked to rank various combinations of goods and monetary outlays. Respondents are asked to rank alternatives from most to least preferred and values are inferred through statistical analysis (Bishop and Herberlein, 1987).

5.2.4.5 Dichotomous-choice format

Most respondents have never attempted to place a monetary value on environmental amenities and may find it difficult to provide a specific dollar value (Boyle and Bishop 1988). In a market, the price of a good is stated and the person must indicate whether they would buy at that price or not. To make the valuation question similar to a type of market, Bishop and Heberlein (1979) pioneered a 'take or leave it' or referendum approach. Since then a number of experiments have been undertaken with discrete responses. (Sellar Chavas and Stoll, 1986; Cameron, 1988; Boyle and Bishop, 1988; Greer and Sheppard, 1990)

In this approach, the respondent is asked to state whether they accept or reject a single take it or leave it offer. Respondents are not asked to state a specific dollar value. The argument in favour of this approach is the simplicity for the application in a survey format. This format can be used in a range of surveys, including mail surveys, unlike other techniques such as bidding games. However, the analysis of this data requires more sophisticated statistical procedures. (Boyle and Bishop, 1988)

With referendum data, the exact magnitude of the individual's valuation is unknown. All the analyst knows is whether it is greater or less than some specified amount (Cameron, 1988). To estimate an equation that infers willingness-to-pay requires a function that translates the yes or no responses into a range of probabilities that vary with the prices offered.

$$Y = f(\$X) \tag{5.7}$$

For this purpose a linear model is inappropriate because:

a) Y could lie outside the zero to one range.

b) Linear models assume that

$$P_i = E(Y=1 \mid \$X) \tag{5.8}$$

which is the probability of individual i answering yes to a dollar value $X. This increases linearly as the value of X increases.

Alternatively, the marginal or incremental effect of $X remains constant throughout.

c) The error term of the estimated function may not be normally distributed.

d) The error term may be heteroscedastic, shown as nonequal variance of the error term.

Therefore, a nonlinear statistical model is necessary. One possible model is a logit model. A logit model is consistent with utility theory (Hanemann, 1984) and has been used previously (Sellar Chavas and Stoll, 1986; Cameron, 1988; and Greer and Sheppard, 1990).

Two utility theoretic motivations for dichotomous choice models have been suggested in the literature by Hanemann (1984) and Cameron (1988). Hanemann's approach allows specification of the indirect utility function, while Cameron's involves specifying a form for the expenditure function. The work by these authors has led to unresolved differences as to the theoretical consistency of alternative function forms (Duffield and Patterson, 1991).

In this thesis Hanemann's approach is followed. With readily available numerical intergration programmes, there is no need to reparameterize the logit equation when using Hanemann's approach, as is necessary when using Cameron's approach.

Mathematically, the logit is expressed as:

$$Prob\ Yes = \frac{1}{1+e^{-z}} \tag{5.9}$$

where e = natural logarithm
z = a function of variables including the initial price offer P which are, hypothesised to predict the respondents answers to the valuation question.

Since the yes and no responses to the valuation question are mutually exclusive events, the probability of a no is equal to [1-Prob Yes]

The probability of a no is

$$Prob\ No = \frac{1}{1+e^{z}} \tag{5.10}$$

Therefore the odds ratio of a yes

$$\frac{Prob\ Yes}{1 - Prob\ Yes} = \frac{1+e^{z}}{1+e^{-z}}$$

$$= e^{z} \tag{5.11}$$

such that

$$\ln\left(\frac{Prob\ Yes}{1 - Prob\ Yes}\right) = z \tag{5.12}$$

Two properties of the logistic function make it particularly well-suited to modelling discrete choices. First, the fact that it is restricted to the zero-one interval permits it to be used as a probability function. Second, the function can be converted to a linear form by the logit transformation (Stynes and Peterson, 1984). A potential disadvantage of logit is that statistical estimation requires the use of maximum likelihood estimation, although this has diminished as a disadvantage with the development of large capacity personal computers and statistical software that routinely includes maximum likelihood estimate techniques.

The logit of a probability of a no response is a cumulative distribution function. A cumulative distribution function is where the probability of X takes on a value less than or equal to *x*, where *x* is some specified numerical value of X. Therefore, the logit function for willingness-to-pay (the probability of a yes) is an inverse cumulative distribution function. The area under the curve is the expected value or mean of the maximum willingness to pay. Mathematically, the expected value is the integral of the inverse cumulative distribution function (Loomis, 1988).

$$WTP = \int_0^{\infty} [1 - \frac{1}{1+e^{z}}]\, dP \tag{5.13}$$

A difficulty with the estimation of maximum willingness to pay is that data does not exist for the range of dollar values from zero to infinity. The tail of the estimated distribution is an artifact of the range of offers. It is impossible to predict accurately how fast the tail approaches the axis beyond the highest data point (Boyle and Bishop, 1988). Duffield and Patterson (1991), argue that the overall mean (calculated by integrating from zero to infinity) is inconsistent with economic theory.

> "The plausible upper limit to the WTP distribution is not infinity, but something less than income" (p. 227)

An alternative method of estimating the value is obtained by truncating the range of integration at the highest data point, (Bishop and Herberlein, 1979) or as suggested by Boyle and Bishop (1988) and Duffield and Patterson (1991) to truncate at an offer of a fixed percentile of the distribution. Boyle and Bishop chose the ninetieth percentile of the estimated logit distribution. Standard statistical practice is not to extrapolate beyond the range of the data (Duffield and Patterson, 1991)

When the willingness-to-pay distribution is skewed, then alternative measures of central tendency, for example, the mean and the median may differ considerably. In a very skewed distribution, the mean is heavily influenced by the upper tail of the distribution and may essentially reflect the values of only a very small proportion of the population. In estimating the mean, any errors in the data or unusual observations will affect the estimate of the mean. The estimation of the median of the distribution, where 50 percent of the respondents will answer yes, is less sensitive to such perturbations and is a more robust measure (Hanemann 1984). A value judgement is required by the researcher as to which measure of central tendency to use.

5.2.5 Biases

There are several biases which may potentially affect the results obtained from a contingent valuation survey. Mitchell and Carson (1989) list the principle sources of bias as:

a) Use of a scenario that contains strong incentives for respondents to misrepresent their true willingness-to-pay amounts.

b) Use of a scenario that contains strong incentives for respondents to improperly rely on elements of the scenario to help determine their willingness-to-pay amounts.

c) Misspecification of the scenario by incorrectly describing some aspect of it or, alternatively, by presenting a correct description in such a way that respondents missperceive it.

d) Improper sampling design or execution, and improper benefit aggregation.

Biases referred to by others (Hufschmidt, et. al., 1983; Schulze, et. al., 1981 and Cummings, et. al., 1986) include strategic bias, information bias, instrument bias, hypothetical bias and sampling bias.

5.2.5.1 Misrepresent biases

Incentives to misrepresent responses can lead to two types of behaviour, strategic behaviour or compliance behaviour. Strategic behaviour is where respondents shape their answers to influence the outcome for personal interest. Originally raised by Paul Samuelson (1954), this normally takes the form of "free riding" or "over pledging". Free riding is where someone pays less than a public good is worth to them in the expectation that others will pay enough to provide the good. This may occur in contingent valuation studies if those questioned believe that they will actually have to pay the amount revealed by them, and they also believe that the good will be provided even if they understate their true willingness-to-pay. Respondents would be expected to overbid if they believe they will not actually have to pay the amount they state, yet also believe that the stated amount can influence provision of the amenity.

A review of the theoretical literature by Mitchell and Carson (1989) showed that strategic behaviour is irrational because surveys normally convey to respondents that a larger number of people are being interviewed and the perceived likelihood that overpledging by a credible amount will affect the outcome is low. Also, most payment vehicles used in contingent valuation studies (such as taxes) evoke strong budget constraints and people do not lightly pledge to increase these. Contingent valuation studies often present scenarios where the provision of the good is uncertain underbidding carries the risk that the good will not be provided. Schulze, et. al. (1981) also found that empirical evidence did not support the existence of strategic bias.

Another concern of contingent valuation is whether the hypothetical character of contingent valuation studies renders their findings meaningless or, under what conditions worthwhile data can be obtained. Empirical evidence suggests that hypothetical studies have the ability to predict behaviour and that the contingent valuation method can bear a sufficiently close relationship to the actual amounts if a market existed (Mitchell and Carson, 1989)

Compliance behaviour is where people are generally motivated to tell the truth but are prone to shape their answers to please either the interviewer or the sponsor.

5.2.5.2 Implied value cues

A significant effort is often required by respondents in answering contingent valuation surveys. This creates incentives to adopt procedures to lighten the task. Techniques intended to overcome the problem of people from casually picking numbers may provoke biased responses. People who are uncertain may be prone to make estimates which they adjust. This is known as anchoring and leads to bias towards the initial value because typically adjustments are insufficient. Anchoring is most likely to occur when respondents fasten upon unintended clues. The major source of these clues are the elicitation techniques used to help people formulate their answers. One example is starting point bias in bidding games. This can be exacerbated by "yea-saying", where some respondents agree with an interviewer regardless of their true values. In a bidding game, even if the initial bid is rejected, starting points well above the respondents' true willingness-to-pay will tend to increase the revealed willingness-to-pay, while starting points well below it tend to decrease it. No generally valid method exists to adjust the findings obtained by the bidding game to compensate for the effect of the starting point bias. Researchers have often tested for it by the use of several different starting points.

Importance bias results from when a respondent infers that one or more levels of the amenity must have value to justify the expense of a survey. In order to minimise this effect, respondents who are not willing to pay anything must feel free in giving that response. Otherwise benefits will be overestimated (Mitchell and Carson, 1989).

5.2.5.3 Misspecification issues

Misspecification occurs when the respondent incorrectly perceives one or more aspects of the contingent market and the good to be valued. Bias caused by misconceptions are a major source of error in contingent valuation studies because scenarios offer many opportunities for them to occur. Misconceptions occur due to understanding terminology such as pollution, lack of understanding of risk, or of dealing with probabilities such as probability of death. Misspecification can be minimized by an intensive programme of questionnaire development including pretesting (Mitchell and Carson, 1989).

Mitchell and Carson (1989) do not consider that hypothetical and information biases are meaningful categories of bias but rather misspecification.

5.2.5.4 Sampling and aggregation issues

The researcher needs to identify all the consumers who might potentially benefit from a given change in order to have that population represented in the analysis. It is also important to identify the full range of benefits.

How to define the population, draw a sample of that population, and aggregate the results are issues that face every surveyor. The magnitude of the aggregation error resulting from sample and non-response biases is potentially very large. People are less likely to respond if they do not highly value the goods in question, and raises the possibility that surveys with high non-response rates may result in overvaluing the goods.

With any survey there is a problem of outliers. An outlier is an observation that is unlikely given the presumed distribution. If the results are not adjusted (this is, outliers removed) the results can be dominated by them.

Contingent valuation surveys that measure the benefits of well-established amenities are not likely to be vulnerable to temporal selection bias. Reiling, et. al., (1990) found that contingent values for the control of black fly were reliable and did not vary significantly with the timing of the survey. Estimates for newly identified goods are more time-sensitive. The adding up of values for separately measured programs is seen to pose a problem of sequence aggregation bias, because of the substitution effects of different amenities such as two lakes.

5.2.6 Advantages and Disadvantages of Contingent Valuation

Contingent valuation studies have the advantage that they can measure more than use values only. The problem is that when valuing, respondents' judgement is a holistic assessment. One approach used by Brookshire, Eubanks and Randall (1983) divided respondents into users and nonusers. The values of nonusers are treated as an expression of existence values. No criteria is used to determine the portion of the user's willingness-to-pay assigned to existence values. Other possibilities include the use of the travel cost method to estimate the use value.

Contingent valuation is just one of the methods available to measure the value of non-market goods. All the techniques measure assigned values which change over time, not held values. The ability to measure the different values such as existence values is better with contingent valuation than other techniques but is still limited. The divergence of willingness-to-pay and willingness-to-accept and the potential to bias results means that contingent valuation studies need to undertaken and used with care. Schulze, et. al. (1981), found that all valuation methods yield values within one order of magnitude in accuracy. Such information in their view was preferable to complete ignorance, on which to base decision making.

CHAPTER SIX

VALUE OF IRRIGATION WATER

This chapter details the linear programming model used to determine the marginal value of irrigation water to individual farmers in the short-run. The resulting values are then aggregated to determine the regional value of irrigation water.

6.1 LINEAR PROGRAMMING

As stated in Chapter 5, a linear programming problem can be formulated when there exists an objective, alternative ways of obtaining this objective and restrictions that can be used in attaining the objective. The objective function is profit maximisation using net margins. That is, the objective function maximises total revenue less total variable costs including the cost of labour. The objective function is subject to the following constraints: land, total crop area, cereal area, pea area, pasture area, farm labour, and water. These constraints reflect the constraints of farm size, and agronomic and farm management practices.

The model provides the marginal value (shadow price) of irrigation water. This is the value of an additional unit of irrigation water, or the change in returns from one additional unit. By parametrically varying the supply of irrigation water available to the farmer, changes in the level of production and net margins are obtained.

6.2 DEVELOPING THE MODEL

In developing the linear programming model, representative farms were defined and the appropriate constraints determined.

Water from the Ashburton River is used by farmers on the community irrigation schemes supplied by the Rangitata Diversion Race, farms on the Greenstreet scheme, as well as individual farmers along the margins of the Ashburton River and its tributaries. Border dyke irrigation is the predominant method of irrigation. It was felt that these farms were not adequately detailed in currently available sources of farm data (New Zealand Statistics Department, Ministry of Agriculture and Fisheries Farm Monitoring Reports and the New Zealand Meat and Wool Boards Economic Service Sheep and Beef Farm Survey) to enable construction of a suitable linear programming model. Therefore, a survey of one of the community irrigation schemes was undertaken.

6.2.1 Ashburton Lyndhurst Irrigation Scheme Survey

In April 1991, with the assistance of the managers of the scheme, farmers on the Ashburton Lyndhurst Irrigation Scheme were surveyed by mail. The aim of the survey was to obtain information on the farm activities undertaken and the performance levels achieved.

The entire population of the Ashburton Lyndhurst scheme of approximately 160 farmers were surveyed (a copy of the survey is in Appendix 1). A response rate of 60 percent or 97 completed forms, was achieved. This accounted for 57 percent of the total area of 26,000 hectares in the Ashburton Lyndhurst scheme.

The results of the survey indicated that 79 percent of the area was irrigated. Of the irrigated area, 84 percent was border dyke irrigation, 13 percent spray irrigation, and 3 percent wild flooding. Spray irrigation was predominantly used on intensive crop farms. About 80 percent of the area spray irrigated was on farms that had over 50 percent of their land in crops.

Land irrigated under this scheme has a high stocking rate and achieves above average stock performance. As at 30 June 1990, there were 176545 stock units (SU) on 14915 hectares. This equates to 11.9 stock units per hectare. Adjusting for the 3453 hectares of crops grown, the stocking rate is 15.8 stock units per hectare of pasture. The breakdown of stock by class is as follows: 116334 sheep stock units (66 percent), 53333 cattle stock units (30 percent), and 6879 other stock units (4 percent), which includes deer, goats, and horses.

Lambing percentage averaged 120 percent, with wool weights of 4.9 kilograms per stock unit, and an average lamb carcass weight of 15.2 kilograms. Milkfat per cow was on average 163 kilograms.

Nearly 23 percent of the area, or 3453 hectares was cropped. Cereals were the main crop, covering 53 percent of the crop area. Crop area percentages for the remaining crops are: peas 9 percent, grass seed 16 percent, clover 9 percent, and other crops including seed rape, linseed, borage etc, 13 percent. Over half the crop activity, 58 percent, occurred on 18 percent of the farm area. Crop yields compared to the Canterbury average were high. Cereals yields were around 5.0 to 5.5 t/ha, peas 3 t/ha, ryegrass in excess of 1 t/ha, and clover 0.4 t/ha.

The responses were divided in the following categories (see Table 6.1):

a) Properties less than 40 hectares. There were 18 responses that averaged 16 hectares and accounted for 2 percent of the total area.

b) Farms that had less than 10 percent of the total area in crop. There were 24 useable responses accounting for 31 percent of the farm area.

c) Farms that had between 10 percent and 50 percent of the area in crop. This represents 38 percent of the farm area, with 24 useable responses.

d) Farms that had in excess of 50 percent of the area in crop. There were only 9 farms accounting for 18 percent of the area.

e) Dairy farms, 12 responses, 12 percent of the area. These farms had 56 percent of the total cattle stock units, and they often supply the cattle for other farmers to fatten.

The results of this survey are representative of the farming activities that occur on the other irrigation schemes in the Ashburton District (Stoker, 1991).

Four representative farms of the Ashburton District were developed from the survey results.

6.2.1.1 Sheep and beef farm

This is a 170 hectare border dyke irrigated farm. The farm carries 2600 stock units, of which 75 percent are sheep and 25 percent cattle. This equates to 1450 breeding ewes, 400 ewe hoggets, 60 rising two year old bulls, and 70 rising one year bulls.

The lambing percentage is 120 percent, with the lambs being sold from March to June at an average of 15 kilograms, carcass weight. Wool weights are 5 kilograms per stock unit. The bulls are sold at 20Xo 22 months of age, averaging 240 kilograms carcass weight.

In the short run, beef numbers would remain around 25 percent of the total stock numbers. This is because cattle require good quality feed all year, whereas this is not as essential for sheep. Over the autumn and winter period cattle need to be fed above maintenance levels to optimise production. During this period the pasture growth on irrigated farms is the same as non irrigated farms limiting the number of cattle that can be successfully run. Another management consideration is mob size. If cattle numbers were to be increased more than one mob would have to be run (Rae, 1991).

Pastures have a life of between 10 and 20 years. Fertilizer rates are 250 kilograms per hectare of superphosphate, with some nitrogenous fertilizer applied in the autumn. Very little cultivation is undertaken. Paddocks that need renovation are sown into greenfeed, normally turnips for winter feed, being planted in barley in the spring prior to pasture in the following autumn.

6.2.1.2 Mixed cropping farm

This farm is similar to the previous farm, except more cropping is undertaken. About 25 percent of the farm area is cropped, with paddocks out of pasture for up to five years. Fewer cattle are carried. Crops grown are predominately spring sown, mainly wheat, barley or peas, determined by price. Greenfeed is grown over the winter months on the area cropped, thus favouring spring crops.

Farm size is slightly larger at 200 hectares. The farm has 1500 ewes, 550 ewe hoggets, 40 rising two year bulls, and 50 rising one year old bulls. Stock performance is the same as the sheep farm.

Table 6.1 Summary of Farms in the Ashburton Lyndhurst Irrigation Scheme

	Sheep Farms	Mixed Cropping	Intensive Cropping	Dairy Farms
Total area(ha) Percentage	4114 (31%)	5128 (38%)	2429 (18%)	1675 (13%)
Irrigated area	3450	3681	2134	1470
Farm size (ha)	171	205	270	140
Sheep SU	44005	55779	11032	0
Cattle SU	15319	4001	2708	28385
Other SU	3012	1960	200	150
Total SU	62336	61739	13940	28535
SU/ha	15.2	12.0	5.7	17
SU/ha pasture	15.5	16.9	23.5	17
Crop Area (ha)	98.5	1237	1835	0
% farm in crop	2%	24%	75.5%	0%
Cereals ha (%)	98(100%)	832 (67%)	808 (44%)	
Peas ha (%)		237 (20%)	67 (4%)	
Grasseed ha(%)		95 (7%)	375 (20%)	
Clover ha (%)		22 (1%)	291 (16%)	
Other ha (%)		51 (4%)	293 (16)	
Greenfeed (ha)	205	1070	607	0

6.2.1.3 Intensive crop farm

This farm, at 270 hectares, is larger than other farms in the District. Half the farm is spray irrigated, and a wider range of crops are grown. Up to 40 percent of the crop area may be in cereal crops, with some of these winter sown to spread the work load and decrease the water demand at critical periods. At the present time, small seeds are an important component. Fescue and amenity grasses as well as overseas clover varieties are grown. Crops such as the amenity grasses, overseas clovers and evening primrose are specialist crops, which require special expertise and equipment.

Stock policies are varied. More trading of stock and selling of grazing is undertaken. Cattle on these farms are often dairy cows that are being grazed over the winter period.

Because of the complexity of modelling this farm class, representative crops are selected as follows: winter wheat, spring wheat and barley (to represent cereals), peas (to reflect specialist crops), and ryegrass (to represent all small seed crops).

Good crop husbandry practices (mainly to prevent diseases such as take-all in cereals and aphanomyces in peas) limits cereals are to 40 percent of the farm, peas to 30 percent and ryegrass 40 percent of the farm.

6.2.1.4 Dairy Farm

This is a factory supply dairy farm. Stocking rates average 2.5 cows per hectare, producing 163 kilograms of milkfat per cow, or 400 kilograms of milkfat per hectare.

6.2.2 Other Assumptions

Variable costs for farm activities were based on 1989 data (Ministry of Agriculture and Fisheries Lincoln). A variable cost for labour was based on the time involved in undertaking the operation. Irrigation labour was based on figures from Taylor, et. al. (1982). These figures and costs were verified by conducting a small personal survey of farmers in the Ashburton catchment. The labour requirement for crop irrigation was double the requirement for pasture due to the need to walk the crop to ensure adequate water coverage. These variable costs are shown in Table 6.2.

Product prices were based on an average of reported prices for the last five years (Burtt and Fleming, 1990). This was to account for the fluctuations that occur in commodity prices.

Production functions for consumptive water use of arable crops were based on agricultural engineering data (Heiler, 1982). The production function for pasture was based on data from Winchmore Irrigation Research Station (Rickard and

McBride, 1986). Irrigated pasture had a annual yield of 12 tonnes of dry matter per hectare (t DM/ha), whereas nonirrigated pasture had a yield of 6 t DM/ha per annum. The relationship between pasture production and stocking rate was based on data from Barlow (1985). One stock unit corresponds to a pasture requirement of 748 kg DM/year for the 'average' farmer and 575 kg DM/year for a 'top' farmer. These figures were consistent with the stocking rates on the Winchmore Irrigation Research Station (Rickard and McBride, 1986). Tables 6.2 to 6.8 show the prices, variable costs, yields, and consumptive water requirements for each crop and livestock activity.

Table 6.2 Coefficients for Winter Wheat

	Units	Irrigation Water				
		100%	90%	75%	50%	0%
Crop Price	$/t	$236	$236	$236	$236	$236
Yield	t/ha	5.5	5.34	5.12	4.68	3.90
Net Irrigation	mm	225.00	202.50	168.75	112.50	0.00
Labour Costs	$/ha	$61	$61	$60	$59	$58
Crop Variable Costs	$/ha	$762	$759	$698	$606	$557

Table 6.3 Coefficients for Spring Wheat

	Units	Irrigation Water				
		100%	90%	75%	50%	0%
Crop Price	$/t	$262	$262	$262	$262	$262
Yield	t/ha	5.00	4.75	4.45	3.85	2.75
Net Irrigation	mm	300	270	225	150	0.00
Labour Costs	$/ha	$56	$56	$55	$54	$53
Crop Variable Costs	$/ha	$723	$718	$663	$610	$493

Table 6.4 Coefficients for Barley

	Units	Irrigation Water				
		100%	90%	75%	50%	0%
Crop Price	$/t	$184	$184	$184	$184	$184
Yield	t/ha	5.00	4.70	4.35	3.70	2.48
Net Irrigation	mm	300	270	225	150	0.00
Labour Costs	$/ha	$56	$56	$55	$54	$53
Crop Variable Costs	$/ha	$565	$560	$514	$478	$401

Table 6.5 Coefficients for Field Peas

	Units	Irrigation Water				
		100%	90%	75%	50%	0%
Crop Price	$/t	$327	$327	$327	$327	$327
Yield	t/ha	3.2	2.94	2.66	2.08	0.99
Net Irrigation	mm	300	270	225	150	0.00
Labour Costs	$/ha	$61	$61	$60	$59	$58
Crop Variable Costs	$/ha	$643	$630	$625	$558	$531

Table 6.6 Coefficients for Ryegrass Seed

Ryegrass	Units	Irrigation Water				
		100%	90%	75%	50%	0%
Crop Price	$/t	$1125	NA	NA	NA	$1125
Yield	t/ha	1.2	NA	NA	NA	0.99
Net Irrigation	mm	300	NA	NA	NA	0.00
Labour Costs	$/ha	$38	NA	NA	NA	$35
Crop Variable Costs	$/ha	$686	NA	NA	NA	$549

Table 6.7 Coefficients for Pasture

Pasture	Units	Irrigation Water				
		100%	90%	75%	50%	0%
Crop Price	$/t	NA	NA	NA	NA	NA
Yield	t/ha	12	11.5	11	8	6
Net Irrigation	mm	441	397	331	220	0.00
Labour Costs	$/ha	$7	$6.5	$6	$5.5	$4
Crop Variable Costs	$/ha	$43	$40	$30	$24	$24

Table 6.8 Coefficients for Stock Enterprises

		Sheep	Beef	75% Sheep 25% Beef	Dairy
Gross Revenue	$/SU	$41	$132.7	$63.93	$106.97
Stock Variable Costs	$/SU	$4.63	$81.5	$23.85	$11.39
Labour Costs	$/SU	$4.7	$4.0	$4.5	$13

The water constraint represents the net irrigation requirement (that is, the net consumption required for irrigation) and not the amount of water delivered to the farm. This accounts for the fact that a certain percentage of water applied (that which is not consumed by the crops or evaporated) will return to the river or the underground aquifers. A field efficiency factor of 63 percent was assumed.

The model does not represent all water abstracted from the Ashburton River for agricultural use. Abstraction for stockwater in the area totals 6.5 cubic meters per second serving a total of around 240,000 hectares. Approximately 3.5 cubic meters per second of the total is abstracted from the Ashburton River and its tributaries, for distribution to 122,000 hectares, almost exclusively by open race (8,000 hectares is supplied by a piped system in the Methven-Springfield area). Race leakage and evaporation losses account for 95 percent of the total water usage of the open race systems (Gabities, Porter and Partners, 1986).

Stockwater is not included in the model because of its status in New Zealand law and because the stockwater race system serves both irrigated and non-irrigated farms. Under the Resource Management Act (1991) a resource consent is unnecessary if water is required for the reasonable needs of animals for drinking, and the taking does not, or is not likely to have an adverse effect on the environment.

The effect of excluding stockwater is to overvalue the marginal value of water to stock enterprises.

6.3 THE LINEAR PROGRAMMING MODELS

Four models were developed to represent the different farms.

6.3.1 The Intensive Crop Farm Linear Program

The objective was to maximise farm profit, namely:

$$\text{Max Profit} = \$236WW + \$262SW + \$184SB + \$327P + \$1125RG + \$41SSU - \$823WW^{1.0} - \$820WW^{0.9} - \$758WW^{0.75} - \$665WW^{0.5} - \$615WW^{0.0} - \$779SW^{1.0} - \$774SW^{0.9} - \$718SW^{0.75} - \$664SW^{0.5} - \$546SW^{0.0} - \$621SB^{1.0} - \$616SB^{0.9} - \$569SB^{0.75} - \$532SB^{0.5} - \$454SB^{0.0} - \$704P^{1.0} - \$691P^{0.9} - \$685P^{0.75} - \$617P^{0.5} - \$589P^{0.0} - \$724RG^{1.0} - \$584RG^{0.0} - \$50Pa^{1.0} - \$47Pa^{0.9} - \$36Pa^{0.75} - \$30Pa^{0.5} - \$28Pa^{0.0} - \$9.33SSU \quad (6.1)$$

where
WW = tonnes of winter wheat
SW = tonnes of spring wheat
SB = tonnes of spring barley
P = tonnes of peas
RG = tonnes of ryegrass seed
SSU = number of sheep stock units
$WW^{1.0}$ = hectares of winter wheat with 100 percent water
$WW^{0.9}$ = hectares of winter wheat with 90 percent water
$WW^{0.75}$ = hectares of winter wheat with 75 percent water
$WW^{0.5}$ = hectares of winter wheat with 50 percent water
$WW^{0.0}$ = hectares of winter wheat with 0 percent water
$SW^{1.0}$ = hectares of spring wheat with 100 percent water
$SW^{0.9}$ = hectares of spring wheat with 90 percent water
$SW^{0.75}$ = hectares of spring wheat with 75 percent water
$SW^{0.5}$ = hectares of spring wheat with 50 percent water
$SW^{0.0}$ = hectares of spring wheat with 0 percent water
$SB^{1.0}$ = hectares of spring barley with 100 percent water
$SB^{0.9}$ = hectares of spring barley with 90 percent water
$SB^{0.75}$ = hectares of spring barley with 75 percent water
$SB^{0.5}$ = hectares of spring barley with 50 percent water
$SB^{0.0}$ = hectares of spring barley with 0 percent water
$P^{1.0}$ = hectares of peas with 100 percent water
$P^{0.9}$ = hectares of peas with 90 percent water
$P^{0.75}$ = hectares of peas with 75 percent water
$P^{0.5}$ = hectares of peas with 50 percent water
$P^{0.0}$ = hectares of peas with 0 percent water
$RG^{1.0}$ = hectares of ryegrass with 100 percent water
$RG^{0.0}$ = hectares of ryegrass with 0 percent water

$Pa^{1.0}$ = hectares of pasture with 100 percent water
$Pa^{0.9}$ = hectares of pasture with 90 percent water
$Pa^{0.75}$ = hectares of pasture with 75 percent water
$Pa^{0.5}$ = hectares of pasture with 50 percent water
$Pa^{0.0}$ = hectares of pasture with 0 percent water

Subject to the following constraints:

Land $\leq$ 270 hectares
Crop area $\leq$ 270 hectares
Cereal area $\leq$ 270 hectares
Pea area $\leq$ 81 hectares
Ryegrass seed area $\leq$ 108 hectares
Pasture area $\leq$ 270 hectares
Irrigation water $\leq$ 123,515 millimeters per hectare
Labour $\leq$ 10,000 hours per annum

These constraints reflect the crops grown on the farm and the limitations that good crop husbandry practices place on the acreage of these crops that can be grown in any one year.

6.3.2 The Mixed Cropping Farm Linear Program

The objective was to maximise farm profit, namely:

Max Profit = \$236WW + \$262SW + \$184SB + \$327P + \$63.93SU - \$823$WW^{1.0}$ - \$820$WW^{0.9}$ - \$758$WW^{0.75}$ - \$665$WW^{0.5}$ - \$615$WW^{0.0}$ - \$779$SW^{1.0}$ - \$774$SW^{0.9}$ - \$718$SW^{0.75}$ - \$664$SW^{0.5}$ - \$546$SW^{0.0}$ - \$621$SB^{1.0}$ - \$616$SB^{0.9}$ - \$569$SB^{0.75}$ - \$532$SB^{0.5}$ - \$454$SB^{0.0}$ - \$704$P^{1.0}$ - \$691$P^{0.9}$ - \$685$P^{0.75}$ - \$617$P^{0.5}$ - \$589$P^{0.0}$ - \$50$Pa^{1.0}$ - \$47$Pa^{0.9}$ - \$36$Pa^{0.75}$ - \$30$Pa^{0.5}$ - \$28$Pa^{0.0}$ - \$28.35SU (6.2)

where WW = tonnes of winter wheat
SW = tonnes of spring wheat
SB = tonnes of spring barley
P = tonnes of peas
SU = number of stock units (sheep and cattle)
$WW^{1.0}$ = hectares of winter wheat with 100 percent water
$WW^{0.9}$ = hectares of winter wheat with 90 percent water
$WW^{0.75}$ = hectares of winter wheat with 75 percent water
$WW^{0.5}$ = hectares of winter wheat with 50 percent water
$WW^{0.0}$ = hectares of winter wheat with 0 percent water
$SW^{1.0}$ = hectares of spring wheat with 100 percent water
$SW^{0.9}$ = hectares of spring wheat with 90 percent water
$SW^{0.75}$ = hectares of spring wheat with 75 percent water
$SW^{0.5}$ = hectares of spring wheat with 50 percent water
$SW^{0.0}$ = hectares of spring wheat with 0 percent water
$SB^{1.0}$ = hectares of spring barley with 100 percent water
$SB^{0.9}$ = hectares of spring barley with 90 percent water
$SB^{0.75}$ = hectares of spring barley with 75 percent water
$SB^{0.5}$ = hectares of spring barley with 50 percent water
$SB^{0.0}$ = hectares of spring barley with 0 percent water
$P^{1.0}$ = hectares of peas with 100 percent water
$P^{0.9}$ = hectares of peas with 90 percent water
$P^{0.75}$ = hectares of peas with 75 percent water
$P^{0.5}$ = hectares of peas with 50 percent water
$P^{0.0}$ = hectares of peas with 0 percent water
$Pa^{1.0}$ = hectares of pasture with 100 percent water
$Pa^{0.9}$ = hectares of pasture with 90 percent water
$Pa^{0.75}$ = hectares of pasture with 75 percent water
$Pa^{0.5}$ = hectares of pasture with 50 percent water
$Pa^{0.0}$ = hectares of pasture with 0 percent water

Subject to the following constraints:

Land $\leq$ 200 hectares
Crop area $\leq$ 50 hectares
Cereal area $\leq$ 50 hectares
Pea area $\leq$ 50 hectares
Pasture area $\leq$ 200 hectares
Irrigation water $\leq$ 123,515 millimeters per hectare
Labour $\leq$ 10,000 hours per annum

The constraints reflect that a smaller area of crops are grown, normally spring sown cereals or peas. The stock units are assumed to be a combination of sheep and trading bull beef in a ratio of 75 percent sheep: 25 percent beef. This is to reflect that any reduction in stock numbers will affect both types of stock (although beef is more profitable) because of the feed constraints mentioned earlier.

6.3.3 The Sheep and Beef Farm Linear Program

The objective was to maximise farm profit, namely:

$$\text{Max Profit} = \$63.93SU - \$50Pa^{1.0} - \$47Pa^{0.9} - \$36Pa^{0.75} - \$30Pa^{0.5} - \$28Pa^{0.0} - \$28.35SU \qquad (6.3)$$

where SU = number of stock units (sheep and cattle)
$Pa^{1.0}$ = hectares of pasture with 100 percent water
$Pa^{0.9}$ = hectares of pasture with 90 percent water
$Pa^{0.75}$ = hectares of pasture with 75 percent water
$Pa^{0.5}$ = hectares of pasture with 50 percent water
$Pa^{0.0}$ = hectares of pasture with 0 percent water

Subject to the following constraints:

Land $\leq$ 170 hectares
Pasture area $\leq$ 170 hectares
Irrigation water $\leq$ 123,515 millimeters per hectare
Labour $\leq$ 10,000 hours per annum

This representative farm model has a similar stock policy as the mixed cropping farm model and therefore has the same sheep cattle ratio. With only stock enterprises on the farm, the opportunities and constraints are fewer than for farms that also involved with cropping.

6.3.4 The Dairy Farm Linear Program

The objective was to maximise farm profit, namely:

$$\text{Max Profit} = \$106.97DSU - \$50Pa^{1.0} - \$47Pa^{0.9} - \$36Pa^{0.75} - \$30Pa^{0.5} - \$28Pa^{0.0} - \$24.39DSU \quad (6.4)$$

where DSU = number of dairy stock units
$Pa^{1.0}$ = hectares of pasture with 100 percent water
$Pa^{0.9}$ = hectares of pasture with 90 percent water
$Pa^{0.75}$ = hectares of pasture with 75 percent water
$Pa^{0.5}$ = hectares of pasture with 50 percent water
$Pa^{0.0}$ = hectares of pasture with 0 percent water

Subject to the following constraints:

Land $\leq$ 140 hectares
Pasture area $\leq$ 140 hectares
Irrigation water $\leq$ 123,515 millimeters per hectare
Labour $\leq$ 10,000 hours per annum

The model dairy farm comprises of only one enterprise. It is assumed that a reduction in pasture production will result in a reduction in milk production which is reflected in a reduction in stocking rate.

The partial matrix for the representative intensive crop farm can be seen in Table 6.9. This shows only four main activities - winter wheat, spring wheat, pasture, and sheep - but contains the full set of constraints.

Table 6.9 Partial Matrix for the Representative Intensive Crop Farm

Activity	Winter Wheat (ha)					Spring Wheat (ha)					...	Pasture (ha)					Sheep	Labour	Water	Selling Activities				Limits
Irrigation Percentage	100	90	75	50	0	100	90	75	50	0	...	100	90	75	50	0	(SU)	(hours)	(mm)	W.Wheat (t)	S.Wheat (t)	Sheep (SU)		
Objective	-$762	-$759	-$698	-$606	-$557	-$723	-$718	-$663	-$610	-$493	...	-$43	-$40	-$30	-$24	-$24	-$4.63	-$10		$236	$262	$41		Maximise
W.Wheat Yield (t)	-5 .5	-5.34	-5.12	-4.68	-3.9						...									1				
S.Wheat Yield (t)						-5.0	-4.75	-4.45	-3.85	-2.75	...										1			
Barley Yield (t)											...													
Pea Yield (t)											...													
Ryegrass Yield (t)											...													
Pasture Yield (t)											...	-12	-11.5	-11	-8	-6	0.75							
Sheep Yield (SU)											...						-1					1		
Crop Water (mm)	225	202.5	168.75	112.5		300	270	225	150		...	441	397	331	220				-1					
Water Supply (mm)											...								1.59				≤	123515
Land Area (ha)	1	1	1	1	1	1	1	1	1	1	...	1	1	1	1	1							≤	270
Crop Area (ha)	1	1	1	1	1	1	1	1	1	1	...												≤	270
Cereal Area (ha)	1	1	1	1	1	1	1	1	1	1	...												≤	108
W.Wheat Area (ha)	1	1	1	1	1						...												≤	108
S.Wheat Area (ha)						1	1	1	1	1	...												≤	108
Barley Area (ha)											...												≤	108
Pea Area (ha)											...												≤	81
Ryegrass Area (ha)											...												≤	108
Pasture Area (ha)											...	1	1	1	1	1							≤	270
Labour Requirements (hr)	6.1	6.1	6	5.9	5.8	5.6	5.6	5.5	5.4	5.3	...	0.7	0.65	0.6	0.55	0.4	0.47	-1						
Labour Supply (hr)											...							1					≤	10000

6.4 Estimation of Demand for Irrigation Water

By parametrically varying the supply of water available to the farmer, changes in the level of production activities and net margins are obtained. Tables 6.10 to 6.13 show the results for the representative farms.

As water availability begins to decrease, the model for the intensive cropping farm suggests that the farmer initially decreases water to pasture resulting in decreased stock numbers. As water is decreased further, ryegrass seed crops receive less water, winter sown crops are substituted for spring sown crops, eventually, winter sown cereals replace all spring cereal plantings and water application of water to pasture is reduced even further. That is, as water becomes increasingly scarce, the model shows that the farmer reduces crop irrigation and selects those activities with the highest marginal value product of water use.

For the representative mixed cropping farm, the model predicts the farmer will initially reduce water to pasture when faced with decreased water availability. Once water restrictions reach 60 percent of full watering, there will be a shift to winter sown cereals instead of spring sown.

For the representative stock and dairy farms, the model demonstrates that reduced water availability results in reduced pasture production and a corresponding reduction in animal performance.

The parametric variation also produces a derived demand curve for water. This relates the shadow price of water (which is the average opportunity cost of water across all farm activities) to the quantity of water available. This indicates the farmer's willingness-to-pay for water. Tables 6.10 to 6.13 list the shadow price of water and Figures 6.1 to 6.4 show the derived demand curves for irrigation water to the individual farms.

Table 6.10 Effect of Reduced Water to the Representative Intensive Crop Farm

	Reduction in Irrigation Water					
	0 %	20 %	40 %	60 %	80 %	100 %
Net Return	$149655	$143511	$136002	$128330	$118885	$102326
Net Irrigation Water (mm)	77814	62252	46689	31126	15563	0
Gross Water	123515	98812	74109	49406	24703	0
Shadow Value Net Irrigation Water ($/mm)	$0.00	$0.48	$0.49	$0.49	$0.62	$1.20
Shadow Value Gross Water ($/mm)	$0.00	$0.30	$0.31	$0.31	$0.39	$0.76
Winter Wheat(ha)	0	0 ha	19 ha	102 ha	108 ha	108 ha
Irrigation Percentage	-	-	50 %	50 %	50 %	0 %
Spring Wheat(ha)	108 ha	108 ha	89 ha	6 ha	0 ha	0 ha
Irrigation Percentage	100 %	100 %	100 %	100 %	-	-
Barley (ha)	0 ha	0 ha	0 ha	0 ha	0 ha	0 ha
Irrigation Percentage	-	-	-	-	-	-
Pea Area (ha)	0 ha	0 ha	0 ha	0 ha	0 ha	0 ha
Irrigation Percentage	-	-	-	-	-	-
Ryegrass Area (ha)	108 ha	108 ha	108 ha	108 ha	108 ha	108 ha
Irrigation Percentage	100 %	55 %	0 %	0 %	0 %	0 %
Pasture Area (ha)	54 ha	54 ha	54 ha	54 ha	54 ha	54 ha
Irrigation Percentage	100 %	75 %	75 %	75 %	14 %	0 %
Sheep Stock Units (SSU)	866	794	794	794	502	433

Table 6.11 Effect of Reduced Water to the Representative Mixed Cropping Farm

	Reduction in Irrigation Water					
	0 %	20 %	40 %	60 %	80 %	100 %
Net Return	$104596	$99645	$90371	$79106	$67841	$53787
Net Irrigation Water (mm)	81150	64920	48690	32460	16230	0
Gross Water (mm)	128809	103048	77286	51524	25762	0
Shadow Value Net Irrigation Water ($/mm)	$0.00	$0.31	$0.69	$0.69	$0.69	$1.20
Shadow Value Gross Water ($/mm)	$0.00	$0.19	$0.44	$0.44	$0.44	$0.76
Winter Wheat(ha)	0 ha	0 ha	0 ha	50 ha	50 ha	50 ha
Irrigation Percentage	-	-	-	50 %	50 %	0 %
Spring Wheat(ha)	50 ha	50 ha	50 ha	0 ha	0 ha	0 ha
Irrigation Percentage	100 %	100 %	100 %	-	-	-
Barley (ha)	0 ha	0 ha	0 ha	0 ha	0 ha	0 ha
Irrigation Percentage	-	-	-	-	-	-
Pea Area (ha)	0 ha	0 ha	0 ha	0 ha	0 ha	0 ha
Irrigation Percentage	-	-	-	-	-	-
Pasture Area (ha)	150 ha	150 ha	150 ha	150 ha	150 ha	150 ha
Irrigation Percentage	100 %	75 %	65 %	40 %	16 %	0 %
Total Stock Units (SU)	2406	2209	2073	1745	1417	1203

Table 6.12 Effect of Reduced Water to the Representative Sheep and Beef Farm

	Reduction in Irrigation Water					
	0%	20%	40%	60%	80%	100%
Net Return	$88472	$83898	$74933	$64526	$54119	$43712
Net Irrigation Water (mm)	74970	59976	44982	29988	14994	0
Gross Water (mm)	119000	95200	71400	47600	23800	0
Shadow Value Net Irrigation Water ($/mm)	$0.00	$0.31	$0.69	$0.69	$0.69	$0.92
Shadow Value Gross Water ($/mm)	$0.00	$0.19	$0.44	$0.44	$0.44	$0.58
Pasture Area (ha)	170 ha	170 ha	170 ha	170 ha	170 ha	170 ha
Irrigation Percentage	100 %	80 %	60 %	40 %	20 %	0 %
Stock Units (SU)	2727	2545	2272	1969	1666	1364

Table 6.13 Effect of Reduced Water to the Representative Dairy Farm

	Reduction in Irrigation Water					
	0 %	20 %	40 %	60 %	80 %	100 %
Net Return	$178477	$167653	$149698	$129401	$109104	$88807
Net Irrigation Water (mm)	61740	49392	37044	24696	12348	0
Gross Water (mm)	98000	78400	58800	39200	19600	0
Shadow Value Net Irrigation Water ($/mm)	$0.00	$0.88	$1.64	$1.64	$1.64	$1.65
Shadow Value Gross Water ($/mm)	$0.00	$0.55	$1.04	$1.04	$1.04	$1.04
Pasture Area (ha)	140 ha	140 ha	140 ha	140 ha	140 ha	140 ha
Irrigation Percentage	100 %	80 %	60 %	40 %	20 %	0 %
Dairy Stock Units (DSU)	2246	2096	1871	1623	1372	1123

Figure 6.1 Demand Curve for Net Irrigation Water for the Representative Intensive Crop Farm

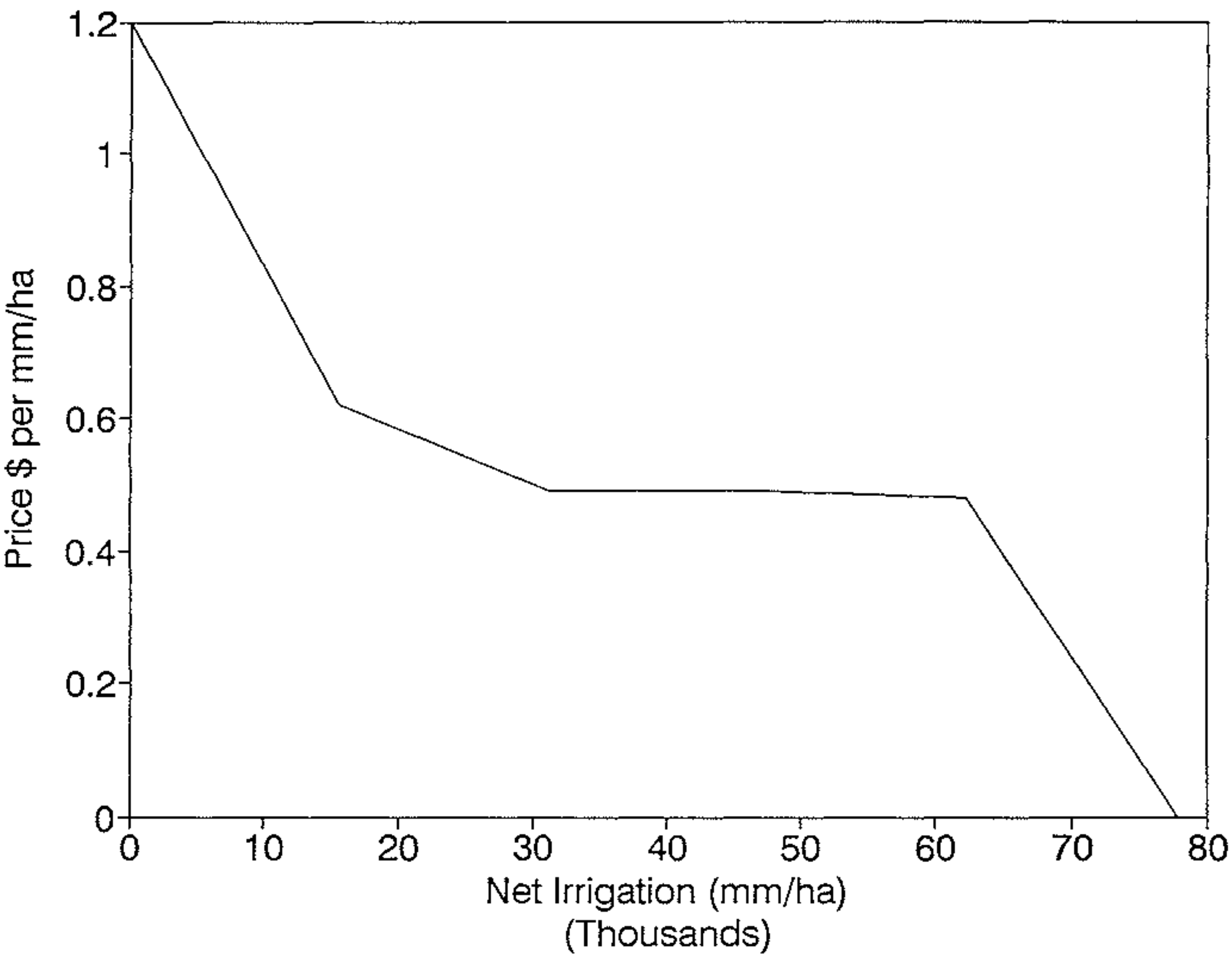


Figure 6.2 Demand Curve for Net Irrigation Water for the Representative Mixed Cropping Farm

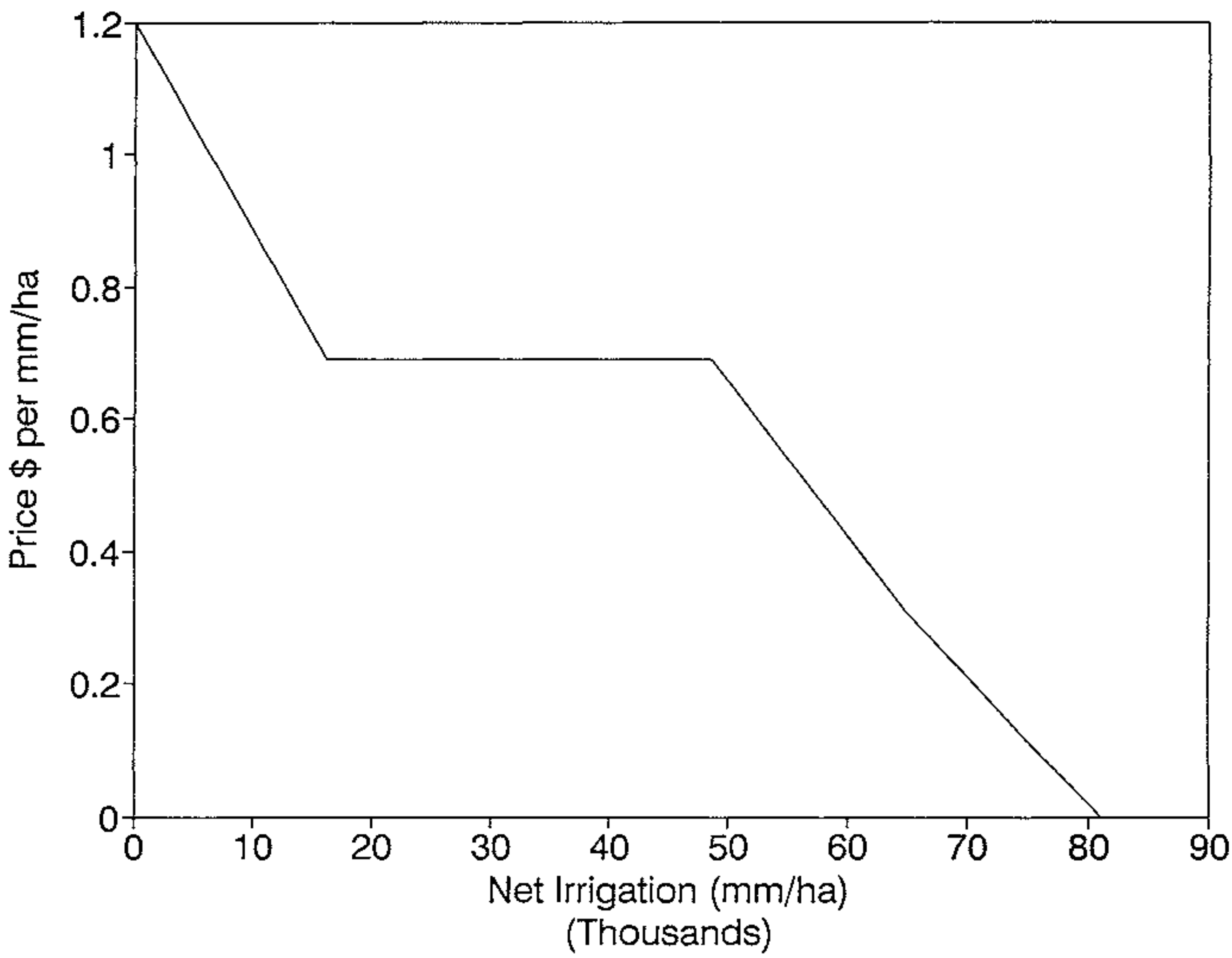


Figure 6.3 Demand Curve for Net Irrigation Water for the Representative Sheep and Beef Farm

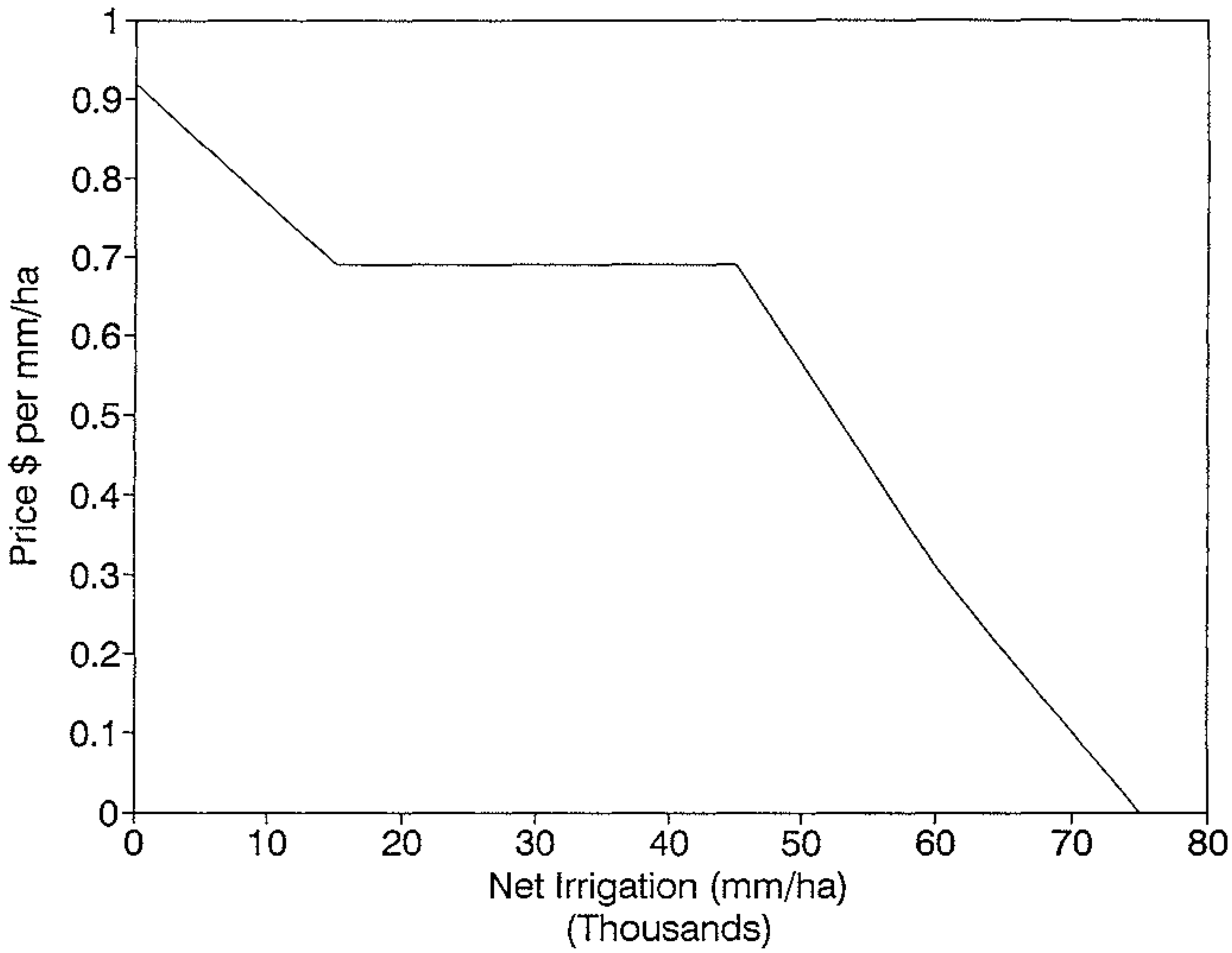
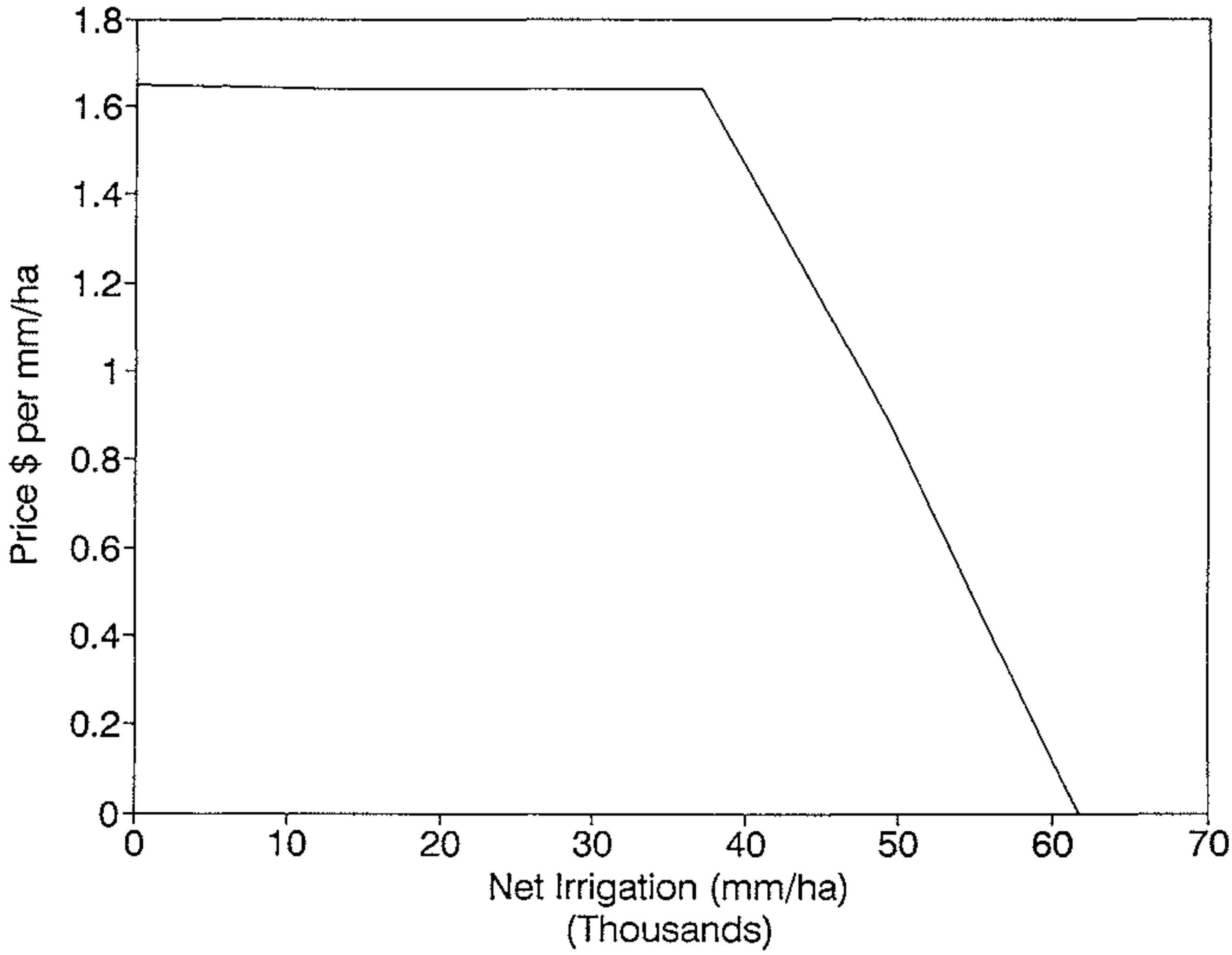


Figure 6.4 Demand Curve for Net Irrigation Water for the Representative Dairy Farm



6.5 AGGREGATION

To estimate the aggregate demand curve for irrigation water from the Ashburton River, individual demand curves for each farm model are weighted by the associated percentage of area represented by these farm models. The weighted individual demand curves are then summed to obtain the aggregated demand curve.

The area within the catchment of each representative farm is shown in Table 6.14, and the aggregated demand for net irrigation water can be seen in Table 6.15, with the aggregative demand curve in Figure 6.5.

Table 6.14 Area in the Ashburton Catchment by Farm Type

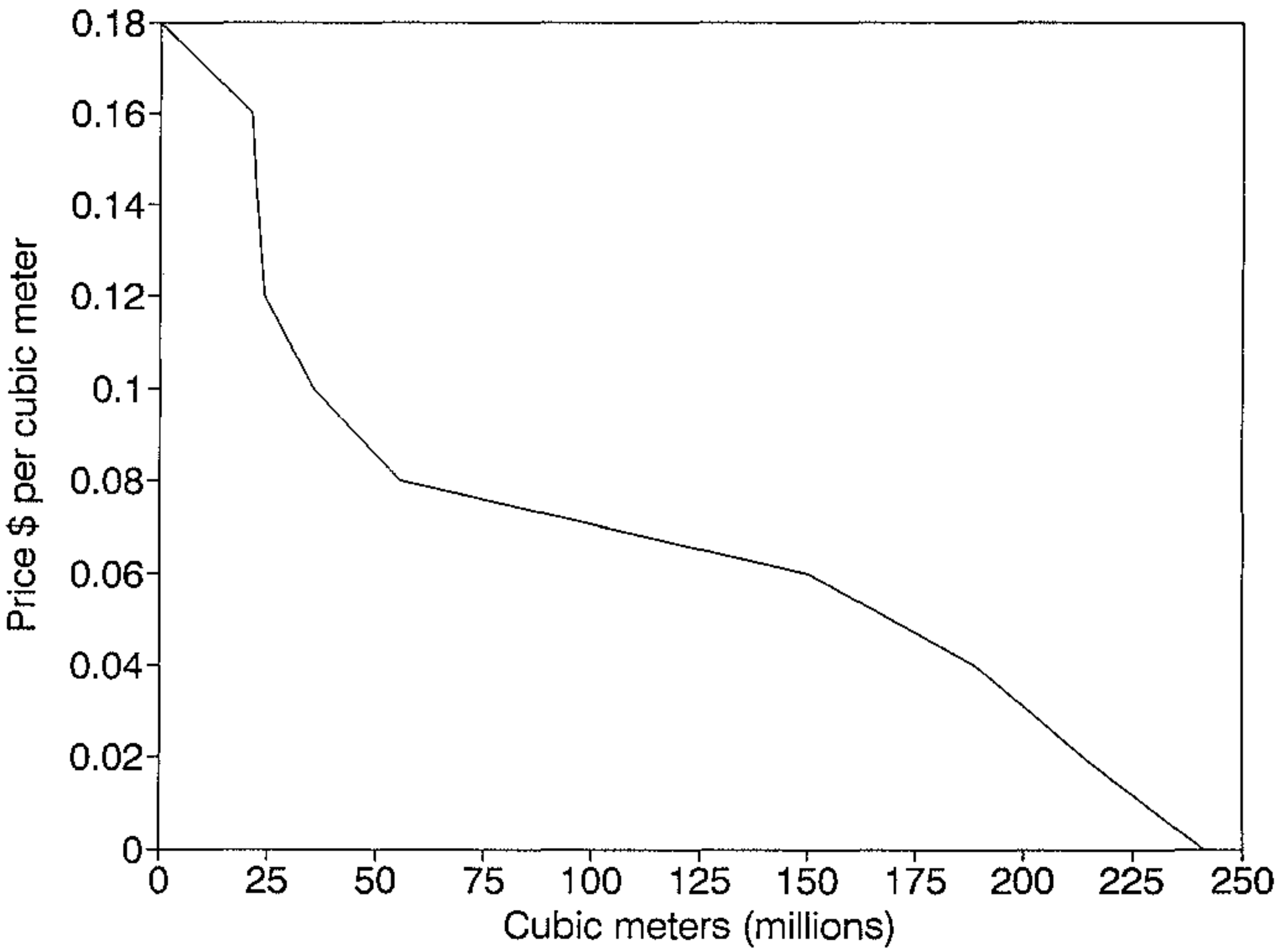
Representative Farm	Area (hectares)
Stock Property	18,631
Mixed Crop Property	22,838
Intensive Crop Property	10,818
Dairy Farm	7,813
Total	60,100

Table 6.15 Aggregated Net Irrigation Demand (millions of cubic meters)*

Price ($/m^3)	Intensive Crop Farm	Mixed Crop Farm	Sheep and Beef Farm	Dairy Farm	Aggregate
$0.18	0.00	0.00	0.00	0.00	0.00
$0.16	0.00	0.00	0.00	21.44	21.44
$0.14	0.00	0.00	0.00	22.73	22.73
$0.12	0.00	0.00	0.00	24.55	24.55
$0.10	2.05	7.33	0.00	26.48	35.86
$0.08	4.32	14.67	8.53	28.18	55.70
$0.06	7.27	60.00	53.24	29.77	150.28
$0.04	26.02	70.00	61.77	31.36	189.15
$0.02	28.64	80.67	71.77	32.73	213.81
$0.00	31.88	92.67	82.16	34.46	241.17

* 1 millimeter of water per hectare is equivalent to 10 cubic meters of water

Figure 6.5 Aggregate Demand Curve for Net Irrigation Water



6.6 VALUE OF ASHBURTON WATER TO FARMERS

The total value of water to farmers is the area under the demand curve. By geometrically integrating the area under the aggregate demand curve, the estimated consumer surplus for net irrigation water in the Ashburton Catchment for the community irrigation schemes is $16.7 million per annum. This includes water that comes from sources other than the Ashburton River. The main alternative source is the Rangitata River

To estimate the value of water equivalent to an increase in the minimum stream flow by 50 percent requires estimating the equivalent loss of water to irrigation from increasing the in-stream flow. An increase in stream flow means that restrictions on abstractions would occur earlier and last longer than currently occurs. For example, in the 1984/85 season there were 34 days of partial restrictions (50 percent restrictions) and 40 days of total restrictions. If the increased minimum flow regime proposed in the 1983-90 management plan was in effect, in 1990 these restrictions would increase to 25 days of partial restrictions and 74 days of total restrictions. For the 1987/88 season there were 9 days of partial and 30 days of total restrictions. This would increase to 6 days of partial and 100 days of total restrictions (Scarf, 1990). These seasons were considered extremely dry seasons. Restrictions that have occurred in other seasons since 1982/83 range from 5 days to 27 days of partial restrictions and 0 to 9 days of total restrictions. The effect on abstractions under the proposed management plan for other seasons has not been modelled (Scarf, 1991).

When restrictions occur, farmers that rely solely on the Ashburton River for irrigation water do not have the opportunity to use water from the Rangitata River via the Rangitata Diversion Race. Therefore, restrictions may affect different users differently. Restrictions on farmers not on the Rangitata Diversion Race may be more adversely affected, although restrictions on the Ashburton River may coincide with restrictions on the Rangitata River.

Therefore, to estimate the opportunity cost of increasing the minimum stream flow the following assumptions are made:

a) an increase in the minimum stream flow of 50 percent over the eight month period from September to May reduces the available water for irrigation by 61.6 million cubic meters. This equates to 38.8 million cubic meters of net irrigation water.

b) the reduced irrigation water will be distributed equally amongst all irrigators, including those on the Mayfield-Hinds and Valetta schemes.

To increase the minimum stream flow by 50 percent by reducing the available water for irrigation results in a net loss of $0.62 million per annum to farmers in the Ashburton District.

The effect of the assumptions is to overestimate the amount of water unavailable for irrigation, and to underestimate the value of the water to some users, especially users whose only source of irrigation water is the Ashburton River, because at times restrictions will affect them more than others who have alternative sources.

CHAPTER SEVEN

ESTIMATING THE VALUE OF IN-STREAM FLOWS

This chapter reports on the construction and implementation of the contingent valuation survey, the response rate of the survey, and how representative of the Canterbury Region the sample was. Results of the survey are presented in Chapters 8 and 9.

7.1 SURVEY CONSTRUCTION AND IMPLEMENTATION

In designing the survey the objectives were to:

a) obtain data to enable the economic value of increased stream flow of the Ashburton River to be estimated,

b) determine what activities currently occur on the river, and how these may change with increased stream flow, and

c) gather information on the respondents' characteristics, which may assist to estimate a valuation function for the increased flows and to verify the sample selection.

The telephone was used as the survey vehicle. It is quick relative to mail surveys and allowed the use of bidding games which mail does not. But telephones exclude the use of diagrams that could be used in mail or personal surveys. The main advantage of telephone over personal surveys is that telephone surveys are less labour intensive, especially where there is a large geographical area to cover.

7.1.1 The Survey Scenario

A contingent valuation approach presents respondents with a hypothetical market to enable them to state how they would respond. The survey sought to establish the respondents' tradeoffs between having a given amount of income or a 50 percent increase in the minimum in-stream flow. That is, the method paired alternative income levels with an increased in-stream flow such that the respondent is left with the same amount of utility.

The 50 percent increase was based on the current management plan, which was established in 1983. The minimum flow standards that could be met at the time, without placing unacceptable restrictions on existing domestic and stockwater supplies, was equivalent to 20 percent of the mean monthly flow (Scarf, 1983). Although this was the minimum flow that was established, the plan intended to raise the minimum flow levels to 30 percent of the mean monthly flow at the review currently being undertaken.

The exact effects of increasing stream flows is not precisely known. By providing the respondent with a flow level and the general effects of increased flow, the respondents could then individually assess the specific effects.

The following description of the river was used in the final survey:

> "Increasing the amount of water in the Ashburton River by one and a half times will likely result in: more river braiding, better water quality, increased fish numbers such as salmon and trout, more protected nesting sites for birds, and improved picnic and swimming spots.
>
> Funding is required if the minimum river level is to increase. The amount of water taken from the river can be decreased by, for example, replacing the existing stockwater races with a piped water system, and/or upgrading the Ashburton township water supply. To fund this work all households will be charged additional rates."

This was followed by either the iterative biding game or a dichotomous choice question, which sought to identify the household's willingness-to-pay (Appendix 2 contains the complete survey). The use of two methods of elicitation was, in part, designed to check for any bias in the payment vehicle.

The scenario was designed so that respondents were not asked to make a trade-off for alternative uses for water from the Ashburton River, for example, between in-stream flows and irrigation. If a trade-off was to be valued it would be possible (and highly likely) that some respondents would be willing-to-pay and others would want compensation (willingness-to accept scenario).

7.1.2 The Target Population

The population of concern was the people who reside in the Canterbury Region. This was considered appropriate because the Regional Council has the statutory responsibility to manage its resources for the benefit of the region. Also funding for the Council comes mainly from regional rate payers and decisions made by the Council will have financial implications for all Canterbrians.

7.1.3 The Appropriate Sampling Unit

Although some activities are individualistic such as fishing, other activities are family orientated, such as picnicking. Thus, defining the appropriate sampling unit on an activity basis is difficult.

Since the Regional Council is, in part, funded by rates, and rates are charged on a household basis, the household was considered to be the appropriate sampling unit.

7.1.4 Sample Size

A sample of the population is used because it is infeasible to sample the entire population. In sampling the population the aim is to obtain a sample large enough to obtain a representative sample and an acceptable degree of precision in statistics, yet small enough not be financially prohibitive.

One method that can be used to determine the sample size for the bidding game, described by Aaker and Day (1983) is:

$$sample\ size = \frac{z^2\sigma^2}{(sampling\ error)^2} \qquad (7.1)$$

where z = 2 for 95% confidence level
σ^2 = the population variance

and

$$Sample\ error = \frac{zs}{\sqrt{n}} \qquad (7.2)$$

where s = sample standard deviation
n = the pretest sample size

The sample size calculation is independent of the size of the population, and dependent on the variation of results within the population. Therefore, to determine the appropriate sample size a pretest survey is necessary to calculate the variation within the results. Most variation was expected in the willingness-to-pay question and it was this question that was used to determine sample size.

Limited information on the desired sample size for dichotomous choice elicitation is available. Many publications (Loomis,1988; Hanemann, 1984; Boyle and Bishop 1988) state a large sample size is required, but do not provide specifics on how to determine the exact size. Similarly, in determining the range of prices offered, very little information was available. Duffield and Patterson (1991) state

> "While the dichotomous choice format shows considerable promise, major problems remain in implementation. These problems arise from the fact that dichotomous choice survey design and analysis are relatively complex. Survey design elements include total sample size, bid range, specific bid levels, and the allocation of the total sample among the bid levels. ... To date, survey design choices have been largely ad hoc." (p. 225)

The sample size was determined in part by financial constraints. One thousand completed interviews was considered a large enough sample to be statistically robust without being financially prohibitive. Because two methods of elicitation of willingness-to-pay was used, the sample would have to be split between the two methods. In determining the sample sizes the aim was to keep the sample for the bidding game survey as small as possible to allow the largest possible sample for the dichotomous choice questionnaire.

7.1.5 Pretest

A survey pretest of 49 households was undertaken in the Canterbury Region in June, 1991. This was carried out by myself and one other person.

The aims of the pretest were to:

a) check the wording of the questionnaire,

b) determine the range of likely values to enable the selection of a suitable range for the dichotomous choice question, and

c) determine a suitable sample size for the bidding survey.

From the pretest results, it was felt that a stratified sample was appropriate. Stratified sampling is where the population is divided in subgroups and a sample is taken from each group or strata. As there was more variation in the responses from the Ashburton District, a larger sample from there was necessary. This was to improve the efficiency of the sample. Sample efficiency refers to the ability to obtain estimates with the same reliability from a small sample size. Reliability refers to the estimate variation caused by the fact that a sample is used instead of a population.

The population of Canterbury is not uniformly distributed throughout Canterbury. Sixty five percent of all residents reside in Christchurch, and only eight percent in the Ashburton District. The distribution within the Ashburton District between the borough and the rural district is about equal.

From the pretest data, a sample size of 64 for outside the Ashburton District and 128 for the Ashburton District was required for a confidence level of 95 percent. These numbers where increased to 100 and 200 respectively to allow for protest bids and unusable surveys.

This left 700 surveys for the dichotomous choice questionnaire. 450 of these were used in the Ashburton District and 250 elsewhere. The proportions between the size of the sample for Ashburton District and elsewhere for the dichotomous choice questionnaire was approximately the same as for the bidding game.

The pretest was used as a guide to determine the range of prices offered in the dichotomous choice questionnaire. The values obtained from the bidding in the pretest survey mainly ranged from $0 to $250 for the Ashburton District. There was one bid of $500 in the District. Bids ranged from $0 to $100 for the area outside the District.

The prices offered for the dichotomous choice question in the final questionnaire ranged from $5 to $450, and $5 to $350 for the Ashburton District and outside the District respectively. This range was felt to be adequate to ensure coverage of respondents valuations.

In determining the distribution of prices offered for the dichotomous choice question, experience by Kerr (1991) favoured using random values over the range of price offered. To generate the actual prices the statistical package Minitab was used to generate the random numbers in $5 amounts.

Following the pretest the following wording changes were made:

a) The description of the good, and the circumstances under which it would be made available was condensed. It was too long to be used on the telephone.

b) The order of the second and third questions were reversed. This was because the majority of people who did not use the Ashburton River were unlikely to use it given increased flows. Therefore if they did not use the river or place any value on the river, they would not use the river given an improvement.

c) Language adjustments were made to the introduction and questions 10 and 11. This was to assist respondents to understand the questions.

7.1.6 Sampling Procedure

To obtain the telephone numbers, a process of systematic sampling was used. This involves systematically spreading the sample through the list of population members. Systematic sampling is very common with telephone surveys (Aaker and Day, 1983).

The number of telephone numbers required was four times the number of completed surveys (Lindo, 1991). This allowed for nonexistent numbers, no replies, engaged or refusals.

For the telephone numbers outside the Ashburton District, approximately four numbers per telephone page (allowing for business sections), or one number per column was required. Four random numbers were generated on a Casio pocket calculator to determine the position of the number selected per column. For example the first random number was 926, the number selected was 23.6 centimeters from the top of the first column (0.926 multiplied by the column length). This process was repeated three times to obtain the appropriate number of each column.

A cardboard template was constructed to enable the repeated selection of numbers to be collected efficiently. When a business number was chosen the next residential number was selected. For pages that contain large number of business numbers, such as the New Zealand page, the whole page was deleted from the selection process. This method was recommended by Dillman (1978).

For the Ashburton District, the number of telephone numbers required equated to one number every 1.5 centimeters. These numbers were selected by using a ruler to measure the distance between numbers selected.

7.2 SURVEY IMPLEMENTATION

A commercial survey firm from Christchurch, Information Insight, was hired to undertake the survey. The firm had previously undertaken survey work for both the Canterbury Regional Council and the Ministry of Agriculture and Fisheries.

A training session was held for all the interviewers on the Sunday prior to the start of the survey. The interviewing was carried out from the interviewers' home. Interviewers were instructed to return completed surveys on a twice-daily basis. This was to enable a check of any potential problems and to allow data entry to occur while the survey was in progress.

The interviews were conducted between 6.30 pm and 9.00 pm Monday to Friday, between 17 June and 28 June.

Interviewers were instructed to call every fourth number on the list. This sub sampling by the interviewers was systematic in the same way as the original sample was drawn. If insufficient interviews were obtained, the remaining numbers were to be used. The interviewer was not expected to call back to numbers where an interview was not immediately obtainable.

Beside the number on the telephone list, interviewers recorded the responses as:

x	completed
eng	engaged
ref	refused
na	not available
nn	no such number

Initially only two thirds of the surveys were distributed to the interviewers. This was to allow a change in the ratio of surveys between the Ashburton District and outside the District, or a change in the price range offered to respondents, if necessary. After the first week the remaining surveys were delivered to the interviewers. No changes were made.

7.3 SURVEY RESPONSE RATE AND OTHER BIASES

The response rate for the survey was 70 percent for the Ashburton District and 53 percent for outside the Ashburton District. The procedure used for determining response rates was to calculate the percentage of completed interviews of contacts with eligible respondents.

$$Response\ Rate = \frac{Number\ Completed}{Number\ in\ sample - (Noneligible + Nonreachable)} \times 100$$

(7.3)

The response rates of telephone surveys average about 85 percent, and range from 73 percent to 92 percent (Dillman 1978). The high response rates have only been obtained when respondents received a prior letter informing them they would be called at a later time. The response rate to recently conducted telephone surveys in New Zealand is normally between 70 percent to 80 percent (McGuinness, 1991).

The response rate, especially for outside the Ashburton District, is low. The response may reflect the lack of interest in the Ashburton River. It may also demonstrate the disadvantage of not undertaking the survey from a central laboratory where this issue may have been able to be addressed over the two weeks the survey was undertaken. The telephone sheets from the interviewers were not available until after the survey was completed.

Refusals provide a theoretical potential for introducing considerable error into the estimates. For example, if an observed distribution on a dichotomous choice question is 75 percent "yes" and 25 percent "no", and the survey had a 50 percent response rate, assuming all those who refused would have answered "no" then the distribution would be changed to 37.5 percent "yes" and 62.5

percent "no". This would be an extreme example of the possible effects of refusals. The extent of the differences between respondents and nonrespondents can seldom be determined (Dillman, 1978)

Studies of people who refuse personal or telephone interviews suggest that refusals occur because of general, rather than survey-specific reasons (Mitchell and Carson, 1989 quoting Stinchcombe, Jones, and Sheatsley, 1981; and Smith, 1983). People who refuse to be interviewed usually reject participation before the specific topic of the survey is made known to them.

In this study, no information is available as to when the potential respondent declined to participate. Therefore no value judgement can be made regarding why the offer to partake in the research was declined.

Some respondents who were surveyed protested about having to pay for an increase in the minimum stream flow of the Ashburton River for reasons other than because they receive no value from such a change. Some failed to completely understand the question. Responses in these two categories were removed from the sample when calculating the economic value from increased stream flows. Protests and invalid responses in the Ashburton District was 9.8 percent and 12.5 percent of respondents for the bidding and dichotomous choice method respectively. For the respondents outside the Ashburton District 3.0 percent and 6.4 percent protested or fully failed to understand the question for the bidding and dichotomous choice methods respectively (see Tables 7.1 and

7.2).

Other sources of bias include interview bias and possible strategic bias (see Chapter 5). It is possible to limit interview bias by having a number of trained interviewers. The exact magnitude of these in this survey is unknown.

7.4 REPRESENTATIVENESS OF THE SAMPLE

Demographic data is normally used to verify the representativeness of the sample. The socioeconomic data that is used includes income, occupation, age, geography. Because the household was used as the sampling unit, age is not relevant in this case. Occupation and geographic location was felt to be more suitable than income, because a number of respondents declined to answer the question or did not know their total household income.

Using occupational classes to verify the sample, the Ashburton District sample is very representative of the District (see Table 7.3). The regional sample reflects a slight biases towards the agricultural occupations (probably due to the biases against Christchurch), and a biases against people involved in production and transport (see Table 7.4). Alternatively, it is possible that a higher percentage of this occupational class declined the survey.

The sample distribution was reasonably representative except for a slightly lower proportion from Christchurch (see Table 7.5). In assessing the dichotomous choice willingness-to-pay, the responses from Christchurch were not statistically different from the rest of the region. Therefore the effect of proportionally having less responses from Christchurch is considered minimal.

Table 7.1 Protest Bids for Households in the Ashburton District

Refusal Reason	Bidding Number (%)	Dichotomous Number (%)
Farmers should pay or decrease abstraction		4 (9.1%)
Opposed to a rate increase	8 (32.0%)	21 (47.7%)
Not on a water supply or already paying for water	5 (20.0%)	10 (22.7%)
Refused to specify reason	4 (16.0%)	4 (9.1%)
Unable to decide	8 (32.0%)	3 (6.8%)
Too old		2 (4.5%)
Total	25 (100%)	44 (100%)

Table 7.2 Protest Bids for Households Outside the District

Refusal Reason	Bidding Number (%)	Dichotomous Number (%)
Farmers should pay or decrease abstraction		
Opposed to a rate increase		9 (47.3%)
Not on a water supply or already paying for water	2 (50.0%)	1 (5.3%)
Refused to specify reason		2 (10.5%)
Unable to decide	1 (25.0%)	1 (5.3%)
Too old		3 (15.8%)
Total	3 (100%)	16 (6.5%)

Table 7.3 Ashburton Occupations

	Population	Sample
Professional	885 (9.6%)	130 (15.1%)
Administrative Managerial	318 (3.4%)	34 (3.9%)
Clerical	951 (10.3%)	73 (8.5%)
Sales	819 (8.9%)	71 (8.2%)
Service	522 (5.7%)	48 (5.6%)
Agriculture	3000 (32.5%)	299 (34.7%)
Production Transport	2739 (29.7%)	206 (23.9%)
Total	9234	861

Table 7.4 Regional Occupations

	Population	Sample
Professional	22710 (15.2%)	94 (21.5)
Administrative Managerial	8121 (5.4%)	46 (10.5%)
Clerical	24777 (16.5%)	70 (16.0%)
Sales	14952 (10.0%)	43 (9.8%)
Service	13176 (8.8%)	25 (5.7)
Agriculture	12873 (8.6%)	63 (14.4%)
Production Transport	53280 (35.5%)	97 (22.1%)
Total	149889	438

Table 7.5 Population by District

District	Population (% of Region)	Survey Numbers (% of Surveys)
Hurunui	9273 (2.3%)	18 (5.0%)
Waimakariri	25400 (6.2%)	31 (8.6%)
Selwyn	20520 (5.0%)	21 (5.8%)
Christchurch	286601 (70.2%)	206 (56.9%)
Banks Peninsula	7232 (1.8%)	5 (1.4%)
Ashburton	-	-
Timaru	43394 (10.6%)	56 (15.5%)
MacKenzie	4866 (1.2%)	4 (1.1%)
Waimate	8234 (2.0%)	14 (3.9%)
Waitaki	2642 (0.7%)	7 (1.9%)

CHAPTER EIGHT

ACTIVITIES ON THE ASHBURTON RIVER

The Ashburton River has been an important recreational asset to the Ashburton community. (Scarf 1983, Eldon, Davis and Unwin 1982). Activities that occur on the river include at least trout and salmon angling, whitebaiting, floundering, picnicking and swimming, bird watching, shooting, boating and walking.

In 1982 Eldon Davis and Unwin stated

> "...the Ashburton River historically has been an important recreational fishery, which has declined markedly in recent years as a result of extended periods of artificially-induced low flows." (p. 1)

In researching how and why people value an improvement in the Ashburton River, it was necessary to identify those activities that are currently undertaken on the river and how these may change if the minimum stream flow increased.

Users have been separated into two groups; users from the Ashburton District and users from outside the District.

8.1 ACTIVITY DATA OF RESPONDENTS WHO LIVE IN THE ASHBURTON DISTRICT

Of the 639 households in the Ashburton District that were surveyed, just under half, 296 (46.3 percent) of these households used the Ashburton River. Picnicking and swimming was the predominant activity with 74 percent of all households that use the Ashburton River partaking in this activity (see Table 8.1). 60 percent of households that use the river, walk or stroll along the Ashburton River. Over a third of the households that use the river use it for angling. Other major activities include shooting (19 percent), other fishing (18 percent) and bike riding (15 percent). The range of activities indicate that some activities, such as fishing, are very dependent on river flows and other activities, such as bike riding, less contingent on river flows.

Activities specified within other activities included four wheel driving, stone and gem hunting, horse riding and camping. When the number of days spent on each activity was asked, no clarification was sought with regard to the type of shooting or bike riding. Therefore, it is not possibly to distinguish between duck and rabbit shooting, or between bicycles and mountain bikes and motor bikes or trikes. Similarly the amount of time spent when the activity is undertaken is unknown. Also the number of members of the household involved in the activity was not obtained.

The amount of times each household undertook these activities varied greatly. Some activities were only undertaken for brief periods of each year, such as jet boating. Other activities, such as walking, occurred all year round. Some households partook in activities only occasionally and some households were more active. Table 8.2 summarises the frequency of use of current activities.

Table 8.1 Current Activities by Households in the Ashburton District

Activity	Number of Households	Percentage of Users
Salmon Fishing	106	35.8%
Trout Fishing	111	37.5%
Other Fishing	53	17.9%
Bird Watching	36	12.2%
Picnicking & Swimming	220	74.3%
Walking	176	59.5%
Jet Boating	35	11.8%
Nonmotorised Boating	26	8.8%
Shooting	57	19.3%
Bike Riding	44	14.9%
Other Activities	17	5.7%

Table 8.2 Number of Days Per Annum Per Activity for Households in the Ashburton District

Activity	Average number of days per year	Standard deviation	Median number of days
Salmon Fishing	16.2	19.6	10
Trout Fishing	14.2	14.8	10
Other Fishing	10.8	16.9	7
Bird Watching	14.0	26.5	5.5
Picnicking & Swimming	12.6	13.6	7
Walking	17.9	35.2	10
Jet Boating	4.7	4.9	2
Nonmotorised Boating	5.2	5.4	2.5
Shooting	15.5	23.1	6
Bike Riding	17.4	29.2	6
Other Activities	8.5	12.9	5

In a normally distributed population, approximately 68 percent of the observations occur within plus or minus one standard deviation of the mean. Approximately 95 percent of the observations occur within plus or minus two standard deviations of the mean. In this case the distribution is skewed and the mean is being influenced by a relatively small number of very frequent users.

The median is the middle measurement when the data is ordered in numerical order, 50 percent of the observations will lie on either side of the median. The median has been reported because it is unaffected by a skewed distribution.

Many households were involved in more than one activity (see Table 8.3). Often anglers fished for both salmon and trout, and many people who picnicked also walked. From the survey data, it is unclear how many households undertook more than one activity per visit.

The respondents were also asked to state which activity was the most important to the household (see Table 8.4). This is because the activity that is undertaken most frequently may not be the most important to the household. For example, it is possible to picnic all year but salmon fishing, which may be the preferred activity, is restricted to a limited period each year. When respondents answered this question, some gave two answers such as salmon and trout fishing. Where this occurred the first answer was recorded. Some respondents stated the most important activity for themselves but mentioned this may not be the most important for other members of the household. For example, particular members may rate salmon fishing as the most important but other members may rate picnicking.

From Table 8.4 it can be seen that about 60 percent of the households that use the Ashburton River consider that either picnicking and swimming or walking is the household's most important activity. Fishing is the most important activity of about 30 percent of the households. These activities are the most important for almost 90 percent of households in the Ashburton District that use the Ashburton River.

In an attempt to clarify the characteristics of the households that use the river, a series of cross tabulations was undertaken. Factors such as household size, number of children, household income, and respondents' occupations were considered with the different activities with whether the household used the river. There were no obvious trends, except with the respondents' occupations versus whether they used the river or not (see Table 8.5). Professional and managerial people had a high probability of using the river, while households whose respondent was either retired or involved in agriculture had a lower probability of using the river.

Table 8.3 Number of Activities Per Household in the Ashburton District

Number of Activities	Number of Users	Percentage of Users
1	47	15.9%
2	83	28.0%
3	74	25.0%
4	41	13.9%
5	31	10.5%
6	15	5.1%
7	3	1.0%
8	2	0.7%

Table 8.4 Most Important Activity for Households in the Ashburton District

Activity	Number of Households	Percentage
Salmon Fishing	47	15.9%
Trout Fishing	31	10.5%
Other Fishing	10	3.4%
Bird Watching	4	1.4%
Picnicking & Swimming	113	38.2%
Walking	61	20.6%
Jet Boating	8	2.7%
Nonmotorised Boating	2	0.7%
Shooting	11	3.7%
Bike Riding	3	1.0%
Other Activities	6	2.0%

Table 8.5 Users Versus Occupation of Respondents in the Ashburton District

Respondents Occupation	Nonuser (%)	User (%)	Total	
			Number	% of all respondents
Professional	32.1%	67.9%	53	8.5%
Managerial	33.3%	66.7%	15	2.5%
Clerical	42.3%	57.7%	26	3.9%
Sales	59.3%	40.7%	27	4.6%
Service	47.1%	52.9%	17	2.7%
Agriculture	64.9%	35.1%	151	24.1%
Production	39.3%	60.7%	89	14.2%
Home Duties	41.9%	58.1%	93	14.6%
Student	33.3%	66.7%	6	0.9%
Retired	71.0%	29.0%	138	21.8%
Unemployed	41.7%	58.3%	12	1.8%
Other	66.7%	33.3%	3	0.4%

If the minimum stream flow was increased, use of the river could be affected in the following ways:

a) Present users could use the river more or less often.

b) Present users could change their activities. For example, households who presently only walk along the river banks may start swimming, or anglers may fish for salmon as well as trout fish.

c) New users may begin using the river.

d) Users may gain more satisfaction from undertaking their recreation without changing the frequency of the activity. For example, with increased stream flow, the occurrence of slime build-up may decrease and anglers may enjoy their fishing more.

e) The importance of activities may change. For example, a household whose most important activity currently is trout fishing, may change that to salmon fishing with increased stream flow.

Respondents were asked how many days members of their household would use the Ashburton River if the river level was increased one and half times (see Table 8.6). Households that currently do not use the river were asked if they would use the river given increased stream flows and if so for which activities and how often. The respondent was required to assess how the increased flow may affect their recreation activities, as no information on these effects was provided at that stage of the survey.

Of the 343 households in the survey that currently do not undertake any activities on the Ashburton River 66 of these households said they would use the river given increased stream flows. Therefore, with improved flows, 56.7 percent of all households in the Ashburton District would use the river as opposed to the 48 percent who currently use the river. Another 24 said they were unsure if they would use the river or not.

Table 8.7 gives the range of activities that new users expect to undertake. The number of activities that new users could become involved in is similar to the range of activities that current users undertake.

Table 8.8 provides figures on how households expected their usage of the river to change with increased minimum stream flows. For the majority of households, there would be an increase in activity. The biggest increases are in the activities that are involved directly with the river flow, as opposed to activities that use the river precincts. Salmon fishing would increase the most, with 72 percent of households expecting to increase their activity. More than half the households expect an increase in use in other types of fishing, including trout fishing, and boating. For activities such as bike riding and shooting, only approximately one household in five expected that those activities would increase as a result of increased stream flow.

Table 8.6 Future Activities by Households in the Ashburton District

Activity	Number of Households	Percentage of Users
Salmon Fishing	162	44.8%
Trout Fishing	144	39.8%
Other Fishing	72	19.9%
Bird Watching	39	10.8%
Picnicking & Swimming	270	74.6%
Walking	206	56.9%
Jet Boating	50	13.8%
Nonmotorised Boating	41	11.3%
Shooting	61	16.8%
Bike Riding	47	13.0%
Other Activities	17	4.7%

Table 8.7 Activities Expected to be Undertaken by New Users in the Ashburton District

Activity	Number of Households	Percentage of New Users
Salmon Fishing	32	48.5%
Trout Fishing	20	30.3%
Other Fishing	13	19.7%
Bird Watching	9	13.6%
Picnicking & Swimming	47	71.2%
Walking	37	56.1%
Jet Boating	11	16.7%
Nonmotorised Boating	8	12.1%
Shooting	9	13.6%
Bike Riding	7	10.6%
Other Activities	3	4.5%

Some respondents, especially mothers of young children, felt an increase in stream flows would not be an improvement and would not lead to an increase in activities. This was often reflected in their household's decrease in picnicking and swimming.

Associated with the increase in frequency of use for salmon fishing with an increase in minimum stream flows, is an increase in relative importance of salmon fishing. Currently only 15.9 percent of users rate salmon fish as their household's most important activity. With an increase in minimum stream flow, 22.1 percent of users expect that salmon fishing will be their household's most important activity (see Table 8.9).

Table 8.10 reports the average and median number of days households in the Ashburton District expect to use the Ashburton River given an increase in the minimum stream flow.

Table 8.8 Change in Usage for Households in the Ashburton District

Activity	Decrease (%)	No Change (%)	Increase (%)
Salmon Fishing	0 (0.0%)	45 (27.8%)	117 (72.2%)
Trout Fishing	2 (1.4%)	56 (38.6%)	87 (60.0%)
Other Fishing	5 (6.8%)	30 (40.5%)	39 (52.7%)
Bird Watching	9 (19.6%)	20 (43.5%)	17 (36.9%)
Picnicking & Swimming	19 (6.9%)	137 (49.6%)	120 (43.5%)
Walking	16 (7.4%)	133 (61.9%)	66 (30.7%)
Jet Boating	3 (5.7%)	16 (30.2%)	34 (64.1%)
Nonmotorised Boating	1 (2.4%)	17 (40.5%)	24 (57.1%)
Shooting	2 (3.3%)	46 (75.4%)	13 (21.3%)
Bike Riding	10 (18.2%)	33 (60%)	12 (21.8%)
Other Activities	3 (15%)	12 (60%)	5 (25%)

Table 8.9 Future Most Important Activity for Households in the Ashburton District

Activity	Number of Households	Percentage of Users	Increased Numbers
Salmon Fishing	80	22.1%	+33
Trout Fishing	32	8.8%	+1
Other Fishing	10	2.8%	0
Bird Watching	6	1.7%	+2
Picnicking & Swimming	134	37.0%	+21
Walking	63	17.4%	+2
Jet Boating	14	3.9%	+6
Nonmotorised Boating	4	1.1%	+2
Shooting	10	2.8%	-1
Bike Riding	3	0.8%	0
Other Activities	6	1.7%	0

Table 8.10 Future Number of Days per Annum for Households in the Ashburton District

Activity	Average Number of Days Per Year	Median Number of Day Per Year
Salmon Fishing	23.6	16
Trout Fishing	20.0	12
Other Fishing	13.2	9.5
Bird Watching	14.0	6
Picnicking & Swimming	15.2	10
Walking	18.1	10
Jet Boating	9.4	6
Nonmotorised Boating	8.0	5
Shooting	16.3	7
Bike Riding	15.3	5
Other Activities	17.8	7

8.2 ACTIVITY DATA FOR RESPONDENTS WHO LIVE OUTSIDE THE ASHBURTON DISTRICT

Three hundred and sixty two households from the Canterbury Regional Council catchment excluding the Ashburton District were surveyed. Of these households, 32 or 8.8 percent use the Ashburton River. Use statistics for users from outside the Ashburton District are listed in Tables 8.11 to 8.14.

Possible reasons why people that are not from Ashburton may use the Ashburton River include:

a) They were once residents of the District, and or have friends or relations in Ashburton.

b) They recreate on the Ashburton during their travels elsewhere. For example, they picnic beside the Ashburton.

c) They are keen anglers that fish a number of rivers.

d) There is something unique to the Ashburton River that makes travelling to the river beneficial.

For households from outside the Ashburton District that use the Ashburton River, their use is not insignificant or incidental. Three fifths of these households use it for three or more activities. The average number of days per annum for recreation for the households that currently use the river is also reasonably high.

Table 8.11 Current Activities for Households Outside the Ashburton District

Activity	Number of Households	Percentage of Users
Salmon Fishing	14	43.8%
Trout Fishing	12	37.5%
Other Fishing	1	3.1%
Bird Watching	3	9.4%
Picnicking & Swimming	21	65.6%
Walking	18	59.4%
Jet Boating	3	9.3%
Nonmotorised Boating	3	9.3%
Shooting	7	21.9%
Bike Riding	4	12.5%
Other Activities	2	6.3%

Table 8.12 Number of Activities per Household Outside the Ashburton District

Number of Activities	Number of Users	Percentage of users
1	6	18.8%
2	7	21.9%
3	11	34.4%
4	5	15.6%
5	3	9.4%

Table 8.13 Number of Days per Annum per Activity for Households Outside the Ashburton District

Activity	Average number of days per year	Median number of day per year
Salmon Fishing	13.2	6.0
Trout Fishing	10.6	5.0
Other Fishing	5.0	5.0
Bird Watching	4.0	1.0
Picnicking & Swimming	6.6	3.0
Walking	8.0	4.5
Jet Boating	3.7	3.0
Nonmotorised Boating	10.3	10.0
Shooting	15.3	2.0
Bike Riding	17.8	12.5
Other Activities	15.0	15.0

Table 8.14 Most Important Activity for Households Outside the Ashburton District

Activity	Number of Households	Percentage
Salmon Fishing	6	20.0%
Trout Fishing	4	13.3%
Other Fishing	0	0%
Bird Watching	1	3.3%
Picnicking & Swimming	11	30.0%
Walking	5	16.6%
Jet Boating	2	6.6%
Nonmotorised Boating	1	3.3%
Shooting	1	3.3%
Bike Riding	0	0%
Other Activities	1	3.3%

In an attempt to clarify the characteristics of the households outside the Ashburton District that use the Ashburton River, a series of cross tabulations was undertaken. The occupation of the respondent which showed some trend for local users did not provide any information of interest. No other demographic characteristics of the respondent showed any trend.

Tables 8.15 to 8.18 provides information on how households outside the Ashburton District expect their usage of the Ashburton River to change given an increase in the minimum stream flow.

The activity data and the effect of increased minimum stream flow is similar for Ashburton residents and for residents outside the Ashburton District. One exception is the relative increase in the number of new users. If the river flow is increased, 39 households not currently using the river said they would use the river and another 28 did not know if they would or not. This may be because an increase in the minimum stream flow is necessary before travelling to the Ashburton River is justified. Alternatively, respondents may feel that if their views are being sought on increasing the minimum stream flow of the Ashburton River, it may be worth a visit if they are currently unfamiliar with the river.

The data for residents outside the Ashburton District needs to be interpreted with care. Given the higher refusal rate of households outside the Ashburton District, it appears the results may contain some self selection biases, where a proportion of households that have no interest in the Ashburton River declined to answer the survey. This would result in the statistics for households outside the Ashburton District being biased upwards. In addition, the activity data for users outside the District is based on a small number of observations making interpretation difficult.

Table 8.15 Future Activities by Households Outside the Ashburton District

Activity	Number of Households	Percentage of Users
Salmon Fishing	36	50.7%
Trout Fishing	34	47.9%
Other Fishing	13	18.3%
Bird Watching	11	15.5%
Picnicking & Swimming	55	77.5%
Walking	38	53.5%
Jet Boating	7	9.9%
Nonmotorised Boating	19	26.8%
Shooting	13	18.3%
Bike Riding	13	18.3%
Other Activities	4	5.6%

Table 8.16 Future Most Important Activity by Households Outside the Ashburton District

Activity	Number of Households	Percentage of Users	Increased Numbers
Salmon Fishing	19	26.8%	13
Trout Fishing	7	9.9%	3
Other Fishing	4	5.6%	4
Bird Watching	2	2.8%	1
Picnicking & Swimming	23	32.4%	12
Walking	4	5.6%	-1
Jet Boating	5	7.0%	3
Nonmotorised Boating	2	2.8%	1
Shooting	1	1.4%	0
Bike Riding	2	2.8%	2
Other Activities	2	2.8%	1

Table 8.17 Change in Usage by Households Outside the Ashburton District

Activity	Decrease (%)	No Change (%)	Increase (%
Salmon Fishing	1 (2.7%)	7 (18.9%)	29 (78.3%)
Trout Fishing	2 (5.6%)	8 (22.2%)	26 (72.2%)
Other Fishing		1 (7.7%)	12 (92.3%)
Bird Watching		3 (27.3%)	8 (72.7%)
Picnicking & Swimming	2 (3.5%)	15 (26.3%)	40 (70.2%)
Walking	2 (5.0%)	13 (32.5%)	25 (62.5%)
Jet Boating		2 (28.6%)	5 (71.4%)
Nonmotorised Boating	1 (5.0%)	1 (5.0%)	18 (90.0%)
Shooting	2 (13.3%)	5 (33.3%)	8 (53.3%)
Bike Riding	2 (13.3%)	2 (13.3%)	11 (73.3%)
Other Activities		2 (50.0%)	2 (50.0%)

Table 8.18 Future Number of Days per Annum for Households Outside the Ashburton District

Activity	Average Number of Days Per Year	Median Number of Day Per Year
Salmon Fishing	10.9	6
Trout Fishing	9.9	6
Other Fishing	7.2	6
Bird Watching	7.2	4
Picnicking & Swimming	7.1	3
Walking	9.9	5
Jet Boating	3.8	3
Nonmotorised Boating	5.2	4
Shooting	13.2	5
Bike Riding	11.3	5
Other Activities	9	7

8.3 REASONS RESPONDENTS VALUE THE ASHBURTON RIVER

All respondents that valued the Ashburton River (whether they were willing-to-pay for an increase in minimum stream flows or not) were asked to rate why they valued an increase in stream flows and what emphasis should be placed on local, regional and national interests in the decision making process.

Respondents were given four categories why they would value an improvement in the Ashburton River:

1) use value, so the household could use the river,
2) option value, so the household could have the option to use the river in future,
3) bequest values, so future generations have the option to use the river, and
4) existence or intrinsic values, which is knowing that the river exists in an improved state.

Respondents were asked to rank each of these in turn from one to five, where one was not important and five was very important. Tables 8.19 and 8.20 reports on this ranking. Rankings for households in and outside the Ashburton District were very similar. Bequest value was rated the highest with almost 80 percent of households ranking it important or very important (that is, a scale of four or greater). Existence was the next most important reason with about two-thirds of the households giving it a ranking of four or five. Just under half the households ranked option value and one-third of the households ranked use values as important or very important.

Although approximately half of all households in the Ashburton District use the Ashburton River for recreation, the ability to use the river now is apparently not as important as the need to maintain the river for future generations. These results are similar to results obtained from other studies (see, for example, Brookshire, et. al., 1983) which suggest that use values often comprise only a small portion of the total value for the environment.

Respondents had the greatest degree of difficulty with this question. Many surveyors reported that some people had difficulty understanding what was required of them. Some people who had declined to pay for an increase in stream flows felt this question did not apply to them. The other difficulty with the question was respondents did not receive the complete question before beginning to answer. This may have resulted in the rankings of each part relative to the other values not accurately reflecting their valuations. Some people ranked all the reasons as very important.

The majority of households felt interests of the people in the Ashburton District were very important when making decisions on the river (see Tables 8.21 and 8.22). Over 80 percent of households rated Ashburton interests as four or greater, compared with about 50 percent for the interests of people in the Canterbury region and about 30 percent for national interests. Therefore, although the respondents valued both option and existence values highly, they see the management decisions of the Ashburton River as a local issue.

Table 8.19 Ranking of Values in the Ashburton District*

	1	2	3	4	5
Use Value	25.2%	14.4%	25.3%	17.1%	18.0%
Option Value	14.1%	10.9%	26.1%	20.3%	28.6%
Bequest Value	3.3%	4.6%	16.0%	22.8%	53.3%
Existence Value	4.6%	7.8%	20.7%	27.8%	39.1%

Table 8.20 Ranking of Values Outside the Ashburton District*

	1	2	3	4	5
Use Value	44.4%	19.1%	16.9%	9.1%	10.6%
Option Value	18.8%	14.1%	24.7%	22.2%	20.3%
Bequest Value	2.5%	3.8%	14.7%	22.8%	56.3%
Existence Value	4.7%	7.8%	19.4%	30.0%	38.1%

* where 1 is not important and 5 is very important

Table 8.21 Ranking of Decision Emphasis for Respondents In the Ashburton District*

	1	2	3	4	5
Ashburton Interests	1.1%	1.6%	14.1%	25.5%	57.7%
Canterbury Interests	5.7%	15.5%	29.5%	22.7%	26.6%
National Interests	21.1%	19.2%	28.2%	12.8%	18.7%

Table 8.22 Ranking of Decision Emphasis for Respondents Outside the Ashburton District*

	1	2	3	4	5
Ashburton Interests	1.2%	0.9%	14.4%	25.4%	58.1%
Canterbury Interests	3.4%	13.8%	35.5%	26.0%	21.4%
National Interests	19.3%	19.6%	27.8%	11.3%	22.0%

* where 1 is not important and 5 is very important

CHAPTER NINE

ECONOMIC VALUE OF INCREASED STREAM FLOWS

This chapter reports the economic values for increasing the Ashburton River minimum stream flow by 50 percent. The survey used two alternative methods to elicit respondents' willingness-to-pay - a bracketed bidding game and a dichotomous choice question.

9.1 THE DICHOTOMOUS CHOICE RESULTS

With the dichotomous choice or take-it-or-leave-it approach, a large number of predetermined prices are chosen to bracket the expected willingness-to-pay amounts of most respondents. Each respondent is quoted one of the prices and asked if he or she would pay that amount for the improvement in the stream flow. A logit model is used to translate the yes or no responses into a function that infers willingness-to-pay.

In this thesis, two logit models were specified: one for the Ashburton District and one for respondents outside the district. A variety of independent variables were tested in each model: bid price, household income, an overall river use variable, a fishing variable, whether the respondent was involved in agriculture or not. The price variable was a continuous variable, all other variables were qualitative (see Tables 9.1 and 9.2).

Table 9.1 Logit Equations for the Ashburton District

Intercept	NonUser	Angler	User Nonangler	Income	Agriculture	Township	Price	Chi Sq
.2689 (1.1)	-.676 (2.61)						-.0057 (5.64)	.26
.0700 (.22)	-.572 (1.99)			.286 (1.04)	.394 (1.28)		-.0054 (5.02)	.24
-.306 (1.34)		**.754 (2.91)**					**-.0057 (5.73)**	**.69**
-.065 (.20)		.875 (3.06)	-.355 (1.06)				-.0059 (5.73)	.67
-.365 (1.25)		.637 (2.25)		.318 (1.16)	.278 (.98)		-.0056 (5.09)	.28
-.185 (.706)		.761 (2.92)				-.190 (.759)	-.0057 (5.62)	.46

Table 9.2 Logit Equations for Outside the Ashburton District

Intercept	Nonuser	Angler	User Nonangler	Income	CHCH	Price	Chi Sq
-.450 (1.45)						**-.0087 (4.08)**	**.64**
.002 (.004)	-.459 (.98)					-.0092 (4.17)	.69
.529 (.83)	-.937 (1.78)			.231 (.49)		-.011 (4.12)	.89
-.463 (1.45)		.679 (1.26)				-.0092 (4.17)	.81
-.462 (.54)		.679 (1.25)	-.001 (.002)			-.0092 (4.15)	.79
-.435 (1.09)					0.059 (.15)	-.0090 (4.13)	.72

According to Gujarati (1988), a good model should be kept as simple as possible and should 'explain much by little'. The estimated parameters must have unique values and be theoretically consistent. For example, economic theory states that the price coefficient should be negative. The model should also have goodness of fit. It should explain as much of the variation in the dependent variable as possible by the explanatory variables included in the model.

The models selected are parsimonious, yet include all statistically significant parameters at the 95 percent level (as measured by the t statistic) and have reasonable Chi square values, although the Chi square may be of questionable value in logit models. This is because logit analysis uses the method of maximum likelihood estimation (regression analysis uses the method of least squares) thus pseudostatistics are calculated. The t values quoted are asymptotic t's because the maximum likelihood method was used (Gujarati, 1988).

For the Ashburton District, the best model estimated is:

$$\log\left(\frac{\textit{Prob Yes}}{1 - \textit{Prob Yes}}\right) = -0.3059 + 0.7536F - 0.00584P \qquad (9.1)$$

(1.339) (2.914) (5.699)

Pearson's Chi square = 0.69

where
t = values are given in parenthesis (values greater than 1.96 are significant at the 95 percent level)
F = indicates whether the respondent fishes in the river
P = is the price offered

For the respondents outside the Ashburton District, the best model estimated is:

$$\log\left(\frac{Prob\ Yes}{1 - Prob\ Yes}\right) = -0.4498 - 0.00877P \qquad (9.2)$$

$$(1.452) \quad (4.078)$$

Pearson's Chi square = 0.64

The Pearson's Chi square is one estimation of the overall fit of the model. Another is how correctly the model predicted the observed data. A two-by-two frequency table of observed and predicted responses was used to check how well the modelled data fitted the observed data (see Tables 9.3 and 9.4). A event was considered to occur when the respondent was willing-to-pay the price offered. A nonevent was where the respondent declined to pay the price offered.

The Ashburton model correctly predicted 78.3 percent of responses. It correctly predicted 14.9 percent of events and 97.7 percent of nonevents. The model for outside the Ashburton District correctly predicted 84.4 percent of responses. It correctly predicted all nonevents, but failed to predict any correct events. The high number of events being predicted as nonevents by the models may be in part due to the fact that events comprise of only a small proportion of total responses.

Table 9.3 Classification Table for the Ashburton District Model

Observed	Predicted: Event	Predicted: Nonevent	Total
Event	14	80	94
Nonevent	7	300	307
Total	21	380	401

Table 9.4 Classification Table for Outside the Ashburton District Model

Observed	Predicted: Event	Predicted: Nonevent	Total
Event	0	36	36
Nonevent	0	195	195
Total	0	231	231

Integrating each function gives the mean willingness to pay. For the Ashburton model, the mean willingness-to-pay as calculated from zero dollars to infinity, is $161.25 per household per year for anglers and people who expect to become anglers given an increase in the minimum stream flow, and $94.48 per household per year for nonanglers. For the outside Ashburton model, the mean willingness-to-pay is $56.25 per household per year (see Table 9.5). The difference in means is accounted for by location, by fishing activity, and overall utility derived from the river.

Truncating the mean at the 90 percentile (this is where the probability of the respondent being willing to pay the price offered is 0.1), results in the upper limits of $452.81, $323.83 and $199.23 for Ashburton anglers, Ashburton nonanglers and households outside the district, respectively. The truncated mean for Ashburton anglers is $143.21, for Ashburton nonanglers is $76.44 and for households outside the district is $44.24 per household per year.

The median value for households who live in the Ashburton District and who fish or expect to fish the Ashburton River given an increase in the minimum stream flow is about $77 per household per year. The medium value for Ashburton nonanglers and non Ashburton District residents is $0. Less than 50 percent of all households both within the district and outside the district are willing-to-pay $1. Table 9.5 reports the results of the mean and median calculations.

Table 9.5 Dichotomous Choice Values

	Dichotomous choice mean	Dichotomous choice truncated mean	Dichotomous choice median
Ashburton Angler	$161.25	$143.21	$76.65
Ashburton Nonangler	$94.48	$76.44	$0.00
Outside the District	$56.25	$44.24	$0.00

9.2 THE BIDDING GAME RESULTS

Of the 237 completed bidding interviews in the Ashburton District, 212 useable bids were obtained. The remaining 25 were discarded because of protest bids or the respondent failed to fully understand the willingness-to-pay question.

Twenty one percent of respondents were unwilling to pay any money for the minimum stream flow of the Ashburton River to be increased (see Table 9.6). Twenty five percent of respondents were only willing to pay $1 or less.

The mean bid for the Ashburton District is $78.03 per year. The distribution of bids is skewed, and the mean bid is influenced by a relatively few high bids. Mitchell and Carson (1989), suggest adjusting the mean by trimming the mean rather than adjust for outliers on an ad hoc basis. Mathematically when the sample is ordered from the smallest to the largest observation, the trimmed mean is defined by

$$\bar{X}_{\alpha} = \frac{X_{[n\alpha]+1} + \ldots + X_{n-[n\alpha]}}{n - 2[n\alpha]} \tag{9.3}$$

where α = the degree of trimming

n = the sample size

X = the smallest observation

X_n = the largest observation

Table 9.6 Distribution of Bids in the Ashburton District

Bid ($)	Frequency	Percentage of Bids	Cumulative Percentage
0	44	20.8%	20.8%
1	8	3.8%	24.6%
2-10	10	4.7%	29.3%
11-25	18	8.5%	37.8%
25-50	42	19.8%	57.6%
51-75	17	8.0%	65.6%
76-100	25	11.8%	77.4%
101-125	13	6.1%	83.5%
126-150	5	2.4%	85.9%
150-200	11	5.2%	91.1%
201-250	12	5.7%	96.8%
250-500	7	3.3%	100%

Statisticians recommend alpha levels between 0.05 and 0.25. Stigler (1977) has shown a 10 percent trimmed mean results in a more efficient and less biased estimate. Accepting Stigler's recommendation, the highest and lowest 10 percent of bids would be deleted and the mean recalculated. This is shown diagrammatically in Figure 9.1

Trimming the mean using an alpha of 0.1 results in a decrease of the mean value by $19.54 (25.0%) to an adjusted mean of $58.49. As alpha is increased, the marginal effect on the mean decreases (see Table 9.7).

An alternative measure is the median. The median represents the amount that at least 50 percent of the population would be willing-to-pay. The median bid for the Ashburton District is $50.00. As the mean is increasedly trimmed the mean approaches the median.

The Ashburton respondents were subdivided into two subgroups: households that fished the Ashburton River, or would fish the river given an increase in the minimum stream flow, and all other households. This was to enable comparison with the dichotomous choice results. The mean, the trimmed mean and the median for each subgroup are reported in Table 9.8.

Figure 9.1 Effect of Trimming the Mean

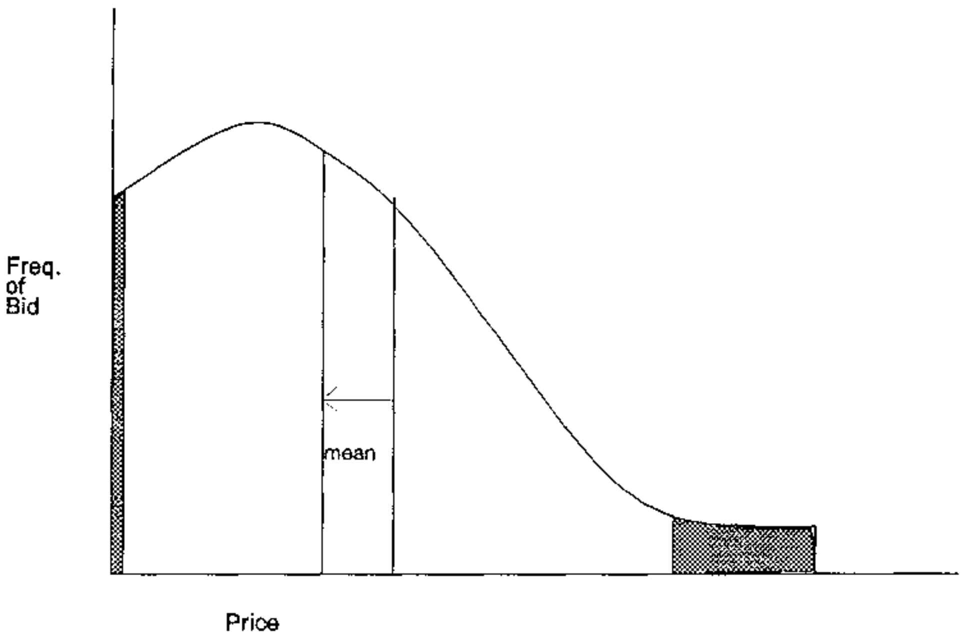


Table 9.7 Sensitivity of Trimmed Mean for the Ashburton District

Alpha	Trimmed Mean
0.00	$78.03
0.05	$64.96
0.10	$58.49
0.15	$53.16
0.20	$51.43
0.25	$50.30

Table 9.8 Summary of the Bids in the Ashburton District

	Ashburton District (212)[a]	Ashburton Anglers (64)[a]	Ashburton Nonanglers (148)[a]
Mean	$78.03 (6.84)[b]	$109.66 (16.21)[b]	$64.35 (6.59)[b]
Adjusted Mean(0.1)	$58.49	$84.97	$48.30
Median	$50	$60.00	$50.00

[a] Sample Size
[b] Standard error

Of the 131 surveys outside the Ashburton District using iterative bidding, 20 respondents protested or failed to fully understand the willingness-to-pay question. Of the 111 useable responses, 28 percent of the respondents were unwilling to pay any money for the minimum stream flow of the Ashburton River to be increased. Nearly 35 percent of the respondents were only willing to pay $1 or less (see Table 9.9).

The mean bid is $62.85 per year. Trimming the mean at an alpha level of 0.1 results in a trimmed mean of $44.67, decreasing the mean by $18.18 or 28.9 percent (see Table 9.10). The median bid for households outside the Ashburton District is $30.00.

Table 9.9 Distribution of Bids Outside the Ashburton District

Bid ($)	Frequency	Percentage of Bids	Cumulative Percentage
0	28	25.2%	25.2%
1	7	6.3%	31.5%
2-10	13	11.7%	43.2%
11-25	4	3.6%	46.8%
26-50	18	16.2%	63.0%
51-75	7	6.3%	69.3%
76-100	14	12.6%	81.9%
125	6	5.4%	87.3%
150	2	1.8%	89.1%
250	11	9.9%	99.0%
500	1	0.9%	100%

Table 9.10 Sensitivity of the Trimmed Mean for Outside the Ashburton District

Alpha	Trimmed Mean
0.00	$62.85
0.05	$52.79
0.10	$44.67
0.15	$39.62
0.20	$36.96
0.25	$34.56

9.3 AGGREGATION OF WILLINGNESS-TO-PAY

To estimate the aggregate willingness-to-pay for an increase in Ashburton stream flows, the number of households in and out of the Ashburton district were multiplied by the individual willingness-to-pay amounts (see Table 9.11).

In aggregating the results, assumptions have to be made regarding the households that declined to partake in the study. The 30 percent and 47 percent refusal rate for the Ashburton District and outside the District, respectively, is reasonably high for telephone surveys. Three scenarios have been considered:

1) The views and values expressed by the respondents are representative of both the Ashburton District and the Canterbury Region.
2) The respondent sample is not representative of the general population. Nonrespondents place zero value on the Ashburton River and are not willing to fund an increase in the minimum stream flow.
3) The refusals in the Ashburton District are representative of the level of refusals for general, rather than survey-specific reasons. The additional 17 percent of refusals outside the Ashburton District occur because those respondents have no interest and place zero value on the Ashburton River.

Accepting the assumptions in scenario 1, the willingness-to-pay values would be aggregated across all households. With scenarios 2 and 3, the appropriate number of zero bids could be added to the sample and the means and trimmed means recalculated.

The dichotomous choice results could be adjusted to reflect the response rate. Ideally, in this case, a record of the price offered to respondents should be made and then the price of those declining to participate added to the sample as no responses. Because this was not done by the interviewers, it is not possible to adjust the dichotomous choice results.

Table 9.11 Aggregated Willingness-To-Pay

	Ashburton		Non Ashburton	Aggregated Value $ million per year	
	Anglers	Nonanglers		Ashburton Only	Total Region
Households	2777	5794	139920	8751	148671
Dichotomous Choice					
Mean	$161.25	$94.48	$56.25	$1.00 m	$8.87 m
Truncated Mean[a]	$143.21	$76.44	$44.24	$0.84 m	$7.03 m
Median	$76.65	$0.00	$0.00	$0.21 m	$0.21 m
Iterative Bid					
Mean	$109.66	$64.35	$62.85	$0.68 m	$9.47 m
Trimmed Mean[b]	$84.97	$48.30	$44.67	$0.52 m	$6.77 m
Median	$60.00	$50.00	$30.00	$0.46 m	$4.65 m
Scenario 2 Iterative Bidding					
Mean	$77.13	$45.14	$33.38	$0.48 m	$5.15 m
Trimmed Mean[b]	$50.25	$28.93	$15.43	$0.31 m	$2.47 m
Median	$30.00	$1.00	$0.00	$0.09 m	$0.09 m
Scenario 3 Iterative Bidding					
Mean	$109.66	$64.35	$52.06	$0.68 m	$7.96 m
Trimmed M*p4[b]90XMean	$84.97	$48.30	$33.11	$0.52 m	$5.15 m
Median	$60.00	$50.00	$10.00	$0.46 m	$1.86 m

[a] Mean truncated at the 90 percentile

[b] Mean trimmed at an alpha level of 0.1

Depending on the assumptions made, the aggregated value to the households of the Canterbury Region for an increase in the minimum stream flow of the Ashburton River by 50 percent is between $0.09 million and $9.47 million per year. This reflects that nonmarket valuation is an imprecise science, and the assumptions made can markedly influence the final result. However, the alternative elicitation methods when using the same assumptions gave aggregated results of similar magnitude. The values derived appear to be consistent with possible actions of respondents. For example, anglers who will receive increased utility from increased stream flows do consider this in their valuation function. Yet use values are only a small portion of the total economic value.

Both the iterative bidding and the dichotomous choice approaches result in a skewed distribution of prices. This suggests that a small proportion of the population place a high value on in-stream flows. The problem is how to reflect this value when aggregating values. The median has appeal from a political viewpoint, in that it represents the largest amount that at least 50 percent of the population would be willing-to-pay. Therefore, if a vote was taken using the median price there would be a high probability of approval.

The trimmed mean has the advantage in that it can adjust results for outliers yet still reflect the proportion of the population that does place a high value on the amenity. A decision has to be made at what level to trim. If alpha, the percentage of trimming, is 0.1, the aggregated value is $6.77 million, 2.47 million and 5.15 million for scenario 1, scenario 2 and scenario 3, respectively. If alpha increased to 0.15 the aggregated value is $6.03 million, $1.83 million and $4.5 million for scenario 1, scenario 2 and scenario 3, respectively.

Scenario 2 provides a lower bound on the economic value of increased in minimum stream flows. Scenario 3 is a reasonable assumption, given the poor response rate for a telephone survey. Therefore, the economic value of an increase in the minimum stream flow of the Ashburton River is between the values stated in scenarios two and three. Accepting a trimmed mean with an alpha level of 0.1 to account for outliers, the economic value of increasing the minimum stream flows of the Ashburton River by 50 percent is between $2.47 million and $5.15 million per annum.

The majority of the economic value for the Ashburton River is outside the Ashburton District. This is because of the distribution of population. The majority of the Canterbury population resides in Christchurch city. No judgement has been made regarding if the values between the district and the region should be weighted. The assumption was made that individual respondents would make this judgement when responding.

Finally, the results have been calculated in a partial analysis framework. The valuation of the Ashburton River has been undertaken in isolation. The value of the river could change if the river was valued in conjunction with all of Canterbury's rivers. For example, if the number of rivers in Canterbury that have improved flows increase, the value of the increased flow in the Ashburton River may diminish.

CHAPTER TEN

CONCLUSIONS AND RECOMMENDATIONS FOR WATER ALLOCATION IN THE ASHBURTON RIVER

The Ashburton River has value to both abstractive users and to people who value in-stream flows. The results of the linear programming and contingent valuation suggest that the value of water needed to increase the minimum in-stream flow by 50 percent is worth about $0.62 million per annum to irrigators in the Ashburton District and between $2.5 million and $5.2 million per annum to the residents in Canterbury, for increased stream flows.

Economic efficiency could be one criteria used for determining the allocation. But Chapter 3 demonstrated that efficiency was, in part, defined by institutional factors. A framework was developed in Chapter 3 to assist in evaluating how effective the institutional structure is at allocating a resource. This contained eight principles: dependability, permanence, adaptability, equity, incentives for maximum effort, economy, political attractiveness, and minimal interference with private decisions. These criteria can be used in analysing the current management plan and any future management plans for the Ashburton River.

10.1 EVALUATION OF THE CURRENT ALLOCATION OF ASHBURTON RIVER WATER

The current system, as explained in Chapter 4, is based around the setting of minimum stream flows. The system is designed to determine how much water is available for abstraction and how this water will be shared.

The Rangitata Diversion Race is owned by the Rangitata Diversion Race Management Company. The shareholders in this company are: the Ashburton-Lyndhurst Irrigation Management Ltd., the Mayfield-Hinds Irrigation Management Ltd., the Valetta Irrigation Coop Society Ltd., Electricorp, the Ashburton District Council, and the Ashburton Electric Power Board (Bagnall, 1992).

The Rangitata Diversion Race had a notified use under the Soil and Water Conservation Act (1967) to abstract water from the Rangitata and Ashburton Rivers. This notified use will expire 10 years after the Resource Management Act (1991) has been in effect. Farmers on the community irrigation schemes do not hold individual water rights, but they do have a vested interest in the company that owns and manages the Rangitata Diversion Race, through the individual irrigation scheme companies.

Water that is abstracted via the Rangitata Diversion Race is allocated by the managers of the Rangitata Diversion Race and the managers of the individual schemes (Mayfield-Hinds, Valetta, and Ashburton-Lyndhurst). The current irrigation allocation is based on 12 hours of water per week per 40 hectares contracted, at a flow rate of 230 litres per second. The contracted area is the area of the farm able to be irrigated. When restrictions are imposed, they affect the farms that are rostered to receive water at the time of restrictions. When restrictions occur on the Ashburton River or the Rangitata River, the reduction is shared between all the schemes fed from the Rangitata Diversion Race.

Water on the Greenstreet scheme is also allocated on a similar basis as for the schemes on the Rangitata Diversion Race.

10.1.1 Evaluation of the Management Plan

The objectives of the Ashburton River Management Plan include setting minimum flows for the Ashburton River and specifying how the available water resources are to be allocated.

10.1.1.1 Dependability

The current system recognises that water is both valuable in-stream and for abstractive purposes. The plan attempts to reflect public values by setting minimum in-stream flows. The minimum flow is also set with regard to the possible economic injury that farmers would incur if insufficient water was available for abstraction. One possible interpretation of the current management plan is in allocating the water between uses it reflected the allocation at the time of implementation. This is reflected in the following comment

> "The minimum flow standards that can be met at this time, without placing unacceptable restrictions on existing domestic and stockwater supplies is ...and gives warning to all abstractive users that in 1990 it intends to raise the established minimum flow levels to the levels listed in Table 3." (Scarf, 1983, p. 17).

Whether the plan fully reflected the views and values of society at the time is unclear.

10.1.1.2 Permanence

The plan has endured since its conception and is currently being reviewed. The review process is part of the contingency to ensure that the plan endures.

10.1.1.3 Adaptability

In the short-run the plan is inflexible. There is limited flexibility to allow water to shift in location or use in response to changing social and economic conditions. With the review process, management is able to be adapted, at least to a limited extent.

10.1.1.4 Equity

Equity and fairness are value judgements. One definition of equity is a "just and fair" collectively agreed upon method of distributing the fruits of society

(O'Connell, 1982). Equity does not necessary refer to equality but rather equal opportunity. Several parties in the Ashburton River allocation process have stated that at times costs have been imposed on them because of the current management plan. At the same time many people commented during the contingent valuation survey that a balanced approach is needed and they felt the river was being well managed.

10.1.1.5 Incentives for maximum effort

Currently, there is limited incentive for maximum effort. More efficient users or producers of high value commodities do not receive additional allocation.

10.1.1.6 Economy

The management process attempts to obtain a consensus of all interested parties. This is a costly and time consuming process. The current review has been under way since November 1990. The objective is to obtain consensus by negotiation rather than by litigation.

If the plan achieved economic efficiency at the outset, the ability for adaptability is limited except for at each review period. The management plan does not ensure that all users continually consider the complete social cost of the river.

10.1.1.7 Political attractiveness

The current system has been accepted by legislators and voters.

10.1.1.8 Minimal interference with private decisions

The current system does not tell individuals exactly what to do, but does not offer the broadest scope of choices. The current system encourages individuals to use their allocation as there is no incentives to allow other users to use their allocation. The prevailing requirements are clear with regard to minimum flows, the sharing of the waters of the Ashburton River, and when and how restrictions will occur.

10.1.2 Allocation of Irrigation Water by the Community Irrigation Schemes

10.1.2.1 Dependability

The current system is dependable. Farmers receive water on a regular basis. The system is well understood, partly due to familiarity with a long-standing process. When restrictions occur, farmers know how they will be applied.

10.1.2.2 Permanence

The allocation of water between schemes on the Rangitata Diversion Race and within schemes has been in existence for a long time.

10.1.2.3 Adaptability

The system is slightly adaptable in that there is no compulsion on farmers to use their allocation. If there is surplus water, it is made available to other farmers. There is limited flexibility to allow water to be shifted in location or purpose of use in response to changing social and economic conditions.

10.1.2.4 Equity

The system relies more on equality of present users than on either efficiency or equity, in that all farms get the same amount of water per area contracted. Given that all users are similar (farm systems are pasture based), the marginal value of water is similar for all users.

10.1.2.5 Incentives for maximum effort

The system does not provide incentives for maximum effort. For example, innovative farmers that are able to design management systems that are more flexible (for example, that could use water earlier in the season and use reduced water over the peak period) are provided with little incentive by the allocation system to do so. More intensive farmers (Barlow (1986) stated that 'top' farmers utilised grass more efficiently), or farmers that currently do not receive water, or who have more restrictions, and farmers that need a secured quantity of water (for example, orchards or producers of other water sensitive crops) are restricted in their ability to obtain more water or a more secured supply of water.

10.1.2.6 Economy

The allocation of water by the community schemes does achieve results at a relatively low cost to farmer participants. Under the current system water is a fixed cost per hectare.

10.1.2.7 Political attractiveness

Farmers on the community schemes appear to be happy with the current allocation system.

10.1.2.8 Minimal interference with private decisions

There is limited interference with private decision making. But, the equal allocation does not encourage farmers to consider the opportunity cost of water to other users (both abstractive and in-stream).

10.2 AN ALTERNATIVE ALLOCATION SYSTEM

The current way of allocating water in the Ashburton River, both between in-stream and consumptive uses and between consumptive users, has many desirable features but the incentives for maximum effort and the flexibility and adaptability for economic growth are limited. Can changes be made to the way water is allocated to improve the allocation process?

In designing or changing the process, the objective is to achieve a more economic efficient allocation of water that can reflect changing economic and social conditions. This way, the largest value to society from the Ashburton River may be achieved.

There are two different measures of economic efficiency:

a) efficient use of all Ashburton water, where the marginal value of water is equal in all uses.

b) efficient use of irrigation water, where the marginal value of irrigation water is equal in all uses.

There are advantages in being able to reallocate irrigation water. For example, the linear programming models suggest that currently dairy farmers have a higher valued use of water than other farming activities. If irrigation water was reallocated, the advantages may be to the region and not necessary to all or existing farmers. That is, in reallocating some farmers may receive less water than they are presently allocated.

Market forces could be used to allocate water. Two advantages of a market system to allocate water are that, the value of water is recognised distinctly and the reallocation is voluntary (buyers and sellers believing it is their own best interests). A market system forces participants to consider the opportunity cost of water. It also provides information to do so in the form of the price of water. A market system can also help to lower transaction costs.

To achieve gains in efficiency not all water has to be part of a market system. For example, the management of the Rangitata Diversion Race, or the individual schemes (Ashburton-Lyndhurst, Valetta and Mayfield-Hinds) could make a percentage, say 80 percent, of its water available under the present rostering system. The remaining water (20 percent) could be made available under a tendering system. In theory, farmers that have the highest value for the additional water would be willing-to-pay the most for it. In effect, this is no different than an individual farmer allocating water to his highest value crop.

Initially, the tendering process could be available only to farmers currently receiving water from the Rangitata Diversion Race. The revenue generated could remain with the management company to ensure that the benefits would initially collectively remain with the current users. The limited tender would enable a gradual adjustment in the allocation process where there is limited risk to existing users, to allow the market system to become established.

The water available for tendering could initially be for either a short period, say two months (four tenders per season), or for a whole season. There is flexibility in how the water available for tender is defined. It could be the final 20 percent of water made available by the Rangitata Diversion Race, or the individual irrigation schemes, and would be the first allocation to be reduced in times of restrictions. This water would have less security of supply than the water allocated by the roster system and the prices tendered should reflect the risks involved. The possibility would also exist for the water to be made available on a priority basis. That is, the farmer with the highest tender price would receive his allocation before the other successful buyers.

Alternatively, the water available for tender could have increased security of supply by allowing the first 20 percent (or a fixed quantity) of water to be available for tender.

Although both Williamson (1991) and Allison (1988) favour priority rights to provide security of the right, there would be difficulty in establishing these given the current system of proportional rights. The tendering system goes some way in providing the security of priority Williamson felt was important. Any new rights that may be issued in future could be given a lower "B" classification that recognises the expectations of current water users. Williamson (1991) acknowledged the need that rights needed to be mobile to prevent inefficient use of water.

10.2.1 Evaluation of the Alternative Allocation System

10.2.1.1 Dependability

The system would be dependable. It would force individuals to consider the opportunity cost of water. The system is based on the present system which had many desirable features that ensured the system was dependable.

However, if relatively few transactions take place, the market is considered "thin" and a key market function, the establishment of a "going" price may be lacking (Colby, 1990). A system of tendering on a regular basis should ensure the establishment of a going price, but if transactions were limited, the system may lack dependability.

10.2.1.2 Permanence

The system should endure. Once participants become familiar with the system if they require more water they have the opportunity to obtain additional water.

10.2.1.3 Adaptability

The system is flexible enough to adopt to normal expansion in economic activities.

10.2.1.4 Equity

Equity issues are not contravened. The investment farmers have made in irrigation is protected. Not only have farmers invested in their farms but they have also invested in the Rangitata Diversion Race. Initially, all farmers have access to 80 percent of their current water allocation.

An important factor affecting equity will be how the revenue generated from the tendering process is utilised. It could be used to pay a dividend to the shareholders, be used to cover administration and running costs as opposed to the current levy charged to all farmers, or be used to fund projects associated with river enhancement.

10.2.1.5 Incentives for maximum effort

The system provides incentives for maximum effort.

10.2.1.6 Economy

The costs of running a tendering process should not be great.

10.2.1.7 Political attractiveness

How attractive the people involved with the Ashburton River allocation process perceive this system remains to be seen. Some current users will see it as having to pay for something that previously they did not have to pay for with a risk of receiving a smaller allocation of water. Other people will see the system as providing them with opportunities that previously did not exist.

10.2.1.8 Minimal interference with private decisions

The system offers more choices to private individuals than previously existed.

10.2.2 Variations on the Alternative Allocation System

As the tendering process becomes established, and the users gain confidence in the system, the opportunity exists to allow more participants into the tender. This could be the electricity producers that source water via the Rangitata Diversion Race, other farmers such as farmers on the Greenstreet scheme, farmers who currently do not receive water, or in-stream representatives.

A greater proportion of the water could also be made available for tender as the system develops. Farmers could also offer part or all of their rostered water for tender, with the proceeds belonging to the farmer.

To facilitate long-term transfers, individuals could be allowed to sell their interests in their irrigation scheme, therefore transferring their water allocation to the buyer. Approval from the scheme's management may be necessary to ensure third parties are not disadvantaged.

The proposed alternative system does not directly allow the opportunity cost of in-stream flows to be considered. For the marginal value of water to be equal in all uses to be equal, all users have to be considered. If the in-stream value is higher than the going irrigation price in-stream users could potentially tender for this water (disregarding free riding and funding concerns).

As a transitional measure, a reserve price could be set (possibly at an estimated marginal value of in-stream flow), say for three years. If the tender price does not reach this price, the water is left in-stream and an organisation such as the Ashburton District Council could compensate the tendering organisation for this water. This would provide time to set up an appropriate organisation to represent in-stream flows.

Income and equity issues are important. With the current proposal, the property rights are assumed to reside with the Rangitata Diversion Race management company or the individual irrigation scheme companies. Under this property right structure, these companies receive the gains from trade. It also assumes that potential buyers, such as in-stream users, have the income to be able to actively partake in the market.

Alternatively, some water permits could be issued to the stewards of in-stream flows. Since the value of water in-stream is not due to water alone, but includes the habitat water provides, the abstractors could investigate the potential of alternative means of providing aquatic habitat (a precedent has occurred with Electricorp and the Waitaki River - see Palmer, 1990). By providing aquatic habitat this would allow more water to be abstracted.

10.3 FURTHER WORK

This thesis estimated the value of water for irrigation and to enhance the minimum stream flow. This implications of these values to the allocation system was then discussed and a potential refinement to the current system was proposed.

The following should be undertaken to refine the work undertaken in this thesis:

a) In determining the value of water for irrigation, the linear programming model could be refined to include such factors as the variation in product prices and the variation in water availability within the season. More work is necessary in quantifying the effect of the increased minimum stream flow would have on the availability of water for abstraction.

b) Further work is necessary with contingent valuation in determining how to reflect the divergent views of respondents (for example, the mean versus the median), and how to best use the results when the majority of the value of a resource lies outside the District in which the resource is located.

c) Further work is necessary to determine how a tendering process may affect individual users and the management of the irrigation schemes. Issues include what the most efficient time span for the tendering process is, such as every two months or another longer time period; whether the benefits of such a tendering scheme outweigh the costs; the income and equity considerations; and how the in-stream values may be given effect in such a process.

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APPENDIX 1

ASHBURTON LYNDHURST IRRIGATION SCHEME

FARMER SURVEY

FARMER SURVEY

Farmers Name:______________________________

Total Farm Area: __________ha **Area able to be Irrigated:**__________

Area Border Irrigated:__________ha **Area Spray Irrigated:**__________

Area Wild Flooded: __________ha

Water Allocation: __________ **hours per week**

Farm Enterprises: (please tick which activities apply to your farm)

- Sheep ☐
- Beef ☐
- Dairy ☐
- Deer ☐
- Arable Crops ☐
- Other (please specify)__________________ ☐

Stock Numbers as at 30/6/90

Ewes	__________
Replacement Ewe Hoggets	__________
Trading Sheep	__________
Other Sheep	__________
Rising 3 Year Bulls	__________
Rising 2 Year Bulls	__________
Rising 1 Year Bulls	__________
Rising 3 Year Steers	__________
Rising 2 Year Steers	__________
Rising 1 Year Steers	__________
Beef Breeding Cows	__________
Dairy Cows	__________
Rising 1 Year Heifers	__________
Rising 2 Year Heifers	__________
Deer	__________
Other________________________	__________

Stock Performance:

Lambing Percentage: __________

Wool weights: __________kg wool/S.U. wintered

Average lamb carcass weight: __________kg

Average beef carcass weight: __________kg

Milkfat: __________kg MF/cow

Crop Performance: (Crops grown this season 1990/91)

CROP	**AREA (ha)**	**YIELD (t/ha)**	**Number Irrigatic per Season**
eg: Winter Wheat	**10**	**4.5**	3

Area of crop stubble sown in greenfeed: ____________________ha

Area of other greenfeed ____________________ha

Area of Lucerne ____________________ha

APPENDIX 2

CONTINGENT VALUATION

TELEPHONE SURVEY

Phone Number ______________________________

Code ______________________________

Good evening, my name is _____________________. I work for Information Insight, a market research company. I am calling on behalf of the Agricultural Economics Department at Massey University. We are undertaking a Canterbury wide survey to find out how people value rivers in Canterbury, in particular the Ashburton River.

Could I please speak to the person who filled out the Dwelling Questionnaire of the New Zealand Census, carried out in March of this year. **(IF A DIFFERENT PERSON, REPEAT THE PREVIOUS PARAGRAPH)**

Your telephone number was drawn in a random sample from the entire region. Your responses are confidential. The questionnaire will take 8 to 10 minutes. Are you willing to answer the questionnaire?

Q-1 Many recreational activities such as; fishing, bird watching, picnicking and walking occur on the Ashburton River. Do any members of your household take part in these, or other activities on the Ashburton River, excluding the Ashburton Lakes?
[CIRCLE NUMBER]

[IF YES GO TO Q-4] YES 1

[IF NO GO TO Q-2] NO 2

Q-2 Is it important to you that the river exists as a fish and bird habitat, or, that your children, or future generations may wish to use the river?

[IF YES GO TO Q-3] YES 1

[IF NO GO TO PAGE 6] NO 2

[IF DK GO TO PAGE 3] **DON'T KNOW [DON'T ASK]** . . . 3

Q-3 If there was more water in the Ashburton River would your household use the river?

[IF YES GO TO Q-6] YES 1

[IF NO GO TO PAGE 3] NO 2

[IF DK GO TO PAGE 3] **DON'T KNOW [DON'T ASK]** . . . 3

Q-4 How many days per year do members of your household use the Ashburton River, excluding the Ashburton Lakes for... **[PLEASE START AT THE RED DOT AND ASK ALL TOPICS BEFORE ASKING K. ENTER NUMBER OF DAYS IN COLUMN 1]**

		No.days/year Col 1	Col 2
A	SALMON FISHING		
B	TROUT FISHING		
C	OTHER FISHING such as whitebait and flounder		
D	BIRD WATCHING		
E	PICNICKING AND SWIMMING		
F	WALKING		
G	JET BOATING		
H	NONMOTORISED BOATING		
I	SHOOTING		
J	BIKE RIDING		
K	ANY OTHERS **[SPECIFY]**_______________________		

Q-5 Which activity is the most important to your household? **[PUT LETTER OF APPROPRIATE ITEM IN COLUMN 1]**

	Col 1	Col 2
MOST IMPORTANT ACTIVITY		

Q-6 If the river level was increased one and a half times, how many days per year would members of your household use the Ashburton River for.... **[REPEAT Q-4 AND Q-5 AND ENTER NUMBER OF DAYS IN COLUMN 2]**

IF RESPONDENTS ANSWERED YES OR DK TO Q-3 OR DK TO Q-2 BEGIN AGAIN HERE

I would now like to ask some questions on your household's view on increasing the amount of water in the Ashburton River.

At present water is being taken out of the Ashburton River for domestic use, irrigation and stock water.

Increasing the amount of water in the Ashburton River by one and a half times will likely result in; more river braiding, better water quality, increased fish numbers such as salmon and trout, more protected nesting sites and food for birds, and improved picnic and swimming spots.

Funding is required if the minimum river level is to increase. The amount of water taken from the river can be decreased by, for example, replacing the existing stock water races with a piped water system, and/or upgrading the Ashburton township water supply. To fund this work all households will be charged additional rates.

Q-7 Assume that the rate increase is the only way to increase the amount of water in the Ashburton River. Would your household be willing to pay $1.00 per year in additional rates? **[CIRCLE NUMBER]**

[IF YES GO TO Q-8] YES 1

[IF NO GO TO Q-9] NO 2

[INTERVIEWER, DO NOT READ THE QUESTION THAT HAS BEEN CROSSED OUT]

Q-8 Would your household be willing to pay $______________ per year in additional rates? **[CIRCLE NUMBER]**

[IF YES GO TO Q-10] YES 1

[IF NO GO TO Q-9] NO 2

Q-8 Would your household be willing to pay $500 per year in additional rates to increase the amount of water in the Ashburton River?....

[IF THE ANSWER IS NO HALVE THE BID AND ASK AGAIN. IF THE ANSWER IS YES INCREASE THE BID BY 50% CONTINUE UNTIL FINAL BID IS REACHED AND ENTER AMOUNT BELOW. GO TO Q-10]

WILLINGNESS TO PAY AMOUNT $__________________

Q-9 Would you mind telling me why your household is not willing to pay additional rates to increase the amount of water in the Ashburton River?

____

____

____

____

____

Q-10 For the following reasons could you please rank from 1 to 5, where 1 is not important and 5 is very important, why your household values an improvement in the Ashburton River? **[CIRCLE NUMBERS]**

For your household to use the river?	1	2	3	4	5
For your household to have the option to use the river in future?	1	2	3	4	5
To know that future generations have the option to use the river?	1	2	3	4	5
Just knowing the river exists in an improved state?	1	2	3	4	5

Q-11 When making decisions concerning the Ashburton River, could you please rank from 1 to 5, where 1 is not important and 5 is very important, the importance that should be placed on **[CIRCLE NUMBERS]**

THE INTERESTS OF THE ASHBURTON DISTRICT	1	2	3	4	5
THE INTERESTS OF THE CANTERBURY REGION	1	2	3	4	5
THE NATIONAL INTERESTS	1	2	3	4	5

I am now going to ask some questions about the members of your household. We need this information to make sure we have a representative sample of the region.

Q-12 How many people are there in your household?

_________________INDIVIDUALS

Q-13 How many of these are children, less than 15 years of age?

_________________NUMBER

Q-14 For each individual over 15 years of age, could you please tell me, starting with yourself, their age, sex and occupation?

Members	**Age**	**Sex**	**Occupation**
Respondent			
1			
2			
3			
4			
5			
6			

Q-15 What was the total income, before tax, of everyone in your household last year? [*CIRCLE NUMBER*]

LESS THAN 10,000 1

BETWEEN $10,001 and $20,000 2

BETWEEN $20,001 and $30,000 3

BETWEEN $30,001 and $40,000 4

BETWEEN $40,001 and $50,000 5

OR $50,001 AND OVER 6

DON'T KNOW [DON'T ASK] 7

REFUSED [DON'T ASK] 8

Finally do you have any comments on the management or use of the Ashburton River?

____

____

____

____

Thank you for you assistance. Goodbye.

INTERVIEWERS EVALUATION

INTERVIEWER: COMPLETE THESE QUESTIONS AS SOON AS POSSIBLE AFTER THE INTERVIEW

These two questions are only concerned with how the respondent answered Questions 7-9, which asked the respondent to value additional water in the Ashburton River.

Q-A In your opinion, how well did the respondent understand what he or she was asked to do in these questions?

UNDERSTOOD COMPLETELY 1

UNDERSTOOD SOMEWHAT 2

UNDERSTOOD A LITTLE 3

DID NOT UNDERSTAND VERY MUCH 4

DID NOT UNDERSTAND AT ALL 5

OTHER (Specify)______________________________________6

Q-B Which of the following descriptions best describe the degree of effort the respondent made to arrive at a value for the additional water in the Ashburton River?

GAVE THE QUESTIONS PROLONGED CONSIDERATION IN AN EFFORT TO ARRIVE AT THE BEST POSSIBLE VALUE 1

GAVE THE QUESTION CAREFUL CONSIDERATION, BUT THE EFFORT WAS NOT PROLONGED 2

GAVE THE QUESTIONS SOME CONSIDERATION 3

GAVE THE QUESTIONS VERY LITTLE CONSIDERATION 4

OTHER (Specify)______________________________________5