Assessing demands for irrigation water in North Queensland

John Rolfe *

Paper presented at the 45th Annual Conference of the Australian Agricultural and Resource Economics Society

22nd – 25th January 2001
Adelaide, South Australia
Stamford Plaza Adelaide

*Faculty of Business and Law, Central Queensland University, Emerald QLD 4720

Abstract

Irrigation underpins approximately one-third of the value of Queensland's agricultural production. There are calls for further development of water infrastructure in northern Queensland to enhance the production of sugar cane, horticulture, aquaculture and other crops. One of the steps in assessing potential new developments is to establish which groups have demands for additional water, and how sensitive they are to price. Surveys are one mechanism that can be used to gauge this information. Various surveys to assess water demands have been carried out in the Mackay, Burdekin and Atherton Tablelands regions and the results are reported in this paper.

Keywords:	water demands, price, stated preferences

1.0 Introduction

Growth in rural industries along the eastern coast of Queensland has been accompanied by demands for increased supplies of agricultural irrigation water. These demands stem from both established and emerging industries. Sugarcane is the dominant industry in many regions, but horticulture, tree crops and aquaculture are other key industries. On the Atherton Tablelands, sugarcane has recently been developed as the major irrigation crop as tobacco and other small crops have become more unviable.

Increased demands for water may be met in two main ways. The first is by reallocating existing supplies of water. The elimination of un-utilised, or under-utilised water supplies through such mechanisms as allocation of licenses or trading of water allocations are important ways of achieving this. Particularly in relation to the latter, increased prices for water supplies help to signal where shortages might occur and where highest value usage might exist.

The second way of meeting increased demand is to establish new sources of supply. In the past, most water supplies were provided through large infrastructure developments that have been funded by Governments. While these are still possible, other mechanisms, such as the development of smaller off-stream storages or the treatment of urban effluent water are also becoming more commonplace.

In Australia, water for agriculture has been traditionally supplied and regulated by governments rather than being provided through market mechanisms. There are several reasons for this, including the common use of public funding to construct large water infrastructure schemes. As well, water has usually been provided at a very cheap rate to farmers, so demand has exceeded supply at those deflated levels. Some form of licenses or regulated allocations by government have been a necessary response to this mismatch between supply and demand (Godden 1997).

The Council of Australian Governments (COAG) established an agreement on Water Resource Policy in 1994 that introduced the principles of microeconomic reform to the water industry. Under the agreement, all state governments in Australia are committed to a number of principles, including full cost pricing, separate markets for land and water, recognition of ecological criteria, and achievement of cost-recovery in any new water infrastructure developments.

The reform process that has followed the COAG agreement has varied between the states. In Queensland, issues of water allocation and recognition of environmental concerns have been addressed with the formation of Water Allocation and Management Plans (WAMPs) for different catchments. Water trading is being introduced in specific areas, beginning with the Mareeba-Dimbula Irrigation Area on the Atherton Tablelands, and annual operating charges are being increased in many irrigation areas to achieve cost recovery.

In Queensland there is still significant interest in many regional areas in water infrastructure as a means to improve local economies. The Borbidge National-Liberal Government established a water infrastructure task force in 1996, which subsequently made a number of recommendations for potential irrigation projects. However, the principles underpinning the COAG agreement mean that future investments in water infrastructure should only proceed if the projects meet economic viability (and ecological) criteria.

The outcomes of the ongoing water reform process and the tighter assessment rules for new projects means that there is increased interest in the economic assessment of the water industry.

A key item in any planning for changes in water allocations or new infrastructure development is to establish the demands for water that exist. If demands for water from a sector or geographic area are substantial, they will tend to be translated into higher prices at limited levels of supply. These higher prices provide a mechanism for signalling transfers of water in an open trading system, or the possible viability of providing new supplies of water. One stage in planning for new developments then is the assessment of likely future demands. In the same way, the development of efficient water markets and associated property rights is conditional on provision of accurate information regarding demand and supply conditions (Easter et al 1998).

In this paper, some aspects of three water demand case studies in North Queensland are reported. The water demand studies were conducted in the Mackay region, on the Atherton Tablelands, and in the Burdekin to Bowen region. The approach used in the case studies was to ask existing irrigators in the regions what their existing and future demands for irrigation water might be. The challenge in this approach is to ensure that results are not subject to various forms of bias, and this is the primary focus of this paper.

The paper is structured as follows. The next section contains some discussion about the use of stated preferences to estimate demands for agricultural water supplies. In section three, the design of three surveys into water demands are outlined, and section four contains an overview of their performance and some results. An analysis of demand information available from the survey data is presented in section five, and conclusions follow in section six.

2. The use of stated preferences to assess demands.

The assessment of water demands is not necessarily straightforward, as they have to be estimated in many cases *ex ante*, that is, before the event. In some cases the demands for water, and associated prices, can be established for schemes that already exist. However, information is not readily available in many areas where little market trading already exists[1]. Water demands for proposed water supplies can be even more difficult to ascertain because there is no existing market data to draw on. There are two broad options that can be pursued.

The first is to do an economic assessment of the existing resources, market opportunities and crop production economics. The broad assumption that is made under this approach is that if commercial potential is identified, and resources such as water supplies are made available to industry, participants will take advantage of the opportunities. An economic analysis would focus on the commercial viability of expanded or new agricultural opportunities if new water resources were made available.

Linear programming methods are often used to model water demands in the short and long term, where resource constraints, production, management and market information are combined to predict what the response of farmers would be to changes in the price and/or supply of different factors. Briggs-Clark (1986) and Pagan et al (1997) provide demonstrations of this type of approach.

The second option is to approach the potential users of new water resources and ask them directly what their demands for additional water supplies might be, what they would use the water for,

[1] The value of water licenses and allocations above the set government charges should be capitalised into land prices. However, there is little work available to identify values for water allocations out of land prices.

and how sensitive their demands might be to variations in price. The advantage of this approach is that it helps to identify actual demands in a region, identify the potential users of new water supplies, gauge the speed of takeup of new water supplies, and estimate sensitivity to price.

Both approaches to estimating water demands are useful because they offer different snapshots of how regional planners/economists/industry leaders and existing irrigators view the potential for development. When the two approaches give very different results, it sometimes indicates that either or both groups do not have access to accurate information, or that structural adjustment (with associated social costs) will be necessary to achieve projected development targets.

Traditionally though economists have only employed the first option in assessing the viability of water infrastructure schemes and the potential demand for water. In some cases there are good practical reasons for this. It is not always possible to identify the potential users (eg when new irrigation areas are established), and potential users may not always have sufficient information to make informed choices (eg when supplies allow new crops to be grown).

However, economic analysis of water infrastructure options have not always proved very accurate. Smith (1998) outlines the process by which the Burdekin Dam was approved in 1980. The scale of the project ($260 million) meant that the funding had to be shared between the Commonwealth and the State governments. The decision process was conducted at a time when projects needed to meet more rigourous economic criteria, and a review conducted in 1978 concluded that the Burdekin Dam would enable some 45,000 hectares of land to be irrigated and a return on investment to be at least 10%.

The economic analysis conducted for the Burdekin was the most thorough that had ever been carried out in Australia for an irrigation scheme. In hindsight, the analysis was super-optimistic, poorly framed, and lacked definitions on what should and should not be included (Smith 1998). Although the Burdekin Dam was completed in 1986, the available water from it has still not been fully utilised, some of the land envisaged for agriculture turned out to be unsuitable for that purpose, and the sale of new farms by auction has been a slow process. The Industry Commission (1992) estimated that the state could not expect to recoup its investment for a period of 70 years (allowing for the Commonwealth contribution of $130 million to be written off). It is clear that the initial projections of a 10% return on capital were wildly optimistic.

The Burdekin Dam example highlights one aspect of normal economic analysis that is difficult to perform accurately in analysis of water infrastructure projects – the estimated rate of takeup of new supplies. Water infrastructure schemes have large up-front capital investment costs, followed by long term revenue streams less the associated operating costs. The present value of those revenue streams are usually very sensitive to how quickly water supplies are taken up and paid for. In practice, take up rates are often very slow[2], partly because the associated private costs of developing land suitable for irrigation and the low real rates of return and capital accumulation in many agricultural industries. The result is that even when economic analysis might predict the total amount of potential development, any delays in the takeup of new water supplies can seriously impact on the profitability of potential developments.

Surveys of grower intentions can be used to gain information about potential demands and rates of takeup. This information can be used to crosscheck the results of case study economic analysis

[2] Water from the Burdekin Dam, the largest in Queensland, is still not fully allocated fifteen years after completion. In the case of the Fairbairn Dam near Emerald, the next largest dam in Queensland, full allocation of the available supply did not occur until about 20 years after completion.

and provide updates of demand intentions. However, assessment of demand intentions in this way has not been very common. Perhaps the closest examples come from water user associations and other irrigator cooperatives which have been useful in countries like Chile to provide local management of irrigation schemes and insights into local supply and demand patterns (Hearne 1998).

There has been reluctance by many agricultural economists to use stated preferences as an instrument for estimating demand patterns or values. This helps to explain why surveys of demand intentions have not been commonplace in Australia. Stated preferences refer to those that people state they have in a survey instrument, while revealed preferences refer to those that can be obtained from market transactions. This reluctance to use stated preferences stems in part from the controversies surrounding the Contingent Valuation Method (CVM). This is a non-market valuation technique which uses stated preferences to estimate values for changes in the provision of (usually) environmental goods.

There are two cases which illustrate the divide that separates some economists on these issues. In Australia, a study was conducted in 1990 by the Resource Assessment to ascertain the non-use values of potential environmental damage at Coronation Hill, a proposed mining site in a conservation zone adjacent to Kakadu National Park. This study (Imber, Stevenson and Wilks 1991) reported that the damage costs of mining the zone were $5876 million, significantly outweighing the net expected $82 million of mining benefits. There was widespread criticism of the results and the methodology of the CVM study (Brunton 1991, Moran 1991, ABARE 1991), and partly as a consequence, the CVM has never been accepted in Australia to the same extent that it was in the United States and Europe (Bennett and Carter 1993).

In the United States, some of the damages arising from the 1989 Exxon Valdez oil spill were assessed with the CVM, leading to widespread debate about its appropriateness, particularly for assessing damages in a court. To address the debate about the validity of the technique, a panel of experts was drafted by the National Oceanic and Atmosphere Administration (NOAA) to assess the appropriateness of the CVM to provide reliable estimates of non-use or existence values. The 1993 report concluded '*that CVM studies can produce estimates reliable enough to be the starting point of a judicial process of damage assessment, including lost passive use values*' (Arrow et al 1993:4601).

Among the concerns expressed about the use of stated preferences in CVM are the potential for those preferences to be inaccurate, and hence not reflect the true willingness to pay (WTP) or willingness to accept (WTA) of respondents for the case study in question. Some of these concerns relate to the potential for respondents to behave strategically, where they overstate or understate their preferences in order to influence the final outcome. Other major concerns relate to the potential for budget constraints or substitute goods to be ignored when choices are made, and for choices to be framed in situations where respondents have little knowledge about the topic in question (Mitchell and Carson 1989).

CVM and another valuation technique termed Choice Modelling (CM) continue to be developed for environmental valuation purposes in ways that address many of these potential bias and framing issues (eg Rolfe, Bennett and Louviere 2000). However, many of the concerns that have to be addressed in the design of non-market valuation experiments are common to any use of stated preferences. Some of the key ones are to ensure that stated preferences are not biased by strategic behaviour, that the preferences are realistic in terms of budget constraints and other opportunity costs, and that respondents have sufficient information about the issue in question to make informed choices.

Strategic behaviour is a potential concern with water demand surveys. Australia has a long history of water infrastructure being constructed for political rather than economic reasons (Smith 1998). Many large water infrastructure projects appear to be been justified more on regional development and social equity grounds than economic criteria (Smith 1998). Landholders and irrigators would normally expect to be better off when governments build new water infrastructure, and so there is potential for strategic bias to influence results of any surveys about projected demand.

The demand surveys that were carried out were designed to minimise these potential problems of strategic behaviour as well as those associated with realistic preferences and informed choices. The steps involved in this process are outlined below.

3. The performance of the surveys.

Three separate case studies have been carried out in Queensland in the past four years. The studies have been performed for a variety of agencies, including the Department of Natural Resources, Canegrowers, the Tablelands Economic Development Corporation, and Bowen Collinsville Enterprises. The case study areas have been:

- Mackay – almost exclusively sugarcane, and
- Atherton Tablelands – sugarcane, tobacco, tree crops, horticulture
- Bowen to Burdekin – sugarcane, horticulture, aquaculture.

The Mackay Study.

The Mackay study was performed in 1998 to ascertain demands for water in the coastal region between Camilla in the south and at St Helen's Creek in the north. The dominant crop in the region is sugarcane. While some of the sugarcane is rain-grown, some is irrigated from underground water and some is irrigated from water storages (Kinchant and Teemburra Dams). There are about 1,400 cane farms in the region, of which about 400 draw water from the two major storages. Nearly 25,000 hectares of cane were grown under irrigation in 1998-99 in the Eton Irrigation Area and the Pioneer River Project schemes. There have been suggestions for more water storages in the area, although the projected environmental impacts at some sites means likelihood of development may be low.

At the same time that there have been demands for more water supplies, the usage of available supplies of water in many years is below optimum levels. For example, in the Eton Irrigation Area in 1997-98, 37,799 megalitres of water were delivered to farms when announced allocation of water (available supplies) were 51,700 megalitres (DNR 1998). The following year, only 1,832 megalitres of water were delivered out of the available 51,569 megalitres (DNR 1999).

Other issues surrounding water reform in the region and the need for information on water demands include the development of salinity in some regions from salt water intrusion, and the possibility of treating effluent water from the city of Mackay for agricultural purposes. The survey was thus designed to provide general information about demands in the region rather than demands relating to any specific projects. The survey was distributed and completed at Canegrowers meetings and shed meetings in the region. About 1,400 surveys were distributed, and 700 responses were received.

The Atherton Tableland study.

The Atherton Tableland study was performed in 2000. On the tablelands, the irrigation industry is centred around Mareeba, where water from the Tinaroo Dam services over 900 irrigation farms in the Mareeba- Dimbula Irrigation Area (MDIA). This region has been going through a substantial restructuring phase as irrigators in the region have moved away from tobacco and other small crops into other industries. Most growth has occurred in sugarcane, tea-tree and tree crops (eg mangoes).

There is about 22,000 hectares currently irrigated in the MDIA, with 158,000 megalitres of water being available allocations in the 1997/98 and 1998/99 years (DNR 1998, 1999). In the 1998/99 year, sugarcane was responsible for the bulk of water use (53%), followed by mangoes (14%), tea-tree (10%) and tobacco (4%). Total water usage has been low for many years, ranging from 69,795 megalitres in the 1995/96 year (less than half the nominal allocation) to 120,184 megalitres in the 1997/98 year.

Water trading has been trialled in the MDIA over the past two years, with open trading allowed after the 1st of July 2000. However, there has been little activity in water trading in the region. Some of the reasons may related to depressed economic conditions, with the downturn in the sugar markets since 1998, adverse seasonal conditions in 2000, and the collapse of the tea-tree market in 2000.

A survey to assess water demands was developed in 1999, and collected on the tablelands during the first half of 2000. Two collectors were used to identify a random sample of irrigators in the region and then approach them to complete a survey form. 116 surveys were successfully completed. The time of the survey performance coincided with some of the most adverse economic and weather conditions over the past decade, and collectors reported low levels of interest in expansion or future water demands.

The Elliot Main Channel study.

The initial projections for the Burdekin Dam were that water would be supplied as far south as Bowen through a proposed channel, the Elliot Main Channel. When some of the soils along the route were found to be unsuitable for irrigation, only the first stage was built. However, the project has remained under consideration because unallocated water remains in the Burdekin Dam, and there are limited water supplies for the horticulture industries at Bowen. En route to Bowen there are several areas of land that might be developed for irrigating sugarcane and other crops. Early projections for the possible development of the Elliot Main Channel have been based on supplying over 220,000 megalitres of water on farm along the total length of the channel.

A survey to assess water demands among local landholders and from horticulture growers in Bowen was developed in 1999 and 2000, and with some surveys collected during 2000. Only 30 valid surveys have been completed to date. Only interim results can be reported from this data, and the low number of responses means the data is unsuitable for statistical analysis.

4. The design of the surveys.

The surveys were designed explicitly to minimise problems of strategic bias and other potential biases associated with stated preference surveys. While the three surveys all differed in some respects according to specific information needs and the circumstances of particular regions, the underlying structure was fairly consistent.

One of the major issues that emerged from planning stages and focus group exercises was that many irrigators have very limited knowledge about actual levels of water usage, which made it difficult for them to ascertain their potential demands. For example, licenses for water extraction from streams or bores are often framed in terms of the size of the pump that is allowed, rather than the amount of water that is extracted.

The surveys thus started with a series of questions that explored the potential for further irrigation to be developed, helping respondents to frame the issues involved in additional water demand. For example, respondents were asked to indicate their farm size, the amount of irrigation that they had, what crops they grew, and what area they had that could be potentially irrigated. These were relatively easy questions for respondents to complete, and helped them to consider their potential development.

Another series of questions focused on their different uses for irrigation water. The types of questions that were asked of the irrigators were whether they were satisfied with their currrent supplies, how supplies could be improved, and what they would like additional water for. The latter question was important in some areas because additional water supplies are not always needed to expand production area, but may also be used to increase production on existing fields, or as an insurance against dry times. These questions helped respondents to compartmentalise their potential demands, as well as aiding in the subsequent statistical analysis.

Another series of questions asked respondents to indicate their potential uses of more irrigation water, usually in terms of crop type, area to be developed, and application rates. Whereas the initial questions had focused on the potential for more irrigation on each farm, this section was focused more on the amount of land that respondents may wish to develop. This allowed a more accurate assessment in areas where farmers were unlikely to develop all of their potential area (MDIA), or may wish to purchase additional land for that purpose (the Elliot Main Channel study).

The final section in the survey focused on collecting information about the potential demands for water. In the key question, irrigators were asked to indicate how much water they might demand at certain price levels. In the Mackay and MDIA surveys, four price levels were given, and irrigators were asked to indicate demands at each price level. In the Elliot Main Channel study, five price levels were given. These are discussed in more detail in section 5.

4.1 Addressing issues of possible bias.

The potential for strategic bias was addressed in two main ways. Firstly, the surveys collected the names and addresses of respondents, as well as real property descriptions. This meant that the answers could be verified. There may also have been the perception on behalf of respondents that misleading information could be traced back to them. In the Elliot Main Channel study, respondents were asked to sign their survey form as a way of demonstrating their good intentions.

The second main way of addressing strategic bias issues was to check the internal validity of survey responses. If respondents were to engage in strategic behaviour, they would be expected to overstate their true demands for water. One way of validating survey results are to compare responses to general industry knowledge. For example, irrigators in the Mackay survey indicated on average that their annual application rate on to sugarcane was 2.52 megalitres per hectare, which matched closely the opinions of local farm leaders.

As well, respondents to the surveys showed a remarkable degree of internal consistency in their answers. In the Mackay survey, respondents were asked to estimate directly their demands for water according to different potential methods of supply. The average across respondents was 113.18 megalitres. This amount of demand could also be estimated indirectly by calculating the amounts of water needed to irrigate current dryland sugarcane, to expand new ground, and to increase application rates on irrigated cane using the areas and desired application rates nominated by respondents. The average implied demand per respondent came out to 112.43 megalitres, a difference of less than 1%.

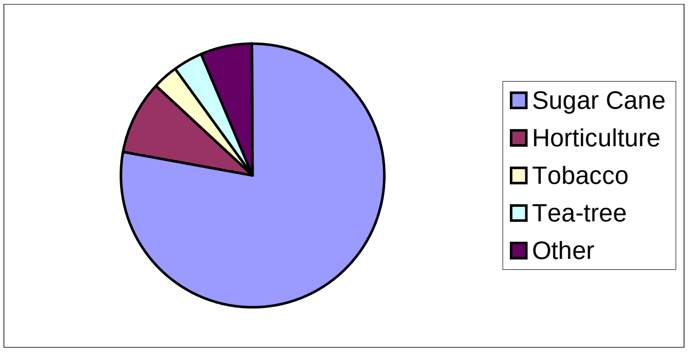
One outcome that might be expected from strategic behaviour is that irrigators would demand more water than they might potentially use on their land. The key test for this could be performed by comparing irrigator demands at the nominated price levels with their potential area of irrigation development. However, in each of the surveys, respondents have tended to demand less water at specific price levels than they might potentially use, indicating that the introduction of pricing has served to restrict demand. In the Mackay survey, the potential demands were estimated at 113.18 megalitres per respondent, but the amount of demand indicated at the lowest price level (averaged across all respondents) was 83.54 megalitres. This indicates that strategic behaviour did not appear to be influencing survey results.

4.2 Indications about demands for water.

The results of the survey questions provide useful background information about demands for water in the different regions. For example, 62% of respondents in the Mackay survey indicated that they were not satisfied with the amount of water that they had for their current irrigation activities. This reflects the fact that many canegrowers in the region do not have access to channel or regulated stream supplies. In contrast, only 28% of irrigators in the MDIA described their supplies as ‘inadequate’ or ‘very inadequate’.

It is clear from the survey results that additional development of irrigation would be largely concentrated on sugarcane. In the Mackay region, about 98% of additional water demands are for sugar cane, while in the Elliot Main Channel region about 86% of additional water would be for sugar cane. The potential expansion area for irrigation in the MDIA can be shown by crop type, as in Figure 1 below. When the estimates are translated in potential water demands, approximately 84% of additional water would be used to grow sugarcane in the region.

Figure 1. Potential expansion of irrigation by area of crop type in the MDIA



One of the most striking outcomes from the MDIA survey was when respondents were asked about their perceptions about the reliability of current supplies. Reliability of water supplies are normally one of the key factors which help to determine price. Rolfe (1998) details how in the Fitzroy catchment an increase in reliability of supply from 85% to 99% matched an increase in price of about 40%. Like most agricultural irrigation schemes in Queensland, the hydraulogical models for allocating water supplies in the MDIA is based on providing medium reliability water (approximately 85% reliability of supply). In practice, under-utilised allocations mean that historical levels of reliability have been much higher.

In one question of the survey, respondents were asked to nominate what they considered to be the current reliability of their current supplies. The answers, shown in Table 1, indicate that 36% of respondents thought that their water was at 95% or 100% reliability. Only 20.7% of respondents gave the most accurate answer of 85%.

Table 1. Estimated Reliability levels in the MDIA

Estimated Reliability Level	Proportion of Responses
70%	18.1
75%	8.7
85%	20.7
95%	12.9
100%	23.3
Not Applicable	7.8
No Answer	8.6

One implication of this result is that it must be very difficult to establish common agreement of the properties of water in an open market trading system. If perceptions about reliability, which is such an important component of price, can vary so widely, then this may help to explain why water trading has not been embraced on the Tablelands.

Respondents to the survey in the MDIA were asked whether they planned to participate in the new flexible water trading arrangements. The responses, summarised in the table below, show that there is some interest in purchasing water but almost no interest in selling water. About one-third of respondents indicated that they were not interested in trading at all. This suggests that expectations about the market are not condusive to the smooth implementation of a fully functioning market system, and that it may take some time for irrigator knowledge about supply and demand factors to develop.

Table 2. Interest in flexible water trading activities in the MDIA

Response	% of respondents
Want to purchase permanent supplies	33.6
Want to purchase temporary transfer	19.8
Want to purchase either permanent or temporary	12.9
Want to sell water	0.8
Not interested in water trading	32.8

5.0 Estimating Demand Relationships.

The key question in each of the surveys was one where irrigators were asked to indicate their potential demands at several different price levels. Responses at the different price levels were needed to be able to calculate demand relationships. To ensure that responses were accurate, the questions were framed in each survey according to the existing water marketing structure in each region. For example, respondents were normally told that the questions did not relate to any particular storage proposals, that the actual price of supplying additional water was still unknown, and that responses did not commit growers to taking nominated amounts of water.

In the Mackay survey, irrigators were asked to nominate their desired additional supplies of water at four annual price levels, being $40, $70, $100 and $150 per megalitre. They were reminded in the preamble that the current cost of water ranged from approximately $30/megalitre from a regulated stream to approximately $70/megalitre from a pumped pipeline system.

In the MDIA survey, irrigators were asked to give their responses at five price levels representing once-off capital costs for purchasing the water. Respondents were reminded that there would still be annual operating charges to meet, assumed to be $25 per megalitre. Responses were invited for two time frames, being short term demands by 2005, or longer term demands by 2010. The capital costs nominated were $250, $300, $500, $750 and $1,250 per megalitre.

In the Elliot Main Channel survey, irrigators were asked to give their responses at four price levels which represented both annual costs of both capital and operating expenses. Like the MDIA survey, responses were invited for two time frames, being short term demands by 2005, or longer term demands by 2010. The four price levels that were nominated were $50, $75, $100 and $150 per megalitre.

Responses to the surveys were analysed using multiple regression techniques. The regression function sought to explain the quantity of water demanded in terms of the price indicated and the other data collected from the survey results. Across the surveys, the relationships between Price and Quantity demanded were generally found to be strongest when at least one variable (Price) was estimated in logarithmic form. This indicated that the demand curves for water were concave in shape.

The water demand question was not always answered fully by survey respondents. Some respondents only indicated the quantities that they would demand at the lowest price levels, while others did not answer the question at all. The results to the regression were affected according to how these partial respondents were treated, and meant that different regression models could be calculated. The best fitting regression models were calculated for the groups of respondents who indicated demands at more than one price level.

5.1 Results from the MDIA.

A regression model of quantity demanded for a sub-group of respondents in the MDIA survey is reported in Table 3 below.

Table 3 **Regression model of average Quantity demanded (Short term) with Price in Log form for the MDIA area**

	Unstandardised Coefficients	Standard Error	Standardized Coefficients	t	Sig.	Average Value
(Constant)	779.735	147.846		5.274	.000	
Hectares of sugarcane irrigated	4.046	.453	.600	8.937	.000	19.86
Need more water for current irrigation area	292.500	42.738	.477	6.844	.000	.1429
LN_PRICE	-117.344	23.438	-.323	-5.007	.000	
Hectares of horticulture currently irrigated	-4.986	1.111	-.319	-4.488	.000	13.52
Potential hectares of horticulture irrigation	11.495	4.819	.170	2.385	.020	1.2857

Dependent Variable: **Quantity of short-term demand**
$r^2 = .734$

From this table, the regression equation for short term demands can be expressed in this way:

> Quantity of water demanded = 779.735 – 117.344 x LN PRICE + 4.046 x (current ha of sugarcane irrigated) + 292.5 x (wanted more water for current irrigation) – 4.986 x (current ha of horticulture irrigated) + 11.495 x (potential ha of horticulture irrigation).

LN PRICE refers to the natural log of the price set for water. When the average responses for the non-price variables are inserted, the equation simplifies to:

> Quantity of water demanded = 849.3 – 117.344 x LN PRICE

The point of unit elasticity can be found by estimating where revenue for water sales is maximised. From this regression equation, this can be estimated at $62.07 per megalitre. Below this price level demands would be expected to be inelastic, while above this price demands would be expected to be elastic.

In the longer term (up to 2010), a different demand model was estimated from the data. This is summarised as follows:

Quantity of water demanded in longer term = 1227 – 168.5 LN Price.

The point of unit elasticity was calculated at $534.80. This implied that while demands for water would increase over the longer term, they would remain highly sensitive to price.

5.2 Results from the Mackay area.

In the same way, the regression equation for the group of respondents in the Mackay survey who indicated demands at more than one price level is reported in table 4.

Table 4. Regression model of average quantity demanded with price in log form for Mackay Area.

Predictor	Coefficient	Signif	Average of response	Coefficient x average
Constant	529.76	0		
Other crops application rate(Q5b)	18.931	0.013	0.026	0.492206
Demands for dryland (Q10a)	-0.385	0.027	25.4	-9.779
Demands from regulated flood harvesting (Q12a)	0.275	0.000	15	4.125
Demands from unregulated flood harvesting (Q12b)	0.493	0.000	9.92	4.89056
Demands from channel or pipeline (Q12c)	0.389	0.000	100.17	38.96613
Demands from licensed ground water (Q12d)	0.394	0.000	13.17	5.18898
Demands from unlicensed ground water (Q12e)	0.49	0.007	3.55	1.7395
Demands from farm dams (Q12f)	0.111	0.000	15.37	1.70607
Demands from other sources (Q12g)	0.381	0.000	11.17	4.25577
Intend to buy aluminium flood pipes (Q13c)	-0.691	0.000	2.4	-1.6584
Intend to buy winch equipment (Q13e)	0.343	0.002	21.05	7.22015
Intend to buy trickle irrigation (Q13h)	-0.836	0.003	1.64	-1.37104
Intend to irrigate dryland at preferred rate	0.158	0.001	89.95	14.2121
Ln Price	-117.83	0.000		

Dependent Variable: **Quantity of water demand**
$r^2 = .587$

The model can be simplified to:

Quantity of water demanded = 599.75 – 117.83 x LN PRICE

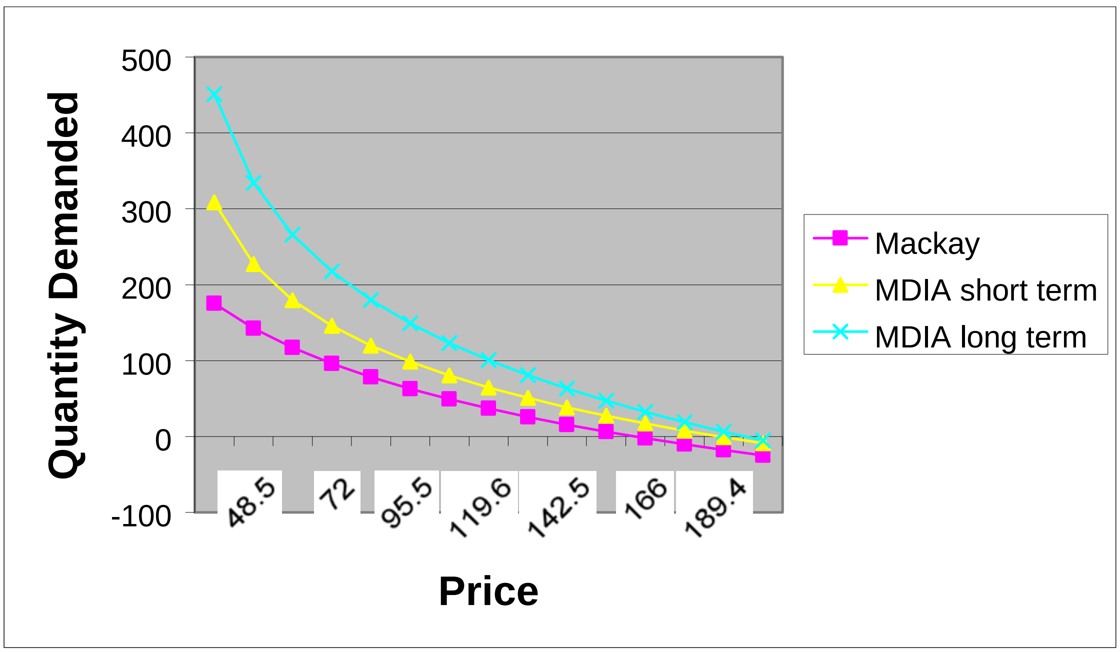
The results of this regression relationship for the Mackay region show that for this group, the demands for water from all the different sources of supply were significant. Notably though, the average demands for water from *Constructed channel or pipeline* were significantly greater (100.17 ML per respondent) than demands from any other source. Also notable is that the demands for water to irrigate current dryland at the preferred application rate were also highly significant. This suggests that for this core group of respondents willing to pay at least $70/ML for some water supplies, their main intention is to irrigate current dryland production. They are mostly interested in using winches to irrigate.

The price level at which revenue is maximised is $513.09. Below that price level demands would be expected to be inelastic, and above that price level the demands should be elastic. If this price level is converted to an annual payment amount over 20 years at a 10% discount rate, the annual price per megalitre of water is $60.27. This is very similar to the $62.07/ML calculated for the MDIA.

5.3 Comparing demands between the MDIA and Mackay regions.

At first glance, the sensitivity of water demands to price appear to be very similar between Mackay and the MDIA, as the short-term demand function for the MDIA has the same slope as the demand function for the Mackay district. However, a direct comparison is not quite accurate, as the Mackay study related demands to annual charges, while the MDIA study related demands to up-front capital costs. To be able to compare the results between Mackay and the MDIA, quantities of water demanded have been estimated for the MDIA demand functions at a series of prices. Those prices have then been converted to annual amounts over twenty years at a 10% discount and the $25/ML operating charges added. For example, a $500 capital lump-sum cost converts to $58.73 as an annual payment plus $25 for the operating costs. Those prices have then been used to estimate demands for the Mackay region.

Figure 2. Average demands for selected farms in the Mackay and MDIA areas



The results, plotted in Figure 2, demonstrate that there is a very similar relationship between water demands in the different regions. The elasticity of the demand curves for Mackay and the MDIA in the short term are very similar, and the demand curves would be almost identical apart from the $25/ML operating charge. Average demands per farm are lower in the Mackay region than in the MDIA, although there is a larger proportion of irrigators in the Mackay region interested in further water supplies than in the MDIA. This means that the aggregate demand schedules for each region may not be as similar as the individual demand curves might suggest.

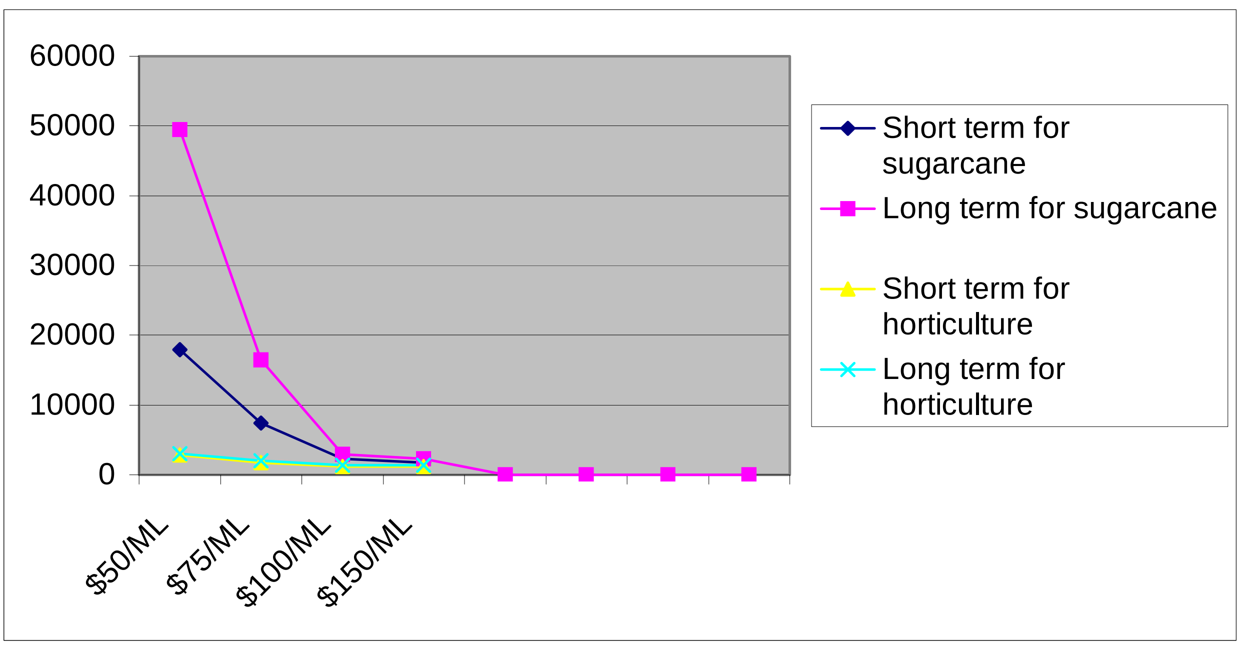
In the longer term in the MDIA, demands for irrigation water should increase. However, the modelling indicates that the demand curve will not simply shift out over time, but will pivot, approximately where it cuts the price axis. This indicates that demands will remain sensitive to price in the longer term.

5.4 Results from the Elliot Main Channel study.

Only interim results for the Elliot Main Channel study are available. However, these results are showing that there are some substantial demands for water in the region, mainly for sugar cane. There was not enough data to derive statistical models of water demand that had strong fits (high r-squared values). From Figure 3, it appears that demands for water for sugarcane become elastic at some level above $50/ML, but remain relatively inelastic for horticulture crops up to $150/ML. This suggests that the ability of sugarcane growers to pay higher water prices is limited, especially in comparison with horticultural growers.

The higher sensitivity of demands in this region to price is to be expected as almost all irrigation areas will need to be developed. As the capital costs of development are high, it is likely that the ability to pay for water supplies will be limited. In contrast, the demands for water supplies for horticulture come mainly from established growers in the Bowen region. As these growers have already made their capital investments, and already have some water supplies, their capital outlays will be proportionally much smaller. As well, water charges are a much smaller component of variable costs in horticulture compared to sugarcane. These factors explain why horticultural demands for water appear to be inelastic relative to those for sugar cane.

Figure 3. Demands according to crop type.



6.0 Conclusions.

Accurate demand information is important to be able to assess the potential for new water infrastructure projects, and to aid in the process of microeconomic reform in Queensland. In this paper, some results from three demand surveys of agricultural water needs in north Queensland have been presented. The use of stated preferences to estimate demands in factor markets is not all that common, and is viewed by suspicion among some economists. Among the reasons for this are the potential for survey respondents to engage in strategic behaviour by overstating or understating their true intentions.

Strategic behaviour problems can be avoided with careful attention to design. In the surveys reported here, the collection of contact information, real property details and other background information all helped to establish an environment where it was difficult for respondents to provide misleading results. In the survey data, the internal consistency of responses appears to be very high, and to match with local expert opinion.

However, substantial differences occurred between the amounts of water that respondents said they could potentially use, and the amounts that they have nominated for use when price has been introduced as a factor. Even at low levels of price there is a marked difference between the amounts demanded and the nominal amount that could be used for further development. This indicates how much difference there may be between demands made through the political process and the demands that are registered in markets.

There was substantial consistency in the results across the different surveys, even though they were conducted at different times and in different regions. This confirms that the production economics underlying sugar cane force very similar water demand responses in different areas. However, there was a marked difference between water demands relating to sugarcane and horticultural crops, where water demands associated with horticulture are much less elastic than demands associated with sugarcane.

The survey results confirm that demands for water in the sugar cane industry remain very sensitive to price. For the groups analysed in the MDIA and Mackay regions, the point of unit elasticity occurs slightly above $60/ML. In the Elliot Main Channel region, which will be a greenfields site, unit elasticity appears to be slightly higher than $50/ML. At these levels, it is unlikely that enough revenues can be generated to justify building many new water infrastructure proposals in the region.

Survey results also indicated that the takeup of new water trading opportunities may be slow. While two-thirds of irrigators in the MDIA are interested in purchasing water, almost none are interested in selling. As well, there are wide variations in perceptions about the reliability of existing supplies, which will help to hinder market operations. These factors suggest that the development of new water institutions in the microeconomic reform process may not be as seamless as is sometimes envisaged.

References.

ABARE 1991 *Valuing Conservation in Kakadu Conservation Zone*, submission to the Resource Assessment Commission, Australian Government Publishing Service, Canberra.

Arrow, K., Solow, R., Portney, P., Leaner, E., Radner, R. and Schuman, H. 1993 “Report of the NOAA Panel on Contingent Valuation”, *Federal Register* 58:4601-4614.

Bennett J W and Carter M 1993 "Prospects for Contingent Valuation: Lessons from the South-East Forests", *Australian Journal of Agricultural Economics*, 37, 2, 79-93.

Briggs-Clark, J., Menz, K., Collins, D. and Firth, R. (1986*) A model for determining the short term demand for irrigation water*, BAE Discussion Paper 86.4, AGPS, Canberra.

Brunton, R. 1991 “Will Play Money Drive Out Real Money? Contingent Valuation Surveys and Coronation Hill”, *Environmental Backgrounder*, 2:1-19.

Department of Natural Resources (DNR) 1998 State Water Projects Yearbook 1997-98, Brisbane.

Department of Natural Resources (DNR) 1999 State Water Projects Yearbook 1998-99, Brisbane.

Easter, K.W., Rosegrant, M.W. and Dinar, A. (eds) 1998 *Markets for Water: Potential and Performance*, Kluwer Academic Publishers, London.

Godden, D. 1997 *Agricultural and Resource Policy: Principles and Practices*, Oxford University Press, Melbourne.

Hearn, R.R. 1998 “Institutional and Organizational Arrangements for Water Markets in Chile”, in K.W. Easter, M.W. Rosegrant, and A. Dinar, (eds) 1998 *Markets for Water: Potential and Performance*, Kluwer Academic Publishers, London.

Industry Commission 1992 *Water Resources and Waste Water Disposal*, IC Report Number 26, AGPS, Canberra.

Imber, D., Stevenson, G. and Wilks, L. 1991 *A Contingent Valuation Survey of the Kakadu Conservation Zone*, Research Paper No 3, Resource Assessment Commission, Australian Government Publishing Service, Canberra.

Mitchell, R.C. and Carson, R.T. 1989 *Using Surveys to Value Public Goods: The Contingent Valuation Method*, Resources for the Future, Washington.

Moran, A. 1991 *Valuing the Kakadu Conservation Zone*, Occasional Paper No. B8, Tasman Institute, Melbourne.

Pagan, P., Fagan, M., Crean, J. and Jones, R. 1997 "Short and long run approaches to water demand estimation", paper presented to the 41st Annual Conference of the Australian Agricultural and Resource Economics Society, Gold Coast, 22 – 24th of January.

Rolfe, J.C. 1998 "Agricultural Demands and the Pricing of Irrigation Water", *Central Queensland Journal of Regional Development*, 5(4):38-49.

Rolfe, J., Bennett, J. and Louviere, J. 2000 "Choice Modelling and its Potential Application to Tropical Rainforest Preservation", *Ecological Economics*, 35:289-302.

Smith, D.I. 1998 *Water in Australia: Resources and Management*, Oxford University Press, Melbourne.