The Australian Journal of Agricultural and Resource Economics, 49, 91–114

Valuing options for reserve water in the Fitzroy Basin*

John Rolfe and Jill Windle†

Option values may be an important component of non-use values when development options for environmental assets are considered. These are values that the community might hold for maintaining options to make future choices about allocating resources. However, option values are very difficult to define, at both theoretical and practical levels, and there has been a retreat over the past decade to the more inclusive concept of option prices. In the present paper, estimates of option values are reported for retaining unallocated water in reserve rather than using it for current development. The use of option values rather than option prices is justified on the basis that the focus is on non-use values, and demand and supply uncertainties have been minimised. These values have been assessed through a series of nine choice modelling surveys that have been conducted over a 3-year period in the Fitzroy River Basin in central Queensland. The results are then extrapolated to the case study areas within the basin to assess whether unallocated water should be held in reserve or used for development.

Key words: choice modelling, environmental assets, supply response.

1. Introduction

Recent water reforms in Queensland have resulted in the development of Water Resource Plans (WRP), which provide the strategic framework for water allocation and management in the major river systems (QDNRM 2003). Once allocations for environmental purposes and existing allocations for irrigation and other uses are confirmed, any remaining water in a river system can be identified. This surplus water (if it is available in a river system) is currently unallocated. An interesting challenge for economists is to evaluate different options for allocating that water. There are economic benefits in allocating water for development (e.g., for agriculture, industry and mining), but there are also likely to be benefits associated with keeping the water unallocated and in reserve. A key benefit is that options for future allocation are still available. If the water remains unallocated, it will not be reserved in any particular location, such as a dam, and will remain in the river system.

* The research reported in the present paper has been supported by the Australian Research Council, the Queensland Department of Natural Resources and Mines and Central Queensland University. The contributions of Adam Loch and Jeff Bennett to the project and the design of the surveys are gratefully acknowledged.

† John Rolfe (email: J.Rolfe@cqu.edu.au) is in the Faculty of Business and Law, Central Queensland University, Emerald, Australia. Jill Windle is from the Centre for Environmental Management, Central Queensland University, Rockhampton, Australia.

Economists typically address allocation questions by assessing the net benefits from a development option compared to the net benefits from a preservation option. The economic benefits of allocating water to development are relatively easy to assess using standard cost–benefit analysis. Such an exercise might involve the assessment of the net returns from increased irrigation production once the costs of infrastructure and water delivery systems had been factored in. Any changes in recreational and environmental benefits would also be included.

The estimation of values for preserving environmental assets is more challenging. Many changes in the provision of environmental assets are not reflected in markets; partly because people hold values for environmental goods without actually using them. These non-use values can be separated into existence values, bequest values and option values (the latter also includes quasi-option values). It is very difficult to assess the different components of non-use values separately and, apart from a few studies (e.g., Walsh *et al*. 1984; Langford *et al*. 1998), these values are regularly assessed as a group. However, there are some situations where it is important to specify non-use values separately. An example might be where specific components of value are needed for a benefit transfer exercise. As a result, there is interest in developing mechanisms and approaches to more accurately measure items like option values.

The key focus of the present paper is to estimate option values associated with reserving water in the Fitzroy Basin. For this purpose, the target was to estimate option values separate to use values and existence values. Choice Modelling (CM) experiments were used for this purpose, where one of the component attributes was framed in a way to explicitly capture option values. However, the design was complicated by the difficulty of defining exactly what option values are.

Option values are usually associated with preservation scenarios, as the choice between development and preservation remains open. In contrast, development benefits do not usually include option values as a component, because environmental losses are normally non-reversible. Option and quasi-option values incorporate notions of risk, uncertainty and ignorance.[1] Option value refers to the values that people might hold for avoiding irreversible decisions and maintaining future options (Weisbrod 1964; Bishop 1982). The concept of option value can be considered as a risk premium associated with possible risk aversion and implies that individuals' risk preferences can affect their values (Chevas and Mullarkey 2002). Quasi-option values are a separate concept. They refer to the value that people have for improving the knowledge about particular trade-offs so that more accurate choices can be made (Arrow and Fisher 1974). This implies that there is a value in delaying irreversible decisions until more complete knowledge is available. Quasi-option values were not explored in the experiments reported in the present paper, and are not discussed further.

A debate over the role played by option values has arisen because earlier beliefs that option values were always positive have been shown to be wrong (Hanley and Spash 1993). One difficulty is that values for preserving options may be offsetting when

[1] Risk is the known probability of known outcomes, whereas uncertainty is the unknown probability of known outcomes. Ignorance relates to unknown outcomes and, hence, unknown probability.

use and non-use purposes are considered. To resolve this, economists have moved to distinguish option value from option price. Freeman (2003) states:

> If option price is defined as the maximum sum the individual would be willing to pay to preserve the option to visit the site before his or her own demand uncertainty is resolved, then the excess of option price over expected consumer's surplus can be called option value. (p. 248)

The consumer surplus referred to relates to use values, so the option value can be thought of as that component of WTP to resolve uncertainty that can be attributed to non-use values. Hanley and Spash (1993) recommend that total value be separated into two components: option price and existence values, where option price is the sum of use values and option values, and existence value is the sum of existence and bequest values.

It is expected that the value of maintaining options will be reduced if there is uncertainty about future demands or about the potential supply of the item. Shogren and Crocker (1990) specify that option values will only be positive when there is no demand uncertainty and when supply uncertainty can be completely removed by the proposed actions (Hanley and Spash 1993). However, these conditions are likely to be met in the case study outlined below, where there is certain demand for environmental goods and where there are clear rules about the allocation of resources in the system. In the case study outlined below, the environmental good in question is unallocated water in a river system and values to be measured are those associated with keeping this water in reserve. It is expected that these values are associated with non-use components, as there is little recreation use or other uses of the water bodies by the populations of interest. The focus of the present study, therefore, is on estimating option values for keeping water in reserve, rather than option price to capture both use values and uncertainty considerations.

In the case of water resources, high levels of uncertainty about resource conditions, environmental resilience, and the interrelationships between various ecological functions all contribute to people being more cautious about the possibilities of environmental losses. In the Fitzroy Basin in central Queensland, there is some potential option value associated with holding water in reserve until more certainty exists about ecological thresholds and the accuracy of current biometric modelling relied on in the Fitzroy WRP assessment. This is partly because the Fitzroy River discharges into the Great Barrier Reef lagoon, and potential environmental losses may be associated with estuary, reef and marine zones (Productivity Commission 2003; State of Queensland and Commonwealth of Australia 2003). Keeping water in reserve rather than allocating it immediately for development would preserve current and future environmental values while keeping future options open.

Identifying how uncertainty about future environmental trends and conditions impacts on value formation is an important topic for research in applications of non-market valuation techniques. People's preferences for non-use aspects of environmental goods are not revealed in market transactions. As a result, revealed preference techniques are not capable of measuring these concepts, and stated preference techniques need to be employed. These include the contingent valuation method (CVM) and

CM.[2] Most development options tend to have multiple impacts on use, indirect use and non-use values; making it difficult to separate out specific option values. CM, with its ability to disaggregate choices according to underlying attributes, has some advantages over CVM in this regard (Morrison *et al*. 1996; Adamowicz *et al*. 1998; Hanley *et al*. 1998; Rolfe *et al*. 2000).

In the present paper, one approach to dealing with this issue is outlined. The results are reported for a series of CM surveys that have been conducted over a 3-year period in the Fitzroy River Basin in central Queensland. One of the attributes used in the CM surveys has been labelled in a way that captures concerns about future environmental impacts. The attribute used for this purpose was the 'amount of water kept in reserve'. It was expected that people who were concerned about the risks and uncertainties of environmental impacts would prefer to keep higher levels of water in reserve above the specified levels held for environmental purposes. In this sense, water kept in reserve can act as an insurance policy in case the environmental risks associated with allocating water to development is subsequently found to be higher than is currently modelled.

The present paper is organised as follows. An overview of water reserves in the Fitzroy Basin is presented in the next section and is followed by a description of the application of the CM surveys and the results. The results are discussed in Section 4, followed by some extrapolation to cost–benefit analysis and specific case studies in Section 5. Conclusions are presented in the final section.

2. Water reserves in the Fitzroy Basin

The Fitzroy Basin, encompassing 142 000 km^2, is the second largest externally draining basin in Australia. Beef cattle, grain, irrigated crops and coal are key primary products in the region. The Fitzroy Basin has two major irrigation centres: the Emerald irrigation area located on the Comet/Nogoa/Mackenzie (CNM) River systems and the Dawson Valley irrigation area located along the Dawson River (Figure 1). The Fitzroy Basin's Water Allocation and Management Plan (WAMP) was released in December 1999 (QDNR 1999). It was amended in December 2003, becoming the WRP (Fitzroy Basin) 2003 (QDNRM 2003), to ensure that it conforms to the statutory requirements (Water Act 2000) of a water resource plan.

The WRP establishes the strategic framework for water allocation and management in the Fitzroy basin and provides for:

- Security of existing users
- Security of water infrastructure operators
- Environmental water requirements
- Opportunities for new water development in the catchment (QDNRM 2003)

Allocations for environmental purposes were generally set at 50 per cent of median flow levels, although slightly lower levels were set in some catchments. Because stream flows are highly variable in the Fitzroy, median flow levels are substantially below mean

[2] Also known as choice-based conjoint and choice experiments.

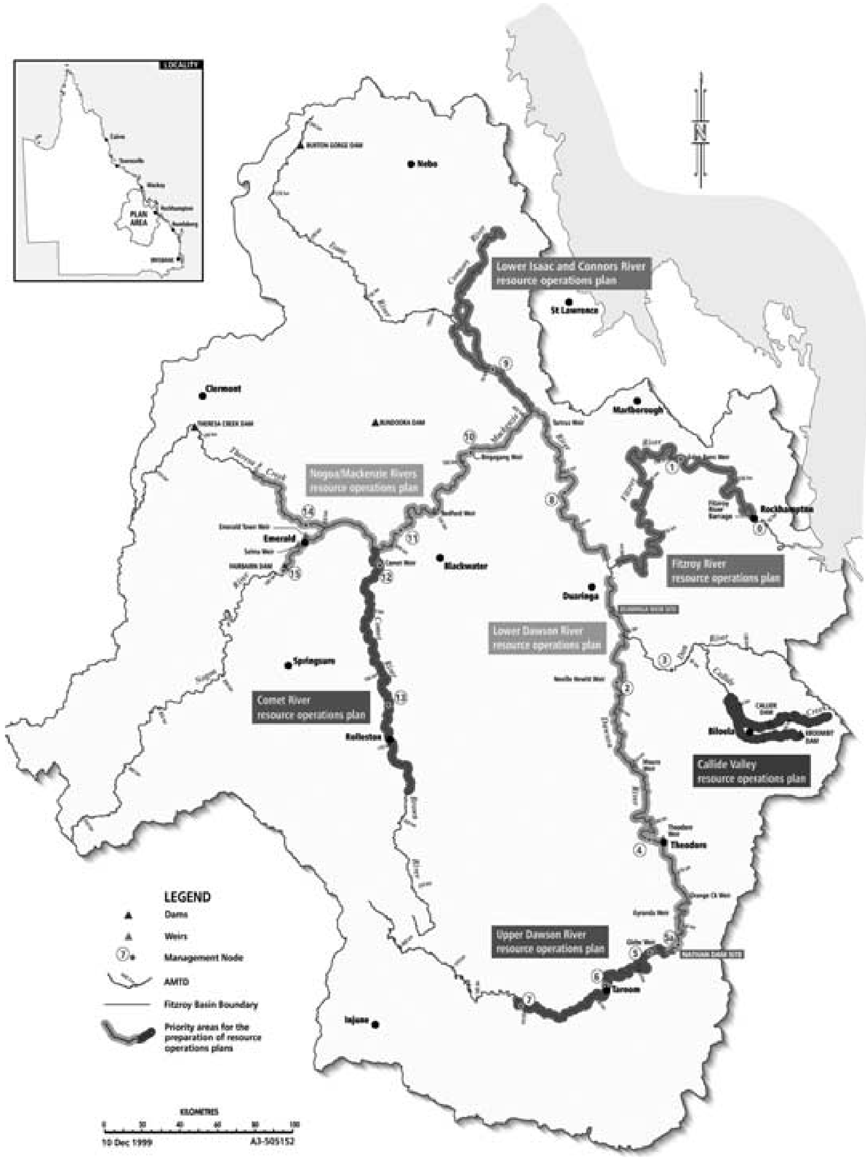

Figure 1 The Fitzroy Basin.

flow levels. The Fitzroy WRP confirmed existing allocations of water, together with the following additional water allocations:

- 190 000 megalitres (ML) of medium priority water for the proposed construction of the Natham Dam
- 3000 ML of high priority water in the Mackenzie River following the stage 2 raising of Bingegang Weir
- 300 ML of high priority water from the minor raising of Moura Weir

In addition, the following amounts were identified as unallocated water (and can potentially be diverted for other uses):

- Up to 300 000 ML of additional mean annual diversions on the Isaac/Connors/lower Fitzroy River systems
- Up to 40 000 ML of additional mean annual diversions in the CNM River system
- Up to 11 500 ML of mean annual diversions from the upper Dawson River above Taroom

Queensland is in the fortunate situation of not having already over-committed water resources in the Fitzroy Basin. However, while the amount of unallocated water (referred to as water reserve) in the lower Fitzroy appears plentiful, demand for water is high in the other catchments, particularly in the CNM River system, as this region supports profitable cotton and horticulture industries that rely on irrigation supplies.

The initial WAMP did not explicitly cover overland flows, although these water resources were counted once they reached defined watercourses. When the initial WAMP was being implemented, a moratorium was placed on taking water from defined watercourses. This resulted in substantial development (on-farm dams) to capture overland flows before they reached defined watercourses. In 2002, an additional moratorium was placed on the capture of overland flows. When the additional water captured from overland flows in the 1999–2002 period is taken into consideration there is very little water left as a reserve in the CNM system.

3. Choice Modelling applications

Three CM studies have been conducted to assess the environmental and social impacts of water development in the Fitzroy Basin. Results of these studies have been reported in a series of research reports. Details and results from Survey One have been reported in Loch *et al*. (2002) and Rolfe *et al.* (2002b). Details and results from Survey Two have been reported in Windle and Rolfe (2002a, 2003), and results from Survey Three have been reported in Rolfe and Bennett (2003). These CM studies have presented water development in terms of a number of associated social and environmental attributes. One of those attributes, ‘amount of water in reserve’, has been framed in terms of assessing option values.

Choice Modelling involves asking survey respondents to make a series of choices from alternative options for environmental management. Each choice set involves a number of profiles describing the alternatives on offer. One of the profiles describes a current or future status quo option, and remains constant between the choice sets. The other profiles vary, so that respondents are being asked to make a series of similar, but different choices.

The profiles are made up of a number of attributes that describe the issue in question. For example, profiles about environmental issues in floodplain management might be described in terms of the ‘health of the waterways, the amount of remnant vegetation in good condition on floodplains, and the proportion of stream flows that are reserved for environmental purposes’. To generate differences between profiles, these attributes are allowed to vary across a number of different levels (e.g., 30, 40 or 50 per cent of healthy vegetation in floodplains). These profiles then represent different options for future development and protection of the issue in question.

The choice information is analysed using a multinomial logistic (MNL) regression model. The probability that a respondent would choose a particular option can be related to the levels of each attribute making up the profile (and the alternative profiles on offer), the socioeconomic characteristics of the respondent, and other factors. The latter might include the ways in which the choices are framed to respondents, through background information and structure of the survey, and the way in which the surveys are conducted (Bennett and Blamey 2001; Rolfe *et al.* 2002a).

The logistic regression function can be used to generate probabilities of choice, and estimates of value (compensating surplus) differences between different choice profiles. Most interest usually lies in finding the difference in value between the status quo option and specific policy relevant profiles. As well as these estimates of value, the models can also be used to generate estimates of marginal value changes for each attribute (Rolfe *et al*. 2000). Known as part-worths, implicit prices, or attribute values, these provide an indication of the value to respondents of each unit change in the provision of an attribute. Both the part-worth and the compensating surplus estimates can be used for testing the equivalence of different models. They may also be used for transferring values (benefit transfer) to other case studies (Morrison and Bennett 2000; Rolfe *et al*. 2000).

The CM surveys reported in the present paper presented respondents with four choice attributes and an associated cost attribute. Four attributes were common to each survey:

- Payment levy (environmental levy collected annually through rate payments for 20 years)
- Amount of healthy vegetation left in floodplains (percentage of original)
- Kilometres of waterways in good health
- Amount of unallocated water in reserve (percentage above the WRP limits)

In Survey One and Survey Three, the fifth attribute was: ‘people leaving country areas each year’, while in Survey Two the fifth attribute was ‘protection of Aboriginal cultural heritage sites’. An example of the choice set presented to respondents in Survey Two is presented in Figure 2.

The design of a CM study involves several logistical and framing challenges, in terms of condensing key factors into a number of attributes and levels, and then defining and describing them concisely to respondents. There are other methodological challenges as well.

Water development trade-offs are typically complex, and can involve both use and non-use values. For example, water may contribute to recreation choices (use values) and biodiversity support (non-use values). A key challenge was to select attributes that captured the multifunctionality of water resources, while keeping the choice sets relevant to the population groups of interest. A small number of attributes was used, to minimise the substitution problems identified by Hoehn (1991). Two attributes were designed to elicit existence values (for waterway health and vegetation) separate to the option value (for keeping water in reserve). The survey was framed to capture

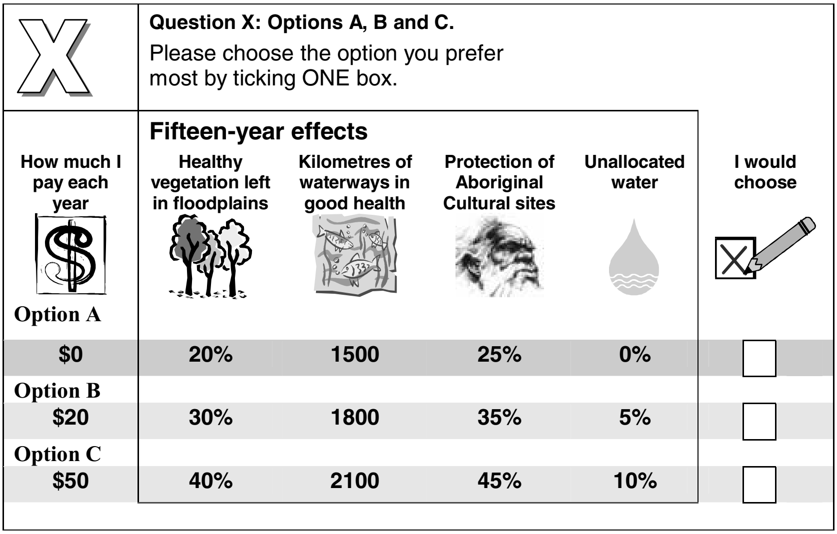

Figure 2 Example choice set used in Survey Two.

non-use values rather than use values, given that the bulk of the population surveyed was 700 km from the catchment. Two population centres within the catchment were also surveyed to ascertain if their responses were also driven by use values (e.g., for recreation purposes).

Another relevant issue for the present study was the possibility that the water reserve attribute was a causal (prior) attribute for the other environmental attributes. If this was the case, respondents may rate this attribute more highly because they perceive that they will get a range of other associated benefits. Careful consideration was given to the information presented to respondents about the water reserve attribute, to ensure it was associated with option values, and that it would not be perceived as a causal attribute for other environmental attributes. Focus groups were held to test that information presented in the survey was sufficient and framed in the intended context (Loch *et al.* 2001). Post-survey tests for causal attributes were also conducted and details are reported in Section 4.

Table 1 displays the description of the water reserve attribute in Survey One.

In survey Two, the last statement was modified and three new statements were added to include issues of relevance to the Aboriginal community (see Table 2).

In Survey Three, a briefer description was used (see Table 3).

Attention in the present paper focuses on two of the attributes common to each survey: cost (payment) and water reserve. The attribute levels presented in the different surveys are shown in Table 4. In each case, the base level describes the estimated condition of the attribute in 20 years time (Survey One and Three) and in 15 years time (Survey Two). The shorter time frame in the second survey resulted from discussions in focus groups with Aboriginal participants and was considered more realistic given their shorter life expectancy.

Table 1 Survey 1: description of water reserve attribute

What does 'amount of water in reserve' mean?
Note that some water in the Fitzroy: Is committed to irrigators and townships Is reserved to avoid large future environmental problems The reserve is the water that has not yet been allocated between those above
The surplus could be allocated now or held. Consider that: Our future demands for water are uncertain Keeping water for the future keeps our options open for either growth or environmental purposes Water kept in reserve now has environmental benefits Water used for development now has economic benefits It is not clear how accurate our current scientific knowledge is

Table 2 Survey 2: description of water reserve attribute

What does 'unallocated water' mean?
Note that some water in the Fitzroy: is already being used and some is allocated to environmental flows (see information above). The remainder, approximately 15 per cent of total flows, could be allocated now or held in reserve.
Consider that: Water allocated for development has economic benefits Water kept in reserve has environmental benefits Unallocated water allows for possible Native Title claims Our future demands for water are uncertain Keeping water in reserve for the future keeps our options open for either growth or environmental purposes Keeping water in reserve allows for Indigenous and other groups to develop their interests Keeping water in reserve allows for more accurate scientific knowledge to be collected Keeping water in reserve provides a buffer if ecological impacts of development end up being larger than currently thought

Table 3 Survey 3: description of water reserve attribute

Currently, Fitzroy River Basin water is either allocated to environmental flows (50 per cent) or to irrigators and other users (35%).
The remaining water (15 per cent) is being held in reserve for future options. In the future, it may be found that more water is required to protect the environment. If the reserve is allocated to irrigation development now, then the flexibility to increase environmental flow in the future is greatly reduced.

3.1 Survey details and results

The same sampling and collection procedure (drop-off/collect from a random sample of households) was applied in all three surveys. Survey One was conducted in late 2000 and populations were sampled from Brisbane (urban centre), Rockhampton (regional centre) and Emerald (regional town). In Rockhampton and Emerald, the

Table 4 Cost (payment) and water reserve attribute levels

Attribute	CNM subcatchment		Dawson subcatchment		Fitzroy Basin	
	Base levels	Choice set levels	Base levels	Choice set levels	Base levels	Choice set levels
Survey One						
Payment ($A)	0	10, 20, 50	0	10. 20, 50	0	20, 50, 100
Water Reserve (%)	0	–2, 2, 4	0	–5, 5, 10	0	5, 10, 15
Survey Two						
Payment ($A)	—	—	—	—	0	10, 20, 50, 100
Water Reserve (%)	—	—	—	—	0	−15, −10, −5, 0, 5, 10, 15, 20†
Survey Three						
Payment ($A)	—	—	—	—	0	20, 50, 100
Water Reserve (%)	—	—	—	—	0	4, 8, 12

†The value of 20 per cent is 5 per cent higher than the current reserve level. In the two subcatchment models, the highest reserve level represented the current reserve level. CNM, Comet/Nogoa/Mackenzie; —, not applicable.

survey focused on the whole Fitzroy Basin. In Brisbane, the survey was split into three versions that focused on:

- The whole Fitzroy Basin
- The Dawson River subcatchment
- The CNM subcatchment

In Brisbane, 340 surveys were collected (all three versions); 122 in Rockhampton and 149 in Emerald. Of all people approached, 50.5 per cent gave back a fully completed survey, 41.5 per cent declined to complete the survey, and 9 per cent of people approached took a survey form and either did not return it to the collector or did not complete it fully. There were five choice sets in each survey, which meant 1700, 610 and 745 choice sets were completed in Brisbane, Rockhampton and Emerald, respectively.

Survey Two was conducted in late 2001 and populations were sampled from the Aboriginal community in Rockhampton, and the general community in both Rockhampton and Brisbane. From an Aboriginal sample of the Rockhampton area, 63 surveys were collected (response rate of 56 per cent); 100 surveys were collected from the general community in Rockhampton (response rate of 83 per cent), and 58 surveys were collected from Brisbane (response rate of approximately 70 per cent). There were eight choice sets in each survey, providing a total of 504, 800 and 464 completed choice sets from the Rockhampton Aboriginal, Rockhampton general and Brisbane populations, respectively.

Survey Three was conducted in mid-2002, and only the Brisbane population was sampled. A total of 168 households were invited to participate, and 98 questionnaires were completed. Of all people approached, 58.3 per cent gave back a fully completed questionnaire, while 26.5 per cent of all people approached declined to complete one, and 15.2 per cent of people approached took a questionnaire and either did not return it to the collector or did not complete it fully. There were eight choice sets in each survey, providing a total of 784 choices sets for the data analysis.

Table 5 Variables used in the choice modelling models

Attribute variables	
Cost	Amount that households would pay in extra rates (or rent) each year to fund improvements
Vegetation	Percentage of healthy vegetation in floodplains remaining
Waterways	Number of kilometres of waterways in catchment remaining in good health
People leaving (Survey One, Three)	Number of people leaving country areas each year
Cultural Heritage (Survey Two)	Percentage of Aboriginal cultural sites protected
Water reserve/unallocated water	Percentage of water resources in catchment not committed to environment or allocated to industry/irrigation/urban
ASC	Constant value: reflects influence of all other factors on why people choose between different choice profiles
Socioeconomic variables	
Age	Age of respondent (in years)
Occupation	Occupation: employed (1); not in workforce (0)
Education	Education: post-school (1); school (0)
Income	Income of household in dollar terms

ASC, alternate specific constant.

When all the split-samples are counted separately, a total of nine CM surveys can be modelled. To facilitate comparisons, standard MNL models have been estimated for each data set.[3] These MNL models related the probability of choosing a choice profile to the attributes describing a profile, selected demographic characteristics of respondents, and a constant reflecting the influence of other factors.

The variables used are defined in Table 5, with most variables having significant coefficients in the models. Full details of the models generated, including the model performance statistics, are presented in Tables 11–14 in the Appendix.

Once the models had been generated it was possible to estimate the mean values that the different populations held for marginal changes in the amounts of water reserve. These values (part-worths) are estimated by taking the ratio of the water reserve and cost coefficients. A Krinskey and Robb (1986) procedure is used to draw a vector of 1000 sets of parameters for each model and calculate confidence intervals. The part-worths are directly comparable between models. The results are presented in Table 6.

4. Analysis of results

The key hypothesis of interest was whether the populations sampled held option values for keeping unallocated water in reserve. The hypothesis can be tested as follows:

$$H_0 \colon \beta\ Reserve = 0$$

$$H_1 \colon \beta\ Reserve \neq 0$$

[3] In many cases, the use of a standard model across individual data sets has reduced the levels of model fit compared to when models can be specifically tailored to a data set.

Table 6 Mean part-worths and confidence intervals for the water reserve attribute

	Population	Fitzroy	CNM	Dawson
Survey One 2000	Brisbane	1.52 (0.22–2.81)[†]	9.36 (5.15–15.65)	2.24 (1.49–3.17)
	Rockhampton	1.43 (not significant)		
	Emerald	2.20 (0.71–3.71)		
Survey Two 2001	Brisbane	3.19 (1.79–5.32)		
	Rockhampton	2.95 (1.93–4.35)		
	Rockhampton Aboriginal	3.86 (2.02–6.73)		
Survey Three 2002	Brisbane	5.77 (3.20–8.85)		

[†]The values in parenthesis are confidence intervals. CNM, Comet/Nogoa/Mackenzie.

where β Reserve is the parameter vector corresponding to the water reserve/unallocated water attribute in the surveys.

The results of the surveys indicate that Reserve was always a significant variable in the models, except for the 2000 Rockhampton survey for the Fitzroy. In all surveys where the attribute was significant, it was signed as expected (positive); indicating that survey respondents preferred increased amounts of the attribute. Therefore, the null hypothesis can be rejected; the evidence suggests that the populations of interest do hold option values in relation to Fitzroy water resources.

The results in Table 6 suggest that Brisbane respondents are prepared to pay $A9.36 for each 1 per cent of water reserve in the CNM system. Survey respondents were informed that current reserves in the CNM system (the 40 000 ML identified in the Fitzroy WRP) equated to approximately 4 per cent of the system. Therefore, Brisbane households, on average, would pay approximately 4 times the amount above, or $A37.44 per annum, to preserve the entire 40 000 ML. For the Dawson system, respondents were willing to pay $A2.24 to preserve each 1 per cent of water reserve. The total reserves in the Dawson were nominated as being 10 per cent of water resources in the valley. This means that the value of preserving all of that reserve was $A22.40 per household per year. For the Fitzroy system, respondents were willing to pay $A1.52 to preserve each 1 per cent of water reserve. The total reserves in the Fitzroy were nominated as being 15 per cent of water resources in the basin. This means that the value of preserving all of that reserve was $A22.80 per household per year.

Total willingness to pay was approximately equivalent across the Fitzroy and Dawson catchments, but the values were much higher in the CNM valley where there were smaller reserves of water. As expected, this implies that marginal values appear to be higher as reserves become diminished.

To assess whether there are significant differences between the part-worths for the different populations and over the different time periods, a Poe *et al.* (2001) simple convolutions process was followed. A Krinskey and Robb (1986) procedure was used to draw a vector of 1000 sets of parameters for each model, and part-worths were calculated for each set of parameters. Differences between part-worths were calculated by taking one vector of part-worths from another. This process is repeated 100 times by randomly reordering one vector of parameters. The 95 per cent confidence interval

Table 7 Proportion of part-worth differences for the reserve attribute falling below zero

Survey One 2000	Brisbane (Fitzroy, CNM)* 0.99999	Brisbane (Fitzroy, Dawson) 0.81858
Survey One 2000	Brisbane, Emerald 0.75536	Brisbane (CNM, Dawson)* 1
Survey Two 2001	Brisbane, Rockhampton general 0.42613	Brisbane, Rockhampton Aboriginal 0.66503
Survey Two 2001	Rock general, Rock Aboriginal 0.73819	Brisbane 2001, Brisbane 2000 0.05204
Survey Three 2002	Brisbane 2002, Brisbane 2001 0.05669	Brisbane 2002, Brisbane 2000 0.0015

*Denotes significance at the 5 per cent level. CNM, Comet/Nogoa/Mackenzie.

is approximated by identifying the proportion of differences that fall below zero. The results are presented in Table 7.

These results indicate that significant differences only occur between the Brisbane 2000 values for CNM subcatchment and the Dawson and Fitzroy systems. There is no significant difference between the different populations surveyed in 2000 or 2001. There is a difference between the Brisbane 2002 and Brisbane 2000 part-worths for the Fitzroy Basin, with values increasing over the 3-year period (Table 6).[4]

In all of the surveys, considerable attention was paid to framing the information supplied. One problem that was considered was the potential for respondents to link the reserve attribute with waterway health. It was possible that some respondents viewed keeping more water in reserve as a causal attribute for waterway health, and may have placed more emphasis on the reserve attribute to achieve higher levels of waterway health. To test whether prior causality was a significant influence, an interaction variable, which combined the results for waterways and reserve, was added and new MNL models were run. The results are presented in Table 8.

The interaction variable was significant in three out of the nine models, indicating that some causality may have been present. However, the size of the coefficient was very small, indicating that the impact of causality was negligible.

5. Should water be reserved rather than allocated?

Once the value that people hold for keeping water in reserve has been established, it is possible to make a tentative assessment on whether to keep water in reserve or allocate it for development. In other words, do the values people have for keeping water in reserve outweigh the economic gains that can be made if the water is allocated to development? These assessments are made in relation to the values held by the Brisbane population for the water reserve in the three different catchment areas, using information collected in the first survey. In order to extrapolate values from a sample to the whole population there are four important issues to consider:

[4] It is possible that this difference was caused by the slight changes in the way that the reserve attribute was described.

Table 8 The significance of interactions between the waterways and reserve attributes

Waterways/reserve	Coefficient	Standard error	Significance
Survey One 2000			
Dawson	−0.00007	0.0002	Not significant at 10% level
CNM	−0.00007	0.00008	Not significant at 10% level
Fitzroy/Brisbane	−0.00009	0.00004	Significant at 5% level
Emerald	−0.00005	0.00003	Not significant at 10% level
Rockhampton	0.000003	0.00003	Not significant at 10% level
Survey Two 2001			
Rockhampton Aboriginal	−0.00004	0.00003	Not significant at 10% level
Rockhampton general	0.00005	0.00002	Significant at 5% level
Brisbane	−0.000005	0.00003	Not significant at 10% level
Survey Three 2002			
Brisbane	0.0003	0.0001	Significant at 5% level

CNM, Comet/Nogoa/Mackenzie.

- How should the values of non-respondents be treated?
- How far does the population extend?
- Do the socioeconomic characteristics of the sample match those of the population
- What is the appropriate discount rate?

The first issue to consider is that of non-response bias: do the people who declined to answer the survey hold the same values as those who responded? The lowest response rate in any of the surveys and places was 50 per cent, which means that in some places up to half the sample population did not respond. Various authors have suggested different ways of assessing the preferences of the non-response sample (Morrison 2000). No information was collected on the reasons why people did not respond, but in a CM valuation of a major wetland area Morrison (2000) reported that 30 per cent of non-responses were a result of people being too busy, and these preferences were treated as being the same as those in the survey sample. For the purposes of the present paper, it will be assumed that 30 per cent of the households that did not respond to the survey hold the same preferences as those in the sample survey.

The second issue is how broadly can these values be extrapolated? Three populations were surveyed in the first survey: Brisbane, the state capital, and Emerald and Rockhampton, two local regional communities. Clearly the values of the whole Brisbane population can be included, but to what extent can the values of the rest of the state population be included? The values held by the Emerald community were significant and although Rockhampton values were not significant in 2000, they were in 2001 (Table 6). There was no significant difference between the values held by the Brisbane and Emerald communities in 2000 and between Brisbane and Rockhampton in 2001 (Table 7). In the present paper, a conservative approach to extrapolation will be adopted. The values of people outside the state will not be included. Within the state, only the values of the Fitzroy region (approximately 5 per cent of the state population, or 63 000 households) and the Brisbane community (approximately 26 per cent of the state population, or 330 000 households) will be estimated.

Table 9 Social demographic details of the sample and population survey respondents and Brisbane

	Survey One respondents	Brisbane[†]	State average[†]
Average age (>17 years)	43	44	46
Employed full/part time (%)	60	60	58
Education (>year 12) (%)	51	45	43
Household income ($A)	43 125	46 800[‡]	39 000[‡]

[†]Figures obtained and estimated from 2001 Census data, Australian Bureau of Statistics 2001 census. [‡]Figures extrapolated from median weekly household income ranges.

The third consideration is the socioeconomic characteristics of the sampled respondents and how well they match those of the population. As an example, details of respondent demographics for the Brisbane 2000 sample that are used as model attributes (see Appendix: Table 12) are presented and compared with the Brisbane and state population (Table 9).

Statistical tests revealed a significant difference between the sample and the Brisbane population in education levels, but not in the other demographic variables. However, education has a mixed effect in the models and is significant and negative for the Fitzroy 2000 model; weakly significant and positive for the Dawson model, and not significant for the CNM model. In the case of the Fitzroy 2000 model, the negative influence of education means that people with higher levels of education were more likely to select the status quo or no cost option and were less likely to select one of the preservation options. The income levels of the sample fall between the estimated levels for the Brisbane and state populations. These results mean that no adjustments need to be made for specific sample characteristics when value estimates are extrapolated across a population.

The fourth consideration is that of an appropriate discount rate. Theoretically, the choice of discount rate is between the market rate (social opportunity cost) and the social time preference rate, which represents the degree to which society is prepared to forego future consumption (usually estimated as the government bond rate). It could be argued that environmental benefits do not decline and may become more important in the future and so should not be discounted, or that a low discount rate should apply. However, individuals may have very high personal discount rates, as evidenced in Windle and Rolfe (2004). Consequently, values are assessed below, using a range of discount rates.

The three case study exercises are conducted by comparing the benefits of holding water in reserve (option values) with the opportunity costs of reduced production. The option values are calculated by extrapolating the model results reported earlier across 255 450 households. This comprises 50 per cent of the Fitzroy and Brisbane households (31 500 and 165 000 households, respectively), and a further 30 per cent as a proportion of non-responses (9450 and 49 500 households in the Fitzroy and Brisbane, respectively). The individual WTP values elicited in the survey were annual payments to be paid for a 20-year period (clearly stated in each choice set) and the present value of the aggregated amount is then calculated using a range of discount

Table 10 Production returns from additional water allocations in the Fitzroy Basin

Location	Model farm size (ha)	Model farm irrigation area (ha)	Values where new farms developed ($A/ha)	Values where existing farms increase operations $A/ha	Average across operations assuming 6 ML/ha (unit: $A/ML)
Upper Comet	3845	249	802	2386	266
Lower Comet	1370	213	2738	4413	596
Upper Mackenzie	892	267	5574	6512	1007
Dawson	1127	332	2419	3513	494
Lower Fitzroy	1000	115	1686	3934	468

ML, megalitre.

rates (6 per cent, 8 per cent and 12 per cent). The total estimated value for the three river systems are described in detail below.

The production benefits available from further water harvesting in the Fitzroy Basin were assessed by Donnett (1998), using a sample of irrigation properties in each catchment. Properties were typically mixed enterprises, with further areas available for development. Donnett (1998) estimated values from increased water harvesting where two separate scenarios were modelled. The first scenario was where further water allocations were used to develop new farms (of similar sizes to the existing ones), and the second scenario was where further water allocations were used to expand and intensify water use on existing farms. Production and cost data from the irrigation properties were used to model returns under different water supply scenarios.

Water supplies were modelled using 95 years of available hydrological data. In each data run, net returns from further irrigation development over 30-year periods were assessed, and then averaged across the number of hydrological patterns modelled. The results indicated the expected returns from further water harvesting over the longer term when variability in streamflow in different sections of the basin was taken into account. In the results, net farm income was averaged to identify the net returns per hectare irrigated.

Results from Donnett (1998) are summarised in Table 10, where estimated returns per hectare have been modelled over 30 years of operation and a net present value analysis applied. Estimated returns per megalitre are also shown. The returns have been averaged across the two scenarios using a base application rate of 6 ML per hectare. The results show that returns range from $A266/ML in the upper Comet to $A1007/ML in the upper Mackenzie. The average across the combined upper and lower Comet and Mackenzie systems is $A623/ML. This value will be used in the assessment of production benefits for the CNM River system outlined below. A value of $A494/ML is used for the Dawson system and $A468/ML for the Fitzroy system.

5.1 Values in the Comet/Nogoa/Mackenzie system

Survey respondents indicated that their households, on average, were willing to pay $A9.36 per annum to preserve each 1 per cent of water reserve in the CNM system or approximately $A37.44 per annum, to preserve the entire 4 per cent (40 000 ML) of unallocated water in the CNM system. This payment stream was converted to present value terms, and extrapolated to a total of 255 450 households. This payment stream amounted to $A109.70m, $A93.90m and $A71.44m using a 6 per cent, 8 per cent, and 12 per cent discount rate, respectively, over a 20-year period. If WTP values are calculated based on the lower ($A5.15) and upper ($A15.65) bounds (Table 6) and a 6 per cent discount rate is applied, the payment stream amounts to $A60.36m and $A183.42m, respectively.

These preservation values can be compared to the production benefits that allocating the water might generate. These have been estimated from the work of Donnett (1998) at approximately $A623/ML. If the whole 40 000 ML were to be valued at approximately $623/ML, the net present value of the production benefits can be calculated at approximately $A25m.

It appears that, on the preliminary figures at least, the option values outweigh the potential production benefits from allocating more water in the CNM system. There may be particular situations where further allocations of water have positive social outcomes without many environmental losses, in which case there may be some justification for allocating more reserve. However, some environmental consequences from allocating more water would normally be expected. This means that in most cases there would appear to be more value in reserving the 40 000 ML of water in the CNM system than allocating it to irrigation. This does not preclude it from future use; the value expressed is to keep it as a backup so that the options for using it for environmental or development purposes remain open.

5.2 Values in the Dawson system

Survey respondents indicated that their households were willing to pay $A2.24 to preserve each 1 per cent of water reserve in the Dawson system. The lower part-worth values for the water reserve in the Dawson system reflect the larger amounts of water that are potentially available for irrigation in the valley. There is effectively a larger gap between the 50 per cent set for environmental flows and the amount currently allocated (excluding the provision for the Nathan Dam) than is the case in the CNM. Because there is a larger amount effectively in reserve at this point compared to the CNM, the value of each 1 per cent loss in water reserve is lower.

The total reserves in the Dawson were nominated as being 10 per cent of water resources in the valley. This means that the value of preserving all of that reserve was $A22.40 per household per year. This translates into a present value of $A65.63m, $A56.18m, and $A42.74m at a 6 per cent, 8 per cent, and 12 per cent discount rate, respectively, over a 20-year period. If WTP values are calculated based on the lower ($A1.49) and upper ($A3.17) bounds (Table 6) and a 6 per cent discount rate is applied, the payment stream amounts to $A43.66m and $A92.88m, respectively.

Under the Fitzroy WRP, 190 000 ML of water supply is reserved for the Nathan Dam, and a further 11 500 ML of supply remains unallocated in the Upper Dawson region. At $A494/ML, the 201 500 ML of extracted water indicates that the total economic benefit from irrigation is approximately $A99m. These preliminary values suggest that the development of the Nathan Dam may create economic value even after option values have been considered. However, there may be marginal effects to consider across the full volume of additional supply, particularly where there are declining qualities of agricultural land available for irrigation expansion.

5.3 Values in the whole Fitzroy system

Respondents in Brisbane indicated that their households were willing to pay $A1.52 to preserve each 1 per cent of water reserve in the whole Fitzroy system. The total reserves in the Fitzroy were nominated as being 15 per cent of water resources in the basin. This means that the value of preserving all of that reserve was $A22.80 per household per year. The net present value of these payments, for 255 450 households, over a 20-year period, is $A66.80m, $A57.18m and $A43.50m, respectively, for a discount rate of 6 per cent, 8 per cent and 12 per cent, respectively.

If WTP values are calculated based on the lower ($A0.22) and upper ($A2.81) bounds (Table 6) and a 6 per cent discount rate is applied, the payment stream amounts to $A9.67m and $A123.50m, respectively. If the WTP values are extrapolated to account for all households in the Brisbane and Fitzroy population, the payment stream amounts to $A102.78m and ranges from $A14.88m to $A190.00m. When all households in Queensland are included, then the payment stream totals $A329.77m and ranges from $A47.73m to $A609.64m.

Under the Fitzroy WRP, a total of 544 800 ML of annual supply is identified. At a net economic value of $A468/ML, the economic value of additional water use is approximately $A254m. This suggests that room for development remains even after option values have been considered. It is only when the WTP values are extrapolated to include the whole state population that the option values start to outweigh the economic benefits of development. Again, there may be important marginal effects to consider, particularly where the use of unallocated water is limited by the supply of suitable land.

5.4 Issues in extrapolating the option values

There are two potential reasons why the option values estimated in the above examples may be too high. The first is that future establishment of water trading mechanisms may make it relatively easy in the future to divert water back for environmental purposes. Allocations can be simply purchased in the market place, and effectively added to environmental flows. The survey results indicate that respondents place a high option value on preserving environment assets associated with the Fitzroy system. High values have been generated for the water reserve attribute, because this is the vehicle that was given for expressing those sentiments. If those options can be maintained without holding some or all of the water in reserve, then it is not clear that the values can continue to be associated with reserving water.

The second reason why some caution needs to be exercised in interpreting the option values for the water reserve attribute is that respondents may not have fully understood the distinction between water already committed to the environment (approximately

50 per cent of median flow amounts), and the surplus unallocated water. If respondents interpreted the water reserve attribute as the only way of holding water back for environmental purposes, then they may place greater importance on the attribute than is warranted. The survey design, labels and explanation sections were focused on avoiding this problem, but the possibility that it may have influenced resulting values should still be recognised.

6. Conclusion

The experiment results presented in the present paper represent one approach to the estimation of option values as a separate component of non-use values. By describing the retention of water in reserve as an available option in the CM experiments, the intention was to specify preference trade-offs and, hence, values, for an option value concept. However, there were a number of practical and theoretical issues that made it difficult to demarcate the attribute clearly in this way.

One issue was that the holding of water in reserve may have generated other use and non-use values apart from the option value. For example, water kept in reserve may have current benefits for recreation and environmental goals apart from maintaining options for future development/preservation choices. Another issue was that option values may not be independent from other use and non-use values. For example, respondents with higher recreation and/or biodiversity protection values might be expected to hold higher option values. These issues were partly tested by conducting some versions of the experiments within the catchment (where recreation and other use values might be important), and others outside the catchment (where recreation and other direct uses are not possible). There were no differences identified for the reserve values held by population samples within or outside of the catchment, implying that those values were at least independent from use values. This provides some justification for defining the values estimated as option values rather than option prices.

An associated problem with this issue of potential substitutability between values for reserve water and values for other environmental goods was that reserve water may act as a causally prior attribute. This is the situation where some respondents might choose higher levels of the reserve attribute in the expectation that there would be subsequent benefits for waterway health and other environmental goals. Tests for this were conducted by identifying significant interactions between the reserve and waterways attributes in the different models, with mixed results. In some cases interactions were significant but minor, implying that causality might have been present but had negligible impact.

Results from the different surveys indicated that option values did display significant marginal effects. In the CNM system, where there are existing high levels of development, the marginal values for the option of keeping water in reserve were significantly higher than values in the other subcatchment or the whole catchment where there were substantial amounts of unallocated water.

However, the experiment results and extrapolation into policy situations also demonstrated the potential problems that occur when multicomponent situations are valued separately. Values for reserving water in the Fitzroy, Dawson and CNM systems were estimated separately, even though the latter two are subcatchments of the former. When the total reserve values were estimated for each catchment, the values for the whole catchment were similar to one subcatchment (Dawson), and much lower for the other (CNM). This demonstrates the arguments of Hoehn and Randall (1989) that part-whole estimation problems can seriously influence the conduct of benefit–cost tests.

It is possible that the option values used in the benefit–cost exercises were overstated because of these substitution effects and part-whole estimation problems. However, the results indicate that option values may be high enough to reserve water in the CNM system even if the values were overstated by a factor of three. In contrast, there are net benefits in allowing further economic development in the Dawson subcatchment and the Fitzroy system as a whole.

References

Adamowicz, W., Boxall, P., Williams, M. and Louviere, J. (1998). Stated preference approaches for measuring passive use values: choice experiments and contingent valuation, *American Journal of Agricultural Economics* 80, 64–75.

Arrow, K.J. and Fisher, A.C. (1974). Environmental preservation, uncertainty, and irreversibility, *Quarterly Journal of Economics* 88, 312–319.

Bennett, J.W. and Blamey, R.K. (2001). *The Choice Modelling Approach to Environmental Valuation*. Edward Elgar Publishing, Cheltenham.

Bishop, R. (1982). Option value: an exposition and extension, *Land Economics* 58, 1–15.

Chevas, J.P. and Mullarkey, D. (2002). On the valuation of uncertainty in welfare analysis, *American Journal of Agricultural Economics* 84, 23–38.

Donnett, R. (1998). *Potential Economic Benefits from Additional Private Water Harvesting Development in Central Queensland*, Report prepared for the Department of Natural Resources. Queensland Government, Brisbane.

Freeman, A.M. (2003). *The Measurement of Environmental and Resource Values. Theory and Methods*, 2nd edn. Resources for the Future, Washington, DC.

Hanley, N. and Spash, C. (1993). *Cost–Benefit Analysis and the Environment*, Edward Elgar Publishing, Cheltenham.

Hanley, N., Wright, R. and Adamowicz, W. (1998). Using choice experiments to value the environment: design issues, current experience, and future prospects, *Environmental Resource Economics* 3–4, 413–428.

Hoehn, J.P. (1991). Valuing the multidimensional impacts of environmental policy: theory and methods, *American Journal of Agricultural Economics* 73, 289–299.

Hoehn, J.P. and Randall, A. (1989). Too many proposals pass benefit cost test, *American Economic Review* 79, 544–551.

Krinskey, I. and Robb, A. (1986). On approximating the statistical properties of elasticities, *Review of Economics and Statistics* 68, 715–719.

Langford, I.H., Kontogianni, A., Skourtos, M.S., Georgiou, S. and Bateman, I.J. (1998). Multivariate mixed models for open-ended contingent valuation data – willingness to pay for conservation of monk seals, *Environmental and Resource Economics* 12, 443–456.

Loch, A., Rolfe, J. and Bennett, J. (2002). Scale Effects and Their Importance for Benefit Transfer of Natural Resource Values in the Fitzroy Basin, *Valuing Floodplain Development in the Fitzroy Basin*, Research report no. 5. Central Queensland University, Emerald.

Loch, A., Rolfe, J. and Windle, J. (2001). Using Focus Groups to Design Choice Modelling Valuation Frameworks for Floodplain Development, *Valuing Floodplain Development in the Fitzroy Basin*, Research report no. 3. Central Queensland University, Emerald.

Morrison, M. (2000). Aggregation biases in stated preference studies, *Australian Economic Papers* 39, 215–230.

Morrison, M.D. and Bennett, J.W. (2000). Choice modelling, non-use values and benefit transfer, *Economic Analysis and Policy* 30, 13–32.

Morrison, M.D., Blamey, R.K., Bennett, J.W. and Louviere, J.J. (1996). *Comparison of State Preference Techniques for Estimating Environmental Values*. Choice modelling research report no. 1. The University of New South Wales, Canberra.

Poe, G.L., Giraud, K.L. and Loomis, J.B. (2001). *Simple Computational Methods for Measuring the Differences of Empirical Distributions: Application to Internal and External Scope Tests in Contingent Valuation*, Staff paper 2001–2005. Department of Agricultural, Resource and Managerial Economics, Cornell University, Ithaca, NY.

Productivity Commission. (2003). *Industries, Land Use and Water Quality in the Great Barrier Reef Catchment*, Research report, Australian Government, Canberra.

QDNR (Queensland Department of Natural Resources). (1999). *Water Allocation and Management Plan (Fitzroy Basin) 1999 (WAMP)*. Queensland Department of Natural Resources, Brisbane.

QDNRM (Queensland Department of Natural Resources and Mines). (2003). *Water Allocation and Management (Fitzroy Basin) Amendment Plan 2003*. Queensland Department of Natural Resources and Mines, Brisbane.

Rolfe, J. and Bennett, J. (2003). WTP and WTA in relation to irrigation development in the Fitzroy Basin, Queensland, *Valuing Floodplain Development in the Fitzroy Basin*. Research report no. 7. Central Queensland University, Emerald.

Rolfe, J.C., Bennett, J.W. and Louviere, J.J. (2000). Choice modelling and its potential application to tropical rainforest preservation, *Ecological Economics* 35, 289–302.

Rolfe, J.C., Bennett, J.W. and Louviere, J.J. (2002a). Stated values and reminders of substitute goods: testing for framing effects with choice modelling, *Australian Journal of Agricultural and Resource Economics* 46, 1–20.

Rolfe, J., Loch, A. and Bennett, J. (2002b). Tests of benefit transfer across sites and population in the Fitzroy Basin. *Valuing Floodplain Development in the Fitzroy Basin*. Research report no. 4. Central Queensland University, Emerald.

Shogren, J. and Crocker, T. (1990). Adaptation and the option value of uncertain environmental resources, *Ecological Economics* 2, 301–310.

State of Queensland and Commonwealth of Australia. 2003, *Reef Water Quality Protection Plan for Catchments Adjacent to the Great Barrier Reef World Heritage Area*, Queensland Department of Premier and Cabinet, Brisbane.

Walsh, R.G., Loomis, J.B. and Gillman, R.A. (1984). Valuing option, existence and bequest demands for wilderness, *Land Economics* 60, 14–29.

Weisbrod, B. (1964). Collective consumption services of individual-consumption goods, *Quarterly Journal of Economics* 78, 471–477.

Windle, J. and Rolfe, J. (2002a). Assessing indigenous values associated with water resources and floodplain development, *Valuing Floodplain Development in the Fitzroy Basin*. Research reports no. 6, June 2002. Central Queensland University, Emerald.

Windle, J. and Rolfe, J. (2002b). *Natural Resource Management and the Protection of Aboriginal Cultural Heritage*. Institute for Sustainable Regional Development, occasional paper 5/2002. Central Queensland University, Rockhampton.

Windle, J. and Rolfe, J. (2003). Valuing Aboriginal cultural heritage sites in central Queensland, *Australian Archaeology* 56, 35–41.

Windle, J. and Rolfe, J. (2004). *Assessing Values for Estuary Protection Using Different Payment Mechanisms in the Choice Modelling Technique*. Paper presented at the Australian Agricultural and Resource Economics Society 48th Annual Conference, Melbourne, Australia, 11–13 February 2004.

Appendix

Choice Models developed from survey results

Full details and results have been reported for Survey One in Loch *et al.* (2002) and Rolfe *et al.* (2002). Survey Two details and results have been reported in Windle and Rolfe (2003, 2002b), and Survey Three results have been reported in Rolfe and Bennett (2003).

Table 11 MNL models for Fitzroy Basins for different populations in Survey One, 2000

	Emerald population		Rocky population		Brisbane Population	
Variables	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Cost	−0.0171***	0.0020	−0.0134***	0.0019	−0.0185***	0.0019
Vegetation	0.0330***	0.0066	0.0180***	0.0065	0.0451***	0.0065
Waterways	0.0012***	0.0002	0.0007***	0.0002	0.0007***	0.0002
People	−0.0047**	0.0018	−0.0038*	0.0020	−0.0052***	0.0019
Water Reserve	0.0379***	0.0130	0.0193	0.0125	0.0272**	0.0126
ASC	0.4352	0.3942	−0.0036	0.3916	0.9761**	0.3941
Age	0.0104	0.0085	0.0116	0.0074	−0.0071	0.0067
Occupation	−0.0034	0.2041	−0.2336	0.2103	−0.0200	0.2050
Education	−0.3773**	0.1903	0.4124**	0.2055	−0.6139***	0.2065
Income	−0.0000	0.0000	−0.0000**	0.0000	−0.0000	0.0000
Model statistics						
Number of choice sets	620		605		650	
Log Likelihood	−580.5984		−619.9409		−620.3609	
Adjusted rho-squared	0.14068		0.05951		0.12453	

***Significant at the 1 per cent level; **significant at the 5 per cent level; *significant at the 10 per cent level. ASC, alternate specific constant; MNL, multinomial logistic.

Table 12 MNL models for CNM, Dawson and Fitzroy Sites (Brisbane population) in Survey One, 2000

	CNM		Dawson		Fitzroy†	
Variables	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Cost	−0.0195***	0.0042	−0.0303***	0.0039	−0.0185***	0.0019
Vegetation	0.0451***	0.0087	0.0278***	0.0062	0.0451***	0.0065
Waterways	0.0028***	0.0005	0.0021***	0.0004	0.0007***	0.0002
People	−0.0124***	0.0034	−0.0039**	0.0019	−0.0052***	0.0019
Water reserve	0.1756***	0.0318	0.0667***	0.0104	0.0272**	0.0126
ASC	0.6198	0.4668	0.1648	0.4434	0.9761**	0.3941
Age	−0.0055	0.0072	−0.0021	0.0067	−0.0071	0.0067
Occupation	−0.5220**	0.2411	−0.0742	0.2303	−0.0200	0.2050
Education	−0.1656	0.2694	0.3356*	0.2011	−0.6139***	0.2065
Income	0.0000	0.0000	−0.0000**	0.0000	−0.0000	0.0000
Model statistics						
Number of choice sets	435		605		650	
Log likelihood	−389.4536		−572.7126		−620.3609	
Adjusted rho-squared	0.17559		0.13116		0.12453	

†These results are the same as for the Brisbane population in Table 11 above. ***Significant at the 1 per cent level; **significant at the 5 per cent level; *significant at the 10 per cent level. ASC, alternate specific constant; CNM, Comet/Nogoa/Mackenzie; MNL, multinomial logistic.

Table 13 MNL models for the Indigenous and general communities in Survey Two, 2001

	Rocky Indigenous community		Rockhampton general community		Brisbane general community	
Variables	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Cost	−0.0093***	0.0021	−0.0126***	0.0018	−0.0125***	0.0023
Vegetation	0.0036	0.0064	0.0270***	0.0056	0.0304***	0.0073
Waterways	0.0005*	0.0003	0.0006**	0.0002	0.0007**	0.0003
Cultural Heritage	0.0300***	0.0066	−0.0252***	0.0055	−0.0159**	0.0071
Water Reserve	0.0337***	0.0066	0.0361***	0.0055	0.0384***	0.0073
ASC	−0.3525	0.4317	0.0357	0.3425	−1.2773***	0.4939
Age	−0.0268***	0.0086	−0.0095*	0.0057	0.0124*	0.0074
Education	−0.0489	0.2460	0.3509*	0. 1849	0.5020**	0.2441
Income	0.0000***	0.0000	0.0000***	0.0000	0.0000***	0.0000
Model Statistics						
N (choice sets)	488		704		408	
Log L	−478.8394		−681.3383		−394.3468	
Adjusted rho-squared	0.09853		0.11339		0.11041	

***Significant at the 1 per cent level; **significant at the 5 per cent level; *significant at the 10 per cent level. ASC, alternate specific constant; MNL, multinomial.

Table 14 MNL models for Brisbane community in Survey Three, 2002

	Coefficient	Standard error
Cost	−0.0172***	0.0021
Vegetation	0.0493***	0.0156
Waterways	0.0010**	0.0004
People leaving	−0.0152**	0.0074
Water reserve	0.0980***	0.0198
ASC constant	−2.7110***	0.4360
Age	0.0137**	0.0059
Education	0.7092***	0.1653
Income	0.0000***	0.0000
Model statistics		
N (choice sets)	784	
Log L	−723.4250	
Adjusted rho-squared	0.15524	

***Significant at the 1 per cent level; **significant at the 5 per cent level; *significant at the 10 per cent level. ASC, alternate specific constant; MNL, multinomial logistic.