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**OPTION VALUES FOR RESERVE  
WATER IN THE FITZROY BASIN**

**RESEARCH REPORT No. 8**

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**VALUING FLOODPLAIN DEVELOPMENT IN THE  
FITZROY BASIN RESEARCH REPORTS**

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## **Abstract**

Many of the environmental values associated with water resource development may be classified as non-use values, meaning that people have values for an asset without necessarily using it. Option values are an important component of non-use values when development options for environmental assets are considered. This is because development effects are often irreversible. Non-use values are normally assessed as a package because it is difficult to separate and estimate values independently. However, the development of the Choice Modelling (CM) technique, with its ability to decompose values into component attributes, provides the potential for option values to be assessed as a separate component.

In this report, one approach to assessing option values is reported in relation to water allocations in the Fitzroy river basin in Central Queensland. A series of CM experiments have been run which assessed people's preferences for further development of water resources in the Fitzroy basin when environmental and social impacts were considered. The alternatives presented to survey respondents also included an attribute designed to capture option values. The option values were described as the opportunity to keep water in reserve for future environmental protection or development options, in case the current estimates about future impacts turned out to be incorrect.

Results for nine CM experiments conducted over a three year period have been reported. The results from eight of those experiments generated positive values for the reserve attribute, suggesting that option values have been successfully estimated. No significant difference could be identified between any of the values that were estimated, suggesting that the values were stable and not particularly sensitive to population or site differences.

The option values have been extrapolated to the case studies within the basin to assess whether unallocated water should be held in reserve. In one catchment with relatively small amounts of unallocated water, values for reserving the water outweigh the potential economic gains of use, but in other catchments the option values and use values are more evenly balanced. However, a number of caveats need to be recognized which may have contributed to option values being overestimated.

## 1. Introduction

The water reform process in Queensland has been in progress for several years following the 1994 Council of Australian Governments (COAG) agreement on a national agenda for water reform. A key legislative component of the reform process in Queensland was the *Water Act 2000*, which provides for Water Resource Plans (WRP) and Resource Operations Plans (ROP). WRPs provide the strategic framework for water allocation and management in the major river systems. Once allocations for environmental purposes and existing allocations for irrigation and other uses are confirmed, any unallocated water in a river system can be identified. The question of what to do with this unallocated water (if it is available in a river system) then needs to be addressed.

All or part of this unallocated water could be allocated for development with subsequent economic benefits. However, there are also likely to be benefits associated with keeping the water in reserve. This is because there may be environmental benefits associated with smaller proportions of water being allocated for human usage. People may hold some preservation values for maintaining a greater proportion of natural systems in their original condition. In a similar way, Indigenous people may hold particular values for maintaining water resources in their natural condition.

Economists typically address these questions by assessing the net benefits from a development option compared to the net benefits of 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.

The economic assessment of the benefits of a preservation option might involve the assessment of community preferences for environmental assets being maintained in good condition. These are non-use values that are not reflected in ordinary, commercial market transactions, and hence specialist techniques are used to assist in valuation. There are various non-market valuation techniques available to assess the non-use values associated with protecting environmental assets. The use of Choice Modelling (CM) has become more widespread in recent years because of the advantages it has over other non-market valuation techniques (Morrison *et al.* 1996, Adamowicz *et al.* 1998, Hanley *et al.* 1998, Rolfe *et al.* 2000). In particular, it has the advantage of distinguishing between the various attributes of the particular good being valued. For example, Rolfe *et al.* (2000) demonstrate how the preservation values of tropical rainforests are associated with a number of factors such as rarity and location.

The economic assessment of development and preservation options is often simplistic because of the difficulties in predicting future events with certainty. For development options, the use of sensitivity analysis within a cost-benefit analysis framework helps to address uncertainties about a number of factors such as future profit levels, future discount rates and so on. With protection options, uncertainty about future outcomes can be even higher because of complex natural processes and low levels of current scientific knowledge. However, these issues are usually ignored in the application of valuation techniques such as Choice Modelling, where survey respondents might be presented with the expected condition of environmental assets at some future point without information about the uncertainty associated with such predictions.

While there are good logistical and framing reasons why respondents to a non-market valuation exercise might be presented with simplistic representations of environmental conditions and trends, levels of risk and uncertainty associated with the protection of environmental resources may be directly associated with environmental values. This association between uncertainty

factors and value formation can be evidenced by many of the debates over protecting environmental assets.

In the case of water resources, high levels of uncertainty about resource conditions, long term trends in environmental resilience, and the interrelationships between various ecological functions all contribute to people being more cautious about the possibilities of environmental losses. The calls for a precautionary approach to many development issues involving environmental losses reflects community concerns about the risks of development when the outcomes are not known clearly in advance.

Concerns about adverse and unforeseen impacts on environmental resources lead people to placing more importance on protecting environmental assets in their current situation. In political or legal settings, these concerns have been represented in the debates for precautionary approaches or safe minimum standards to be adopted. In non-market valuation applications, it would be expected that such concerns would lead people to have values for keeping the option open for environmental protection or economic development. Underlying concerns about risk and uncertainty are thus expressed in preferences used in economic analysis as well as by calls for specialist decision rules such as the safe minimum standard (Rolfe 1995).

These issues are very relevant to the Fitzroy basin, where the key arguments for not allocating all water to development purposes above some minimum environmental requirements relate mostly to issues of risk and uncertainty. Keeping more water in reserve does mean that there will be less development, and resulting opportunity costs have to be weighed up against the values for marginal improvements in stream health, vegetation retention and other environmental factors. In many cases, the evidence is that the benefits of increased production will outweigh slight marginal losses in the condition of environmental assets.

The key argument against the full allocation of water resources for productive purposes is that there may be unforeseen ecological or other risks associated with this allocation. The Murray-Darling basin provides many examples of where high levels of water allocation in the past were associated with subsequent environmental losses that were not foreseen. In the Fitzroy basin, one key area of concern is about the levels of scientific knowledge about environmental processes and whether the modeling of ecological requirements of water resources is fully accurate. Another issue of concern is about the future impacts on the Great Barrier Reef system and the coastal zone.

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. In this report, one approach to dealing with this issue is outlined. This has been to label one of the attributes used in CM experiments 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 modeled.

The report is organised as follows. An overview of water reserves in the Fitzroy basin in the next section is followed by a definition of option value and quasi-option value in section three. A description of the application of the CM experiments follows in section four, and results are discussed in section five. Some extrapolation to cost-benefit analysis studies are presented in section six, and conclusions are presented in the final section.

## **2. Water Reserves in the Fitzroy Basin**

The Water Resource Plan for the Fitzroy basin is the Water Allocation and Management Plan (Fitzroy Basin) 1999 (WAMP) which was approved by the government in 1999. This 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.

Allocations for environmental purposes were generally set at 50% 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 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 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:

- Up to 300,000 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 Comet/Nogoa/Mackenzie River system, and
- 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 Comet/Nogoa/Mackenzie (CNM) River system, as this region supports profitable cotton and horticulture industries that rely on irrigation supplies. The Fitzroy WRP did not include overland flows, and substantial development occurred to capture these after a moratorium was placed on allocating river pumping allocations when the WAMP was being implemented. In 2002 an additional moratorium was placed on the capture of overland flows as well. When overland flows are taken into consideration it is unlikely there will be any water reserve remaining in the CNM system.

The economic benefits of using the water reserve can be assessed in terms of the price farmers are willing to pay for additional water. The economic benefits of keeping water in reserve are harder to evaluate and require some knowledge about the values people place on preserving the water reserve. Such values need to include the possibility of using the reserve at some time in the future, and the uncertainty associated with the impacts of using water for development now, or of preserving it for some future use.

### **3. Option and Quasi-Option Values for the Water Reserve**

The utility that people derive from environmental goods, such as water resources, relates to the benefits that those goods provide. Some benefits are directly used by people. For example, water can be used for irrigation purposes, and can be directly priced through market mechanisms. Some direct use benefits, such as recreational uses of water resources, have public good characteristics and therefore more complex provision and pricing characteristics. These may be termed as non-consumptive use values. There are other benefits, such as water filtering services, that are termed indirect use benefits.

There are also a range of benefits that do not rely on direct use for their existence. These are generally referred to as non-use or passive use values. They include option value, quasi-option value and existence values. Existence values refer to the benefits that an individual may receive from simply knowing that something, such as a species exists, even if they never visit or see it.

Option value refers to the values that people might hold for avoiding irreversible decisions and maintaining future options (Weisbrod 1964, Bishop 1982). Preserving the environment is usually associated with option values, as the choice between development and preservation remains open. In contrast, development decisions are usually not associated with option values, because environmental losses are normally non-reversible. Quasi-option values refer to the value that people have for improving the knowledge about particular tradeoffs 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.

In relation to the Fitzroy, there is some potential value associated with holding water in reserve until more certainty exists about ecological thresholds and the accuracy of current biometric modeling relied on in the WAMP assessment. Similar arguments can be made for maintaining water flows into the Great Barrier Reef system until better knowledge is available about the resilience of that system to changed flow patterns. Once better knowledge is available, water may then be allocated for development or the environment.

It is possible that people have high option values for maintaining ecological processes associated with the Fitzroy basin, and will be reluctant to endorse maximum development options while uncertainty exists about future ecological impacts. Those option values might translate to values for water being held in reserve rather than being allocated for development immediately (even if the water may ultimately be used for development).

If people hold quasi-option values, this implies that they will value research or other activities that will improve the knowledge set for making decisions. That information may support either development or preservation options.

### **4. The 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 experiments have been reported in a series of research reports, notably Rolfe *et al.* (2002b), Loch, *et al.* (2002), Windle and Rolfe (2002a) and 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.



CM involves asking survey respondents to make a series of choices about 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 (eg 30%, 40% or 50% 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 logistic 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 socio-economic 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 collected (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 this report presented respondents with four choice attributes and an associated cost attribute. Four attributes were common to each survey:

- Payment levy (a one off environmental levy collected through rate payments)
- Amount of healthy vegetation left in floodplains (% of original)
- Kilometres of waterways in good health (kms)
- Amount of unallocated water in reserve (% above the WAMP 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”. Survey One details and results have been reported in Loch *et al.* (2002) and Rolfe *et al.* (2002b). Survey Two details and results have been reported in Windle and Rolfe (2002b, 2003), and Survey Three results have been reported in Rolfe and Bennett (2003). An example of the choice set presented to respondents in Survey Two is presented in Figure 1.

**Figure 1. Example Choice Set used in Survey Two**

<b>X</b>	<b>Question X: Options A, B and C.</b> Please choose the option you prefer most by ticking ONE box.					
<b>How much I pay each year</b> 	<b>Fifteen-year effects</b> <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <b>Healthy vegetation left in floodplains</b>   </div> <div style="text-align: center;"> <b>Kilometres of waterways in good health</b>   </div> <div style="text-align: center;"> <b>Protection of Aboriginal Cultural sites</b>   </div> <div style="text-align: center;"> <b>Unallocated water</b>   </div> </div>				<b>I would choose</b> 	
<b>Option A</b>						
<b>\$0</b>	20%	1500	25%	0%	<input type="checkbox"/>	
<b>Option B</b>						
<b>\$20</b>	30%	1800	35%	5%	<input type="checkbox"/>	
<b>Option C</b>						
<b>\$50</b>	40%	2100	45%	10%	<input type="checkbox"/>	

The design of a CM study involves a number of 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. One relevant issue for this study was the possibility that the *Amount of water in reserve* attribute was a causal (prior) attribute for the other environmental attributes. If this was the case, respondents rate this attribute more highly because they perceive that they will get a range of other associated benefits. If the perceptions are spurious, the results from a CM exercise may be misleading.

The challenges in defining the *Amount of water in reserve* attribute were firstly to associate it with option values, and secondly to ensure that it would not be perceived as a causal attribute for other environmental attributes. To a large extent, meeting the first criteria would ensure success in the second, because it would define water use for downstream and different purposes to the other environmental attributes used (*Health of the waterways* and *Amount of vegetation in floodplains*).

The water reserve attribute was described in first CM study as follows:

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

In the second CM study the last statement was modified and three new statements were added to include issues of relevance to the Indigenous community. The relevant description was as follows:

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% 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

In the third CM study, a briefer description was used, as follows:

Currently, Fitzroy River Basin water is either allocated to environmental flows (50%), or to irrigators and other users (35%). The remaining water (15%) 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 flows in the future is greatly reduced.

In the second and third surveys, ranking questions were used to help frame some of the underlying issues for option values to respondents. For example, in the third survey, the relevant framing question on reserve values was as follows.

**4b. Below is a list of reasons for keeping water in reserve. Indicate how you feel about them by ranking them from most (1) to least (4) important**

- ☐ Unknown impacts on ecosystems and environment of taking too much water from river systems
- ☐ Possible downstream effects on coastal estuaries and the Great Barrier Reef
- ☐ Reserving water for future development
- ☐ Guaranteeing entitlements of current irrigators

#### **4.1 Survey Logistics and Results**

Survey One was conducted in late 2000 and populations were sampled from Brisbane (urban centre) Rockhampton (regional centre) and Emerald (regional town). The survey was split into three versions that focused on:

- the whole Fitzroy basin
- the Dawson river sub-catchment
- the Comet-Nogoa-Mackenzie sub-catchment

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. Survey Three was conducted in mid-2002, and only the Brisbane population was sampled. When all the split-samples are counted separately, a total of nine CM surveys can be modeled. To facilitate comparisons, standard multinomial logistic models have been estimated for each data set. The variables used are defined in the table below.

**Table 1. Variables Used in the CM Applications**

Cost	Amount that households would pay in extra rates (or rent) each year to fund improvements
Vegetation	% of healthy vegetation in floodplains remaining
Waterways	Number of kilometres of waterways in catchment remaining in good health
People Leaving (Survey 1,3)	Number of people leaving country areas each year
Cultural Heritage (Survey 2)	% of Aboriginal cultural sites protected
Water Reserve/ Unallocated water	% 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
Age	Age of respondent (in years)
Occupation	Occupation (various categories)
Education	Education (ranges from primary only to tertiary degree)
Income	Income of household in dollar terms

Attention in this report 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 2.

**Table 2. Cost (Payment) and Water Reserve Attribute Levels**

Attribute	CNM sub catchment		Dawson sub catchment		Fitzroy Basin	
	Base Levels	Choice set Levels	Base Levels	Choice set Levels	Base Levels	Choice set Levels
<b>Survey One</b>						
Payment (\$)	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
<b>Survey Two</b>						
Payment (\$)					0	10, 20, 50, 100
Water Reserve (%)					0	-15, -10, -5, 0, 5, 10, 15, 20*
<b>Survey Three</b>						
Payment (\$)					0	20, 50, 100
Water Reserve (%)					0	4, 8, 12

\* The value of 20% is 5% higher than the current estimated reserve level. In all other cases the highest reserve level represented the full amount of unallocated water in reserve.

The survey responses were analysed by fitting a multinomial logistic regression model to the data sets. Full details of the models generated are presented in Appendix 1. Once the models had been generated it was possible to estimate the marginal values that the different populations held for marginal changes in the amounts of water reserve. These values (known as part-worths) are estimated by taking the ratio of the water reserve and cost coefficients, and are directly comparable between models. Confidence intervals were estimated with the Krinsky-Robb procedure. The results are presented in Table 3.

**Table 3. Marginal Values for the Water Reserve Attribute**

	Population	Fitzroy	CNM	Dawson
<b>Survey One</b>	Brisbane	Not significant	6.59 (3.49 to 11.08)*	2.53 (1.72 to 3.62)
	Rockhampton	2.81 (0.06 to 5.97)		
	Emerald	1.97 (-0.16 to 3.99)		
<b>Survey Two</b>	Brisbane	4.13 (2.33 to 6.60)		
	Rockhampton	3.19 (1.82 to 5.11)		
	Rockhampton Indigenous	4.05 (1.85 to 8.19)		
<b>Survey Three</b>	Brisbane	5.31 (3.33 to 7.71)		

\* the values in parenthesis are confidence intervals.

## 5. 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:

Ho:  $\beta \text{ Reserve} = 0$

H1:  $\beta \text{ Reserve} \neq 0$

where  $\beta \text{ Reserve}$  is the parameter vector corresponding to the *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 Brisbane 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. It is notable that even though a range of populations were surveyed and the three surveys were conducted a year apart, there does not appear to be any significant difference (confidence intervals all overlap) between the different samples. Values appear to be relatively stable across populations, sites and time. These results indicate that there

the null hypothesis can be rejected, and that the evidence suggests that the populations of interest do hold option values in relation to Fitzroy water resources.

Further support for this result comes from the analysis of results to the framing questions in Survey Three. The results, shown in the table below, indicate that 75% of respondents thought that avoiding potential impacts on the Great Barrier Reef or unknown impacts on ecosystems were the most important reasons for keeping water in reserve.

**Table 4. Ranking of Reasons Why Keeping Water in Reserve is Important.**

Reason	Average rating	% ranking first
Unknown impacts on ecosystems and environment of taking too much water from river systems	2.12	31.6
Possible downstream effects on the Great Barrier Reef	1.79	44.7
Reserving water for future development	2.55	16.7
Guaranteeing entitlements of current irrigators	3.5	7

The model results also raise some questions about why slightly different results have been reached between the surveys. The first issue of note is why in the first survey the Reserve attribute in the Fitzroy basin was not significant for Brisbane respondents, when the attribute was significant in the two sub-catchments. One possible explanation is that respondents have indicated the marginal values of the reserve involved. Because there are large amounts of unallocated water across the Fitzroy system, the marginal value of keeping each 1% back was not significant. In the smaller catchments, where reserves are much lower, the marginal values of keeping some back were significant.

The results in Table 3 suggest that Brisbane respondents are prepared to pay \$6.59 for each 1% 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 WAMP) equated to about 4% of the system. Thus Brisbane households, on average, would pay about 4 times the amount above, or \$26.36 per annum, to preserve the entire 40,000 ML. For the Dawson system, respondents were willing to pay \$2.53 to preserve each 1% of Water Reserve. The total reserves in the Dawson were nominated as being 10% of water resources in the valley. This means that the value of preserving all of that reserve was \$25.3 per household per year. Total willingness to pay was approximately equivalent across the two catchments, but the smaller reserves of water in the CNM valley imply that WTP is higher to keep that water in reserve. As expected, marginal values appear to be higher as reserves become diminished. The results lend support to the argument that if reserves are very substantial then marginal values will be low and possibly insignificant.

The second issue of note is why in the first survey the Reserve attribute in the Fitzroy survey was not significant for Brisbane respondents, while in the third (and very similar) survey the attribute was highly significant. One possibility is that the attribute was better defined in the third survey, particularly by the use of the framing question. Another possibility is that there were subtle differences in the sampling of the population or survey conduct which caused the differences. A third possibility is that superior presentation of the third survey (in a professionally designed booklet) encouraged respondents to take the survey more seriously with subsequent impact on results.

### 5.1 The Relationship Between Reserve Levels and Choice

In Survey Two, the experimental design used allows some further analysis of the models to take place. Respondents in this survey were presented with eight different levels of Reserve, which included three negative levels and four positive levels (Table 2). The negative levels imply that water could be allocated for irrigation and other uses below the thresholds currently allocated for environmental purposes.

This level of detail allowed two different tests to be conducted. First, the Reserve attribute was split into two variables, one for the negative range and one for the positive range. The purpose of the split was to test if there was a significant difference in model coefficients for the split attribute. The expectation was that there would be higher values for the negative Reserve range, indicating that people would have greater losses associated with reserves being taken from the environmental allocation.

**Table 5. Multinomial Logit Models for Brisbane and Rockhampton General Populations<sup>1</sup>**

Variable	Model with +ve and -ve <i>Water Reserve</i> levels		Model with separated <i>Water Reserve</i> levels	
	Coefficient	Std. Error	Coefficient	Std. Error
Cost	-0.0115***	0.0013	-0.0110***	0.0013
Vegetation	0.0255***	0.0039	0.0248***	0.0039
Waterways	0.0005***	0.0002	0.0005***	0.0002
Cultural Heritage	-0.0191***	0.0041	-0.0186***	0.0042
Water Reserve - positive	<b>0.0414***</b>	<b>0.0091</b>		
<b>Water Reserve - negative</b>	<b>0.0459***</b>	<b>0.0140</b>		
<b>W Reserve negative 15%</b>			<b>-0.5469**</b>	<b>0.2394</b>
<b>W Reserve negative 10%</b>			<b>-0.6994***</b>	<b>0.2359</b>
<b>W Reserve negative 5%</b>			<b>-0.0142</b>	<b>0.2093</b>
<b>W Reserve positive 5%</b>			<b>0.2084</b>	<b>0.2199</b>
<b>W Reserve positive 10%</b>			<b>0.4569**</b>	<b>0.1970</b>
<b>W Reserve positive 15%</b>			<b>0.6437***</b>	<b>0.2051</b>
<b>W Reserve positive 20%</b>			<b>0.7975***</b>	<b>0.2056</b>
ASC	0.2090	0.1479	-0.0286	0.1239
Misunderstood	0.4067*	0.2244		
Income	-0.68 E-05***			
<b>Model statistics</b>				
No of Choice Sets	1232		1232	
Log Likelihood	-1213.16		-1237.77	
Adjusted R squared	0.0885		0.081	

\*\*\* = significant at 1% level, \*\* = significant at 5% level, \* = significant at 10% level.

Model results are presented in Table 5. Both the positive and negative values were significant, with values being slightly higher for the negative ranges (higher coefficient). However, there is no significant difference between the coefficients, indicating that the marginal values of increases in

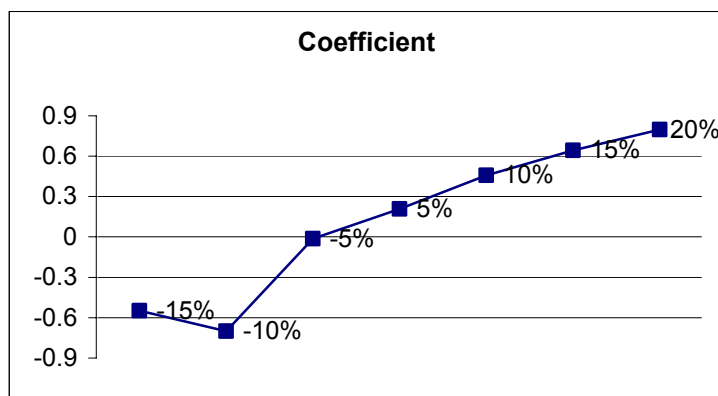
<sup>1</sup> Values held by the Rockhampton Aboriginal community for positive and negative values could not be determined as there were insufficient survey responses to run a model.



Reserve are similar across both the negative and positive ranges. Two other variables were significant in this model. *Income* was significant with a negative coefficient indicating that people with a higher income were more likely to support the status quo option (Reserve value of zero). The positive coefficient for the *Misunderstood* variable indicates that respondents who felt they did not completely understand the information in the survey were more likely to choose the status quo option.

In the second test, each level of the Reserve attribute was coded separately, and a different model estimated. The results (Table 5) indicate that Water Reserve values close to zero were not significant, but higher levels were significant. The negative coefficient for larger negative values signify that respondents reacted negatively to these losses in Water Reserve and were less likely to select them. On the other hand, there was a positive response to higher Water Reserve levels and these were more likely to be selected. Generally, it appeared that values for the Water Reserve increased as the amount of water increased (Figure 2). While there may be some slight fall in marginal values as values increased (represented by a curve in the plotted relationship), the trend is very slight. These results suggest that the marginal values are not very sensitive to the quantities of Reserve on offer.

**Figure 2. Coefficient Values for Separate Water Reserve Levels**



Significant values were held for a 20% water reserve level, which would represent a “clawback” of currently allocated water in some catchments.

## 6. Discussion - Should Water Be Reserved Rather Than Allocated?

Now that values that people hold for keeping water in reserve have 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?

### 6.1 Values in the CNM System

Brisbane households, on average, would pay about \$26.36 per annum, to preserve the entire 40,000 ML. This payment stream can be converted to present value terms, and multiplied by the number of households in Brisbane (approx 300,000) to arrive at a total value. At an 8% discount rate, this payment stream grosses up to about \$77.64 Million in current value. At a 12% discount

rate, the payment stream grosses up to about \$59.07 Million. When the rest of Queensland households are counted in, these values for reserving the water in the CNM system would approximately double.

These preservation values can be compared to the production benefits that allocating the water might generate. The production benefits can be conveniently thought of as being captured in the prices that irrigators might pay for the water, as this usually represents the discounted stream of future profits from using the resource. Most of the additional allocations in the basin will come from irrigators directly harvesting or capturing water supplies, rather than allocations from established infrastructure. Water that is taken by irrigators in the form of overland flows or river harvesting has lower values than water in regulated systems because the irrigators have to meet all the infrastructure and supply costs. If the whole 40,000 ML's were to be valued at approximately \$300/ML<sup>2</sup>, the net present value of the production benefits can be calculated at approximately \$12 Million.

It appears that, on the preliminary figures at least, the preservation values outweigh the potential production benefits from allocating more water in the CNM system. There may be particular situations where further allocations of water has 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 megalitres 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.

## **6.2 Values in the Dawson System**

Survey respondents indicated that their households were willing to pay \$2.53 to preserve each 1% of Reserve in the Dawson system. The lower part-worth values for the Water Reserve in the Dawson system probably reflect the larger amounts of water that are potentially available for irrigation in the valley. There is effectively a larger gap between the 50% 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% loss in Reserve is lower.

The total reserves in the Dawson were nominated as being 10% of water resources in the valley. This means that the value of preserving all of that reserve was \$25.3 per household per year. At an 8% discount rate over 20 years, and across 300,000 households, this translates into a present value of \$74.52 million. At a 12% discount rate, the present value would be \$56.69 million. When the rest of Queensland households are counted in, these values for reserving the water in the CNM system would approximately double.

Under the Fitzroy WAMP, 190,000 megalitres of water supply is reserved for the Nathan Dam, and a further 11,500 megalitres of supply remains to be allocated in the Upper Dawson region. The 201,500 megalitres of annual supply could be expected to have a market value of between \$1,000 and \$1,500 per megalitre if supplied as regulated water to irrigators (Rolfe 1998). If a nominal value of \$300/ML is used to identify the value of the water supplies instream (taking the

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<sup>2</sup> This is an arbitrary value, as information about market prices for non-regulated water is not available. The value of medium security water supplied from regulated systems is approximately \$1,100 - \$1,500 / ML.

costs of infrastructure into account), the total value of irrigation is approximately \$60 million. These preliminary values suggest that the values of reserving water in the Dawson are higher than the potential production benefits of allocating it to irrigation.

### **6.3     *Values in the Whole Fitzroy System***

In Survey Three, respondents in Brisbane indicated that their households were willing to pay \$5.31 to preserve each 1% of Reserve in the whole Fitzroy system. The total reserves in the Fitzroy were nominated as being 15% of water resources in the basin. This means that the value of preserving all of that reserve was \$79.65 per household per year. At an 8% discount rate over 20 years and across 300,000 households, this translates into a present value of \$235 million. At a 12% discount rate, the present value would be \$178 million. When the rest of Queensland households are counted in, these values for reserving the water in the Fitzroy system would approximately double.

Under the Fitzroy WAMP, a total of 544,800 megalitres of annual supply is identified. At a net economic value of \$300/ML, the economic value of additional water use is approximately \$166 million. These preliminary values suggest that the values of reserving water in the Dawson are higher than the potential production benefits of allocating it to irrigation.

### **6.4     *Issues in Extrapolating the Options Values***

There are four 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 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 follows the same logic. If the values that have been generated reflect the option values for preserving the environmental assets rather than specific values for preserving water in reserve, other offset actions that maintain environmental options may be potentially substituted for holding water in reserve. For example, improvements by land managers over impacts on water quality may offset (for option value purposes) increased allocations of water currently in reserve.

The third reason is that option values are likely to be sensitive to the marginal amounts of water held in reserve. Economists would expect that as water became more committed to productive uses, the marginal value of holding some water in reserve would increase. By inference, the marginal option values that exist when the stock of unallocated water is large could be expected to be much lower. Because the option values that have been estimated are effectively averaged across the range of quantities, it is likely to overstate the values of holding large quantities of water in reserve (and understate the values of reserving the final quantities of available water).

The fourth reason why some caution needs to be exercised in interpreting the option values for the Reserve attribute is that respondents may not have fully understood the distinction between water already committed to the environment (approximately 50% of median flow amounts), and the surplus unallocated water. If respondents interpreted the 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 recognized.

When these caveats are considered, it appears possible that the production benefits of further water allocations in the Fitzroy and Dawson systems may outweigh the values for keeping water in reserve. However, it is less likely that values for keeping water in reserve in the Comet-Nogoa-MacKenzie basin are lower than the production opportunities. This is in line with the expectation that as reserve levels are reduced, the marginal values for keeping water in reserve increases.

## **7. Conclusion**

Uncertainty about future environmental outcomes and the irreversibility of development decisions can impact on the values that people hold for preservation options. A component of non-use values termed option value can be used to estimate these influences, although it is rarely measured separately. The development of the Choice Modelling (CM) technique, with its ability to decompose values into component attributes, provides the potential for option values to be assessed directly within a valuation exercise.

In this report, a series of CM experiments have been reported where one of the attributes used to describe the environmental and social impacts of water resource development was specifically framed to capture option values. The attribute was described as the amount of unallocated water held in reserve in the Fitzroy basin after existing allocations (35%) and reserves for the environment (50%) were considered. If respondents to a CM survey wanted to hold water back for future development or environmental purposes when better information was available, they could indicate this through the choice alternatives available.

Results for nine CM experiments conducted over a three year period have been reported. The results from eight of those experiments generated positive values for the reserve attribute, suggesting that option values have been successfully estimated. No significant difference could be identified between any of the values that were estimated, suggesting that the values were stable and not particularly sensitive to population or site differences.

The option values have been extrapolated to the case studies within the basin to assess whether unallocated water should be held in reserve. In one catchment with relatively small amounts of unallocated water, values for reserving the water outweigh the potential economic gains of use, but in other catchments the option values and use values are more evenly balanced. However, a number of caveats need to be recognized which may have contributed to option values being overestimated.

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## Appendix 1. Choice Models Developed from Survey Results

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

**Table 6. Multinomial Logit Models for Different Populations in Survey One**

Variables	Emerald Population		Rocky Population		Brisbane Population	
	Coeff.	St. Error	Coeff.	St. Error	Coeff.	St. Error
Cost	-0.018***	0.002	-0.012***	0.002	-0.0203***	0.0021
Vegetation	0.031***	0.008	0.025***	0.008	0.0354***	0.0080
Waterways	0.001***	0.000	0.001***	0.000	0.0005**	0.0002
People	-0.005***	0.002	-0.003	0.002	-0.0060***	0.0019
<b>Reserve</b>	<b>0.035**</b>	<b>0.017</b>	<b>0.035**</b>	<b>0.016</b>	<b>0.0094</b>	<b>0.0163</b>
ASC	0.944	0.659	0.910	0.690	-1.3674	0.5969
Age	-0.027***	0.010	-0.028***	0.009	-0.0053	0.0112
Occupation	-0.023	0.075	-0.075	0.074	0.1283	0.0812
Education	-0.022	0.085	-0.175*	0.088	0.3153***	0.0884
Income	0.0001	0.0001	0.0001**	0.0001	0.0001***	0.0001
<b>Model Statistics</b>						
Number of Choice Sets		630		605		650
Log Likelihood		-579.29		-611.70		-601.27
Adjusted rho-square		.13911		.06813		.14818
Chi-square (D. of Freedom = 15)		144.09		102.26		193.68

\*\*\* - P<0.001 \*\* - P<0.01 \* - P<0.10

**Table 7. MNL Models for CNM, Dawson and Fitzroy Sites (Bris. pop.), Survey One.**

Variables	Comet/Nogoa/Mackenzie		Dawson		Fitzroy	
	Coeff.	St. Error	Coeff.	St. Error	Coeff.	S.Error
Cost	-0.023***	0.004	-0.029***	0.004	-0.020***	0.0021
Vegetation	0.032***	0.010	0.037***	0.009	0.035***	0.0080
Waterways	0.002***	0.0006	0.002***	0.0005	0.001**	0.0002
People	-0.015***	0.004	-0.004*	0.002	-0.006***	0.0019
<b>Water Reserve</b>	<b>0.153***</b>	<b>0.032</b>	<b>0.074***</b>	<b>0.012</b>	<b>0.009</b>	<b>0.0163</b>
ASC	-1.139	0.761	0.341	0.752	-1.367	0.5969
Age	0.007	0.009	-0.013	0.008	-0.005	0.0112
Occupation	-0.035	0.106	0.071	0.101	0.128	0.0812
Education	0.286**	0.119	-0.343***	0.106	0.315***	0.0884
Income	0.000**	0.000	0.000***	0.000	0.000***	0.000
<b>Model Statistics</b>						
Number of Choice Sets		435		605		650
Log Likelihood		-377.02		-548.39		-601.27
Adjusted rho-square		.19724		.16547		.14818
Chi-square (D.of Freedom = 15)		129.88		195.22		193.68

\*\*\* - P<0.001 \*\* - P<0.01 \* - P<0.10

**Table 8. Multinomial Logit Models for the Indigenous and General Communities (Survey Two)**

Variable	Rocky Indigenous Community		Rockhampton General Community		Brisbane General Community	
	Coefficient	S. Error	Coefficient	S. Error	Coefficient	S. Error
Variables						
ASC	0.5197	0.5452	0.3781	0.4956	0.1415	0.6195
Cost	-0.0084				-0.0126	
	***	0.0019	-0.0118 ***	0.0017	***	0.0022
Vegetation	-0.0009	0.0059	0.0281 ***	0.0050	0.0269 ***	0.0064
Waterways	0.0005 **	0.0002	0.0006 ***	0.0002	0.0006 *	0.0003
Cultural Heritage	0.0295 ***	0.0061	-0.0223 ***	0.0051	-0.0142 **	0.0065
<b>Water Reserve</b>	0.0341 ***	0.0088	0.0376 ***	0.0076	0.0520 ***	0.0104
Age	0.0128	0.0097	0.0076	0.0066	0.0004	0.0076
Education	-0.0542	0.0887	-0.1097	0.0769	-0.0198	0.0966
Income	0.0000 ***	0.0000	0.0000 **	0.0000	0.0000	0.0000
Model Statistics						
N (Choice Sets)	496		768		464	
Log L	-470.48		-639.08		-436.68	
Adj. rho-square	.068		.208		.209	
Chi-square (DoF=18)	267.30		356.29		198.79	

\*\*\* Significant at the 1% level, \*\* Significant at the 5% level, \* Significant at the 10% level.

**Table 9. Multinomial Logit Models for Brisbane community (Survey Three)**

	Coefficient	Standard.Error
Rates	-0.016***	0.002
Vegetation	0.054***	0.015
Waterways	0.001**	0.000
People leaving	-0.013*	0.007
Reserve	0.101***	0.019
Constant	-3.330***	0.548
Age	0.011*	0.006
Education	0.218***	0.071
Income	0.000***	0.000
Model Statistics		
N (Choice Sets)	864	
Log L	-813.12	
Adj. rho-square	0.26314	
Chi-square (DoF=23)	469.42	

\*\*\* = significant at 1% level, \*\* = significant at 5% level, \* = significant at 10% level.



## Other Research Reports in this Series

Rolfe, J. 2000, *Valuing Floodplain Development in the Fitzroy Basin – Project Overview*, Valuing Floodplain Development in the Fitzroy Basin Research Reports, No. 1, September 2000, CQU.

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