Commercial-in-Confidence

Pricing for Water Conservation in the Non-Residential Urban Sector

Prepared for the
Steering Committee of the Smart Water Fund

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Economics Policy Strategy

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Executive summary

Non-residential potable water in Melbourne is currently based on a combination of a low connection fee and a constant volume charge per kL of water used. These arrangements apply across the 3 supply utilities and have applied in this form for several years. While they do post *some* incentives to manage usage – because the usage charges are technically avoidable – there are a number of issues which are likely to become increasingly important:

- The strength of any such incentives may be diluted if price is significantly below long run marginal cost (given the dynamic nature of LRMC and the periodic nature of the price setting process). For example, recent estimates have increased the perceived level of LRMC in Melbourne;
- The potential for marginal cost to move above average cost (as currently regulated), which raises the question of how best to avoid revenue over-recovery; and
- Inflexibility in the pricing arrangements to set prices for conservation objectives and to manage the balance between price and level of conservation.

This study has drawn on several sources of information to provide a better information base for considering the possible role for pricing for water conservation in the non-residential sector:

- A limited range of existing studies, mainly in respect of industrial sectors in several locations around the world;
- Preliminary modelling of price/demand relationships based on data on historical prices and volumes, and limited sector classification detail, fairly readily obtained from the utilities;
- Results from a dedicated survey of the top 5000 water-using customers, designed to deliver better information, especially for sectoral classification and businesses, on attitudes to alternative pricing structures, and on stated expectations of how the firms would adapt to a series of possible future price scenarios; and
- Further and more detailed modelling using the combination of utility-provided data linked to survey results.

All these data sources have their limitations and no single source is compelling. We have relied on a balanced weighing of the strengths, weaknesses and complementarities that emerge from this range of sources of insight, as a basis for drawing conclusions with some robustness as a basis for policy.

Reliance on direct modelling of price responsiveness based solely on recent historical data, while appealing because of its use of hard 'revealed preference' data, would risk serious distortion from a range of simultaneous pressures for conservation that could not easily be fitted into the modelling. We would expect the resultant price elasticity estimates to be biased upwards by the combined impact of only small increases in real prices (limiting the true price component of any observed change in usage), conservation pressures growing rapidly with the development of the drought and increasing concerns for the impact of climate change, as well as the maturation of water planning processes in many firms.

Results were very much consistent with these expectations, with the modelling producing 'apparent' elasticity estimates using real historical usage volumes and real price data around -2 for most firms, and around -2.4 for firms in the top 1000 group of largest users. These estimates are much greater than those in the literature and well outside our expectations. Nonetheless, given the likely explanation of the pattern (reflecting responses to expectations of substantially higher future costs of accessing water), these analyses did strongly suggest, qualitatively, that there could be a significant response to a substantial rise in the real price of water.

More robust inferences would necessarily require some ability to control for company expectations regarding future prices – and hard data on these were not available. Instead, we incorporated reliance on company responses to specific scenarios that set out a range of future pricing possibilities, rising to a 50 per cent increase over current variable charges.

The key insights to emerge from the analyses that drew on the survey data, merged with actual past volume data for respondents, included:

- Some respondents suggested they would not adjust to the higher prices, but these responses were not consistent with revealed past behaviour and were discounted. Modelling of the remaining respondents suggested:
  - Elasticity estimates were around -0.6 for smaller users around -1.1 for larger users, figures broadly consistent with those in the literature.
  - Manufacturing sector and higher water intensive industries tended to be more price responsive – both patterns appearing reasonable.
  - Respondents who already have Water Management Plans (WMPs) averaged slightly lower elasticities all other things being equal – suggesting some demand hardening.
- In terms of tariff structure preferences, survey respondents expressed a preference for the status quo, with in excess of 50% of respondents preferring the constant usage charge over other options. However, almost 25% of respondents preferred some form of increasing block tariff.
  - While the difference is large, there is likely to be a strong bias away from tariff structures that incorporate incentives to conserve water due to respondent's interpretation of higher costs for their own business

rather than recognising that a higher marginal cost does not necessarily imply a higher bill.

- A range of pricing structures apply around the world, with the main alternative to charging a constant unit price being a tariff structure where the rate increases with usage, such as an increasing block tariff and/or (less frequently) to apply a form of scarcity pricing where the marginal cost of usage would vary over time to reflect current system status (due, for example, to drought or demand growth).
- The two approaches attack different incentives, with scarcity pricing being concerned with prices that vary across time, reflecting a varying system cost of usage, while increasing block tariffs apply to increased usage at any point in time.
  – Scarcity pricing is concerned essentially with efficient price signals, while the use of inclined blocks involves some trade-off between perceptions of efficiency and equity, though another function of the increasing block tariff arrangements can be to limit the recovery by utilities of revenues that are excessive to their revenue requirements.
  – These two approaches could operate together.
- Clearly a move to increasing block tariffs in which a significant proportion of users would see marginal costs well above current levels could intensify conservation incentives, at least for firms with scope for further limiting demand at a modest cost.
  – However, for some firms a major change in demand is likely to require significant and costly system reengineering – and for this to make commercial sense it is likely to be necessary to be able to achieve significant savings across the band of reduced usage.
  – For this reason lumpy investment in large savings is likely to be less attractive under an increasing block tariff than under a single block tariff with a comparable marginal cost for the firm. For many firms with a single dominant use of water, total water cost may be more important than the marginal (top tier) water charge rate.
- There are other reasons for reservations regarding the role of inclined block tariffs in a non-residential setting:
  – Increasing block tariffs can provide inefficient disincentives to pursuing scale economies, by penalising larger firms and mergers even if the growth/merger would result in lower aggregate water usage for the same level of production.
  – Managing the distortions across sectors that increasing block tariffs introduce is likely to be an administratively difficult and probably costly.
  – In possible contrast to residential use, it is harder to give a convincing equity rationale for favouring small as opposed to larger firms as defined by water usage.

  - Effectively each kilolitre of consumption of water by a firm can be expected to impose the same incremental cost on the system – this incremental cost does not rise rapidly with increasing single firm consumption.
    - In this sense, the variable charge rate structure of increasing blocks could be viewed as not truly cost reflective – it does not reflect the system costs of incremental usage.
  - Unlike the residential sector there is no clear distinction between essential and discretionary usage, which limits the equity and efficiency benefits of a tiered structure (given that discretionary usage is more price elastic).
- As an alternative, at least for the longer term, scarcity pricing offers a way of avoiding adverse economic price signals by maintaining a uniform usage charge across users competing in the market, but allowing for variation in the rate through time to deliver significant incentives for conservation. As dam levels drop, the opportunity cost of marginal water use can move substantially and this will be reflected in the usage rate.
  - This regime encourages pre-emptive reengineering by firms to hedge against this price risk – while providing clear guidance as to how the prices will evolve in the event of a severe shortage.
  - Highest prices would only be charged when conservation of supplies offers the highest benefits.
  - The empirical work, pointing to substantial moves to conservation in anticipation of future price rises suggests there could be a significant demand response, even in advance of the triggering of such price arrangements.
  - Scarcity pricing could allow for lower rates most of the time, focusing on conservation when it is needed most.
- High top tier pricing (indicatively of the order of long run marginal cost) without an inclined block structure (but plausibly also with one that posts reasonable incentives, in which most customers would see a significant price) will raise the issue of balancing revenue against price incentives.
  - There is modest scope for compensation through reductions in the fixed charge.
  - In theory there would be scope and a basis for reopening the RAV in the light of the major shift in system knowledge as a result of the drought and climate change modelling effectively implying a higher value in sunken assets.
  - Alternatively higher revenues derived in times of scarcity could be "logged up" and recognised in future price review periods, where they could serve to limit the price impact (for fixed charges) of future supply/demand balance expenditures.

- There would be scope for applying different price structures across different groups of firms, to ensure most firms do see a high marginal price – but this would require complicated definition and management and would almost certainly post some perverse incentives.
- Consideration could be given to allocation a greater share of the benefits of the established low supply cost system to the residential sector, where an increasing block tariff may well stand up better to scrutiny – recognising that this would imply an increase in average water costs in the non-residential sector, and possibly justifying a phased introduction timed to reflect the reinvestment cycles of firms.

* Water management plans have been shown by the analysis to be effective and can act as a natural complement to any pricing strategy.

1 Purpose

This report provides the main overview reporting and assessment of strategy implications arising from the study that ACIL Tasman has undertaken for the Smart Water Fund – relating to its project: *Pricing for Water Conservation in the Non-Residential Sector*. The purpose of the study was to explore the possible role for different pricing models, in relation to non-residential water supply, as part of the package of measures directed at cost effective water conservation measures.

Several other reports were produced in the course of the study, laying the foundation for this report, and have been included as attachments or as stand alone documents:

- Literature Review – Pricing for Water Conservation in the Non-Residential Urban Sector (Appendix A);
- Issues Paper – Pricing for Water Conservation in the Non-Residential Urban Sector (Provided as a separate stand alone document accompanying this report);
- Survey of Non-Residential Customers – Pricing for Water Conservation in the Non-Residential Urban Sector (Appendix B); and
- Modelling of Price Responsiveness – Pricing for Water Conservation in the Non-Residential Urban Sector (Appendix C).

The study was undertaken with active support and guidance from a Smart Water Fund Steering Committee. The assistance of the Steering Committee throughout the process is acknowledged and has been greatly appreciated – in particular, the survey as conducted would not have been possible without their active assistance.

1.1 Context

Non-residential potable water in Melbourne is currently based on a combination of a low connection fee and a constant volume charge per kL of water used. These arrangements apply across the 3 supply utilities and have applied in this form for several years. While they do post *some* incentives to manage usage – because the usage charges are technically avoidable – there are a number of issues which are likely to become increasingly important:

- The strength of any such incentives may be diluted if price is significantly below long run marginal cost (given the dynamic nature of LRMC and the periodic nature of the price setting process). For example, recent estimates have increased the perceived level of LRMC in Melbourne;

- The potential for marginal cost to move above average cost (as currently regulated), which raises the question of how best to avoid revenue over-recovery; and
- Inflexibility in the pricing arrangements to set prices for conservation objectives and to manage the balance between price and level of conservation.

At the same time, these pricing arrangements are simple, appear to apply equitably and consistently across all non-residential customers, and make striking prices to meet revenue requirements relatively straightforward. This simplicity limits the scope for prices to cause serious distortion of incentives between different sectors and different forms of organisation.

Concern for the 'demand management' role of pricing has increased greatly in recent years, through a combination of the effects of the current drought, and the growing evidence that rainfall in the major Melbourne catchments is likely to have shifted towards a much drier outlook than is suggested by the historical record. System security has dropped significantly, and serious consideration is now being given to substantial new investments to restore security.

In this situation, improved conservation incentives can both add directly to supply security and allow some deferral/restructuring of major new investments, with associated cost savings. *Prima facie*, the costs avoided by greater conservation are now much higher than was believed to be the case till very recently – and this could well imply that a shift in pricing strategy that might not previously have been justifiable would now warrant reassessment.

Any change in pricing strategy would need to take into account a range of considerations, including the likely effectiveness of the measures in reducing demand; whether the resultant demand reduction would be reasonably efficient, in the sense of entailing modest cost relative to alternative instruments, whether the pricing would be seen as sufficiently equitable in its impacts on different firms, and more generally customer attitudes to any such changes.

2 Background & approach

The Smart Water Fund is aimed at encouraging and supporting innovative development of sustainable water use projects throughout the geographic areas of greater metropolitan Melbourne and regional urban Victoria.

Programs targeted at the non-residential sector have been limited to the provision of water audits for large consumers, education and water efficiency programs for local councils, and open space management through various partnerships. While there has been considerable recent action on pricing reforms in the residential sector (including the recent adoption of an increasing block tariff), less attention has been given to pricing in the non-residential sector.

This project has been designed to enhance the understanding of non-residential water consumption characteristics, and likely attitudes to and demand responses to alternative pricing structures. A primary objective of this project is to provide information to better inform decisions on the potential role and specific form of pricing in the non-residential sector that might contribute to balancing supply and demand in an efficient and effective manner.

A key thrust of the White Paper and broader reforms in the industry over recent years has been to send appropriate signals to users regarding the cost of supply, including incentives for water conservation. This has been codified into the pricing principles in the Water Industry Regulatory Order (WIRO), administered by the Essential Services Commission (ESC) in regulating prices in the Victorian water industry.

The moves towards a 'user pays' system of pricing for water in Melbourne and away from the previous property value based regime has been an evolving process that commenced in the 1980s. In general, reforms to pricing for the non-residential sector have lagged behind those in the residential sector. For example, the "free allowance" that applied to water consumed up to the value of the rate charge (that effectively gave no incentive to conserve water within this threshold) remained in place long after residential customers faced a signal on every kilolitre of water consumed. Similarly, while increasing block tariffs have been adopted in the residential sector, less attention has been given to pricing structures in the non-residential sector.

Demand management initiatives targeted at the non-residential sector have been primarily focused on the provision of water audits for large consumers, education and water efficiency programs for local councils, and open space management through various partnerships. However some non-residential customers are impacted, to some extent, by restrictions imposed at times of water shortage (for example open space, golf courses etc) and the new Permanent Water Saving Rules. Opportunities for using recycled water for various non-potable purposes by non-residential users (e.g. for use in industrial processes and for open space irrigation) are also being actively explored.

The non-residential sector accounts for some 28 per cent of total water consumption in Melbourne (or around135 GL p.a.). Moreover, current projections indicate a growth in the population of metropolitan Melbourne of around one million by 2030. Melbourne's non-residential sector is likely to expand at least as quickly as the residential sector, with population growth and continued economic prosperity. According to the 'Planning for the future of our water resources' report for Melbourne, around 9 GL p.a. could be saved by the adoption of water conservation practices by industrial users through developing Water Management Plans with the top 200 industrial water users across Melbourne.

Most commercial and industrial use has been exempted from water restrictions, despite the severity of the drought – and across Australia there has been an understandable reluctance to impose restrictions (as opposed to encouraging conservation practices) across commercial uses.

Historically, movements in Melbourne non-residential water prices have been modest, and have predated current heightened awareness of supply and reliability concerns, and increased general community sensitivity to water use inefficiencies. Furthermore, there is only limited information that brings together water consumption information and details relating to usage patterns.

These information limitations mean that there is only limited scope for extracting high quality policy-relevant information on likely attitudes to, and demand responses to, alternative pricing arrangements. The present study has been designed to address these information limitations in several ways.

This study has drawn on several sources of information to provide a better information base for assessing the possible role for pricing for water conservation in the non-residential sector:

- A literature review, looking for relevant lessons available from other water supply systems – especially where these have yielded possibly more robust estimates of demand elasticities and/or have involved alternative pricing models.
  - The various models that emerged from this review were subject to further assessment in a separate Issues Paper.
  - Preliminary modelling of price/demand relationships based on data on historical prices and volumes, and limited sector classification detail, fairly readily obtained from the utilities;
  - While this did provide some insights of direct value, the main purpose of this exercise was as an input to the next two stages of the study.
- A survey was conducted of the top 5,000 non-residential users, to provide (after linkage to the utility data) more detailed information on which to base analysis of attitudes and demand sensitivities.
  - In particular, the survey yielded much better information on industry classification, on the extent to which companies were already planning for greater water efficiency, on attitudes to specific price structures, and on stated views as to how each company would respond to different levels of change in the effective usage cost of water.

- Further and more detailed modelling using the combination of utility-provided data linked to survey results.
  - These data were subjected to both cross-tabulation and econometric analyses, with the opportunity now provided to base modelling of demand sensitivity on both:
    - historical actual demands; and
    - stated response to possible future prices.

The study presents a balanced weighing of the strengths, weaknesses and complementarities that emerge from this range of sources of insight, as a basis for drawing conclusions with some robustness as a basis for policy.

The study has also addressed the question of the form that any such pricing instruments reasonably take – considering relative strengths and weaknesses.

In reality, good data are not available – and cannot be readily and quickly produced, for purposes of detailed and thorough modelling of price responses. This exercise has involved a lot of effort directed at minimising the limitations of the readily accessible information. This may have implications for the on-going monitoring of price sensitivities, possible as the basis for on-going adaptation of the pricing strategy as one of the elements in the overall approach to supply/demand balance.

The ideal data set involves a combination of detailed cross-sectional and time series data that realistically needs to be gathered over several years (rather than being done retrospectively) and that includes significant *non-trend variation* in real prices for water across this period. The approach involves using this detailed data to estimate sector-level production functions, from which water price sensitivities can be inferred on the assumption that firms seek to maximise their performance within the constraints of their production functions, input costs and output values.

A range of overseas studies using this broad approach indicate medium- to long-term price elasticities – a measure of the percentage change in demand likely to follow from a 1 per cent change in price – in a band, but one concentrated mainly in the range from about -0.5 to -1. This suggests a 1 per cent price increase (i.e., increase in the marginal usage charge) is likely to lower usage by between half a per cent and 1 per cent. Some variation attributable to local conditions and varying by sector and firm size could be expected. The quality of the data available and the detail of the estimation methods used varied across studies.

The variation between short- and long-run estimates, with greater long-run responsiveness, is as would be expected. Given time, firms will commonly be able to adjust business models cost effectively to deliver greater savings –

where such adjustment in the short-term would be either not possible or not cost effective. This is particularly true where there is a need to invest in reengineering the business systems or product range. In effect, both theory and these studies suggest a lag in achieving the maximum response to a price rise.

The survey did not, of course, resolve all the data limitations recognised above. In the context of a one-off survey (as opposed to a rolling longitudinal survey that would offer increasing flexibility over time) it was necessary to strike a balance between the level of detail of information sought – especially in relation to activities in past years where data would not necessarily be readily at hand – and willingness of respondents to cooperate in the survey, with associated management of non-response biases. The requirements of this balancing largely prescribed the nature of the econometric modelling that was feasible.

As a snapshot of performance by the business users at a particular point in time, the survey lacks a measure of how this performance has changed over the years - which would be useful for assessing the effect of operational factors including water prices on their water consumption.

However, it has been possible to map these data against known levels and types of usage and prices, in developing a better understanding of what can be inferred from past behaviour regarding price responsiveness in Melbourne. This has yielded a very useful data set, though not one well-suited to the above 'ideal' analysis. Instead, we have focused on direct modelling of demand as a function of price, turnover, sector and other factors such as temperature – and have probed the apparent role of water planning processes in influencing these levels of usage.

A key limitation on deriving precise estimates from such modelling is the fact that there has been very *little variation in real prices* of water in recent years – with such variation being crucial to any *attribution of demand changes to actual price effects*. This limitation has been further complicated by the operation of the drought, the progressive emergence of stronger restrictions and increased reporting of a likely structural shift towards reduced rainfall. In this situation, longer term *price expectations* are probably bigger determinants of behaviour than the modest shifts in real prices reported to date – and price expectations are likely to have changed substantially across the analysis period. Another way of looking at this is that the modest price changes fed into the modelling are small in relation to the plausible future price changes driving demand adaptation.

Indeed, the econometric analysis is strongly suggestive of this being an important factor. In effect, demand changes as measured across the survey period are likely to be greater than long-term sustained responses to a one-off price change of the magnitude seen during that period. This will be particularly true where price expectations have led to water planning and to the actual roll-out of changed business strategy in order to lower water use (or substitute from other sources) – but where the investment can only be justified on the basis of future water price rises (or reduced reliability).

Another way of looking at this is that a key feature – and limitation – of the present data from recent history is that it relates to a period in which firms' awareness of, concern for and willingness to consider business reengineering in response to future water supply and price scenarios has been undergoing dramatic change. These pressures have been in the same direction as would be pressure from an actual trend in real prices and, given the small rate of rise in real prices, may well have been much stronger in their aggregate impact on behaviour of firms. There has not been in place a simple, stable water demand situation with gradually changing technologies. While traditional modelling methods often incorporate adaptive expectations, these are typically based on relatively simple evolution of recent price trends, rather than on dramatic rethinking of future price trends that may differ greatly from recent experience.

Of course, these changes in response to future price expectations are real, are important, and have implications for future pricing strategy – as well as for other strategy instruments directed at encouraging more sophisticated water planning. However, they do create a serious limitation on the scope for deriving good estimates of price elasticities likely to apply in the future because of the way the recent demand changes are likely to have embodied both normal response to past price changes and a block of concentrated anticipatory responses to future price changes.

To help compensate for this effect in deriving estimates of normal price sensitivity, and for wider limitations in the available hard historical data, we drew heavily on aspects of the survey that confronted interviewees with a range of price rise scenarios and asked for the likely impact on forward water usage. A strength of this approach is that the scenarios describe the price expectations – so in a sense we have recorded stated change in response to known price expectations. A further strength laid in the scope for seeking responses to much larger price increases than have been observed. A weakness of the approach lies in the limited ability of respondents to answer with both precision and accuracy in relation to price. We therefore see the two sets of analyses as complementary.

The report has been designed to extract the key messages from this body of work and to work through likely implications for strategy – in terms of both acceptability and effectiveness. Specific results from the earlier stages have been documented in the range of reports included as attachments.

During the course of the study, the Essential Services Commission of Victoria (ESC) released a consultation paper setting out framework, approach and preliminary thinking in relation to the 2008 Water Price Review (Essential Services Commission, 2006). Relevant aspects are discussed in Section 3.5 below.

3 Key messages

3.1 Literature Review

The detailed report of the literature review is provided at Appendix A. The following reflects only key points of relevance to the later assessment of options.

The literature review covers a number of areas – in particular water pricing structures that are employed in various jurisdictions and the theoretical and empirical literature on the estimation of price elasticities; it also looks at pricing structures in use in other industries that might be relevant to water.

3.1.1 Pricing structures

While recognising the important roles of the pricing structure in relation to revenue generation and cost allocation, the review was focused on its role in providing suitable economic incentives – reflecting the emphasis of the present study on incentives for water conservation.

Pricing structures considered are: fixed fee, uniform rate, increasing block tariff, seasonal rate, excess use rate, pyramid rates, sliding scale rates, scarcity pricing, and spatial pricing.

- Fixed fees are still charged in some countries;
  - they provide stable revenues but lead almost certainly to an inappropriate allocation of costs and usage incentives; and
  - assuming that the true incremental/marginal cost of extra supply is non-zero, the usage incentives must be distorted in favour of greater usage by individual users, and must favour larger scale enterprises.
- Uniform tariffs – i.e. constant unit usage charges – are widely used.
  - Including by all 3 water retailers in Melbourne.
  - There is some evidence in the literature that moving from a fixed to uniform tariff structure provides an effective incentive to reduce consumption, – e.g. Hunter Water 1982.
- Use of increasing block tariffs for non-residential customers is becoming more prevalent, however.

- In March 2005, the ESC failed to approve an application for increasing block structures; on the basis that there is large variation in consumption levels and it is difficult to define what is the appropriate level of non-discretionary water use.
  – These same arguments recur in the recent ESC Framework Paper in relation to the 2008 price review – discussed further in Section 3.5 below.
- Increasing block tariffs will also penalise growing firms, (either organically or through acquisitions) that are using water efficiently;
  – possibly even if they are achieving increasing economies in water usage as a result of the growth.
- Seasonal tariffs are most commonly employed in tourist communities, and are justified on the basis that they recoup infrastructure costs that exist because of tourism-generated peak demand.
  – This rationale is not about conserving water but about allocating the costs of peak supply capacity, and seasonal tariffs appear far more justifiable in this role than as conservation instruments.
- Excess-use tariffs are similar to increasing block structures but demonstrate a marked increase in price above some ‘acceptable’ level.
  – Excess use tariffs are applied to irrigators in El Paso, Texas and to industrial users in the WA Goldfields.
- Decreasing block tariffs are offered by UK water companies to large users, although they also levy a higher capacity charge.
  – These structures could make good sense as cost allocation devices, where there are no strong pressures to price for conservation, in situations where there are size economies in supply once the capacity costs have been covered.
  – In the presence of large size economies in water usage across the non-residential sector, such pricing could deliver useful economic incentives (encouraging a more rapid shift to exploit these size economies), but it would be very difficult to strike a sensible balance of incentives.
  – Decreasing block tariffs may also address access concerns amongst current suppliers by ameliorating the threat of larger users moving to alternative water sources.
    ⋯ On the other hand, unless the reductions are soundly based in true scale economies, there could be adverse consequences from a whole of system perspective if this limited fair competition.
- Scarcity pricing was applied in 1993 by the LA Dept of Water and Power.
  – They specifically employed an increasing block tariff which was adjusted to reflect scarcity conditions in drought years.
  – ACIL Tasman, in conjunction with the Institute for Sustainable Futures, has recently commenced a study of water restrictions for the

National Water Commission that includes more detailed consideration of a cost-reflective scarcity-based pricing model that is based on the way the loss of *system option value* changes as a result of marginal consumption.

  - This is an extension of the real options modelling approach used in relation to optimising investment strategy for the Sydney Metropolitan Water Strategy.

- Non-residential wastewater pricing is generally levied on the same basis as potable water supply.
  - ie. if uniform tariff is used for water, then a uniform tariff is also applied to sewerage.
  - Sewerage volumes are generally assumed to be a scaled percentage (discharge factor) of water supplied.
    - This assumption is likely to be increasingly challenged by on-site water reuse schemes.

The separate issues paper sets out a more detailed review of the various pricing options.

3.1.2 Price responsiveness and elasticities

Little attention has generally been given to the formal modelling of non-residential water demand, and most of this effort has been directed at the more water intensive industrial uses, as opposed to commercial demand.

- The majority of detailed econometric studies of industrial demand rely on the modelling of sectoral production functions, from which price responses can be inferred.
  - Provided that data suited to such estimation is available, this approach has considerable attraction compared to direct modelling of usage as a function of price and other variables.
  - Most of the modelling has been based assuming that each production function is of a 'translog form'
    - This form offers a lot of flexibility to fit data without needing to impose strong assumptions that could bias elasticity estimates, though other less flexible forms (notably Cobb-Douglas) have sometimes been used.
  - Data requirements for this production function approach are substantial and generally require a commitment to collection over a period of years to generate the needed data.
- Estimated price elasticities from a dozen or so international studies dating from 1979 to 2004, and using a range of econometric techniques, vary widely.

– However, own-price elasticities were almost always estimated to lie between 0 and -1, in most cases closer to -1 than to 0.
  ⋯ 'inelastic demand' – with a water price increase encouraging a real, but somewhat less than proportionate, reduction in water usage.

Table 1 **Estimates of the price elasticity of non-residential demand for water**

Authors	Year	Area	Production Function	Price Elasticity
Grebenstein and Field	1979	USA	Translog	-0.80/-0.33
Babin, Willis and Allen	1982	USA	Translog	-0.66/+0.14
Ziegler and Bell	1984	USA (Arkansas)	Cobb-Douglas	-0.08
Williams and Suh	1986	USA	Log/Log	-0.97/-0.44
Renzetti	1988	Canada (British Columbia)	Cobb-Douglas	-0.54/-0.12
Schneider and Whitlatch	1991	USA (Columbus, Ohio)	Log/Log	-1.16
Renzetti	1992	Canada	Translog	-0.59/-0.15
Wang and Lall	1999	China	Translog	-1.0
Dupont and Renzetti	2001	Canada	Translog	-0.77
Onjala	2001	Kenya	Translog	-0.6/+0.37
Féres and Reynaud	2003	Brazil	Translog	-1.08 on average
Goldar	2003	India	Translog	-0.4/+0.64
Reynaud	2003	France	Translog	-0.79/-0.10
Kumar	2004	India	Translog	-1.11 on average

Source: This table is drawn from the literature review (Table 4) and is sourced in detail there.

3.2 Issues Paper

The issues paper incorporates a more detailed review of the economic issues that arise with different tariff structures, documentation of current structures that apply to non-residential use in Melbourne, an overview of key cost drivers and a discussion of key issues seen, at the time of drafting, as needing to be addressed in the survey and analysis.

Most of this discussion is now addressed elsewhere in this present paper and is not repeated here. However, in relation to cost drivers it is worth noting the concluding comments (Section 6.6 of the issues paper):

> "From the discussion above, it is clear that the cost drivers are complex for both water and sewerage services, and includes many factors other than average annual volumes supplied/collected. Moreover, as one moves down the distribution system

> towards the customer, peak factors become relatively more important, so that volumes per se carry less importance in the sizing of capacity.
>
> "Some of these additional cost drivers are reflected in tariffs – namely the charges for loads contained within the trade waste charging schedules. However, the charges for water supply and non-trade waste sewerage services are currently based on a simple two-part tariff.
>
> "The argument for incorporating other charges for non domestic customers – such as peak charges for water supply and pollutant loads of sewage for non trade-waste customers will reflect a trade-off between the efficiency gains associated with more cost-reflective tariffs versus the administrative costs of introducing more complicated tariffs (and the associated decrease in understandability and transparency of charges).
>
> "Currently the level of charges appears to be some way above estimates of the marginal cost of supplying or disposing of an addition volume of water/sewage (in terms of the internal costs of the businesses). This margin can be seen as allowing for the presence of externalities and/or the cost of scarcity."

We note that views in the industry of the level of marginal cost have since changed significantly.

3.3 Survey

The questionnaire on water use went out the top 5,000 customers of the 3 Melbourne metropolitan water utilities, representing about 75% of total water use. The top 1000 were covered through an internet survey (of which 298 responses were received), undertaken in cooperation with Deloitte Consulting, recognising that two separate surveys at the same time would have been damaging to response rates. The remaining 4000 were covered through a mail survey dedicated to the purposes of this study (278 responses were received). A total of 576 responses were received across all 5,000 customers, corresponding to a response rate of about 12% – a not surprising figure, but one that was low enough to require some probing for indications of poor representativeness. The results of the probing were reasonably reassuring.

Not surprisingly, a lot of what emerged from the survey was confirmation of what would reasonably be expected, but this then laid the foundation for more detailed probing. Crucially, the survey information allowed much better linkage between the nature of the firms and their historical water consumption records; and provided important data on attitudes to specific forms of water pricing, attitudes to likely responses to elevated usage charges and the extent of commitment already made to water planning.

A summary of results obtained directly from the survey is provided below:

- Water intensity (measured relative to employment and to turnover) varied widely and predictably across industries.

  - High intensity industries are Manufacturing, Personal services, Agriculture and Culture and Recreation.
  - Medium density industries are Accommodation, Cafes and Restaurants, Health and Community services.
  - Low intensity industries are Finance, Property and Telco, Government Administration, Education and Wholesale/Retail.
- In terms of supplementation from other water sources, about 35% of respondents either recirculate or recycle their water. Manufacturing sector firms predominantly do this.
- A large proportion of respondents (36%) has already introduced water saving programmes or developed water management plans.
- The most active sectors in implementing water savings are: Manufacturing, Government, Education, Culture and Recreation, and Personal and Other Services.
- There is a strong positive correlation between those who have implemented water savings and water intensity, confirming expectations that the ability or willingness to adjust to water prices depends on the extent of water use in a business.
- Implementation of water saving processes has been growing strongly over time, reflecting increased awareness of water conservation issues.
- Customers with annual consumption in excess of 10ML are encouraged to have a water management plan in place.
  - Manufacturers have been quickest to implement the plans, reflecting the high intensity of use in this sector.
  - However, only approximately 30% of manufacturing firms have a plan in place, and there appears to be significant scope for further improvement – while recognising that not all manufacturing involves high water use intensity.
- The primary drivers for the introduction of water saving processes are future cost savings and environmental concerns.
- Respondents indicated a strong preference for a constant unit price tariff. Results are likely to be tainted by degree of ‘gaming’.
- The main factors cited by respondents as influencing their choice of preferred tariff are, Certainty, Simplicity, Fairness, Consistency and Incentives.

3.4 Econometric analysis

A summary of the econometric work is provided below:

- The modelling work employed a direct model of water demand where water demand is expressed as a function of a set of explanatory variables.

- The quality of time series data were not considered sufficient to support a full expenditure share/production function-based model, as discussed earlier and common in the literature, though a base is now in place that could be improved with future surveys.
- Data limitations include:
  - the absence of historical information that make it difficult to account for large changes in volumes over time.
  - Incorrect and inconsistent reporting.
  - Stated preference data also suffers from the limitation that the actual response may be different from the stated intention.

- Using the real historical usage volumes and real price data, the 'apparent' price elasticity was estimated to be about -2 for most firms, and about -2.4 for the firms in the top 1000 group of largest users.
  - These figures are well above those suggested by the literature review and are almost certainly too big, for good reasons.
  - The most likely explanation lies in the rapidly changing perceptions of future water price and reliability that have accompanied the deepening drought and the climate change modelling – accompanied by pressures for firms to plan for water savings.
  - The short-run impact of these changes, that have strengthened greatly over the past few years in line with a modest rise in real prices, appears to have been to deliver usage restraint out of kilter with the size of the recorded price rises – for the reason that a lot of the usage change was driven by price rises yet to be recorded and by response to wider community pressures.
  - Unfortunately, the data for credible *direct* modelling of these expectations effects are not available. Traditional models incorporating adaptive expectations would be inappropriate, as the input assumptions regarding the nature of the expectations would drive the output, and not themselves be amenable to testing.
    - Instead, as discussed below, we have relied on an indirect method – using survey data in which expectations are moulded by the question, to probe these effects more deeply.
- There were no major differences in these estimated price elasticities across the 3 utilities.
- The survey delivered a set of data in which respondents indicated the likely impact on their water consumption of different future price scenarios – 10, 25 and 50 per cent increases. The effect of this approach was to set forward price expectations and to seek response to these.
  - Over half of those questioned indicated they would not change their usage – answers that contradicted the evidence of significant recent price response amongst the same firms. These answers may have been

driven by a mix of uncertainty and of gaming of a question that might have been seen as having dangerous implications.

- Modelling, for the remaining respondents who indicated they would change behaviour, and using the same model structure as earlier, yielded price elasticities as follows:
  - Around -0.6 for the majority of firms; and
  - About -1.1 for the large water using firms – those in the 'top 1000 customers'.
  - Of course, there is not a precise line between the two groups, and the data are indicating a procession from perhaps -0.5 through to somewhat less than -1, depending largely on the level of water usage.
    - Furthermore, the modelling pointed to greater price sensitivity for firms in the manufacturing sector than in other sectors.
- These figures accord well with the overseas studies and are seen as far more credible than the higher elasticities that flowed from modelling of historical responses only.
  - At the same time, the comparison of the two sets of results is extremely valuable in highlighting the extent of demand response recently driven by changing expectations.
    - This strongly supports the view that significant short term conservation benefits could flow from a process that confirms industry views that medium- to longer-term prices are likely to be substantially above current levels – even if these price rises are not immediately set in place.
    - For major users, substantial reduction in usage or usage intensity will require reengineering and the benefits are likely to flow in a 'lumpy' form, rather than one tailored to the real time prices.

3.5 ESC Framework Paper

The ESC Framework Paper deals only lightly (in Section 2.2.2 and some of 2.2.3) with non-residential pricing structures. However, the following points are relevant to any consideration of pricing strategy by utilities, while the present study may well usefully inform both submissions to the Price Review and the ESC assessment.

- The paper highlights that alternatives to the current two part tariff structure have emerged in electricity and gas;
  - Variation in pricing between peak and off-peak periods, that could be seen as broadly analogous to drought/non-drought periods or to scarcity-based pricing in relation to water;
  - Differentiation based on customer categories, with size of customer being the only example cited.

    … This appears to be proposed as one option that should be considered.

- The paper notes that one alternative pricing structure could be the extension of the block tariff approach to non-residential customers.
  - But notes that this could result in prices that favour certain industries or, alternatively, would introduce substantial complexity in determining the level at which to set blocks.
  - The paper recognises the weak relationship between level of water usage and efficiency of water usage in the non-residential sector.
- Once-off charges for the right to increase system usage levels are not viewed favorably relative to on-going price signals;
  - while discounts for reductions are seen as likely to be difficult to administer because of incentives for gaming.
- The paper appears more neutral in its views towards pricing structures tailored to particular types of customer. While not being explicit, it is likely that these types could be defined by either or both of sector and size.

4 Wider policy implications and considerations

Price structures

While a range of structures apply around the world, the main relevant alternatives to the current uniform tariff approach that would provide usage incentives directly would be:

- Some form of tariff where the rate rises with usage – such as an increasing block tariff or a conceptually similar excess usage tariff; and/or
- Scarcity pricing where the marginal cost of usage would rise to reflect current system status – with highest prices as supply levels drop and the need for deeper restrictions, the likelihood of needing to trigger major new investment of the risks of major shortage are greatest.

The former 'taxes' increased usage at a progressive rate, with some intuitive appeal, but also with serious, and potentially counterproductive, limitations in the way it might interfere with incentives to achieve greater business efficiencies – including some that would involve lower aggregate water use.

The latter complies better with textbook economics principles – being in-principle cost reflective and encouraging greatest restraint when each unit of restraint is of greatest value in reducing risks or deferring costs.

The two approaches provide different incentives. Scarcity pricing is concerned essentially with efficient price signals, while the use of inclined blocks involves some trade-off between perceptions of efficiency and equity, though another function of the increasing block tariff arrangements can be to limit the recovery by utilities of revenues that are excessive to their revenue requirements. Inclined block tariffs are also capable of transmitting a spread of price signals between lower and upper bound estimates of LRMC. The two approaches could operate together.

User preferences

The survey revealed a clear (>50%) preference for the status quo, followed at almost 25% by the increasing block tariff structures (inclusive of excess usage tariffs). The difference is big but perhaps not altogether definitive. There are likely to have been some incentives to game the answers, especially by firms with growth expectations, and some respondents who might have assessed the increasing block tariffs as pushing up their costs relative to competitors when this need not be the case.

The factors stated as driving preferences as to structure were certainty, simplicity, fairness, consistency and incentives. A problem with fairness and consistency is that it is open to widely differing interpretations. Is it fair to charge proportionately more to a bigger water user, if that user is more water efficient – if for example the firm is achieving twice the output from 150% of the water input? Is a fixed unit price consistent across sectors with very different levels of water intensity and options for substituting alternative production processes? Aspects of these ambiguities are likely to be present in the mixed responses.

Water conservation strategies

Just over a third of all respondents (and most respondents in manufacturing) recirculate or recycle at least some of their water. A similar proportion has established water saving programs or has developed water saving plans. Planning for water saving and implementing these plans is best viewed as a part of the demand response of the non residential sector. For many businesses using substantial volumes of water, system reengineering is the only practical way to achieve significant reductions in calls on potable supply.

Demand/price responsiveness

As mentioned previously, the literature suggests an average price elasticity of between 0 and -1 (although closer to -1), varying across sectors and firms – but not based on Melbourne-specific data.

The analysis of the historical hard data for Melbourne led to nominal indications of a substantially stronger price response. It is important to recognise that, for reasons discussed above; these figures are likely to overstate the long-run elasticities, by including changes driven by future price expectations as well as actual price changes.

- The modelling pointed to a statistically significant difference in elasticities between the large water users (characterised by being in the top 1000 customers) and other users:
  - Nominal elasticities for large users were of the order of -2.4, and about -2 for other users. This differential could in part be attributable to earlier progress by the larger firms in water planning and roll-out of measures to deal with future price and reliability expectations.
- The modelling found the manufacturing sector to be more price sensitive than the other sectors and industries, with (not surprisingly) low water intensity being least price sensitive.

These figures are not necessarily inconsistent with the figures reported in the literature – expectations of prices rising in real terms over several years could have justified these substantial usage shifts during the present drought.

The analysis[1] of the stated response patterns under the substantial price rise scenarios used in the survey yields some interesting fresh insights and supports the earlier argument regarding the impact of rising price expectations on water usage patterns.

Over half of respondents suggested they would not adapt their behaviour to the increased prices. This is despite the fact that analysis of the historical pattern of demand response for the same respondents suggested they are already making significant changes in response to more modest price changes and expectations. Likely explanations include a lack of serious thought being given to response possibilities, in the context of a history of stable prices, and a level of gaming of responses to reduce the likelihood of increasing marginal prices being introduced.

For the remaining respondents, the results broadly mimicked the above historical data results but with less extreme responses.

- Again, there were statistically significant differences between the large water users and the rest;
  - Elasticities for the large users were estimated at about -1.1, and for the smaller users at about -0.6.
- Again there were significant differences in levels of water use across sectors, but little evidence of this translating to a big difference in elasticities.

[1] Based on the same model structure as was used for the above historical estimates

We are inclined to lean towards these latter estimates, that are broadly consistent with the overseas literature based on hard data and more sophisticated modelling methods, as being probably the most credible currently available for Melbourne, with an average elasticity of around -0.8, but with the individual firm responsiveness rising with increasing water usage – to be around -1.1 for the larger firms.

The comparison with the much higher figures from analysing the historical data does suggest significant scope for forward price expectations to encourage behaviour change. This suggests that a policy change that confirms this trend towards higher usage charges could well trigger an early response that would be quite large, even if the initial rise in marginal price were modest.

Translation into plausible demand impacts

Demand elasticities are technically defined in terms of response to small price increases. There is a risk of serious error, usually in the form of overestimation of demand impacts, if these effects are extrapolated without care. For example, an elasticity of -1 suggests that a 1 per cent price rise would reduce demand by 1 per cent. It does not follow that a 100 per cent price rise would drop demand by 100 per cent, even if this elasticity holds across all prices – it should only halve it[2]. This arises because of the non-linear nature of the demand curve which approaches the Y and X axis but never actually reaches it. Larger and larger percentage rises in price will lead to reductions in volume but at a reducing rate, approaching a maximum of 100% but never quite reaching it.

The following table sets out the translation of plausible combinations of marginal price rise and elasticities into percentage reductions in demand under the modelling assumptions used in the analysis.

Table 2 **Impact of elasticities and price changes on demand**

Price increase	10%	20%	30%	40%	50%
Elasticity					
-0.6	5%	10%	14%	17%	20%
-0.7	6%	12%	16%	20%	23%
-0.8	7%	13%	18%	23%	27%
-0.9	8%	15%	21%	26%	30%
-1	9%	17%	23%	29%	33%

2 The formula which relates the percentage change in volume to percentage change in price used in Table 2 is, $\%\Delta V = \text{price elasticity} \times (1 - 1/(1+\%\Delta P))$.

A second important point relates to the extent to which demand changes are driven by marginal or average costs of water. For many firms, substantial demand reduction will require significant investment in business reengineering. In order to cover such investment, substantial cost savings would be needed – not just the avoidance of the high price of the last few kL of water used.

In this situation, systematic rising of total usage charges because of a reassessment of, for example, the long run marginal cost of supply could be expected to feed into significant usage response, even under present constant usage charges arrangements.

It is likely that survey respondents would have answered mainly on the presumption that, for example, a 25% price increase (the mid-range scenario presented) would imply a 25 per cent rise in water bill unless offset by some usage reduction. This could well justify a big change. On the other hand, restructuring the bill, with a lower large bottom tier and a narrow high priced top tier might well not imply savings big enough to justify the investment, if it required major system reengineering.

Detailed probing of these issues would require much more detailed, and probably case study-level, engineering modelling in the absence of hard data involving large price changes. The alternative would be to rely on an adaptive approach in which data is gathered in response to early price changes and the strategy is progressively refined over time. Such an approach would not score well on user's 'certainty' criterion – but it may be that high levels of uncertainty in water supply costs are unavoidable, and it will not necessarily be efficient for the associated risks to fall solely to the utilities.

An interesting issue relates to the speed of adjustment of firms to higher marginal usage charges given our estimated elasticities. It is likely that there will be a lag between any price rise and the adjustment process of many firms. This is due to the requirement of many firms, particularly in manufacturing, to invest in new technologies and processes to reduce water consumption. These new processes are likely to take some time to implement. Therefore, any analysis using our estimated elasticities should take into account these lags, perhaps by reducing their impact in the short run, and then gradually increasing them up to a maximum over some appropriate period.

From a policy perspective then, the major messages coming from the analysis include:

- A clear preference for constant unit usage charges, as currently applied;
  - Coupled with significant support for some form of tariff that rises with large usage – and that may not come too distant a second amongst at least some of those expressing a preference for the constant rates.

- Strong evidence of a significant level of price responsiveness, at least across the bigger water users in the non-residential sector, involving three and probably four key elements:
  - A normal price elasticity, measuring the usage response to a one-off, then sustained, change in the inflation-adjusted marginal usage cost of water, probably of the order of -0.6 for the average firm outside of the very large (characterised by top 1000 customers) water users.
  - A stronger elasticity, around -1.1, for the biggest water users.
  - Evidence of a willingness by firms to make pre-emptive changes to business patterns in order to respond to expectations of future price rises or drops in reliability.
    - Translating into apparent usage/price responses in very recent years approximately 3 times the size suggested by the above elasticities alone.
  - Relatively weak evidence of significant differences in elasticities across sectors, over and above those implied by the above separation between large and smaller users.
    - But clear and unsurprising evidence of cross-sectoral differences in water usage relative to business size, implying a differential impact of a price rise across sectors and firms, and a differential absolute level of usage response.

Together, these results certainly support the view that alteration to pricing structures to confront firms with higher marginal usage charges could be expected to translate into reduced usage. Indeed, it seems likely that confirmation of higher future prices, even if phased in over time, would trigger significant pre-emptive investment and could deliver early demand response of the type already being seen in the historical data.

Higher constant usage rates

It seems likely that the long run marginal cost of water supply in Melbourne will be further reassessed upwards as a result of the experience of the current drought and the strengthening evidence of systematic and adverse climate shift in the region. With serious consideration being given to major recycling and desalination schemes, it seems unlikely that long run marginal cost would not be substantially above current usage charge levels of under $1.

Maintenance of the current approach of levying water charges on the basis of a constant usage rate could be expected to feed through, under these circumstances, to increases in the marginal rate without any shift in basic price structure. This can be expected to translate to lower usage by the non-residential sector.

Inclined block usage charges

Clearly if this were to be accompanied by increasing tier charges, the demand response would be intensified. This could be done either through a balanced lowering of the bottom tier and rising of the upper tier to maintain adequate revenues, or by raising the upper tier without lowering the associated main tier (leaving it at or near LRMC). These two approaches would be quite different, with clear regulatory implications.

The latter would unambiguously lower demand even further. The former is likely to have a more muted impact amongst firms that would need to undertake major reengineering to deliver further demand reductions – the threatened price rises would need to translate into avoidable cost impacts big enough to justify the reengineering.

Any move to multi-tier pricing will detract from the simplicity of the system, and there is evidence that this would be viewed as a negative. Major considerations then are whether such arrangements could improve efficiency, and would be acceptably fair.

We have very serious concerns for the potential efficiency impacts of inclined block tariff structures in the non-residential sector – not because of their effectiveness in lowering demand, but because of their potential impacts on much wider economic incentives in a dynamic economy.

A problem with these measures lies in determining and maintaining an appropriate threshold beyond which higher prices apply. It is not practical to adopt a one size fits all while delivering the intended incentives at the margin to most users – unless the threshold is set very low, effectively implementing a higher constant rate.

It might be tempting to take the view that big users should face the higher costs on either equity or efficiency grounds, but this reasoning is far more applicable to a fairly homogeneous group focused on end-use consumption – possibly residential customers – than to commercial firms. It would not seem efficient to actively discourage two firms from merging where this might, for example, result in a 25 per cent reduction in total water usage, and greater competitiveness as a result of scale economies. Is it equitable to charge two small firms less for their water than one large firm using less water for the same total output? Some people might want to discourage some mergers on wider grounds, but water pricing would hardly seem the appropriate instrument to rely on. Similarly, marginal usage costs that are in excess of incremental system costs could prove quite inefficient in discouraging firm growth, or distorting growth patterns in favour of higher cost, and possibly higher water using, models that reduce this marginal water price impact.

Some firms in some sectors are far better placed than others to substitute alternative technologies in response to price change, and again a major change in pricing could be seen to have equity consequences here, though our concerns would be more efficiency related.

ESC Framework Paper concepts

The recent ESC Framework Paper for the 2008 Pricing Review recognises some of these points in relation to inclining block tariff structures and expresses analogous concerns. It does float the possibility of pricing that differs across groups in some way. Of course, setting the thresholds for multi-tier pricing at different levels would be one way into this, but would not get around the above concerns. If the groups are sector-based, then the distortions in respect of firm size would be a concern. If size-based, then very different effects would flow depending on the measure of size, but it is hard to imagine any system, barring one with impossibly high administration costs, not delivering serious price distortions.

These problems arise in any attempt to set marginal prices at a level that deviates from the incremental system costs associated with marginal usage of water. Once this happens, prices are not cost-reflective and investment decisions are likely to be distorted. Of course, water use would probably drop, but the gaming opportunities created by these price differentials could reduce even these benefits – and the drop in consumption could be quite inefficient.

There could be scope for offering incentives for reductions, relative to past use, in water usage – especially if tied to planning. While this might work reasonably from the perspective of individual firms of relatively stable size, it could involve real difficulties in relation to incentives for growth and for tapping size economies – including economies in water usage. More elaborate audit processes might get around these difficulties, but almost certainly at high administrative cost.

The ESC also recognises, without showing any leanings one way or the other, the scope for developing tariff structures across different 'types' of non-residential customers. This approach might, with a lot of effort, address the major within-industry distortions. The chances that it could also deal efficiently with inter-industry distortions, including distortions for firms looking at multi-enterprise arrangements, possibly exploiting joint economies between industries, would seem a lot lower. They would certainly require a lot of effort directed at detailed modelling, and the flexibility and discretion to respond appropriately to new technologies and opportunities for resizing to deliver greater overall efficiencies.

Scarcity pricing

One possible way of avoiding the adverse economic price signals, delivering a truly cost-reflective pricing package and delivering significant incentives for conservation when it would be most valuable is that of scarcity pricing.

The term scarcity pricing has been used fairly loosely and differently in recent years, but we have in mind a specific approach that is the subject of current work being done for the National Water Commission by ACIL Tasman and the Institute for Sustainable Futures. This approach involves implementation of an options-based approach to valuing the system opportunity cost of water usage and its real time variation.

This approach would (probably) retain constant (across customers) unit charges for all non-residential users but would allow these charges to vary over time, dependent on system status in a manner, that is reflective of the *changing assessment of the long-run cost of maintaining system supply*. Deep in a drought, usage can substantially bring forward the expected timing of commitments to new investment in capacity – with significant implications for LRMC. Consequently, the opportunity cost of water usage can vary substantially depending on system status.

Scarcity pricing could involve either usage charges being set at this opportunity cost, or being set on a basis that is related to this opportunity cost. Either way, users face some price uncertainty (not favoured by users based on the survey) but also understand the pricing rules in ways that allows for planning to reduce exposure. The above results certainly point to a willingness to adapt behaviour in light of future price risk, so we would certainly expect such pricing to post conservation incentives – even outside of droughts. These incentives would rise with increased appreciation of the impact of climate change (assuming the assessment remains adverse).

For scarcity pricing to be implemented in a way that posts timely incentives and that meets utility revenue requirements would almost certainly require a change to the regulatory arrangements.

Fixed vs. usage cost relationships

It is not inconceivable that pricing for all usage at a price approximating the long run marginal cost could involve revenues in excess of investment needs – given continued access to the sunk, and relatively low cost, existing infrastructure. Fixed charges for non-residential users are only modest and even moving to a zero fixed charge might imply excess revenues.

There would be several ways of looking at this. One would be to note that recent trends, by requiring movement into new augmentation with a much higher 'new entrant cost' has effectively resulted in increased value of the sunk investments. Water bills increase, but rates of return, assessed against revalued assets, is unchanged. This would require reopening the RAV – and this would be a big step for the regulation process, though one that *might* be justified, and quarantined, on the basis of the recent substantial shift in expectations regarding future hydrology and appropriate supply augmentation options and timing. In effect, reopening the RAV would recognise the increased market value of the sunken assets.

An alternative option might be to differentiate between the residential and non-residential sectors in terms of allocating the benefit of the existing low-cost supply system (through the allocation of the RAV to customer groups). Concentrating the benefit of the low-cost existing assets on the residential sector would both fit with the equity objectives behind the rising tier tariffs and be less likely to require negative fixed charges to compensate for increasing volumetric prices.

In either of these cases there will be concerns with a very rapid rise in bill costs. However, the evidence above suggests that knowledge of future price rises can be influential in encouraging reduced usage, so there may well be scope for phasing in such an effect, with little if any loss of efficiency and with a lot less pain.

A third option would be to hold the regulatory asset value, and to seek revenues that are adequate – with the implication of negative fixed costs if constant usage charges reflecting LRMC are to be used. This may sound a strange approach, but in fact it would parallel market-delivered outcomes in areas such as telecommunications, where fixed user costs are sometimes negative (free phones etc), subject to a contracted level of forward usage or even just technical configuration to ensure equipment can only be used on the supplier's network.

5 Assessment of strategic options

5.1 Assessment criteria

Traditionally, pricing structures have been assessed in relation to criteria of efficiency, equity and administrative cost and practicality, and in a regulated pricing setting it is common to focus on ensuring the prices recover sufficient, but not 'too much', revenue. In relation to water pricing, Hanemann (1997) identifies three primary roles for a water rate structure, as being: revenue generation, cost allocation and economic incentives. These are discussed further in the issues paper, but some overall comments are worth drawing from that discussion.

The first of the roles is simply to generate sufficient and stable revenues without excessive administrative costs. The second relates to a fair allocation of costs among the different users, the avoidance of cross-subsidies and the full allocation of private and social costs. The third criterion is the more complex, and there are four criteria relevant to the economic incentives of pricing structures: static efficiency, dynamic efficiency, conservation and transparency.

Applying these criteria can be difficult because some conflict, or at least *may* conflict, with each other – for example, revenue stability may conflict with posting the most appropriate price incentives. The final reason for difficulties in applying these principles is the difficulty in measuring and allocating economic costs – and the fact that allocation of fixed costs can interfere with usage incentives. Difficulties in measurement, and commonly a level of arbitrariness in the attribution of some fixed costs, can result in a situation where negotiating power is a key determinant of the outcomes, rather than just the prescriptive application of the principles.

In this paper we are concerned with assessing approaches to pricing for reasonableness, for strengths and for weaknesses – as a basis for consideration of these strategies by the utilities and possibly by regulators and customers – rather than prescribing a specific pricing schedule.

5.2 Critique of user preferences

Based on the survey results, the majority of non-residential users favour flat rate tariffs. Effectively, all non-residential users face the same uniform rate per kL for water used. Reasons why this should come as no surprise include:

- This is the current arrangement, with which users are familiar – 'better the devil you know'.
- It also scores well on simplicity and consistency (with the only real competition being a fixed fee tariff that would almost certainly have been judged by most to be unacceptable or infeasible, and could well have been seen as threatening to any firms with larger competitors.
- Relative to increasing block tariff structures (including excess use tariffs), it might be seen as less threatening to the growth plans that many respondents might harbour.
- A decreasing block tariff would probably be judged not to viable in the present climate and could again be seen as threatening by firms with larger competitors.
- It scores well on simplicity and consistency grounds relative to seasonal tariffs, and we assume that concerns for the costs of seasonal demand/supply variations (that might have favoured these structures on the grounds of incentives) are low.

- It scores well on both simplicity and certainty grounds relative to scarcity pricing.
- In terms of incentive effects, it clearly costs more to use more.

While just over half of all respondents favoured a constant unit price, almost a quarter favoured increasing block or excess use tariffs that would result in increasing unit costs for increased usage. This suggests significant, but clearly minority, support for charging proportionately more to the larger users.

In surveys of this type it is always difficult to ensure a good separation between responses made solely from the perspective of the respondent, with no changes in pricing to other parties, and a response predicated on everyone facing the same changes. This could be important here.

Large companies and companies with growth aspirations are likely to have concerns with increasing block tariffs – they could well impact on competitiveness. Anyone answering solely from the perspective of their company could interpret an increasing block tariff as implying a need to pay more, and could again see this as a concern.

In the context of a detailed face-to-face interview there would have been more scope for ensuring there was a clear and consistent understanding of proposals that would change the structure of the revenues, but not increase the total take. This might have led to a somewhat different position, though it seems unlikely that the overall, pattern would change dramatically.

However, there was almost certainly a level of gaming involved in responses to the questions that look likely to entail some increase in marginal prices or price uncertainty. Respondents would work through what the strategic implications of different answers might be and are likely to gravitate towards the relatively non-threatening status quo.

The preference for uniform unit charges is strong but not overwhelming compared to more 'incentive-oriented' pricing. It is not inconceivable that the gap could be narrowed through a different approach, emphasising the severity of the shortages, the need to both conserve and to appropriately allocate to large users the costs of scarcity etc.

Another way of looking at this could be that the evidence does not rule out scope for selling some form of increasing price if it clearly offered benefits overall and if immediate concerns for own-business competitiveness could be addressed. However in practice, we see serious practical difficulties with these increasing marginal price arrangements for non residential customers.

5.3 Increasing marginal price

Along with the relevant discussion in Section 4, the ESC's commentary is highly relevant here, though we believe it can possibly be pushed even further. There would be a need for a resource-intensive and on-going administrative/regulatory function – with quite demanding information requirements – if serious distortion in market incentives across different sectors and businesses is to be avoided. Even then, it is doubtful that the process could avoid reducing the flexibility of the market to seek out more efficient business models.

The ESC notes the relatively greater homogeneity of residential units compared to businesses – in terms of the value of water and the scope for adjusting behaviour to alter water usage. It does not follow that there is homogeneity – large vs. small families, houses with gardens vs. high rise etc can be quite significant. However, such effects are likely both to be modest relative to variation across commercial enterprises, and to be amenable to relatively easy adjustment should there be a need/desire for this. Under these circumstances, increasing block tariff arrangements could probably be targeted with reasonable equity and limited economic inefficiencies.

The ESC does raise the possibility of different pricing models for different types of businesses. This could address some of the problems with inclining tariffs, but not all. Furthermore, the different types would create a range of 'boundaries' between types, with incentives for gaming the pricing differences.

5.4 Improving the basis for setting uniform rates

Textbook economics focuses on marginal costs as the key determinant of investment incentives. There is some truth in this – but some care is also needed as has already been recognised. An inclining block tariff that imposes a higher charge on the last 5 per cent of water usage may well not be enough to justify reengineering a business. There is an inherent 'lumpiness' in many business structures, and there is likely to be a size of avoidable cost that determines whether a strategic investment in water usage efficiency is justified or not. If the costs are avoidable across all of a firms production that might in fact post a stronger incentive than an inclining tariff involving a similar bill cost.

It seems highly unlikely that current usage charges are currently close to a soberly assessed long run marginal cost or other mainstream measure of the incremental cost of water usage. With usage charges currently around 90 cents, this almost certainly reflects out-dated estimates of LRMC, which do not take account of the impact of climate change and the current drought.

One possibility would be to continue towards explicit LRMC pricing with higher volumetric prices, but retaining the constant rate structure with its simplicity, predictability etc – and hence avoiding the above distortions. This might include compensating adjustments to fixed costs (though this might well entail an need for negative fixed charges in some cases) or might be handled by recognising that the now much elevated cost of system augmentation has effectively pushed up the market value of the sunk assets.

The results from the earlier data analysis strongly suggest that a move to such arrangements could be staged over several years, probably without greatly diluting the incentives for large users to move as quickly as is practical to adjust to the new price expectations.

6 References

Essential Services Commission (2006), *2008 Water Price Review Consultation Paper – Framework and Approach*, December.

Hanemann, M. (1997), "Price and Rate Structures", in *Urban Water Demand Management Planning.*

Confidential

Appendix A: Literature Review

Pricing for water conservation in the non-residential urban sector

Prepared for the Steering Committee of the Smart Water Fund

June 2006

ACIL Tasman

Economics Policy Strategy

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1 Introduction

This literature review aims to encapsulate pertinent domestic and international research on non-residential urban water pricing. This is a targeted but comprehensive review of the literature, structured to provide support to the project team undertaking the analysis of non-residential urban water demand.

This review is structured to:

- Identify the possible pricing structures and any evaluation of the experience with alternative pricing structures for non-residential water customers adopted in other jurisdictions;
- Summarise the theoretical and empirical literature on the price elasticity of non-residential demand for water; and
- Examine the pricing frameworks adopted in other relevant industries that might assist in identifying and assessing alternative pricing approaches for water.

2 Pricing Structures

There is a diverse range of pricing structures exhibited internationally, and even within countries, due to the regional nature of water supply in many countries. Whilst there are a number of studies comparing the price of residential water supply there are far fewer relating to non-residential urban supply.

The main reason for this is the difficulty in gathering comparable data about commercial and industrial demands. Firstly, only broad aggregates are available from which comparisons can only be constructed with difficulty. Secondly, industrial and commercial firms use water for different purposes and in different intensities and qualities; some have the flexibility to adjust their water use, others do not. Finally, when sewerage and trade-effluent charges and regimes are incorporated into the analysis a bewildering array of pricing structures are demonstrated. In addition, municipal supply of water can be a relatively small proportion of industrial supply when there are substitute sources of water, and when abstraction charges and discharge fees are included in the analysis, the result is even greater complexity.

Michael Hanemann[1] identifies three primary roles for a water rate structure, being: Revenue generation, cost allocation and economic incentives. The first of these is simply to generate sufficient and stable revenues without excessive administrative costs. The second relates to a fair allocation of costs among the

[1] "Price and Rate Structures", Hanemann, M., in Urban Water Demand Management and Planning, 1997.

different users, the avoidance of cross-subsidies and the full allocation of private and social costs. The third criterion is the more complex, and the one which is explicitly addressed in this literature review.

Hanemann identifies 4 criteria relevant to the economic incentives of pricing structures: static efficiency, dynamic efficiency, conservation and transparency.

Applying these criteria is difficult because some conflict with each other, such as revenue stability and economic efficiency. Other reasons for differences in rate structures are the different balances of power and lobbying in the rate setting process. The final reason for difficulties in applying these principles in pricing is the difficulty in measuring and allocating economic costs.

2.1 Tariff Structures

This literature review has sought to identify the different tariff structures that are used in the water industry to meet these conflicting criteria. In most jurisdictions water and sewerage charges are based on a fixed charge combined with a usage charge, a so called “two-part tariff”.

The fixed fee is theoretically justified as a contribution to the water business’ costs of infrastructure and holding capacity. It should be independent of the volume of water, but related to the peak supply capacity. In many jurisdictions these relate to the meter size and are accordingly labelled “metering charges”.

Usage charges are levied on the metered usage of the customer. Following Coase (1964) society’s welfare is maximised where price is equal to marginal cost. However, marginal costs are difficult to quantify, and much of the debate about usage pricing revolves around this subject.

The following usage charges are analysed in this survey:

- Fixed Fee
- Uniform Rates
- Increasing Block Tariffs
- Seasonal Rates
- Excess-Use Rates
- Pyramid Rates
- Sliding-Scale Rates
- Scarcity Pricing
- Spatial Pricing

Although many of these tariff structures are applied to non-residential customers internationally, there are very few studies which provide specific case-studies or analysis of the impacts of these schemes on non-residential demand. Often analysis is limited to studies whereby non-residential consumption is combined with residential demand; studies which control for the impact of other demand-management policies to isolate the effect of pricing policies on non-residential demand are even rarer.

The following sections detail the tariff structures which are applied internationally, and where an analysis of the impact of this tariff is available, these are detailed in the relevant section. Table 1 also summarises the tariff structures evidenced internationally in 1999 according to the OECD survey of industrial water prices carried out at that time. Section 2.2 also details the structures for sewerage services and section 2.3 details structures for trade effluent charges from the same OECD survey.

2.1.1 Fixed Fee

In some countries, non-residential customers are charged a fixed fee only, with no usage element. Often this fee is based on rateable value, property size or a maximum level of consumption, and there was no charge for usage up to limits.

Previously in Melbourne there was a free allowance which applied to water consumed up to the value of the rate charge, which essentially represented a fixed fee to this point.

The OECD study of industrial water pricing identified that some provinces of Canada allow their water companies to negotiate prices individually with industrial users, and that this sometimes resulted in fixed fees. However, this study was carried out in 1999 and there are several studies of the Canadian non-residential water demand which indicate that such contracts are being replaced with more conventional pricing structures. There is evidence that residential rates in Canada remain flat, and some irrigation tariffs remain flat, based on the size of the irrigable area.

Whilst this method may ensure stable and sufficient revenues, it is unlikely to lead to appropriate allocations of costs, and it is accepted that this structure provides no economic incentives for water conservation and is being discontinued in all countries facing water shortages.

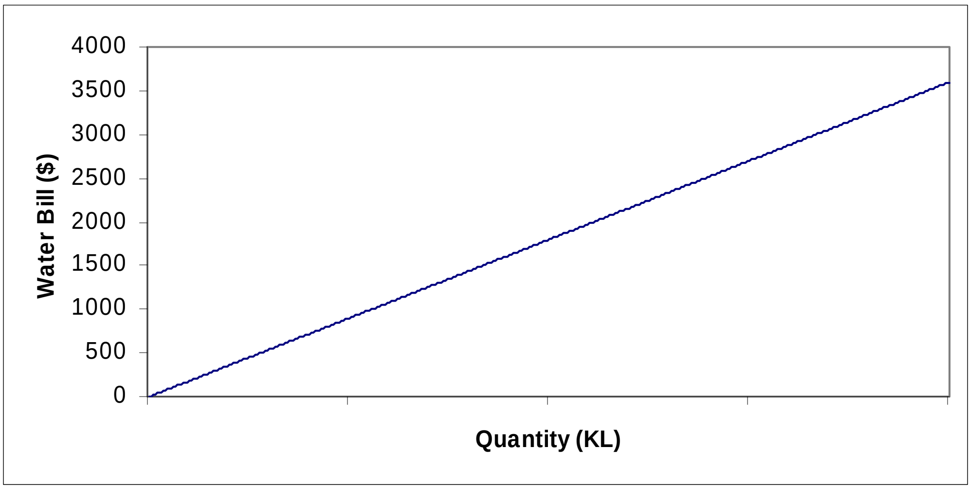
Steven Renzetti is based in Canada, which has historically offered industrial users fixed fee tariffs, and he has produced a number of studies of the industry which indicate that the price of water in industrial uses is very low (typically below 1% of total costs) and that accordingly the price elasticity of demand is low.

2.1.2 The Uniform Tariff

A uniform tariff relates to a fixed price for the usage of water which does not vary between customers. Where more than one water quality is supplied, prices may vary, but the price for a given quality is uniform.

Since price is constant, the cost to the non-residential user is a simple linear function as shown in Figure 1 below. Often uniform tariffs are used in combination with fixed charges, as part of a two-part tariff system.

Figure 1 **Water charges under a uniform tariff**



Uniform tariffs are commonplace for non-residential users, and are currently employed by all three water retailers in Melbourne; the ESC in its 2005 draft determination on water prices indicated that it believed that uniform tariffs were the appropriate mechanism for pricing non-residential water and wastewater services. Other countries which utilise this system include: Canada, USA, UK and Japan, although there are variations within each of these countries.

As an example of the effectiveness of moving from a flat fee to a two part tariff incorporating a uniform usage charge, Hunter Water introduced a two-part tariff for residential customers in 1982. After imposition of the tariff, average consumption declined by 10% in the first year[2], and another 10% in the second year. Over the nine years after its introduction, consumption was reduced by 30% against the trend that existed prior to the 1980–82 restrictions. Higher consuming customers reduced use by 60 percent, middle range consumers reduced by 15%, and lower range consumers, except for those below 100 kilolitres per year, held roughly constant. Elasticity of water

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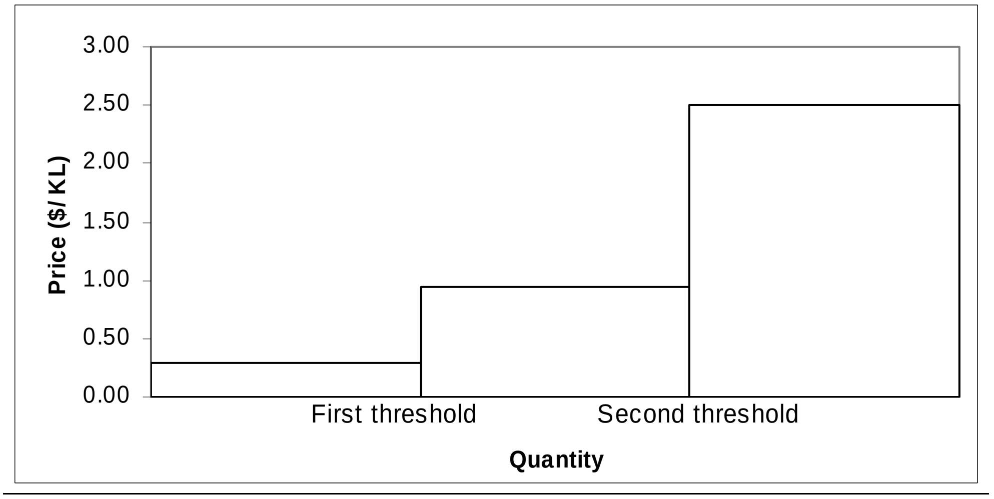
[2] Broad, P.A., Hunter Water Corporation (1992) "The `User- P a y s ' Principle: How its Introduction Can Prepare Service Providers for a Competitive Service Environment. A Case Study by the Hunter Water Corporation".

consumption was therefore found to be highest at high consumption (-0.70); low at average consumption (-0.20), and very inelastic at low consumption (-0.05). Of course, these data are simplistic in that other factors such as consumer education have not been controlled for in this analysis, and some estimates indicate that the tariff structure only account for one third of the reduction in overall demand, but even this reduction would be substantial.

2.1.3 Increasing Block Tariffs

This tariff structures demonstrates an increasing price for larger purchases of water as demonstrated in Figure 2 below.

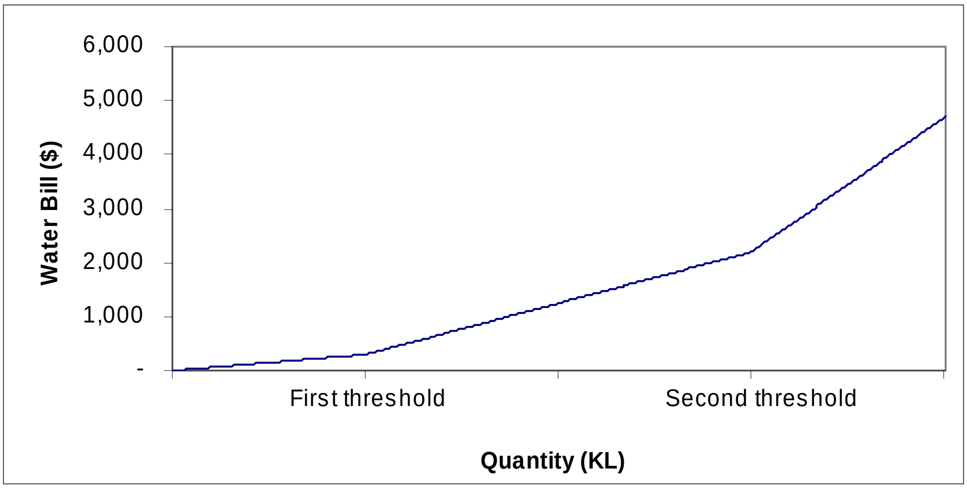
Figure 2 **Increasing block tariff structure**



Such tariffs can be effected in two ways: either the marginal price can increase once the volume supplied has crossed a threshold, so that the price will now be higher for additional units ("Increasing Block Tariff"), or the tier change can affect the price of previously provided "infra marginal" units ("Sliding Scale Rates"), so that the total supply is now at the higher price. The effect of increasing block tariffs on the cost of water to the non-residential user is shown graphically in Figure 3.

Thresholds can vary by season under quarterly billing, or can be related to a percentage of normal winter use (see scarcity pricing).

Figure 3 **Water charges under increasing block tariffs**



A difficulty in estimating the price elasticity of demand under increasing block tariffs is that both the price and the quantity are selected simultaneously by the customer, and the regression technique should incorporate this, as well as the production function of the customer.

Increasing block tariffs are more commonly used for residential customers, although the use amongst non-residential customers is increasing across the countries surveyed in this literature review. However, in its March 2005 draft determination on metropolitan and regional businesses' water plans the ESC did not approve inclining block tariff structures proposed by North East Water, Portland Coast Water and South West Water for non-residential customers on the basis that there are large variations in consumption levels and difficulties in defining non-discretionary water use for non-residential users. Declining block tariffs were proposed by Central Highland Water for non-residential consumers and were not approved on the basis that they do not send appropriate signals about water conservation. The ESC determined that a uniform rate should be applied which reflects the LRMC of supply.

San Antonio (USA) has four increasing block tariffs for residential users, but operates only two blocks for industrial and commercial customers. In the city of Cleveland (Ohio, USA) increasing block tariffs are directed at industrial users, nearly doubling the price from the first block to the next.

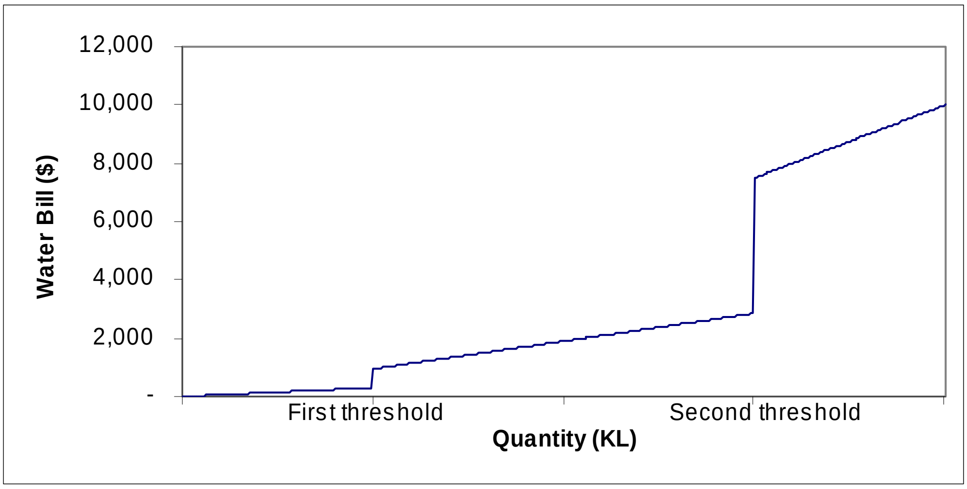
Tucson Water (USA) has employed increasing block tariffs as a conservation measure for over a decade. Unfortunately, whilst an impact assessment of non-residential customers is difficult to find, the impact of seasonal increasing block tariffs was that usage in the upper half of the volume bands decreased from 8.8% to 6% of residential consumption, and weather normalised consumption in the peak month declined 11% between 1982-6.

Wang et al. note that with low price elasticities of demand, regulated utilities receive an increase in revenue from increasing the price of water, and that care must be taken if the goal of revenue neutrality is to be maintained while moving towards conservation-based pricing. This typically involves lowering the fixed access component of a two-part tariff.

2.1.4 Sliding Scale Rates

In a similar fashion to increasing block tariffs, the price of water increases with the amount consumed, although with sliding scale rates the price for the total supply rises with consumption, so that the price is raised for the "infra-marginal" supply. Figure 4 shows the total cost of water for a company facing sliding-scale rates.

Figure 4 **Water charges under sliding scale rates**



Such sliding scale rates are currently applied to residential water users in government housing in parts of Western Australia[3]. They are less common in non-residential situations. Some discussions of tariffs seem to confuse sliding scale rates and increasing block tariffs.

2.1.5 Seasonal Rates

Seasonal rates imply that increases in the opportunity cost of water during peak demand months are reflected in the price. This is in some respects a form of marginal cost pricing.

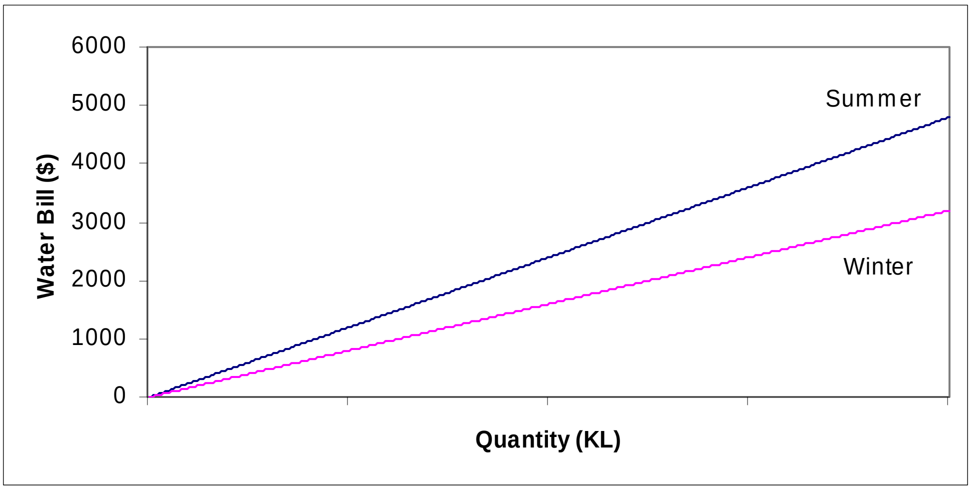
For non-residential users, this scarcity may reflect increases in agricultural and residential outdoor demand, and not be caused by an increase in non-residential water demand. However, seasonal rates have been justified in

[3] http://www.dhw.wa.gov.au/396_532.asp

tourist communities to recoup the infrastructure costs that exist because of tourist-generated peak demand, but are not paid outside of the peak season.

The impact of seasonal rates on consumers' water bills is demonstrated in Figure 5 below.

Figure 5 **Water charges under (uniform) seasonal pricing**



Seasonal rates operate throughout much on the US Midwest and the tourism-based seasonal charge is currently operating in Kentucky, USA. Seasonal tariffs also apply in French municipalities including the south of France. In Sweden as described by the OECD 1999 survey, seasonal tariffs were explicitly banned.

Seasonal rates could also be applied to two-part tariffs and fixed fee tariffs.

2.1.6 Excess-Use Rates

Excess-use rates are similar to increasing block tariffs, but demonstrate a marked increase in the price for above average use. This is a penalty rate to discourage over-consumption. As with increasing block tariffs the quantity level at which the price increases, and the amount of the increase are crucial factors in the extent to which they work as an economic incentive.

Excess-use rates are applied to irrigators in El Paso (Texas, USA), where they are monitored by irrigation meters. Water Corp also employs excess use rates in the Goldfields.

2.1.7 Decreasing Block Tariffs

These tariff structures demonstrate a decreasing price for larger purchases of water as demonstrated in Figure 6 below.

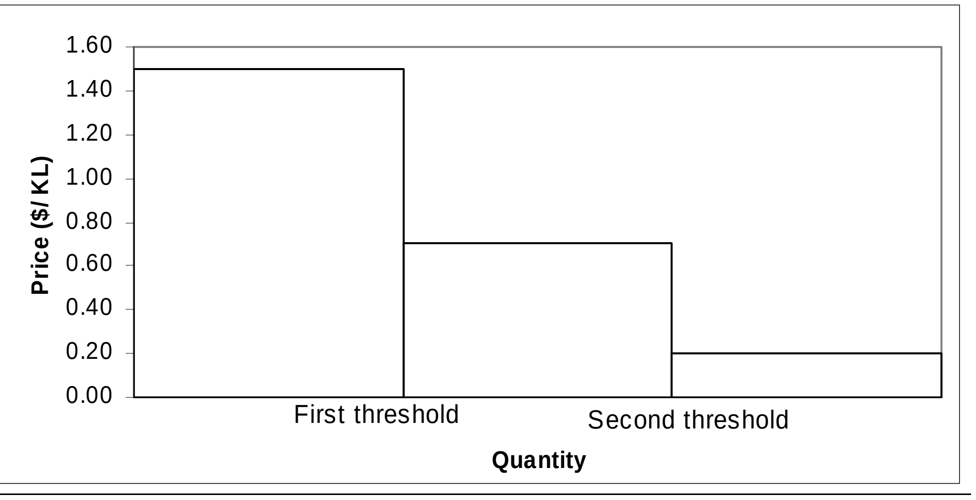
These structures were introduced in the UK on the grounds that "Large users may have more stable demands, avoid some peak costs (particularly if on site storage is provided). Where water is supplied in large pipes, some of the costs in the distribution system (including leakage) may also be avoided.[4]"

Water companies in the UK continue to offer decreasing block tariffs to large users, although they levy a higher capacity charge on these customers, and also charge penalty rates on the customer if they exceed their allotted capacity[5].

In Belgium large users of water may negotiate special supply contracts which can significantly reduce the price of water supplied. In France and Canada, large users and water companies may negotiate the volumetric rate, and this sometimes results in decreasing-block rates.

The Hunter Water Corporation in New South Wales offers decreasing block tariffs for water supply to its residential and non-residential customers, although this is to be phased out in the period to 2009.

Figure 6 **Decreasing block tariff**



Decreasing block tariffs do not provide incentives to reduce water consumption, and do not reflect the increasing marginal cost of supplying a scarce resource.

For this reason the Texas Natural Resource Conservation Commission does not allow decreasing rates and has the capacity to force all utilities under its supervision to utilise at least a uniform rate.

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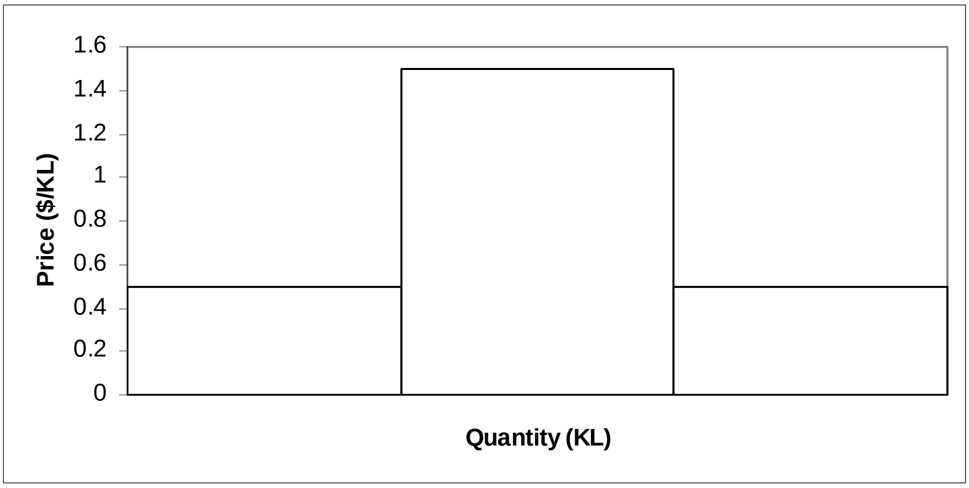
4 Ofwat, RD9/93, "Tariffs for Business Customers", June 1993.

5 http://www.ofwat.gov.uk/aptrix/ofwat/publish.nsf/AttachmentsByTitle/Largeusertariffs05-06.pdf/$FILE/Largeusertariffs05-06.pdf

2.1.8 Pyramid Rates

It is possible to set rates to redistribute the costs of water in a way that may reflect the costs of peak supply to users. Pyramid rates apply low rates to small users, low rates to consistently large (without peak) users and relatively high rates to other users.

Figure 7 **Pyramid rate structure**



Pyramid rates are rare for industrial users, although the Louisville Water Company (Kentucky, USA) sets rates to reduce costs for residential users and to large industrial and commercial water users who consume at the same high volume throughout the year. This creates a pyramid block that includes a low cost per thousand gallons for both relatively small consumers and large industrial consumers, and a relatively high block for consumers, such as restaurants, who use water in amounts typical of intermittent heavy users. This method of pricing is not a water conservation rate, given that the heaviest users pay the lowest rate.

2.1.9 Peak Pricing, Scarcity Pricing (Drought Rates)

Drought rates were applied by the Los Angeles department of water and power (LADWP) in 1993 in combination with a move to create revenue neutral increasing block tariffs during normal hydrological conditions. For non-residential users, LADWP did not use an absolute amount as the threshold for the increasing block tariff, instead it was determined to be 125% of their normal winter use. The second block rate was the same for all users, and was based on LADWP's estimate of the LRMC of supply. These increasing block tariffs were adjusted to reflect scarcity conditions in drought years, with a reduction in the threshold in proportion to the severity of the drought combined with an increase in the second tier tariff based on the estimated price which would equilibrate demand and supply. Data are not available to determine the success of the scheme, but after recalibrating the threshold to take account of local climates and requirements, and to better reflect local variations in the value of water, the seasonal increasing block tariff and the scarcity uplift are generally well regarded and have (in combination with other water-conservation measures) reduced water demand.

2.1.10 Spatial Pricing

This pricing structure attributes the estimated cost of supplying water to the customer's premises. This discourages new or difficult-to-serve connections, and requires an accurate schedule of connection costs, joint costs and the marginal cost of supply. Developer charges often provide an element of spatial pricing, although the use of uniform developer charges distorts the economic incentives associated with this form of pricing.

2.1.11 Combination Tariffs & Self-Selection

It was noted during the review of international tariffs that tariffs offered for large and intermediate non-residential users in the UK are varied, and that customers can select different combinations of higher-fixed charges and lower usage charges, interruptible supply and non-interruptible supply[6].

This self selection allows users to choose the tariff structure which minimises their costs.

2.1.12 Summary

Although dated, the 1999 OECD survey provides the most comprehensive information about industrial tariff structures employed internationally, and this information is reproduced below:

Table 1 **Industrial water pricing in OECD countries**

	Tariff structure	Full cost recovery	Non-discrimination	Marginal Cost Pricing	Different tariffs for industry?	Special tariffs	Subsidies
Australia	Fixed + volume-based	yes	no	yes	yes	no	n.a.
Austria	Fixed + volume-based	yes	no	n.a.	no	n.a.	yes
Belgium	Fixed (meter rental) + volume-based	yes	yes	n.a.	no	Large volumes	Regional
Canada	Fixed fees (annual fees) or volume-	no	no	no	yes	Contract-based	yes

[6] A summary of the available tariffs in the UK is provided at: http://www.ofwat.gov.uk/aptrix/ofwat/publish.nsf/AttachmentsByTitle/Largeusertariffs05-06.pdf/$FILE/Largeusertariffs05-06.pdf

	based, decreasing-blocks						
Czech Republic	n.a.	yes	no	n.a.	yes	Contract-based (lower quality)	yes
Denmark	Connection (based on area) + fixed (various bases) + volume-based	yes	yes	n.a.	no	no	no
Finland	Connection + fixed (meter and property size) + volume	yes	yes	no	no	Exceptionally contract-based (large users)	Negligible
France	Connection + fixed + volume (decreasing-blocks)	yes	yes	yes	yes	Contract-based	yes
Germany	Fixed + volume-based	yes	yes	yes	yes	Large users, contract -based	no
Greece	Connection + volume-based	n.a.	no	n.a.	yes	n.a.	yes
Hungary	Volume-based	n.a.	n.a.	n.a.	n.a.	Capital contributions	yes
Iceland	Fixed (meter fee) + volume (varies with meter size)	n.a.	n.a.	n.a.	yes	n.a.	n.a.
Ireland	Connection + volume based	no	no	n.a.	yes	Capital contributions	yes
Italy	Fixed (meter fee) + volume-based (rising blocks)	no	no	yes	no	Industrial networks	yes
Japan	Fixed (pipe size) + volume	no	no	no	n.a.	Contract-based	yes
Korea	Fixed (pipe size) + volume	yes	no	no	no	no	yes
Mexico	Fixed + volume, majority are increasing-block tariffs	no	no	no	n.a.	n.a.	yes
Netherlands	Connection + fixed (size of meter) + volume-based	yes	yes	no	no	Operating hours	no
New Zealand	Annual fee + volume-based	n.a.	n.a.	no	n.a.	n.a.	n.a.
Norway	Connection + fixed charge	yes	n.a.	n.a.	n.a.	n.a.	Regional
Poland	Volume-based	n.a.	no	n.a.	n.a.	n.a.	yes
Portugal	Fixed (meter size) +volume (increasing-blocks)	no	n.a.	n.a.	yes	n.a.	n.a.
Spain	Diversity of structures Majority are increasing two-blocks	no	n.a.	n.a.	n.a.	n.a.	yes
Sweden	Fixed (size industrial estate, meter size) + volume-based	yes	no	yes	no	Cooling water tariff.	no

Switzerland	Fixed + volume-based	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Turkey	Fixed + volume based	no	no	no	yes	Contracts	n.a.
UK	Connection + fixed (pipe size) + volume-based	yes	yes	no	yes	Large- user tariffs	no
US	Connection and development fees, diversity of block structures More increasing-block rates	yes	no	no	yes	Seasonal tariffs Excess use charges	no
Australia	Fixed + volume-based	yes	no	yes	yes	no	n.a.
Austria	Fixed + volume-based	yes	no	n.a.	no	n.a.	yes

Note: "n.a." "data not available"

- Tariff structure: What types of *tariff structures* are in place?
- Full cost recovery: Are total revenues required to cover operating expenditure, plus depreciation, plus a return on capital employed?
- Non-discrimination Are the tariffs for each customer group required to reflect the costs of the customer group concerned?
- Marginal Cost Pricing: Is there any *marginal cost pricing?*
- Different tariffs for industry? Do industrial customers have a *different tariff structure* compared with other customers?
- Special tariffs: Are there any *special tariffs* for industrial customers?
- Subsidies: Are there any *subsidies*?

Data source: OECD, "Industrial Water Pricing in OECD Countries", ENV/EPOC/GEEI(98)10/FINAL, 1999.

However, this study is now very dated, with more cost reflective and conservation-oriented pricing being introduced for non-residential customers in most countries since 1999.

2.2 Wastewater pricing

It was not possible to identify any case where there was a direct cost for the use of the sewerage system. In the majority of cases, the sewerage charge was levied on the same basis as the potable water supply. That is, if a fixed fee was employed, the sewerage charge was a fixed fee. If a uniform tariff was employed for water supplied, then the sewerage charge was levied on the basis of the a uniform charge, and the same applied for increasing and decreasing block tariffs where the charges were related to the water intake.

Because the level of water returned as waste is not the same quantity as that supplied, the volume assumed to be returned is a scaled percentage of the water supplied, where this discharge factor is often related to the customer's industry.

For example, Southern Water in the UK levies its residential sewage charge on a uniform basis, but the percentage of water supply assumed to be returned through the sewers is higher in the winter than the summer to reflect the increased outdoor use in the summer.

The table below details sewerage tariffs as presented in the OECD's 1999 survey. Again, caution should be exercised due to the age of this study.

Table 2 **Industrial sewerage tariffs in OECD countries**

	Sewerage Charge	Tariff structure	Full cost recovery	Non-discrimination	Marginal Cost Pricing	Different tariffs for industry?	Special tariffs	Subsidies
Australia	Yes	Fixed (various basis) + volume basis (various basis)	Yes	No	Yes	Yes	Yes	n.a.
Austria	Yes	Fixed (property size) or volume based on water use	Yes	No	n.a.	No	Yes	Partial rebates if less discharges than water used
Belgium	Yes	Depends on load	Yes	Yes	n.a.	Yes	No	n.a.
Canada	Yes	Treatment costs included in water bill if no extra strength	n.a.	n.a.	No	Yes	n.a.	n.a.
Czech Republic	Yes	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Denmark	Yes	Fixed (size of property) + Based on water volume	Yes	n.a.	n.a.	n.a.	No	n.a.
Finland	Yes	Paid within the water bill Volume + connection charges	Yes	Yes	No	No.	negl.	n.a.
France	Yes	Percentage of water bill	n.a.	n.a.	n.a.	Yes	n.a.	Contract-based
Germany	Yes	Based on water volume or surface area	Yes	Yes	Yes	Yes	No	Rebates if less discharges than water used
Greece	Yes	Based on water volume	n.a.	n.a.	n.a.	n.a.	No	n.a.
Hungary	Yes	Based on water volume	n.a.	n.a.	n.a.	n.a.	Yes	n.a.
Iceland	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Ireland	No	Within water bill, not separate	n.a.	n.a.	n.a.	n.a.	Yes	Capital contributions
Italy	Yes	Based on water volume	No	No	Yes	Yes	Yes	n.a.
Japan	Yes	Based on water volume	No	n.a.	n.a.	Yes	Yes	n.a.
Korea	n.a.	Based on water volume	Yes	No	No	No	Yes	None
Luxembourg	Yes	Based on water volume	n.a.	n.a.	n.a.	n.a.	Yes	n.a.
Mexico	Yes	Based on water volume	No	n.a.	n.a.	n.a.	Yes	n.a.
Netherlands	Yes	Function of pollutant	Yes	n.a.	n.a.	Yes	Yes	n.a.
New Zealand	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Norway	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Poland	No	Percentage of water bill	n.a.	No	n.a.	Yes	Yes	n.a.
Portugal	Yes	Based on water volume or property size	n.a.	n.a.	n.a.	n.a.	Yes	n.a.
Spain	Yes	Recover operating and maintenance costs	Yes	No	n.a.	Yes	No	n.a.
Sweden	No	Fixed (size of meter or property) + volume based	Yes	No	Yes	Yes	No	n.a.
Switzerland	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Turkey	Yes	Based on water volume + Connection charge	No	No	No	Yes	Yes	n.a.
UK (England and Wales)	Yes	Based on water volume Surface and highway drainage	Yes	Yes	n.a.	Yes	No	Large user tariffs
US	Yes	Uniform structure, or increasing-block tariffs	n.a.	n.a.	n.a.	Yes	n.a.	No seasonal tariff

Note: "n.a." "data not available"

- Tariff structure: What types of *tariff structures* are in place?
- Full cost recovery: Are total revenues required to cover operating expenditure, plus depreciation, plus a return on capital employed?
- Non-discrimination Are the tariffs for each customer group required to reflect the costs of the customer group concerned?
- Marginal Cost Pricing: Is there any *marginal cost pricing?*
- Different tariffs for industry? Do industrial customers have a *different tariff structure* compared with other customers?
- Special tariffs: Are there any *special tariffs* for industrial customers?
- Subsidies: Are there any *subsidies*?

Data source: OECD, "Industrial Water Pricing in OECD Countries", ENV/EPOC/GEEI(98)10/FINAL, 1999.

2.3 Trade Waste Charges

Charges for trade waste are based on the user-pays principle and are determined with reference to the nature, strength and amount of pollutants in the water and the cost of dealing with these. This is a common practice, and variations are mostly found in the details of the charges, such as the frequency of inspections, the level of on-site treatment that is required and the prices charged per unit of pollutants.

A general overview of the Trade Waste Regimes internationally was presented in the OECD 1999 survey, which is reproduced below:

Table 3 **Trade effluent charges in OECD countries**

	Strength charge?	Levied by?	Based on?	Specifications
Australia	Yes	Service providers	List of pollutants	Levied by certain providers only
Austria	Yes	Some municipalities	For example, COD above given volume of water used	Applies everywhere
Belgium	Yes	Municipalities — Fund	Pollution unit, based on industry factor	Some charges on water temperature
Canada	Yes	Large municipalities	Percentage added to water bill	Levied by certain providers only
Czech Republic	Discharge charges	n.a.	n.a.	n.a.
Denmark	Yes	Municipalities	Volume and pollution control	Levied by certain providers only
Finland	Yes	Municipalities	Volume + pollution content (extra cost)	n.a.
France	Yes	River Basin Agencies	Allocated pollution loads by industry Pollution parameters	Charge varies with pollution location, applies everywhere
Germany	Yes	Länder or municipalities	Pollution unit by pollution parameter	n.a.
Greece	No	n.a.	n.a.	n.a.
Hungary	No	n.a.	n.a.	n.a.
Ireland	Yes	Local authorities	Volume related	Levied by certain localities only
Italy	Yes	Municipalities	Quantity + quality criteria	n.a.
Japan	Yes	n.a.	n.a.	Levied by certain municipalities only
Korea	Discharge charges	n.a.	n.a.	n.a.
Luxembourg	Discharge charges	n.a.	n.a.	n.a.
Netherlands	Yes	Water Boards	Charge per pollution unit	Large industrials are closely monitored
Poland	Discharge charges	n.a.	n.a.	n.a.
Portugal	No	n.a.	n.a.	n.a.
Spain	Yes	River Basin Agencies invest in treatment	Pollution content in population equivalent	Applies everywhere
Sweden	Yes	Municipalities	Pollution content	Contract based
Turkey	Yes	Municipalities	Fixed charge plus pollution	Applies everywhere

			content	
UK (England & Wales)	Yes	Water companies	"MOGDEN" formula (pollution content)	Varies
US	Yes	Water networks	Pollution content	Monitoring expenses

Note: "n.a." "data not available"

Data source: OECD, "Industrial Water Pricing in OECD Countries", ENV/EPOC/GEEI(98)10/FINAL, 1999.

3 Elasticities for Non-Residential Water Demand

3.1 Introduction: Common themes

There is considerable research available for review on the topics of domestic or agricultural demand for water, but remarkably little attention has been directed to studies of industrial demand. In Melbourne, non-residential demand for water accounts for 28% of total water consumption, relating to use by industrial and commercial customers.

In the case of commercial and industrial demand analysis, the statistical or econometric approach involves estimating the relationship between inputs from actual observations on quantities consumed and costs of water, together with the corresponding data on other explanatory variables. Furthermore, economic theory suggests that in addition to the price of water, the prices of other factor inputs, the type of technology or production process and output level might be significant. Where there are non-uniform prices, the price and the quantity consumed are determined simultaneously by the consumer. However, relatively few studies have access to data at the individual customer level, which is required to model the interaction between the consumer's production technology and the tariff-quantity choice available to him. Instead data are typically aggregated across users.

The majority of econometric studies of industrial water demand specify the production function as a translog function. This is because this function is derived as a local second-order (Taylor series) approximation to an arbitrary cost function (in logarithmic form) and its flexible form fits data better than alternative, more restrictive formulations. The translog form does not a priori impose particular productivity and scale restrictions, but rather permits these aspects to be established by the parameter values (Krouse, 1990; Renzetti, 1992). The translog form also provides the coefficient estimates necessary to compute the own-and cross-price elasticities of water use.

3.2 The Literature

3.2.1 Water supply

The literature review was first conducted on Google, casting the widest net regarding available articles. A variety of searches were performed, with the intention of finding articles which either contain empirical estimates of non-residential price elasticities of demand, or a theoretical discussion of the issues in estimating price elasticities of demand in the non-residential sector. The most successful specification terms were: *Industrial urban water demand price elasticity*.

The earliest paper reviewed was Grebenstein and Field (1979), which used aggregate data from the US at state level for the year 1973 and used average prices incurred, cost shares for water ranged between 1.2% and 1.9% with resulting price elasticities of demand ranging between -0.33 and -0.80. This paper also demonstrated that labour and water were substitutes, and that water and capital were complements.

Babin, Willis and Allen (1982) used translog production functions for different manufacturing industries in the USA. They used aggregate data and four inputs to production. The cost share of water was typically below 1%. The price elasticity ranged between +0.14 in the food industry to -0.66 in the paper and wood industry.

Ziegler and Bell (1984) analysed a sample of 26 industrial users in the high water use industries of paper and chemicals in Arkansas (USA) using a Cobb-Douglas production function and using the average price of water as the relevant input price. The elasticity was extremely low, at -0.08.

Williams and Suh (1986) used data across 120 municipalities in the USA during 1973. Industrial water demand depended upon price, the value of production in the municipality and the number of industrial connections in the municipality. Demand equations were estimated with OLS separately using the marginal price and the average price. The price elasticity estimates ranged between -0.44 and -0.97 depending on the price specification being considered.

Schneider and Whitlatch (1991) estimated water demand elasticity for six classes of water user. Explanatory variables tested were price; per capita income; resident population per user account; housing composition; and summer precipitation. Pooled cross-sectional and time series annual data from the city of Columbus, Ohio were used in the analysis. A partial adjustment, generalized least-squares model with cross-sectional dummy variables was used to estimate coefficients. Price was a significant factor for all user categories (including municipal and commerce) except industry.

The seminal paper analysing the price elasticity of industrial demand for water was Renzetti[7] in 1992. In this paper a sample of 2000 Canadian industrial firms across seven industry subgroups was conducted, modelling four types of water input, other inputs and the prices of these inputs using a translog production function. The sample represented 95% of total water used by the manufacturing industry. Price elasticities were significant in four of the industries and ranged between -0.15 and -0.59. Renzetti also showed that intake and recirculation were substitutes. This study was repeated in Dupont and Renzetti (2001) where again water intake was a substitute for recirculation as well as energy, labour and capital. The median price elasticity of demand was -0.77.

Renzetti (1998) analysed four types of water input in four manufacturing subgroups using a Cobb-Douglas specification of the production function. His estimates of the price elasticity of demand were between -0.12 and -0.54.

Whilst Renzetti's specification of production functions and input choices was groundbreaking, his results may not carry across to other countries, as the Canadian tariff structures are predominantly flat, do not recover marginal costs and allow for industrial users to negotiate separate contracts. Renzetti was also more focussed on large, non-urban industrial users, for whom water abstraction and self-treatment are viable substitution options.

Wang and Lall (1999) used a marginal productivity analysis to generate price elasticities for industrial demand in China and generated an elasticity of -1.0. This method used the derived marginal cost of water as a variable in the analysis. This is higher than the actual price faced by firms and may therefore overstate the price elasticity of demand by artificially increasing the proportion of costs represented by water in the industries studied.

Onjala (2001) analysed the determinants of industrial demand in Kenya incorporating the effects of corruption and non-payment into the analysis. Tariff rates in the five districts analysed were two-part tariffs incorporating either increasing and decreasing block tariffs. Water rates had been increasing rapidly since 1990 and represented a higher proportion of total input costs than the studies carried out in more developed nations. Onjala used panel data covering 51 plants in seven industries. His elasticity estimates were often insignificant, although in his 2002 PhD thesis, he corrected for simultaneity bias and achieved more significant results.

Reynaud (2003) estimated industrial water demand using a panel of French industrial firms in the Girlonde district between 1994 and 1996. Reynaud used

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[7] Renzetti, S., 1992. Evaluating the welfare effects of reforming municipal water prices. Journal of Environmental Economics and Management 22(1), 147-163.

a translog production function (after statistically rejecting the Cobb-Douglas specification) and three types of water inputs and estimated the relationships using the Seemingly Unrelated Regression technique and Feasible Generalised Least Squares (FGLS). Elasticities were estimated through simulation techniques, because the non-linearity of the discrete continuous choice model required simulation to determine the marginal effects in the changes in the independent variables on water demand. The resulting elasticities were -0.33 across all pricing structures, with these elasticities increasing when customers faced increasing block pricing, although this could be due to either a behavioural response or heterogeneity between the two samples.

Féres and Reynaud (2003) used this same technique on a panel of 404 industrial firms near Sao Paolo in Brazil. The average elasticity estimated was -1.08 from a sample where water's share of input costs was below 1%.

Goldar (2003) used a marginal productivity approach with aggregate data on inputs and outputs, where the water input data is on quantity purchased, rather than the quantity consumed. The author estimated price elasticities between -0.4 and +0.64.

Kumar (2004) used an input-distance approach and a translog production function on a panel of 92 firms in India over three years. His average estimate of the price elasticity of demand was -1.11.

The following table summarises these estimates of the price elasticity of demand:

Table 4 **Estimates of the price elasticity of non-residential demand for water**

Authors	Year	Area	Production Function	Price Elasticity
Grebenstein and Field	1979	USA	Translog	-0.80/-0.33
Babin, Willis and Allen	1982	USA	Translog	-0.66/+0.14
Ziegler and Bell	1984	USA (Arkansas)	Cobb-Douglas	-0.08
Williams and Suh	1986	USA	Log/Log	-0.97/-0.44
Renzetti	1988	Canada (British Columbia)	Cobb-Douglas	-0.54/-0.12
Schneider and Whitlatch	1991	USA (Columbus, Ohio)	Log/Log	-1.16
Renzetti	1992	Canada	Translog	-0.59/-0.15
Wang and Lall	1999	China	Translog	-1.0
Dupont and Renzetti	2001	Canada	Translog	-0.77
Onjala	2001	Kenya	Translog	-0.6/+0.37
Féres and Reynaud	2003	Brazil	Translog	-1.08 on average
Goldar	2003	India	Translog	-0.4/+0.64

Reynaud	2003	France	Translog	-0.79/-0.10
Kumar	2004	India	Translog	-1.11 on average

Note: These estimates are for industrial elasticities of demand; there are very few studies of commercial elasticities using similar techniques to those above.

Data source: Adapted from Reynaud,A., "An Econometric Estimation of Industrial Water Demand in France", Environmental Resource Economics, 25, Sept 2002. See also the bibliography for references to specific papers.

3.2.2 Case studies of responses to water prices

There are very few studies of changes to water tariffs which separate out the effects on non-residential users. The following case-studies reflect the experience of applying water conservation-oriented rates in the US[8].

Price elasticity is often assumed to be inelastic for many users. Experience in Northern Delaware, as well as in most of the jurisdictions interviewed for the research carried out by Wang et al. showed that pricing, when combined with conservation education, produced sizeable and persistent conservation behaviour.

When the city of San Antonio first began utilising water conservation-oriented rates it experienced unanticipated outcomes. For example, it expected fourth block users to reduce consumption and fall into the third block, but it did not expect so many existing third-block users to reduce consumption to the second block. Whilst this demonstrated that the pricing was creating incentives for water conservation, it left a shortfall in the finances of the utility.

4 Alternative Pricing Frameworks Adopted in Other Industries

Other industries offer a variety of pricing methods which might be applied to water pricing.

4.1 Time-of-use billing

Telecoms and electricity companies commonly utilise time-of-use billing to recover the costs created by peak-users. By charging more during peak use times, demand is smoothed across the day, and the requirement for peak capacity is reduced.

Time-of-use metering is considered prohibitively expensive in the water sector, but would be a method of reducing peak demand should the technology become more affordable.

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[8] "Water Conservation-oriented rates: Strategies to extend supply, promote equity, and meet minimum flow levels", Wang, Smith and Bryne, 2005, American Water Works Association

4.2 Self-selection of tariffs

Allowing customers to self-select which tariff they are on is a tariff setting technique which is used regularly in the telecommunications sector. The principle of allowing consumers to select the tariff that minimises their costs given their pattern of usage will is generally used as a form of price discrimination to increase the economic rent received by the supplier.

For this technique to achieve desirable outcomes it is necessary to incentivise users to select the tariff which achieves the desired goal, in Smart Water's case, water conservation. This form of pricing may actually increase water consumption if consumers respond to marginal prices and choose to pay higher fixed costs and lower usage charges, and may not be capable of producing water conservation.

In the UK, this self selection is applied to industrial water users, who can choose which tariff scheme they wish to pay, with different combinations of fixed charge, usage charge and interruptible supply being offered to customers.

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Confidential

Appendix B: Survey of Non-Residential Customers

Pricing for water conservation in the non-residential urban sector

Prepared for the Steering Committee of the Smart Water Fund

December 2006

ACIL Tasman

Economics Policy Strategy

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1 Survey of Non Residential Customers

1.1 Purpose of Survey

As part of the research into water use a survey of non residential customers was conducted.

The purpose of the survey was to gain a deep understanding of how water is used by the non-residential sector and their ability to adjust their operations in response to water conservation initiatives.

Both qualitative and quantitative information was collected as part of the process.

1.2 Information collected and analysed

The survey was designed to collect information on likely responses to changes in tariff levels and structures, the extent to which water users supplemented their water supply from alternative sources, information on the implementation of water saving processes and water management plans and the motivation for doing so.

Specifically, the survey sought to gain insights on:

- The extent to which water use varies with output or sales revenue
- Ascertain whether respondents recirculate water in their production processes, or supplement their supply from recycled water, groundwater, a river, or rainwater tanks
- Determine the extent to which water saving processes or water demand management programmes have been implemented and their effectiveness
- The year in which these programmes were first introduced and the amount of water savings achieved per annum
- The motivations relevant in decisions to implement water saving programmes, such as costs and environmental concerns
- Preferences for a variety of tariff structures and any reasons why some structures are preferred over others. Tariff structures assessed in the questionnaire are fixed fee, constant unit price, seasonal tariff, scarcity tariff, increasing and decreasing block tariff and excess use tariff
- Assess stated responsiveness to changes in usage charges of 10%, 25% and 50%.
- Gather size information such as Sales revenue, employment and plant and equipment to be used in an econometric analysis of prices and volumes to estimate price elasticities of water demand across different industries

The survey responses were linked back to the water utilities water volume databases to allow comparison of water consumption and water intensity across industries, and to uncover any patterns in the answers the survey respondents have provided and their water use.

1.3 Survey design

1.3.1 Questionnaire design

A questionnaire was designed to gather the relevant quantitative and qualitative information required for the analysis. In order to test the questionnaire's likely performance in terms of response rates and the quality of information collected, a pilot survey was conducted prior to going live.

The pilot questionnaires were distributed to 100 organisations, 50 customers of City West Water and 50 from South East Water. Two versions of the questionnaire were sent out, both a long and short version.

Respondents and non respondents of the pilot survey were contacted and questioned on their overall opinions of questionnaire and their understanding of specific questions and terminology used in the questionnaire. Their responses were then used to amend and improve the questionnaire.

The relative performance of the long and short versions of the questionnaire in the pilot revealed that it was not feasible to proceed with the long and detailed questionnaire because of the high rate of non response experienced. For this reason, the main survey proceeded with the shorter questionnaire with the minimum information requirements to proceed with the qualitative and econometric analysis.

1.3.2 Scope of survey and sample size

The scope of the survey was the top 5,000 combined non residential water customers of City West, Yarra Valley and South East water in terms of 2005/06 volumes.

The sample of the top 5,000 water users represents approximately 75% of total non residential water volume in 2005/06.

This sample covers both high water volume water intensive industries as well as gaining good coverage of some of the smaller non-residential water users.

Recipients of the questionnaire represented the whole range of industries operating within the sphere of the three water companies regions of operation. These covered sectors such as Manufacturing, Retail and Wholesale trade, Accommodation, Cafes and Restaurants, Finance, Property and Business

Services, Education, Health, Culture and Recreation, Personal Services, Government Administration and Agriculture.

1.3.3 Survey implementation and processing

Implementation of the survey was split into two groups, with those businesses whose volume exceeded 10,000 kL per annum surveyed via an online survey in conjunction with Deloitte Consulting. These businesses were contacted by telephone and received reminders encouraging them to complete the survey.

Entities ranked outside the top 1,000 of water users were surveyed via paper based survey received in the mail. These businesses had a minimum water volume of about 3,200 kL per annum.

For businesses earmarked to receive the paper based questionnaire, postal addresses of each of their billing addresses were obtained from South East Water, Yarra Valley Water and City West Water.

Mail processing was outsourced to an external mail and data processing company, which distributed the questionnaires, collected the responses and entered the data into an electronic file.

1.3.4 Potential bias and errors

Bias and error can be introduced into the sample through a number of means.

Coverage errors

These arise when some units or sections of the population are missing from the sampling frame. This type of error was unlikely to present a problem in our survey as the water companies maintain up to date billing information of their customers.

Non response bias

Non response bias arises when the non respondents to a survey differ from the respondents with regard to the survey variables collected. One example of possible non response bias might be that some industries are under represented in the responses compared to the sampling frame. This was not a major issue in our case, as the numbers of responses received covered the whole range of industries operating within the jurisdictions of the three water companies.

Editing of responses

Once the complete data sets were received they were subjected to rigorous checking and editing to identify errors and inconsistencies. Where possible these errors were identified and rectified.

1.4 Survey results

1.4.1 Response rates

A total of 5,000 survey questionnaires were distributed to the highest water consuming entities of the three participating water utilities, South East Water, Yarra Valley Water and City West Water. From the top 1,000 customers, those basically corresponding to the businesses with an annual consumption in excess of 10 ML, 298 responses were received. Of the remaining 4,000 smaller businesses, 278 responses were received. This corresponds to an overall response rate of about 12%, and is generally in line with expectations formed as a result of conducting a pilot survey. Comments received by respondents indicated that there is a strong community awareness of the need to conserve water, and respondents felt that they were making a contribution by participating in the survey. This helped boost response rates.

Response rates for the top 1000 businesses approached 30%. This reflects the fact that these businesses were given a follow up telephone call asking for their co-operation to complete the questionnaire. Results from the pilot survey also indicated that larger entities seemed to be more responsive to the water use questionnaire. This was also confirmed in the main survey.

1.4.2 Profile of respondents

By industry

Table 1 **Number of responses by industry**

Industry	> 10ML	<10 ML	Total
Food and Beverage Manufacturing	35	14	49
Textiles, Clothing, Paper, Chemicals	27	9	36
Metal Products, Machinery and Equipment	21	21	42
Other Manufacturing	11	9	20
Wholesale/Retail	20	19	39
Accommodation, Cafes and Restaurants	36	38	74
Education	23	45	68
Health/Community Services	39	32	71
Culture and Recreation	30	23	53
Agriculture	6	36	42

Government Administration	7	7	14
Finance, Property, Telecommunications and Transport	32	11	43
Personal/Other Services	11	14	25
Total	**298**	**278**	**576**

Data source: ACIL Tasman

Table 1 shows the spread of responses across the various industries comprising the non residential sector. A good spread of responses was received across the major industries and the two size segments.

The greatest number of responses received by industry sector were; Accommodation, Cafes and Restaurants (74), Health/Community Services (71), Education (68), Culture and Recreation (53), Food and Beverage Manufacturing (49), Finance and Property (43), Agriculture (42) and Metal Products, Machinery and Equipment Manufacturing (42).

Health and Community services categorized businesses were largely comprised of private and public hospitals and aged care facilities. Culture and Recreation businesses were mostly swimming pools, sporting clubs and associations. The Personal/Other services category was largely made of car washes and coin laundrettes.

By size and Industry

Table 2 **Responses by sales revenue**

Revenue	<10ML		>=10ML		Total	
	No:	%	No:	%	No:	%
Less than $10m	180	64.7%	95	31.9%	275	47.7%
$10m- $15m	13	4.7%	17	5.7%	30	5.2%
$15m-$25m	7	2.5%	19	6.4%	26	4.5%
$25m-$50m	12	4.3%	21	7.0%	33	5.7%
$50m-$75m	1	0.4%	20	6.7%	21	3.6%
$75m-$100m	2	0.7%	9	3.0%	11	1.9%
$100m-$150m	2	0.7%	15	5.0%	17	3.0%
$150m-$200m	0	0.0%	3	1.0%	3	0.5%
$200m-$250m	0	0.0%	4	1.3%	4	0.7%
> $250m	4	1.4%	29	9.7%	33	5.7%
N/A	57	20.5%	66	22.1%	123	21.4%
Grand Total	278	100%	298	100.0%	576	100.0%

Data source: ACIL Tasman

Table 2 and Table 3 show responses by sales revenue and employment size respectively. It is not surprising that the majority of respondents with a water usage less that 10 ML per annum, generate sales revenue of less than $10 million (64.7%), and have fewer than 10 employees (39.9%). The majority of respondents with a water usage in excess of 10 ML also generated sales revenue of less than $10 million (31.9%), although proportionally this category was significantly smaller for the larger water user group compared to the less than 10 ML group. The majority of respondents with in excess of 10 ML of annual water consumption had in excess of 250 employees (29.2%).

A total of 21.4% of respondents refused to provide any details of their sales revenue.

Table 3 **Responses by employment size**

Employment size	<10 ML		>=10ML		Total	
	No:	%	No:	%	No:	%
<10	111	39.9%	29	9.7%	140	24.3%
10-29	64	23.0%	48	16.1%	112	19.4%
30-49	30	10.8%	30	10.1%	60	10.4%
50-99	37	13.3%	45	15.1%	82	14.2%
100-249	21	7.6%	55	18.5%	76	13.2%
>=250	15	5.4%	87	29.2%	102	17.7%
N/A		0.0%	4	1.3%	4	0.7%
Total	278	100.0%	298	100.0%	576	100.0%

Data source: ACIL Tasman

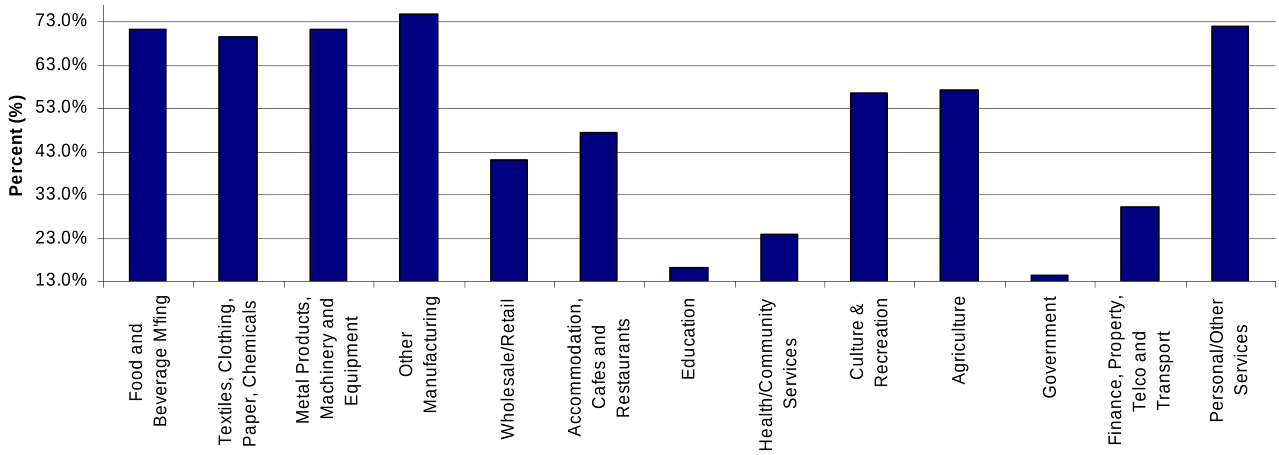
Relationship between water consumption and output

In response to the question of whether water consumption varies proportionally with output, 47.1% of all respondents answered yes.

Across industry sectors, we observed wide variation in the proportion of businesses' whose water use varied with their output or production. As expected, those businesses operating in the more water intensive manufacturing sector were more likely to report that their water use varies proportionally with their production or output. Food and beverage (71.4%), Textiles, Clothing, Paper, Chemicals (69.4%), Metal products Machinery, equipment (71.4%) and Other Manufacturing (75.0%) all reported significantly higher proportions of responses whose water use varied with output compared to the overall proportion for all businesses of 47.1%.

Figure 1 and Table 4 below show the proportion of respondents answering yes across the major industry sectors.

Figure 1 **Does water consumption vary with output, by industry?**



Data source: ACIL Tasman

The Personal/Other services sector also reported a larger than average number for the proportion of business whose water use varies with output, with 72.0% of businesses answering yes. This is largely a consequence of the fact that the majority of businesses comprising this sector in the survey are car washes and coin laundrettes. These businesses tend to be the largest water using personal services businesses across metropolitan Melbourne.

Table 4 **Does your water consumption vary with output or sales revenue?**

	No	Yes	Total	Percentage answering yes
Food and Beverage Manufacturing	14	35	49	71.4%
Textiles, Clothing, Paper, Chemicals	11	25	36	69.4%
Metal Products, Machinery and Equipment	12	30	42	71.4%
Other Manufacturing	5	15	20	75.0%
Wholesale/Retail	23	16	39	41.0%
Accommodation, Cafes and Restaurants	39	35	74	47.3%
Education	57	11	68	16.2%
Health/Community Services	54	17	71	23.9%
Culture & Recreation	23	30	53	56.6%
Agriculture	18	24	42	57.1%
Government	12	2	14	14.3%
Finance, Property, Telco and Transport	30	13	43	30.2%
Personal/Other Services	7	18	25	72.0%

Data source: ACIL Tasman survey

As expected, those sectors of the economy where employees occupy office space and where water is not a significant part of the operations of such an activity such as Education (16.2%), Government Administration (14.3%), and Finance, Property etc. (30.2%), Health and Community Services (23.9%) do not report a high proportion of businesses whose water use varies proportionally with output. In the case of Accommodation, Cafes and Restaurants, and Culture and Recreation 47.3% and 56.6% of respondents respectively answered yes to this question.

1.4.3 Determinants of water use/Main uses of water

Main uses of water sited by the respondents by industry groupings are shown below. These are:

Food and Beverage Manufacturing

- As a raw material in production
- For cleaning
- Washing of materials- i.e. fruits and vegetables
- Water used in a milling process

Textiles, Clothing and Footwear

- Dyeing and finishing textiles
- In boiler to create steam

Petroleum, Coal and Chemical Product manufacturing

- As an additive in water based products
- For cooling towers and extruders

Non Metallic Mineral products

- Used in the manufacture of concrete

Metal product Manufacturing

- Rinsing of components
- Dust and smoke suppression
- Powder coating
- Electroplating

Machinery and Equipment Manufacturing

- Cooling Towers

Other Manufacturing

- Creation of steam
- Services and toilets
- Rinsing and washing in production processes

Construction

- Toilets and taps
- Clean ups
- Mixing concrete

Wholesale/Retail trade

- Weather and temperature
- Watering of plants in the case of plant nurseries
- Bathroom and kitchen needs

Accommodation, Cafes and Restaurants

- Number of customers, Occupancy levels
- Showering and toilet use for residents and guests
- Washing glasses and dishes in restaurants
- Food preparation
- Laundry use
- Maintaining plants in garden

Transport and storage

- Washing of vehicles and tankers
- Refrigeration – freezers, chillers and cooling

Telecommunications, Finance and Property Services

- Water use determined largely by the number of employees in a building
- Mainly toilet flushing

Government, Administration and Defence

- Water use is largely determined by ground condition and climate in the case of local councils
- Open space watering, grounds and sporting fields
- Street cleaning
- Drain cleaning
- General amenities

- Fire services

Education

- Water use is largely determined by the number of students on campus.
- Main uses are for toilets, drinking taps
- Upkeep of school grounds and ovals
- Water use is seasonal as schools and universities close at various times during the year.

Health and Community services

- This sector is largely comprised of hospitals and aged care centres/nursing homes.
- Main determinant of water use is the number of residents or patients in a hospital or facility
- Main uses include toilets, showers, basins
- Food preparation
- Laboratory uses

Cultural and Recreational Services

- This segment largely comprises of sporting clubs, public golf courses, swimming pools
- Main use of water is in maintaining sporting facilities and so demand is highly seasonal and affected by factors such as temperature and rainfall.

Personal and Other Services

- Main business types represented here with a large enough volume to fall within the scope of the survey are car washes, coin operated laundries and industrial laundries
- Water use is determined by the number of customers
- Water is used for washing of cars and in washing machines

Agriculture

- Water is used predominantly for feeding animals, chickens and cattle and watering plants
- Water use is highly dependent on weather conditions

1.4.4 Water volumes and growth in volumes of respondents

For 416 of 576 responses to the survey, we were able identify their annual water consumption. Table 5 and Table 6 below show water volumes and growth in water volumes from 2001-02 to 2005-06 for these 416 businesses.

In the 2005-06 financial year these businesses consumed 12.5 million kilolitres of water, or an average of 29,961 kilolitres per business. Covering the period from 2001-02 to 2005-06, water consumption for these businesses has grown by 2% per annum.

Table 5 **Water volumes of respondents by industry (kilolitres)**

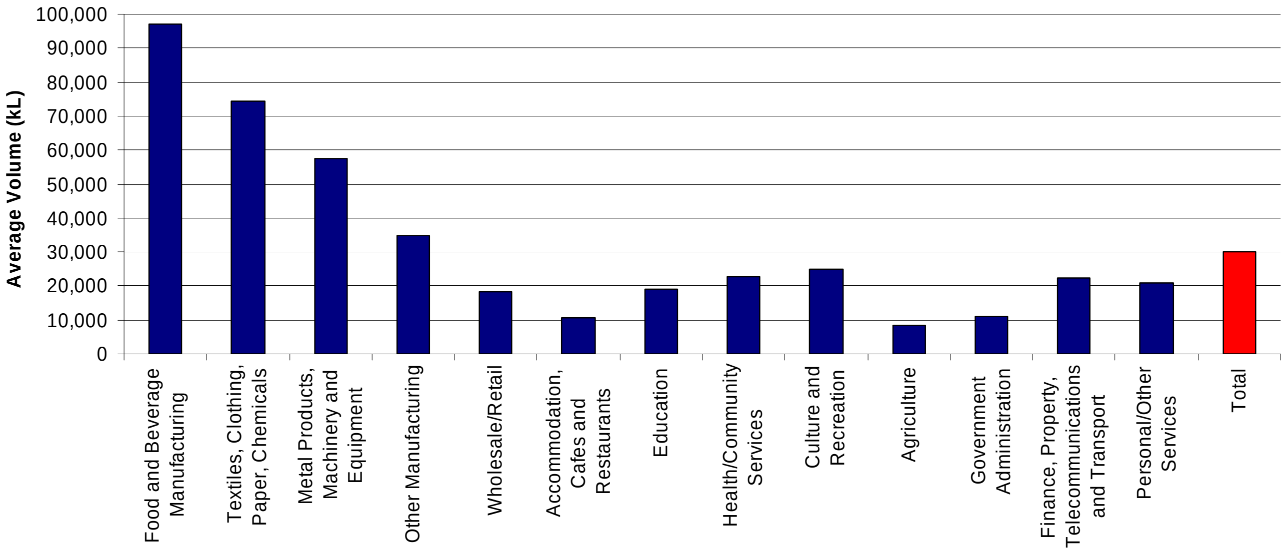
INDUSTRY	2001-02	2002-03	2003-04	2004-05	2005-06
Food and Beverage Manufacturing	2,711,973	2,735,600	2,994,443	3,089,082	3,206,790
Textiles, Clothing, Paper, Chemicals	1,477,177	1,742,815	1,427,805	1,260,671	1,336,127
Metal Products, Machinery and Equipment	1,973,454	1,968,415	1,755,041	1,768,120	1,786,369
Other Manufacturing	547,986	571,879	560,527	585,392	524,254
Wholesale/Retail	412,154	449,487	459,055	490,348	516,604
Accommodation, Cafes and Restaurants	471,819	509,673	489,734	545,290	557,311
Education	850,287	1,200,641	1,071,187	1,120,902	1,107,535
Health/Community Services	1,000,704	977,661	1,005,002	1,030,759	1,062,386
Culture and Recreation	716,222	958,454	824,150	785,745	895,541
Agriculture	241,878	374,707	354,895	368,217	350,263
Government Administration	97,319	138,941	104,061	104,129	111,296
Finance, Property, Telecommunications and Transport	630,772	568,958	558,562	638,930	651,879
Personal/Other Services	381,546	371,326	380,147	387,357	357,450
All industries	**11,513,290**	**12,568,556**	**11,984,609**	**12,174,942**	**12,463,805**

Data source: ACIL Tasman survey

On an industry basis, there has been wide variation in the growth in water volumes. Food and beverage manufacturers have increased there water consumption by 4.3% per annum over the period under consideration. Other sectors that have shown solid annual growth in water consumption are Wholesale/retail (5.8% p.a), Accommodation, Cafes and Restaurants (4.3% p.a), Education (6.8% p.a), Culture and recreation (5.7% p.a) and Agriculture (9.7% p.a).

With the exception of Food and Beverage Manufacturing, the other manufacturing sectors have exhibited declines in their water usage over the period. In the case of Textiles, Clothing, Paper and Chemicals and Metal products, Machinery and Equipment, annual growth rates have been -2.5% per annum. In the other Manufacturing category, water consumption has been shrinking by 1.1% per annum.

Figure 2 **Average water consumption by industry, 2004-05**



Data source: ACIL Tasman survey

Table 6 **Growth in water volumes of respondents by industry (percent %)**

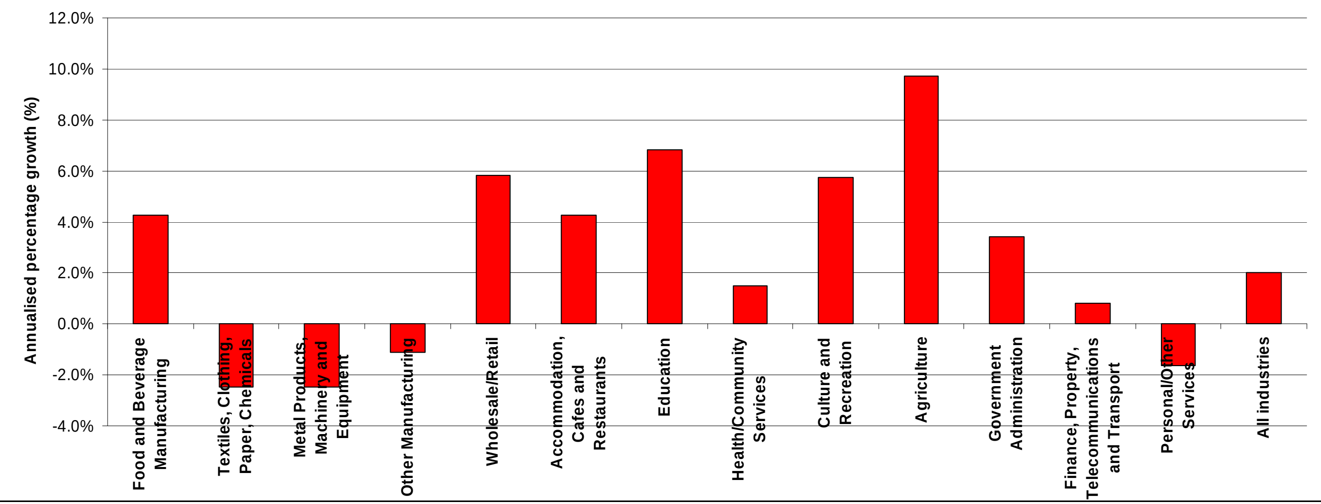
INDUSTRY	2001/02 to 2002/03	2002-03 to 2003-04	2003/04 to 2004/05	2004/05 to 2005/06	Annualised growth from 2001/02-2005/06
Food and Beverage Manufacturing	0.9%	9.5%	3.2%	3.8%	4.3%
Textiles, Clothing, Paper, Chemicals	18.0%	-18.1%	-11.7%	6.0%	-2.5%
Metal Products, Machinery and Equipment	-0.3%	-10.8%	0.7%	1.0%	-2.5%
Other Manufacturing	4.4%	-2.0%	4.4%	-10.4%	-1.1%
Wholesale/Retail	9.1%	2.1%	6.8%	5.4%	5.8%
Accommodation, Cafes and Restaurants	8.0%	-3.9%	11.3%	2.2%	4.3%
Education	41.2%	-10.8%	4.6%	-1.2%	6.8%
Health/Community Services	-2.3%	2.8%	2.6%	3.1%	1.5%

Culture and Recreation	33.8%	-14.0%	-4.7%	14.0%	5.7%
Agriculture	54.9%	-5.3%	3.8%	-4.9%	9.7%
Government Administration	42.8%	-25.1%	0.1%	6.9%	3.4%
Finance, Property, Telecommunications and Transport	-9.8%	-1.8%	14.4%	2.0%	0.8%
Personal/Other Services	-2.7%	2.4%	1.9%	-7.7%	-1.6%
All industries	**9.2%**	**-4.6%**	**1.6%**	**2.4%**	**2.0%**

Data source: ACIL Tasman survey

Figure 3 below shows the growth in water consumption across industry sectors graphically.

Figure 3 **Annualised percentage growth in water volumes by industry, 2001/02 to 2005/06**



Data source: ACIL Tasman

1.4.5 Water intensity

The intensity of water users participating in the survey was calculated using two ratios; the number of kilolitres of water consumed per employee and the number of kilolitres of water consumed per thousand dollars of revenue generated by the business.

Table 7 shows these measures by industry for the 416 survey respondents for which we had water consumption data.

Table 7 **Water intensity by industry**

INDUSTRY	kL/employee	kL/('$000)
Food and Beverage Manufacturing	809.2	2.08
Textiles, Clothing, Paper, Chemicals	665.7	1.42

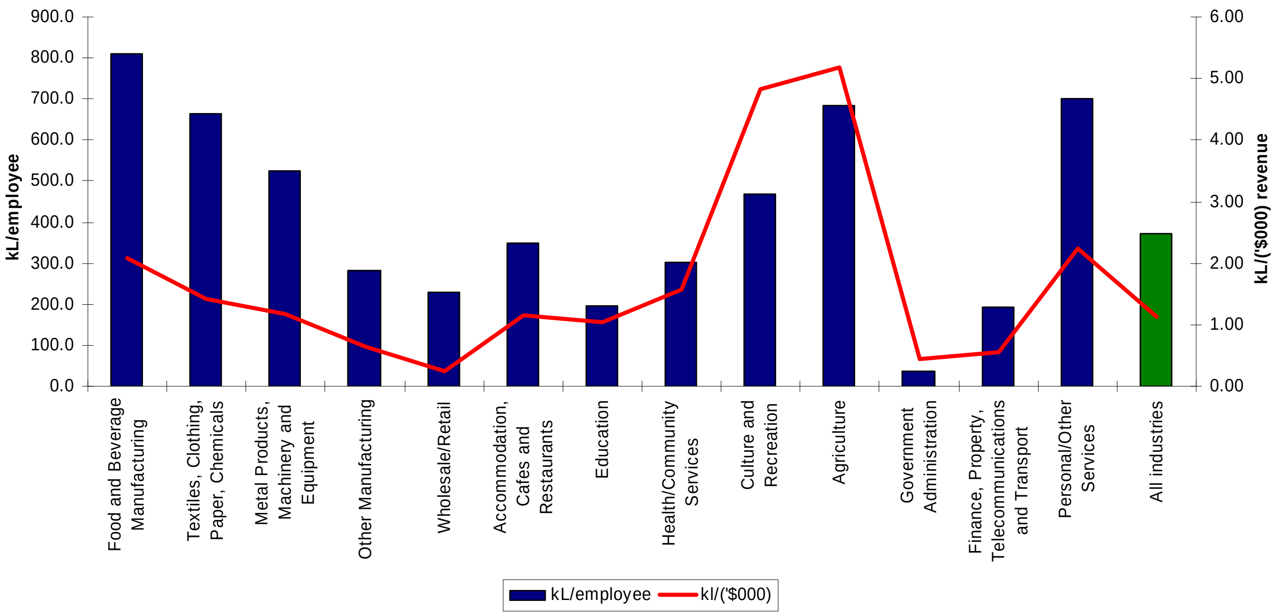
Metal Products, Machinery and Equipment	523.1	1.17
Other Manufacturing	280.6	0.64
Wholesale/Retail	229.8	0.24
Accommodation, Cafes and Restaurants	347.6	1.16
Education	195.0	1.04
Health/Community Services	302.5	1.58
Culture and Recreation	467.3	4.84
Agriculture	685.6	5.17
Government Administration	37.3	0.44
Finance, Property, Telecommunications and Transport	191.1	0.55
Personal/Other Services	700.9	2.24
All industries	**370.7**	**1.12**

Data source: ACIL Tasman analysis

On the basis of kL/employee, Food and Beverage Manufacturing was the most water intensive industry of all those surveyed, with an intensity of 809.2 kL/employee. This was followed by Personal Services and Agriculture with water intensity measures of 700.9 and 685.6 respectively. Other sectors with above average water intensities include Textiles, Clothing, Paper, Chemicals (665.7 kL/employee), Metal Products, Machinery and Equipment (523.1 kL/employee), and Culture and Recreation (467.3 kL/emp).

Those sectors with low water intensities on the basis of kilolitres used per employee include Education (195.0), Government Administration (37.3) and Finance, Property etc. (191.1).

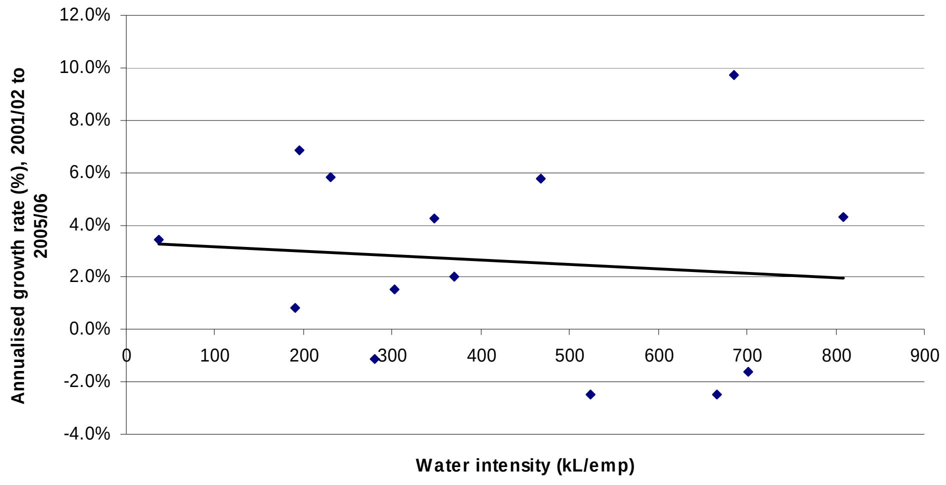
Figure 4 **Water intensity by industry (kL per employee and kL per $'000)**



Data source: ACIL Tasman analysis

In terms of kilolitres of water consumed per thousand dollars of revenue generated, the relative water intensities of the various industrial sectors remain largely unchanged. However, Agriculture and Culture and Recreation are two industries that are less labour intensive compared to the other sectors surveyed, and their water intensities based on this measure have increased, to be ranked 1st and 2nd respectively. The agricultural sector used 5.17 kilolitres of water per thousand dollars of revenue generated and Culture and recreation used 4.84 kL/('$000).

Figure 5 **Relationship between growth in water volumes and water intensity**



Data source: ACIL Tasman

Figure 5 plots the growth in water use by industry against each industries water intensity. The graph shows a slight negative relationship between an industries water intensity, and the rate of growth in water consumption for the period under consideration. Despite the goodness of fit of the relationship being quite poor, there is perhaps some indication that water intensive industries have taken some measures to limit the growth of their water consumption. Obviously, there are a multitude of potential other factors at play here which can have an influence on any observed relationship.

1.4.6 Supplementation from other sources

Table 8 **Proportion of businesses who supplement from other sources**

Water source	All businesses	> 10 ML	< 10ML
Recirculate water	20.1%	23.5%	16.5%
Recycled water	14.4%	15.8%	12.9%
Groundwater	4.3%	5.0%	3.6%
River	2.3%	1.7%	2.9%
Rainwater tank	12.3%	7.7%	17.3%
Other	5.7%	4.4%	7.2%

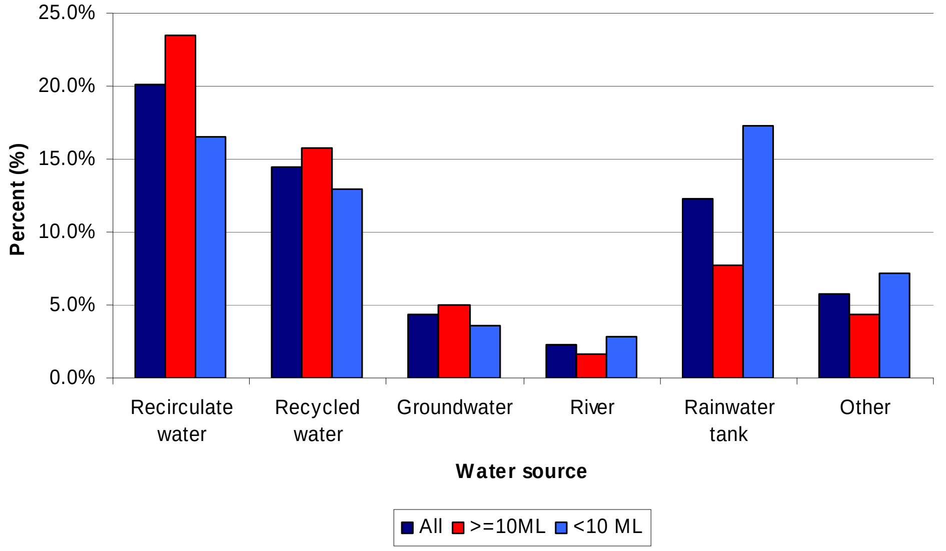
Data source: ACIL Tasman survey

Table 8 shows the percentage of respondents who obtain water from alternative sources. The available options provided in the questionnaire were recirculating water through a production process, using recycled water, obtaining groundwater through a well, supplementing water from a river, or supplementing their water supply with water from rainwater tanks.

The results show that 20.1% of respondents choose to recirculate their water supply by running it through a process more than once. This approach tended to be adopted by larger water using businesses, with 23.5% of respondents with annual water consumption of greater than 10 ML applying this water saving measure. This compares with only 16.5% of respondents who use less than 10ML of water per annum.

Overall, 14.4% of all respondents recycle water in the course of their day to day operations. Larger water users were also more likely to recycle water compared with their smaller counterparts, with 15.8% of respondents with annual water volumes in excess of 10ML reporting that they recycle water compared with 12.9% for those with water use below 10ML per annum.

Figure 6 **Supplementation from other sources by water volume**



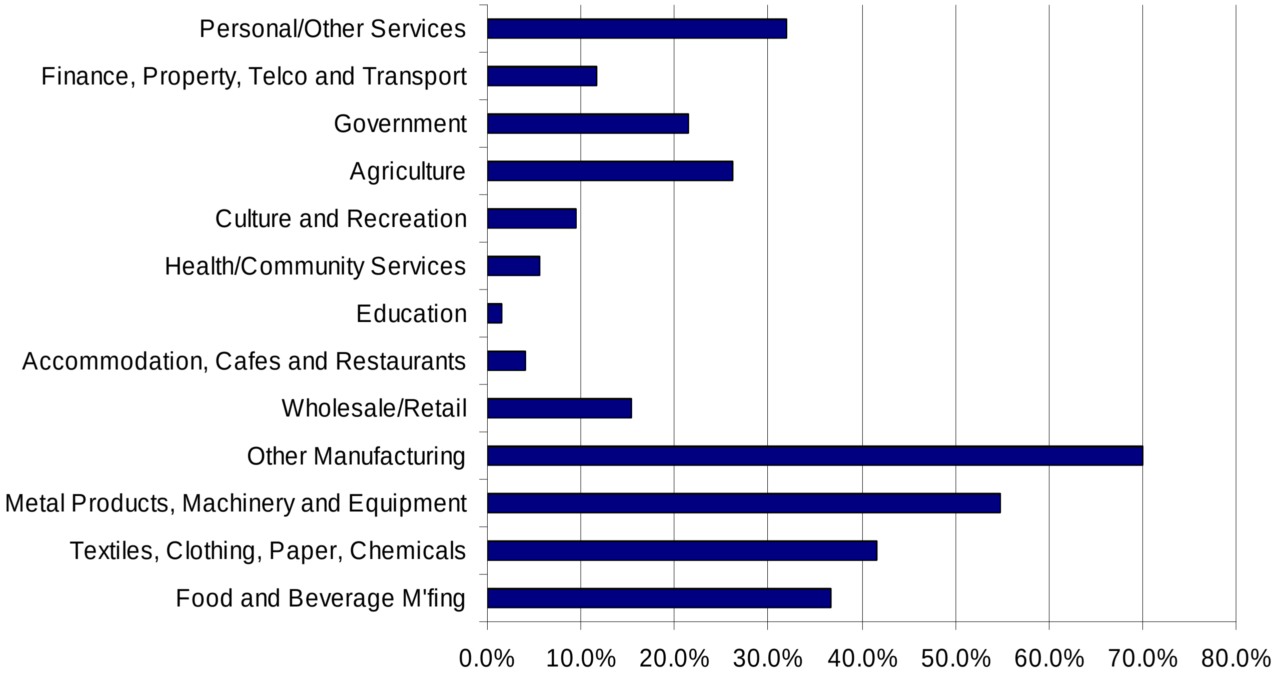
Data source: ACIL Tasman

The other significant source of water supplementation is that which comes from rainwater tanks, with 12.3% of all respondents reporting that they have installed rainwater tanks. This source of supplementation tends to be favoured by smaller water consumers, 17.3% of respondents in the less than 10ML p.a category reporting that they use rainwater tanks.

Supplementation levels from groundwater sources and rivers remain low, with 4.3% and 2.3% of all respondents supplementing their water supply from groundwater sources and rivers respectively.

An additional 5.7% of respondents chose to supplement their supply by 'Other' means. In nearly all cases this other source of supplementation was via a private dam or the utilisation of stormwater runoff.

Figure 7 **Proportion of businesses who supplement with recirculated water, by industry**



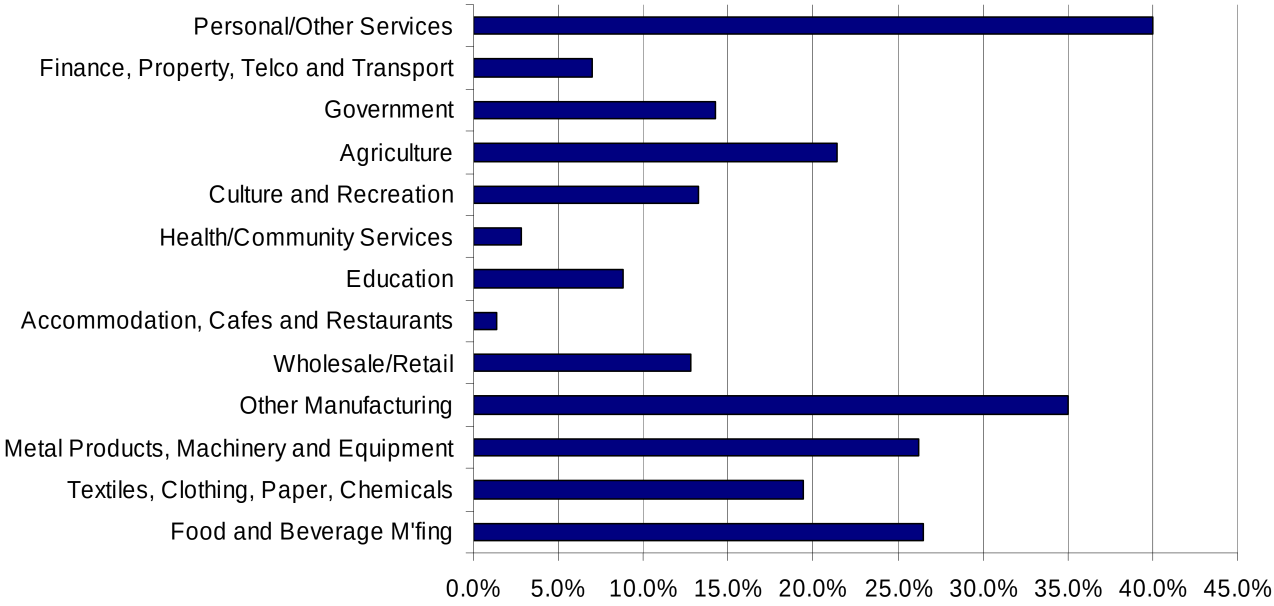
Data source: ACIL Tasman survey

On an industry by industry basis, there is wide variation in the sources of water supply supplementation adopted. In the case of recirculation and recycling, it is the manufacturing industries that are most likely to supplement from these sources of supply.

In the use of recirculated water, it is not surprising that the manufacturing sector, which utilises water within its production processes has the largest scope to recirculate water. Other manufacturing (70.0%), Metal products, machinery and equipment (54.8%), Textiles, Clothing , Paper, Chemicals (41.7%) and Food and Beverage Manufacturing (36.7%) were the industries that recorded the highest percentage of firms who recirculate their mains water supply.

The Personal Services sector shows the highest percentage of firms supplementing supply by recycling water (40.0%), followed by Other Manufacturing (35.0%), Food and Beverage Manufacturing (26.5%) and Metal Products, Machinery and Equipment Manufacturing (26.2%).

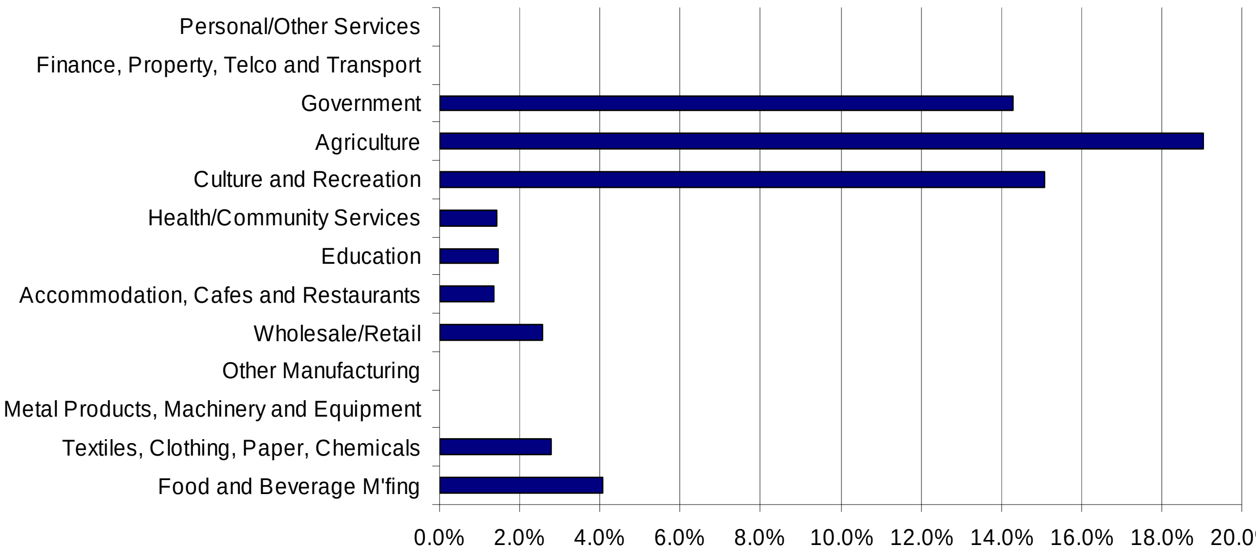
Figure 8 **Proportion of businesses who supplement with recycled water, by industry**



Data source: ACIL Tasman survey

When it comes to supplementation from groundwater, rivers or rainwater tanks, it is the Agricultural and Government Administration sectors that are dominant relative to other industries.

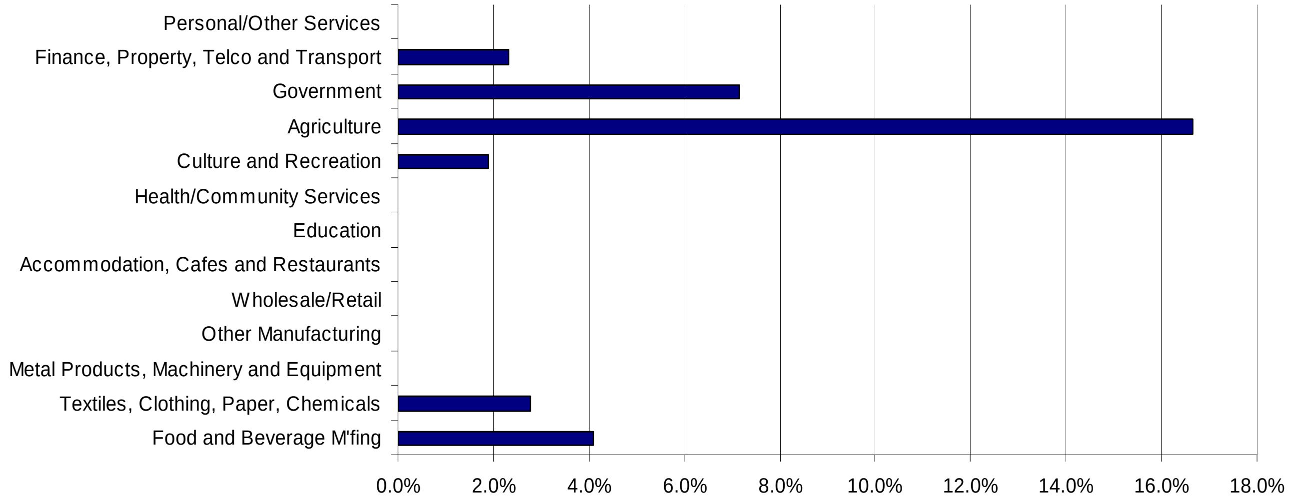
Figure 9 **Proportion of businesses who supplement with groundwater, by industry**



Data source: ACIL Tasman survey

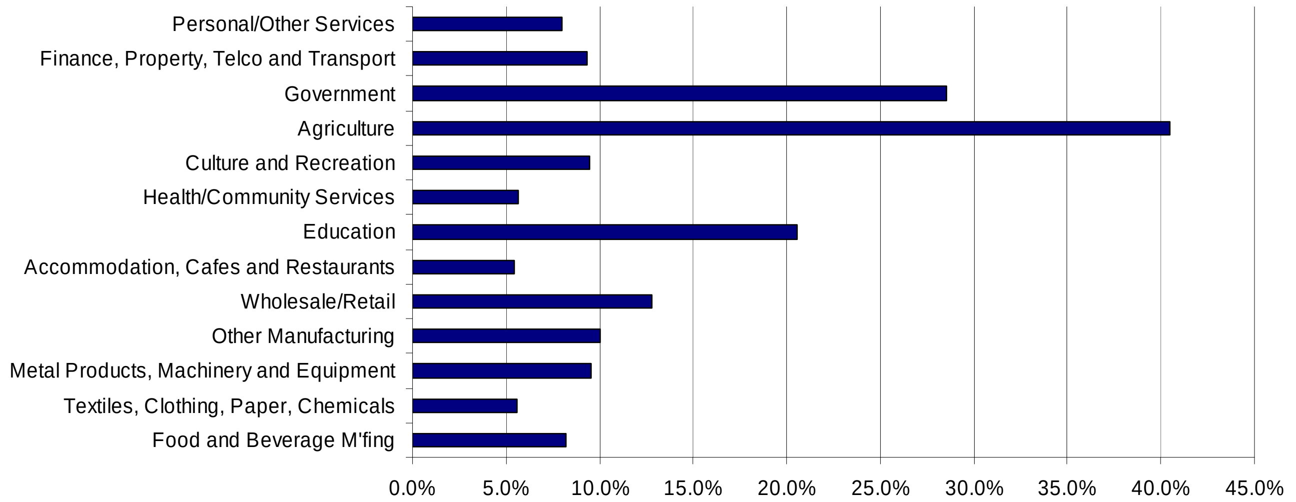
In the case of firms supplementing their supply with groundwater, those sectors with the highest proportion of firms adopting that method of supplementation are Agriculture (19.0%), Culture and Recreation (15.1%) and Government Administration (14.3%).

Figure 10 **Proportion of businesses who supplement with river water, by industry**



Data source: ACIL Tasman survey

Figure 11 **Proportion of businesses who supplement through rainwater tank, by industry**



Data source: ACIL Tasman survey

The sectors most likely to supplement their supply with river water are Agriculture (16.7%) and Government (7.1%). These two sectors are also dominant in the use of rainwater tanks, with 40.5% of agriculture sector respondents and 28.6% of government entities having supplemented their supply through the use of rainwater tanks. The education sector ranks third by industry in the percentage of organisations using rainwater tanks (20.6%).

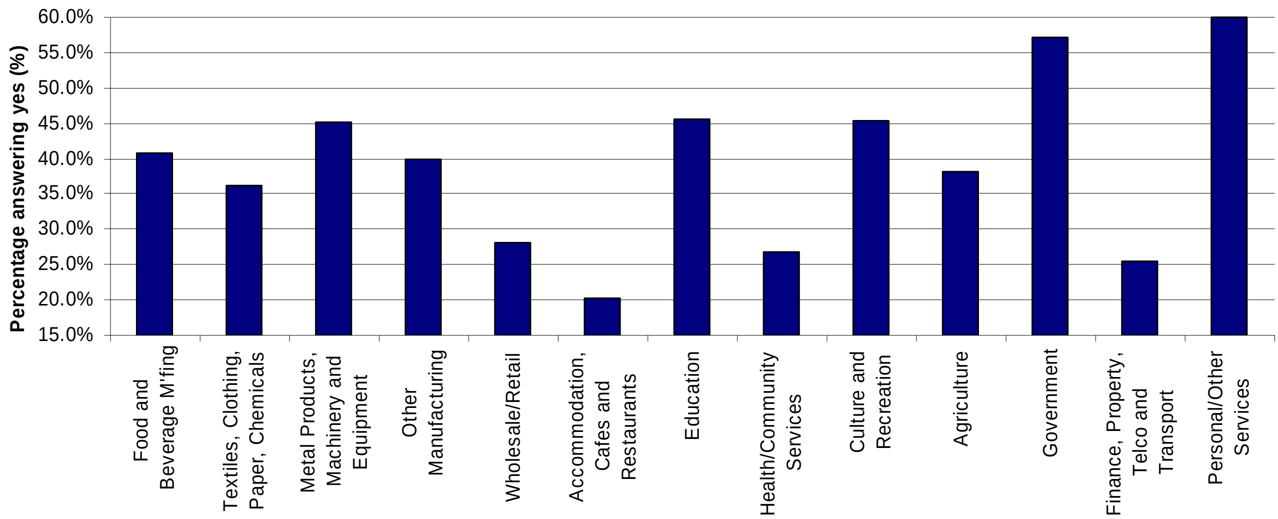
Manufacturing firms operating within the Melbourne metropolitan area seem to have very little opportunity or use for supplementation from groundwater, rainwater tanks or rivers, given the results presented graphically above.

1.4.7 Water saving processes and demand management programmes

The questionnaire asked respondents to provide information on whether they had invested in water saving processes, or implemented demand management programmes (with their water provider) since 2001.

The results are presented in Figure 12 below. Overall, 36.4% of respondents answered in the affirmative.

Figure 12 **Proportion who have implemented water saving processes or demand management programmes, by industry**



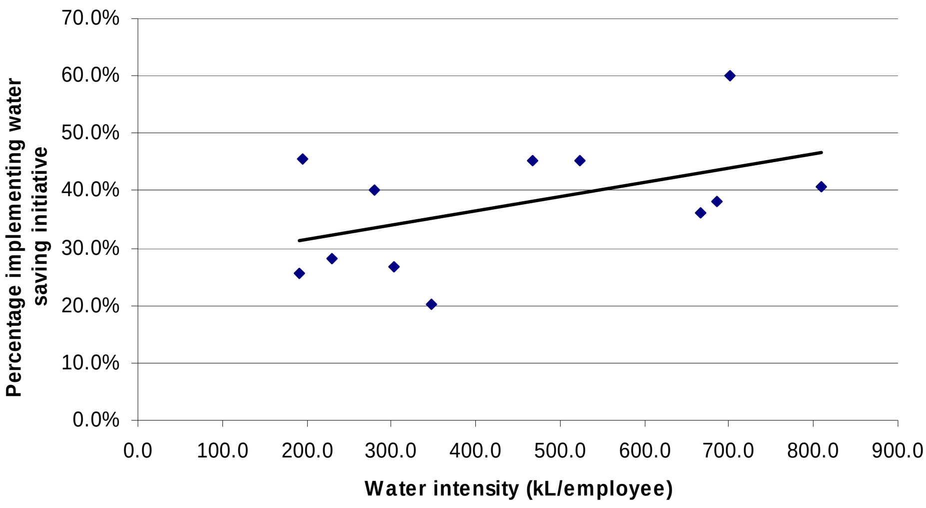
Data source: ACIL Tasman survey

Personal services (60.0%), Government administration (57.1%), Education (45.6%), Culture and Recreation (45.3%) and Metal product, Machinery and Equipment Manufacturing (45.2%) recording the highest proportions of respondents who have implemented water saving or demand management programmes since 2001.

Those sectors with relatively low water use, such as Wholesale/Retail (28.2%), Accommodation, Cafes and Restaurants (20.3%), Finance and Property (25.6%) and Health and Community services (26.8%) have all recorded below average levels of investment in water saving practices. In the vast majority of these types of firms water consumption is limited to toilet and shower use. The cost of water saving initiatives in these instances is likely to be high relative to any cost savings from water savings derived.

The 2 figures below indicate a positive relationship between the percentage of businesses implementing water saving initiatives within an industry and that industries water intensity. Similarly, strong positive correlation exists between firm size as measured by revenue, and the proportion of firms having implemented water saving initiatives within each category of firm size.

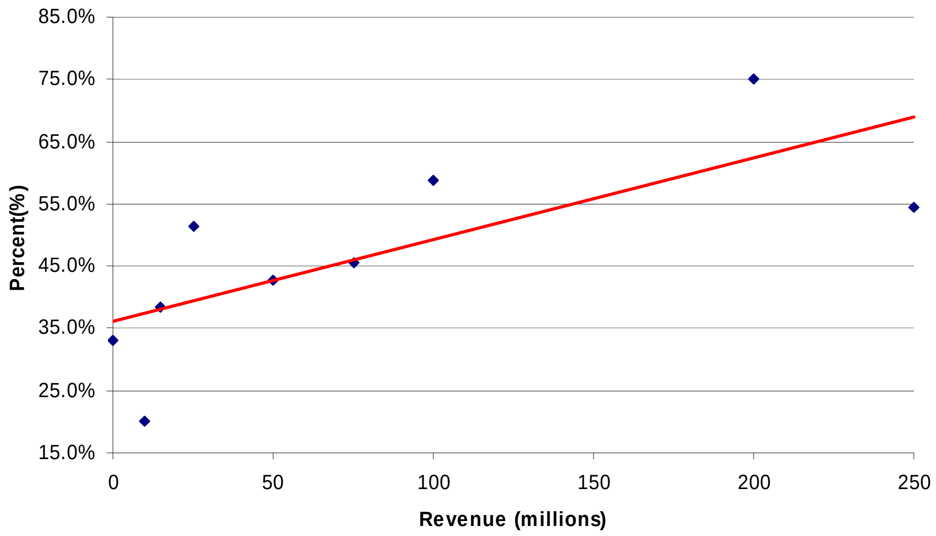
Figure 13 **Proportion implementing water saving processes versus Water intensity**



Note: This chart excludes the effect of Government administration

Data source: ACIL Tasman survey

Figure 14 **Proportion implementing water saving processes by revenue**

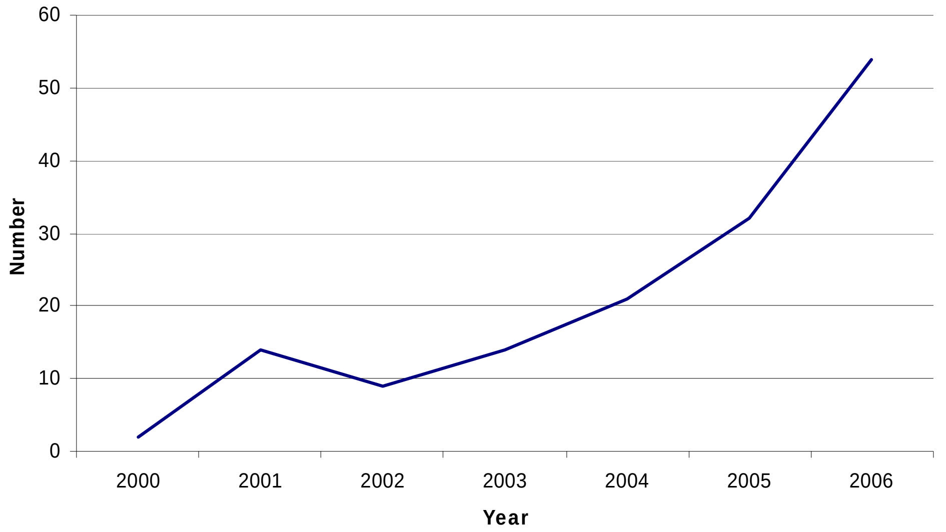


Data source: ACIL Tasman

The results indicate that large water intensive industries, as large users of water are also more likely to have a wide array of technical options at their disposal to reduce water consumption. This is reflected in Figure 13 and Figure 14 and lends support to the notion that water intensive industries such as manufacturing, are responsive to changes in the price of water.

The number of respondents who have made the decision to invest in water saving initiatives or demand management programmes has grown strongly over time. For those respondents who identified the year in which any decision to invest in or implement initiatives was made, Figure 15 plots the number of respondents implementing water saving practices/demand management programmes over time.

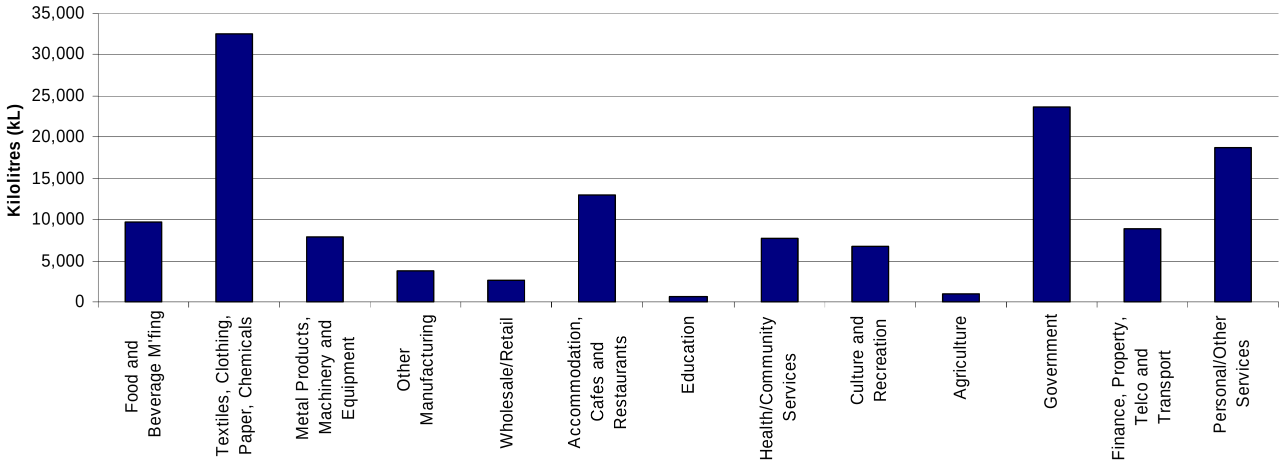
Figure 15 **Implementation of water saving practices/demand management plans over time**



Data source: ACIL Tasman

The chart shows strong growth in the introduction of such initiatives since 2002, reflecting the increasing importance of water conservation issues and/or better education on water conservation issues provided by the water utilities.

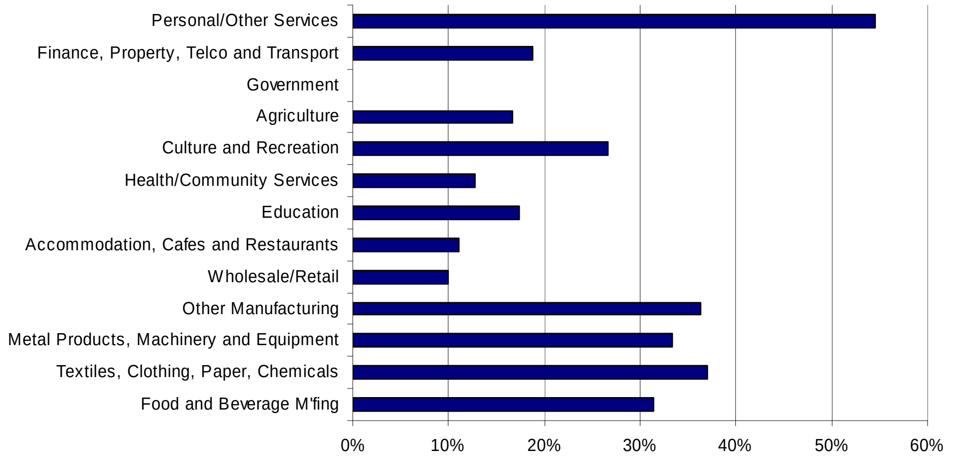
Figure 16 **Average water savings by industry (kilolitres per annum)**



Data source: ACIL Tasman

Figure 16 shows the water savings made on average per firm which has invested in water saving initiatives across the different industries represented in this survey. It should be noted that respondents were asked to provide an estimate of the annual water saved as a result of the investment they have made. In the majority of cases, respondents either could not or simply did not want to provide an estimate. Therefore, the data used to construct the above chart are subject to a high degree of uncertainty.

Figure 17 **Proportion of respondents with water usage > 10ML who have completed a water management plan, by industry**



Data source: ACIL Tasman

The top 1,000 water users for each of the 3 water companies have been asked to work in conjunction with their water provider to formulate a water management plan. Figure 17 shows the proportion of all non-residential users by industry class, who fall into this category who indicated that they have completed a water management plan.

Those industries with the highest rates of implementation of water management plans are Personal/Other services (54.5%), Food and Beverage Manufacturing (31.4%), Textiles, Clothing, Paper and Chemicals (37.0%), Metal products, Machinery and Equipment Manufacturing (33.3%) and Other Manufacturing (36.4%) and Culture and Recreation (26.7%).

The results show that non residential water users in the Health/Community services (12.8%), Wholesale/Retail trade (10.0%), Accommodation, Cafes and Restaurants (11.1%) have been slow in formulating water management plans.

Other sectors such as Education (17.4%), Agriculture (16.7%) and Finance (18.8%) fall into the intermediate categories.

1.4.8 Motivation for implementation of water saving practices

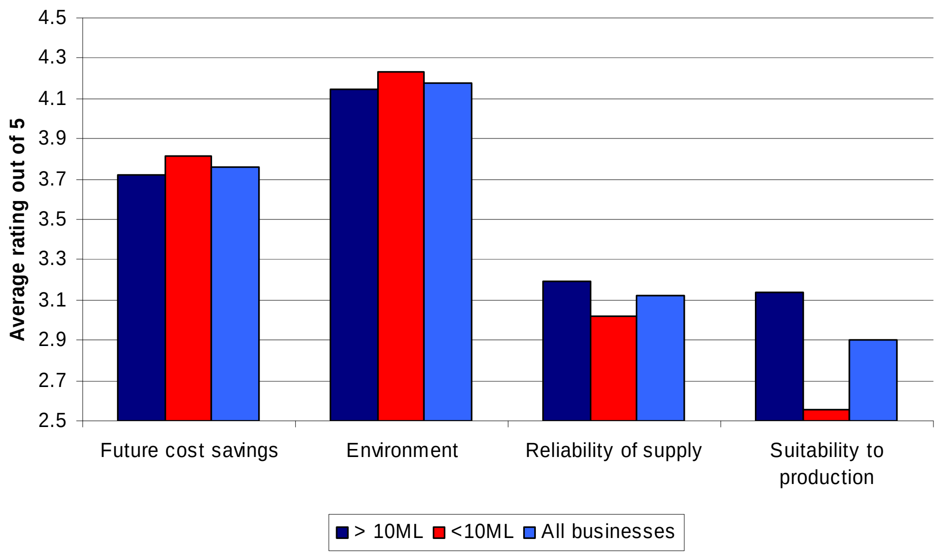
Another aspect of the questionnaire was to examine the main motivations and drivers of those water users who have implemented water saving measures or water management plans.

Respondents were asked to rate the extent to which the following motivations on a scale from 1 to 5 were relevant in their decision;

- Future cost savings
- Environmental concerns
- Reliability of Supply
- Suitability to Production

Overall results are shown in Figure 18 below, for those businesses who consume in excess of 10ML per annum and those that don't.

Figure 18 **Reason for water saving practice/management plan by water use**

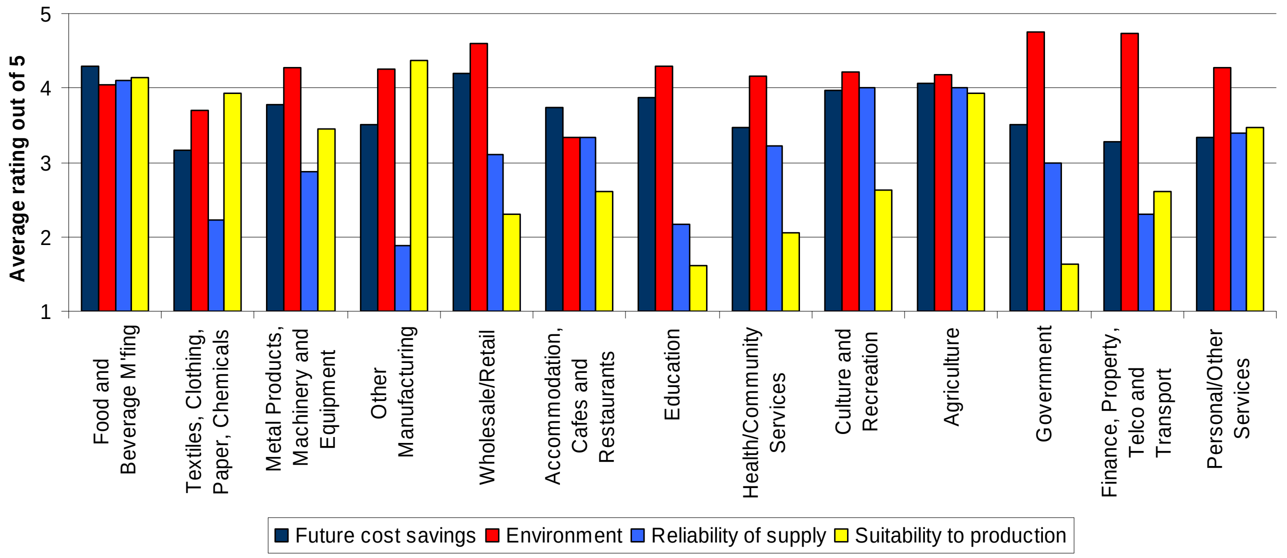


Data source: ACIL Tasman

Environmental concerns have proven to be a significant motivator for implementing water saving practices. Across all respondents, Environmental concerns were given an average rating of 4.18 out of 5. This compares to 3.76 for futures costs savings, 3.13 for reliability of supply and 2.90 for suitability to production process.

The other interesting observation that can be drawn from the data is that smaller water users have a relatively higher level of concern for cost savings and the environment than reliability of supply or suitability to production process.

Figure 19 **Reason for water saving practice/management plan by Industry**



Data source: ACIL Tasman

Figure 19 shows the plots the results across the 13 industry sectors classified in our dataset. The data show that reliability of supply is more of an issue in Food and Beverage Manufacturing, Culture and Recreation and the Government sector.

The suitability to production processes is of more importance to the 4 manufacturing sectors.

Environmental and Future costs savings rated relatively highly across all industry categories, however, Government sector respondents seemed to place proportionally greater importance to environmental concerns than was the case in most other industries.

Table 9 shows the average ratings by industry, for each of the 4 motivations for implementing water saving measures.

Table 9 **Motivation for water saving practices, by industry sector**

INDUSTRY	Future cost savings	Environment	Reliability of supply	Suitability to production
	Average rating out of 5			
Food and Beverage Manufacturing	4.29	4.05	4.10	4.14
Textiles, Clothing, Paper, Chemicals	3.15	3.69	2.23	3.92
Metal Products, Machinery and Equipment	3.78	4.28	2.88	3.44
Other Manufacturing	3.50	4.25	1.88	4.38

Wholesale/Retail	4.20	4.60	3.10	2.30
Accommodation, Cafes and Restaurants	3.73	3.33	3.33	2.60
Education	3.87	4.29	2.16	1.61
Health/Community Services	3.47	4.16	3.21	2.05
Culture and Recreation	3.96	4.21	4.00	2.63
Agriculture	4.06	4.18	4.00	3.94
Government	3.50	4.75	3.00	1.63
Finance, Property, Telco and Transport	3.27	4.73	2.30	2.60
Personal/Other Services	3.33	4.27	3.40	3.47
All industries	**3.76**	**4.18**	**3.13**	**2.90**

Data source: ACIL Tasman survey

1.4.9 Water saving efficiencies introduced by survey respondents

This section summarises the various approaches adopted across all industry sectors to achieve water saving efficiencies.

In the manufacturing sector, water saving efficiencies range from adjustments to production processes that involve recycling water, or improved scheduling to reduce water use or the purchase and use of modern water efficient equipment.

In the other sectors, water efficiency measures have typically involved such innovations as the use of timed or computerised sprinkler systems, installation of rainwater tanks, the installation of sensor urinals, dual flush toilets, and pressure reducing valves.

It is evident that the manufacturing sector, as a significant user of water within its various production processes, has significant scope to implement water saving efficiencies through the adjustment of production processes.

The other sectors use water primarily for watering gardens or for personal use, toilets, showers and hand washing. Water saving technologies implemented reflects this.

A sector by sector summary of water efficient practices is provided below:

Food and Beverage Manufacturing

- Upgrade of production line
- Recovery of water from bottle rinsing
- Improved filtration to prevent spillage and overflow
- New high pressure cleaning equipment

Petroleum, Coal and Chemical Product manufacturing

- High pressure cleaning
- Improved production scheduling resulting in lower water use
- Reuse of condensate in production process

Non Metallic Mineral products

- Water recovery from dryer
- Establishment of recycling plant

Metal Product Manufacturing

- Recycling of water from waste plant
- Improved process control

Other Manufacturing

- High efficiency cooling towers
- Automated bio-filter watering system
- Improved water blow down from boilers and cooling towers

Wholesale/Retail trade

- Cisterns, taps fitted with restrictors
- Dual flush toilets
- Pressure reducing valves

Accommodation, Cafes and Restaurants

- Timed water sprinklers
- Water saving garden additives
- Fountain water recycling
- Water savers on taps, restricted shower heads
- Sensor men's urinal, dual flush cisterns

Telecommunications, Finance and Property Services

- Meters installed to understand usage and for benchmarking purposes
- Flow restrictors installed on taps, pans and urinals

Education

- Automated sprinklers system with water sensor
- Underground rainwater tank

Health and Community services

- Recycling of water from sterilizers
- Flow control valves installed
- Upgrade of cooling tower systems

Cultural and Recreational Services

- Construction of stormwater dams
- Refinement of irrigation system

Personal and Other Services

- New water efficient machinery
- Recycling of water used for cooling of machinery

Agriculture

- Computerised sprinkler systems

1.4.10 Tariff structure preferences

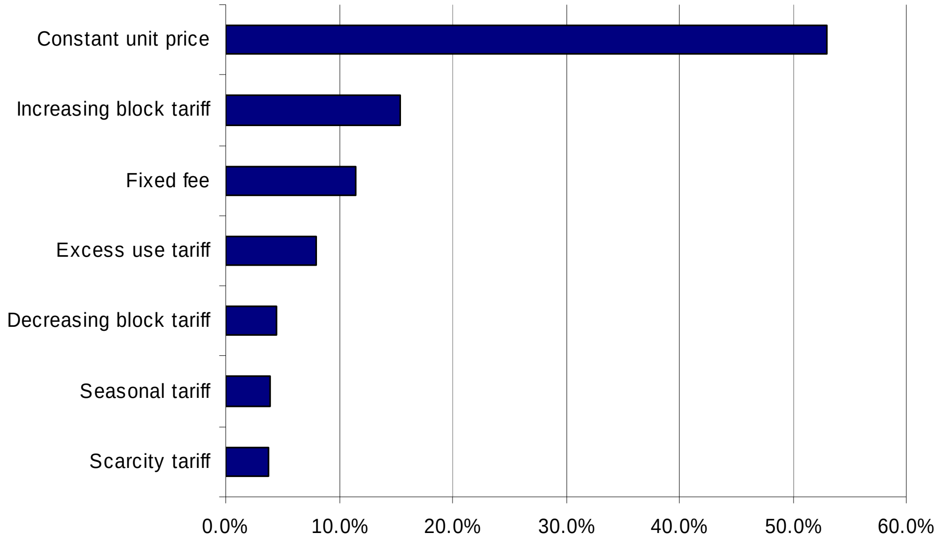
In the water use questionnaire respondents were asked to choose their preferred tariff structure from a set of seven possible structures. The question specifically asked that respondents consider those tariff structures which provide them with the greatest incentives to manage their water resources more efficiently.

The tariff structure options were:

- Fixed Fee
- Constant unit price
- Seasonal tariff
- Scarcity tariff
- Increasing block tariff
- Decreasing block tariff
- Excess use tariff

Results are shown in Figure 20 below.

Figure 20 **Tariff preferences of all respondents**



Data source: ACIL Tasman

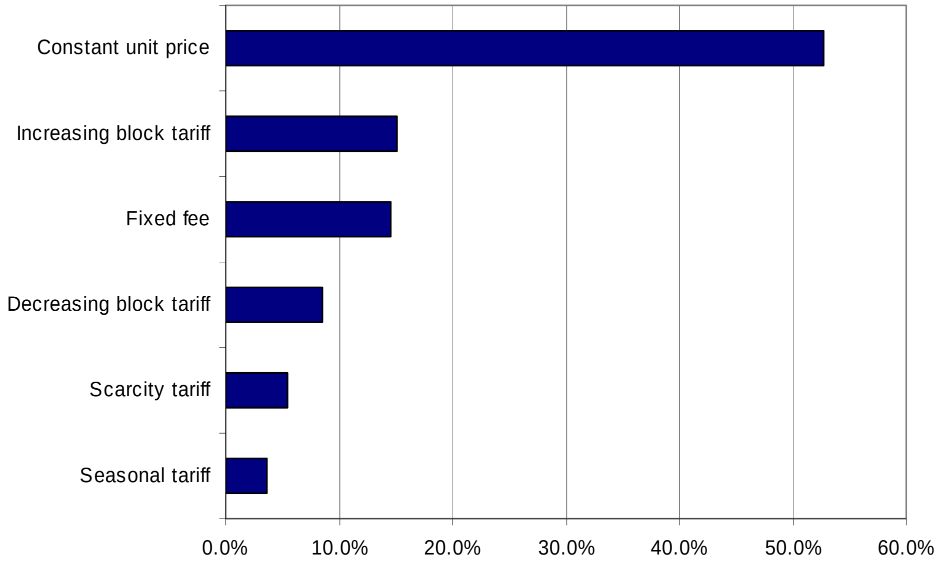
The most preferred tariff structure by a considerable margin was the constant unit price. This is the current tariff structure that non residential users currently face, and the result reflects a strong preference on the part of respondents to maintain the status quo.

Of all respondents, 53% preferred maintaining a constant unit price. The next most popular option was the increasing block tariff, favoured by 15.4% of respondents. This was followed by fixed fee (11.4%), and Excess use tariff (7.9%).

The other available options were only favoured by a very small proportion of total respondents. Overall, 4.0% preferred a seasonal tariff, 4.4% a decreasing block tariff and 3.7% a scarcity tariff.

Figure 21 below charts the tariff preferences of the top 1000 water users consuming in excess of 10ML of water per annum. The ranking of preferred tariff structures is broadly similar to the results for all users.

Figure 21 **Tariff preferences of larger users, > 10ML per annum**



Note: Larger users were not given the option to express a preference for an excess use tariff.
Data source: ACIL Tasman

Table 10 below displays the percentage of respondents preferring each tariff structure across all industry groups. The same results are presented graphically in Figure 22.

Table 10 **Tariff preferences by industry**

	Fixed fee	Constant unit	Seasonal	Scarcity	Increasing block	Decreasing block	Excess use
	Percentage of respondents in each industry						
Food and Beverage M'fing	6.1%	69.7%	3.0%	0.0%	15.2%	3.0%	3.0%
Textiles, Clothing, Paper, Chemicals	11.5%	50.0%	0.0%	3.8%	19.2%	7.7%	7.7%
Metal Products, Machinery and Equipment	6.1%	60.6%	0.0%	6.1%	15.2%	6.1%	6.1%
Other Manufacturing	0.0%	50.0%	5.6%	5.6%	38.9%	0.0%	0.0%
Wholesale /Retail	16.1%	45.2%	0.0%	6.5%	12.9%	9.7%	9.7%
Accommodation Cafes and Restaurants	14.5%	49.1%	10.9%	0.0%	20.0%	1.8%	3.6%
Education	5.5%	41.8%	12.7%	10.9%	16.4%	1.8%	10.9%
Health /Community Services	9.3%	62.8%	2.3%	2.3%	7.0%	2.3%	14.0%
Culture and Recreation	27.0%	45.9%	0.0%	8.1%	8.1%	5.4%	5.4%
Agriculture	16.2%	56.8%	2.7%	0.0%	8.1%	8.1%	8.1%

Government	0.0%	42.9%	0.0%	0.0%	42.9%	0.0%	14.3%
Finance, Property, Telco and Transport	5.9%	58.8%	0.0%	0.0%	17.6%	8.8%	8.8%
Personal/Other Services	21.1%	52.6%	0.0%	0.0%	10.5%	0.0%	15.8%
All industries	11.4%	53.0%	4.0%	3.7%	15.4%	4.4%	7.9%

Data source: ACIL Tasman survey

Although the popularity of the constant unit price tariff is confirmed across all industry sectors, there are some interesting differences to be observed.

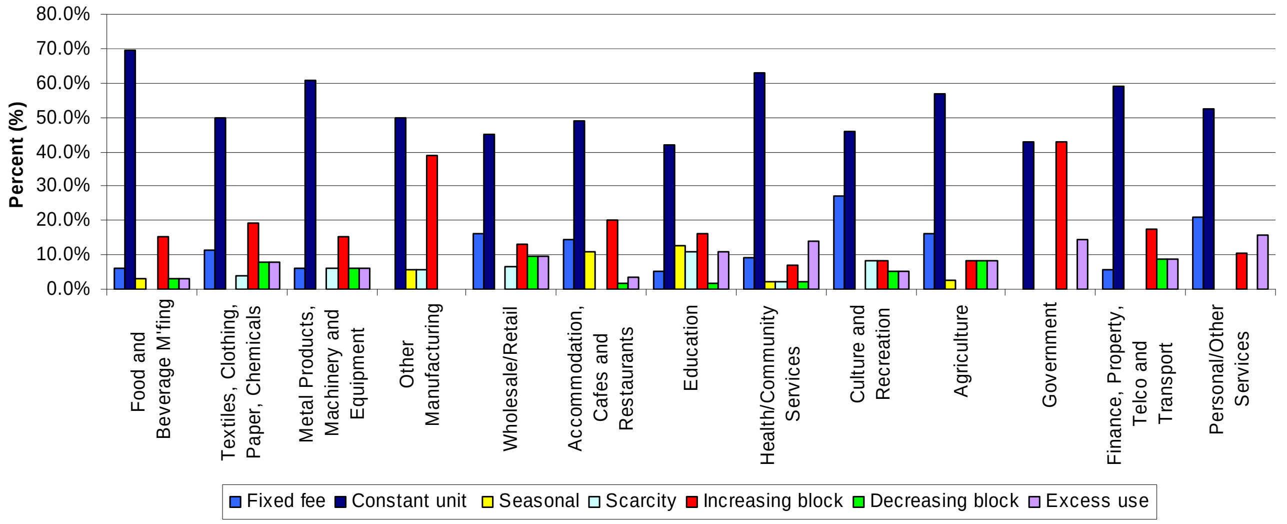
Firstly, the manufacturing sectors which use large amounts of water strongly preferred constant unit price tariffs. However, a sizeable minority of respondents in these sectors did express a preference for incentive based pricing such as increasing block tariffs.

Also, many schools identified that a seasonal tariff which prices water higher during the summer months was in their interest because their demand for water during these months was close to zero. The other industry group that showed above average support for seasonal tariffs was Accommodation, Cafes and Restaurants.

Local Government Councils and Other Manufacturing respondents registered a higher than average preferences for increasing block tariffs.

Taken together, over 23% of respondents expressed a preference for increasing block or excess use tariffs. Although still a minority view, a large segment of respondents across all sectors expressed support for tariff structures which incorporate appropriate incentives to conserve water.

Figure 22 **Tariff preferences by industry**



Data source: ACIL Tasman

1.4.11 Justifications of tariff structure choice

Respondents offered a diverse range of reasons to justify their choice of preferred tariff structure. The main determining factors cluster around the following principles;

- Certainty or predictability
- Simplicity
- Fairness
- Consistency
- Incentives

The main points offered in the choice of each specific tariff structure are provided below.

Fixed Fee

- Allows for easy budgeting and forecasting
- User has no control over usage
- Certainty

Constant unit price

- Constant factory output
- Simplified budget process
- Usage of water is mostly fixed with little scope for water saving

- Water savings restricted by regulatory constraints on recycling (abattoir)
- Little scope to vary water consumption without significant capital investment
- Usage not seasonal or cost driven
- Fair system, Level playing field
- Consistency
- Only way of fairly treating businesses of different sizes. Rising block structures unfairly penalise larger businesses
- Predictability of costs
- Simplicity and Fairness

Seasonal tariff

- Favoured by those with low water consumption in the summer months i.e. schools and universities

Scarcity tariff

- Higher cost of water in times of drought mobilizes interest in saving water
- Provide incentives for reduced water consumption
- Encourage planning for drought conditions

Increasing block tariff

- Provides appropriate incentives to reduce water usage and find other water sources, i.e. rain tanks
- High water consumers should pay a higher unit cost for water to encourage greater innovation.

Decreasing block tariffs

- Provides economies of scale

Excess use tariff

- Provides benchmarks of water use
- Provides incentives to conserve water use or find alternative sources
- Determining normal versus excess use is tricky
- Fair in the sense that some industries/organisations require more water than others
- Favoured by businesses who can accurately forecast their water usage or whose water usage is well managed and known.
- Enables goal setting for usage

It is clear that the main advantage of the constant unit price tariff lies in its simplicity and fairness. Respondents were concerned that larger businesses would be unfairly penalised for using large amounts of water. Constant unit price also has the advantage of being easily understood, with respondents feeling that the constant unit price allows for some degree of predictability of costs. Constant unit price tariffs were preferred by the more commercial sectors.

A number of respondents expressed the view that there was little scope to adjust their water consumption, and given this, the constant unit price tariff was the most appropriate way of charging for water use.

Those sectors of the economy that are less commercially driven, such as Education and Government, were more willing to express a preference for increasing block, seasonal, scarcity and excess use tariffs. In all cases it was recognised that these tariff structures provide incentives to promote water conservation.

In interpreting these results it should remembered that stated preference studies where respondents are asked to express a preference should be evaluated cautiously. It is not unreasonable to expect a certain amount of 'gaming' of responses by respondents will take place. Also, what is preferred by respondents is not necessarily the most appropriate or beneficial policy approach, either from the point of view of the individual or from the wider objectives of water conservation.

1.4.12 Customer responsiveness to price changes

The survey also questioned respondents as to their likely consumption response to a 10%, 25% and 50% rise in the metered usage charge of water. A total of 62 respondents from a total sample of 577 indicated they would respond to a 10% price increase. This then rose to 98 respondents who indicated they would respond to a 25% increase, and finally 109 indicated they would respond to a 50% price rise.

Table 11 indicates that overall, just over 25% of all respondents in the survey indicated that they would adjust their consumption in response to a change in the metered usage charge.

Of those businesses in the top 1000 ranked customers, corresponding to an annual usage in excess of 10ML, a total of 19.8% answered in the affirmative that they would alter their consumption in the face of price changes. This proportion is less than that for the less than 10ML group, of which nearly 32% indicated that they would reduce their water consumption if faced with a higher usage charge.

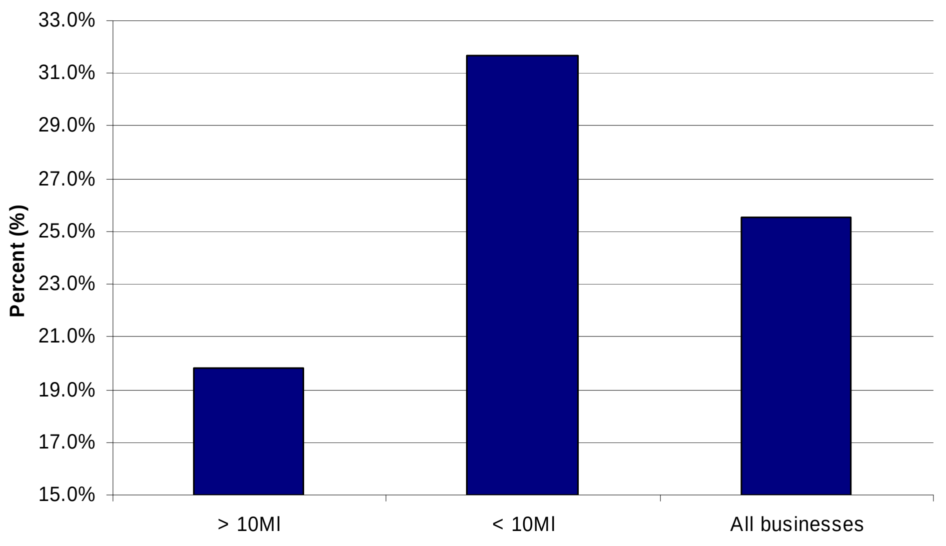
Of those customers with annual consumption greater than 10ML, who also have a water management plan, 43% said they would reduce consumption if water usage charges were to rise. This compares with only 13% of those larger customers without a water management plan, indicating that those respondents who have taken the trouble to put in place a water management plan may be better placed to respond to the need to adjust their consumption if prices rise.

Table 11 **Customers indicating responsiveness to price changes**

	Yes		No	
	number	percent	number	percent
Those with WMP	29	42.6%	39	57.4%
Those without WMP	30	13.0%	200	87%
Those in top 1000 customers	59	19.8%	239	80.2%
Those outside top 1000 customers	88	31.5%	191	68.5%
All customers	147	25.5%	430	74.5%

Data source: *ACIL Tasman survey*

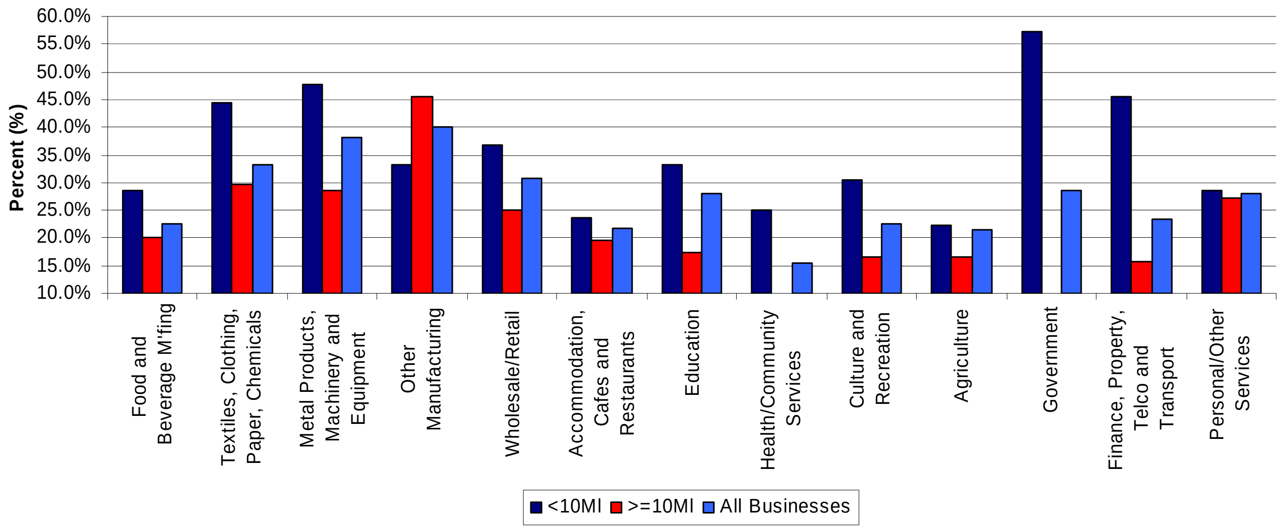
Figure 23 **Proportion who would reduce their water consumption in response to an increase in the usage charge**



Data source: ACIL Tasman

Responses not only varied by size, but also across different industries. It can be seen in Figure 24 below that overall, those respondents operating in manufacturing industries are more likely to express an intention to reduce consumption in response to a price rise. These industries also tend to be the more water intensive ones. Other sectors that are not so water intensive and where water does not play an important role in their operation have indicated that they are unlikely to adjust their behaviour in response to an increased usage charge. These include Education, Health and Community services, Culture and Recreation and Accommodation and Cafes. Respondents operating in the Agricultural sector are an exception to the general relationship found between water intensity and stated price responsiveness. Those operating in the Agriculture sector are operating at high levels of water intensity, however, due to the nature of their operations have very little scope to adjust their water consumption.

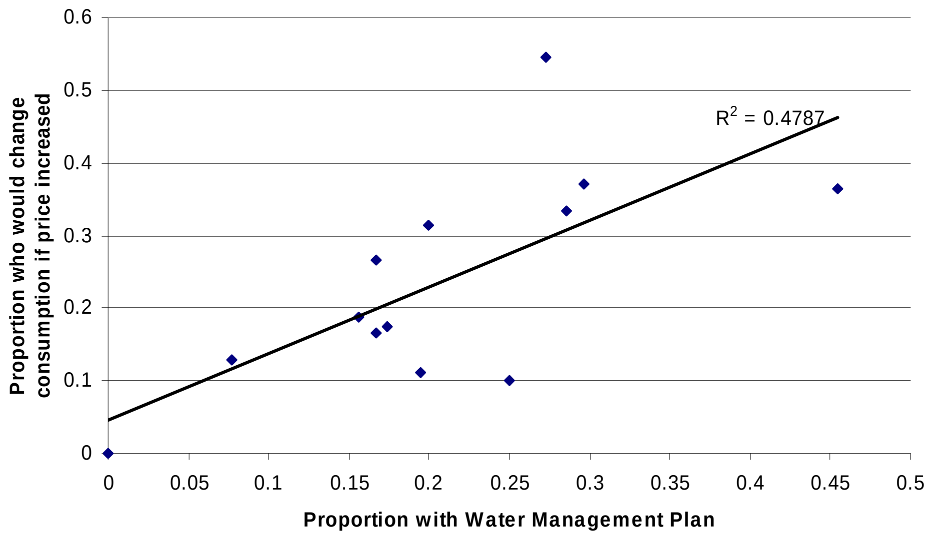
Figure 24 **Proportion who would reduce their water consumption in response to an increase in the usage charge by industry**



Data source: ACIL Tasman

Figure 25 below show a strong relationship between those industries that have a high proportion of members that have implemented a water management plan and the proportion in that industry category who have indicated an intention to reduce consumption in response to higher prices. This is consistent with results shown in Table 11 which show a strong relationship between stated responsiveness and the presence of a water management plan.

Figure 25 **Relationship between respondents who will reduce consumption in response to usage charge rises and those with water management plan**



Data source: ACIL Tasman

Confidential

Appendix C: Modelling of Price Responsiveness

Pricing for water conservation in the non-residential urban sector

Prepared for the Steering Committee of the Smart Water Fund

January 2007

ACIL Tasman

Economics Policy Strategy

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Estimation of water price elasticities

1 Introduction

One of the important elements for developing innovative tariff structures to promote sustainable water consumption are price elasticities, that is how users vary their consumption in response to changes in water prices. Our approach for deriving estimates of price elasticities involves econometric modelling to establish the relationship between water consumption and water prices and other determining factors associated with the business users such as firm's revenue, employment, industry grouping etc. The modelling makes use of the information collected from the water use survey and water consumption data retrieved from the utilities' customer billing records.

2 Overview of methodology and results

This section presents a summary of the methodology applied and results obtained from the econometric analysis.

The modeling approach involved a direct model of water demand, where water demand was expressed as a function of explanatory variables such as real prices, firm size as measured by turnover, rainfall, temperature and other factors that may have an influence on water demand such as the specific industry a firm operates in, whether they supplement from other sources or have implemented a water management plan or other water saving processes.

The sample included only firms that operated continuously over the period under consideration. Those that ceased operating during the period were excluded from the analysis.

Two approaches to estimating price elasticities of demand were taken, the first utilizing actual price volume data from the individual utilities databases that were matched back to the survey; and the second using respondents answers to a question on how they would adjust there water consumption in response to a 10%, 25% and 50% increase in the price of water.

Both of these approaches have their respective benefits and drawbacks. The direct approach utilizing real price and volume data produces elasticity estimates that are large compared to data obtained from the literature review. This upward bias results because our model excludes the impact of changing perceptions or expectations of future water prices and community pressures to conserve water, which have increased markedly in the last few years despite real water prices not having changed significantly over this period.

By adopting an indirect method, the expectations of the respondents are incorporated into their answers which results in more credible estimates. However, as the data are based on the assessments of the survey respondents, there is no guarantee that respondents will act in a way that is consistent with their answers in the survey.

Estimated price elasticities of demand utilizing the 2 approaches are shown in the table below for large users (Top 1000 or greater than 10 ML per annum) and smaller users (less than 10ML per annum).

The table below summarises the estimates for the 2 approaches.

Table 1 **Estimated price elasticities of demand**

Category	Actual data	Stated responses
Large users (> 10ML)	-2.4	-1.1
Small users (<10 ML)	-2.0	-0.6

Data source: AT modelling

The results indicate that large users are more responsive to changes in prices, using the estimates obtained from both approaches. The elasticities are interpreted as the demand response to a small price increase, say 1%. For example, in the case of the stated response results a 1% increase in price translates into a reduction of demand of 1.1% for a large user and 0.6% for a small user. However, due to the nature of the demand curve, there is a risk of overestimating the demand impacts if the effects are extrapolated over a large price increase. The main report sets out the impacts of price elasticities on water demand in greater detail.

The analysis also extracted elasticity estimates across different user groups, these being the manufacturing sector, with the remaining firms grouped into low, medium and high water intensity categories. The low intensity group comprises wholesale/retail trade, government administration and finance and property services. Medium intensity is made up of accommodation, cafes and restaurants, education and health/community services and the high intensity group includes culture and recreation, agriculture and personal and other services.

Table 2 below shows the range of estimates for these groups for both estimation methodologies and by small and large users. Although the relationship is not particularly strong, there appears to be some positive relationship between the degree of water intensity and the estimated price elasticity.

Table 2 **Estimated price elasticities of demand by user groups**

	Actual data		Stated responses	
User group	Small users (<10ML)	Large users (> 10ML)	Small users (<10ML)	Large users (> 10ML)
Manufacturing	-3.1	-3.7	-0.4	-1.0
Low water intensity	-3.1	-3.5	-0.7	-1.0
Medium water intensity	-0.2	-0.6	-0.3	-0.9
High water intensity	-2.0	-2.1	-1.2	-1.4

Data source: AT modelling

A more detailed exposition for the technically minded reader is presented in the sections that follow.

3 Data

3.1 Data list

The water use survey provides the following information for 416 business establishments.

- The supplying utility – City West, South East or Yarra Valley,
- Industry that the business belongs to;
- Revenue earned in the year 2005/06;
- Employment size;
- Value of plant and equipment
- Use of supplementary water, if any;
- Investment in water saving processes or participation in water demand management programs;
- Preferred tariff structures;
- Likely change in potable water consumption if water usage charge was increased (by 10%, 25% and 50%);
- If the establishment completed a water management plan;
- Water consumption volumes;
- Sewerage discharge volumes.

In addition, the utilities' customer billing database provides water and sewerage volumes, though not complete, for the years from 1998 to 2006. Usage prices and service charges for water and sewerage are also provided by the utilities.

ACIL Tasman has obtained other economic data including the consumer price index, and wages by industry from the Australian Bureau of Statistics. Temperature and rainfall data was sourced from the Australian Bureau of Meteorology.

3.2 Issues relating to the survey and billing data

Several issues have been identified with the available data that may affect satisfactory modelling of water consumption. They are;

1. The survey only provides a snapshot of the businesses, that is, most of the data such as revenue and employment only relate to the latest year i.e. 2005-06. Historical information on the establishments is not available for assessing their possible effects on levels of water consumption over the years.
2. There appears to be significant inconsistency between the revenue and employment data. This may be due to:
   - Incorrect reporting by the respondents, for example, revenue values are given for the parent companies while the number of employees for the local establishments; and
   - For certain industry groups such as Cultural and Recreational Services, the number of employees include volunteers and non-salaried personnel.
3. For a large number of establishments, changes in their water volumes from one year to the next are very large. This may not be an issue in itself if historical information were available for these businesses to help explain these variations. In the absence of such information, it would not be appropriate to try explaining the variations in water use by the establishments with price changes alone. Consequently, it is decided that historical data for water consumption are excluded if they show a 20 percent deviation from the 2005-06 level for the respective establishments. This rule ensured that only businesses operating over the full period were included in the analysis.
4. For the survey year i.e. 2005-6, different water prices are charged by the three utilities and users of a particular utility pay the same water price. Further, changes in real water prices over the last few years have not been very significant. There is thus limited variation in the price variable which is used as an explanatory variable in the water demand model. This makes it difficult to accurately assess, even with the use of statistical methods, the sensitivity of water consumption with respect to water prices.
5. The survey also probes from the respondents likely changes in water consumption if the usage charge was increased (by 10%, 25% and 50%). The responses to these larger, though hypothetical, price increases can be used in the modelling to estimate price elasticities. The use of this

information, however, needs to be qualified because customers may not actually do as they say they would do.

4 Model specification

Demand for potable water by business users is influenced by many factors including – the firm's size (revenue), production process (type of industry), use of various input factors, water prices and other factor prices, temperature and use of supplementary water sources. The modelling of the relationship between water use and these factors can take one of the following possible approaches.

4.1 Direct model of water demand

This is a common approach used to study how the demand for a good or service may change with respect to its determining factors. The firm's water demand (dependent variable) is directly expressed as a function of the factors (explanatory variables). For example, the model where water demand has constant elasticities with respect to output and water price takes the following form.

$$\text{Log(Water Demand)} = b_0 + b_1.\text{Log(Output)} + b_2.\text{Log(Price)} \quad (1)$$

Model (1) above can be extended to include other factors as appropriate. The advantage of this model form is that it is easy to understand and it requires less data. A possible drawback of the model structure is that it implicitly assumes fixed input output ratios i.e. thus no substitution or complementariness between the factors of production.

Because of its parsimonious data requirement and the problems identified above with the water survey data, Model 1 is the preferred method to assess the effects of the relevant factors on water consumption.

4.2 Model of expenditure shares

The shares of input expenditures, including the cost of water as a proportion of the firm's output, can be modelled with respect to the respondent firm's output levels and factor prices e.g. cost of labour, water prices. This model of industrial water demand is constructed on the assumption that the representative user firm chooses its input usage, including water consumption, to minimise the cost of its production. The inclusion of all factor prices allows for an assessment of the substitution (or complementariness) between the input factors.

The translog functional form is commonly used for modelling input expenditure shares i.e. a translog cost function is assumed. The resulting cost share equations are expressed as follows.

$$S_i = a_i + SUM\,[\,a_{ij}.Log(Price_j)\,] + b_i.Log(Output) \qquad (2)$$

Where:

- i and j are the factors of production, potentially including water, sewerage, labour and capital
- SUM is summing over all values of i.

Due to the constraint of the water survey data, particularly the inconsistency between the revenue and employment data, the current analysis does not include the application of Model 2 i.e. its estimation with the limited available data does not provide satisfactory results.

5 Model estimation

The direct model of water demand was estimated using actual water price data: in real terms i.e. deflated by CPI, for the years from 2000 to 2006 and the hypothetical price changes specified in the water use survey (10 percent, 25 percent and 50 percent price increases).

5.1 Model estimation using actual real water prices

Model 1 was extended to include the following variables.

- The dependent variable is the log of water consumption volumes (LWCON).
- The explanatory variables include:
  - Log of the establishment's revenue (LREVENUE);
  - Log of real water usage price (LWPRICE);
  - Interaction variable (OUTTOP) which is the product of the variable LREVENUE and the dummy variable (TOP1000) indicating if the user belongs to the group of top 1000 users (assigned value of 1) or not (assigned value of 0). The coefficient of this variable captures the differential between the output elasticities of the two groups;
  - Interaction variable (PRICETOP) which is the product of the variable LWPRICE and the dummy variable TOP1000. The coefficient of this variable captures the differential between the price elasticities of the two groups;
  - Temperatures corresponding to the operating areas of the supplying utilities in years (TEMPERAT);

- Rainfall for each year during 2000-2006 but without changes by location (RAINFALL);
- Dummy variable indicating the period when Stage 2 water restrictions were implemented (RES2);
- 6 dummy variables indicating different types of supplementary water (DUMQ7A to DUMQ7F);
- Dummy variable indicating establishment's investment in water saving processes or participation in water demand management programs (DUMQ8A);
- 12 dummy variables indicating the industry that the business belongs to (QDUM1 to QDUM12);
- Dummy variable indicating if the establishment completed a water management plan (DUMWMP);

The model was estimated using ordinary least square (OLS) method with correction for error heteroskedasticity i.e. errors tend to be larger for larger water users and smaller for smaller users.

5.1.1 Modelling results

Estimation of the above model was carried out using real water usage prices. The model produced the following estimates of price elasticities.

- For users that are not within the Top 1000 group, a price elasticity of around -2;
- For users that are in the Top 1000 group, an elasticity differential of -0.39 or a total price elasticity of around -2.4.

The results are shown in Table 3 below.

Table 3 **Model using real water prices**

Variable name	Code	Estimated coefficient	T ratio
Revenue	LREVENUE	0.059	5.3
Price	LPRICE	-1.988	-3.8
Revenue elasticity differential	OUTTOP	0.366	11.5
Price elasticity differential	PRICETOP	-0.388	-5.5
Temperature	TEMPERAT	0.144	4.7
Rainfall	RAINFALL	0.000	0.9
Food and Beverage Manufacturing	QDUM1	-0.043	-0.4
Textiles, Clothing, Paper, Chemicals	QDUM2	0.140	0.8
Metal products, Machinery and Equipment	QDUM3	-0.056	-0.4
Other manufacturing	QDUM4	-0.179	-1.1
Wholesale/Retail	QDUM5	-0.142	-1.1
Accommodation, Cafes and restaurants	QDUM6	-0.342	-3.1
Education	QDUM7	-0.258	-2.3
Health/Community services	QDUM8	-0.232	-2.2
Culture and Recreation	QDUM9	0.042	0.4
Agriculture	QDUM10	-0.125	-1.1
Government	QDUM11	-0.696	-4.7
Finance, Property services	QDUM12	-0.814	-5.9
Constant	CONSTANT	14.105	5.9
R Square	**0.7680**		

Data source: ACIL Tasman model

5.1.2 Discussion of modelling results

Significant results of the modelling are provided as follows.

- The revenue of the establishment is the most important factor in determining water consumption level.
  - For users that are not within the Top 1000 group, a small output elasticity of around 0.06;
  - For users that are in the Top 1000 group, a significant output elasticity of around 0.43.
- The coefficient estimates for the water usage price, LWPRICE, and the price elasticity differential, LWPRICE2 are statistically significant at 5 percent. The price elasticity estimates for both the Top 1000 user group and the users outside the Top 1000 group have the right negative sign.
  - The Top 1000 has a higher degree of price sensitivity;

  - The magnitude of the price elasticity estimates, -2.0 and -2.4, well exceeds the range of estimates obtained from previous studies in Australia and overseas (between -0.5 and -1.0). A possible explanation for these high estimates is that recent changes in water consumption may be a response to expectation of larger future price increases rather than to the actual increases in real tariffs which are much smaller.
- Temperature has a significant positive effect on water consumption. The coefficient estimate of 0.144 suggests that if average temperature throughout the year is higher by one degree, water consumption increases by 14.4 percent. This sensitivity, however, appears too high and may be overstated because the temperature variable with its regional variations also captures the effect of the customer composition of the different utilities;
- Rainfall was not found to have a significant effect on water consumption;
- The model did not find a significant effect of the use of a supplementary water source on potable water consumption;
- The inclusion of the dummy variables indicating the establishment's investment in water saving processes or participation in water demand management programs did not produce plausible results i.e. they positively correlate with water consumption level. The correlation exists because larger users are more likely to have made water saving investments or participated in demand management programs. As a causal relationship is not estimated, the variables are dropped from the current model. A separate analysis is provided below to assess the effect of water saving investment;
- Estimated coefficients for the industry dummy variables indicated that industry groups Accommodation, Cafes and restaurants, Government and Finance, Property services use less water than the others, other things being equal.

5.1.3 Other results and considerations

Other findings were obtained in the modelling exercise but were not presented in the above results. They include:

- The estimation did not detect significant differences in the price elasticities for different industry groups. This is because of the limitation of the sample price data and the high degree of collinearity of dummy variables for the industry groups and those introduced to assess differential industry elasticities;
- Inclusion of the dummy variable for Stage 2 water restrictions seriously affects the estimation of the price elasticity i.e. a positive sign was obtained collinearity between this dummy variable and the water price variable. Consequently, this variable was dropped from the model;

- When included, the coefficient for the dummy variable DUMWMP is statistically significant but has a wrong (positive) sign. This is due to the fact that large water users tend to have completed a water management plan but not smaller users. As such, this is a not a causal relationship for explaining water demand, this variable is dropped from the model. A separate analysis is carried out by using the price scenario data and selecting a suitable sample of data to measure this effect.

5.1.4 Model results for individual industry groups

The model is estimated for four different industry groupings: Manufacturing and three water intensity groups (Low, Medium and High).

The resulting estimates of price elasticities are presented in the following table.

Table 4 **Water price elasticities by industry group**

	Model elasticity estimates [1]	
User group	Small Users	Top 1000
Manufacturing	-3.1	-3.7
Low Intensity	-3.1	-3.5
Medium Intensity	-0.2	-0.6
High Intensity	-2.0	-2.1

Note: (1) Low intensity group include industries Wholesale/Retail trade, Government administration and Finance and Property; medium intensity group include industries Accommodation Cafes and Restaurants, Education and Health/Community services; high intensity group include industries Culture and recreation, Agriculture and Personal/other services.

Data source: ACIL Tasman estimates

5.1.5 Differential price elasticities by supplying utility

The estimation results indicate that there is no significant difference between the water price elasticities for the three supplying utilities.

5.2 Model estimation using scenario water prices

5.2.1 Modelling specification

In the survey, respondents indicated the likely changes in their water consumption for the scenarios where the usage charge was increased (by 10%, 25% and 50%). Based on this data, Model 1 can be estimated to derive price elasticities. This approach of using information on users' intention is referred to as 'boot strapping'. While there is a modelling advantage given the hypothetical large variations in water prices, caution needs to be taken because customers' intention may differ to their actual response in real situations.

The following considerations are taken into account in formulating the model.

- Out of 416 respondents:
  - 103 respondents indicated that they would change their consumption in response to one of the scenario price changes;
  - 276 respondents indicated that they would not change their consumption with any of the price changes; and
  - 37 respondents provided no information on their possible response.
- There are four price scenarios: the base case (2005-06 prices), 10 percent price increase, 25 percent price increase and 50 percent price increase.
- To obtain more reliable estimates of water price elasticities, most of the modelling is carried out using the responses from the first group above.
- The model includes the following variables.
  - The dependent variable is the log of water consumption volumes (LWCON).
  - The explanatory variables include:

a) Log of the establishment's revenue (LREVENUE);

b) Log of the hypothetical water usage price (LWPRICE)

c) 6 dummy variables indicating different types of supplementary water (DUMQ7A to DUMQ7F);

d) Dummy variable indicating establishment's investment in water saving processes or participation in water demand management programs (DUMQ8A);

e) 12 dummy variables indicating the industry that the business belongs to (QDUM1 to QDUM12);

5.2.2 Model results

Estimation using all responses

The model estimation results are provided below. The estimates of water price elasticity for small users and large users are:

- For users that are not within the Top 1000 group, a small price elasticity of around -0.16;
- For users that are in the Top 1000 group, a more significant price elasticity of around -0.42.

Table 5 **Model using all responses**

Variable name	Code	Estimated coefficient	T ratio
Revenue	LREVENUE	0.062	6.1
Price	LPRICE	-0.156	-1.4
Revenue elasticity differential	OUTTOP	0.308	9.3
Price elasticity differential	PRICETOP	-0.256	-3.7
Food and Beverage Manufacturing	QDUM1	0.062	0.5
Textiles, Clothing, Paper, Chemicals	QDUM2	0.324	2.0
Metal products, Machinery and Equipment	QDUM3	-0.092	-0.8
Other manufacturing	QDUM4	-0.236	-1.8
Wholesale/Retail	QDUM5	-0.024	-0.2
Accommodation, Cafes and restaurants	QDUM6	-0.090	-0.9
Education	QDUM7	-0.119	-1.1
Health/Community services	QDUM8	-0.021	-0.2
Culture and Recreation	QDUM9	-0.004	0.0
Agriculture	QDUM10	-0.091	-0.8
Government	QDUM11	-0.609	-4.8
Finance, Property services	QDUM12	-0.751	-5.2
Constant	CONSTANT	8.826	16.5
R square	**0.734**		

Data source: ACIL Tasman model

Estimation using only non-zero responses in one of the price change scenarios

Modelling with the complete data set on price responses may not be the most effective approach as it involves the redundancy of re-estimating price elasticities for the group of users that have stated that would not change their water consumption regardless of the price increases i.e. the survey provides a priori information on zero price elasticity for this group (assuming that they do not respond either to price increases greater than 50 percent which is considered to be an upper limit of plausible price changes).

However, even more significantly, separate modelling for these respondents based on historical price data shows that they have in fact been quite responsive to even the modest price changes in recent years or, as seems even more likely, to expectations of greater price rises in the future. The 'zero responses' for this group have therefore been discounted for purposes of assessing the impact of expected price change on demand. These responses could reflect either or both of a lack of depth in the formal planning for a response or some gaming of a question that could be seen as posing a risk of even greater or earlier price rise. Although excluding a large number of observations from the analysis may be seen as reducing the accuracy of the estimates, for the purposes of achieving statistically significant results the remaining sample size remains sufficiently large.

Consequently, we believe that more informative estimation can be carried out using only the survey results for those users that would reduce their water consumption in at least one of the price scenarios. While this approach is expected to produce statistically significant and more reliable estimates of price elasticities, a number of considerations need to be made.

- To ensure that the model relationship is established using the full information available for the base case (at 2005-06 price levels), data for all users is included. The estimation thus provides the contrast of the non-zero responses in the price scenarios with the water consumption patterns prior to the price change (as well as variations between users).
- The model estimates of price elasticities are thus only applicable to the selected sample group. This information is valuable in itself because
  - Firstly, it measures the extent to which customers may vary their water consumption if they do respond to price changes; and
  - Secondly, the non-zero responses may generally be considered to be more reliable than the zero responses in the water use survey i.e. the former group of respondents needed to actively assess the impact while the latter group (or a proportion of it) may just not report the likely effects of price increases if these are not large.
- Assuming that the zero responses truly reflect what these respondents would do in the events of substantial price increases, the price elasticities for the whole population of users can be calculated using the elasticity estimates for those who respond to price changes and the proportion of their water consumption i.e. weighted average elasticity calculated based on water uses. Because the number of zero responses makes up a large proportion of all responses at 73 percent, caution needs to be taken in using the price elasticity estimates derived for the population.
- It would be useful to follow up with a selected number of zero responses to establish the underlying reasons for their non-responsiveness. In a later section, an analysis is prepared using the information available in the water use survey to assess the difference in the characteristics of the zero and nonzero respondents.

Results of the model estimation are reported in Table 6 below. The water price elasticity for the users outside the Top 1000 is estimated at -0.6 and for the Top 1000 group is -1.09. Both estimates are statistically significant at 5 percent level.

As the above elasticity estimates are derived for only the establishments that would change their consumption in response to one of the scenario price changes, adjustment is required to derive the water price elasticity for the whole population of business users i.e. based on the proportion of water consumption for this group (approximately 30.8 percent for both the Top 1000 group and the other user group). If the stated preference of the group that do not respond to any scenario price increases specified in the survey is accepted on face value (note that the analysis in Section 5 casts doubt on this acceptance) then the adjusted estimates of price elasticities are:

- For Top 1000 group, -0.336 ; and
- For users outside the Top 1000, -0.185.

Table 6 **Model using non zero responses**

Variable name	Code	Estimated coefficient	T ratio
Revenue	LREVENUE	0.064	4.4
Price	LPRICE	-0.599	-3.4
Revenue elasticity differential	OUTTOP	0.406	8.2
Price elasticity differential	PRICETOP	-0.486	-4.5
Food and Beverage Manufacturing	QDUM1	0.217	1.4
Textiles, Clothing, Paper, Chemicals	QDUM2	0.201	0.9
Metal products, Machinery and Equipment	QDUM3	0.011	0.1
Other manufacturing	QDUM4	-0.190	-1.1
Wholesale/Retail	QDUM5	0.082	0.5
Accommodation, Cafes and restaurants	QDUM6	-0.098	-0.7
Education	QDUM7	-0.049	-0.3
Health/Community services	QDUM8	0.041	0.3
Culture and Recreation	QDUM9	0.084	0.5
Agriculture	QDUM10	-0.226	-1.4
Government	QDUM11	-0.550	-3.0
Finance, Property services	QDUM12	-0.807	-3.6
Constant	CONSTANT	10.760	13.0
R square	**0.754**		

Data source: ACIL Tasman model

5.2.3 Difference in price elasticities between industry groups

Of interest is whether different industry groups may have different degrees of price sensitivity. The following results are obtained with the modeling using only non-zero responses.

As before, the price scenario model is estimated for four different industry groupings: Manufacturing and three water intensity groups (Low, Medium and High).

The model produced statistically significant estimates of price elasticities for the industry groupings which are presented in the following table.

Table 7 **Water price elasticities by industry group**

	Model elasticity estimates [1]	
User group[2]	Small Users	Top 1000
Manufacturing	-0.41	-1.0
Low Intensity	-0.74	-0.97
Medium Intensity	-0.26	-0.91
High Intensity	-1.23	-1.42

Note: (1) based on those responsive to price changes

(2) Low intensity group include industries Wholesale/Retail trade, Government administration and Finance and Property; medium intensity group include industries Accommodation Cafes and Restaurants, Education and Health/Community services ; high intensity group include industries Culture and recreation, Agriculture and Personal/other services.

In addition, it has been found that some specific industries within the same user sub-groups have different price elasticities to the others within the same group. These results are shown below.

Table 8 **Difference in price elasticities within industry group**

User group[1]	Specific sub-group	Elasticity differential to Group
Manufacturing	Food & Beverage Mfg	0.04
Low Intensity	Government Admin	-0.12
High Intensity	Agriculture	-0.05

Note: (1) Low intensity group include industries Wholesale/Retail trade, Government administration and Finance and Property; medium intensity group include industries Accommodation Cafes and Restaurants, Education and Health/Community services; high intensity group include industries Culture and recreation, Agriculture and Personal/other services.

5.2.4 Differential price elasticities by supplying utility

The price scenario model is estimated allowing for differential price elasticities of water consumption for the three supplying utilities. The results indicate that there is no significant difference between price elasticities for the three utilities.

5.2.5 Significance of water management plans

Of interest is whether users who have a water management plan (WMP) in place would respond differently to those who don't. The model is extended to include a variable which represents the interaction of the WMP and the water price. It was found that those with a WMP have lower price elasticity than those without a WMP i.e. a difference of 0.18 which suggests some degree of demand hardening for this group.

5.3 Analysis of price response by respondent group

5.3.1 Characteristics of customers that respond to price changes

A major question arising from the survey is why some customers adjust their water use in response to the scenario price increases while others do not. To help explain this, a 'logit' model is constructed, expressing the likelihood (probability) that a customer is a nonzero respondent in terms of their business and water management characteristics.

- The model includes the following variables.
  - The dependent variable is the dummy variable (GROUP) which has the value of 1 for those who respond to at least one of the scenario price increases and the value of 0 for those who do not respond to any of the scenario price increases.
  - The explanatory variables include:
  a) Dummy variable indicating establishment's investment in water saving processes or participation in water demand management programs (Q8A);
  b) Dummy variable indicating manufacturing sector (DUMMAN); and
  c) Dummy variable indicating customer of Yarra Valley Water (YVW).

The model results are shown in Table 9 below.

Table 9 **Logit model for likelihood of non-zero responses**

	Q8A	DUMMAN	YVW	Constant
Coefficient	0.70	0.51	0.66	-1.64
t statistic	2.9	1.9	2.7	-8.0
LOG-LIKELIHOOD FUNCTION = -212.5				

Data source: ACIL Tasman model

The logit model results are interpreted as follows.

- Customers who have invested in water saving processes or participated in water demand management programs are more likely to respond to price increases. This may be due to this group's greater concern with their cost of water;
- Manufacturing customers are more likely to respond to price increases compared to the other sectors. This is not likely due to their higher water intensity since the high-intensity non-manufacturing group does not show the same behaviour, but more likely due to the ability of the manufacturing sector to modify their production processes to conserve water use; and
- Customers of Yarra Valley Water are more likely to respond to price increases. This may be due to the different profile of this utility's business customers compared to that of the other utilities.

5.3.2 Analysis of differential price response by respondent group

As above, based on the survey results on their stated preference, respondents can be put into 2 different groups: those who respond to at least one of the scenario price increases (the nonzero group) and those who do not respond to any of the scenario price increases (the zero group). It would be of particular interest to undertake analysis of the actual water consumption and price data to confirm or refute the following findings derived from the modeling of the scenario price data i.e. whether respondents' revealed preference would validate their stated preference.

- Whether the price elasticity of the zero group is, indeed, zero, that is, they do not respond to price changes in actual behaviour;
- The price elasticity of the nonzero group is high or at least higher than that of the zero group, and if so, what is the difference in their price sensitivity;
- The analysis measures the extent to which the zero group may be gaming in their response to the survey questions by understating their likely response to the price changes.

The model in Section 5.1.1 is re-estimated for the nonzero and zero groups separately. The estimates of price elasticities for the two groups are shown in Table 10 below.

Table 10 **Price sensitivity estimates for nonzero and zero groups**

Variable name	Code	Non-zero group	Zero group
Price response (smaller users)	LPRICE	-2.2 (-2.6)	-1.97 (-3.1)
Price response differential (top 1000)	LPRICE2	-1.2 (-8.7)	-0.2 (-2.8)
Sample size		280	850

Data source: ACIL Tasman model

Note: Numbers in brackets denote t statistics

The estimated coefficients of both price variables have the correct signs and are statistically significant.

- The estimated coefficient (price elasticity) for variable LWPRICE for the nonzero and zero groups are -2.2 and around -2 respectively. This suggests that, on the basis of revealed preference, the price elasticity for the zero group is not exactly zero and indeed may be quite significant. It is concluded that this group has either gamed their survey response or just did not provide true feedback for other reasons e.g. negligence; and
- The estimated coefficient for variable LWPRICE2 for the nonzero group at -1.2 is significantly larger than that for the zero group at -0.2. This means only the top 1000 users who have indicated in the survey they would respond to price increases, are found to be clearly more price sensitive than the smaller users. This finding on revealed preference is consistent with the survey result on stated preference.