MODELLING THE COSTS AND BENEFITS OF WATER DEMAND MANAGEMENT INITIATIVES

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ABSTRACT

Water authorities require robust methods to enable them to evaluate and prioritise capital expenditure - both for new water sources and for demand management initiatives.

AECOM has developed a Cost Benefit Analysis (CBA) tool to assist in justifying and prioritising capital expenditure in demand management and enable robust and well-informed future planning.

The Demand Management Assessment Tool (or 'DMAT') was designed to assess both individual demand management options, or a suite of options, and for each of these undertake CBA analyses from different perspectives: a social (economic) CBA, a financial CBA from the perspective of the Water Authority, and a financial CBA from the perspective of customers.

This approach allowed an understanding of to whom costs and benefits are likely to accrue, and therefore provides some insight into the most appropriate way of implementing the initiatives. For example, where an initiative is expected to provide net benefits to customers through reductions in their water and heating bills, then the Authority may only need to educate their customers of this potential. In other cases, cost sharing or financial incentives may be required.

Total carbon savings can also be calculated in addition to water savings and inclusion of environmental costs and benefits is also possible.

A case study is examined through the development of the DMAT model for an example water authority.

KEYWORDS

Water demand management, water conservation, cost benefit analysis, prioritisation

1 INTRODUCTION

Water supply authorities in New Zealand and internationally continue to struggle with increasing demands on water resources, and the balance between capital investment in new supplies, and investment in reducing demand (demand management, or water conservation).

Nationally, demand is increasing due to more intensive land use and irrigation, particularly for agriculture, and a growing population, which in turn drives expansion of municipal supplies for human and industrial use.

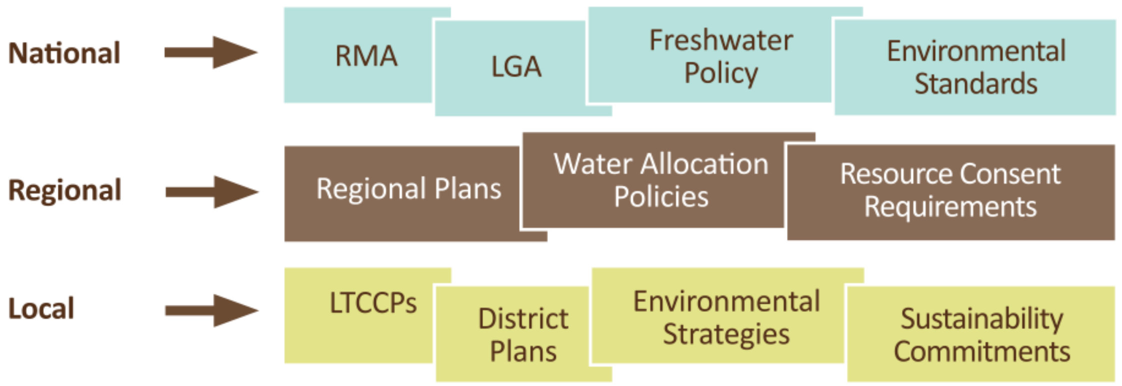
NZBCSD (2008) states that "over a significant proportion of New Zealand, and particularly in our highly populated and main agricultural areas, the known available water resource is expected to be fully allocated by 2012".

It is important to qualify this statement by saying that in many cases, this allocated water is not used in its entirety; however, there is limited ability to transfer any surplus or unused water within current legal frameworks.

This rapid increase in abstraction and allocation, as well as a continuing decline in water quality, has meant water authorities, central and local government, and industry organizations are paying increasing attention to these issues and have been developing strategies and plans to begin to address some them.

New Zealand's current legislative framework provides a solid and clear direction for managing water demand, through the RMA, LGA and various other national, regional and local policy instruments. See Figure 1 below.

Figure 1 Legislative drivers for demand management (Source: Water New Zealand, 2009)



In addition, the benefits of demand management are generally well known and include: Lower operating costs, deferral of capital expenditure, improved efficiency, meeting consent requirements, providing resilience to climate change impacts, among others. However, despite this, the implementation of demand management has to date, been poor.

Some recent reports have addressed and emphasized the importance of demand management, as follows;

- 'Local Authorities: Planning to meet the Forecast Demand for Drinking Water' (Office of the Auditor General, Feb 2010). This report summarises the review of eight local authorities throughout NZ and their approaches to management of water supplies. Key recommendations included:

    - preparation of comprehensive demand management plans that integrate a broad range of supply and demand strategies, to reduce the demand on existing water sources and the risk of over-investing in drinking water supply infrastructure, and to benefit from cost savings;

    - undertaking rigorous evaluation of the costs and benefits of supply and demand strategy options, to choose the most cost-effective and sustainable options;

- The recent Land and Water Forum Report 'A Fresh Start for Freshwater' (MfE, Sept 2010) was commissioned by MfE to review management of Freshwater in NZ and make recommendations for improvements. Management of urban water supplies are a key focus in the report and recommendations are made around setting limits for both abstraction and quality of water, and improving methods for allocation of water. The following statement is taken from the report which, in part ii), reinforces the potential economic benefits of demand management.

    Developing definitions of reasonable domestic take and setting up national templates for demand management plans should be part of this system. The gains possible from this include:

    i. *more efficient use of water, as a price signal for supply is added to the range of other measures that can be used to encourage water efficiency. Those councils that apply a volumetric charge to water tend to have much lower water use than councils that do not*

    ii. *more efficient use of water means that there will be meaningful deferrals to the need for future infrastructure and its development cost*

    iii. *there are likely to be energy savings possible as less water (and wastewater) needs to be pumped*

- The National Infrastructure Plan (New Zealand Government, 2011) – which identifies: "*Better demand management practices and consistent performance criteria for water infrastructure",* as a key strategic opportunity.

Internationally, the picture is no different. In fact, in the 2009 report entitled 'Charting Our Water Future' (Water Resources Group, 2009), the following statement is made:

In the world of water resources, economic data is insufficient, management is often opaque, and stakeholders are insufficiently linked. As a result, many countries struggle to shape implementable, fact-based water policies, and water resources face inefficient allocation and poor investment patterns because investors lack a consistent basis for economically rational decision-making. Even in countries with the most advanced water policies there is still some way to go before the water sector is managed with the degree of sophistication appropriate for our most essential resource. Without a step change improvement in water resource management, it will be very difficult to meet related resource challenges, such as providing sufficient food or sustainably generating energy for the world's population.

These above recent reports and documents emphasise the increasing importance of demand management in the managing of water supplies. Given the wide range of initiatives and possible implementation methods available to generate water demand reductions, it is considered important that authorities evaluate costs and benefits of a particular programme (or suite of initiatives) in order to justify investment. The development of a bespoke tool to facilitate this has assisted in decision making for a number of authorities. A Demand Management Assessment Tool (DMAT) was developed by AECOM, and has been applied in New Zealand and Australia. The DMAT approach is discussed further below.

2 DEVELOPMENT OF DMAT

2.1 OVERVIEW

The Demand Management Assessment Tool (DMAT) allows the user to assess the economic merit of individual and packages of options for managing water demand as they apply to different categories of water users. In addition, the quantity of water saved and reductions in carbon emissions that are achieved for different options is also assessed. It is noted that the assumed savings generated by the various options are savings in average water consumption rates, and not reductions in peak flow rates.

The DMAT is underpinned by a Cost Benefit Analysis (CBA) methodology that allows for an evaluation of water demand initiatives on three key categories of water use:

- Domestic;
- Commercial (including institutional use); and
- Industrial (including agricultural use).

The outputs of the CBA are produced from three perspectives:

- Society;
- Water Supply Authority; and
- Customers.

In addition to these outputs, the DMAT provides a sensitivity analysis of the results to individual key variables and assumptions.

2.1.1 COST BENEFIT ANALYSIS METHODOLOGY

Cost Benefit Analysis (CBA) is the primary methodology by which options are evaluated within the DMAT. CBA is a well-established systematic process that involves the assessment of costs and benefits of a project over a defined time period.

Costs and benefits are always measured as incremental changes relative to a base case (or 'business as usual' case). For example, when measuring the benefits of a water saving appliance, an incremental benefit of the appliance is the reduction in water use – that is, the water use in the base case with the old appliance minus the water use with the new appliance. This water saving is then assessed against the incremental change in cost – that is, the cost of installing and operating the new appliance less any costs associated with the old appliance.

Costs and benefits that occur in different time periods are made comparable in the present time period by converting to Present Values using a process known as discounting. The basic premise is that society has a preference for benefits to be achieved sooner rather than later (known as a 'social time preference') and that delays in receiving these benefits impose an opportunity cost. Therefore, $100 in benefits received today is worth more than $100 received in ten years. Similarly, the occurrence of costs is preferred later rather than earlier. Therefore, $100 in costs today is a greater burden than $100 to be paid in 10 years.

The degree to which future costs and benefits are reduced to convert them to Present Values is determined by the discount rate. Higher discount rates reduce future streams of costs and benefits more relative to lower ones, and indicate a relatively higher social preference for more immediate net benefits.

The difference between the present value of costs and the present value of benefits is known as the Net Present Value (NPV). Projects with a positive NPV are considered economic and should be considered for implementation within the context of other options available and allowable budget. Projects with a negative NPV are uneconomic and should not proceed unless there are considerable external benefits that are not quantifiable within the CBA.

2.1.2 DEMAND MANAGEMENT INITIATIVES

There are a wide range of demand management initiatives that can be implemented by a water authority. This study did not review the range of options, nor the effectiveness of them in reducing water consumption. Instead, it relied on previous studies and provided flexibility within the DMAT model to alter demand reduction values as required.

Initiatives were divided within the three key categories of water use – residential, commercial and industrial. Table 1 below indicates some examples of initiatives that could be considered.

Table 1 Example Demand Management Initiatives

Residential	Commercial	Industrial
Toilets - Dual Flush	Water audit	Water audit
Toilet adaptor	Pricing and incentives	Process reduction %
Shower head & reduced time	Smart metering	Source substitution
Washing Machines 80l/load	Wastewater charge	Pricing and incentives
Taps -aerators	Toilets retrofit	Smart metering
Rainwater Tanks	Toilet adaptor	Wastewater charge
Grey water reuse	Urinals	Toilets retrofit
Pressure reduction	Showers	Toilet adaptor
Swimming pool cover	Source substitution	Urinals
Efficient shower head		Showers
Car/boat washing - restrictions		Water efficient replace
Water audits		

Each initiative was then assigned a motivator for change, and a target for the initiative (existing users, new users, or both existing and new users). Motivators were taken from previous studies, and included:

- Education;
- Cost Saving;
- Drought;
- Policy;
- Rebate;
- Regulation;
- Regulation & Rebate; and
- Customer / Water authority partnership.

Each combination of initiative, motivator, and target defines an individual option. For example, an option may be the installation of dual flush toilets, motivated by rebates, targeted at existing households. This option will have specific characteristics regarding implementation and effectiveness. Therefore, for each individual option the following characteristics are defined within the DMAT:

- Percentage of population targeted (for each of existing and new users);
- Program period (years);

- Initiative uptake during program period (% of targeted population for each of existing and new users);
- Initiative uptake after program period (% of annual uptake rate that occurred during program period);
- Time to saturation (years until program no longer effective);
- Fixed cost to undertake program payable by Water Authority ($);
- Variable program cost per household/business unit ($);
- Percentage of variable cost paid by Water Authority (%);
- Percentage reduction in water use by end use from implementing option; and
- Total percentage reduction in water use from implementing option (if not available by end use).

The DMAT allows for 3 packages of options to be developed that consist of individual options selected from the full list. For example, one option package may consist of only initiatives aimed at domestic users, while another package might consist of education options across all categories of water user. This allows comparisons of combinations of options rather than just individual options.

3 OUTPUTS OF DMAT

For each option package, the DMAT provides total volume of water saved, carbon emissions reduced, and Cost Benefit Analyses from three distinct perspectives:

- Society (Economic CBA);
- Water Authority (Financial CBA); and
- Customers (Financial CBA).

The Social CBA includes the Water Authority, the customer, and all other members of society, and only considers net changes to the overall economy. From this perspective transfers that occur within the system are unimportant – only the net change is important. For example, reduced water usage represents a loss in revenue to the Water Authority (which is reflected in the Financial CBA), however this loss to the Authority is a saving in payments by the customer (which is reflected in the customer's Financial CBA). The Authority's loss is the customer's gain, and the net effect is a transfer within the system with no overall change to economy. The reduction in water use, however, reduces the operational costs of delivering water, maintenance costs, and environmental impacts on the waterways, along with providing a whole range of other benefits. These wider benefits are captured by the Societal CBA.

3.1.1 COSTS AND BENEFITS

The aim of demand management initiatives is to reduce water use. As such, the economic benefits of these initiatives arise almost entirely through cost savings associated with reduced costs of supplying water and wastewater services.

The types of benefits and costs assessed by the DMAT from each of the three perspectives are presented in Table 2. All costs and benefits outputs are represented as present values within the DMAT.

Table 2 Types of costs and benefits assessed across the three CBA perspectives

Type of cost/benefit	**Social CBA**	**Water Authority Financial CBA**	**Customer Financial CBA**
Costs			
Fixed cost of Implementing Option	✓	✓	
Variable cost of Implementing Option	✓		
Variable cost of option payable by Water Authority		✓	
Variable cost of option payable by			✓
Lost water sales revenue		✓	
Lost wastewater sales revenue		✓	
Benefits			
Operational cost savings	✓	✓	
Maintenance cost savings	✓	✓	
Infrastructure deferment costs savings	✓	✓	
Hot water energy savings	✓		✓
Water bill savings			✓
Wastewater bill savings			✓
Environmental (waterway) benefits	✓		

3.1.2 NET PRESENT VALUE AND BENEFIT COST RATIO

The DMAT presents both Net Present Value and Benefit Cost Ratios as outputs for the CBA from all three perspectives described above.

The Net Present Value (NPV) is the present value of all benefits less the present value of costs. The NPV is a measure of the *absolute* return on invested funds. Options that have a positive Net Present Value are economic and considered worthwhile investments.

The Benefit Cost Ratio (BCR) is the present value of all benefits divided by the present value of costs. The BCR is a measure of the *proportional* return on invested funds. Options with a BCR that is greater than 1 are economic and considered worthwhile investments.

An economic project will always result in a positive NPV and a BCR greater than 1, and an uneconomic project will always result in a negative NPV and a BCR less than 1. However, the NPV can sometimes give conflicting results – sometimes a project may have a lower BCR but a higher NPV than another project.

Which is more important?

This depends on the circumstances. The goal is to get the maximum value from the available funds to be invested, with the assumption that any unused dollars can be invested elsewhere and achieve an expected return equal to the discount rate. If projects are mutually exclusive, then choosing the project with the highest positive NPV within budget is always preferred.

If projects are not mutually exclusive, we want to choose a combination of options to get the greatest total NPV within the available budget. This may not mean always choosing the option with the largest NPV first, since there may be combinations of options that use the budget set more effectively. For example, if you have a maximum budget of $100,000, then choosing two options that cost $50,000 each and both have NPVs of $20,000 is preferable to choosing a $70,000 project with an NPV of $30,000 (despite it being more highly ranked on the NPV scale).

However, if the aim is to achieve the greatest return on investment funds without reference to a budget constraint, and projects are not mutually exclusive, then choosing projects based on BCR provides the best economic outcome.

Cost sharing and incentives

Options that, for example, are economic from a social perspective but uneconomic from the perspective of the customer may provide some justification for subsidies/rebates to the customer. For example, if installing low-flow showerheads results in an NPV of $200 per household to society, but an NPV of -$100 to the household, then providing a government rebate to the customer of between $100 and $200 will turn the option in to a win-win situation - which may provide enough incentive for the householder to implement the option. In economic parlance, this is known as a Pareto improvement.

By providing economic indicators from all three perspectives, the DMAT can provide an insight into not only the value of different options from these perspectives, but also whether incentives are justified to bring about change.

3.1.3 LEVELISED COSTS

Levelised costs are a measure of the cost effectiveness of achieving a gain in one specified variable. The DMAT provides levelised costs for water savings, measured as $ per ML saved. This allows for comparisons of water savings and benchmarks to be established when water savings is the key variable of interest. It is however, inferior to CBA outputs such as NPV and BCR in determining the worth of an option.

Levelised costs differ from more basic cost effectiveness assessments in that the variable in question is discounted to account for time preference. For example, water savings that occur sooner are preferred to those that occur later. By applying a discount rate to the volume of water saved, in the same way that we do for costs and benefits in a CBA, more weight is given to those savings that are achieved sooner.

The levelised cost of water savings of an option is therefore the discounted costs of the option over the project period divided by the discounted volumes of water saving that occur over the project period.

3.1.4 SENSITIVITY ANALYSIS

There are degrees of uncertainty in almost all the assumptions and inputs within the DMAT, which is to be expected. The DMAT incorporates a sensitivity analysis that tests the sensitivity of the CBA results to key variables of interests. These are:

- Connected population;
- Baseline per capita demand;
- Electricity price; and
- Discount rate.

Performing sensitivity analyses for other variables is as simple as altering them within the appropriate worksheets and recording the results.

4 DMAT LIMITATIONS

As with any model, there will always be gaps in knowledge, data, and information that will to a degree reduce the level of uncertainty of the results. However, the DMAT has been specifically set up so that inputs can be updated as better information becomes available.

There is a level of uncertainty regarding the combined impacts of options and the interactions between options that alter the effectiveness of each of the options within the combination. Some options are expected to provide synergies that would enhance the effectiveness of the combination as compared to the options assessed individually, other combinations would incur some ‘cannibalisation’ of the effectiveness of options. A thorough literature search proved relatively fruitless in regard to this aspect. This means there is very little guidance on the best approach to incorporate this.

This uncertainty is also overlayed by the uncertainty in the target population; if we assume that 50% are targeted by one option and 50% by another, should we assume that in combining the options that the same 50% are implementing both options (resulting in interactions between options) or do we assume that they are completely different subsets? In the absence of better information, the only logical option is to assume no interaction between options – and this is currently how the DMAT is set up.

5 EXAMPLE APPLICATION

5.1 MODEL SETUP

A DMAT model was developed for a virtual water authority, assuming base information from Australia and New Zealand. This involved a range of inputs and assumptions as detailed below. The following data inputs are indicative only, to demonstrate how the tool can be applied practically.

Discount Rate

An 8.0% real discount rate was applied in the DMAT. Real discount rates are adjusted for average rates of inflation (as opposed to nominal discount rates). As a result, costs and benefits do not need to be inflated over time in the CBA.

The impact of using higher and lower discount rates is assessed in the sensitivity analysis.

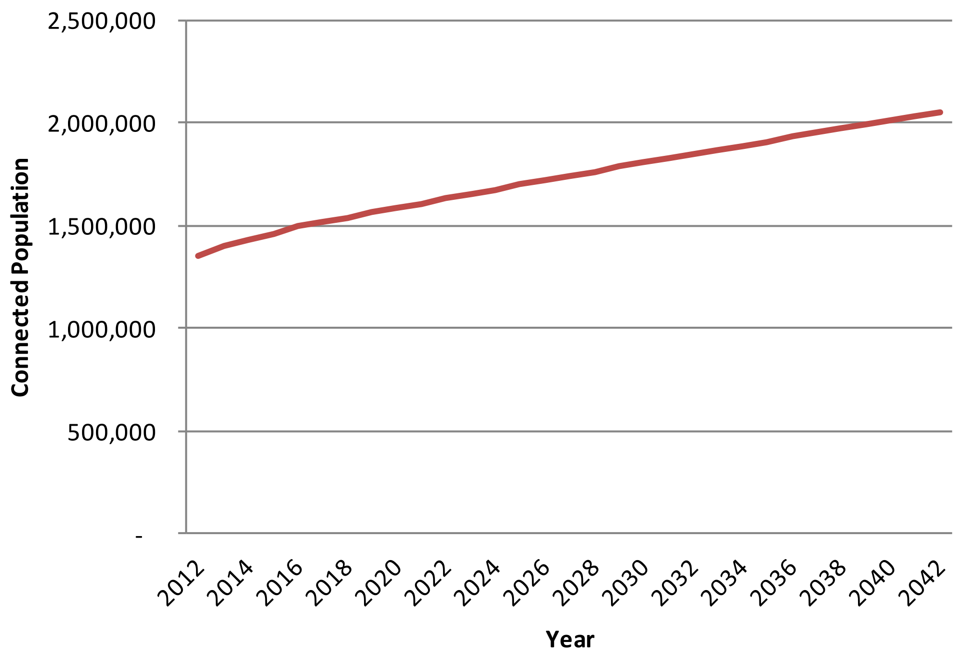
Household occupancy

The average number of people occupying a household was assumed to be 2.97 people.

Connected population

Current and projected populations for the next 30 years were used. Current connected population was estimated at approximately 1.36 million, and is expected to grow at a reducing rate over the next 30 years, as presented in Figure 1,

Figure 2 Projection of connected population over the next 30 years



Demand for water

An example demand for water is presented in Table 3. It was assumed in the base case that per capita demand and the percentage break-down across water use categories will be unchanged over the project period (30 years), however total water use within each category is expected to grow as the connected population grows. These numbers were applied to population and total consumption to get per capita figures.

Table 3 Break-down of water demand across key water use categories

Category of water use	% of total
Domestic	63%
Commercial & Institutional	20%
Industrial & agricultural	5%
Non-revenue	12%
TOTAL	***100%***

Source: Adapted from BRANZ (2008)

Domestic Water and Wastewater

Domestic use makes up approximately 63% of all water demand. BRANZ (2008) investigated water use in 51 Auckland households and determined the average proportion of daily water use by end-use within the household. These findings were incorporated in the DMAT and are presented in Table 4.

Also presented in Table 4 are estimates of the hot water component of water used by end-use, as well estimates of the percentage of water used that flows to wastewater.

Energy calculations to heat the water are based on calculations using the specific heat capacity of water and an assumed average temperature increase of 40 degrees C (from 10 degrees to 50 degrees C)[1].

[1]Based on the relationship $Q = cm\Delta T$, where Q is energy required in kwh, m is the mass of water (1 kg per litre), ΔT = 40 degrees (heated from 10 degrees to 50 degrees), and c is a specific heat capacity constant equal to $1.17*10^{-3}$ /kg°C

Table 4 Domestic end-use assumptions for water use, hot water use, and wastewater

Domestic end-use	Average % of daily domestic use	Hot water component	Energy for heating (kwh/capita/day)	% of water that becomes wastewater
Shower	27%	40%	0.90	95%
Bathtub	2%	70%	0.09	95%
Taps	14%	60%	0.68	85%
Dishwasher	1%	60%	0.05	95%
Washing Machine	23%	30%	0.57	90%
Toilet	18%	0%	-	100%
Miscellaneous	1%	0%	-	0%
Outdoor	12%	0%	-	0%
Leaks	3%	0%	-	0%
TOTAL	***100%***	***28%***	***2.28***	***79%***

Source: Adapted from BRANZ (2008)

Commercial & Institutional Water and Wastewater

Commercial and Institutional water use makes up 20% total water demand. Within the DMAT, the Commercial & Institutional category was further divided into the sub-categories presented in Table 5.

Table 5 Break-down of Commercial & Industrial water use by sub-category

Comm. & Inst. sub-category	Total Volume (kl/year)	litres/capita/day
Commercial (including municipal)	21,748,757	44.6
Community (e.g. church)	1,258,144	2.6
Hospital	1,225,444	2.5
School	1,580,486	3.2
Sports & Recreation	838,999	1.7
TOTAL	***26,651,830***	***54.7***

A breakdown of water demand by commercial and institutional water users has been developed based on a 2006 study produced by Queensland's Department of Natural Resources and Water (now the Department of Environment and Resource Management). No New Zealand based studies were available for commercial water use. The DNRW study investigated the end-use demand for a range of commercial sectors.

The DNRW study was used as the basis for developing end-use breakdowns for each of the Commercial and Institutional sub-categories.

The total of these sub-categories is presented in Table 6. Hot water and wastewater percentages were sourced from previous work and appear reasonable.

Table 6 Commercial & Institutional end-use assumptions for water use, hot water use, and wastewater

Commercial & Institutional end-use	Average % of daily use	Hot water component	Energy for heating (kwh/capita/day)	% of water that becomes wastewater
Sink/dish rinse	10%	60.0%	0.15	95%
Dishwasher	5%	30.0%	0.04	95%
Ice Machine	2%	0.0%	0.00	30%
Basin	4%	40.0%	0.04	95%
Toilet/urinal	34%	0.0%	0.00	100%
Shower	2%	40.0%	0.02	100%
Laundry	1%	40.0%	0.01	95%
Cleaning	2%	40.0%	0.02	95%
Cooling Tower	26%	0.0%	0.00	0%
Irrigation	9%	0.0%	0.00	0%
Pool	1%	0.0%	0.00	0%
Losses	0%	0.0%	0.00	10%
Other	4%	0.0%	0.00	0%
TOTAL	***100%***	***11%***	***0.28***	***95%***

Source: Queensland Department of Natural Resources and Water (2006)

Industrial & Agricultural Water and Wastewater

Industrial & Agricultural use was divided into the sub-categories presented in Table 7.

Table 7 Break-down of Industrial & Agricultural water use by sub-category

Ind. and Agric. sub-category	Total Volume (kl/year)	l/c/d
Industrial	6,632,796	13.6
Agricultural	508,819	1.0
TOTAL	***7,141,615***	***14.6***

In addition to these, the DMAT allows for up to 3 specific industries to be assessed. These fields, including end-uses, can be populated and used when particular industries are likely to be targeted for specialised initiatives so that the assessment can be customised to the individual industries in question.

The combined end-uses were used to derive an overall end-use breakdown for the Industrial and Agricultural Use category, presented in Table 8. Assumptions relating to hot water and wastewater were drawn from previous studies and appear reasonable.

Table 8 Industrial & Agricultural end-use assumptions for water use, hot water use, and wastewater

Industrial & Agricultural end-use	Average % of daily use	Hot water component	Energy for heating (kwh/capita/day)	% of water that becomes wastewater
Showers	0%	40%	-	100%
Toilets	5%	0%	-	100%
Urinals	3%	0%	-	95%
Air-conditioning	5%	0%	-	0%

Industrial & Agricultural end-use	Average % of daily use	Hot water component	Energy for heating (kwh/capita/day)	% of water that becomes wastewater
Process	82%	30%	0.17	70%
Irrigation	6%	0%	-	0%
Other	0%	0%	-	0%
TOTAL	***100%***	***25%***	***0.17***	***65%***

Source: Adapted from BRANZ (2008)

Electricity

The average electricity required for treating and supplying water, and collecting and treating wastewater, was input into the model, as well as current energy prices. The DMAT provides the capability to alter the proportion of water demand that is sourced from different water sources, with different energy rates, to allow for changes in expectations about projected availability of water from different sources.

Environment

Carbon emissions were assessed within the DMAT based on a grid average emission factor of 0.209 $kgCO_{2-e}$/kWh. This was taken from the New Zealand Ministry for the Environment advice.

A field was created within the DMAT to include the environmental impacts of extracting water from the waterways once an appropriate 'Willingness-to-Pay' analysis (or other non-market valuation) is undertaken with which to quantify such impacts. No value is currently assigned within the model.

Operation and Maintenance costs

Average operation and maintenance costs ($/kilolitre) were estimated an included within the model. These values are exclusive of electricity costs, which are calculated separately within the DMAT.

Wastewater inflow factor

The volume of water that enters the wastewater system is only partially derived from the wastewater from water users. The remainder is from natural sources that infiltrate the wastewater system. As a result, wastewater savings achieved by water users are partially replaced within the system by infiltration before reaching treatment plants. This effect is more pronounced in wet seasons than dry, and as such it is assumed that reductions in wastewater flows (and corresponding reductions in pumping requirements) will likely only occur during dry weather conditions.

Utilising some available data from an analysis of a local pump station it was calculated that over a period of a year, approximately 55% of total wastewater pumped (by volume) occurred during dry weather conditions. As such, as a rough approximation, this 55% was applied to any wastewater savings (and corresponding electricity savings) generated through demand management initiatives. That is, for every kilolitre of wastewater savings being achieved by customers, only 0.55 of a kilolitre is reduced at the treatment plant.

Retail prices for water and wastewater services

An average volumetric retail price of water of $1.30 per litre was used within the DMAT. A field was created within the DMAT to be used for volumetric wastewater pricing as well.

Future Infrastructure Augmentation – Long Run Marginal Capital Cost

The Long Run Marginal Capital Cost (LRMCC) is the change in the cost of future capital works programs caused by anticipated changes in demand. Put another way, every kilolitre of water saved delays the need to augment the system with additional infrastructure. This delay results in a cost saving.

For the purposes of the example, a LRMCC estimate was used based on previous work done by AECOM. A default value equal to the value for water supply was used in the interim for the LRMCC for wastewater.

5.2 EXAMPLE RESULTS

As a demonstration of the type of analysis that the DMAT can facilitate, this section contains an example assessment based on options currently contained within the DMAT.

The example presented here is a package of options that use education as the motivator to target existing domestic users. This has been chosen to focus on the process of assessment and the interpretation of outputs, and is the same process as would be applied for option packages that contain options that apply to other categories of water user. Values are indicative only.

5.2.1 INPUTS TO ASSESSMENT

List of Options and Target Population

The list of options contained within the package, along with their motivator and target population are presented in Table 9. Information regarding the % of existing or new premises being targeted is also entered.

Table 9 Options and Target population

OPTION	MOTIVATOR	TARGET	Section of population targeted (%)	
			Existing premises	New premises
Toilets - Dual Flush	Education	Existing	60%	0%
Shower head & reduced time	Education	Existing	40%	0%
Washing Machines 80l/load	Education	Existing	60%	0%
Taps -reduced time	Education	Existing	100%	0%
Grey water reuse	Education	Existing	70%	0%
Pressure reduction	Education	Existing	60%	0%
Rainwater Tanks	Education	Existing	60%	0%
Swimming pool cover	Education	Existing	100%	0%

Source: DMAT model

Program Implementation

The inputs associated with implementation of the program are presented in Table 10. Individual option packages vary in their rates of uptake, program period, and time until saturation (ie point at which no more uptake occurs).

Table 10 Program implementation

OPTION	Initiative Uptake over program period (%)		Uptake after Program Period (% of annual uptake during program period)		Time to Saturation (years)
	Existing premises	New premises	Existing premises	New premises	
Toilets - Dual Flush	40%	0%	20%	0%	30
Shower head & reduced time	40%	0%	20%	0%	20
Washing Machines 80l/load	20%	0%	30%	0%	20
Taps -reduced time	15%	0%	10%	0%	20
Grey water reuse	1%	0%	5%	0%	30
Pressure reduction	30%	0%	10%	0%	20
Rainwater Tanks	2%	0%	5%	0%	30
Swimming pool cover	2%	0%	10%	0%	20

Source: DMAT model

Option Costs

The costs associated with implementation of the options are presented in Table 11. Note that the costs associated with the options should include the full cost of implementation, not just the educational component. For example, providing education on the benefits of installing dual flush toilets does not result in actual water savings benefits unless dual flush toilets are actually installed. Therefore, the cost of installing the toilets is included in the option cost, not just the cost of the education. Providing education improves the uptake rate.

The costs presented here should be revised to include a fixed cost of undertaking the education program.

Table 11 Option Costs

OPTION	Fixed cost to undertake program (start up cost)	Variable Progam Cost per Household/Business Unit	% of Variable Cost paid by Watercare
Toilets - Dual Flush	$ -	$ 250.00	33%
Shower head & reduced time	$ -	$ 60.00	100%
Washing Machines 80l/load	$ -	$ 1,000.00	0%
Taps -reduced time	$ -	$ -	0%
Grey water reuse	$ -	$ 5,000.00	0%
Pressure reduction	$ -	$ 110.00	0%
Rainwater Tanks	$ -	$ 5,000.00	0%
Rainwater Tanks	$ -	$ 800.00	0%

Source: DMAT model

Effectiveness of options

Presented in Table 12 is the effectiveness of each of the options in reducing water demand. The calculated reductions on the far right column of the table are calculated based on assumed reductions in each of the end uses within domestic households. Where assumptions have not been made for individual end-uses, an assumed total percentage reduction is used, as is the case for the 'Pressure Reduction' option.

It should be noted that the total percentage reduction in domestic use stated here is for households implementing that option, not an overall reduction in the domestic water use category.

Table 12 Option effectiveness

Option	Assumed total % reduction in water use (over-rides calculated water use)	Calculated total % reduction in water use
Toilets - Dual Flush		9%
Shower head & reduced time		2%
Washing Machines 100l/load		4%
Washing Machines 80l/load		8%
Taps -reduced time		2%
Grey water reuse		20%
Pressure reduction	5%	
Rainwater Tanks		37%
Swimming pool cover		0%

Source: DMAT model

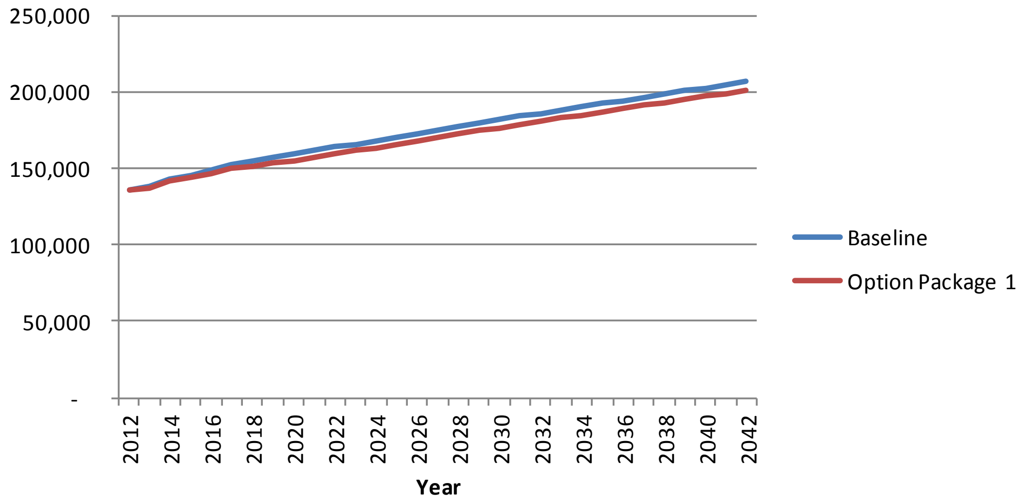
5.2.2 RESULTS OF ASSESSMENT

A summary of the example results for the overall domestic education package is presented here. Data is indicative only and serves to illustrate the functioning of the model.

Water Savings

The total water saved over 30 years from implementing the domestic education package was expected to be approximately 131 GL. A profile of the water saving relative to the base case is presented in Figure 3.

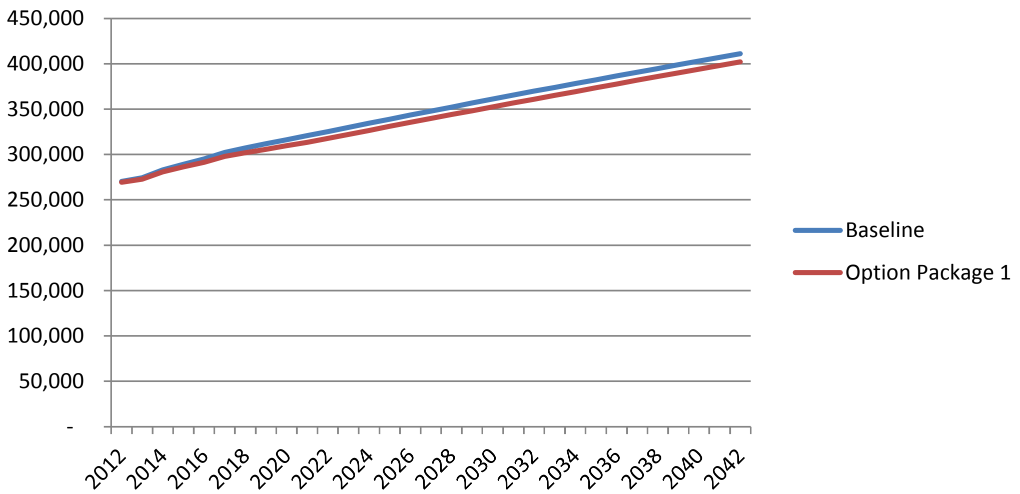
Figure 3 Water demand over time (megalitres)



Carbon Emission Reductions

The total reduction in carbon emissions from implementing this package arise mostly through reductions in energy required for domestic water heating. The total reduction in carbon emissions is approximately 265,000 tonnes over the 30 year period. A profile of these carbon reductions over the 30 year period is presented in Figure 4.

Figure 4 Carbon emissions over time (Tonnes CO_2 per annum)



5.2.3 SOCIAL (ECONOMIC) COST BENEFIT ANALYSIS

The Social CBA describes the analysis of the total costs and benefits of proposed initiatives from the perspective of society, which includes the water authority, its, customers, and the remainder of the community.

The results of the Social CBA are presented in Table 13. For this example, the domestic education package is a highly economic set of options, with an NPV of approximately $54 million and Benefit Cost Ratio of 1.53.

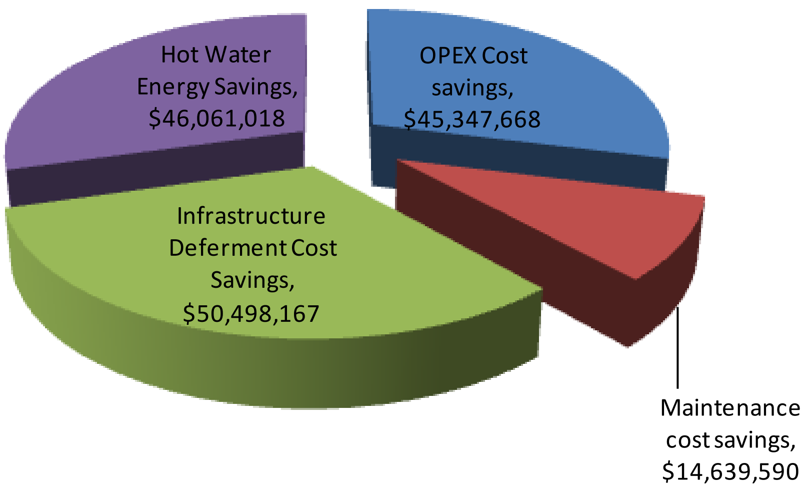
Table 13 Social CBA results (discounted at 8% over 30 years)

TOTAL OPTION COST (PRESENT VALUE)			*$*	*102,424,793*
BENEFITS (PRESENT VALUE)	OPEX Cost savings	Water Supply	$	19,959,923
		Wastewater	$	25,387,745
	Maintenance cost savings	Water Supply	$	5,201,767
		Wastewater	$	9,437,824
	Infrastructure Deferment Cost Savings	Water Supply	$	34,740,372
		Wastewater	$	15,757,795
	Hot Water Energy Savings		$	46,061,018
	Environmental (Waterway) Benefits		$	-
	TOTAL BENEFITS		$	156,546,444
NET PRESENT VALUE				$54,121,650
BENEFIT COST RATIO				1.53
LEVELISED COST OF WATER SAVINGS ($/ML)			$	2,757

Source: DMAT model

It can be seen in Figure 5 that a large portion of the benefits are achieved through reduced water heating requirements in homes as a result of reductions in hot water use. The benefits of deferring capital infrastructure as a result of reduced water and wastewater use are also significant.

Figure 5 Breakdown of social benefits



5.2.4 FINANCIAL COST BENEFIT ANALYSIS

The financial analysis looks at the costs and benefits that accrue to the water authority /municipal water provider only. These are presented in Table 14.

The package will indicate return on investment.. Despite the loss of revenue due to reduced demand for water services, the benefits of reducing operation and maintenance costs and deferring infrastructure requirements significantly outweigh these losses. It is worth remembering that wastewater charges have not yet been included within the model, so there will be an additional loss in revenue once these prices are incorporated that will reduce the financial attractiveness of these results.

Table 14 Financial CBA results (discounted at 8% over 30 years)

COSTS (PRESENT VALUE)	Fixed cost of implementing option		$ -
	Variable cost of option payable		$ 9,555,641
	Lost Water Sales Revenue		$ 48,302,122
	Lost Wastewater Service Revenue		$ -
	TOTAL OPTION COST		*$ 57,857,762*
BENEFITS (PRESENT VALUE)	OPEX Cost savings	Water Supply	$ 19,959,923
		Wastewater	$ 25,387,745
	Maintenance cost savings	Water Supply	$ 5,201,767
		Wastewater	$ 9,437,824
	Infrastructure Deferment Cost Savings	Water Supply	$ 34,740,372
		Wastewater	$ 15,757,795
	TOTAL BENEFITS		*$ 110,485,425*
NET PRESENT VALUE			***$52,627,663***
BENEFIT COST RATIO			***1.91***
LEVELISED COST OF WATER SAVINGS ($/ML)			***$ 1,557***

Source: DMAT model

5.2.5 CUSTOMER FINANCIAL COST BENEFIT ANALYSIS

This financial CBA looks at the costs and benefits that accrue to customers (as a group) as a result of implementing the package of options. These are presented in Table 15.

The package is marginally economic from the perspective of customers with an NPV of $1.5 million and a BCR of 1.02. Just under half of the benefits are realised through reduced electricity use for heating water, with the remainder being reductions in water bills from reduced water use.

This suggests that there is sufficient incentive for customers to adopt the water savings package as a whole, provided they are well informed of the potential net benefits. However the results of the individual options within the package suggest that only dual flush toilets, pressure reduction, and reduced time using taps and showers will be economically attractive to customers.

Only one option, washing machines using 80 litres per load, has shown to be both economically viable from a social perspective and economically unviable from a customer perspective. This shows that there may be some justification for some financial incentives to be provided to customers to enhance adoption of this option.

Table 15 Customer Financial CBA results (discounted at 8% over 30 years)

COSTS (PRESENT VALUE)	Variable cost of option payable by Customers	*$*	*92,869,153*
BENEFITS (PRESENT VALUE)	Water bill savings	$	48,302,122
	Wastewater bill savings	$	-
	Hot Water Energy Savings	$	46,061,018
	TOTAL BENEFITS	*$*	*94,363,140*
NET PRESENT VALUE			$1,493,987
BENEFIT COST RATIO			1.02

Source: DMAT model
Note: Wastewater bill savings have been assumed to be zero, as there was no uniform volumetric wastewater charge in effect at the time of writing this report.

6 RECOMMENDATIONS FOR FURTHER IMPROVEMENT

A number of recommendations are made, with a view to improving the model. Aside from the required improvements in data capture and data quality, the following are suggested:

Inclusion of non-market impacts on consumers – an inherent assumption within the DMAT is that the savings in water bills that customers receive from reducing their water use adequately compensates them for the loss in utility they incur from using less water. For example, the value that customers place on having a long shower may be greater than the cost to them of the additional water that this requires. They would therefore incur a loss of utility from reducing their shower time that is greater than the savings they receive in their water bill. Measuring this loss of utility requires dedicated studies into consumers' willingness to pay for additional water (or alternatively their willingness to accept payment for water reductions).

Environmental benefits assessment – in addition to the savings to the water provider as a result of a reduction in water consumptions, reductions in water extracted from New Zealand's waterway could provide environmental benefits which would ultimately accrue to society. It is expected that these benefits would become larger as demand increases and rivers become increasingly stressed from extractions. An investigation into society's willingness to pay for environmental improvements in their waterways (or willingness to accept payment for degradation of the waterways) would provide an input that can be included within the Cost Benefit Analysis of the DMAT.

7 CONCLUSIONS

The DMAT model allows assessment and prioritising of investment in demand management. It allows a water authority to input the costs and details of a particular option, or suite of options, and understand the level of benefit provided, and to whom (society, the customer, or the authority itself). This then can allow appropriate subsidies to be justified, or programmes / policies formulated based on the results. For example, where an initiative is expected to provide net benefits to customers through reductions in their water and heating bills, then the Authority may only need to educate their customers of this potential. In other cases, cost sharing or financial incentives may be required.

Total carbon savings can also be calculated in addition to water savings and inclusion of environmental costs and benefits is also possible.

The DMAT model is flexible, and able to be adjusted an updated as improved information comes to hand, which is an important feature, given the paucity of robust data within the industry.

The example developed was based on a number of assumptions and provisional data. However, the sensitivity analysis is able to test the impact of data assumptions and will likely give indicative rankings for initiatives with broad differences.

Approaches such as the DMAT, are anticipated to provide significant benefit as we move away from the attitude of thinking water should be freely available as of 'right' and start treating it as a valued and limited natural resource.

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