WA7090/3

Integrated Water Management Design Criteria Report

Final

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About This Report

Title

Integrated Water Management Design Criteria Report

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Abstract

The three-fold purpose of this project was to develop a product design criteria methodology to assess water saving products and systems; identify water products and systems that perform well against the design criteria; and comment on any potential commercial opportunities.

Different products scored differently against different criteria, with the best overall 'score' coming from a combined 'system', comprising a low flow shower head, a water efficient washing machine, a 9,000 litre rain water tank and greywater reuse.

Two potential commercial opportunities were identified; the installation of a relatively small 200 litre rainwater tank attached to the side of the house to supply toilet water only; and a 'modular' tank system where small storage blocks of 200 to 300 litres each could be connected up in irregular shapes to fit under decks, etc.

Reference

Kettle, D. July 2009. Integrated Water Management Design Criteria Report.Report WA7090/3 for Beacon Pathway Limited.

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1 Executive Summary

The purpose of this Beacon project is to:

- Develop a product design criteria methodology to assess water saving products and systems on their relative efficiency and effectiveness at the home and neighbourhood scale.
- Identify water products and systems that perform well against the design criteria.
- Report on the findings and any potential commercial opportunities.

Beacon has a number of water saving targets centered on reducing total household water use, reducing household and council reticulated water demands and improving resilience to future uncertainties.

A set of product design criteria were developed from a synthesis of existing water assessment criteria and expanded to include a holistic integrated water management approach including relatively new criteria such as resilience, how well all three waters (stormwater, water supply and wastewater) are integrated, the degree of water treatment appropriate for its end use, climate change and energy uncertainty. The criteria were also grouped under the New Zealand Government's four well-beings of culture, social, economic and environmental.

A range of water-saving products were assessed to represent the range of products available from small relatively simple products such as a low flow shower head; large multi purpose rain water tanks; composting toilets requiring significant behaviour change; small to large financial investments; and at household and neighbourhood scales. Products were given points according to how well they performed against the different criteria. The total number of points indicates the cumulative benefits of each product.

Different products provided a range of benefits in different areas. For example, the low flow shower heads had a relatively high economic benefit (due primarily to the power savings from reduced hot water use) but relatively low other benefits (cultural, social and environmental) with minimal impacts on stormwater and relatively low overall water quantity benefits. On the other hand, large rain water tanks (3,000 to 9,000 litres) have a lower economic score (due to the higher capital and operating costs) but greater other benefits due to the greater water quantity savings and stormwater benefits.

The composting toilet had the lowest total score with a relatively high capital cost, moderate water quantity score, no stormwater benefits and a low social score.

The greywater use system (used for irrigation and toilet) had the highest product score with a moderate capital cost ($2,750) and a good water quantity score with the reuse of greywater.

The highest scores were obtained from combining a number of products into a 'system'. The maximum score was achieved by combining the 9,000 litre rain water tank, greywater reuse, low flow shower head and water efficient washing machine. The increased benefits more than outweighed the additional costs. This emphasised that a multi-product approach is required to gain maximum benefits because different products have benefits in different areas.

A neighbourhood approach was also found to be beneficial in the area of rain water tanks. Having larger, but fewer, rain water tanks communally owned scored better than each house having their own individual rain water tank and pump. A body corporate, or similar body, would need to be in place to deal with such communally owned assets.

Potential commercial opportunities were assessed based on findings from the Save Water Save Energy Expo in Melbourne and lessons learnt from the products design criteria assessment of existing products and systems.

Two possible commercial opportunities were identified:

1) Introduction of modular rain water storage blocks (200 to 300 litres) that can be connected up in irregular shapes to fit under decks etc.
2) Further development of a small 200 litre rain water tank that attaches to the side of the house under the eave to collect rain water from the roof and gravity feed to the toilet.

Several Australian companies are currently producing the modular tanks, but no one is currently producing the 200 litre tank product in New Zealand on a commercial scale.

A more detailed analysis of the 200 litre rain tank product against the product design criteria showed that although the product does not provide a very high water quantity score (due to only affecting the reticulated water supply in and not actually reducing the total amount of water used), it scores high in the other criteria of material cycle, technical, governance and life cycle energy. The 200-litre rain water tanks offers other benefits in the ease of installation for retrofitting the existing housing stock, and that it is a relatively low investment (if through mass production the installation cost can come down below the $1,000 ‘barrier’) and raising awareness of more appropriate use of our limited water resources. Initial investigations indicate there is interest from the local Waitakere plumber who builds and installs the 200 litre tanks to expand and go into commercial production.

2 Introduction

Beacon has set a goal that 90% of New Zealand homes reach a high standard of sustainability by the year 2012. The four main areas of sustainability being addressed by Beacon are energy, water, indoor environment quality and materials. This project is focussed on the area of water.

For water, the Beacon targets are (Beacon Pathway Ltd 2007):

- **Target 1: Water demand in all homes (i.e. new and existing)** – 90% of homes reduce demand for reticulated water by 40% per capita and council supply to domestic uses is reduced by 50% per capita by 2012; and use of water within dwellings is appropriate for quality and use.
- **Target 2: Water resilience in all homes and neighbourhoods** – New Zealand homes and neighbourhoods have improved and integrated management of storm, grey and black water to decrease their negative impact on the residential and natural environment, thereby making a more resilient water system by 2020.

To achieve these targets households need to use less water and become more aware of the different types of water uses around the home. For example, do we need to treat water to drinking water standards to flush the toilet? It is important to also note that the Beacon demand target is focused around the reticulated water supply, which may be different to the actual water used by each house. For example, the installation of rain water tanks to collect water from individual house roofs and using it to flush the toilet may not produce a direct reduction in water use, but does produce a significant reduction in the use of reticulated water.

In addition, simply reducing reticulated water supply is not the main objective of Beacon. The wider objective is to ensure that the nation's resources (including water, energy, minerals and so on) are used in an efficient manner and to provide a greater resilience against future uncertainties in all areas of life including the 'four well beings' of cultural, social, economic and environmental. For water, this means looking at the entire water cycle including changing rainfall patterns, stormwater runoff, water collection and extraction, groundwater levels and stream baseflows, the impact on stream ecological corridors, matching water quality to its end use, and the discharge and treatment of wastewater and stormwater into the environment.

The purpose of this project is to:

- **Develop design criteria** in order to assess the products and systems on their relative efficiency and effectiveness in their ability to integrate urban water management at the home and neighbourhood scale.
- **Identify water products and systems that** perform well in relation to the required design criteria where available and,
- **Report on the findings and any potential commercial opportunities.**

3 Method

The methodology followed five general steps:

3) Assessment of existing and emerging products in local and overseas markets.
4) A synthesis of existing water assessment criteria was carried out based on existing Beacon reports and general indicator literature.
5) Develop design criteria to assess the **Integrated Water Management** (that is, the combined water supply, stormwater and wastewater) performance of different water products and systems expanding on existing assessment criteria found in 2) above.
6) Analysis of existing water products and systems (a collection of products).
7) Report on research and potential commercial opportunities.

Save Water Save Energy Expo, Melbourne

The 3rd Save Water Save Energy Expo is Australia's largest showcase of products and services which save water, save energy, reduce waste, or provide cleaner energy. This expo provided an excellent one-stop opportunity to see the many different water products and systems currently on the market.

Integrated Water Management Product Design Criteria

To develop product design criteria for assessing the Integrated Water Management (IWM) performance of different water products and systems a synthesis of existing water assessment criteria was carried out and expanded to include relatively new assessment criteria areas such as resilience, how well all three waters (stormwater, wastewater and water supply) are integrated, the degree of water treatment appropriate for its end use, climate change and energy uncertainty.

Analysis of Existing Products/Systems

The design criteria were then applied to a range of products and systems to assess how they contribute to or provide the "ideal" design. The results are tabulated and presented to reflect their performance under the 'Four Well-beings' of cultural, social, economic and environmental. How the results are analysed, combined and reported is a vital step in order to clearly show the often competing demands, for example, the pros and cons of the low cost – low benefit versus the high cost – high benefit?

Potential Commercial Opportunities

Potential commercial opportunities were identified based on what products are already in the market and potential short and long-term future trends (both in public acceptability/knowledge and regulatory codes).

4 Results

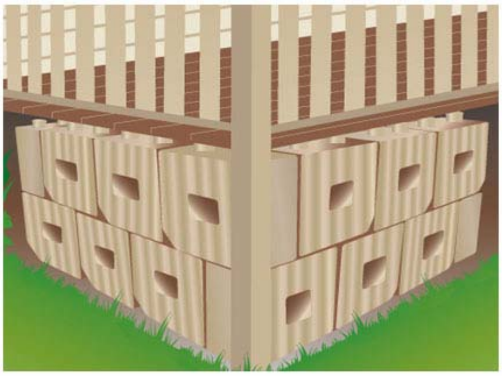
The results are presented in four sections:

1) Findings from the Save Water Save Energy Expo in Melbourne – Section 3.1
2) The Integrated Water Management Product Design Criteria – Section 3.2
3) Analysis of existing water products and systems – Section 3.3
4) Potential commercial opportunities – Section 5.2

4.1 Save Water Save Energy Expo

Appendix A lists websites for the numerous different water products that were at the expo under headings of water tanks and accessories, low flow devices, gutters, grey water systems and composting toilets. Websites are also given for other areas of energy and air quality. Websites of different Australian organisations working in the area of water and energy are also listed.

There are an increasing number of suppliers of rain water storage systems, primarily steel, high density polyethylene and concrete tanks, with both round and 'slimline' (narrow-long shapes) tanks being very common. One storage system not seen yet in New Zealand is the use of modular 'building blocks' that can be made up into any shape and others that form part of a foundation. For example, the New Zealand 'raft' type foundations that use Styrofoam 'fillers' could use modular connected water compartments in place of the Styrofoam. Other examples are modular blocks to go under decks, as in the figure below.



Example modular blocks under a deck.
Cost a bit more at $0.60 to $0.75 per litre, but still less than going underground.
Example comparisons for 3,000 litre storage:
Modular blocks - $1,800 to $2,250
Steel round - $1,000
Steel Slimline - $2,300
HDPE round - $750
HDPE Slimline - $1,500
Underground HDPE $3,500

Note: All prices approximate in Australian $$.

There were several water 'sac' options which comprised large plastic sacks that were low, flat and less expensive than the more rigid tank storage systems.

For accessories, there were several automated pump/switching systems for controlling mains water top up for tanks, gutter screens for leaves etc., and low flow tap fixtures that reduce flows down to 3 to 5 litres/min (which still 'felt' like good flows).

Most of the focus of grey water systems was on using it for irrigation. Grey water was collected from the shower, bath, vanity, laundry tub and washing machine. The Victoria rebate of $500 for permanent grey water irrigation systems was a big driver. This AU$500 rebate meant that for small systems (to irrigate small flower gardens) the price was reduced from AU$600 to AU$100, with larger systems (for irrigating lawns etc) being reduced from around AU$3,000 to AU$2,500. Products designed to use grey water for non-potable use (such as toilet flushing) were significantly more expensive, in the range of AU$8,000 to AU$10,000.

It was interesting to note that composting toilets, like the internationally recognised Clivus Multrum, were still not allowed in urban areas, even in dry Australia, so the likelihood of them being accepted in New Zealand urban areas is still likely to be low for a while yet.

A significant driver is the rebates (AUS$$) being offered by the Victoria Government. These include (www.ourwater.vic.goc.au):

- $500 – greywater permanent system
- $150 to $1,000 – rainwater tanks based on size (600 to 5000 litres) and number of uses (outdoor, laundry, toilet)
- Dual-flush toilet - $50
- Water conservation audit - $50
- Hot water recirculator - $150
- Water efficient showerhead (limit 2 rebates per property) - $10 for showerheads of value $30 to $100, $20 for value > $100.
- Basket offer - $30 rebate when purchasing $100 worth of goods such as mulch, compost bin, garden tap timer, drip watering system, shower timers, flow control valves etc.

The Victoria government also had significant energy rebates (AUS$$), such as:

- Solar hot water systems – with up to $2,500 of rebates system costs come down from $4,000 - $5,500 down to $1,800 - $3,000.
- Solar power systems – with rebates of $9,000 entry level systems of 1kW come down from around $13,000 to $4,000.
-

4.1.1 Main findings relevant to potential opportunities:

- Numerous companies selling all different size and shapes of tanks and accessories:
  - Small modular blocks (200 to 300 litres) to fit under decks etc were produced by several suppliers, but not seen in New Zealand yet.
  - But none were like a New Zealand small (200 litre) tank that fits under the eave, above the toilet, to gravity supply toilet flushing water

- Main focus of greywater was for irrigation only. Even with the extreme Australian water shortages, the Australian codes for grey water use are surprisingly more strict (than here in New Zealand where, for example, the New Zealand manufacturer 'EcoPlus' produces a $2,750 household system that treats greywater from bath, shower, laundry for toilet use. Australian household greywater systems to supply anything in addition to irrigation water are in the $8,000 to $10,000 range because of additional treatment to meet drinking water standards for household use.
- Composting toilets still not accepted in drought stricken urban Australia.

4.2 Integrated Water Management Product Design Criteria

4.2.1 Introduction

Some introductory comments are useful to explain the characteristics of the integrated water management product design criteria developed specifically for this Beacon project. The specific characteristics are listed below in bullet form.

- **Focus on products** (and systems, comprised of a number of different products) – the Beacon project had a specific focus on criteria to 'analyse and identify whether existing products/systems could contribute to or provide the 'ideal design' and 'on potential commercial opportunities'. This meant an emphasis has been placed on products such as water tanks and water efficient appliances/products rather than 'non-product' water saving options such as changing water conservation behaviour, household water audits, leak detection and drought tolerant planting. It is acknowledged that a holistic water demand management program has to include both 'product' and 'non-product' methods, it is just that the 'non-product' methods are not the focus of this specific Beacon project.
- **Focus on the householder** and neighbourhood level – The Beacon project is focussed on looking at water demand from the point of view of the householder. The Beacon vision being 'Creating homes and neighbourhoods that work well into the future and don't cost the Earth.' It is fully understood that saving water at the household (and neighbourhood) level has definite benefits at the catchment and regional water authority scales and so some of these benefits have been included in the product criteria list, such as, reduction in peak water demand (commonly, it is the peak water demand that determines the water network infrastructure sizing rather than, say the average annual water use which is how the householder pays for the water services). This householder focus is brought out in the Beacon water targets which include both household water use and council reticulated water supplied based on the numeric of average litres per person per day.
- **Focus on household economics -** The same focus on the household applies to the economic criteria; these are focussed around what the householder would pay for, rather than trying to actually cost any of the larger scale council infrastructure costs and savings. Again it is acknowledged that a holistic economic analysis would need to include all costs at all levels, but this level of complexity is beyond the scope of this Beacon household product focus. Where possible, these larger catchment and water authority scale impacts have been included in the way of general statements rather than detailed calculations.
- **Economic costing methods** – there is a lot of debate around the most appropriate economic parameters and methodology to use for 'long-term' (that is greater than 20 to 50 years) assessments. This is primarily around the choice of discount rate – the rate at which future expenses are 'discounted' to 'present day costs'. In economics, this is called net present value (NPV) calculations. Often agencies use a discount rate of around 7 to 10% (approximately before-tax return on investment – reflecting the opportunity cost of displaced investment). The New Zealand Transport Agency's Economic Evaluation Manual (2008) recommends a discount rate of 8% per annum. However, recent developments in costing for long-term sustainability suggests much lower (around 2%) or

close to zero discount rates. Chong et al (2008) cites the recent *Stern Review Report on the Economics of Climate Change* use of discount rates of between 1.6% and 2.1%, derived from different economic scenarios. Chong goes on to quote from Quiggen (2006, p.18) in a review of the criticisms of Stern's low discounting rates that: "Stern's choice….is primarily the result of applying the standard utilitarian view that all people count equally. If this view is accepted, the pure rate of time discount, reflecting the probability of social extinction, must be close to zero." For the Beacon product design criteria, two discount rates (0% and 10%) are applied to indicate the likely range from these two different perspectives.

- **Water and Power costs/savings over time** – another economic parameter affecting the net present value calculations is the current and future costs for water and power. Apart from the conventional inflation increases, the costs of providing water and power services are likely to increase due to increasing demands and decreasing resource availability. For the Beacon product criteria, the cost of water and power have been conservatively estimated to double in the next 25 years. Users are recommended to check with the latest forecasts given the uncertainty around future predictions and specific localities, particularly around water sources in specific geographic areas, energy supply and dependence on imported oil.
- **Relative rather than absolute criteria and ranking –** particularly in the area of sustainability, absolute criteria are difficult to define and measure. It is also important to include both objective (e.g. water quantity and cost) and subjective (e.g. social acceptability) criteria. The subjective being often more difficult to define and measure. For reasons such as these, the criteria scoring should be seen as providing a relative comparison between different products/systems rather than an absolute assessment of an individual product on its own. This allows simplicity and greater flexibility in the range and number of criteria used to better represent the total integration of as many cultural, social, economic and environmental criteria as possible.
- **Cumulative point scoring –** the product design criteria worksheet uses a multiple point scoring methodology which allows the accumulation of points for the more benefits attained. This follows the trend in recent manuals such as 'CEEQUAL' (The **C**ivil **E**ngineering **E**nvironmental **Qual**ity Assessment and Awards Scheme, 2008) and 'LEED' (Leadership in Energy and Environmental Design, 2008). The multiple point scoring methodology is preferred over the other common method of scoring all criteria over the same range of say 1 to 5 (1 being worst to 5 being best) as it allows for greater simplicity and flexibility in assigning the number of points for each individual criterion. For instance, it allows you to gain another point or two for more sustainable actions without having to define each criterion over a specific range (e.g. add 2 points if product complies with the definition of 'made in New Zealand' under the Fair Trading Act.).
- **Multiple point scoring –** often criteria scoring systems actively discourage 'double counting', that is, where one action can score benefits in more than one criteria. On the contrary, in an 'integrated' water management it is exactly these synergies that make a system more integrated. The Beacon product design criteria consist of many synergistic qualities. For example, when dealing with wastewater discharges, these affect criteria on water quantity volumes, appropriate use, nutrient cycle and cultural aspects.

- **Weighting –** the number of points allocated to each of the criteria determines the relative weightings. Weightings are inherently subjective and open to debate. Best efforts have been made to use the most appropriate relative weights for the purposes of Beacon's focus on affordable household products. Users can, if desired, change the weights by adjusting the number of points allocated to each criterion. The current design criteria contain a maximum possible of 158 points. The maximum number of points allocated to the eleven categories and their percentage relative weights are summarised below in Table 1(refer Section 4.2.3 for more detail). Table 1 shows the focussed weighting on Beacon's water quantity targets (Criteria 1.1 with 30%) and to ensure they 'don't cost the Earth' (Economic Criteria 1.11 with 29% weighting).

Table 1: Design Criteria Maximum Points and Relative Weighting

Product Design Criteria		**Maximum Points**	**Relative Per Cent Weighting**
Number	Description		
1.1	Water Quantity	47	30%
1.2	Water Quality	10	6%
1.3	Nutrient Cycle	4	3%
1.4	Material Cycle	8	5%
1.5	Cultural Issues	6	4%
1.6	Resilience	7	4%
1.7	Technical Issues	10	6%
1.8	Governance	6	4%
1.9	Social	9	6%
1.10	Life Cycle Energy	5	3%
1.11	Economic	46	29%
	Total	158	100%

Another way of tabulating the relative weightings is to sum up the number of points allocated to the sustainability 'four well-beings', cultural, social, economic and environmental, refer Table 2. An additional area of governance has been added to cover the increasing importance of the wider water authority/council aspects, criteria such as, the council water supply, technical issues, ownership, operation, maintenance and authority approvals.

Table 2L Four Well-Beings Relative Weighting

Four Well-Beings	Maximum Points	Relative Per Cent Weighting
Cultural	6	4%
Social	17	11%
Economic (Criteria 1.11 only)	46	29%
Governance	23	14%
Environmental	66	42%
Total	158	100%

Due to the inherent subjective nature of the criteria and the 'scoring system', the list of draft criteria and weightings were reviewed by representatives of people in the area of sustainable water services from three areas; a council water manager (Hugh Blake-Manson of Selwyn District Council), a consulting engineer (Steven Roberts, a consultant engineer to Kapiti Coast District Council) and a product supplier (Craig Brown of Eco-plus who supply a greywater system).

4.2.2 Background

An integrated water management system needs to consider many aspects, including:

- The integrated way in which the product/system manages all 3-waters of stormwater, water supply and wastewater; and the 4th groundwater – as close as possible to the natural water cycle.
- The integrated way of addressing the New Zealand Government's sustainability four well-beings (cultural, social, economic and environmental)
- The acceptability to the public and willingness to change their behaviours
- The acceptability to new and emerging ideas
- The ever increasing importance given to how and what the product is made of (for instance, embodied energy – the amount of energy used to manufacture the product)
- The resilience to uncertainties around climate change and dependence on oil.

While there have been many studies done on the efficiencies of different water systems, few have addressed all of the above issues into one 'relatively' easy to use system. They are often very technical such as life cycle assessments (LCA) requiring extensive data manipulation and inputs, and/or very detailed such as the 12MEuro Swedish Urban Water Programme carried out by eight Swedish universities (with 16 PhD projects) from 1999 to 2005 (www.urbanwater.org).

Nevertheless, these existing studies do provide insight into the types of criteria to be used and how they are arranged. Two illustrative examples are given below:

- An international example of the United Kingdom SWARD project (Sustainable Water Industry Asset Resource Decisions) which has a specific water infrastructure focus, and
- A local New Zealand general product 'sustainability' assessment scheme.

The UK SWARD Project

In the United Kingdom, the SWARD project (Sustainable Water Industry Asset Resource Decisions) differentiates between sustainability principles, criteria and indicators. The four sustainability principles are (Ashley, Blackwood et al. 2004):

- Social progress which recognises the needs of everyone;
- Effective protection of the environment;
- Prudent use of natural resources
- Maintenance of high and stable levels of growth and employment

These principles are then followed by four criteria (Social, Technical, Economic and Environmental), which have their own set of indicators, Table 3:

Table 3: The SWARD Criteria and Indicators

Social Criteria	Technical Criteria
■ Impact on risks to human health ■ Acceptability to stakeholders ■ Participation and responsibility ■ Public awareness and understanding ■ Social inclusion	■ Performance of the system ■ Reliability ■ Durability ■ Flexibility and adaptability
Economic Criteria	**Environmental Criteria**
■ Life Cycle Costs ■ Willingness to pay ■ Affordability ■ Financial risk exposure	■ Resource utilisation ■ Service provision ■ Environmental impact

The project was funded by the Engineering and Physical Sciences Research Council and the UK Water Industry. The SWARD project was undertaken by a consortium of UK academics in collaboration with water service providers in Scotland, England and Romania (Ashley, Blackwood et al. 2004)

Greenlist – Find Green Products and Services in New Zealand

The 'Greenlist' website (www.greenlist.co.nz), produced by the Sustainable Business Network and Ecobob Ltd 2009, provides a service for buyers to browse for sustainable products and services. Products and services register on the site by filling out a questionnaire and the answers displayed for people to see. It is a self assessed rating system, under five headings; cyclic, solar, efficient, social, safe and certified. The areas covered under each of the headings are:

Cyclic: renewable materials, creates no waste, is compostable, repairable, reusable, recyclable

Solar: has low embodied energy as it is made from, or runs on renewable energy (e.g. solar, hydro, wind)

Efficient: uses less resources; either through locally sourcing of materials in its design & manufacturer, packaging or distribution, includes kiwi made, long life products & website sales.

Social: cares for people & the environment. Made locally, or with fair trade practices with staff and community wellbeing in mind, and/or encourages sustainability behaviours.

Safe: safe to use and dispose of. Does not contain or generate hazardous materials or by-products for humans or nature, or enhances biodiversity.

Certified: Part of or all of the listing has a recognised third party environmental or social management system or product label.

4.2.3 The Proposed IWM Product Design Criteria

The proposed integrated water management product design criteria presented below has been developed from the above examples and other national and international sustainability assessment criteria, with a focus on the Beacon water targets and product design. There are 11 categories, with a total of 31 criteria, see Table 4.

Table 4: IWM Design Criteria

Summary Design Criteria	Detailed Assessment Criteria	Explanation of criteria
To take an integrated approach to managing water supply, wastewater, stormwater and ground water quantities.	**1.1 Water Quantity**	Different indicators for water supply, stormwater and wastewater are used to measure how well the product/system 'integrates' all of the 'waters' going into and out of the house. Criteria 1.1.2 and 1.1.3 specifically address Beacon's two household water targets.
	1.1.1 Total Water Use	
	1.1.2 Reticulated Water Supply IN	
	1.1.3 Council Water Supply	
	1.1.4 Wastewater OUT	
	1.1.5a Stormwater Volumes	
	1.1.5b Stormwater Peak Flows	
	1.1.6 Groundwater	

To take into account water quality.	**1.2 Water Quality** 1.2.1 Most Appropriate Use 1.2.2 Stormwater Discharge Quality	The two water quality criteria measure how appropriate the quality of water is to its end use (e.g. treated drinking water is not necessary to flush the toilet) and the degree of contamination of the discharged stormwater.
To consider the nutrient cycle, specifically of wastewater discharges.	**1.3 Nutrient Cycle**	This criterion measures the degree to which the nutrients in the wastewater are used as a 'resource' and put back onto the land as opposed to being discharged (and 'wasted') to water or landfills.
To address the sustainable use of materials.	**1.4 Material Cycle** 1.4.1 % Recycled / Designed for Reuse 1.4.2 Life of the Product 1.4.3 Made in New Zealand	Rather than detailed technical calculations, some qualitative criteria have been used as a 'relative' measure between different products as to how well they maintain the 'material cycle', with less waste.
To take into account any Cultural issues.	**1.5 Cultural Issues**	The primary cultural issue is the required disposal and treatment of wastewater onto land rather than directly to water. Other criteria of the 'food gathering' (Mahinga kai) quality of the stream and the site status (does it have cultural associations) are also included but are more relevant to the wider neighbourhood scales.
To increase resilience of the product/system to function	**1.6 Resilience**	Resilience – *'the ability of a system to absorb disturbance and still remain its basic function and structure'* is measured by the number of *'resilience principles'* the product fulfils (e.g. decentralisation, emergency preparedness and multiplicity)
To consider technical and governance issues around the take up of a new	**1.7 Technical Issues** 1.7.1 New or Proven Technology	While some of these issues are similar to 'resilience' above, here the focus is on specific

	1.7.2 Flexibility – Changing Demand 1.7.3 Flexibility – Technological Advances 1.7.4 Risk of Failure	
	1.8 Governance 1.8.1 Ownership, Operation and Maintenance 1.8.2 Authority Approval	With new and/or emerging technologies the public/private responsibilities and authority approvals can be one of the major impediments to their uptake and general acceptance.
To consider social issues around the public's up-take of a new product.	**1.9 Social** 1.9.1 Social Acceptability 1.9.2 Public Awareness and Understanding 1.9.3 Risk to Human Health	The social issues around new technologies can also have a major impact on their uptake. For water services, public health is very important for direct or indirect contact with humans and comes under The Ministry of Health.
To consider the increasing importance of energy consumption in the life cycle of a product.	**1.10 Life Cycle Energy** 1.10.1 Life Cycle Energy Estimate	Life Cycle Energy includes both annual energy use and embodied energy (the amount of all energy used to manufacturer the product) and is becoming increasingly important with the uncertainty of future energy sources.
To achieve the most cost effective solution.	**1.11 Economic** 1.11.1 Initial Capital Cost 1.11.2 Average Annual Maintenance 1.11.3 Water Savings 1.11.4 Energy Savings 1.11.5 Net Present Value (NPV)	While Net Present Value (NPV) calculations include all capital, maintenance, water and energy costs/savings, they are also included here as separate criteria as the general public are often more interested in their direct day-to-day costs rather than the more 'theoretical' long term calculations, especially for small cost items (say less than $500 or $1,000). For larger price items of $2,000 to $10,000 they are more likely to also look at the NPV 'pay-back-period'.

A detailed design criteria manual and data input Excel spreadsheets are attached in Appendix B: Design Criteria Manual. Appendix B comprises:

- Integrated Water Management (IWM) Product Design Criteria Manual – a word document describing each of the design criteria and allocation of points
- IWM Design Criteria Water Quantity Calculations Worksheets – an Excel worksheet summarising water quantity assumptions for each of the products/systems assessed to estimate the specific water quantity criteria, 1.1.1, 1.1.2 and 1.1.4.
- IWM Design Criteria Economic Worksheets – an Excel worksheet summarising economic assumptions for each of the products/systems assessed to estimate the specific economic criteria, 1.11.
- IWM Design Criteria Points - an Excel worksheet summarising the points allocated for all the criteria for all the products/systems assessed.

The next section, Section 4.3, summarises the analysis of the selected list of products and systems using the above list of product design criteria.

4.3 Analysis of Water Products and Systems

4.3.1 Introduction

The analysis of selected water products and systems has been carried out to assess the impact of different design criteria on:

- How the products contribute to or provide the "ideal" system, and
- Possible commercial opportunities (addressed in the next section, Section 5)

In this context, not all of the water saving options have been assessed. Selected water products and systems have been chosen to be representative of the range of different types of products/systems available, including:

		Examples
Size of product:	**Small**	Low flow showerhead
	Medium	Water efficient washing machine, 200 litre rain tank
	Large	9,000 litre rain water tank
Required behavioural change:	**None**	Low flow shower head - can still take the same length of shower, and provided a good quality low flow shower head is used, there is no detectable difference in the feeling of the shower)
	Some	Rain water tank - can be used with a mains water supply backup so have seamless water supply, but still requires some maintenance such as pump repair, and periodical cleaning of the spouting and tank)
	Significant	Composting Toilet – requires significant changes such as adding dry material after each visit and periodical cleaning and emptying of the contents.

Size of financial investment	**Small**	Low flow shower head (up to around $100)
	Medium	Water efficient washing machine, greywater system
	Large	9,000 litre rain water tank ($5,000 or more)
Individual household or neighbourhood scale	**Individual**	Individual rain water tanks for each household
	Neighbourhood	Collective rain water tanks to serve more than one household (e.g. the Earthsong Eco-Neighbourhood community in Ranui, Waitakere)

As this project is focussed on products or a collection of different products (systems), other water saving options such as stopping household leaks and water conservation gardening techniques have not been assessed at this stage.

The key to all multi-criteria assessments is the presentation and summary of the data. This report presents the data in two ways:

5) Summary of points scored by each of the selected products and systems – Section 3.3.2
6) Summary of the significant lessons learnt from the scoring of the design criteria and how the criteria influence an "ideal" system – Section 3.3.3

4.3.2 Summary of Points Scored by each Selected Product/System

The points scored by each of the selected products and systems are attached in the Excel spreadsheets in Appendix B. The data is summarised at three levels of detail:

High Level Overall Summary – this is a graph of the total number of points scored. The combined Social-Cultural-Environmental-Governance categories is plotted on the y-axis versus the Economic points score on the x-axis, see Figure 1. (Refer Appendix B, Design Criteria Points, 'Summary' worksheet)

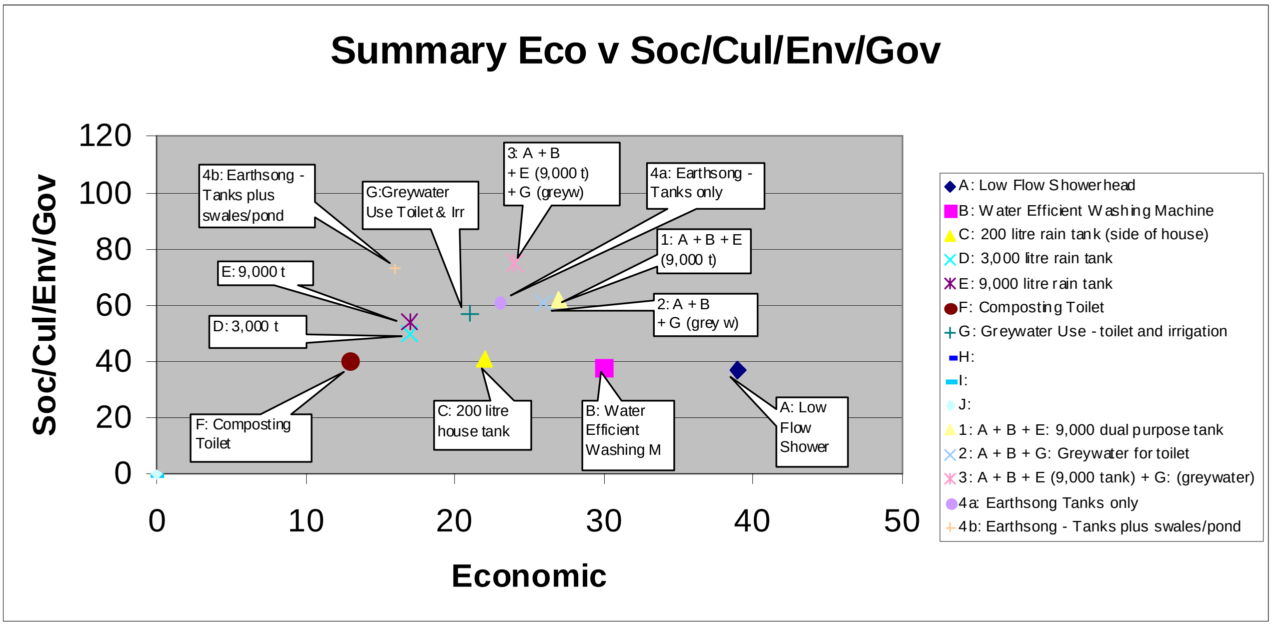
Mid level Points Summary – This is a summary table of points gained for the 11 sub-criteria, with subtotals for Cultural, Social, Economic/Governance and Environmental and Grand Total for all options, see Figure 2 for the points for the 11 sub-criteria. (Refer Appendix B, Design Criteria Points, 'Summary' worksheet)

Detailed Input Summary – This lists all individual points input into each criteria for all the options. (Refer Appendix B, Design Criteria Points, 'Points' worksheet).

It should be stressed that the points scoring is for comparison purposes only and should not be taken as an absolute score for each individual product. Many of the criteria are inherently subjective and have been scored relative to the other products being assessed. This provides a simple to use, very useful guide to assessing comparative products without having to carry out very detailed, time consuming and costly analysis of each individual product.

Another point worth noting is that the public uptake of new or alternative products/systems can occur on a 'step-by-step' basis. That is, irrespective of the overall points scored, the public may simply be more amenable to taking up a certain product before something else. One example is the public perception of greywater systems. Even though the greywater system has a higher overall 'score' than say, a small 200 litre rain tank, the public are just not ready to accept the 'greywater concept' over a 'rainwater tank' concept. The concept of using relatively clean rain water is easier to accept than using 'dirty' greywater. For example, in Australia they have found that irrespective of the amount of water quality treatment given to greywater, there is a lot of reluctance to reusing greywater for anything more than just irrigation and flushing the toilet. The high level overall summary graph is presented below in Figure 1.

Figure 1: High Level Overall Summary



Some points to note from the above graph on **individual products (numbered A to G)** are:

- This is a 'quasi benefit-cost' plot, with the Social-Cultural-Environmental-Governance 'benefits' on the y-axis and the 'Economic' costs on the x-axis.
- Products A and B (Low flow shower heads and water efficient washing machines) have a relatively high economic score (due primarily to the power savings from reduced hot water use, e.g. the low flow shower head saves approximately $100 per year in power savings from reduced hot water use, while only $50 per year comes from reduced water volumetric charging) but relatively low other benefits with minimal impacts on stormwater and relatively low overall water quantity benefits.
- Product C (200 litre house tank) has medium economic score (due to the moderate $1,000 capital cost and no power savings due to the reduced water usage being only cold water)

and relatively low other benefits due to relatively low water savings compared to other larger rainwater tanks.

- Products D and E (larger 3,000 and 9,000 litre rainwater tanks) have less economic score than the smaller 200 litre tank (product C) due to the higher capital costs ($3,500 to $4,500) and power costs due to the need for individual water pumps, but have more other benefits due to the greater water quantity savings and stormwater benefits.
- Product F (composting toilet) has a low economic score due to the significant capital cost and low other benefits with minimal impacts on stormwater and low social acceptability.
- Product G (greywater reuse for toilet and irrigation) has moderate economic score (moderate capital cost of $2,750) and moderate other benefits due to a good water quantity score from the reuse of greywater.

Some points to note from the above graph on **systems (numbered 1 to 4)** are:

- Systems 1 and 2 - Combining the "high economic – low other benefit" low flow shower head and water efficient washing machine (A and B) to the "low/moderate economic – moderate other benefits" 9,000 litre water tank or greywater reuse (E or G) results in a combined system with an overall "medium to high" benefit-cost score.
- System 3 - Adding both the 9,000 litre water tank (E) and the greywater reuse (G) to the low flow shower head and efficient washing machine leads to a combined system with greater "other benefits" and the greatest overall score, all be it at a reduced economic score relative to systems 1 and 2.
- System 4a - The neighbourhood rainwater tank option increases both the economic score and other benefits, when compared to the individual household rainwater tank options (Products C, D and E) due to the cost sharing of a fewer number of larger tanks.
- System 4b - The neighbourhood rainwater tank and stormwater measures (swales, pond, permeable paving) have increased other benefits over System 4a, but at a reduced economic score due to the additional capital and maintenance costs. Note, for a true comparison, one would need to compare the cost of these on-site stormwater measures to equivalent off-site stormwater measures, such as a downstream wetland. These are the larger catchment scale options that have not been included in this particular project.

The mid-level point's summary is presented below in Figure 2.

				Individual Products											Systems				
			Weighting	A: Low Flow Showerhead	B: Water Efficient Washing Machine	C: 200 litre rain tank (side of house)	D: 3,000 litre rain tank	E: 9,000 litre rain tank	F: Composting Toilet	G: Greywater Use - toilet and irrigation	H:	I:	J:	0	1: A + B + E: 9,000 dual purpose tank	2: A + B + G: Greywater for toilet	3: A + B + E (9,000 tank) + G: (greywater)	4a: Earthsong Tanks only	4b: Earthsong - Tanks plus swales/pond
Item		Total																	
No.	Description	Points																	
1.1	Water Quantity - TOTAL	47	30%	6	3	4	13	18	13	22	0	0	0		25	26	38	22	26
	Water Use in the House Subtotal	35		6	3	3	10	10	13	22	0	0	0		17	26	30	19	19
1.1.5	Stormwater Runoff OUT Subtotal	12		0	0	1	3	8	0	0	0	0	0		8	0	8	3	7
1.2	Water Quality - TOTAL	10	6%	0	0	2	4	4	1	2	0	0	0		4	2	4	4	10
1.3	Nutrient Cycle - TOTAL	4	3%	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0
1.4	Material Cycle - TOTAL	8	5%	1	5	7	6	6	3	5	0	0	0		6	5	6	7	7
1.5	Cultural Issues - TOTAL	6	4%	0	0	0	0	0	2	2	0	0	0		0	3	3	0	1
1.6	Resilience - TOTAL	7	4%	1	1	4	4	4	4	5	0	0	0		4	4	5	5	6
1.7	Technical Issues - TOTAL	10	6%	9	9	9	9	9	6	7	0	0	0		9	7	7	9	9
1.8	Governance - TOTAL	6	4%	6	6	5	5	4	4	5	0	0	0		4	5	4	4	4
1.9	Social - TOTAL	9	6%	9	9	6	6	6	3	5	0	0	0		6	4	4	6	6
1.10	Life Cycle Energy - TOTAL	5	3%	5	5	4	3	3	4	4	0	0	0		4	5	4	4	4
1.11	Economic - TOTAL	46	29%	39	30	22	17	17	13	21	0	0	0		27	26	24	23	16
	TOTAL	158		76	68	63	67	71	53	78	0	0	0		89	87	99	84	89

Figure 2: Mid-Level Points Summary

Lessons learnt from the points scored under the 11 sub-criteria (listed as 1.1 to 1.1) is presented below in Section 4.3.3 on the qualities of an “ideal system”.

4.3.3 Lessons Learnt for an "Ideal" System

The following table lists the lessons learnt from assessing the selected products and systems against the design criteria. These lessons can help guide us to the qualities of an "ideal" system and also to the identification of any commercial opportunities. The lessons learnt for an "ideal" system are tabulated below under the design sub-criteria headings, the possible commercial opportunities are presented in the next section, Section 5 – Conclusions and Potential Opportunities.

Table 5: Lessons Learnt for an "Ideal" System

Design Sub-Criteria	Lessons Learnt
Integrate water supply, wastewater and stormwater quantities. (1.1 Water Quantity)	Maximum benefits are achieved when: Water supply is reduced through using less water (e.g. low flow shower heads), reusing water (e.g.greywater) or using water from a local source (e.g. rain tanks). Wastewater reduced through using less water or reusing water. Stormwater reduced through using rain water as household water (e.g. tanks). The ideal system – needs multiple products in order to address all "3-waters" and using local sources of water (either greywater or rain water) has multiple benefits. Need to look more closely at which products reduce peak demand as well as long-term average water quantities as peak demand often has a greater influence on council infrastructure than average yearly water volumes.
Include water quality. (1.2 Water Quality)	The ideal system - uses the most appropriate water quality for its end use (e.g. using locally sourced rainwater to flush the toilet rather than treated piped "drinking water" from a distant treatment plant) and addressing the quality of the stormwater when it leaves the site.
Consider the nutrient cycle (specifically wastewater). (1.3 Nutrient Cycle)	The ideal system – puts the nutrients back on to the land (specifically from wastewater with addition to composting products and/or irrigation) for beneficial use rather than piped out to sea. No assessed products/systems addressed this criterion. An example of a system that would is an on-site wastewater treatment system, but these are generally not suitable for the conventional medium density urban environment.
The sustainable use of materials. (1.4 Material Cycle)	The ideal system – is designed for reuse, using recycled materials, has a long life and is made in New Zealand. There is no reason why most products can not meet these criteria with the right incentives and public demand. For example, the use of recycled materials in high density polyethylene or concrete rainwater tanks. Most products scored reasonably well in this regard, but there is room for improvement.

Take into account cultural issues. **(1.5 Cultural Issues)**	Cultural issues generally come in to play at the larger catchment scales which are not part of this project. One cultural area with impacts at the household level is the reduction of wastewater volumes. In this area composting toilets and greywater systems scored points for their significant reductions in wastewater volumes. The ideal system – would **acknowledge traditional cultural associations** with the site, enhance the **ability to harvest food** locally and **discharge wastewater on to the land** through addition to composting operations and land irrigation.
To increase resilience of the product/system to function. **(1.6 Resilience)**	Examples of increased resilience came from: • Getting water from local and different sources decreases dependence and demand on centralised single-source networks, hence increased resilience to disturbance, breakdowns or shortages in supply from the one central network affecting large communities. (e.g. local tanks) • Being better able to handle increasing variability in rainfall patterns from future predicted climate change impacts. For example, a focus on reducing water use in drier regions. • Systems that have local feedback loops so users are more aware of how well the system is functioning and the ability to take remedial actions. The ideal system – uses **multiple**, **local sources** that are **flexible to changing conditions.**
To consider technical and governance issues around the take up of a new product. **(1.7 Technical Issues and 1.8 Governance)**	Technical and governance issues that had a positive benefit on the take up of a product were: • Using proven technology (all products scored high here) • Ability to change parts to accommodate changing demand and/or technological advances. • Low risk of failure through less likelihood of occurrence and less consequence of failure. • Systems with fewer issues over communal ownership. • Using a technology already proven by authorities. (e.g. most products scored well here except for greywater) It is recognised that some of these qualities can be seen as “anti-innovation” and “anti-new products”. Therefore, the ideal system – will try to **minimise risks** from new technologies to both private and public concerns to an acceptable level so that the public still **take up the new product** with an **overall benefit to the community** as a whole.

To consider social issues around the take up of a new product. **(1.9 Social)**	Social issues, as well as the technical and governance issues outlined in the above criteria, affect the take up of a product. Social issues having a positive benefit on the take up of a product were: • Increased social acceptability (e.g. low flow shower heads and water efficient washing machines scored relatively better than rain tanks, with greywater and composting toilets the least acceptable) • Increased public awareness and understanding (products scored same relative values as for social acceptability) • Low risk to human health (e.g. use of rainwater scored better than use of greywater) The ideal system – is **readily acceptable** to the public, requires **little additional public awareness and understanding** and has a **low risk to human health**.
To consider the increasing importance of energy consumption in the "life cycle" of a product. **(1.10 Life Cycle Energy)** **The life cycle energy criterion was used as also being representative of the products 'carbon footprint'.**	The calculation of Life Cycle Energy is a very technical and complex area as it includes the 'embodied energy' used in manufacturing the product and the 'energy use' during the life of the product. The simplified factors used to assess the relative life cycle energy benefits between products were: • Longer product life (e.g. concrete tanks) • The relationship between the mass of the product and the type of material (i.e. HDPE, steel and concrete) – For example, for tanks the most beneficial life cycle energy is generally for steel, then concrete, and last in HDPE (even though the HDPE is much lighter it has a far greater embodied energy per mass of material) • The greater recycled content • Lower energy use The ideal system – takes into account **both mass and type of material (for tanks, 1st choice is steel, next concrete and then HDPE)**, has a **long life**, contains **recycled materials** and uses **less energy**.

To consider both short term and long term economic implications. (1.11 Economic)	The short and long term economic benefits included: • Lower initial capital cost (e.g. water efficient washing machine. Note, the scoring was based on the cost comparison between the 'water saving product' and a 'non-water saving product'. Although the actual cost of a water efficient washing machine is not small, the difference between a water saving and a non water saving model is relatively low) • Lower annual maintenance (e.g. low flow shower head versus a rainwater tank system including a water pump and dual household plumbing for potable and non-potable water) • Greater water volume savings (via water bill) (e.g. medium to large water tanks) • Greater energy use savings (via energy bill) (e.g. low flow shower head reduced hot water use) • Lower pay back period (taken as the net present value of capital and maintenance costs) (e.g. low flow shower head and when communal ownership of larger rain water tanks can spread the cost of a tank over a greater number of households). The ideal system – has a **low capital cost**, **low maintenance**, and a **large saving in both cold and hot water use**.

It can be seen from the above lessons learnt that many of the design criteria are contradictory. That is, there are inherent "trade-offs' to get the maximum overall benefit. The total overall score being dependent on the weightings given to each criteria, as discussed previously in Section 4.2.1.

Lessons learnt from combining individual products into a system were presented in Section 4.3.2 (Systems 1 through to 4a and 4b). In summary, the lessons learnt for ideal systems are:

- A better total score by combining rainwater storage tanks into fewer, but larger communally owned tanks (provided communal ownership issues can be managed).
- Combining small relatively inexpensive products with high economic but low other benefits (e.g. low flow shower head and water efficient washing machine) with other larger more expensive products that had greater wider other benefits (e.g. rain water tanks and greywater systems) made for a better total score. For example, the system that scored the greatest number of points (System 3 - 99 points) was for the combined:
  - Low flow shower head
  - Water efficient washing machine
  - Large rainwater tank
  - Greywater reuse

5 Potential Commercial Opportunities

Potential commercial opportunities were assessed based on:

- Findings from the Save Water Save Energy Expo in Melbourne
- Lessons learnt from the products design criteria assessment of existing products and systems.

Two possible commercial opportunities have been identified:

1) Introduction of modular rain water storage blocks (200 to 300 litres) that can be connected up in irregular shapes to fit under decks etc.
2) Further development of a small 200 litre rain water tank that attaches to the side of the house under the eave to collect rain water from the roof and gravity feed to the toilet.

Melbourne's Save Water Save Energy Expo is Australia's largest showcase of products and services which save water, save energy, reduce waste or provide cleaner energy. It provided an excellent one-stop look at the full range of water products and services currently on the market and/or in an emerging market. The main conclusions coming out of the Expo relating to commercial opportunities were with respect to rain water tanks. Although there are numerous companies selling all different size and shapes of rain water tanks and accessories, there were two possible commercial opportunities:

- **Possible Modular Tanks introduced into New Zealand -** One type of rain tank on display at the Expo but not yet seen in New Zealand was the option of small modular blocks (200 to 300 litres) that could fit under decks and irregular spaces. These were generally more expensive than the above ground standard shaped tanks, but less expensive than going underground (refer Figure 3).

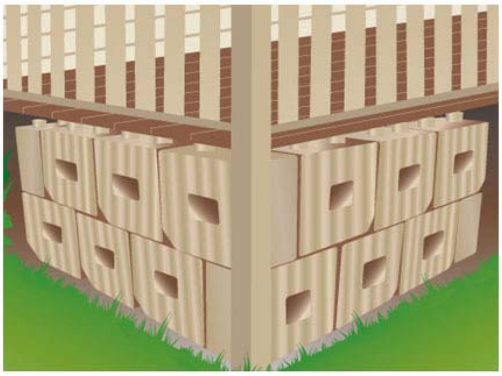


Figure 3: Picture of Modular Tanks

- **Further development of existing 200 litre tank already in New Zealand** – The one type of rain tank not seen at the Expo was New Zealand's 200 litre tank that attaches to the side of a house under the eave to collect roof water and gravity feed to the toilet. This product is currently manufactured in Waitakere City by a local plumber. See Figure 4 and further explanation below.

Figure 4: Photos of 200-litre tank on side of the house

Because several Australian companies are currently producing the modular tanks where as no one is currently producing the 200 litre tank product on a commercial scale, the potential commercial focus is on the 200 litre tank. A more detail description of the 200 litre tank option is given below, along with a tabulated summary of how well it performs against the product design criteria (see Table 6) to give a more complete picture of the integrated water management benefits.

Product- Modular Tanks

There were several different companies producing slightly different variations to the theme of modular tanks. In order to assess the commercial opportunities of modular blocks one would need to first assess the existing manufacturers in Australia, their potential and/or interest in expanding into the New Zealand market, and then assess whether to go into a partnership or in competition. This product has not been assessed in more detail at this stage.

Product - 200 litre rainwater tank attached to the side of the house.

Product description: The storage tank contains 192 litres with dimensions of 2.4m long, 0.4m deep and 0.2m outward from the wall. The 192 litres holds enough water for 18 full flushes or about 36 half-size flushes. Preferably the tank is mounted on the outside of the wall, below the guttering and above the toilet cistern. The tank is made from 24 gauge galvanised steel with an estimated life of 25 years. A stainless steel gauze inlet filter screens foreign material such as leaves. The system has a float valve assembly connected to the main supply to ensure a continuous supply of water. Rainwater flows down an overflow pipe if the tank is full.

Product Assessment: A detailed assessment of how well the 200 litre tank product performs against the product design criteria is presented below in Table 6.

Table 6: 200 litre Rain Tank Product Design Criteria Assessment

Product Design Sub-Criteria	Performance of 200 litre house mounted rain tank
Water Quantity	Low, but significant, score due to the small size of the tank compared to the larger 3,000 to 9,000 litre tanks and does not produce in total water savings – the toilet still uses the same amount of water, but it does reduce the reticulated water supply as approximately 50% (for Auckland typical annual rainfall, varies depending on climate) of the water is obtained from collecting roof runoff, the other 50% has to come from the main supply top-up valve when the 200 litre tank is empty during dry periods.
Water Quality	Low, but significant score, with the use of the more appropriate rain water to flush the toilet compared to using mains treated 'drinking water' quality.
Nutrient Cycle	No score.
Material Cycle	High score as steel can be recycled, it has a 25 year life, and predominantly made in New Zealand.
Cultural	No score.
Resilience	Moderate score due to use of a tank to store water in times of disruption to the mains reticulated water supply. Has added benefit that it operates during a power cut as it relies on gravity feed to the toilet cistern.
Technical	High score due to using a proven product technology with a low risk of failure, that is, the product is currently in use and performs well.
Governance	High score with few ownership, operation and maintenance issues and generally approved by authorities.
Social	Moderate score due to moderate social acceptability.
Life Cycle Energy	High score due to being made of steel (for tanks, steel has a lower life cycle energy than concrete or HDPE) and being relatively small in size.
Economic	Moderate score with a low/moderate capital cost ($1,200), water saving and a 'non-discounted' simple pay back period of approximately 22 years, (excluding other benefits if applied over a large scale, such as deferred costs for future capacity upgrades.)

The above analysis shows that, while the 200 litre tank product does not provide a very high water quantity score (due to only affecting the reticulated water supply in and not actually reducing the total amount of water used), it scores high in the other criteria of material cycle, technical, governance and life cycle energy. It has a moderate economic score due to the moderate capital cost of $1,200; some water savings and neutral power benefit (no power savings as no reduction in hot water, but no power cost as product does not need a water pump).

The 200 litre tank is currently being made and installed by Waitakere plumbers Jan and Ard Sas. Initial contacts with Ard Sas have indicated that he is interested in developing his product further. His original idea was to have the tank as an 'off-the-shelf' kit that could be purchased from hardware stores such as Placemakers etc. With mass production it is expected the manufacture and installation cost could come down to under $1,000.

One benefit of the small 200 litre tank is that it is a relatively small investment (especially if under the $1,000 barrier) that raises awareness of more appropriate use of our limited water resources. A recent example is a proposed demonstration project in Waitakere City where they were initially planning the larger 5,000 litre tanks, but with budget restraints were looking at cancelling the rain water tank option. Instead of cancelling, they are now looking at the less expensive 200 litre tank option.

The economic score could be enhanced by:

- Reducing installed cost to at or below the $1,000 "barrier" through mass production.
- Including the option of a discounted small "high economic benefit" product (such as a low flow shower head) which would give the purchaser some power savings and increased water savings.

Another benefit is the applicability to retrofit situations. Beacon has identified that to make a significant impact on the total housing stock, attention needs to be focussed on the existing houses as they are by far the greatest proportion. These 200 litre tanks are easily attached on the side of an existing house where as experience with the installation of larger tanks indicate that the cost for retrofitting is almost doubled that of installing in a new house (i.e. an increase from $4,000 - $5,000 up to between $7,000 to $10,000). Also, in retrofit cases, the existing toilet could be a single flush, so the addition of a device to reduce the volume of each flush (such as a weight to reduce the time the cistern fills, or a brick to reduce the water volume in the cistern), and the 200 litre tank attached to the side of the house could provide a significant reduction in mains water supplied to the toilet.

6 Conclusions

The threefold purpose of this project was to:

- Develop product design criteria
- Assess products and systems (a collection of products) according to the design criteria
- Report on findings and any potential commercial opportunities.

The conclusions from the assessment of selected products and systems against the developed product design criteria are presented in Section 5.1. Section 5.2 summarises the conclusions on potential commercial opportunities.

6.1 Assessment of Products and Systems against Design Criteria

The products were assessed against 11 product sub-criteria. The assessment process used a multiple point scoring methodology allowing accumulation of points for the more benefits attained. The number of points allocated to each criterion determined the relative weightings. The sub-criteria, maximum allocated points, and their relative weighting are summarised below in Table 7.

Table 7: Design Criteria Maximum Points and Relative Weighting

Product Design Criteria		**Maximum Points**	**Relative Per Cent Weighting**
Number	Description		
1.1	Water Quantity	47	30%
1.2	Water Quality	10	6%
1.3	Nutrient Cycle	4	3%
1.4	Material Cycle	8	5%
1.5	Cultural Issues	6	4%
1.6	Resilience	7	4%
1.7	Technical Issues	10	6%
1.8	Governance	6	4%
1.9	Social	9	6%
1.10	Life Cycle Energy	5	3%
1.11	Economic	46	29%
	Total	158	100%

Seven individual products and five combined systems were assessed (refer Table 8 for a list of the products). Three of the combined systems were at the household scale (numbered 1 to 3 in the table below) and two were at the neighbourhood scale (numbered 4a and 4b). The neighbourhood scale information was provided by Earthsong Eco-Neighbourhood and is gratefully acknowledged.

Table 8: Products and Systems Assessed

Individual Products	Combined Systems
	Combined Household Systems (all three include low flow shower heads (A) and water efficient washing machines (B), with different combinations of rain tanks and greywater use)
A: Low flow showerhead	1: A + B + E (9,000 litre rain tank)
B: Water efficient washing machine	2: A + B + G (Greywater use)
C: 200 litre rain tank (attached to the side of the house)	3: A + B + E + G (9,000 litre rain tank and greywater use)
D: 3,000 litre rain tank	
E: 9,000 litre rain tank	Combined Neighbourhood Systems (Source: Earthsong Eco-Neigbourhood, Ranui, Waitakere City Council)
F: Composting toilet	4a: Earthsong Rain water tanks only
G: Greywater Use – toilet and irrigation	4b: Earthsong rain water tanks plus additional stormwater measures of swales, pond and permeable paving.

The assessment of the above products and systems showed:

- Low flow shower heads (A) and water efficient washing machines (B) had a relatively high economic score but relatively low other (Social-Cultural-Environment-Governance) benefits.
- The small 200 litre rain tank attached to the side of the house (C) had a medium economic score and relatively low other benefits due to relatively low water quantity savings compared to other larger rain tanks.
- The larger more expensive 3,000 and 9,000 litre rain water tanks (D and E) have less economic score than the smaller 200 litre tank but greater other benefits from greater water savings and stormwater benefits.
- The composting toilet had a low economic and other benefit scores, with the lowest total score of 53 points. It had a high capital cost, moderate water quantity score, but no stormwater benefits and a low social score.

- The greywater use had moderate economic and other benefits score, with the highest total score of 78 points. It had a moderate capital cost and a good water quantity score with the reuse of greywater.
- Combining the "high economic – low other benefit" low flow shower head and efficient washing machine (A and B) with the "low/moderate economic – moderate other benefits" 9,000 litre tank or greywater use (E or G) results in a greater total score of 87 to 89 points.
- The maximum total score of 99 points was achieved by combining both the 9,000 litre tank and greywater reuse (E and G) with the low flow shower head and water efficient washing machine (A and B). This reinforces the fact that maximum benefits can only be obtained with a multiple product approach, as different products have benefits in different areas.
- A neighbourhood approach, such as communal larger, but fewer, rain tanks have a better total score than individual tanks on each house (84 points compared to 67 to 71 points for the 3,000 and 9,000 litre tanks).

In terms of the product design criteria, the above analysis showed that an "ideal" system would:

- **Water Quantity -** need multiple products in order to address the entire water cycle, including water supply, wastewater and stormwater (and groundwater).
- **Water Quality -** use the most appropriate water quality for its end use and address the quality of the stormwater discharges.
- **Nutrient Cycle** – put nutrients back on to the land.
- **Material Cycle** – be designed for reuse, use recycled materials, have a long life and be made in New Zealand.
- **Cultural** – acknowledge traditional 'iwi' cultural associations, enhance the ability to harvest food and discharge wastewater on to land.
- **Resilience** – use multiple, local sources that are flexible to changing conditions.
- **Technical and Governance** – minimise private and public risks so the public still take up new products with an overall benefit to the community as a whole.
- **Social** – be readily acceptable to the public, require little additional public awareness and understanding, and have a low risk to human health.
- **Life Cycle Energy** – take into account both mass and type of material, have a long life, contain recycled material and use less energy.
- **Economic** – have a low capital cost, low maintenance, and a large saving in both cold and hot water use.

6.2 Potential Commercial Opportunities

Two possible commercial opportunities have been identified:

1) Introduction of modular rain water storage blocks (200 to 300 litres) that can be connected up in irregular shapes to fit under decks etc.
2) Further development of a small 200 litre rain water tank that attaches to the side of the house under the eave to collect rain water from the roof and gravity feed to the toilet.

A further detailed assessment was carried out on the 200-litre rain water tank opportunity as this is a new product not seen anywhere else in the literature or product listings. A detailed assessment was not carried out on the modular blocks as these are already in the market place with several suppliers in Australia and so the question here would be to first assess the 'competition' suppliers as well as the products individual benefits.

Additional assessment of the 200-litre rain water tank showed:

- Low water quantity score due to only affecting the reticulated water supply and not actually reducing the total amount of water used.
- Scores high in other criteria of material cycle, technical, governance and life cycle energy.
- Moderate economic score due to the moderate economic capital cost of $1,200 with a neutral electrical power benefit (no power savings as no reduction in hot water, but no power costs as product does not need a water pump, it uses gravity to feed water into the toilet cistern)

The 200-ltre tank is currently being made and installed by Waitakere Plumbers Jan and Ard Sas. Initial contacts with Ard Sas have indicated that he is interested in developing his product further.

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Appendix A: Save Water Save Energy Expo – Melbourne

See separate files

Appendix B: Design Criteria Manual and Spreadsheets

See separate file