A TOTAL ECONOMIC VALUATION APPROACH TO THE ASSESSMENT OF WATER QUALITY INTERVENTION OPTIONS WITHIN THE AUCKLAND REGION

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ABSTRACT

Auckland Council's Healthy Waters Department is developing a Freshwater Management Tool (FWMT) to assist with decision-making around the development of freshwater management targets required by the National Policy Statement for Freshwater Management (NPS-FM). The FWMT will use a stormwater management model (SUSTAIN) to assess a range of structural and source control interventions for improving stream hydrology and water quality in urban and rural areas within the Auckland Region. A key part of this assessment is understanding the costs and benefits of implementing different intervention scenarios for future planning and decision making.

While understanding cost is a vital part of the decision-making process, being able to quantify and/ or acknowledge benefits of a particular intervention is just as crucial. Business cases often ignore many potential benefits to the community or the environment, and it is common for the "value engineering" process to under weigh or eliminate benefits that are not seen as integral to a particular project. This leads to a de-valuing of the project outcomes, and can lead to subpar policy recommendations, particularly in terms of public welfare.

A total economic valuation (TEV) approach provides a framework for decision-making which not only acknowledges the multiple benefits of an approach, but also quantifies them where possible. The Cooperative Research Centre (CRC) for Water Sensitive Cities outlines the key components of a TEV approach:

1. Direct costs: the present value of all upfront and ongoing expenditure required to construct (where applicable) and operate water management infrastructure
2. Indirect costs: other delivery costs required to manufacture parts or modify or add to road, regional drainage or other assets, along with supporting administration costs.
3. Avoided costs: both local and downstream – the present value of avoided capital and operating costs associated with water management infrastructure.
4. Direct benefits: the value that will be gained by the organisation installing water management infrastructure (e.g. the value of water for irrigation if the scheme includes rainwater harvesting).
5. Indirect benefits: broader community benefits of water management infrastructure, such as recreation-related benefits, or avoided sicknesses (including non-use or option values).

6. Other environmental/ community benefits: non-monetised benefits which are relevant and should be incorporated into decision making.

In order to fully integrate a TEV into the FWMT, a toolkit approach to better understanding the direct and indirect costs and benefits from different intervention methods has been taken. The paper explores the methodology used to quantify costs and benefits of various water quality interventions practices, for integration and use within the FWMT and for the wider council. As part of this approach the whole life costs of interventions has been calculated, including the cost to maintain devices. Understanding the future costs of maintaining devices in a condition to provide required water quality treatment can have wide ranging benefits for asset management and business planning purposes.

KEYWORDS

Total economic valuation; direct costs and benefits; Freshwater Management Tool; life cycle costs; total acquisition costs; maintenance costs

PRESENTER PROFILE

Sue Ira is the Director of Koru Environmental Consultants Limited. She is an environmental scientist with more than 20 years' experience working in stormwater management. Sue has extensive experience in catchment management planning, peer review and stakeholder consultation. She was the primary developer of the COST_{NZ} Model and has developed a catchment-scale stormwater LCC model for NIWA and the Cawthron Institute. Most recently she has been involved in researching long term costs of stormwater management as part of the National Science Challenge for Building Better Homes, Towns and Cities "Activating WSUD in NZ" project.

1 BACKGROUND

Auckland Council is currently facing significant stormwater infrastructure related challenges from changing rural production, continual growth, development and redevelopment of urban centres within the region. To assist with future planning of stormwater infrastructure to address these challenges, Auckland Council's Healthy Waters Department is developing a Freshwater Management Tool (FWMT – see Stephens *et al*., 2019). The FWMT will also assist with decision-making around the development of freshwater management targets required by the National Policy Statement for Freshwater Management (NPS-FM).

The FWMT is based on open-sourced US-EPA modelling software applied extensively in the United States (e.g., Loading Simulation in C++ for watershed modelling; System for Urban Stormwater Treatment and Analysis Integration for process-based interventions [Shen *et al*., 2004; Shoemaker *et al.,* 2009]). LSPC simulates flow and contaminant build-up/wash-off and transformation (e.g., deposition, resuspension, scour, desorption, nitrification and denitrification). Whilst SUSTAIN simulates and optimises for the costs and benefits of implementing different intervention scenarios on hydrology or water quality.

This paper provides a brief summary of the proposed economic analysis framework to be included within the FWMT to support intervention decision-making. A total economic valuation (TEV) approach is discussed, along with the toolbox of methods to be used.

The paper particularly focuses on the life cycle cost modelling work that has been completed.

2 TOTAL ECONOMIC VALUATION

Understanding cost is a vital part of the decision-making process, as cost estimation plays a key role in all development activities, from costs to private developers, to on-going maintenance costs to network operators. However, being able to quantify and/ or acknowledge benefits of a particular intervention is just as crucial. Business cases often ignore ancillary benefits to the community or the environment, and it is common for the "value engineering" process to eliminate these benefits since they are not seen as integral to a particular project. This leads to a "de-valuation" of the project, and an alternative set of project outcomes, which often ends up excluding ancillary benefits to the community or environment. This can result in recommending different options than if benefits and public welfare were considered.

It is for this reason that Auckland Council is applying a TEV framework to the FWMT. A TEV approach provides a framework for decision-making which not only acknowledges benefits of an approach (as well as costs), but quantifies and monetizes them where possible. The CRC for Water Sensitive Cities (2016) outlines the key components of a TEV approach, as applied to the evaluation of projects involving Green Infrastructure (GI):

1. **Direct costs:** the present value (or life cycle costs - LCC) of all upfront and ongoing expenditure required to construct and operate GI practices.

2. **Indirect costs:** other costs derived from manufacturing or transporting parts used within stormwater assets, along with administration costs to support GI (e.g. the cost of carbon from either the manufacturing stage or transport stage of a material/ product).

3. **Avoided costs:** both local and downstream – the present value of avoided capital and operating costs associated with GI.

4. **Direct benefits:** the value that will be gained by the organisation installing GI (e.g. the value of water for irrigation if the scheme includes rainwater harvesting).

5. **Indirect benefits:** broader community benefits of GI, such as recreation-related benefits, or avoided sicknesses.

6. **Other environmental/ community benefits:** non-monetised benefits which are relevant and should be incorporated into decision making.

3 A TEV APPROACH FOR AUCKLAND

In order to fully integrate a TEV framework into the FWMT, a range of modelling approaches is needed ~~toolkit approach~~ to better understanding the direct and indirect costs and benefits from different intervention methods has been taken (there is no "one" economic model which can account for all six features listed in Section 2 above). **Figure 1** provides an illustration of this approach which includes:

- Using LCC to quantify direct costs, and indirect costs where practical;

- using willingness to pay and benefit transfer studies to quantify and monetise direct and indirect benefits, where practical;
- using international studies to qualitatively assess a wider range of non-quantifiable direct and indirect benefits and indirect costs.

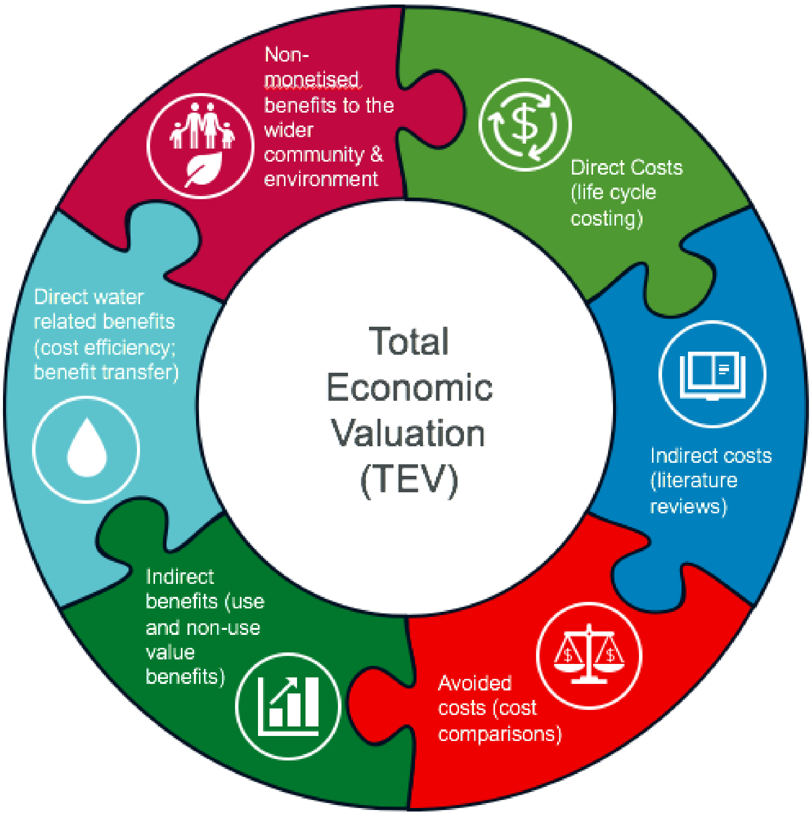

Figure 1: A total economic valuation approach, as applied to the Auckland Council Freshwater Management Tool.

Based on work undertaken via the "Activating WSUD in New Zealand" research project (Ira and Simcock, 2019), new, purpose-built LCC models have been developed to assess LCCs of a range of stormwater devices (see **Section 4**). These models supersede the COSTnz LCC models (Ira, *et. al.*, 2008) and can be used nation-wide to better understand costs of stormwater treatment in New Zealand. Using these new models, LCCs generated for a range of interventions will then be incorporated into the FWMT.

Willingness to pay and benefit transfer studies are currently underway to estimate benefit values related to water quality, recreation, property prices, wetlands, riparian areas, beach closures and open space. Two methods will be used to synthesise the results of the cost and benefit studies to deliver a holistic assessment of benefits: the More Than Water (MTW) Tool (Moores *et al*., 2019), developed by the Activating WSUD research project; and the Benefits of SuDs Tool[1] (B£ST), developed by the UK's CIRIA.

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[1] https://www.susdrain.org/resources/best.html

In summary, the following approach will be undertaken to identify and assess benefits for the FWMT (**Figure 2**):

1. An initial qualitative screening assessment of benefits and avoided costs using the New Zealand developed "More Than Water" tool.

2. An initial quantitative assessment of benefits and costs based on B£ST, an internationally recognised and reviewed cost and benefits assessment tool.

3. Detailed life cycle cost analysis and Auckland-based willingness-to-pay benefit studies.

4. Finally, the results of the various assessment methods will be brought together in a holistic assessment of benefits and costs by updating the qualitative and quantitative assessments undertaken in points 1 and 2 above.

More Than Water has previously been described in Moores *et al.* (2019). It provides a qualitative screening method for identifying the extent to which each of multiple benefits is delivered by a project, as well as assessing their relative importance and the level of certainty around their assessment. The **Benefits of SuDs Tool (B£ST)** was developed by the United Kingdom's (UK) CIRIA. B£ST provides a way of qualifying and quantifying (monetizing) up to twenty types of benefits of WSUD projects. It has been widely used in the UK to support business cases for WSUD**Error! Bookmark not defined.**. The tool guides users through a structured assessment, beginning with an initial qualitative assessment to help users decide which benefits to attempt to quantify. B£ST can provide monetized estimates (Net Present Value (NPV)) of most (but not all) of the benefits of a project using one of two approaches. Where location-specific estimates are not available, B£ST uses benefit transfer from the international literature to estimate NPV values from a 'values library' based on inputs provided by the user. When local studies can be used to estimate individual benefits, they can be incorporated into the B£ST tool to explore sensitivity to different assumptions. The authors are currently investigating its potential customisation with NZ data and the reliability of benefit transfer from its UK values library or other international valuation studies. Initial discussions with the developers of B£ST, as well as CIRIA representatives, have been positive and they have indicated that they are highly supportive of this project and would be willing to provide support and expertise in the review and use of the B£ST model.

The first trials of MTW and B£ST will take place in the second half of 2020 following pilot runs of SUSTAIN in the FWMT, for several Auckland catchments.

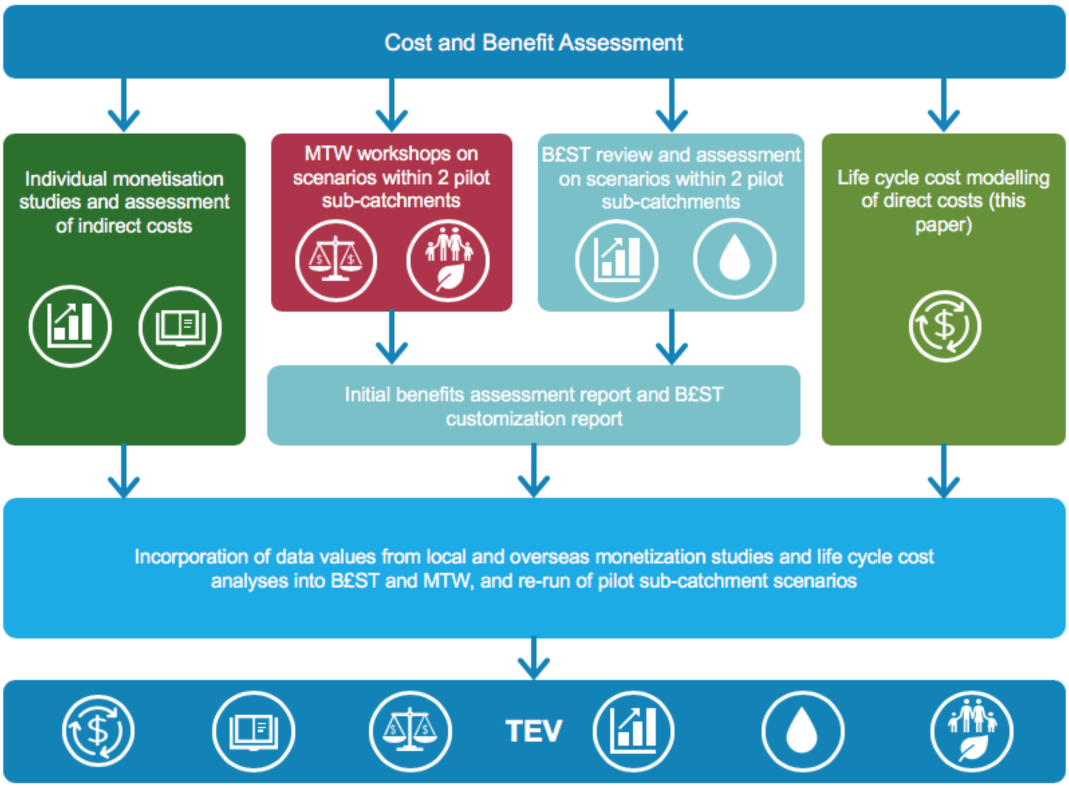

Figure 2 Proposed process for assessment of costs and benefits

4 LIFE CYCLE COSTING

4.1 AN UPDATE TO COST$_{NZ}$

LCC work undertaken in New Zealand has previously been reported by Ira (2017) and Ira *et al.* (2008 and 2012), and most recently through the Activating WSUD in NZ project (Ira and Simcock, 2019). This previous research was used to create a database of costs for discussion with Auckland Council. New cost data was collected from Auckland Council officers and a refined, more Auckland-focused cost database created. Using this data, individual easy-to-use excel based LCC models were developed. The purpose of the models is to provide an indicative non-financial estimate of LCCs, related either to the surface area of the device or the catchment area treated. It is considered that the models will be most useful for undertaking a relative comparison of costs of different types of devices, and can be used for catchment planning purposes. Key LCC features of the model are:

- Users can use the default cost information provided in the model or they can input their own cost data.
- Additional rows are provided under the routine and corrective maintenance tables to allow for additional maintenance activities to be included.
- The default discount rate set in the model is 4%. However, this parameter can be changed so that sensitivity of the effect of the discount rate on long term costs can be modelled. Discounting is used to find the value at the base year of future costs associated with a stormwater device. Future costs are discounted by a discount rate that reflects an opportunity cost comprising time preference (utility of current

consumption versus future consumption) and compensation for risk (uncertainty about the future requires greater expected return). Real costs are used in LCC analysis and are discounted by the real discount rate, so they do not include an inflation component. Sensitivity analysis is recommended using different discount rates to account for the potentially significant impact of the discount rate on the estimated LCC (e.g., a cost that is accrued 10 years from the base year is reduced by 29% if the discount rate is 3.5% per annum but by 61% if the rate is 10%). Auckland Council's Chief Economist Unit recommends sensitivity analysis be undertaken using 2%, 4% and 6% discount rates (pers. comm. 12 December 2019).

- The total life cycle analysis period (LCAP) for all models is 50 years.
- The model includes a "Renewals" function which is linked to the life span of a device. If the life span is less than 50 years, then more than 1 renewal cost will be included in the life cycle analysis.
- The base date of the default cost data is 2018. If users enter their own cost data, this information should be inflated or deflated to 2018 to ensure it is comparable with the default cost information.
- No default values are provided for land costs. This information would need to be obtained separately.
- The model includes a "cost development factor". In general it is more expensive to design and construct stormwater mitigation measures in brownfields than in greenfields areas. This cost increase is primarily because of the need to modify existing services, have increased traffic management controls and work in restricted spaces. The factor is based on work undertaken by the USEPA[2].
- All costs given are excluding GST.

4.2 LCC RESULTS

Using these new models, over 120 model runs were undertaken for a range of devices (wetlands, rain gardens, tree pits, infiltration basins, filter systems, permeable paving rain tanks, swales and green roofs), surface areas, catchment areas, unit cost rates and discount rates in order to generate low and high LCCs for inclusion in the FWMT's stormwater model. Results presented and discussed in this paper relate to wetlands and rain gardens.

With respect to the total acquisition costs (TACs) used within the model, the cost data is based on actual devices which have been designed to achieve a 75% total suspended solids removal over a long term average basis (Auckland Council, 2003; Auckland Council, 2017).

The maintenance costs (MCs) used within the model are based on best practice maintenance guideline documents (Auckland Council, 2003; NZTA, 2010 and Healy *et al.*, 2010), along with the expert opinion of maintenance operators and green infrastructure specialists. The activities and frequencies assume that the device which is being maintained (and therefore costed) has been designed and constructed according to best

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[2] Memo from Karen Mateleska, EPA Region-I to Opti-Tool TAC, 20 February 2016.

practice standards, and is functioning as designed. Costs relating to activities such as traffic management and botulism events can be highly variable. Whilst a best estimate of costs is provided, the models may not be fully reflective of on-the-ground maintenance which is currently occurring for a range of existing devices.

The graphs (**Figures 3** and **4**) illustrate a low and high LCC scenario for various wetland and rain garden surface area sizes. They highlight that there is an inverse relationship between device surface area and unit cost (LCC/m^2/year). This trend is likely caused by the dominance of the long term maintenance costs for each device. Much of the maintenance and associated cost is not area dependent and needs to be undertaken regardless of device size (e.g., inspections). This leads to clear economies of scale being achieved for larger devices.

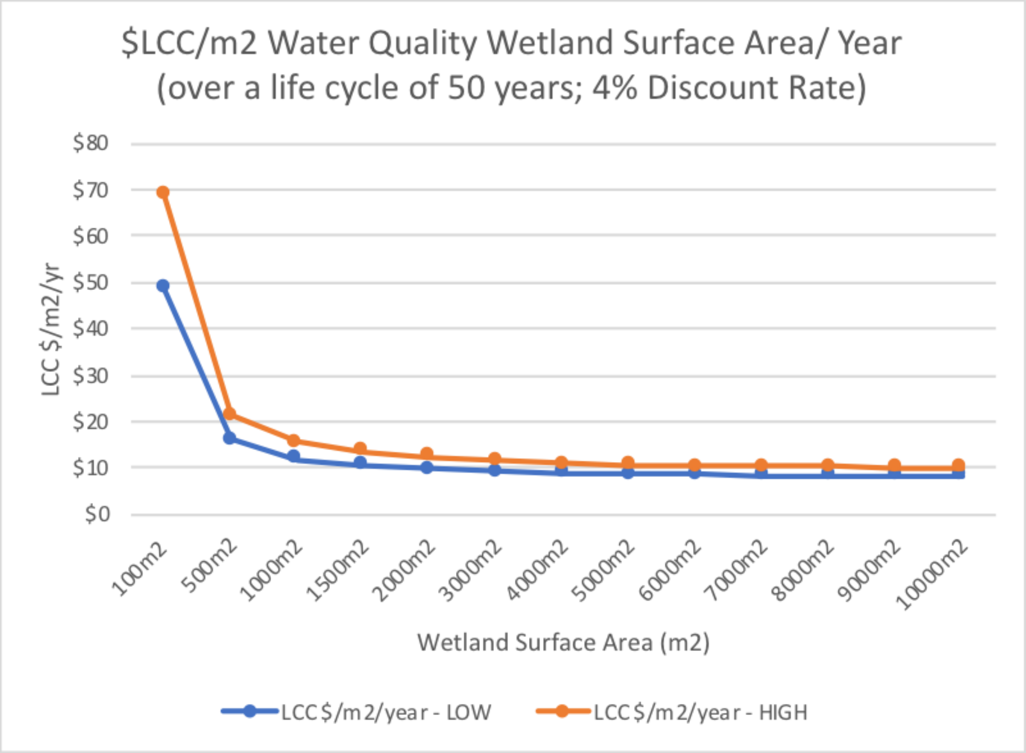

Figure 3: Low and high indicative LCC estimates for a range of water quality wetland surface areas ($LCC/m^2/year, over a life cycle of 50 years; 4% Discount Rate)

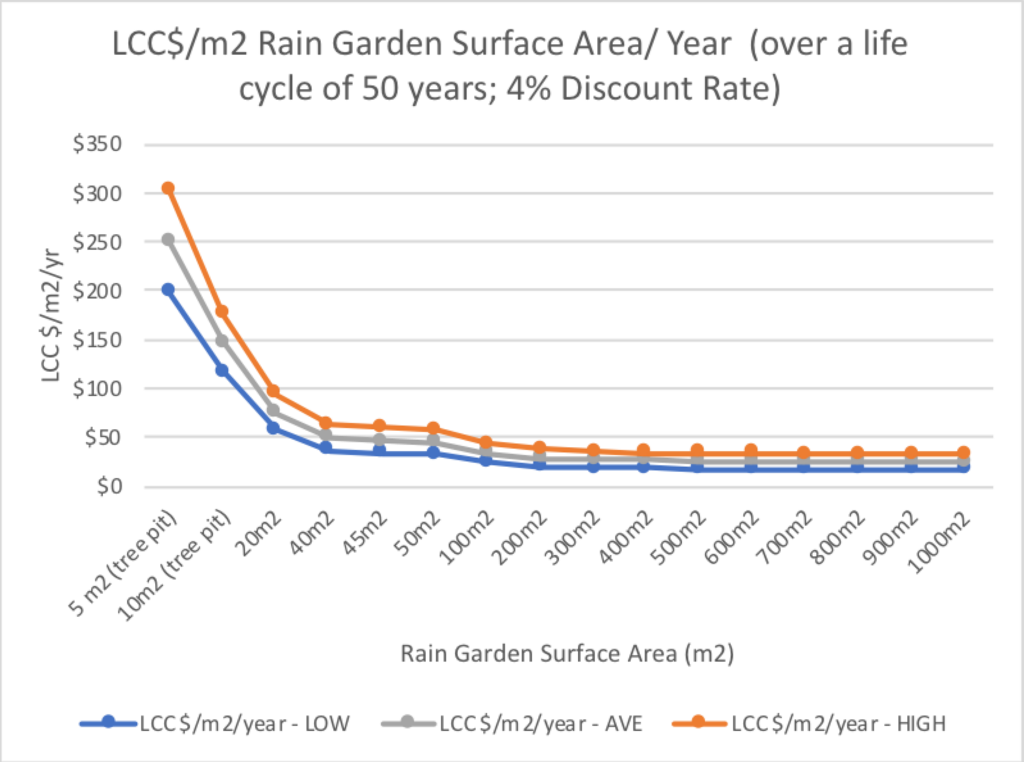

Figure 4: Low, average and high indicative LCC estimates for a range of rain garden and tree pit surface areas ($LCC/m^2/year, over a life cycle of 50 years; 4% Discount Rate)

4.3 EFFECT OF THE DISCOUNT RATE

As mentioned in **Section 4.1**, the discount rate (DR) is used to bring future costs back to today's dollar values, as well as estimate the NPV of a benefits stream over time. By discounting the costs we are able to determine the total sum that would need to be invested now in order to meet the required costs over the total life cycle.

Discounting is one of the most debatable and controversial aspects of a LCC assessment. Having said this, the actual DR used is not as important as ensuring that the same DR is used for all assessments (NZ Treasury, 2015). The public sector discount rate is published by the NZ Treasury. It is currently set at 6%[3]. A discount rate of 3.5% has been used in previous NZ costing work (Ira *et. al*., 2012 and 2015; Ira and Symcock, 2019). COSTnz provides an option of either a 3% or 6% discount rate, or users can specify their own rate.

LCC models were run for 2%, 4% and 6% discount rates, and the effect of the discount rate (**Figures 5** and **6**) on the LCCs is also clearly evident. As expected, the higher discount (6%) rate places less emphasis on the long-term maintenance costs and leads to a reduction in the LCC. Conversely, the 2% discount rate costs are the highest and can therefore be taken as a more conservative assessment of long-term costs. This re-enforces findings noted in Ira *et. al.*, 2012 and 2015). When comparing discount rates across the full range of devices modelled (wetlands, rain gardens, filter systems, infiltration basins, permeable paving and rain tanks), it was found that the relative cost difference between these interventions is the similar for all discount rates.

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[3] Additional information about Treasury discount rates can be found at: https://treasury.govt.nz/information-and-services/state-sector-leadership/guidance/financial-reporting-policies-and-guidance/discount-rates

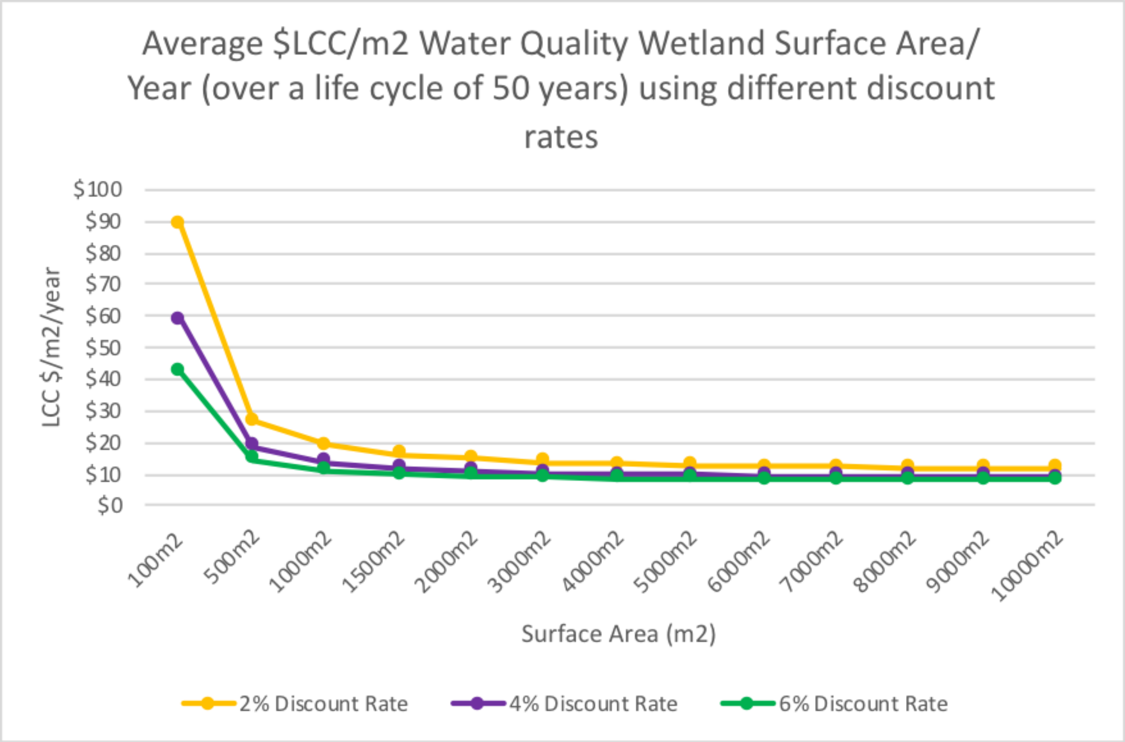

Figure 5: Average water quality wetland $LCC/m2 /year (over a life cycle of 50 years) using a 2%, 4% and 6% discount rate.

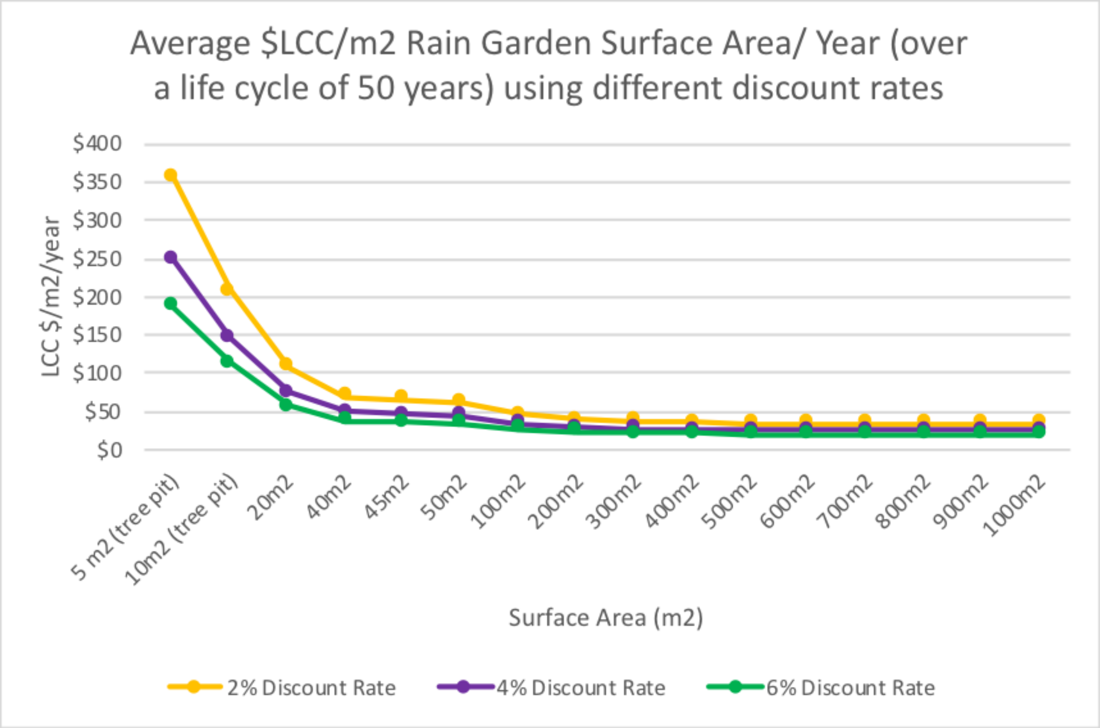

Figure 6: Average rain garden and tree pit $LCC/m2 /year (over a life cycle of 50 years) using a 2%, 4% and 6% discount rate.

4.4 RAIN GARDENS OR WETLANDS?

This current LCC modelling work has highlighted that one of the key cost drivers is device size, mainly due to maintenance cost efficiencies which can be realised by larger devices. **Figures 3** and **4** illustrate that small rain gardens and wetlands are not cost-efficient solutions, either for a private individual or for councils. From a purely LCC perspective, economies of scale can be realised for rain gardens of around 50m^2 - 100m^2 (**Figures 4** and **7**), and that for surfaces areas of less than 400m^2, rain gardens would be a cheaper stormwater solution (from a treatment perspective) than wetlands (**Figure 7**). However, understanding LCCs is only one part of the decision-making process and other factors, such as resilience, ease of adaptation and institutional frameworks (i.e. ownership models) would also need to be considered. For example resilience theory indicates that distributed systems of smaller devices are considered more resilient in the long term than catchment scale devices (Moores and Semadeni-Davies, 2015). Further research is needed to investigate the relationship between cost and different device considerations.

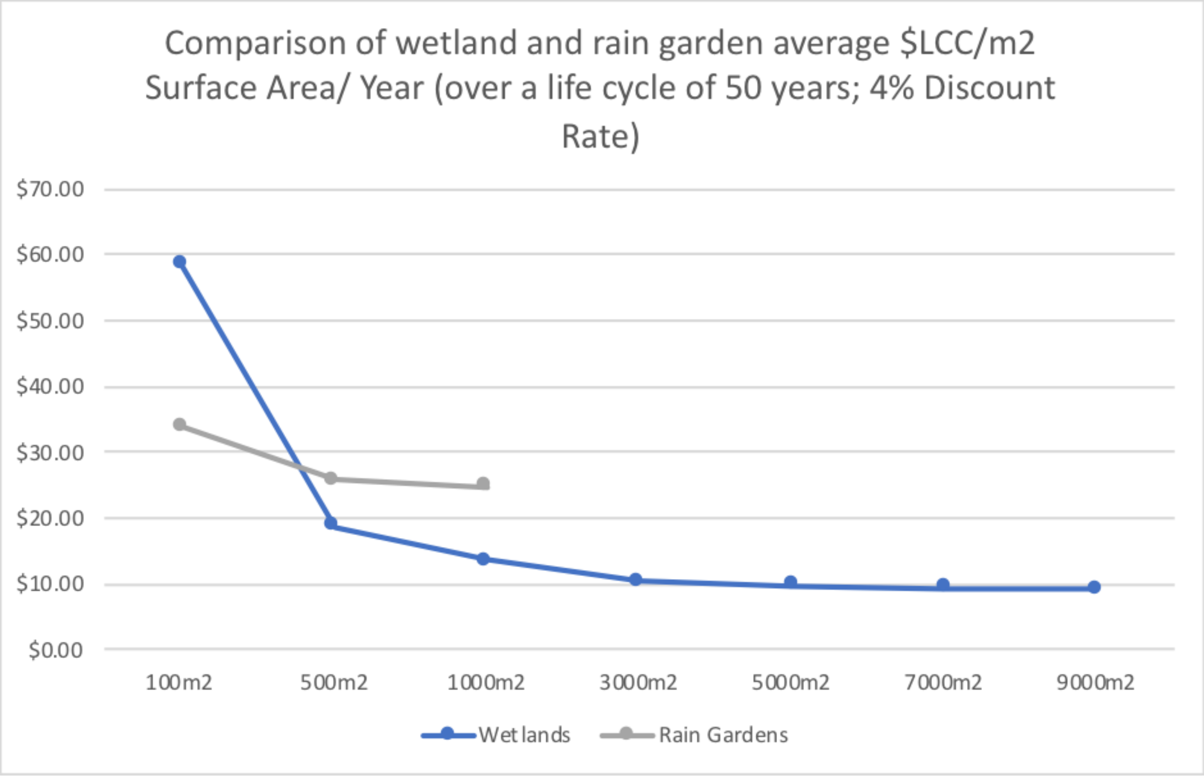

Figure 7: A comparison of wetland and rain garden and permeable paving average $/LCC/m2/yr for a range of surface sizes.

5 CONCLUSIONS AND RECOMMENDATIONS

Understanding cost is a vital part of the decision-making process, however, being able to quantify and/ or acknowledge benefits of a particular intervention is just as crucial. The TEV approach being integrated within the Auckland Council’s FWMT is therefore integral to better understanding both the costs and benefits of particular interventions, and to make decisions in a more holistic manner. The application of the More Than Water and B£ST benefit valuation tools, linked with a LCC approach will assist decision-makers to understand benefits and costs of a particular interventions not only to both the community and the environment. Benefit scenario runs will be undertaken in the second half of 2020.

Initial LCC results for wetlands and rain gardens, from a significant number of LCC model runs, have been presented. Low and high LCCs have been generated and the effect of the discount rate on long term maintenance costs analysed. The relationship between and effect of long term maintenance costs on device size has also been investigated. The LCC results have re-enforced prior research undertaken by Ira *et al.* (2016) and highlighted 3 clear cost drivers:

1. the area which the device treats;
2. the level of treatment provided; and
3. the frequency and type of maintenance undertaken.

Device design, construction methodology, topography, geographical location, soils and availability of materials all also have an affect cost. Unfortunately the lack of meaningful cost data and the poor resolution of the data means that these secondary cost drivers cannot be identified within the data. Further work is needed to collect cost information in clearly defined templates to refine our existing cost databases and better understand how these secondary cost drivers affect overall LCCs.

Further research is also needed to investigate the relationship between cost and different device considerations which affect factors such as resilience, ease of adaptation for long term climate change and institutional frameworks.

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