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Report 10
A Total Economic Valuation Approach to Understanding Costs and Benefits of Intervention Scenarios – Part 2 Urban Source Control Costs

Auckland Council
Te Kaunihera o Tāmaki Makaurau

Freshwater Management Tool: Report 10. A Total Economic Valuation Approach to Understanding Costs and Benefits of Intervention Scenarios – Part 2 Urban Source Control Costs

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Costs presented in this report are non-financial indicative life cycle cost estimates and are based on current available information and should be read in the context of the assumptions presented in this report. Cost information has been gathered and modelled in order to gain an understanding of the relative difference in cost between different solutions, not the actual cost of each solution.

Any decision that is made after using this data must be based solely on the decision-makers own evaluation of the information available to them, their circumstances and objectives.

Executive summary

Auckland Council's Healthy Waters Department is developing a Freshwater Management Tool (FWMT) to assist with decision-making around the development of freshwater management outcomes required by the National Policy Statement for Freshwater Management (NPS-FM) (e.g., both regulatory and operational programmes). A key part of this assessment is understanding the costs and benefits of implementing different intervention scenarios for future planning and decision-making.

Whilst source control has long been recognised as a cost effective approach for managing effects of stormwater discharges (Andoh and Declerk, 1998), research into the cost of implementing source control interventions as alternatives to structural devices is limited. In general, they are assumed to be more efficient than structural devices (especially for reducing effects of stormwater discharges in existing urban or brownfield areas), whilst having the added benefit of reducing the design capacity of downstream structural devices.

The purpose of this report is to document the cost data sources, assumptions and process undertaken to generate indicative life cycle cost (LCC) estimates for urban stormwater source control interventions for use within the FWMT, namely:

- street sweeping;
- catchpit cleaning;
- mitigation of roofing surfaces;
- good septic tank systems;
- countryside living/ urban riparian margins;
- wastewater overflow reduction;
- use of copper-free brake pads;
- use of low zinc or zinc free tyres; and
- behaviour change targeted at the general public to achieve good environmental outcomes.

The report is an extension of Ira *et al.* (2020) and provides details on available literature, assumptions, unit costs and LCCs for various urban source control interventions. Information about the LCC model, how the cost results should be interpreted and how they should be considered alongside our understanding of indirect costs and benefits can be found in Ira *et al.* (2020).

For each source control intervention, separate low and high LCC model runs were undertaken based on available unit cost data. Unit costs used in the model runs are best estimates and based on a range of cost estimates for materials, plants, vehicle hire, labour, etc. and ongoing maintenance. Given that industry costs and estimates for these items vary depending on the company providing a quote and/ or engineer estimates, low and high unit cost estimates are provided in the report and used in the low and high cost LCC model runs. Since the FWMT requires a single LCC for each intervention, the annual LCCs from the low and high LCC model runs have been averaged and are suggested for use (Table ES.1). Average annualised LCCs are provided for catchpit cleaning, street sweeping, roofing materials, urban riparian margins and septic tanks, and are summarised for a range of discount rate (DR) scenarios in Table ES.1 (see Ira *et al.*, 2020 for discussion on the DR and its effects on the annualised LCC).

Table ES.1 Average annualised LCCs for catchpit cleaning, street sweeping, roofing materials, urban riparian margins and septic tanks, using a 2%, 4% and 6% discount rate.

Intervention	Average Annualised LCC$ - 2% DR	Average Annualised LCC$ - 4% DR	Average Annualised LCC$- 6% DR
Street sweeping (LCC$/ 35km swept/ year)	$900	$627	$469
Catchpit cleaning (LCC$/ day/ year)	$1,997	$1,392	$1,041
Low zinc alloy roof (LCC$/ m^2 roof area/ year – for a $200m^2$ roof)	$5.10	$3.69	$2.96
Inert roof (LCC$/ m^2 roof area/ year – for a $200m^2$ roof)	$5.40	$4.03	$3.17
Urban riparian margins (LCC$/$m^2$/year – for a $10m^2$ buffer strip including fencing)	$2.60	$2.46	$2.37
Urban riparian margins (LCC$/$m^2$/year – for a $10m^2$ buffer strip without fencing)	$2.53	$2.41	$2.32
Septic tank system (aerated) (LCC$/L/year)	$1.29	$0.97	$0.79

Unit cost information is provided for reducing wastewater overflows using pump stations. Prior to being able to generate LCCs for this source control intervention, the following further work is recommended:

- specific information on wastewater storage options needs to be developed;
- consultation needs to be undertaken with Watercare regarding the proposed options and likely TACs;
- additional maintenance activity, frequency and cost data needs to be collected from existing Auckland pump stations in order to refine the maintenance cost estimates and allow for a routine maintenance cost database to be developed. Corrective maintenance costs could be identified through historic records for the pump stations, or based on total pump replacement every 10 years, along with a sum for other minor repairs.

A literature review was undertaken to obtain cost information for copper free brake pads, low zinc tyres and behaviour change initiatives.

The review found that it is likely that current legislation in the USA and Europe, which restricts copper brakes, has had a flow-on effect in the market and it appears that ceramic and semi-metallic brake pads (which are considered copper free or low copper) are now the norm, both here in New Zealand as well as internationally. However, it is unclear what percentage of copper is contained within the semi-metallic brakes installed in New Zealand. If most cars are currently using copper free or low copper brake pads, then the validity of including copper-free brakes as a source control intervention in the FWMT (over and above the business as usual) should be considered carefully in future scenarios. To inform that decision, it is recommended that:

- further research be undertaken to determine the extent of cars within the Auckland region which would still have copper brake pads. This could be based on the age and make of the car, obtained from NZTA records.
- further interviews should be held with brake pad manufacturers to confirm sales data of copper vs copper free brake pads;
- the metal composition of the semi-metallic brake pads used in New Zealand needs to be further investigated;

- if needed, collection of further cost data, directly from suppliers, on the cost differential between copper and copper-free brake pads for different types of vehicle categories (i.e. sedans/ hatchbacks; SUVs, Utes, 4x4 vehicles, trucks) be undertaken.

With respect to tyres, the review determined that there is very little, if any, awareness within the industry regarding the issue of zinc leaching as a result of tyre wear, and that low zinc or zinc free tyres have little market presence internationally (Bauters, 2012). Additionally, limitations of the current vulcanization process (CASQA, 2015) mean that it is unclear whether or not using low zinc/ zinc free tyres as an intervention option within the FWMT is feasible (i.e., it is possibly technologically unfeasible let alone cost-prohibitive at present for widespread adoption). It is recommended that:

- further research be undertaken to determine the currently preferred vulcanization approach for tyres and determine whether or not this is still consistent with a 1 – 1.5% zinc weight, as per the findings of CASQA (2015). Specific tyre manufacturers (rather than just their distributers) would need to be approached, and the vulcanization approach used for NZ-made and imported tyres established, along with costs of alternative processes (if available).
- further discussion is needed on the appropriateness of low zinc tyres as a feasible source control intervention.

Behaviour change programmes vary widely in their scope and implementation, from narrowly focussed educational programmes, to full community engagement, political endorsement, media attention and economic incentive schemes. No information on the implementation costs of these schemes to government agencies was available. In order to allow cost information to be collected for behaviour change interventions it is recommended that:

- the scope of the behaviour change programme intervention option is carefully defined in order to:
  - provide reasonable cost estimates relating to proposed activities; and
  - ensure that any benefits accruing from the programme (as a result of pro-environmental behaviour) can be reasonably quantified in terms of contaminant reduction and receiving environment outcomes.
- researchers at the CRC for Water Sensitive Cities be approached to determine whether costs of implementation of the community engagement and education process for Stringybark Creek Restoration Project were documented as part of their review (as this could be linked to their water quality monitoring programme for the Creek).
- if available, unit costs for educational campaigns, marketing information, etc. be obtained from Auckland Council officers (based on previous environmental education initiatives that the Council has undertaken).

Finally, it is recommended that consideration should be given to including the percentage cost reduction of source control interventions emanating from the subdivision design and building stage from a WSD approach within the FWMT.

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Cost definitions

Term	Abbreviation	Definition
Corrective Maintenance Costs	CMC	These are costs associated with large scale maintenance of the treatment device. They tend to occur infrequently over the life of a device.
Decommissioning Costs	DC	Costs associated with the decommissioning or complete removal of the treatment device at the end of its life span.
Discount Rate	DR	The discount rate is a percentage rate used to discount future costs back to their present day value. The real discount rate is used. Discounting is used to find the value at the base year of future costs, in other words, the present value.
Green Infrastructure	GI	Green infrastructure refers to stormwater assets which use soils and vegetation to restore some of the natural process used to manage stormwater and provide for healthier urban receiving water systems.
Life Cycle Cost	LCC	The life cycle cost is the sum of the acquisition and ownership costs of an asset over its life cycle from design, planning, construction, usage, and maintenance and renewals through to disposal costs.
Life Cycle Costing		The process of assessing the cost of a product over its life cycle or portion thereof, as defined in the Australian/New Zealand Standard 4536:1999.
Life Span	LS	The functional life of the treatment device in years.
Life Cycle Analysis Period	LCAP	This is the period of time (in years) over which the life cycle costing analysis is conducted.
Present Value	PV	The present day value of all future costs and benefits (i.e. the value of future costs or benefits when discounted back to the present time).
Renewal Cost	RC	Costs associated with renewing the device back to its original design state at the end of its life span.
Routine Maintenance Costs	RMC	These are annual costs which relate to routine maintenance events such as mowing grassed areas, weeding, general inspections, etc.
Total Acquisition Cost	TAC	The TAC relates to the design, planning, consenting and construction costs of a device.

1. Introduction

1.1 Background

Auckland Council's Healthy Waters Department is developing a Freshwater Management Tool (FWMT) to assist with decision-making around the implementation of the National Policy Statement for Freshwater Management (NPS-FM). Implementation requirements span both regulatory decisions on objectives and limits, and operations decisions on investment for interventions and management (e.g., stormwater network, rural land use, urban land use). The FWMT includes a Stormwater Management Model (SUSTAIN) which will be used 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. Ultimately, by doing so the FWMT can deliver evidence to underpin planning and operational responses in Auckland Council for future development, climate and national regulation.

Ira *et al.* (2020) documented the cost data sources, assumptions and process undertaken to generate indicative life cycle cost (LCC) estimates for urban structural (device) stormwater interventions for use within the FWMT Stage 1, within the context of a total economic valuation assessment. The FWMT programme is a decadal strategic and operational model development exercise, with three stages anticipated (i.e., of increasing modelling scope, resolution and/or complexity).

1.2 Purpose of this report

This report is an extension of Ira *et al.* (2020) and its purpose is to document the cost data sources, assumptions and process undertaken to generate indicative life cycle cost (LCC) estimates for urban source controls configured within the FWMT Stage 1, ensuring a total economic valuation (TEV) assessment is supported.

The report recommends how the urban source control LCC results should be aligned whilst noting limitations in our understanding of the indirect costs and the benefits associated with alternative intervention scenarios. The costs developed here can also be used as an input to other Auckland Council modelling efforts, as well as in future planning. Limited discussion of LCC modelling and how the cost results should be interpreted is recorded here, with the reader directed to Ira *et al.* (2020).

1.3 Structure

Section 2 further defines source control as a concept, in relation to stormwater quality treatment; provides information on the cost efficiency of source control as an intervention; and outlines the source control interventions which are investigated.

Section 3 provides background to the life cycle costing process and assumptions used, as well as methods used to collect unit cost data and undertake the literature reviews.

Section 4 summarises the unit cost data used in the LCC models for each of the interventions, as well as the LCC model results which will be used in the FWMT for catchpit cleaning, street sweeping, urban riparian margins, roofing, septic tanks and wastewater pump stations. It provides a summary of the results of the literature reviews undertaken for copper brake pads, zinc-free tyres and behavourial change programmes.

Section 5 recommends the future research needed to further refine the cost information provided in this report.

2. Source control

2.1 Introduction

The Auckland Unitary Plan's objectives for stormwater management are designed to prevent or minimise the adverse effects of stormwater discharges, as they relate to land-use activities that generate stormwater contaminants and increase runoff (Auckland Council, 2016). One of the key approaches which has been offered as a way to meet these objectives is through adopting water sensitive design (WSD) as a core development approach.

WSD is an alternative to conventional (grey infrastructure) forms of urban development and mitigation of stormwater, and includes the following approaches or principles (Ira and Simcock, 2019):

- minimising site disturbances;
- reducing impervious areas and associated piped infrastructure (through streetscape design and clustering)
- creating or enhancing natural areas;
- water reuse/ rain tanks;
- using green infrastructure (such as bioretention, green roofs, wetlands) in conjunction with source control;
- using infiltration to reduce runoff volumes; and
- aiming for zero additional maintenance over and above traditional stormwater infrastructure.

Reducing contaminant sources and the volume of stormwater generated via source control is integral to the WSD process. A reduction in runoff can be achieved by limiting site disturbance, retaining existing natural systems, minimising impervious surfaces and re-using stormwater stored in rain tanks. A reduction in contaminant sources can be achieved by, for example, adopting erosion control practices, isolating hazardous materials on site, or minimising the use of materials that leach contaminants (e.g. using inert roofing materials) (Auckland Council, undated). Other examples of non-structural (or source control) interventions include educational programmes and incentives to promote pro-environmental behaviour, and regulatory or legislative mechanisms which could restrict the use of certain materials (e.g. copper in brake pads).

2.2 Cost-efficiency of source control

Whilst source control has long been recognised as a cost-effective approach for managing effects of stormwater discharges (Andoh and Declerk, 1998), research into the cost of implementing source control interventions is limited. In general, they are assumed to be more efficient than structural devices (especially for reducing effects of stormwater discharges in existing urban areas), whilst having the added benefit of reducing the design capacity and/ or maintenance obligations of downstream structural devices.

An international literature review was undertaken for the MBIE funded research programme "Urban Planning to Sustain Waterbodies" (Ira, 2014 on behalf of NIWA and the Cawthron Institute Trust) to investigate the cost differential between traditional approaches to development and WSD, including source control measures relating to the development process. Ira (2014) found that on average, development costs were cheaper under a WSD approach, primarily due to the savings accrued by the following source control interventions:

- minimising site disturbances (internationally, average cost saving of 26% on site preparation and earthwork costs);

- clustering of urban development[1] –
    - associated impervious area savings on average of 34% internationally;
    - associated stormwater infrastructure cost average savings internationally (i.e. reduced pipe network) – 28%.

Ira (2014)'s findings that it is both environmentally and economically beneficial to employ WSD in urban development are substantiated by other research (e.g. Boubli and Kassim, 2003; Clar, undated; Conservation Research Institute, 2005; ECONorthwest, 2007 and 2011; Foraste *et al.,* 2011; Royal Haskoning DHV, 2012; Scholz, *et al*., 2005; Shaver, 2009; Stovin and Swan, 2007; and USEPA, 2013). More recently, Ira and Simcock (2019) collected cost information from New Zealand development projects and found that WSD savings from improved site preparation and earthworks generally range between 14 – 35% over a traditional development approach. Restrictive codes of practice in many parts of New Zealand mean that reducing impervious areas and clustering is often difficult to achieve (Bennett and Megahghin, 2008), with a development in the South Island achieving only a 6% saving (Ira and Simcock, 2019). This finding is supported by the Ministry for the Environment's (MfE) "Urban Water Working Group" (UWWG) (UWWG and MfE, 2020) who stated that transformational change is needed to influence how urban water is managed. The UWWG recommend (UWWG and MfE, 2020) that primary and secondary legislation is reviewed to identify changes which need to be made to "protect and Te Mana me te Mauri o te Wai in urban areas" (p. 12, UWWG and MfE, 2020). This includes further identifying legislative barriers preventing the adoption of WSD (i.e. further to the Activating WSUD in NZ work – Ira *et al*., 2019). Better understanding the implications of policy changes to support widespread implementation of WSD (as is being undertaken via the FWMT) would form a vital part of future review processes, providing an evidence base for potential future policy changes.

Whilst reducing impervious area reduces both contaminants and the volume of stormwater discharged as runoff, most source control interventions are targeted at a single contaminant. For example, minimising site disturbances will reduce sediment discharges, but do little to reduce ongoing lead, zinc and copper contamination. In order to elicit the benefits of a source control approach, interventions generally need to be targeted at specified contaminants.

Metals have been identified as key contaminants of concern in Auckland (Auckland Council, 2016), and both copper and zinc (total and dissolved) contaminants are simulated by the FWMT Stage 1, regionwide for generation and transport throughout regional freshwater streams.

Key sources of metals within the Auckland region were investigated by Kennedy *et al.* (2008) and include:

- zinc: roofing materials and tyre wear;
- copper: brake pads, and to a lesser extent, copper roofs and spouting;
- lead: paints and historic sources of lead found in soils.

Although some of the sources of copper and zinc remained unidentified, international studies (as summarised in Müller *et al*., 2020) have reinforced Kennedy *et al.*'s (2008) findings that deposition on roads from vehicular activities are a disproportionate (critical) source of heavy metals from urban land activities to waterways (Figure 2.1).

[1] Clustering is a concept where houses, businesses or multi-storey dwellings designed in a 'cluster' configuration (often with shared driveways) to deliver the same built capacity as a traditional approach to land development, while retaining relatively large areas of green space and urban parks. Clustering reduces impervious areas, pipes, earthworking and soil disturbances whilst maximises green spaces within urban areas. See Auckland Council's "Water Sensitive Design for Stormwater" GD2015/ 04: http://content.aucklanddesignmanual.co.nz/regulations/technical-guidance/Documents/GD04%20WSD%20Guide.pdf

Specific source	Pollutants released	References
Vehicle operation		
Exhaust gases and particles	Hydrocarbons, PAHs, NOx, Ni, BTEX	Markiewicz et al. (2017); Brinkmann (1985); Huber et al. (2016); Kayhanian (2012); Duong and Lee (2011); Liu et al. (2018b)
Catalytic converters	Rh, Pd, Pt	Rauch et al. (2005)
Vehicle wear		
Tires	TSS, Cd, Cu, Zn, PAHs, microplastics	Muschack (1990); Councell et al. (2004); McKenzie et al. (2009); Legret and Pagotto (1999); Kose et al. (2008); Horton et al. (2017a)
Tire studs	W	Huber et al. (2016)
Brakes	TSS, Cd, Cu, Ni, Pb, Sb, Zn, PAHs	McKenzie et al. (2009); Hjortenkrans et al. (2007); Markiewicz et al. (2017)
Engine and vehicle body wear	Cr, Ni	Gupta et al. (1981); Ward (1990)
Body paint	Pb	Kayhanian (2012)
Wheel balance weights	Pb, Fe (steel), Zn	Root (2000); Bleiwas (2006)
Vehicle washing		
Commercial car washing facilities	Pb, Cd, Cr, Zn Phthalates, NPs, NPEOs	Sörme et al. (2001) Björklund (2010)
Road abrasion		
Abrasion by tires (non-studded and studded)	TSS	Hvitved-Jacobson and Yousef (1991); Van Duin et al. (2008) Lindgren (1996)
	PAHs	Markiewicz et al. (2017)
	Microplastics	Magnusson et al. (2016); Horton et al. (2017b); Vijayan et al. (2019a)

Figure 2.1 Sources of pollutants released by vehicular traffic in urban areas (Müller *et al*., 2020 – Table 2, p. 7))

Whilst the costs of controlling sediment at source and reducing impervious areas to reduce the volume of runoff discharged have been researched in New Zealand, minimal studies have investigated costs of using alternative building or vehicular materials. More so, when considering benefits of other types of source control interventions, such as behaviour change and educational programmes. The latter in particular are most difficult to quantify and lack empirical data about outcomes (this is further discussed in Section 4.8).

2.3 Source control interventions

This report makes a notable contribution to the paucity of source control research for urban water quality planning and costing for a range of source control interventions to be modelled in the FWMT Stage 1, including:

- street sweeping;
- catchpit cleaning;
- mitigation of roofing surfaces;
- urban riparian margins;
- good septic tank systems;
- wastewater overflow reduction;
- use of copper-free brake pads;
- use of low zinc or zinc free tyres; and

- behaviour change targeted at the general public to achieve good environmental outcomes.

Section 2.2 has highlighted that source control can also be undertaken via a WSD approach to development (i.e. minimising disturbances, reducing impervious areas and piping). Consideration should be given to including the percentage cost reduction from this intervention within the FWMT future stages.

This report documents our current knowledge surrounding the cost of implementation of the above urban source control initiatives.

2.4 Life Cycle Costing Analysis

A life cycle costing (LCC) approach has been previously used to assess costs associated with urban stormwater devices in the FWMT Stage 1 (Ira *et al*., 2020). This report adopts the same unit-based LCC approach for consistent scenario modelling of urban devices and source controls within the FWMT.

The Australian/New Zealand Standard 4536:1999 (1999) defines LCC as the process of assessing the cost of a product over its life cycle or portion thereof. The life cycle cost is the sum of the acquisition and ownership costs of an asset over its life cycle from design, manufacturing, usage and maintenance through to disposal (Figure 2.2). A cradle-to-grave time frame is warranted because future costs associated with the use and ownership of an asset are often greater than the initial acquisition cost and may vary significantly between alternative solutions to a given operational need (Australian National Audit Office, 2001).

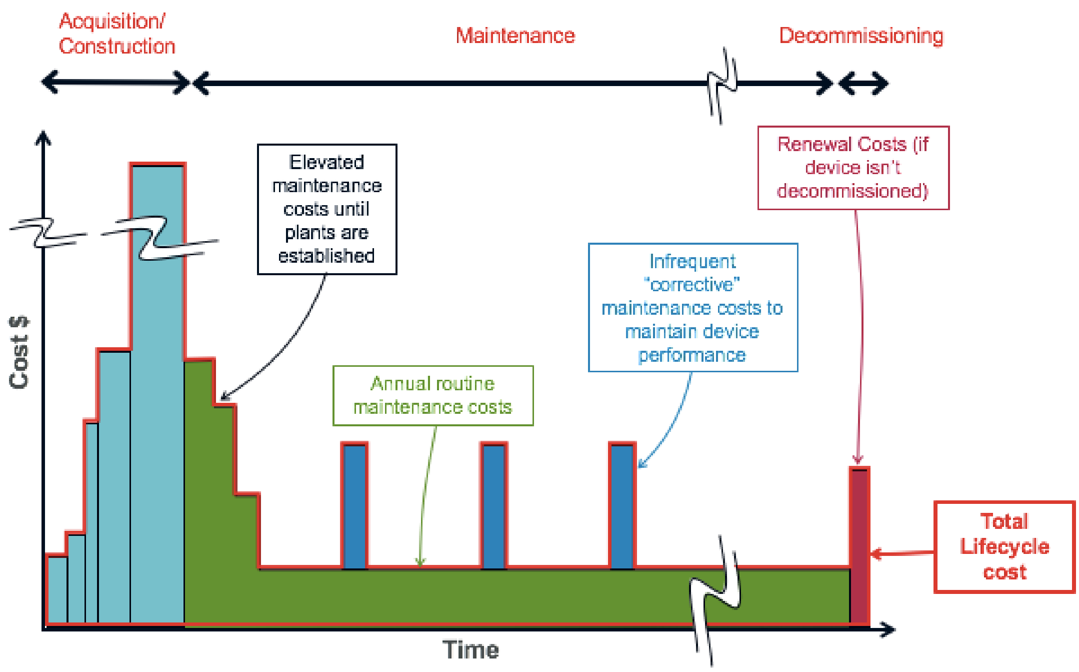

Figure 2.2 Phases in the life cycle of stormwater interventions and potential long term costs (Ira *et al.,* 2020)

LCC has a number of advantages and supports a number of applications and analyses (Lampe et al 2005):

- It allows for an improved understanding of long-term investment requirements.

- It helps decision-makers make more cost-effective choices at the project scoping phase.
- LCC provides for an explicit assessment of long-term risk.
- It reduces uncertainties and helps local authorities determine appropriate development contributions.
- LCC assists decision-makers understand the relative cost difference between two or more management options without the full-blown costs of detailed engineering assessments.

LCC is therefore able to describe the type, frequency and level of cost associated with a specific stormwater intervention across the life span of that intervention.

Decision making on the use of green and grey stormwater infrastructure needs accurate and comprehensive data on the technical and financial performance of these devices. The financial performance depends on the sum and distribution, over the life cycle of the device, of the acquisition and maintenance costs which include design, construction, use, maintenance, and disposal. LCCs can be used for structuring and analysing this financial information. However, whilst LCC is an important tool in understanding the costs associated with infrastructure development, it is only one parameter in the evaluation process (Taylor, 2003), and needs to be considered in the context of social, cultural and environmental goals and benefits.

LCCs are normally expressed as either a total Net Present Value (NPV) over the life cycle of the device, or a present value per year for each year of the device life span. The total NPV LCC is the lump sum amount that a person would need today to meet all the costs of installing, maintaining and using that device over its lifetime. Here, the NPV is set to 2018 NZ dollars (i.e., consistent with Ira *et al.,* 2020).

3. Methods

3.1 Data collection

Over the course of this project, workshops and cost data collection meetings were held with AC Healthy Waters officers, as described in Ira *et al*. (2020 - page 9, Table 3-2). Where cost information was not available from AC it was obtained (Table 3.1):

- directly from suppliers; or
- from previous research undertaken through the Activating WSUD in New Zealand study (Ira and Simcock, 2019); and the Te Awarua-o-Porirua (TAoP) Whaitua Collaborative Modelling Study (Ira, 2017a and 2017b).

Table 3.1 Key data sources used to collect source control cost information

SOURCE CONTROL INTERVENTION	DATA SOURCE
Street sweeping	Healthy Waters, Auckland Council
Catchpit cleaning	Healthy Waters, Auckland Council
Use of inert roofing surfaces	TAoP study (Ira 2017a), roofing suppliers
Urban riparian margins	TAoP study (Ira, 2017a), Healthy Waters, Auckland Council
Septic tank systems	TAoP study (Ira 2017b), septic tank suppliers
Wastewater overflow reduction	TAoP study (Ira 2017b)
Copper-free brake pads	Literature review; brake pad suppliers
Low zinc or zinc free tyres	Literature review; tyre suppliers
Behaviour change	Literature review

It should be noted that accurate cost data is notoriously difficult to obtain. Many suppliers refuse to provide estimates, developers do not like divulging sensitive cost information and many councils do not store cost data related to construction and maintenance activities in a meaningful way. As a result, the unit costs and associated LCCs presented in this report are best estimates based on the information provided.

3.2 Literature review

A brief review of national and international literature, focusing on the costs of source control WSD stormwater solutions was undertaken. The desktop review of literature was undertaken based on a number of key "search terms" used in internet searches within a number of scholarly databases (e.g., Google Scholar, EVRI, jstor.org and Science Direct). These terms included: water sensitive design, source control, cost differential, copper brake pads, zinc tyres, zinc roofs, economic assessment, costs of replacement, WSD behavior change, education.

3.3 Modelling process

3.3.1 LCC Model Overview and assumptions

Ira *et al.* (2020) documented the cost data sources, assumptions and process undertaken to generate indicative life cycle costs (LCC) estimates for urban structural stormwater interventions for use within the FWMT, within the context of a TEV assessment. The source control mitigation options utilise the same unit-based LCC Model, which adjusts them into a consistent framework with both urban structural interventions and the broader mix of structural and source control interventions in the rural sector (e.g., Muller *et al*., 2020). Combined, this ensures cost-accounting within the FWMT Stage 1 supports integrated and consistent scenario modelling (e.g., integrated across rural and urban activities, across device and source control options).

A simple, unit based LCC model has been developed in Excel in general accordance with the Australian/New Zealand Standard (4536:1999) for LCC (Ira *et al.*, 2020). The structure of the models is the same for all mitigations and is based on the following LCC assumptions:

- default low and high unit cost values provided in each of the Excel LCC models were collected as described in Section 3.1 and have been applied in the models as described in Section 4;
- separate low and high unit cost estimates for the mitigations were obtained based on either actual construction/ maintenance costs or actual cost estimates for parts, labour and installation of source control mitigations. Given that costs and estimates for parts, labour and installation vary depending on engineer estimates, market prices, construction/ maintenance methodology, availability of materials and procurement methods, low and high cost scenario model runs were undertaken. Having a LCC "envelope" between the low and high cost scenario runs assists in accounting for and encompassing this inherent variability in cost. Given that the FWMT requires a single cost for each intervention, the high and low LCC results have been averaged;
- a 50 year life cycle analysis period has been used in order to provide consistency with the urban structural and rural intervention LCCs;
- interventions have been modelled using a 2%, 4% and 6% discount rate[2], as recommended by Auckland Council's Chief Economist Unit (Ira *et al*., 2020);
- base date for all costs is 2018;
- all costs are in NZ$ and are excluding goods and services tax (GST);
- unless otherwise specified, the total acquisition cost portion includes an overhead and indirect cost factor of between 15% and 20% the construction cost - this accounts for time needed to plan, consent or implement potential mitigations, and associated contingencies, and is based on a likely overhead cost for urban structural interventions (Ira and Simcock, 2019) and advice from suppliers/ engineers;
- where appropriate, full mitigation renewal costs are included in the relevant year(s);
- where necessary (i.e. for septic tanks and urban riparian margins), land costs (to be taken from the AC rates database) need to be added to the LCC estimates provided (Appendix A).

3.3.2 Interpreting LCC results

LCCs generated via the LCC models are indicative LCC estimates which should only be used for the comparison of various source control intervention scenarios. It is important to focus attention on the relative cost differences between different interventions, rather than the absolute dollar cost amount. LCC allows "like for like" comparison of additional costs between interventions. LCC assessment does not make any assumptions about the feasibility, timing, uptake or optimisation of interventions in specific location(s), or about financing, governance or distributions of costs for particular catchments or activities.

[2] The discount rate (DR) is a function of the cost of capital, an inflation factor and a risk adjustment factor. It can be real or nominal. The real discount rate is use for LCC and doesn't include an inflation component . The total NPV LCC is the lump sum amount that a person would need today to meet all the costs of installing, maintaining and using that device over its lifetime. In other words, costs which occur later in time within the LCC cycle are given less weight than those which occur sooner (and the higher the discount rate, the less weight is given to future costs). The DR is therefore used to bring future costs back to today's dollar values. By discounting the costs we are able to determine the total buying power (cash value) needed over the total life cycle. Discounting is one of the most debatable and controversial aspects of a LCC assessment. Although, the DR used is less important than ensuring a consistent DR is used for all devices (NZ Treasury, 2015). For more information about the real discount rate, please see the Australian/New Zealand Standard Life Cycle Costing: An Application Guide, AS/NZ 4536:1999.

4. Source control costs

This section details the data and key assumptions used for relevant source control interventions, as well as the LCCs generated (where possible) for use in the FWMT Stage 1.

4.1 Street sweeping

Table 4.1 summarises the unit cost data for street sweeping, as provided by Auckland Council. It is noted that there are no 'traditional' total acquisition (i.e. construction, design, etc) costs associated with street sweeping as it has been assumed that the sweeper trucks are not owned by AC. However, a maintenance contract 'set-up' cost has been allowed for. This is applied every 5 years throughout the 50 year life cycle analysis period. Low and high unit cost estimates are provided in Table 4.1.

Table 4.1 Unit costs for street sweeping in Auckland

Street sweeping	Unit	Frequency	Rate/ Cost
Contractual Set-up Costs	Lump sum	Every 5 years	16% of yearly maintenance cost
Sweeper truck	Per hour		$100 - $150
Disposal of Sediment	Per ton per day		$227 - $315

LCCs have been generated based on 35km of road kerb-line being swept over a 9 hour working day and include disposal costs for 3.5 tons of sediment disposed per day (Table 4.2).

However, these costs should be considered draft or "placeholder" costs given the anecdotal source of information and, ideally, more than one data source is needed to improve the quality of the cost estimates. Low and high LCCs relate to the low and high unit cost estimates provided in Table 4.1. Given that the FWMT requires a single cost for each intervention, the high and low LCC results have been averaged and are suggested for use.

Table 4.2 LCC$/ 35km of road swept/ year (placeholder cost) (NZ$ 2018 base date over 50 years)

Street Sweeping LCC$/ 35km swept/ year	2% DR	4% DR	6% DR
Low Cost Scenario	$726	$506	$379
High Cost Scenario	$1,073	$748	$559
AVERAGE COST SCENARIO	**$900**	**$627**	**$469**

4.2 Catchpit cleaning

Table 4.3 summarises the unit cost data for catchpit cleaning, as provided by Auckland Council. It is noted that there are no 'traditional' total acquisition (i.e. construction, design, etc) costs associated with catchpit cleaning as it has been assumed that the cleaner trucks are not owned by AC. However, a maintenance contract 'set-up' cost has been allowed for. This is applied every 5 years throughout the 50 year life cycle analysis period. Low and high unit cost estimates are provided in Table 4.3.

Table 4.3 Unit costs for catchpit cleaning in Auckland

Catchpit cleaning	Unit	Frequency	Rate/ Cost
Contractual Set-up Costs	Lump sum	Every 5 years	16% of yearly maintenance cost
Cleaner truck	Per hour		$150 - $240
Disposal of Sediment	Per ton		$65 - $90
Average cost per catchpit cleaned (incl disposal)	Per catchpit		$11 - $17

On average approximately 6 - 8 catchpits are cleaned within an hour. LCCs have been generated based on a 10 hour working day and are shown in Table 4.4a and costs per catchpit per year are shown in Table 4.4b. However, these costs should be considered draft or "placeholder" costs as, ideally, more than one data source is needed to improve the quality of the cost estimates. The low and high LCCs relate to the low and high unit cost estimates provided in Table 4.3. Given that the FWMT requires a single cost for each intervention, the high and low LCC results have been averaged and are suggested for use.

Table 4.4a LCCs of catchpit cleaning: LCC$/ day/ year (placeholder cost) (NZ$ 2018 base date over 50 years)

Catchpit Cleaning LCC$/ day/ yr	2% DR	4% DR	6% DR
Low Cost Scenario	$1,554	$1,083	$810
High Cost Scenario	$2,439	$1,700	$1,272
AVERAGE COST	**$1,997**	**$1,392**	**$1,041**

Table 4.4b LCCs of catchpit cleaning: LCC$/ catchpit/ year (placeholder cost) (NZ$ 2018 base date over 50 years)

Catchpit Cleaning LCC$/ catchpit/ yr	2% DR	4% DR	6% DR
Low Cost Scenario	$22.49	$15.68	$11.73
High Cost Scenario	$35.30	$24.61	$18.41
AVERAGE COST	**$28.90**	**$20.14**	**$15.07**

4.3 Roofs

As part of the Te Awarua-o-Porirua (TAoP) Whaitua Collaborative Modelling Study cost information was collected for inert and zinc roofing materials (as reported in Ira, 2017a). The TAoP Whaitua cost data was updated and refined as part of this project. Nine roofing companies were contacted and asked to provide cost information on the cost of purchase and installation of different roofing materials. Of the nine contacted, three companies were willing to provide cost data. In addition to calling companies directly, an internet search was undertaken[3] and costs for different types of roofing materials obtained (e.g. metal roofs, butyl rubber, concrete and clay tiles, asphalt shingles).

[3] https://www.refreshrenovations.co.nz/advice/roofing-material-options/ ; https://builderscrack.co.nz/estimates/roofing (accessed on 18 March 2020)

Total acquisition costs (TAC) for roofs includes the cost of a new roof (installation and labour), scaffolding costs, and indirect and overhead costs (as described in *Ira et al.*, 2020) (Table 4.5). Low and high unit cost estimates are provided.

Table 4.5 Total acquisition unit costs for roofs

Roofs	Unit	Unit Cost
Low zinc alloy roofs	$\$/m^2$	\$55 - \$65
Inert roofs	$\$/m^2$	\$60 - \$80
Scaffolding	per roof	\$3,000 - \$4,000
Indirect and overhead cost	percentage	15% of construction cost

Maintenance costs were taken primarily from the TAoP study, and frequencies of maintenance were informed by manufacturers warranties. Maintenance activities include:

- Clean/ lichen removal (every 3 years)
- Touch-ups/ painting (every 15 years)
- Roof replacement (every 25 years – it is noted that manufacturer warranties ranged from 15 - 30 years depending on the geographical environment in which the roof is located).

Low and high unit cost estimates are provided in Table 4.6.

Table 4.6 Maintenance activities, frequencies and unit costs for roofs

Roofs	Frequency	Unit	Unit Cost
Lichen/ Moss removal/ treatment	Every 3 years	per roof	\$300 - \$400
Repainting/ touch-ups	Every 15 years	$\$/m^2$	\$15 - \$35
Removal and disposal	Every 25 years	per $100m^2$ of roof	\$1,500 - \$3,600
Scaffolding	Every 25 years	per roof	\$3,000 - \$4,000
New roof	Every 25 years	$\$/m^2$	\$55 - \$60 OR \$60 - \$80

Low and high unit costs received from suppliers were used in the LCC models to generate low and high LCCs for low zinc alloy roofs and inert roofs, using a 2%, 4% and 6% discount rate, as shown in Tables 4.7a – 4.7c. Given that the FWMT requires a single cost for each intervention, the high and low LCC results have been averaged and are suggested for use. Costs for green roofs have been reported in Ira *et al*. (2020).

Table 4.7a Low, high and average LCCs for low zinc alloy and inert roofs, based on a 2% discount rate

Low Zinc Alloy Roofs	LCC $\$/m^2$/year - LOW	LCC $\$/m^2$/year - HIGH	LCC $\$/m^2$/year - AVE
$150m^2$	\$4.46	\$6.49	\$5.48
$200m^2$	\$4.14	\$6.05	\$5.10
$250m^2$	\$3.95	\$5.79	\$4.87
$920m^2$	\$3.39	\$5.02	\$4.21
$5130m^2$	\$3.22	\$4.79	\$4.01

Inert Roofs	LCC $/m²/year - LOW	LCC $/m²/year - HIGH	LCC $/m²/year - AVE
150m²	$4.67	$6.70	$5.69
200m²	$4.35	$6.44	$5.40
250m²	$4.16	$5.67	$4.92
920m²	$3.61	$5.43	$4.52
5130m²	$3.44	$7.14	$5.29

Table 4.7b Low, high and average LCCs for low zinc alloy and inert roofs, based on a 4% discount rate

Low Zinc Alloy Roofs	LCC $/m²/year - LOW	LCC $/m²/year - HIGH	LCC $/m²/year - AVE
150m²	$3.30	$4.66	$3.98
200m²	$3.06	$4.32	$3.69
250m²	$2.91	$4.13	$3.52
920m²	$2.49	$3.55	$3.02
5130m²	$2.37	$3.37	$2.87
Inert Roofs	**LCC $/m²/year - LOW**	**LCC $/m²/year - HIGH**	**LCC $/m²/year - AVE**
150m²	$3.46	$5.16	$4.31
200m²	$3.23	$4.83	$4.03
250m²	$3.08	$4.63	$3.86
920m²	$2.66	$4.05	$3.36
5130m²	$2.54	$3.88	$3.21

Table 4.7c Low, high and average LCCs for low zinc alloy and inert roofs, based on a 6% discount rate

Low Zinc Alloy Roofs	LCC $/m²/year - LOW	LCC $/m²/year - HIGH	LCC $/m²/year - AVE
150m²	$2.69	$3.69	$3.19
200m²	$2.50	$3.42	$2.96
250m²	$2.38	$3.26	$2.82
920m²	$2.03	$2.78	$2.41
5130m²	$1.93	$2.63	$2.28
Inert Roofs	**LCC $/m²/year - LOW**	**LCC $/m²/year - HIGH**	**LCC $/m²/year - AVE**
150m²	$2.84	$3.86	$3.35
200m²	$2.64	$3.69	$3.17
250m²	$2.52	$3.22	$2.87
920m²	$2.18	$3.07	$2.62
5130m²	$2.07	$4.13	$3.10

4.4 Urban riparian margins

4.4.1 Unit costs

Data for unit costs of riparian margins within the urban area was obtained from a range of sources, namely the COSTnz Model (Ira et al., 2008); NIWA UPSW cost model (Ira and Batstone, 2012); the TAoP Whaitua Collaborative Modelling Study cost model (Ira, 2017a); and the Kaipara Moana Remediation business case (KMR, 2019).

The high and low unit costs shown in Tables 4.8 – 4.10 are best estimates and based on a range of cost estimates for plants, labour, materials, planting and ongoing maintenance. Given that industry costs and estimates for plants, labour, materials and planting vary depending on engineer estimates, plant supply costs, type of plant, manufacturing costs, topography, soils, availability of materials and procurement methods, the various cost estimates were collated and low and high unit cost estimates provided.

Table 4.8 Total acquisition costs for urban riparian margins

Total Acquisition costs	Unit	Low Unit Cost	High Unit Cost
Planting costs: grasses/ sedges/ trees	$\$/m^2$	$25.65	$33.60
Labour	$\$/m^2$	$5.95	$5.95
Transport	$\$/m^2$	$8.65	$8.65
Weeding	$\$/m^2$	$0.25	$0.30
Earthwork/ Regrading costs	$\$/m^2$	$1.50	$1.50
Fencing	$/m	$8.00	$20.00
Logistics, Supervision & Co-ordination	$\$/m^2$	$7.55	$7.55
Resources (fert tabs, combiguard)	$\$/m^2$	N/A	$5.95
Indirect and overhead costs	% of TAC	15%	20%

Table 4.9 Initial maintenance costs for urban riparian margins (for the first 5 years)

Initial Maintenance Costs (for 5 yrs)	Unit	Low Unit Cost	High Unit Cost
Weeding	$\$/m^2$	$0.25	$0.30
Replanting	$\$/m^2$	$5.40	$10.80
Fencing	$/m	$0.10	$0.25
Labour	$\$/m^2$	$3.55	$4.75

Table 4.10 Ongoing maintenance costs for urban riparian margins

Ongoing Maintenance Costs	Unit	Low Unit Cost	High Unit Cost
Long term aftercare of plants	$\$/m^2$	$0.25	$0.30
Fencing	$/m	$0.10	$0.25

4.4.2 Comparison of rural and urban riparian margin unit costs

A comparison of the urban riparian margin costs was undertaken against unit costs provided for the rural riparian planting costs. Whilst it is likely that the level of effort and plants could be different, along with types of fencing, the unit costs themselves for similar activities (e.g. weeding or aftercare of plants) are analogous and arguably, consistent.

Unit costs and LCCs for rural riparian margins are reported in PerrinAg (2020) and PerrinAg and Koru Environmental (2020) respectively. The comparison is provided in Table 4.11 below.

Table 4.11 Comparison of rural and urban riparian margin unit costs (source of rural unit cost information: PerrinAg, 2020)

Activity	Rural Unit Cost	Urban Unit Cost	Comment
Total Acquisition Costs			
Overhead and indirect costs	17.5% of TAC	15% - 20%	The rural percentage was based on work undertaken for urban green infrastructure costs (Ira and Simcock, 2019)
Planting costs	$27.50/m^2$ (plants include a grasses and sedges mix and are inclusive of labour and preparation costs, but exclude fertilisers and pest management)	$25.65 - $33.60/ m^2 (plants include a mix of larger trees, small trees, sedges and grasses).	Additional urban riparian planting costs include: labour, transport of plants, earthworks and regrading costs. These are likely to be additional to the rural area since urban riparian corridors are usually constructed as part of larger scale subdivisions which incorporate these types of activities via urban landscaping and earthwork contractors.
Fencing	$8.40 - $18.20/ linear m	$8 - $20/ linear m	
Initial Maintenance Costs (for 5 years for both rural and urban riparian margins)			
Plant establishment and care	Yr 1: $10.25/$m^2$; Yr 2: $7.69/$m^2$; Yr 3: $5.13/$m^2$; Yr 4: $4.50/$m^2$.	$0.25 - $0.30/ m^2 for weeding; $5.50 - $10.80/$m^2$ for replanting; $3.55 - $4.75/$m^2$ for labour	Urban costs are reflective of labour costs and likely greater effort needed to establish plants for aesthetic as well as water quality purposes.
Ongoing Maintenance Costs			
Weeding	$0.05 - $0.32/ linear m	$0.25 - $0.30/$m^2$	
Fencing	$0.25/linear m	$0.10 - $0.25/ linear m	

Overall, it is considered that the urban and rural unit TACs and MCs for riparian buffers are reasonably consistent. Additionally, the urban costs are rightly reflective of the greater level of effort needed during the construction and planting phase for aesthetically pleasing and diverse urban riparian buffers. The slightly higher costs and additional levels of effort within the urban area are expected due to potential public access to the margins, and the aesthetic value of urban riparian margins are highly valued. This is also reflected in the literature which documents a decrease in property prices when green infrastructure, including riparian margins, are poorly maintained (Ira, 2017b).

4.4.3 Urban riparian margin LCC model and results

Separate low and high LCC model runs were undertaken for a 5m, 10m and 15m buffer strip (with and without fencing), based on the unit cost data presented in Tables 4.8 – 4.10 and using a 2%, 4% and 6% discount rate. The LCC model run results are shown in Tables 4.12a and 4.12b. Given that the FWMT requires a single cost for each intervention, the high and low LCC results have been averaged and are suggested for use. Land costs (to be taken from the AC rates database) will need to be added to the LCC estimates provided when used in the FWMT (see Appendix A).

Table 4.12a Low, high and average LCC results for urban riparian margins with fencing for a 2%, 4% and 6% discount rate.

	5m Riparian Strip			10m Riparian Strip			15m Riparian Strip		
Riparian Margins (LCC$/m^2/yr)	**2% DR**	**4% DR**	**6% DR**	**2% DR**	**4% DR**	**6% DR**	**2% DR**	**4% DR**	**6% DR**
Low Cost Scenario	$2.05	$1.93	$1.85	$2.01	$1.90	$1.82	$1.99	$1.89	$1.82
High Cost Scenario	$3.29	$3.11	$2.98	$3.19	$3.03	$2.91	$3.16	$3.00	$2.89
Average Cost Scenario	**$2.67**	**$2.52**	**$2.41**	**$2.60**	**$2.46**	**$2.37**	**$2.57**	**$2.45**	**$2.35**

Table 4.12a Low, high and average LCC results for a 10m urban riparian margin without fencing for a 2%, 4% and 6% discount rate.

	10m Riparian Strip		
Riparian Margins (no fencing) (LCC$/m^2/yr)	**2% DR**	**4% DR**	**6% DR**
Low Cost Scenario	$1.96	$1.87	$1.80
High Cost Scenario	$3.09	$2.95	$2.84
Average Cost Scenario	**$2.53**	**$2.41**	**$2.32**

4.5 Septic tanks

As part of the TAoP Whaitua Collaborative Modelling Study cost information was collected for septic tanks (as reported in Ira, 2017b). The TAoP Whaitua cost data was updated and refined as part of this project. Three septic waste companies were contacted and asked to provide cost information on the cost of purchase and installation of an on-site aerated wastewater treatment system (and associated driplines). All 3 companies provided cost information. The proprietary aerated tank systems ranged from $12,760 to $19,640 (capacity of 1080L/day), suitable for a standard 3-4 bedroom home. According to the companies contacted, the price of the systems is very sensitive to the installation difficulty (i.e. groundwater level, soil type, slope, access). A contingency of 30%, as recommended by the manufacturers, as well as council engineers, was added to the installation cost to account for this uncertainty, which includes the overhead and indirect costs. The TAC used within the LCC model is therefore comprised of the purchase and installation cost, along with the specified contingency.

Maintenance activities and frequencies, along with the life span of the system, were based on manufacturers recommendations. Maintenance activities include routine inspections at 6 monthly intervals, a yearly mandatory system service and ongoing daily electrical running costs. System replacement (renewal) is recommended at 20 yearly intervals, with pump replacements occurring every 5 years.

The average aerated treatment system LCCs, suggested for use in the FWMT, are shown in Table 4.13. Land costs (to be taken from the AC rates database) will need to be added to the LCC estimates provided when used in the FWMT (see Appendix A).

Table 4.13 LCCs of aerated septic tank systems (LCC$/ L/ year) (NZ$ 2018 base date over 50 years)

Septic Tank (LCC$/L/yr)	LCC $ - 2%	LCC $ - 4%	LCC $ - 6%
Low Cost Scenario	$1.02	$0.77	$0.63
High Cost Scenario	$1.55	$1.17	$0.95
AVERAGE COST SCENARIO	**$1.29**	**$0.97**	**$0.79**

4.5 Wastewater overflow reduction

Generally, in order to reduce wastewater overflows, additional storage is created within the wastewater network via oversized pipes or pump stations. In the Auckland Region Watercare are responsible for the wastewater network, and costs of any interventions to reduce wastewater overflows would need to be undertaken in consultation with them. Specific interventions to reduce wastewater overflows have not been provided to date, however, some general cost information relating to pump stations can be reported here. As part of the TAoP Whaitua Collaborative Modelling Study cost information was collected for pump stations (as reported in Ira, 2017b). No further data collection has been undertaken for this study at this stage.

For the TAoP Whaitua, the construction and installation cost of wastewater pump stations was estimated from actual pump stations constructed in Auckland, as well as cost data provided by Wellington Water. Wellington Water recommended that an additional cost of 55% of the construction and installation cost be added onto this cost to account for planning, design, preliminary and general, fees and contingencies. The cost data received was based on pump stations ranging from 18 L/s to 1700 L/s (Table 4.14).

Table 4.14 Total acquisition costs (TACs) for wastewater pump stations (NZ$, 2017 base date)

Low TAC (cost per L/s)	Mean TAC (cost per L/s)	High TAC (cost per L/s)
$3,800	$9,500	$28,800
[>1000 L/s pump capacity]	*[300 – 900 L/s pump capacity]*	*[<300 L/s pump capacity]*

The investigation found that pump stations with greater pump capacity rates (i.e. high L/s rate) have the lowest TAC, whilst smaller pump stations with smaller pump capacity rates have higher TACs (as shown by the indicative pump capacity guidance in Table 4.14).

As part of the TAoP Whaitua study, maintenance costs were also investigated (Ira 2017b). Maintenance activity, frequency and cost information for wastewater pump stations was obtained from one Auckland source only. The source provided information based on his professional judgement and made the assumption that it was for a large scale, high loading pump station. The maintenance contractor stated that, over the course of 10 years, the amount spent on repairs to the pump station each year would likely equate to the total pump value (Table 4.15).

Table 4.15 Potential maintenance activity, frequency and cost information for pump stations (NZ$, 2017 base date)

MAINTENANCE ACTIVITY	FREQUENCY	UNIT	COST
Routine Maintenance			
Pump station inspection (usually 4 hours per month)	Weekly-fortnightly	Per hour	$85
Moving pumps for closer inspection	Every 3 months	Per station	$850
Corrective Maintenance			
Chamber lid replacement	Within 25 years	Per lid	$3,000
General maintenance/ inspection of pumps	Every 10 years, although possibly every 6 years if close to a daycare or school	Per pump	Total replacement cost of pump
Chamber repairs	Every 25 years	Per chamber	Inspection fees ($65 - $85 per hour), plus possible repair costs.

Based on the Wellington Water and WaterCare Asset Management Plans (2016 – 2036), the replacement costs for wastewater pump stations can vary from $54,600 - $694,000.

Due to the limited number of pump stations from which cost information was available, and the lack of cost data obtained for pump station maintenance, a LCC model cannot be developed at this time. In order for this to occur it is recommended that:

- specific information on wastewater storage options be provided;
- consultation be undertaken with Watercare regarding the proposed options and likely TACs;
- additional maintenance activity, frequency and cost data needs to be collected from existing Auckland pump stations in order to refine the maintenance cost estimates and allow for a routine maintenance cost database to be developed. Corrective maintenance costs could be identified through historic records for the pump stations, or based on total pump replacement every 10 years, along with a sum for other minor repairs.

4.6 Copper brake pads

In the early 1990s, it was identified that San Francisco Bay continually failed to meet water quality objectives for copper and other heavy metals (Enberg, 1995). The Regional Water Quality Control Board Basin Plan for San Francisco Bay required that the amount of copper discharged to the Bay needed to be reduced by 25,854 kg/yr. Investigations into the source of non-point source copper by Santa Clara County identified that vehicle brake pads were a significant contributor of copper (Enberg, 1995). Copper is added to friction material in brake pads to allow for smoother braking and reduce squeaking and shuddering (Hwang *et al.*, 2016). In response to these early findings, both the States of California and Washington mandated the near phase-out of copper in vehicle brake pads and transition to <0.5% copper brake pads (often called copper free) (CSQA, 2016).

Following copper being phased out of brake pads in several US states, manufacturers were challenged to ensure that any new brake system maintained a stable brake force (i.e., ensuring a stable friction coefficient [Hitachi Chemical, 2017]). Copper free brake pads are generally ceramic or 'semi-metallic' to achieve smooth braking forces. Semi-metallic brake pads are a lower cost option than ceramic brakes and are now generally made using steel[4]. The pads do contain copper (as well

[4] https://www.knowyourparts.com/technical-resources/brakes-and-brake-components/friction-materials-going-copper-free/ (accessed on 9 June 2020)

as iron, steel and other composite alloys) which are combined with a graphite lubricant[5]. The metal composition within the brake pad can vary between 30% and 70%[5] and it is unclear whether or not they would meet a <0.5% copper requirement. It is noted that semi-metallic brake pads also produce more brake dust than ceramic brakes, but tend to be preferred by drivers because they offer improved braking performance in a much wider range of temperatures and conditions[5].

In 2016 in the USA, 44% of available brake pads contained <0.5% copper, and brake pads manufactured in 2021 are expected to contain 81-99% less copper than they did in the early 2010s (CSQA, 2016). In 2015, the USEPA, state governments and the motor industry signed a memorandum of understanding to reduce copper as well as other metals in brake pads, with an aim to reducing copper to <0.5% in 2025. The memorandum of understanding also includes a voluntary initiative to reduce mercury, lead, cadmium, asbestiform fibres, and chromium-six salts in brake pads[6].

Despite the large volume of literature documenting the sources of copper and source control solutions to reduce copper loads to the receiving environment, negligible information is available on costs of implementation. In March 2018, Environment Canterbury published a news article on "*the hidden pollutant in our brakes*"[7]. The article discussed the leaching of copper from brake pads and stated that the cost of installing copper free or reduced copper brakes was only $10 - $15 more expensive than traditional brakes. However, in an interview for Radio New Zealand (9 September 2018), Safe R Brakes parts manager, Guy Chambers, stated that copper free brake pads cost about 50% more than traditional brakes[8].

In addition to the literature search, 3 motor vehicle companies were contacted and asked to provide cost information on the cost of purchase and installation of copper free brake pads. Guy Chambers of Safe R Brakes was re-interviewed, and he stated that: "*approximately 80% of the cars on the road today are copper free and that only older models still have copper in them*". New brakes which are made, replaced or imported nowadays tend to be ceramic or semi-metallic brakes and their prices are now reasonably similar to the traditional copper brakes. The other 2 companies contacted stated that the traditional copper brakes are no longer sold or installed at their branches. Costs of current brake pads vary in quality and price, with the semi-metallic ones being more affordable. Table 4.16 provides a summary of costs for family-sized sedans and a larger commercial ute.

Table 4.16 Example of costs of some currently available brake pads in New Zealand[9]

Vehicle Type	Low Tier	Mid Tier	Premium
	Silverline (semi-metallic) TruStop (ceramic)	Repco RCT (ceramic)	TRW (ceramic)
Sedan	~$59	~$89	~$247
Ute	~$55	~$89	~$261

[5] https://www.bridgestonetire.com/tread-and-trend/drivers-ed/ceramic-vs-metallic-brake-pads (accessed 7 June 2020)
[6] https://www.epa.gov/npdes/copper-free-brake-initiative (accessed 5 June 2020)
[7] https://www.ecan.govt.nz/get-involved/news-and-events/2018/the-hidden-pollutant-in-our-brake-pads/ (accessed 5 June 2020)
[8] https://www.rnz.co.nz/news/national/366053/push-to-cut-copper-brakes-from-mainstream-use-over-pollutants (accessed 5 June 2020)
[9] https://www.repco.co.nz (accessed on 8 June 2020)

It is likely that legislation in the USA and Europe which restricts copper brakes has had a flow-on effect in the market, and it appears that copper-free (or low copper) brakes are increasingly common if not widespread already in Auckland. However, it is unclear what percentage of copper is contained within the semi-metallic brakes installed in New Zealand. Without quantifying the copper content and brake dust production rates of semi-metallic brakes, it remains challenging to identify how any shift to the latter's use would affect benefits to water quality (e.g., change in yields from roading surfaces in the FWMT). Equally, if most cars are currently using copper free or low copper brake pads, including copper-free brakes as a source control intervention in the FWMT (over and above the business as usual) would be nonsensical (i.e., result in a theoretical but otherwise impossible benefit to realise widespread adoption in the FWMT Stage 1 baseline period).

LCCs have not been developed for copper free brakes at this stage and further research is needed to confirm whether or not they are, in fact, the norm. It is recommended that:

- further research be undertaken to determine the extent of cars within the Auckland region which would still have copper brake pads. This could be based on the age and make of the car, obtained from NZTA records.
- further interviews should be held with brake pad manufacturers to confirm sales data of copper vs copper free brake pads;
- the metal composition of the semi-metallic brake pads used in New Zealand needs to be further investigated;
- if needed, collection of further cost data, directly from suppliers, on the cost differential between copper and copper-free brake pads for different types of vehicle categories (i.e. sedans/ hatchbacks; SUVs, Utes, 4x4 vehicles, trucks) be undertaken.

4.7 Low zinc tyres

Tyres and galvanised metals are two of the largest sources of zinc in the urban environment (CASQA, 2015). Tyres contain zinc at about 1- 1.5% by weight, and tyre tread wear releases particles of zinc laden dust (Hwang *et al*., 2016). Breaking, accelerating and making tight turns causes a considerable amount of zinc to be released, and CASQA (2015) estimated that truck tires have about 70% higher zinc levels than car tires. Hwang et al. (2016) estimated that between 0.073 and 0.6 million kg of zinc was released from tyres annually in various individual countries in Europe in the late 1990s and early 2000s.

According to Bauters (2012) low-zinc and zinc-free tires currently have little market presence in the USA and are not available for most vehicles. CASQA (2015) reports that zinc reduction appears to not be possible within existing vulcanization approaches, rather a completely different vulcanization process would be needed to eliminate zinc. Through the literature search, only one manufacturer of zinc free tyres was found, i.e. Roadrunner Rubber Corp (Houston, Texas, USA[10]). Greg Ritchie, the owner, was contacted and he stated that the tyres are manufactured in a solid rubber version and are only available for industrial operations such as forklifts. He stated that, on average, their zinc free tyres cost between 30% - 50% more than traditional tyres used for the same purpose (pers comm., 10 June 2020).

In addition to the literature search, 2 New Zealand based motor vehicle companies were contacted and asked to provide cost information on the cost of purchase and installation of low zinc or zinc free tyres. Both companies were unaware of the fact that tyres comprised zinc, and none had heard of any products that were specifically zinc free or low zinc. There is clearly very little, if any,

[10] http://roadrunnertires.com/99-zinc-free-tires/ (accessed on 8 June 2020)

awareness within the industry regarding this issue. Based on findings within this review, it is unclear whether or not using zinc-free tyres as an intervention option is feasible.

Due to the lack of awareness of the zinc composition in tyres, as well as the lack of cost information available for low zinc tyres, a LCC model cannot be developed at this time. In order for this to occur it is recommended that:

- further research be undertaken to determine the currently preferred vulcanization approach for tyres and determine whether or not this is still consistent with a 1 – 1.5% zinc weight, as per the findings of CASQA (2015). Specific tyre manufacturers (rather than just their distributers) would need to be approached, and the vulcanization approach used for NZ-made and imported tyres established, along with costs of alternative processes (if available).
- further discussion is needed on the appropriateness of low zinc tyres as a feasible source control intervention.

4.8 Behaviour change

Behaviour change is based on the premise that social and economic stimuli can encourage people to act in a pro-environmentalist manner (Northern Ireland Environment Agency, undated and Teen, 2019).

Teen (2019) undertook an extensive literature review on programmes which have been implemented internationally to reduce or prevent urban stormwater contamination. The review found that whilst time and resources invested in education may extend people's knowledge of environmental issues, it does not necessarily equate to a change in behaviour. This is because decisions to undertake pro-environmental actions are not made in isolation, but are rather based on a complex relationship of social, cultural, practical and economic factors (Figure 4.1 overleaf). Kollmuss and Agyeman (2002 as documented in Teen, 2019) state that current behaviour change models demonstrate that increases in knowledge and awareness, and attempts to change attitudes, will not always lead to pro-environmental behaviour.

Take home learnings from Teen (2019) are that education and messaging alone is unlikely to lead to behaviour change. As a result, any programme design to encourage pro-environmental behaviour needs to be carefully designed to maximise benefits and the likelihood that they will lead to changes in behaviour patterns.

Programmes need to be multi-dimensional if true pro-environmental behaviours are desired. In addition to messaging and education, programmes would need to include (as adapted from Northern Ireland Environment Agency, undated):

- scientific validation reinforcing the message;
- existence of champions or popularisers to 'spread the message';
- supportive media attention;
- dramatization of the problem in visual or symbolic terms;
- economic incentives for taking the desired (positive) action; and
- existence of institutional sponsors (such as councils, NGOs, government).

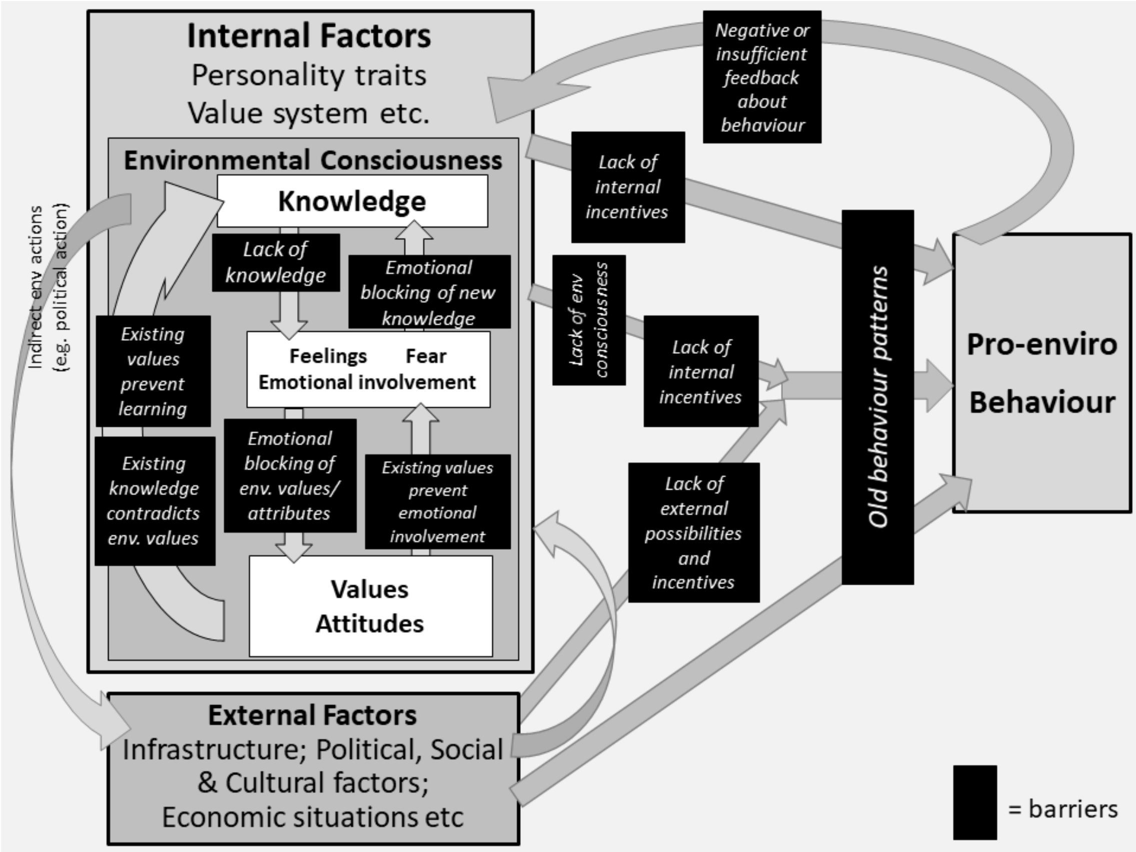

Figure 4.1 Interaction of factors and barriers to pro-environmental behaviours (Kollmuss & Agyeman, 2002 p. 257, as documented in Teen, 2019)

These factors are consistent with research undertaken by the CRC for Water Sensitive Cities (Brown et al., 2016) on transitioning to a water sensitive city. They are also consistent with findings from Ira and Batstone (2019), whose international review of alternative funding strategies found that implementation of economic incentives is critical to ensuring long term implementation of WSD and associated behaviour change, and that incentives or rebates must be high enough to allow buy-in from and benefits to the local community.

In Melbourne, Australia, a project was initiated within the Little Stringybark Creek catchment to restore the degraded Creek by implementing alternative forms of stormwater management such as rain tanks, rain gardens and detention basins to reduce the volume of water and contaminants entering the Creek. Along with a number of publicly funded works, the project relied on private residences retrofitting rain tanks to their houses for water re-use. The agencies involved (Melbourne Water and the local water board) co-funded implementation of rain tanks on private properties. Uptake of the cost sharing scheme was encouraged by undertaking a comprehensive proactive community engagement process to “normalize” WSD (Ira and Batstone, 2019). A review of the project implementation found that, given around 50% of run-off from urban surfaces comes from private property, effective householder engagement, along with financial incentives and personal co-benefits, was crucial in ensuring uptake of the rain tanks (H. Brown *et al.,* 2016).

Whilst the Teen (2019) literature review was extensive and the Brown *et al.* (2016) review comprehensive, they did not contain any information regarding the costs of implementing behaviour change programmes to the different agencies.

Due to the lack of cost information regarding the implementation of behaviour change programmes, no LCCs can be determined. It is therefore recommended that:

- the scope of the behaviour change programme intervention option is carefully defined in order to:
    - provide reasonable cost estimates relating to proposed activities; and
    - ensure that any benefits accruing from the programme (as a result of pro-environmental behaviour) can be reasonably quantified in terms of contaminant reduction and receiving environment outcomes – the literature highlights that education alone (which is what is proposed in this case) is unlikely to lead to a significant change towards pro-environmental behaviour.
- researchers at the CRC for Water Sensitive Cities be approached to determine whether costs of implementation of the community engagement and education process for Stringybark Creek Restoration Project were documented as part of their review (as this could be linked to their water quality monitoring programme for the Creek).
- if available, unit costs for educational campaigns, marketing information, etc. be obtained from Auckland Council officers (based on previous environmental education initiatives that the Council has undertaken).

5. Next steps

This report has assessed several urban source control interventions for inclusion in scenario modelling of cost and water quality by AC's FWMT. The report is an extension of Ira *et al.* (2020) and provides details on available literature, assumptions, unit costs and LCCs for various urban source control interventions. Information about the LCC model, how the cost results should be interpreted and how they should be considered alongside our understanding of indirect costs and benefits can be found in Ira *et al.* (2020).

High and low annualised LCCs have been provided for catchpit cleaning, street sweeping, roofing materials, urban riparian margins and septic tanks. These LCCs have then been averaged in order to allow for a single cost estimate to be used within the FWMT Stage 1.

Unit cost information has been provided for reducing wastewater overflows using pump stations. Prior to being able to generate LCCs for this source control intervention, the following further work is recommended:

- specific information on wastewater storage options needs to be developed;
- consultation needs to be undertaken with Watercare regarding the proposed options and likely TACs;
- additional maintenance activity, frequency and cost data needs to be collected from existing Auckland pump stations in order to refine the maintenance cost estimates and allow for a routine maintenance cost database to be developed. Corrective maintenance costs could be identified through historic records for the pump stations, or based on total pump replacement every 10 years, along with a sum for other minor repairs.

A literature review was undertaken to obtain cost information on copper free brakes, low zinc tyres and behaviour change initiatives. A lack of cost information for each of these source control interventions meant that LCCs are not able to be generated and further research is needed.

For source control cost information relating to **copper free brake** pads it is recommended that:

- further research be undertaken to determine the extent of cars within the Auckland region which would still have copper brake pads. This could be based on the age and make of the car, obtained from NZTA records.
- further interviews should be held with brake pad manufacturers to confirm sales data of copper vs copper free brake pads;
- the metal composition of the semi-metallic brake pads used in New Zealand needs to be further investigated;
- if needed, collection of further cost data, directly from suppliers, on the cost differential between copper and copper-free brake pads for different types of vehicle categories (i.e. sedans/ hatchbacks; SUVs, Utes, 4x4 vehicles, trucks) be undertaken.

For source control cost information relating to **zinc free or low zinc tyres** it is recommended that:

- further research be undertaken to determine the currently preferred vulcanization approach for tyres and determine whether or not this is still consistent with a 1 – 1.5% zinc weight, as per the findings of CASQA (2015). Specific tyre manufacturers (rather than just their distributers) would need to be approached, and the vulcanization approach used for NZ-made and imported tyres established, along with costs of alternative processes (if available).
- further discussion is needed on the appropriateness of low zinc tyres as a feasible source control intervention.

For source control cost information relating to **behaviour change** it is recommended that:

- the scope of the behaviour change programme intervention option is carefully defined in order to:
    - provide reasonable cost estimates relating to proposed activities; and
    - ensure that any benefits accruing from the programme (as a result of pro-environmental behaviour) can be reasonably quantified in terms of contaminant reduction and receiving environment outcomes – the literature highlights that education alone (which is what is proposed in this case) is unlikely to lead to a significant change towards pro-environmental behaviour.
- researchers at the CRC for Water Sensitive Cities be approached to determine whether costs of implementation of the community engagement and education process for Stringybark Creek Restoration Project were documented as part of their review (as this could be linked to their water quality monitoring programme for the Creek).
- if available, unit costs for educational campaigns, marketing information, etc. be obtained from Auckland Council officers (based on previous environmental education initiatives that the Council has undertaken).

Finally, it is recommended that consideration should be given to including the percentage cost reduction of source control interventions emanating from the subdivision design and building stage from a WSD approach within the FWMT.

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Appendix A – Summary of source control intervention LCCs

CATCHPIT CLEANING

Base date of costs: 2018
Analysis period: 50 years

The total life cycle cost is a function of:
TOTAL LCC over 50 years per device = ((**LCC$/UNIT/yr***50) * number of days (or hours or catchpits) when catchpits cleaned

Catchpit Cleaning LCC$/ hr/ yr	2% DR	4% DR	6% DR
Low Cost Scenario	$155	$108	$81
High Cost Scenario	$244	$170	$127
AVERAGE COST	**$200**	**$139**	**$104**

Catchpit Cleaning LCC$/ day/ yr	2% DR	4% DR	6% DR
Low Cost Scenario	$1,554	$1,083	$810
High Cost Scenario	$2,439	$1,700	$1,272
AVERAGE COST	**$1,997**	**$1,392**	**$1,041**

Catchpit Cleaning LCC$/ catchpit/ yr	2% DR	4% DR	6% DR
Low Cost Scenario	$22.49	$15.68	$11.73
High Cost Scenario	$35.30	$24.61	$18.41
AVERAGE COST	**$28.90**	**$20.14**	**$15.07**

Disclaimer:
The cost information used to generate the above values has been collated from various councils, contractors and consultants around New Zealand and the cost models are based on the best available information at the time of writing this report. However, cost information is notoriously variable, and information surrounding maintenance activities, frequencies and costs is scant. Whilst every effort has been made to ensure the consistency and integrity of the data collected and analysed, reliance should not be placed on actual dollar values. Decision-makers should rather use the costing information to understand the potential relative difference between the different green infrastructure solutions. Cost information is provided in good faith for the sole purpose of the comparison of intervention options within SUSTAIN.

STREET SWEEPING

Base date of costs: 2018
Analysis period: 50 years

The total life cycle cost is a function of:
TOTAL LCC over 50 years per device = ((**LCC$/UNIT/yr***50) * (kms KERB-LINE swept/35)

Street Sweeping LCC$/ 35km kerb-line swept/ yr	2% DR	4% DR	6% DR
Low Cost Scenario	$726	$506	$379
High Cost Scenario	$1,073	$748	$559
AVERAGE COST	**$900**	**$627**	**$469**

Disclaimer:
The cost information used to generate the above values has been collated from various councils, contractors and consultants around New Zealand and the cost models are based on the best available information at the time of writing this report. However, cost information is notoriously variable, and information surrounding maintenance activities, frequencies and costs is scant. Whilst every effort has been made to ensure the consistency and integrity of the data collected and analysed, reliance should not be placed on actual dollar values. Decision-makers should rather use the costing information to understand the potential relative difference between the different green infrastructure solutions. Cost information is provided in good faith for the sole purpose of the comparison of intervention options within SUSTAIN.

ROOFS
Base date of costs: 2018
Analysis period: 50 years
2% Discount Rate

The total life cycle cost is a function of:
TOTAL LCC over 50 years per device = ((**LCC$/UNIT/yr***50) * m2 roof area

2% DISCOUNT RATE

Low Zinc Alloy Roofs	LCC $/m2/year - LOW	TAC Portion of LCC	LCC $/m2/year - HIGH	TAC Portion of LCC	LCC $/m2/year - AVE	TAC Portion of LCC
150m2	$4.46	39%	$6.49	32%	$5.48	36%
200m2	$4.14	39%	$6.05	32%	$5.10	36%
250m2	$3.95	39%	$5.79	32%	$4.87	36%
920m2	$3.39	39%	$5.02	32%	$4.21	36%
5130m2	$3.22	40%	$4.79	32%	$4.01	36%
Inert Roofs	**LCC $/m2/year - LOW**	**TAC Portion of LCC**	**LCC $/m2/year - HIGH**	**TAC Portion of LCC**	**LCC $/m2/year - AVE**	**TAC Portion of LCC**
150m2	$4.67	39%	$6.70	34%	$5.69	37%
200m2	$4.35	40%	$6.44	34%	$5.40	37%
250m2	$4.16	40%	$5.67	34%	$4.92	37%
920m2	$3.61	40%	$5.43	34%	$4.52	37%
5130m2	$3.44	41%	$7.14	34%	$5.29	37%

4% DISCOUNT RATE

Low Zinc Alloy Roofs	LCC $/m2/year - LOW	TAC Portion of LCC	LCC $/m2/year - HIGH	TAC Portion of LCC	LCC $/m2/year - AVE	TAC Portion of LCC
150m2	$3.30	52%	$4.66	45%	$3.98	49%
200m2	$3.06	53%	$4.32	45%	$3.69	49%
250m2	$2.91	53%	$4.13	45%	$3.52	49%
920m2	$2.49	54%	$3.55	45%	$3.02	49%
5130m2	$2.37	54%	$3.37	45%	$2.87	49%
Inert Roofs	**LCC $/m2/year - LOW**	**TAC Portion of LCC**	**LCC $/m2/year - HIGH**	**TAC Portion of LCC**	**LCC $/m2/year - AVE**	**TAC Portion of LCC**
150m2	$3.46	53%	$5.16	48%	$4.31	50%
200m2	$3.23	53%	$4.83	48%	$4.03	51%
250m2	$3.08	54%	$4.63	48%	$3.86	51%
920m2	$2.66	55%	$4.05	48%	$3.36	51%
5130m2	$2.54	55%	$3.88	48%	$3.21	51%

6% DISCOUNT RATE

Low Zinc Alloy Roofs	LCC $/m2/year - LOW	TAC Portion of LCC	LCC $/m2/year - HIGH	TAC Portion of LCC	LCC $/m2/year - AVE	TAC Portion of LCC
150m2	$2.69	64%	$3.69	57%	$3.19	61%
200m2	$2.50	65%	$3.42	57%	$2.96	61%
250m2	$2.38	65%	$3.26	57%	$2.82	61%
920m2	$2.03	66%	$2.78	57%	$2.41	62%
5130m2	$1.93	66%	$2.63	57%	$2.28	62%
Inert Roofs	**LCC $/m2/year - LOW**	**TAC Portion of LCC**	**LCC $/m2/year - HIGH**	**TAC Portion of LCC**	**LCC $/m2/year - AVE**	**TAC Portion of LCC**
150m2	$2.84	65%	$3.86	59%	$3.35	62%
200m2	$2.64	65%	$3.69	60%	$3.17	62%
250m2	$2.52	66%	$3.22	60%	$2.87	63%
920m2	$2.18	67%	$3.07	60%	$2.62	64%
5130m2	$2.07	67%	$4.13	60%	$3.10	64%

Disclaimer:

The cost information used to generate the above values has been collated from various councils, contractors and consultants around New Zealand and the cost models are based on the best available information at the time of writing this report. However, cost information is notoriously variable, and information surrounding maintenance activities, frequencies and costs is scant. Whilst every effort has been made to ensure the consistency and integrity of the data collected and analysed, reliance should not be placed on actual dollar values. Decision-makers should rather use the costing information to understand the potential relative difference between the different green infrastructure solutions. Cost information is provided in good faith for the sole purpose of the comparison of intervention options within SUSTAIN.

RIPARIAN PLANTING AND FENCING

Base date of costs: 2018
Analysis period: 50 years

URBAN RIPARIAN MARGINS (5 - 15m strips)

The total life cycle cost is a function of:
TOTAL LCC over 50 years per device = ((**LCC$/UNIT/yr***50)+(**land cost** $/m2)) * m2 planted area

LCC COST (WITH FENCING)	5m Riparian Strip			10m Riparian Strip			15m Riparian Strip		
Riparian Margins (LCC$/m2/yr)	**2% DR**	**4% DR**	**6% DR**	**2% DR**	**4% DR**	**6% DR**	**2% DR**	**4% DR**	**6% DR**
Low Cost Scenario	$2.05	$1.93	$1.85	$2.01	$1.90	$1.82	$1.99	$1.89	$1.82
High Cost Scenario	$3.29	$3.11	$2.98	$3.19	$3.03	$2.91	$3.16	$3.00	$2.89
AVERAGE COST	**$2.67**	**$2.52**	**$2.41**	**$2.60**	**$2.46**	**$2.37**	**$2.57**	**$2.45**	**$2.35**

LCC COST (NO FENCING)	10m Riparian Strip		
Riparian Margins (LCC$/m2/yr)	**2% DR**	**4% DR**	**6% DR**
Low Cost Scenario	$1.96	$1.87	$1.80
High Cost Scenario	$3.09	$2.95	$2.84
AVERAGE COST	**$2.53**	**$2.41**	**$2.32**

LAND COSTS

Land costs per HRU to be provided separately by AC Healthy Waters.

RURAL RIPARIAN MARGINS

- can use above costs as placeholders until PerrinAg refine the rural riparian costs through their work.

The total life cycle cost is a function of:
TOTAL LCC over 50 years per device = ((**LCC$/UNIT/yr***50)+(**cost of loss of productive land/m2**)) * m2 planted area

LOSS OF PRODUCTIVE LAND

This item relates to loss of productive land within the rural area. Cost to be provided by PerrinAg.
If the riparian margin is within an urban or countryside living area, then cost of loss of productive land = $0.

Disclaimer:
The cost information used to generate the above values has been collated from various councils, contractors and consultants around New Zealand and the cost models are based on the best available information at the time of writing this report. However, cost information is notoriously variable, and information surrounding maintenance activities, frequencies and costs is scant. Whilst every effort has been made to ensure the consistency and integrity of the data collected and analysed, reliance should not be placed on actual dollar values. Decision-makers should rather use the costing information to understand the potential relative difference between the different green infrastructure solutions. Cost information is provided in good faith for the sole purpose of the comparison of intervention options within SUSTAIN.

SEPTIC TANKS

Base date of costs: 2018
Analysis period: 50 years

SEPTIC TANKS

The total life cycle cost is a function of:
TOTAL LCC over 50 years per device = ((**LCC$/UNIT/yr***50)+(**land cost** $/m2))

LCC COST

	2% DR - LCC$/system/yr		4% DR - LCC$/system/yr		6% DR - LCC$/system/yr	
Septic Tank (LCC$/ system/yr)	**LCC $**	**TAC Portion**	**LCC $**	**TAC Portion**	**LCC $**	**TAC Portion**
Low Cost Scenario	$1,025	32%	$772	43%	$628	53%
High Cost Scenario	$1,548	33%	$1,166	44%	$950	54%
Average	**$1,286**	**33%**	**$969**	**43%**	**$789**	**53%**

	2% DR - LCC$/L/yr		4% DR - LCC$/L/yr		6% DR - LCC$/L/yr	
Septic Tank (LCC$/L/yr)	**LCC $**	**TAC Portion**	**LCC $**	**TAC Portion**	**LCC $**	**TAC Portion**
Low Cost Scenario	$1.02	32%	$0.77	43%	$0.63	53%
High Cost Scenario	$1.55	33%	$1.17	44%	$0.95	54%
Average	**$1.29**	**33%**	**$0.97**	**43%**	**$0.79**	**53%**

LAND COSTS

Land costs per HRU to be provided separately by AC Healthy Waters.

Disclaimer:

The cost information used to generate the above values has been collated from various councils, contractors and consultants around New Zealand and the cost models are based on the best available information at the time of writing this report. However, cost information is notoriously variable, and information surrounding maintenance activities, frequencies and costs is scant. Whilst every effort has been made to ensure the consistency and integrity of the data collected and analysed, reliance should not be placed on actual dollar values. Decision-makers should rather use the costing information to understand the potential relative difference between the different green infrastructure solutions. Cost information is provided in good faith for the sole purpose of the comparison of intervention options within SUSTAIN.

Find out more: fwmt@aucklandcouncil.govt.nz

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Te Kaunihera o Tāmaki Makaurau