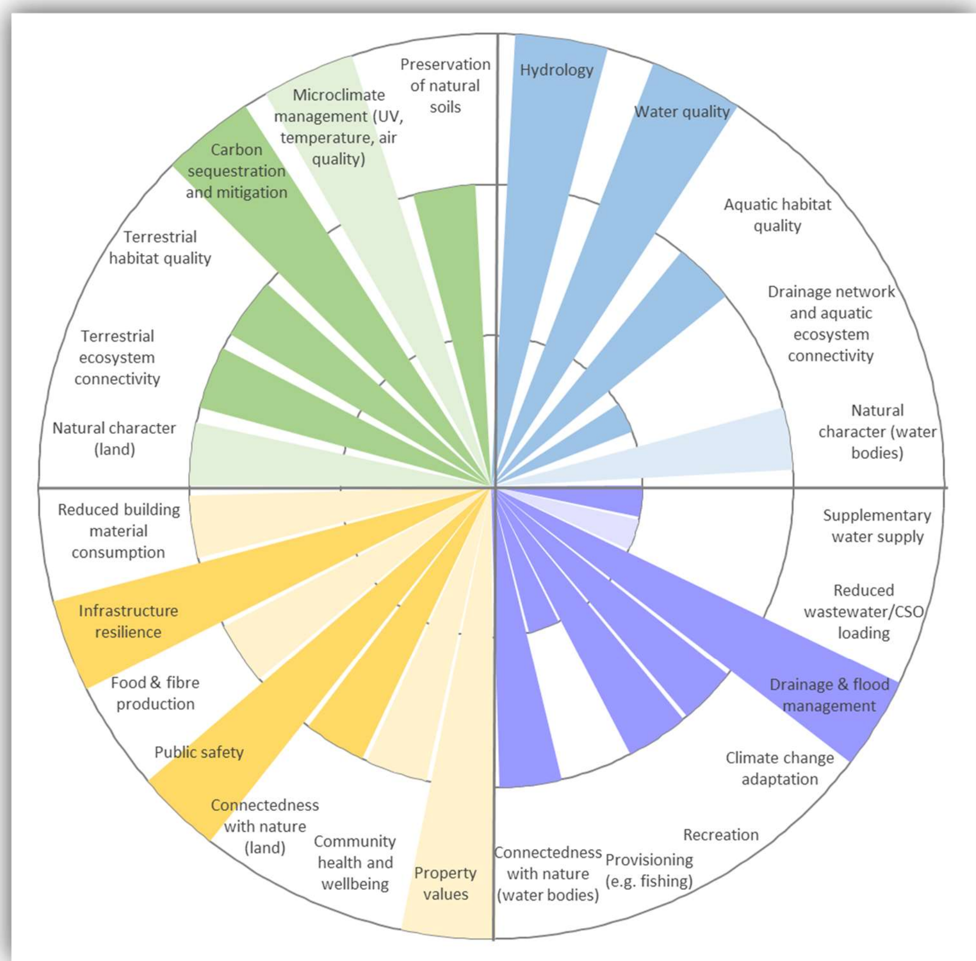
The 'More Than Water' WSUD Assessment Tool



Activating WSUD for Healthy Resilient Communities

The 'More Than Water' WSUD Assessment Tool

Activating WSUD for Healthy Resilient Communities

Funded by the Building Better Homes, Towns and Cities National Science Challenge

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Cover: Screenshot of an evaluation of WSUD benefits using the 'More than Water' assessment tool

Contents

Executive Summary

This report describes the More Than Water (MTW) assessment tool, developed for evaluating the benefits and costs of Water Sensitive Urban Design (WSUD) projects. The name of the tool reflects the notion that WSUD can deliver multiple co-benefits and cost-related advantages, in addition to more familiar considerations associated with management of the hydrological and water quality effects of urban development.

The tool employs a qualitative assessment method that is easy to use and provides graphic demonstration of benefits and cost outcomes and how these might vary under different scenarios. It is suited to screening level assessments and communication processes that involve both the technically-familiar and lay audiences.

Use of MTW involves making assessments of the level, importance and reliability of a series of benefits and costs criteria, drawing on guidance information provided with the tool. While assessments can rely on expert judgement, they can also be informed by the results of supporting analyses, such as hydrological modelling and life cycle cost calculations, where these are available.

Typically, use of the tool will involve comparing an assessment of the benefits and costs of a WSUD project with those of some alternative, such as a 'business as usual' scenario employing conventional development practices. This approach has been demonstrated through the application of the MTW tool in three case studies: Kirimoko Park residential subdivision, the Auckland Manukau Eastern Transport Initiative (AMETI) transport project and Talbot Park Community Renewal project. In all three cases the use of the tool demonstrated that, compared with a conventional stormwater management approach, WSUD delivers a greater range and level of benefits and performs better across a range of cost outcomes.

The current version of MTW should not be considered an end-product. As a next step, we recommend that the real-world utility of MTW be assessed by practitioners trialling the use of the tool in WSUD projects, providing feedback for further development of the tool and underlying assessment methods.

1. Introduction

1.1 Background

The Building Better Homes Towns and Cities National Science Challenge (BBHTC) is funding the 'Activating Water Sensitive Urban Design (WSUD) for healthy, resilient communities' research project. The project aims to deliver research and enhance capability to address critical current barriers to the uptake of WSUD in New Zealand.

In Phase 1 of the project, engagement with WSUD's community of practice guided the development of a programme of short term (9 to 12 month) research activities capable of delivering on high priority 'quick wins'[1]. Two of the core activities identified were the development of guidance for:

- Characterising, evaluating and demonstrating the full benefits of WSUD; and
- Understanding the full lifecycle costs of WSUD.

The findings of phase 1 indicated that, without a better understanding of the benefits and costs of WSUD, and ways to evaluate those benefits and costs, making the business case for WSUD in New Zealand will remain a significant challenge.

In research to address these needs, the Activating WSUD team has reported that assessments of WSUD benefits that focus solely on its water-related outcomes are incomplete. In our report on benefits[2] we describe other non-water benefits (or "co-benefits") that can arise from WSUD's use of Green Infrastructure (GI): some of these are other environmental outcomes (for instance, moderation of air temperature), while others are consequential outcomes for people and communities (for instance, health benefits).

Similarly, assessments of the costs of WSUD can be inadequate, often focusing on perceived higher maintenance associated with GI. In our report on costs[3], we demonstrate how a more comprehensive assessment of the economic outcomes of WSUD takes into account factors such as the avoided costs of hard infrastructure and the cost-effectiveness of WSUD in delivering on desired environmental outcomes.

In combination, these research activities have demonstrated need for a 'quick win' method by which practitioners can take account of the wider-ranging benefit and cost considerations that might otherwise be excluded from a business-case assessment of a WSUD project.

The Activating WSUD research team has addressed this need by developing the 'More Than Water' (MTW) assessment tool described in this report[4]. The name of the tool reflects the notion that WSUD and GI can deliver multiple co-benefits and cost-related advantages, many of which are unrelated to addressing the hydrological and water quality effects of urban development.

The tool allows comparison of WSUD and GI projects against conventional development approaches. It employs a qualitative assessment method that is easy to use and provides graphic demonstration of benefits and cost outcomes and how these might vary under different scenarios. It is suited to

[1] Moores, J., Batstone, C., Simcock, R. and Ira, S. (2018). Activating WSUD for Healthy Resilient Communities – Discovery Phase: Results and Recommendations. Research report to the Building Better Homes, Towns and Cities National Science Challenge.
[2] Moores, J. and Batstone, C. (2019). Assessing the Full Benefits of WSUD. Research report to the Building Better Homes, Towns and Cities National Science Challenge.
[3] Ira, S. and Simcock, R. (2019) Understanding Costs and Maintenance of WSUD in New Zealand. Research report to the Building Better Homes, Towns and Cities National Science Challenge.
[4] Available at: Link to MTW on website

screening level assessments and communication processes that involve both the technically-familiar and lay audiences.

As well as reflecting a synthesis of outputs from the Activating WSUD 'benefits' and 'costs' research activities, the continued development of the MTW tool is informed by a third research area: the project's exploration of WSUD from a Te Ao Māori perspective. In that research, the team has investigated how well WSUD recognises and provides for culturally-specific benefits for Māori, and how it could do better[5]. By drawing on the findings of this work, the further development of the MTW tool aims to make it explicitly suited to assessing WSUD projects in Aotearoa New Zealand and distinguishes it from methods developed elsewhere.

1.2 Scope and structure of this document

This document describes the MWT tool and illustrates its use in case studies. Section 2 describes considerations arising from the 'benefits' and 'costs' research activities that have guided the development of the tool. Section 3 describes the MTW tool: how to use it and how to interpret the outputs that it generates. Section 4 applies the MTW tool to three of the Activating WSUD project's case studies: Kirimoko Park residential development (Wanaka), Talbot Park residential development (Tamaki, Auckland) and the Auckland Manukau Eastern Transport Initiative (AMETI) transport project (Panmure, Auckland). Section 5 makes suggestions for the application of the tool, while Section 6 outlines limitations. Section 7 provides a summary of the report and makes recommendations for future research.

[5] Afoa, E. and Brockbank, T. (2019) Te Ao Māori & Water Sensitive Urban Design. Research report to the Building Better Homes, Towns and Cities National Science Challenge.

2 Considerations for development of an assessment tool

This section describes eight considerations that have guided the development of the MTW tool.

(1) There is no New Zealand tool providing comprehensive assessments of benefits and costs

Overseas tools exist for assessing the benefits and/or costs of WSUD and GI, some of which are described in our 'benefits' report[6]. None of these is immediately applicable in New Zealand because of: (a) uncertainty over the relevance of the underlying data for local use (e.g. benefit and cost data can be locally specific and not transferable between jurisdictions); and (b) inadequacies in providing for assessments that reflect New Zealand's socio-cultural context. On the latter point, the Activating WSUD project aspires to giving special recognition and provision to the values of Māori communities in the way in which benefits are described and assessed. Linking with complementary research to consider WSUD from the perspective of Te Ao Māori[7] in the continued development of the MTW tool is key towards pursuing this objective.

(2) The tool avoids monetization of benefits

Overseas tools, and supporting studies, monetize benefits of WSUD to allow their aggregation and comparison with costs. The MTW tool does not take this approach, for the reasons outlined in our 'benefits' report. These include: a lack of New Zealand data to express environmental outcomes in dollar terms; a need for a relatively simple 'quick win' assessment tool that could be developed (and used) with limited resources and information; and a range of cautionary considerations about the monetization approach. Among these considerations is the experience that highly quantitative (and by extension, monetized) assessments can be challenging for participants in collaborative planning processes. The MTW tool avoids monetization and provides for qualitative (or descriptive) assessments that focus on demonstrating variations in the range and extent of benefit and costs outcomes associated with a WSUD project. See also point (5) below.

(3) There are existing tools for costing WSUD projects

There are existing methods for estimating the life cycle costs of WSUD projects, including models developed in New Zealand[8]. However, these costing models generally do not take into account the avoided costs of environmental remediation, flood remediation and property clean-up costs, and avoided project construction and landscaping costs. Nor do they assess projects or infrastructure delivery in terms of the cost effectiveness of delivering water quality, hydrological and habitat quality (aquatic and terrestrial) outcomes or effects on housing affordability or private development yield. In general, the short-term cost of delivering a project tends to be the singularly most important decision-making criteria. The MTW tool allows estimates made using New Zealand cost models to be considered in terms of avoided cost and cost efficiency criteria to inform a wider-

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[6] Methods developed in the UK (https://www.susdrain.org/resources/best.html), Australia (https://watersensitivecities.org.au/research/our-research-focus-2016-2021/integrated-research/irp2-wp3/) and USA (http://greenvalues.cnt.org/national/calculator.php) are reviewed in Moores, J. and Batstone, C. (2019). Assessing the Full Benefits of WSUD. Research report to the Building Better Homes, Towns and Cities National Science Challenge.

[7] Afoa, E. and Brockbank, T. (2019) Te Ao Māori & Water Sensitive Urban Design. Research report to the Building Better Homes, Towns and Cities National Science Challenge.

[8] Ira, S. and Simcock, R. (2019) Understanding Costs and Maintenance of WSUD in New Zealand. Research report to the Building Better Homes, Towns and Cities National Science Challenge.

ranging qualitative assessment, thereby supporting a more holistic and long-term economic efficiency analysis of alternative project scenarios.

(4) WSUD costs lie in different parts of the urban development value chain

Traditional cost models do not take account of where costs will fall within the urban development value chain. In other words, whether costs are developer-related, public utility, private business or house-hold costs[9]. The range of cost criteria in the MTW assessment tool provide a basis for understanding more clearly where the upfront costs of a WSUD project may fall.

(5) WSUD is implemented across a range of scales

WSUD projects can be implemented at site, neighbourhood and catchment scales. Assessments at these different scales are likely to focus on different sets of benefits and costs. For instance, an assessment of the re-development of a city block is likely to focus on the site-scale design and implementation of GI, while a catchment-based assessment of a greenfield subdivision will necessarily consider the effects of the development on the characteristics of receiving water bodies. Accordingly, the MWT tool has been developed to be applicable across this range of scales.

(6) Assessments can involve a range of stakeholders

Information from assessments of WSUD projects can be used in a range of settings. Some of these are likely to involve communication with lay audiences interested in understanding the benefits and cost outcomes that a WSUD project might be expected to deliver. In some instances, for instance collaborative planning exercises, stakeholders from a range of backgrounds might also contribute to the assessment itself. As a result, it is important that assessment methods are easily understood, outputs easily-interpreted and guidance is provided so that users of the MTW tool can readily reach a judgement on each assessment criteria.

The development of the MTW has drawn on precedents such as the Healthy Streets assessment tool[10] developed to guide street design in London. That tool uses a system of ten indicators relating to the extent to which streets are healthy, safe and welcoming environments. Designers are provided with narrative guidance to help them assign scores to each of a range of factors contributing to the indicators. The Healthy Streets outcomes are plotted on a radar chart, showing how well each indicator performs for the proposed street layout relative to the existing layout (see Figure 2-1).

(7) The reliability of assessments varies with the information available

In some instances, assessments of WSUD projects may be supported by access to information such as the results of running models, monitoring data and detailed engineering design plans and reports. However, this will not always be the case. Accordingly, the development of the MWT tool has recognized the need to enable users to consider the type of evidence on which an assessment is based and the reliability of these sources. This provides a basis for identifying which benefits and costs may require further effort in coming up with a more detailed evaluation.

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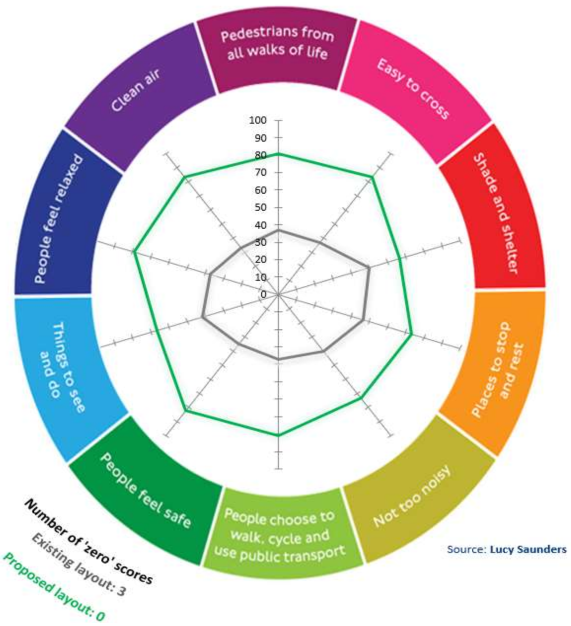
[9] Eventually, all costs are borne in differing proportions by private individuals via "on-charging" from developers, network utility fees or rates (targeted and other wise), businesses increasing the price of their goods or services, or everyday household costs.

[10] https://tfl.gov.uk/corporate/about-tfl/how-we-work/planning-for-the-future/healthy-streets



Healthy Streets Indicators' scores (%)
(Results will only display once all metrics have been scored)

	Existing layout	Proposed layout
Pedestrians from all walks of life	37	81
Easy to cross	37	83
Shade and shelter	50	67
Places to stop and rest	47	73
Not too noisy	40	73
People choose to walk, cycle and use public transport	37	81
People feel safe	35	83
Things to see and do	42	67
People feel relaxed	38	79
Clean Air	33	83
Overall Healthy Streets Check score	38	80
Number of 'zero' scores	3	0

Figure 2-1 – Healthy Streets tool: illustration of results of a street design assessment (source: Lucy Sanders, https://tfl.gov.uk/corporate/about-tfl/how-we-work/planning-for-the-future/healthy-streets)

(8) The things communities value are likely to vary

A further consideration is the weighting or importance of the range of benefits and costs which are included in an assessment. In community consultation and collaborative governance settings, it can be expected that some benefits and economic outcomes will be more highly valued than others. In some projects and/or places, certain benefits may not apply. By enabling these differences to be factored into an assessment, use of the MTW tool allows the consideration of alternatives to focus on the outcomes that communities and stakeholders value the most.

3. The More Than Water (MTW) Assessment Tool

3.1 Introduction

This section describes the More Than Water (MTW) assessment tool.

Reflecting the considerations outlined in Section 2, MTW is designed to enable qualitative assessments of differences in the benefits and costs of alternative WSUD project scenarios. For example, it can be used to contrast the range and level of benefits and costs associated with variations on the green infrastructure theme and a conventional hard engineering or 'business as usual' approach.

While the MTW tool itself provides for qualitative assessments, its application can be informed by quantitative analyses conducted using other methods. For instance, the assessment of the hydrological or water quality benefits of various scenarios could be informed by the results of running catchment models or engineering design calculations, while avoided costs of reduced impervious areas could be calculated using engineers estimates. However, MTW recognises that other benefits or costs are likely to be less routinely assessed using quantitative methods. In these cases, assessments can be made using methods such as expert judgement, informed by guidance material provided with the tool and information on the proposal. Because of this potential to be informed by a range of information and supporting analyses, MTW can be viewed as a collection point for assessments made by more than one method, rather than a method in itself. Users of the tool are able to assign reliability estimates, enabling more influence to be given to the assessment of benefits or costs which are supported by analysis of project-specific information[11].

Reflecting the qualitative nature of MTW, the tool does not require input scores or weightings nor generate an overall 'benefit-cost' score. Instead, the range and level of benefits and cost outcomes associated with a given project scenario are represented by graphical techniques designed to allow easy visual appreciation of how the outcomes assessed for one scenario compare with those for another.

The following sections explain the information required as inputs to an assessment, where to find supporting documents that provide guidance for an assessment and how to interpret outputs from MTW. It also illustrates the use of the tool by applying it in three Activating WSUD case studies. The section concludes by describing various ways in which MTW can be applied and noting limitations on its application.

3.2 Using the MTW tool

MTW is available as an excel spreadsheet file that can be downloaded from the Activating WSUD website[12]. There are two worksheets in the file: one for benefits and one for costs. The structure and functionality of the two worksheets is the same. While the following description focuses on the example of the benefits worksheet, exactly the same conventions apply to the costs worksheet.

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[11] As a minimum, assessments using MTW will benefit from having access to: subdivision and stormwater plans, design drawings and consenting reports; landscape sketches; and wider knowledge (based in prior data collection and/or site visits) of the characteristics and condition of the local and receiving environments.

[12] http://www.landcareresearch.co.nz/science/living/cities,-settlements-and-communities/water-sensitive-urban-design/more-than-water-mtw-assessment-tool

The benefits worksheet presents (Figure 3-1):

- On the left-hand side, a list of the potential benefits of a WSUD project[13]. Inputs to the assessment of each benefit are made by selecting from drop-down menus in columns D, E and F.
- On the right-hand side, a 'sector' chart showing the outputs of the assessment.

Guidance for conducting the assessment is provided in a pair of tables contained in Appendix A of this report.

For each benefit, the assessment involves:

1. Determining the **LEVEL** of the benefit. The qualitative descriptions under the column headings 'None', 'Low', 'Medium' and 'High' in the guidance tables are intended to help guide this assessment by providing illustrations of what delivery of the different levels of benefit may look like in practice.

2. Determining the **IMPORTANCE** of the benefit. This is a subjective choice of the individual, communities or stakeholders making the assessment. Where assessments do not have access to information on the values of communities and/or stakeholders, 'importance' can be held constant for all benefits.

3. Determining the **RELIABILITY** of the assessment. Text under the heading 'Benefits and assessment methods' in the relevant guidance table lists examples of assessment methods that could be used to provide a high (evidence-based) level of reliability. In general, reliability is more likely to be 'high' where an assessment considers project-specific information and data. Where an assessment relies on inference from background knowledge of WSUD, or information from other projects, reliability is more likely to be 'low'.

The results of assessing the three factors (level, importance and reliability) influence the way in which results are presented in the sector chart in different ways:

- The level of a given benefit is reflected in the length of its sector from the centre of the chart;
- The importance of a given benefit is reflected in the width of its sector; and
- The reliability of the assessment of a given benefit is reflected in the intensity of the colour of its sector.

Table 3-1 lists the options available when assessing each of the three factors and describes how these are represented in the sector chart. It references examples shown in Figure 3-2.

[13] Refer to Moores, J. and Batstone, C. (2019). Assessing the Full Benefits of WSUD. Research report to the Building Better Homes, Towns and Cities National Science Challenge.

MORE THAN WATER - WSUD Benefits Assessment

		Benefit	Level	Importance	Reliability
Water	Environmental	Hydrology	High	High	High
		Water quality	Med	High	High
		Aquatic habitat quality	Med	High	Low
		Drainage network and aquatic ecosystem connectivity	Low	High	Low
		Natural character (water bodies)	Med	Med	High
	Social	Supplementary water supply	High	High	High
		Reduced wastewater/CSO loading	Med	High	Low
		Drainage & flood management	High	High	High
		Climate change adaptation	Med	High	Low
		Recreation	Low	Med	High
		Provisioning (e.g. fishing)	Low	Med	High
		Connectedness with nature (water bodies)	Med	High	Low
Non-water	Environmental	Preservation of natural soils	High	High	High
		Microclimate management (UV, temperature, air quality)	Med	Low	Low
		Carbon sequestration and mitigation	High	Med	High
		Terrestrial habitat quality	Med	High	High
		Terrestrial ecosystem connectivity	Low	High	Low
		Natural character (land)	High	Med	High
	Social	Reduced building material consumption	Med	Med	High
		Infrastructure resilience	High	High	High
		Food & fibre production	Low	Low	Low
		Public safety	High	High	High
		Connectedness with nature (land)	Med	High	Low
		Community health and wellbeing	Med	High	High
		Property values	High	High	Low

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Note: If "N/A" is selected for "Level" then the benefit label disappears from the chart, as that particular benefit is deemed to be not relevant to the assessment of a particular project. However, if "None" is selected then the label remains, but no slice is shown - this represents the situation where a benefit is relevant to the assessment of a given project but is completely absent.

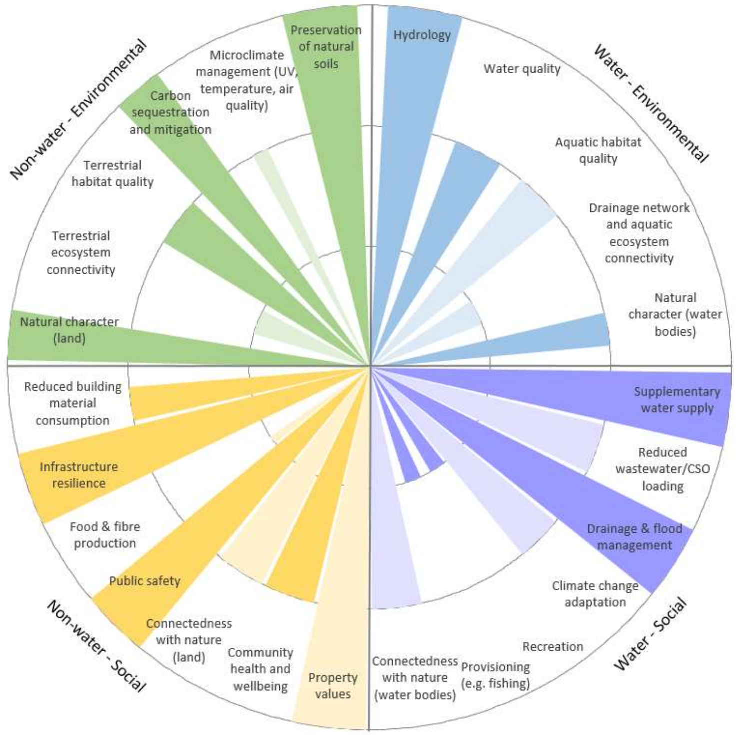


Figure 3-1: Screenshot of MTW benefits assessment worksheet

Table 3-1: Available input selections and corresponding representation

Factor	Selection	Chart display	Illustrative example (see Figure 3-2)
Level	High	Sector extends to perimeter	Hydrology
	Med	Sector extends 2/3 of distance to perimeter	Aquatic habitat quality
	Low	Sector extends 1/3 of distance to perimeter	Natural character (water bodies)
	None*	Sector missing, but label shown	Preservation of natural soils
	N/A*	Sector missing and no label	Infrastructure resilience
Importance	High	Wide sector	Terrestrial habitat quality
	Med	Narrow sector	Terrestrial ecosystem connectivity
	Low	Very narrow sector	Natural character (land)
Reliability	High	Sector colour relatively dark	Drainage & flood management
	Low	Sector colour relatively light	Climate change adaptation

* 'None' means the benefit is a relevant consideration for the assessment but is absent, while 'N/A' means the benefit is not a relevant consideration for the assessment.

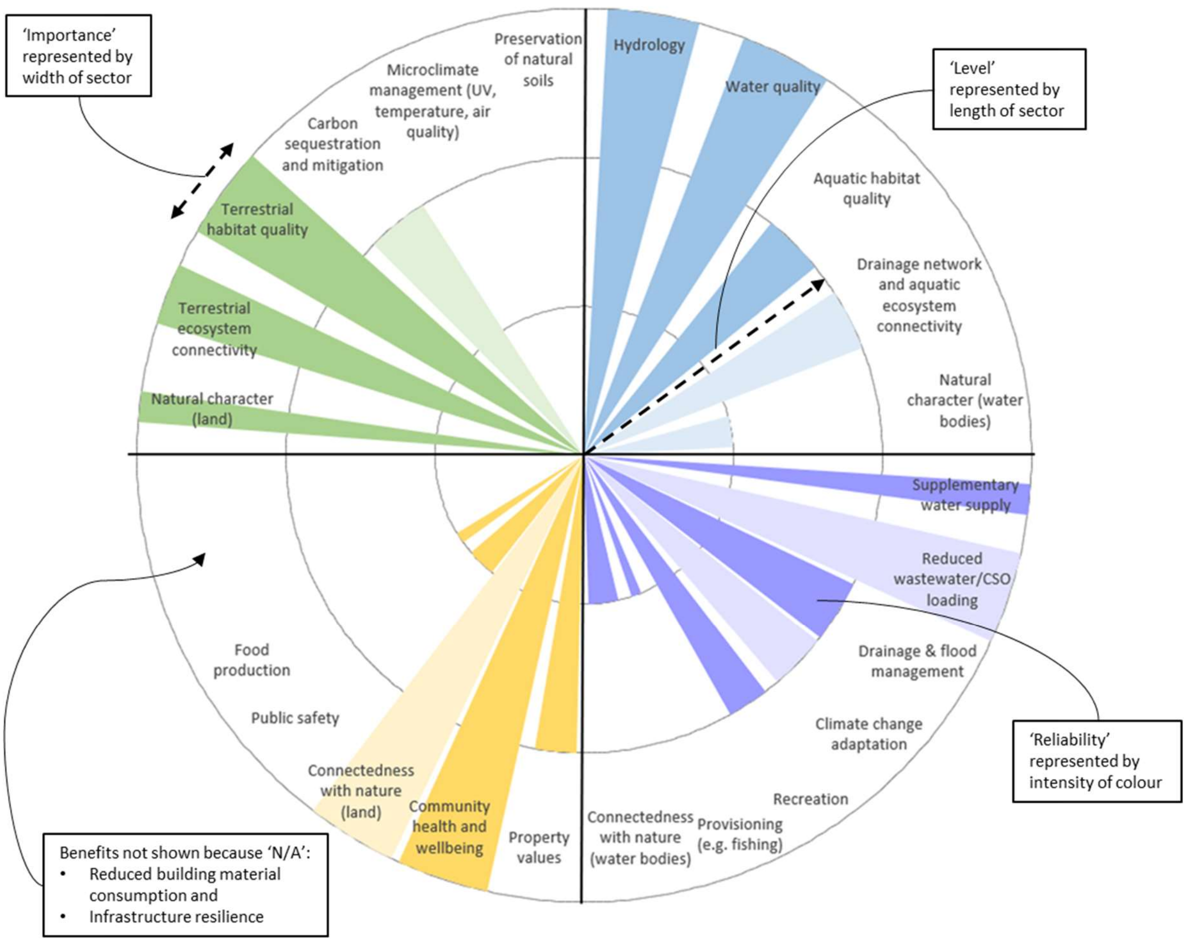


Figure 3-2: Illustrative example of a benefits assessment showing how the three factors 'level', 'importance' and 'reliability' are represented (refer to Table 3-1).

4 Case studies

4.1 Introduction

The use of MTW is illustrated by applying it to three case studies: the Kirimoko Park residential subdivision in Wanaka; AMETI; and Talbot Park Community Renewal project in east Auckland. The results presented below also appear in case study information sheets on the Activating WSUD website[14] as part of an integrated assessments of costs, benefits and maintenance features of these case studies.

The assessment results presented below are based on the combined expert judgement of the Activating WSUD research team. Reference was made to existing information, such as engineering design details, supplemented by observations made on-site and impressions gained from discussions with other parties involved in these projects. Other than work to estimate costs[15], no supporting data collection, qualitative analyses or modelling was undertaken. This approach was deliberate, demonstrating the ease with which the tool can be applied to make relative assessments of the benefits of alternative project scenarios. In both case studies the 'importance' of each benefit and cost criterion was held constant, as the research team did not to attempt to make judgements on the relative merits of different benefits on behalf of others.

4.2 Kirimoko Park

4.2.1 Background

Kirimoko Park is a 12ha subdivision in Wanaka, about 2km north of the town centre and 1km east of Lake Wanaka. The subdivision was conceived as a sustainable residential development project, with property owners subject to the 'Kirimoko Code' governing matters such as building size and location (to preserve views), materials and energy use. The development has been phased over three stages, between which there exists some variation in relation to stormwater management and road characteristics. In general, however, Kirimoko Park features a reduced construction footprint and lower level of imperviousness than neighbouring subdivisions, through the building of narrower roads and footpaths. Grass swales, infiltrating raingardens and detention basins manage stormwater (see Figure 4-1). The green infrastructure has used plants that perform well in Wanaka's environment, including many native species consistent with the natural character and biodiversity of the area. A more detailed description of Kirimoko Park can be found in the case study information sheet.

In the following case study, we have used the MTW tool to assess the benefits and costs delivered by Kirimoko Stage 2 compared with a hypothetical conventional development approach.

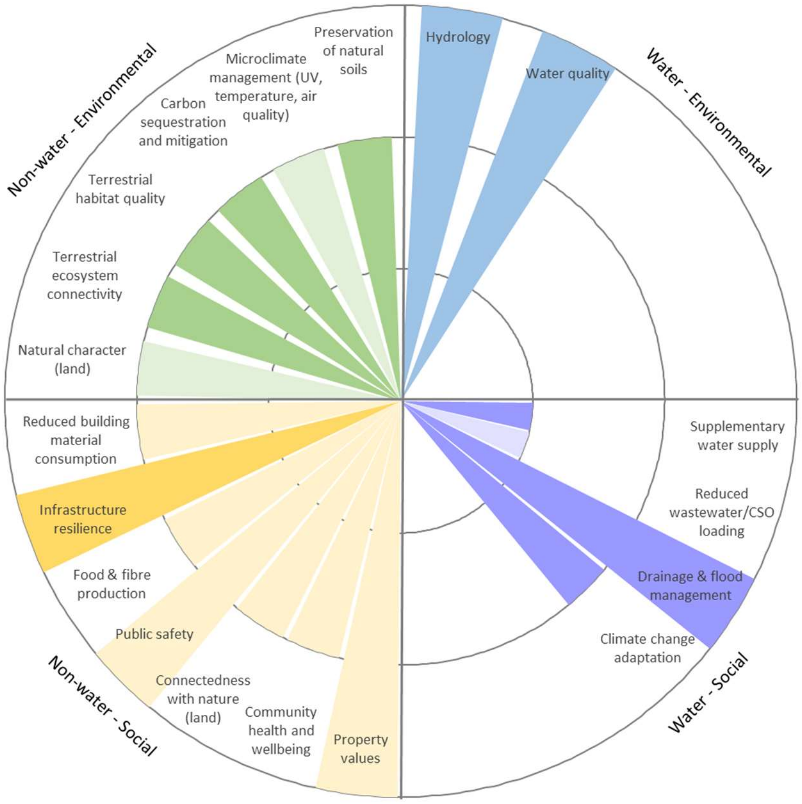
4.2.2 Results of assessment

Figures 4-2 and 4-3 present a comparison of the assessed benefits and costs, respectively, for Kirimoko Park Stage 2 as constructed and the hypothetical alternative ('business as usual', BAU). The BAU option was based on conventional subdivisions featuring reticulated stormwater networks. Six of the benefits criteria and one cost criterion were assessed as being not applicable and so are absent from the respective figures.

[14] http://www.landcareresearch.co.nz/science/living/cities,-settlements-and-communities/water-sensitive-urban-design/research-outputs

[15] Ira, S. and Simcock, R. (2019) Understanding Costs and Maintenance of WSUD in New Zealand. Research report to the Building Better Homes, Towns and Cities National Science Challenge.

Figure 4-1 – Photos of the Kirimoko Park development showing road and swale design (upper) and stormwater detention area (lower).



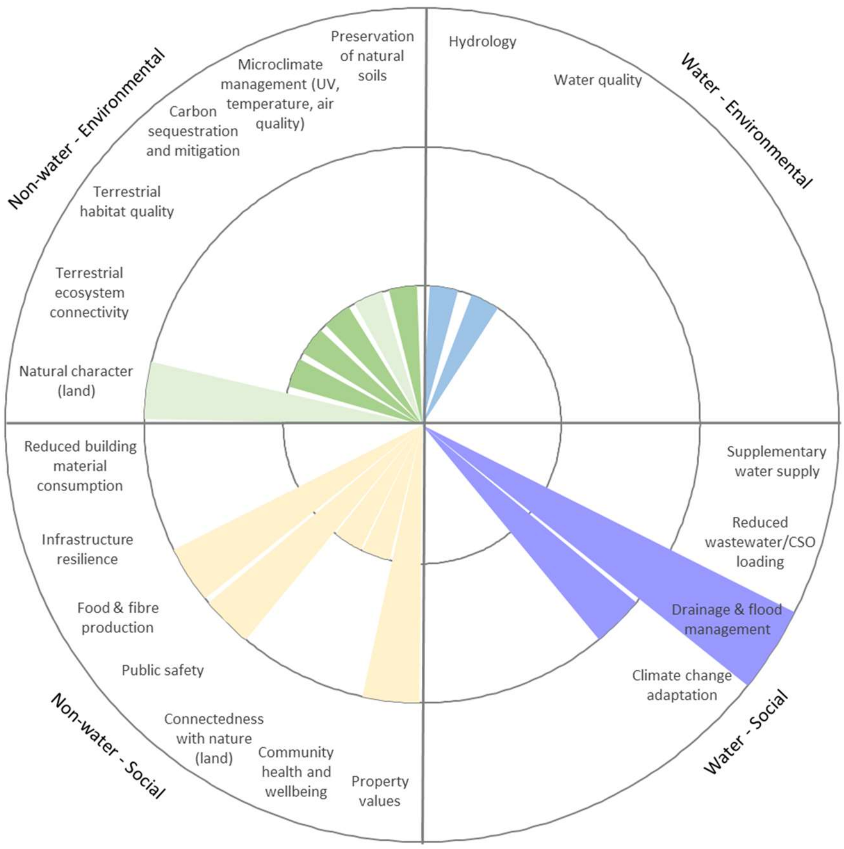


Figure 4-2 – MTW output showing assessed benefits for Kirimoko Stage 2 as constructed (upper) and hypothetical 'business as usual' alternative (lower).

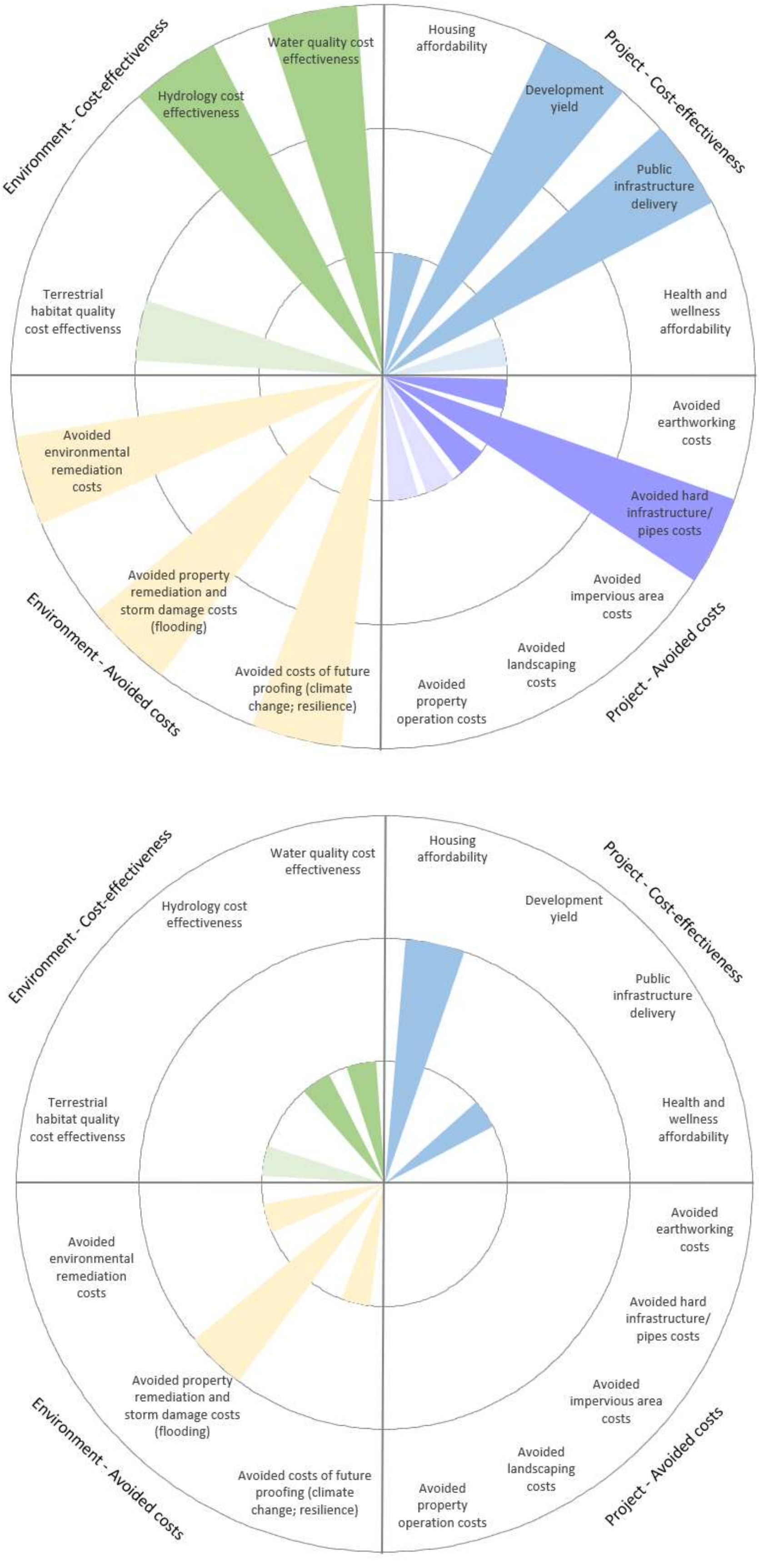


Figure 4-3 – MTW output showing assessed costs for Kirimoko Stage 2 as constructed (upper) and hypothetical 'business as usual' alternative (lower).

Stage 2 ‘as constructed’ was assessed as delivering markedly better outcomes than ‘business as usual’. Six benefits were assessed as being delivered at a high level by Stage 2, with four of these considered to be based on highly-reliable assessments. These benefits were: hydrology; water quality; drainage and flood management; and infrastructure resilience. In contrast the ‘business as usual’ was assessed as delivering only one benefit at a high level, this being drainage and flood management. Of the remaining benefits, the majority of these were assessed as being medium under Stage 2, compared with low under ‘business as usual.’ In both cases, the reliability of the assessment was considered to be low slightly more than half of the time.

Eight of the cost criteria were assessed as being delivered at a high level by Stage 2, with all but one of these considered to be based on highly-reliable assessments. These criteria were: private development yield; public infrastructure delivery; avoided hard infrastructure/pipes costs; avoided costs of future proofing; avoided environmental remediation costs; water quality cost effectiveness; and hydrology cost effectiveness. In contrast the ‘business as usual’ was assessed as delivering none of the cost criteria at a high level, with the majority assessed as low. A notable anomaly was housing affordability, which was assessed as medium under ‘business as usual’, compared with low under Stage 2. The reliability of the assessment of housing affordability was judged to be high.

4.2.3 Rationale

Tables 4-1 and 4-2 summarise the rationale for the assessed benefits and costs, respectively, indicating the basis for assessing both the level of and reliability of each assessment criterion.

Table 4-1 Rationale for assessed benefits – Kirimoko Park Stage 2 as constructed (AC) and 'business as usual' (BAU) alternative.

Benefit	Commentary
Water - Environmental benefits	
Hydrology	Focus is site runoff hydrology, as there is no receiving stream within the boundaries of the assessment. Stage 2 AC assessed as "High" based on use of swales and raingardens that infiltrate 80% of annual runoff. BAU assessed as "Low", based on highly modified hydrology associated with conventional pipe conveyance systems. Reliability "High" based on availability of design information.
Water quality	Focus is on site runoff quality, as water quality of receiving environment (Lake Wanaka) requires whole-catchment consideration. Stage 2 AC assessed as "High" based on use of swales and raingardens that infiltrate and treat 80% of annual runoff. BAU assessed as "Low", based on lack of treatment by conventional conveyance systems. Reliability "High" based on availability of design and land use information.
Aquatic habitat quality	N/A – no water bodies within boundaries of assessment.
Drainage network and ecosystem connectivity	N/A – no stream network within boundaries of assessment.
Natural character (water bodies)	N/A – no water bodies within boundaries of assessment.
Water - Social benefits	
Supplementary water supply	Stage 2 AC assessed as "Low" based on limited avoidance of landscaping irrigation due to stormwater infiltration in below-grade areas. BAU assessed as "None" based on absence of water re-use in conventional three-waters management. Reliability "High" based on availability of design information and site observations.
Reduced wastewater / combined sewer system loading	Stage 2 AC assessed as "Low" based on potential uptake of water conservation measures on private properties in accordance with the Kirimoko code, but all wastewater discharged to reticulated system. BAU assessed as "None" based on absence of water conservation in conventional three-waters management. Reliability "low" because assessment had no access to any evidence of conservation measures.
Drainage and flood management	Both Stage 2 AC and BAU assessed as "High" because, using different design approaches, both are designed to avoid flooding of public and private property. Reliability "High" based on availability of design information and site observations.
Climate change adaptation	Both Stage 2 AC and BAU assessed as "Medium" because, using different design approaches, both allow for changed rainfall intensity in stormwater design. More could be done to improve drought resilience by installing rainwater tanks. Reliability "High" based on availability of design information and site observations.
Recreation	N/A – no water bodies within boundaries of assessment.
Provisioning (e.g.: fishing)	N/A – no water bodies within boundaries of assessment.
Connectedness with nature (water bodies)	N/A – no water bodies within boundaries of assessment.

Non-water - Environmental benefits	
Preservation of natural soils, soil hydrological function and plants	Stage 2 AC assessed as "Medium" because of reduction in earthworks area and retention of area of remnant native vegetation (kanuka shrubland). BAU assessed as "Low" based on conventional earthworks approach, although protected remnant vegetation would have been retained. Reliability "High" based on availability of design information, photos of pre-development land cover and site observations.
Microclimate management	Stage 2 AC assessed as "Medium" because presence of street trees and lower impervious cover makes the site less vulnerable to heating, while more could have been done to create shady spots in public areas such as dry detention basins (replacing gravel-mulch with trees). BAU assessed as "Low" based on likely more limited use of trees and hedging in conventional approach to development. Reliability "Low" as lack of evidence on potential for GI to influence microclimate in relatively low-impervious environment.
Carbon sequestration and mitigation	Stage 2 AC assessed as "Medium" because presence of street trees, while more could through more widespread planting in dry detention basins, which double up as public spaces. BAU assessed as "Low" based on likely more limited use (wider spacing) of trees and replacement of hedges with fences in conventional approach to development. Reliability "High" given well-established link between vegetation biomass and carbon sequestration.
Terrestrial habitat quality	Stage 2 AC assessed as "Medium" because of extent, quality and proportion of no-mow, perennial vegetation on streets and private property, while more could through more widespread planting in public areas. BAU assessed as "Low" based on likely more limited use of trees and higher area of mown grass in conventional approach to development. Reliability "High" based on availability of design information and site observations.
Terrestrial ecosystem connectivity	Stage 2 AC assessed as "Medium" because extent of linkage of vegetated, unmown areas via streets, overland flow paths and private property. BAU assessed as "Low" based on likely more limited extent of unmown vegetated corridors and trees in conventional approach to development. Reliability "High" based on availability of design information and site observations.
Natural character (land)	Stage 2 AC assessed as "Medium" because of use of locally-characteristic native plant species and protection of view shafts to maintain views of surrounding landscape. BAU also assessed as "Medium" because likelihood of similar attention to aesthetic considerations in a high-value development, even if using a conventional development approach. Reliability "Low" because requires assessment by landscape architect.
Non-water - Social benefits	
Reduced building material consumption	Stage 2 AC assessed as "Medium" because of construction of narrower roads and footpaths and smaller building footprints than allowed by zoning. BAU assessed as "None" because maximum building material consumption likely in a conventional development. Reliability "Low" because assessment had no access to relevant evidence, other than road and footpath widths.

Infrastructure resilience	Stage 2 AC assessed as "High" because of design of stormwater system is highly modular and incorporates redundancy, some diversity and some multifunctionality (e.g. dry detention basins). BAU assessed as "None" because conventional pipe-based approach highly susceptible to failure. Reliability "High" based on availability of design information and site observations.
Food and fibre production	Stage 2 AC and BAU both assessed as "Medium" because plentiful opportunities for food production, given retention of free-draining soils on private property under either scenario. Reliability "Low" because based on limited observations of food production on site and unknown depth of replaced topsoil or amendments with organic matter.
Public safety	Stage 2 AC assessed as "High" because subdivision design and surrounding areas of Wanaka generally appealing places to live with potential for crime minimised, as per CPTED attributes (see Appendix A). BAU assessed as "medium" because of higher traffic-related risk without traffic calming measures. Reliability "Low" because requires assessment by experts in this field.
Connectedness with nature (land)	Stage 2 AC assessed as "Medium" because widespread presence of GI but natural values of the immediate area were depauperate prior to development (being grazed farmland). BAU assessed as "Low" based on likely more limited extent of green space in conventional approach to development. Reliability "Low" because requires assessment by experts in this field.
Community health and wellbeing	Stage 2 AC assessed as "Medium" because widespread presence of GI but the high natural values of the wider Wanaka environment may limit the influence of the locally-derived Kirimoko 'nature dose' on health and wellbeing. BAU assessed as "Low" based on likely more limited extent of green space in conventional approach to development. Reliability "Low" because requires assessment by experts in this field.
Property values	Stage 2 AC assessed as "High" because Kirimoko residential property values well above market average[16]. BAU assessed as "Medium" because, even with conventional development approach, the location of Kirimoko relative to the town and lake makes it likely that house prices would be above the market average. Reliability "Low" because analysis has yet to be conducted on the extent to which price premium reflects WSUD/GI approach, or other factors such as location relative to lake views.

[16] Exploratory data analysis showed statistically significant price premiums for Kirimoko Park residential sales of the order of 10-15%, similar to the international experience for WSUD developments. Additional spatial econometric analysis to establish relationships between WSUD features and those price premiums is beyond the scope of this project, but highly recommended as a fruitful direction for future research.

Table 4-2 Rationale for assessed costs – Kirimoko Park Stage 2 as constructed (AC) and 'business as usual' (BAU) alternative

Costs	Commentary
Project - Cost effectiveness	
Housing affordability	Stage 2 AC assessed as "Low" - while costs associated with the stormwater management approach (swales which discharge to soft rain gardens) are reduced, the individual lots have extensive landscaping requirements and covenants required through the Kirimoko Code. BAU assessed as "Medium" because the effect on housing affordability is around neutral due to the a traditional approach to subdivision design and infrastructure provision. Reliability "High" as a life cycle cost analysis was undertaken and some housing sales data were available for use.
Development yield	Stage 2 AC assessed as "High" because the development design plans show that some of the roads in Stage 2 were narrower than allowed for under the District Plan and sections were smaller and closer together than adjacent conventional subdivisions. BAU assessed as "None" because a conventional subdivision design would have no effect/change in development yields. Reliability "High" based on the engineering design plans and interviews with consulting engineers.
Public infrastructure delivery and maintenance	Stage 2 AC assessed as "High" as the developer paid for the delivery of the stormwater infrastructure while private homeowners are responsible for the maintenance of infrastructure via the residents association (RA). BAU assessed as "Low" - the infrastructure would be owned and operated by the network utility operator. Reliability "High" as the subdivision has been built and the residents association created (long term operations and maintenance included and budgeted for in the RA documents).
Health and wellness affordability	Stage 2 AC assessed as "Low" as the subdivision does not make good use of urban parks. The gravel detention basin could have been better integrated as a public space for the community. However, the area does use GI as traffic calming devices. BAU assessed as "None" because a conventional subdivision design would have no effect on existing health and wellness. Reliability "Low" as there is no local evidence for any changes in health and wellness affordability in this area.
Project - Avoided costs	
Avoided earthworking costs	Stage 2 AC assessed as "Low" because the avoided cost of reduced earthworks under the current development is estimated to be 13%. The site is not particularly steep and didn't lend itself to large-scale savings, even with a WSUD approach. BAU assessed as "None" as no costs are avoided through the conventional subdivision approach. Reliability "High" based on availability of engineer's estimates for a traditional vs "as constructed" approach for Kirimoko.
Avoided hard infrastructure costs	Stage 2 AC assessed as "High" because comparison of the Stage 2 "as constructed" with a conventional approach shows a 50% saving attributed to the use of swales instead of pipes. BAU assessed as "None" as no costs are avoided through the conventional subdivision approach. Reliability "High" as engineer's estimates are available for both scenarios.
Avoided impervious area costs	Stage 2 AC assessed as "Low" as the narrower widths led to an average avoided impervious area cost of 2%. BAU assessed as "None" as no costs are avoided through the conventional subdivision approach. Reliability "High" as engineer's estimates are available for both scenarios.

Avoided landscaping costs	Stage 2 AC assessed as "Low" due to the use of predominantly native vegetation, but the subdivision also includes deciduous trees which require autumn leaf removal, hedges that require regular trimming; and some very low native groundcovers that are vulnerable to invasion by pasture weeds. Some bollards and boulders used to protect swales and corners are expensive to replace when damaged. These increase costs. BAU assessed as "None" as no costs are avoided through the conventional subdivision approach. Reliability "Low" as costs have been inferred from observations of visible landscaping.
Avoided property operation costs (& reduced risk) of the built environment that can be delivered by GI	Stage 2 AC assessed as "Low". The Kirimoko Code lists specific 'sustainable features' and each property has to elect to use three of the features. One option is water efficient systems. Rain tanks were one of the 'additional options' and were only taken up by one person. BAU assessed as "None" as no costs are avoided through the conventional subdivision approach. Reliability "Low" as the assessment was inferred from information on building layout, the Kirimoko Code, energy systems and stormwater management plan.
Environment – Cost effectiveness	
Water quality cost effectiveness	Stage 2 AC assessed as "High" based on estimated water quality treatment cost performance with swales and raingardens. BAU assessed as "Low" – some treatment would be gained via the catchpits and infiltration basins, but at a high cost. Reliability "High" because estimates calculated using COSTnz costing models.
Hydrological cost effectiveness	Stage 2 AC assessed as "High" as the focus of the stormwater management plan was to dispose of stormwater via infiltration. Options were included for rain tanks, the level of earthworks and impervious surfaces were reduced. BAU assessed as "Low" – some attenuation would be gained via undersized culverts and infiltration basins, but at a high cost. Reliability "High" as the assessment is based on consented and constructed engineered design plans.
Receiving aquatic habitat quality/ stability cost effectiveness	N/A – no water bodies within boundaries of assessment.
Terrestrial habitat quality/stability cost effectiveness	Stage 2 AC assessed as "Medium" as the development incorporates some deciduous, non-native trees and does not fully create green space corridors or 'nodes'. While the GI devices themselves may be cost effective, the development does not also deliver fully on biodiversity values (these could have been boosted by planting more of the dry detention basins). BAU assessed as "Low" - slight reductions in additional landscaping may be achieved using a conventional approach. Reliability "Low" as based on expert opinion only.
Environment – Avoided costs	
Avoided environmental remediation costs	Stage 2 AC assessed has "High" as the Kirimoko Park development is self-mitigating and unlikely to create any additional environmental remediation costs to Lake Wanaka. BAU assessed as "Low" as the lack of treatment via GI and source control leads to increased environmental remediation costs. Reliability "High" based on assessments of quality and quality of stormwater via raingarden samples.

Avoided property remediation and storm damage costs (flood related)	Stage 2 AC assessed has "High" as the development would have been required to avoid impacts on properties downstream. Also the subdivision discharges to primarily to ground. BAU assessed as "Medium" as requirements to attenuate stormwater to reduce flood damage are consistent with a traditional approach to development. Reliability "Low" as based on expert opinion only.
Avoided costs of future proofing (climate change; resilience)	Stage 2 AC assessed has "High" as the design allows for climate change and also includes key principles of infrastructure resilience such as redundancy and modularity. BAU assessed as "Low" as it is likely that only climate change (increased rainfall) will have been taken into account through the design. Reliability "High" as the assessment is based on consented and constructed engineered design plans.

4.3 AMETI

4.3.1 Background

The Auckland Manukau Eastern Transport Initiative (AMETI) has been designed to '*create a dedicated, congestion-free busway between Panmure, Pakuranga, and Botany town centre*'. This case study focuses on the Panmure end of the project, where a combined busway/bus and train station and new Te Horeta road with its new cycling and walking paths was completed in 2013 and 2014.

The AMETI site is located in an industrial area featuring important Māori and European cultural histories which were largely hidden prior to the re-development. Stormwater is characterised by moderate to high contaminant levels, typical of runoff from areas of high traffic volumes and old (unpainted) galvanised roofing on some industrial buildings. This stormwater discharges into Panmure Basin (a tidal volcanic crater) and the Tamaki Estuary.

The AMETI stormwater design philosophy included minimising effects on the downstream receiving environment and providing efficient drainage to avoid any worsening of flooding. In the Panmure train station re-development these objectives were reflected in the use of green screen stormwater planters, extensive raingardens, tree pits and permeable paving (see Figure 4-4). The project also involved works in Van Damm's lagoon and reserve, which receives stormwater from the catchment prior to discharge to Panmure Basin. Additional value to the project was provided by revealing cultural histories, bringing people closer to the water by creating new wetland with lookout at William Harvey Place, and not discharging runoff from the new road into this new wetland, which also receives water from a culturally-important spring (which was not located). The process of discovery and co-design with mana whenua, included archaelological investigations and informed interpretation panels at both entrances to Van Damms Lagoon, and at William Harvey Place spring. Design included sculpture at Horoeka Road entrance, patterning on the newly covered main trunk sewer and naming of bridges and landforms .

A more detailed description of the AMETI project can be found in the case study information sheet[17].

In the following case study, we have used the MTW tool to assess the benefits and costs delivered by re-development of the train station area along Te Horeta Road and William Harvey Place wetland to Van Damm's lagoon, relative to a stormwater management approach that might conventionally be associated with a transport project. In this assessment it was assumed that the conventional

[17] http://www.landcareresearch.co.nz/science/living/cities,-settlements-and-communities/water-sensitive-urban-design/research-outputs

approach would avoid the use of GI (instead using underground filters and street sweeping to reach treatment standards required) and exclude any remediation of the Van Damm's lagoon other than improving outflow capacity to mitigate flooding. This BAU is effectively a 'worst case' scenario.

Figure 4-4 – Photos of the AMETI project showing transport interchange parking area (upper) and Van Damm's Lagoon (lower).

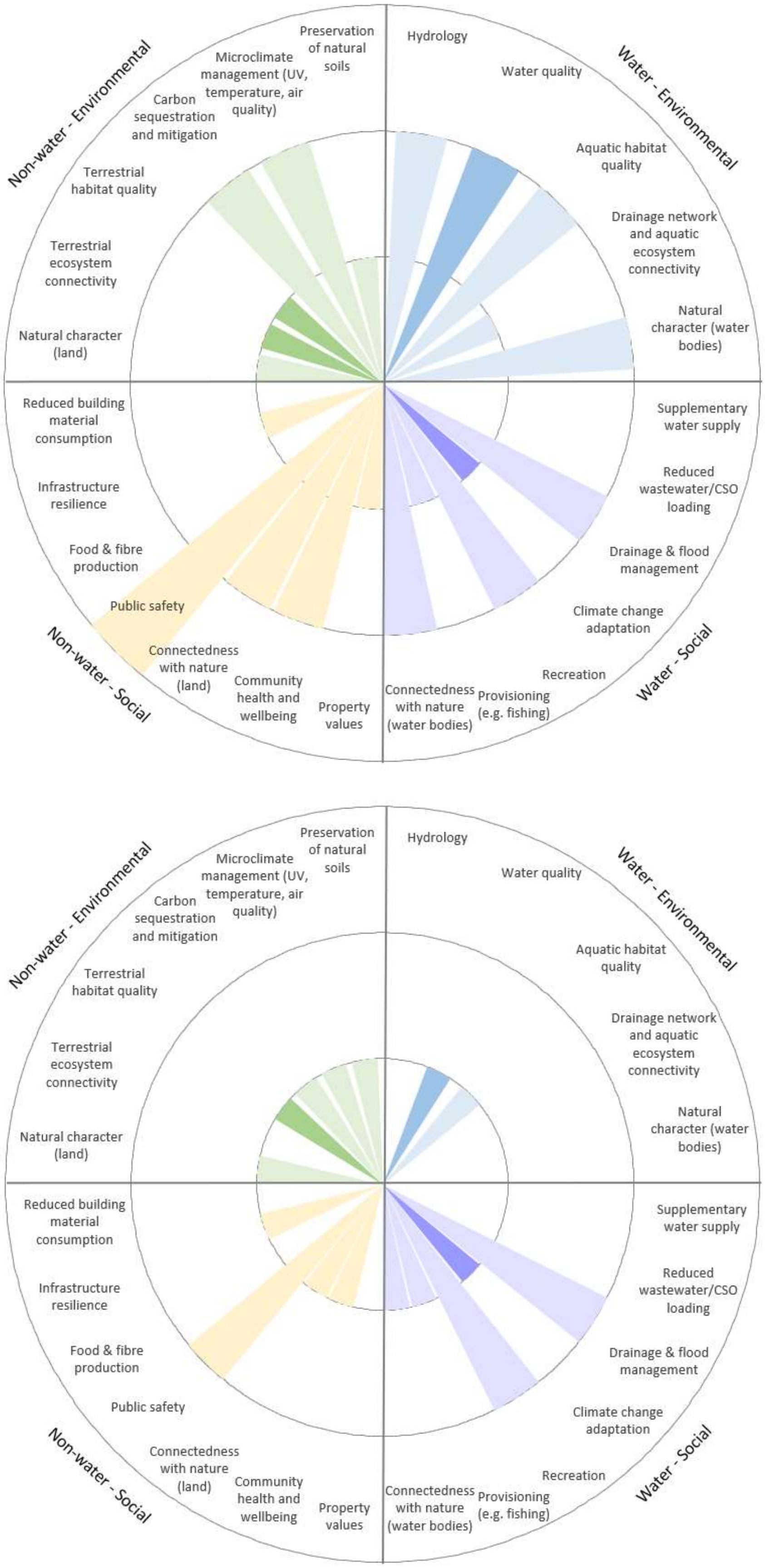


Figure 4-5 – MTW output showing assessed benefits for AMETI as constructed (upper) and hypothetical 'business as usual' alternative (lower).

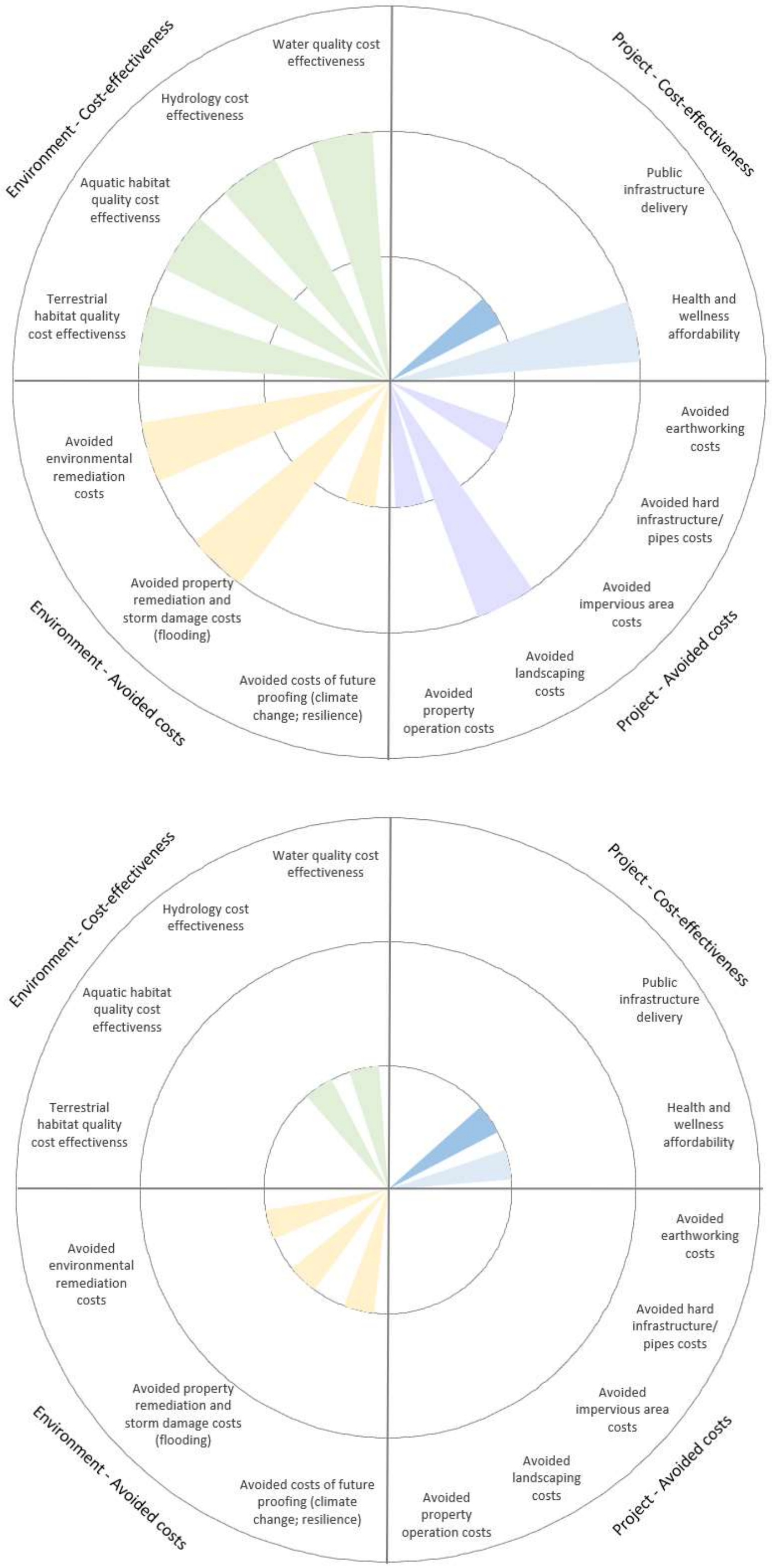


Figure 4-6 – MTW output showing assessed costs for AMETI as constructed (upper) and hypothetical 'business as usual' alternative (lower).

4.3.2 Results of assessment

Figures 4-5 and 4-6 present a comparison of the assessed benefits and costs, respectively, for AMETI as constructed and the hypothetical alternative (‘business as usual’, BAU). While all of the benefits were considered to be relevant for the assessment, two of the cost criteria were not (housing affordability and development yield) and are not shown in Figure 4-4.

AMETI as constructed was assessed as delivering better outcomes than ‘business as usual’, but with far fewer criteria assessed as “High” and with a lower reliability of assessment than was the case in the Kirimoko Park case study. Only one benefit was assessed as being delivered at a high level by AMETI (public safety). A further eleven benefits were assessed as “Medium” and these were well distributed between water/non-water and environmental/social. In contrast, ‘business as usual’ was assessed as delivering only three benefits at medium level, being drainage and flood management, recreation and public safety. The reliability of the assessment was considered to be low for all criteria, other than water quality, climate change adaptation, terrestrial habitat quality and terrestrial ecosystem connectivity.

None of the cost criteria were assessed as being delivered at a high level. Eight of the criteria were assessed as being delivered at a ‘Medium’ level by AMETI as constructed, half of these being environment-cost effectiveness criteria. In contrast, ‘business as usual’ was assessed as delivering seven of the cost criteria at a ‘Low’ level and seven not all (‘None’), including all five of the Project-Avoided Costs criteria. The reliability of the assessment was considered to be almost universally ‘Low’, the exception being the public infrastructure delivery criterion.

4.2.3 Rationale

Tables 4-3 and 4-4 summarise the rationale for the assessed benefits and costs, respectively, indicating the basis for assessing both the level of and reliability of each assessment criterion.

Table 4-3 Rationale for assessed benefits – AMETI as constructed (AC) and 'business as usual' (BAU) alternative.

Benefit	Commentary
Water - Environmental benefits	
Hydrology	AMETI AC assessed as "Medium" because of presence of some distributed stormwater management devices (raingardens and swale) as well as bottom-of-catchment devices. BAU assessed as "None" as based on highly impacted hydrology – Van Damm's Lagoon is at the bottom of the catchment and provides no hydrological control for upstream environments. Reliability "Low" because assessment was qualitative and was not based on modelling.
Water quality	AMETI AC assessed as "Medium" as project involves comprehensive use of treatment devices, while noting constraints on limiting imperviousness as it is a roading project. BAU assessed as "Low" as Van Damm's Lagoon with gross litter traps provides some treatment of stormwater, street sweeping frequency and catchpits provide some mitigation. Reliability "High" based on inference from land use status and stormwater design plan.
Aquatic habitat quality	AMETI AC assessed as "Medium" based on combined influence of better water quality and riparian habitat in freshwater system (with retention of raupo) and ecological values of Panmure Basin. BAU assessed as "Low" reflecting highly impacted urban stream environment, but recognising ecological values of Panmure Basin. Reliability "Low" as not based on any local evidence (e.g MCI scores or input from stream ecologist).
Drainage network and ecosystem connectivity	AMETI AC assessed as "Low" as the values of Van Damm's lagoon and connected stream are limited in extent - the catchment is extensively piped upstream. BAU assessed as "None" reflecting disconnected drainage system and ecosystems. Reliability "Low" as not based on any local evidence of ecosystem connectivity and functioning.
Natural character (water bodies)	AMETI AC assessed as "Medium" reflecting riparian planting along the stream and within the wetland area, removal of sediment to create deeper area in lagoon, and removal of weeds. BAU assessed as "None" as no attempt to mitigate previous stream modification. Reliability "Low" as not based on input of any expert in landscape assessment.
Water - Social benefits	
Supplementary water supply	Both AMETI AC and BAU assessed as "None" – project does not feature stormwater harvesting and re-use, for instance for use in station amenities or irrigation of nearby sportsfields. Reliability "High" based on design information and on-site observation.
Reduced wastewater / combined sewer system loading	As above.
Drainage and flood management	Both AMETI AC and BAU both assessed as "Medium", reflecting the objectives of the project which include managing flooding by reducing flood levels where possible, and assuming both projects would have added second outlet to the lagoon. Reliability "Low" because no information on the modelled flood extent considered in the assessment.

Climate change adaptation	Both AMETI AC and BAU both assessed as "Low" as climate change only taken into account via sizing of the stormwater management system. Reliability "High" based on knowledge of stormwater design plan and hydrological approach.
Recreation	AMETI AC and BAU both assessed as "Medium" based on likely delivery of similar level of recreational use of Panmure Basin as has existed historically (water skiing etc.) under both scenarios. Neither project considered contact recreation in the Basin or upstream waterways. AMETI AC project considered unlikely to markedly change water-based recreation. Reliability "Low" based on inference from current use.
Provisioning (e.g.: fishing)	AMETI AC and BAU both assessed as "Low" as wild foods and materials are present but probably only in very low abundance, with risk of human health effects from harvesting due to poor microbial water quality or elevated toxicant concentrations, and human access to areas is deterred (fencing excludes people from the upstream wetlands). AMETI AC project considered unlikely to markedly change water-based provisioning. Reliability "Low" based on inference from environmental condition.
Connectedness with nature (water bodies)	AMETI AC assessed as "Medium" as improvements to Van Damm's Lagoon have made this a more accessible public reserve, including new formal tracks/footpaths, with combination of natural and modified characteristics. New, naturalistic inlet waterfall and clear, rocky stream-channel immediately downstream boosts connectedness at low flows. Eels can be seen sometimes. BAU assessed as "Low" as the lagoon previously had highly impacted characteristics. Reliability "Low" as not based on input of any relevant expert.
Non-water - Environmental benefits	
Preservation of natural soils, soil hydrological function and plants	Given the site is in a brownfields area with limited natural soils and tree cover, both AMETI AC and BAU assessed as "Low". Both scenarios likely to have similar retention of older trees around Van Damm's Lagoon which was required under tree bylaws and through resource consent conditions that minimised damage and tree removal. Reliability "High" based on expert inference from observation and consent evidence.
Microclimate management	AMETI AC assessed as "Medium" as design includes significant number of (what will be) medium and large trees providing shade, along with locally-specific benefits of the 'green screens'. BAU assessed as "Low" as likely to exclude the large trees that are present in rain gardens and on bridges. Reliability "Low" as no differences in tree cover between the two scenario uncertain.
Carbon sequestration and mitigation	AMETI AC assessed as "Medium" and BAU assessed as "Low" based on description of tree cover given above. Reliability "Low" as given above.
Terrestrial habitat quality	Overall, AMETI AC assessed as "Low" (despite local "High" habitat quality provided by Van Damm's Lagoon) because station and wider transport project provides little in the way of terrestrial habitat. BAU also assessed as "low" based on presence of at least some vegetation. Reliability "High" based on expert inference from observation.
Terrestrial ecosystem connectivity	AMETI AC assessed as "Low" reflecting lack of perennial vegetated corridors with scattered refuges, although limited areas of green infrastructure and trees provide a degree of connectivity. BAU assessed as "None" based on likely presence of isolated and patchy vegetation. Reliability "High" based on expert inference from observation.

Natural character (land)	AMETI AC and BAU both assessed as "Low" as some large trees have been retained, along with use of local materials and plants from local ecosystems and/or heritage. Both may have retained a basalt outcrop in the train station. Reliability "Low" as not based on input of any expert in landscape assessment.
Non-water - Social benefits	
Reduced building material consumption	AMETI AC and BAU both assessed as "None" reflecting similar extent of impervious surfaces and pipe networks under both scenarios. Reliability "High" based on design information and observation.
Infrastructure resilience	AMETI AC and BAU both assessed as "Low" as conventional infrastructure has generally been used, while noting some provision of redundancy/spare capacity in stormwater design. Reliability "Low" based on limited knowledge of non-stormwater design features.
Food and fibre production	AMETI AC and BAU both assessed as "None" based on lack of food and fibre species in landscaping. Reliability "High" based on expert inference from observation.
Public safety	AMETI AC assessed as "High" as the proposal meets all six CPTED criteria (see Appendix A). BAU assessed as "Medium" as most CPTED criteria relating to public spaces would be met, but safety issues likely to remain in Van Damm's Lagoon reserve. Reliability "Low" because requires assessment by experts in this field.
Connectedness with nature (land)	AMETI AC assessed as "Medium" as Van Damm's Lagoon area and road corridor with wetlands and other landscaping provides good quality green space with easy access via formal tracks/footpaths and cycleways. A variety of seating and rest-areas (including grassed areas and wetland/lagoon lookouts) are provided. However, the project area as a whole lacks significant areas of relatively undisturbed or restored natural vegetation. BAU assessed as "Low" as Van Damm's Lagoon area would remain highly modified with limited opportunity to connect with nature (partly due to narrow paths with steep drops). Reliability "Low" as not based on input of any relevant expert.
Community health and wellbeing	As above.
Property values	Uncertainty arises from the likelihood that any observations of property price effects based in GI/WSUD will be interwoven with the location of the transport interchange itself having positive effects arising from ease of access to the wider region. The potential influence of the GI aspects of the project is constrained to the area bounded by the railway line and industrial premises, with the residential area around Van Damm's Lagoon likely to be the only properties that might benefit. AMETI AC assessed as "Low" as the improvements to Van Damm's Lagoon make this a perceived safer space and returning these properties to market neutrality (previously likely to be below market average). BAU assessed as "None" reflecting undesirable and unsafe nature of this environment. Reliability "Low" as not based on any relevant data or analysis.

Table 4-4 Rationale for assessed costs – AMETI as constructed (AC) and 'business as usual' (BAU) alternative.

Costs	Commentary
Project - Cost effectiveness	
Housing affordability	N/A – not a housing project, considered to be outside of the scope of the assessment.
Development yield	N/A – as above.
Public infrastructure delivery and maintenance	AMETI AC and BAU both assessed as "Low" because, despite difference in the use of GI and conventional approaches, both scenarios involve full ownership and operation of infrastructure by a public operator. Reliability "High" as ownership status is not the subject of any uncertainty.
Health and wellness affordability	AMETI AC assessed as "Medium" as health and wellness is moderately promoted through the use of isolated green infrastructure, public transport and traffic calming. BAU assessed as "Low" as design likely to feature only limited health related benefits, e.g. shading provided by retained large trees. Reliability "Low" as there is no local evidence for any changes in health and wellness affordability in this area.
Project - Avoided costs	
Avoided earthworking costs	AMETI AC and BAU both assessed as "None" as the project involves re-development of a reasonably flat site with an existing level of high imperviousness - likely to be no avoided earthworking costs. Reliability "Low" based on inference from general knowledge of the project area - assessment did not consider any specific cost data.
Avoided hard infrastructure costs	AMETI AC assessed as "Low" as potentially a low level of cost saving achieved via the use of green infrastructure, reducing the extent of expensive pipe upgrades and avoiding large underground vault that may otherwise be needed to treat stormwater. BAU assessed as "None" as a conventional approach likely to involve a fully reticulated stormwater network. Reliability "Low" based on inference from knowledge of GI approach - assessment did not consider any specific cost data.
Avoided impervious area costs	AMETI AC and BAU both assessed as "None" as project involves re-development with a high level of imperviousness. Reliability "Low" based on inference from general knowledge of the project area - assessment did not consider any specific cost data.
Avoided landscaping costs	AMETI AC assessed as "Medium" as some landscaping aspects are integrated with the use of GI, with some use of native vegetation and 'auto-watering' by stormwater. BAU assessed as "None" as in a conventional project landscaping is undertaken separately from and over and above a piped stormwater system and requires separate irrigation system. Reliability "Low" based on inference from landscaping plans - assessment did not consider any specific cost data.
Avoided property operation costs (& reduced risk) of the built environment	AMETI AC assessed as "Low" as property operation costs are slightly reduced as a result of integrating landscaping with GI practices. BAU assessed as "None" as conventional landscaping would need to be irrigated in summer and would require maintenance over and above any stormwater network maintenance works. Reliability "Low" based on inference from building layout design and the stormwater management system.

Environment – Cost effectiveness	
Water quality cost effectiveness	AMETI AC assessed as "Medium" as it features stormwater infrastructure which is relatively expensive to build and maintain but which provides a good level of water quality source control and treatment (i.e. the solution provides a reasonable level of cost effectiveness). BAU assessed as "Low" as costs to deliver an equivalent level of treatment using conventional methods likely to be very high. Reliability "Low" as based on inference from design information rather than any local water quality data.
Hydrological cost effectiveness	AMETI AC assessed as "Medium" as the level of attenuation provided for the cost of the infrastructure falls within this cost efficiency criteria. In this case, the GI provides a small degree of attenuation along with further attenuation through the pipe network (undersized culverts) and wetland. BAU assessed as "Low" because a system solely featuring a pipe network delivers lower attenuation for a higher cost. Reliability "Low" as based on inference from design information rather than any local hydrological data.
Receiving aquatic habitat quality/ stability cost effectiveness	AMETI AC assessed as "Medium" because water quality treatment and removal of sediments from Van Damm's lagoon delivers aquatic habitat outcomes while avoiding the costs of hard infrastructure modifications to the watercourse. BAU assessed as "None" as conventional modified channels deliver little habitat value for a high cost. Reliability "Low" as based on inference from design information rather than any local hydrological data.
Terrestrial habitat quality/stability cost effectiveness	AMETI AC assessed as "Medium" as GI provides habitat connectivity as a co-benefit without additional costs. BAU assessed as "None" as conventional landscaping unlikely to contribute to connectivity and duplicates some of the costs of having a separate pipe system. Reliability "Low" as based on inference from design information and site observations.
Environment – Avoided costs	
Avoided environmental remediation costs	AMETI AC assessed as "Medium" reflecting use of stormwater source control and treatment which provide a "minimum bottom-line" level of treatment, limiting additional contamination of the lagoons and reducing potential remediation costs. BAU assessed as "Low" due to the lack of source control and GI making further contamination (and future remediation) of the lagoons more likely, along with higher remediation costs. Reliability "Low" as based on inference from design information.
Avoided property remediation and storm damage costs (flood related)	AMETI AC assessed as "Medium" as stormwater ponds/wetlands are used to provide attenuation to reduce habitable floor level flooding and future remediation costs. BAU assessed as "Low" as likely to be no change in current flood remediation costs for brownfield areas resulting from a conventional version of the project. Reliability "Low" based on inference from engineering design documents and design plans.
Avoided costs of future proofing (climate change; resilience)	AMETI AC and BAU both assessed as "Low" as the stormwater design takes account of increased rainfall intensities, although no consideration given to building redundancy and modularisation into the stormwater system. Future costs associated with providing resilient systems are therefore likely to remain high. Reliability "Low" as based on inference from design information and site observations.

4.3 Talbot Park

4.3.1 Background

Talbot Park Community Renewal project aimed to improve living conditions for Housing New Zealand residents by providing medium-density housing, quality urban design and community strengthening that addressed key local concerns that included community and personal safety, lack of local employment and poor health. The project, completed in 2007, used WSUD and CPTED[18] principles to deliver sustainable urban design for 750 people within 219 homes. Iwi, conservation and recreational groups strongly supported sustainable design features.

The case study is of particular interest because although it is a housing development, the focus was social housing regeneration in which strict commercial considerations, e.g. development yield and price effects, had low priority. Social outcomes had more emphasis.

The redevelopment featured some of the first roadside raingardens in Auckland city. These are the most highly visible WSUD features, along with retention of several large specimen trees in prominent places and planting of new trees (see Figure 4-7). Other WSUD features include small areas of permeable paving and rainwater storage tanks on a variety of properties. These were plumbed to enable reuse in toilet flushing and garden watering, with top-up from mains water. Overland flow paths were retained, defined and protected from development by using permeable decks and plantings to passively exclude vehicles. A more detailed description of Talbot Park can be found in the case study information sheet[19].

In the following case study, we have used the MTW tool to assess the benefits and costs delivered by Talbot Park as constructed, relative to a conventional approach. The conventional approach was assumed to lack the use of GI for stormwater management but be the same as Talbot Park as constructed in all other respects, including urban design, building density and landscaping - because these elements were a key part of the project's focus on improving social outcomes.

4.3.2 Results of assessment

Figures 4-8 and 4-9 present a comparison of the assessed benefits and costs, respectively, for Talbot Park as constructed and the hypothetical alternative ('business as usual', BAU). Six of the benefits criteria and two cost criteria were assessed as being not applicable and so are absent from the respective figures.

Talbot Park as constructed was assessed as delivering better outcomes than 'business as usual', although the difference between the two scenarios was notably less marked across many criteria than was the case in the previous two case studies. In the case of benefits, 'business as usual' was assessed as delivering all of the non-water criteria at exactly the same level as Talbot Park as constructed (see identical left-hand sides of MTW outputs, Figure 4-5). This reflects the assumption that, for this assessment, the 'business as usual' version of Talbot Park uses trees and landscaping to the same extent as actually exists. The majority of non-water benefits were assessed as being delivered at a medium level under both scenarios, with two delivered at a high level (community health and wellbeing and property values). However, because plantings in the BAU version were assumed to provide no stormwater management function, the water benefits criteria were virtually all assessed to be 'none' (with two exceptions: Hydrology and Drainage and Flood management, assessed as low). In contrast, four of the water benefits criteria were assessed being present at a

[18] Crime Prevention Through Environmental Design. http://www.cpted.net/
[19] http://www.landcareresearch.co.nz/science/living/cities,-settlements-and-communities/water-sensitive-urban-design/research-outputs

medium level under Talbot Park as constructed. The reliability of the assessment of benefits criteria was high for six criteria, but otherwise low.

Eight of the cost criteria were assessed as being delivered at a medium level by Talbot Park as constructed, only three of these were also assessed as being delivered by the BAU. These were all project scale criteria: development yield, health and wellbeing affordability and avoided property operation costs. ‘Business as usual’ performed much more poorly than Talbot Park as constructed in terms of the assessed level of environment scale criteria (see left-hand sides of MTW outputs, Figure 4-6). The ‘as constructed’ version was assessed as delivering one criterion at a high level (avoided costs of future proofing) and four at a medium level. The BAU was assessed as failing to deliver on the majority of environment cost criteria (level of “none”), with three exceptions delivered as a low level. The reliability of the assessment of all cost criteria was considered to be low.

Figure 4-7 – Photos/plan of the Talbot Park re-development showing the area before redevelopment and as redesigned (source: Boffa Miskell, 2005) (upper) and road side rain gardens (lower).

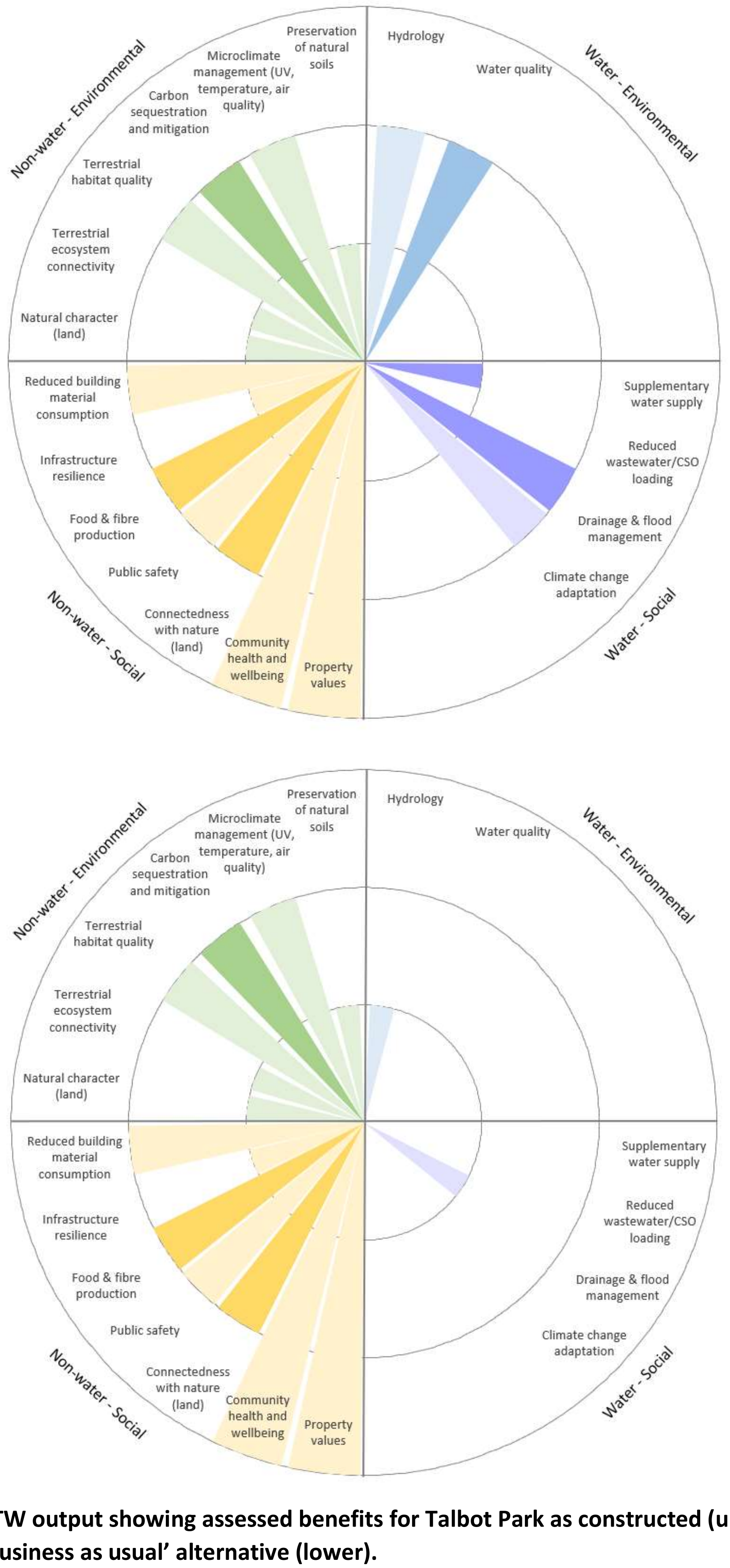


Figure 4-5 – MTW output showing assessed benefits for Talbot Park as constructed (upper) and hypothetical 'business as usual' alternative (lower).

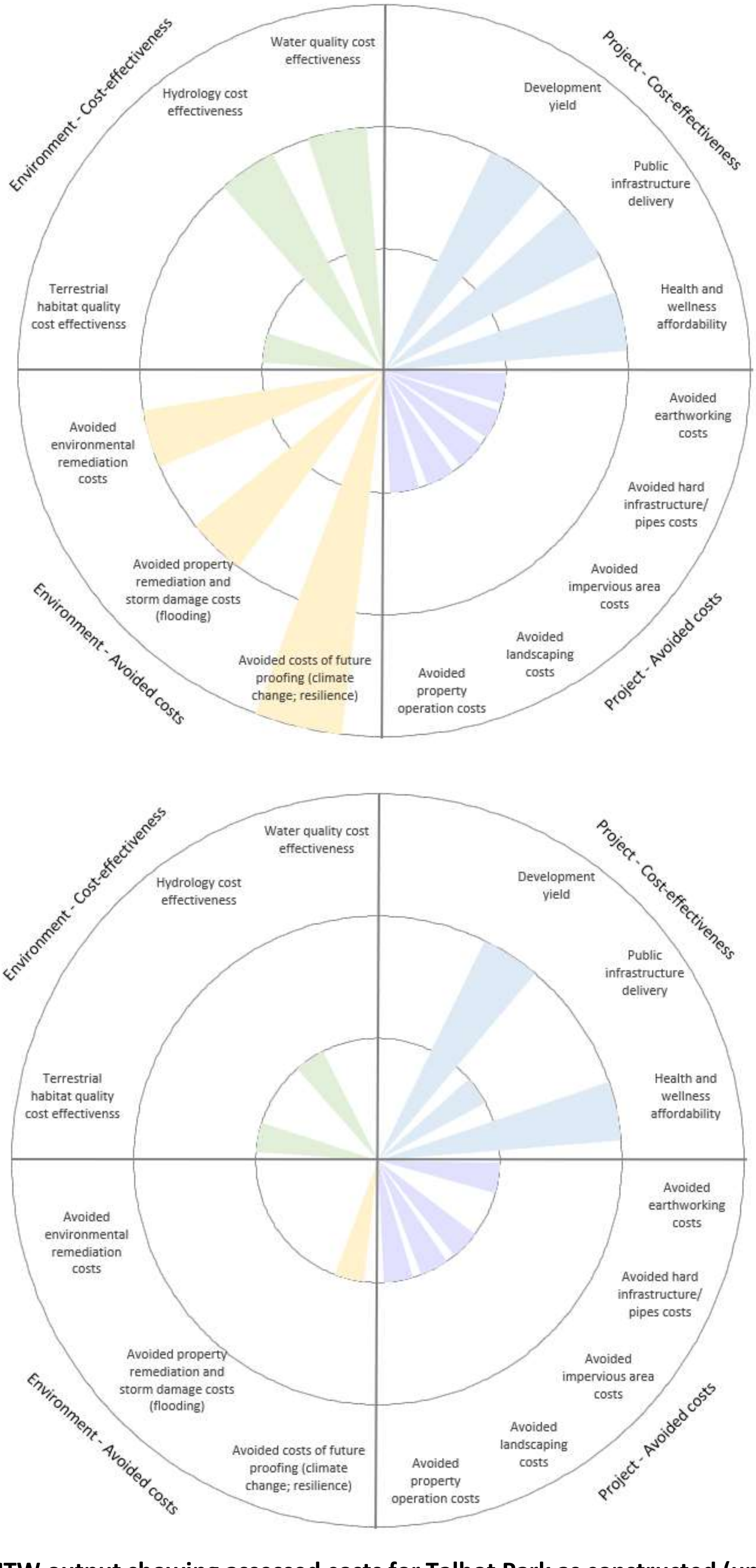


Figure 4-6 – MTW output showing assessed costs for Talbot Park as constructed (upper) and hypothetical 'business as usual' alternative (lower).

4.2.3 Rationale

Tables 4-5 and 4-6 summarise the rationale for the assessed benefits and costs, respectively, indicating the basis for assessing both the level of and reliability of each assessment criterion.

Table 4-5 Rationale for assessed benefits – Talbot Park as constructed (AC) and 'business as usual' (BAU) alternative.

Benefit	Commentary
Water - Environmental benefits	
Hydrology	Talbot Park AC assessed as "Medium", reflecting reasonably widespread use of raingardens rather than direct connection to pipe network, while use of rain tanks not fully exploited. BAU assessed as "Low", reflecting design which features lower imperviousness but would otherwise employ conventional drainage systems. Reliability "Low" based on inference from site observations.
Water quality	Talbot Park AC assessed as "Medium", reflecting widespread use of raingardens to provide treatment but absence of full treatment train approach. BAU assessed as "None", reflecting lack of treatment provided by conventional pipe system (conveyance only). Reliability "High" based on expert knowledge of stormwater system performance.
Aquatic habitat quality	N/A – no water bodies within boundaries of assessment.
Drainage network and ecosystem connectivity	N/A – no stream network within boundaries of assessment.
Natural character (water bodies)	N/A – no water bodies within boundaries of assessment.
Water - Social benefits	
Supplementary water supply	Talbot Park AC assessed as "Low", reflecting limited use of rain tanks on a minority of properties (and variable effectiveness). BAU assessed as "None" as rainwater capture and reuse unlikely in conventional development. Reliability "High" based on design information and site observations.
Reduced wastewater / combined sewer system loading	Both Talbot Park AC and BAU assessed as "None" as no evidence of any household water conservation practices that would reduce wastewater disposal and none likely in conventional development. Reliability "Low" as no recent information available on household water use.
Drainage and flood management	Talbot Park AC assessed as "Medium", reflecting protection of overland flow paths, while potential use of two reserves (redeveloped at the same time) for surface water storage was not taken up – but could have delivered major benefits, including for water quality. BAU assessed as "Low", based on assumption that a non-WSUD design would have failed to protect overland flow paths. Reliability "High" based on design information and site observations.
Climate change adaptation	Talbot Park AC assessed as "Medium", reflecting availability of additional spaces for constructing further raingardens (spare capacity/redundancy). BAU assessed as "None", based on conventional design failing to protect space for future construction of much larger end-of-pipe detention. Reliability "Low" based on inference from site observations.
Recreation	N/A – no water bodies within boundaries of assessment.

Provisioning (e.g.: fishing)	N/A – no water bodies within boundaries of assessment.
Connectedness with nature (water bodies)	N/A – no water bodies within boundaries of assessment.
Non-water - Environmental benefits	
Preservation of natural soils, soil hydrological function and plants	Both Talbot Park AC and BAU assessed as "Low" based on urban design which protected mature trees and retained reasonable areas of natural soils by adopting a lower imperviousness approach (irrespective of the use of GI for stormwater management). Reliability "Low" based on inference from site observations.
Microclimate management	Both Talbot Park AC and BAU assessed as "Medium" based on retention and planting of large trees and many medium-sized trees in public road and 'parklets' (irrespective of the use of GI for stormwater management). Reliability "Low" based on inference from site observations, no consideration of data on effects of tree shading.
Carbon sequestration and mitigation	Both Talbot Park AC and BAU assessed as "Medium" for the reason given above. Reliability "High" based on site observations of the extent of tree cover.
Terrestrial habitat quality	Both Talbot Park AC and BAU assessed as "Medium" based on retention of large trees, generally good quality of remnant garden landscaping and street landscaping (irrespective of the use of GI for stormwater management), although non-natives are used in raingardens, widespread use of mown grass in parks, and planting of weedy palms in parks are considered missed opportunities. Reliability "Low" based on inference from site observations.
Terrestrial ecosystem connectivity	Both Talbot Park AC and BAU assessed as "Low" because, despite good quality of street and original garden landscaping, the parks are considered a missed opportunity to provide ecosystem connectivity because they are mostly mown grass with sparse, mostly non-native trees. Reliability "Low" based on inference from site observations.
Natural character (land)	Both Talbot Park AC and BAU assessed as "Low" because, despite pocket-park and street landscaping, the parks are considered a missed opportunity to provide enhanced natural character in the area. Reliability "Low" based on inference from site observations.
Non-water - Social benefits	
Reduced building material consumption	Both Talbot Park AC and BAU assessed as "Medium" based on adoption of a relatively low-imperviousness development approach featuring clustering and multi-storey housing. Reliability "Low" based on inference from site observations.
Infrastructure resilience	Both Talbot Park AC and BAU assessed as "Low" based on adoption of limited resilience principles, e.g. spare capacity in setting aside land or sizing of pipes. Reliability "Low" based on inference from site observations.
Food and fibre production	Both Talbot Park AC and BAU assessed as "Medium" based on presence of soils suitable for vegetable and fruit growing and some uptake of this via some relatively large communal gardens and some private productive gardens. Reliability "High" based on observations of extent of communal gardens.

Public safety	Both Talbot Park AC and BAU assessed as “Medium” as almost all CPTED criteria met (see Appendix A), but potential for improvement by addressing abundance of litter. Reliability “Low” because requires assessment by experts in this field.
Connectedness with nature (land)	Both Talbot Park AC and BAU assessed as “Medium” as the area has some good quality green space with easy access via formal tracks/footpaths, while the project area as a whole lacks any significant areas of relatively undisturbed or restored natural vegetation. Reliability “High” based on observations of extent of green space.
Community health and wellbeing	Both Talbot Park AC and BAU assessed as “High” based on aspects such as extent and quality of green space, road design and public safety which are in marked contrast to some other state housing areas. Early reports about the project noted greatly reduced tenant turnover, but also that this was heavily influenced by responsiveness and management by Housing New Zealand. Reliability “Low” as not based on input of any relevant expert.
Property values	Both Talbot Park AC and BAU assessed as “High” based on low reported rental turn over rates compared to some other state housing areas. Reliability “Low” as based on anecdotal evidence.

Table 4-6 Rationale for assessed costs – Talbot Park as constructed (AC) and 'business as usual' (BAU) alternative.

Costs	Commentary
Project - Cost effectiveness	
Housing affordability	N/A – state housing development.
Development yield	In the context of the provision of social housing the assessment of development yield focused on the number and quality of dwellings delivered, rather than profitability or return on investment on the development. Both Talbot Park AC and BAU assessed as "Medium" as design featured narrower road corridors. While more dwellings could have been constructed this may have conflicted with community objectives. Reliability "Low" based on inference from project design.
Public infrastructure delivery and maintenance	Talbot Park AC assessed as "Medium" as the ongoing GI maintenance and delivery is shared between the public operator and Housing New Zealand tenants. BAU assessed as "low" as conventional infrastructure operation would have been fully in the public sector. Reliability "Low" based on inference from project design.
Health and wellness affordability	Both Talbot Park AC and BAU assessed as "Medium" based on likely health and wellness benefits of improved road safety and provision of green space that are present under both scenarios. Reliability "Low" based on inference from project design.
Project - Avoided costs	
Avoided earthworking costs	Both Talbot Park AC and BAU assessed as "Low", as project involved redevelopment of a relatively flat site and both scenarios would have had the same footprint. Reliability "Low" based on inference from project design.
Avoided hard infrastructure costs	Talbot Park AC assessed as "Low" as the rain gardens and rain tanks may have reduced the need for costly pipe upgrades. BAU assessed as "None" as conventional approach would have used full piped system. Reliability "Low" based on inference from project design.
Avoided impervious area costs	Both Talbot Park AC and BAU assessed as "Low" based on use of narrower roads in both scenarios. Reliability "Low" based on inference from project design.
Avoided landscaping costs	Both Talbot Park AC and BAU assessed as "Low" based on use of native plantings in either scenario. Talbot Park raingardens were damaged by sediment and physical injury during site buildout and most plants were replaced. Reliability "Low" based on site observations.
Avoided property operation costs (& reduced risk) of the built environment	Both Talbot Park AC and BAU assessed as "Low" based on retention of overland flow paths (reducing flood damage) and of large trees in both scenarios which may contribute to reduced energy use for summer cooling (where this is used). Impact on winter heating would depend on individual tree location, canopy form and if they are deciduous. Reliability "Low" based on site observations.
Environment – Cost effectiveness	
Water quality cost effectiveness	Talbot Park AC assessed as "Medium" based on use of raingardens for treatment of street runoff, including to manage observed spills, delivering good bang-for-buck in terms of contaminant removal. BAU assessed as "None" as conventional reticulated system provides virtually no treatment, so bang-for-buck is very poor. Reliability "Low" based on

	inference from project design.
Hydrological cost effectiveness	Talbot Park AC assessed as "Medium" based on stormwater retention in soils and enhanced evapotranspiration by trees and landscaping, narrower roads and limited use of rain tanks delivering hydrology benefits without costly hard infrastructure. BAU assessed as "Low" as landscaping would provide some benefit in terms of localised retention but conventional kerb and channel approach expected to offset benefit of narrower roads, so bang-for-buck poor. Reliability "Low" based on inference from project design.
Receiving aquatic habitat quality/ stability cost effectiveness	N/A – no water bodies within boundaries of assessment.
Terrestrial habitat quality/stability cost effectiveness	Both Talbot Park AC and BAU assessed as "Low" based on some use of native plants in street landscaping, with the larger parks considered a major missed opportunity to restore terrestrial ecosystems and deliver better bang-for-buck than the largely mown grass approach. Regularly mown grass is expensive to maintain and very little habitat value. Reliability "Low" based on site observations.
Environment – Avoided costs	
Avoided environmental remediation costs	Talbot Park AC assessed as "Medium" based on stormwater treatment delivering a neutral influence that does not add to water quality remediation of receiving environments required as a result of contamination from the wider catchment. BAU assessed as "None" as lack of stormwater treatment adds to need for remediation of receiving water bodies. Reliability "Low" based on inference from project design.
Avoided property remediation and storm damage costs (flood related)	Talbot Park AC assessed as "Medium" based on protection of overland flow paths avoiding surface flooding of properties. BAU assessed as "None" as overland flow paths not protected. Reliability "Low" based on inference from project design.
Avoided costs of future proofing (climate change; resilience)	Talbot Park AC assessed as "High" based on availability of space for future adaptation (not built out - further buildings and additional raingardens could be added), retention of large trees. BAU assessed as "Low" as similarly not built out but conventional approach to stormwater management costly to retrofit for climate change. Reliability "Low" based on inference from project design.

5 Applications of the Tool

As indicated in earlier sections, the MTW assessment tool is designed to enable qualitative assessments of the types and levels of benefits and costs delivered by WSUD/GI projects. In the case study examples presented in Section 4, the tool was used to compare the range and level of benefits and costs delivered by pairs of different scenarios.

Typically, we expect MTW will be useful for:

- comparing the benefits and costs of a GI proposal with those associated with a hypothetical 'business as usual' version of the same project;
- conducting a post-development assessment of the benefits and costs of completed projects that have differing levels of GI;
- comparing the merits of competing proposals for GI developments planned for different locations to support project prioritisation;
- identifying 'gaps' in proposed projects, where additional expenditure could deliver additional value, and who might fund this; and
- identifying projects for which there may be value in conducting further, more detailed assessments of benefits and costs.

A consistent theme in this range of applications is the use of the tool to compare outcomes relative to some counterfactual, baseline or alternative. This is generally likely to be a more informative use of MTW than simply applying it to a single project or proposal without a point of reference.

However, there are other potential applications of MTW beyond its use for a comparative analysis of benefits and costs. For instance, the tool could be used in collaborative planning exercises to help stakeholders identify objectives and prioritise the features that they would like a GI project to deliver. This 'reverse' use of the tool would involve collectively identifying, firstly, the importance of each benefit and/or cost criterion and, secondly, the level to which these attributes are currently delivered. Benefits and/or cost criteria with a high importance that are only being delivered at a low level (or not at all) would emerge as those most in need of addressing through project design. Additionally, by providing an indication on the distribution of costs within the value chain (i.e. public vs private vs developer costs) use of MTW can help to portray differences in the level of cost savings or efficiencies for particular stakeholders.

A further use of MTW is to help identify key gaps in an assessment, based on the evaluation of the importance of each benefit and cost, and estimates of the reliability of their assessment. Benefits and costs with a low level of reliability but which are assessed as being highly important can be prioritized for further evaluation, including data collection and quantitative analyses where appropriate. It may be the case that, with repeated application of the tool, recurring themes emerge showing that some benefits and costs assessments are consistently considered to have low reliability. This would indicate target areas for the further development of assessment methods to support application of the tool and for conducting assessments of GI benefits and costs more widely.

We suggest that, wherever possible, the use of the MTW tool takes place in a multi-disciplinary setting. While knowledgeable WSUD practitioners will be able to make an attempt at assessing all of the criteria, a comprehensive assessment will benefit from the input of specialists across a range of disciplinary fields (e.g., engineers, environmental scientists, economists and social scientists) and sectors (e.g., council, developers, consultants and community organisations). In the experience of the Activating WSUD team, MTW is well-suited to a workshop environment, and particularly workshopping supported by site visits, plans and pictorial renderings of outcomes. The results of the assessment can be displayed in real time, reviewed and reconsidered. With the guiding assessment tables (Appendix A) at hand, the workshop can record its rationale for each criterion, providing a benchmark for assessments of subsequent scenarios.

6 Limitations

The principal limitation of the MTW tool is that, consistent with its purpose, it will only provide qualitative[20] assessments of benefits and costs. The results of assessments are expressed graphically but not numerically. Benefits and costs are not scored or monetised, either individually nor in aggregate. This is deliberate: some benefits and costs are closely related and even overlap, depending on interpretation. By avoiding quantification and aggregation, the tool avoids the potential for double-counting of linked benefits and/or costs. Instead of trying to isolate benefit and cost criteria from one another, the tool aims to demonstrate the wide range of benefits and cost outcomes that can be associated with GI in a way that is accessible to multiple audiences, including those without a strong numeracy or technical background.

While the MTW tool can be used in stand-alone mode where a quick qualitative assessment is sufficient, it can also be used to provide a preliminary screening-level assessment of projects that can be followed up with more targeted analyses. For instance, the results of an assessment using MTW may justify attempting a more sophisticated cost-benefit or cost effectiveness analysis using methods summarized in the Activating WSUD benefits and costs reports.

MTW may not represent all the benefits and costs that could be associated with GI. Users may think of other assessment criteria, although the majority that appear in the international literature are reflected in the tool. There is no reason why further benefits and costs cannot be added in future revisions of the tool, particularly those related to specific cultural values or specific sites.

MTW uses coarse assessment scales. There are only four ‘levels’ of benefits and costs (high, medium, low and none), three levels of ‘importance’ (high, medium and low) and two levels of ‘reliability’ (high, low). However, constructing the tool with greater resolution would be challenging and likely to be subject to spurious accuracy. For instance, there is appeal in allowing the assessment of the ‘level’ of each benefit and cost to be made using a 0-5 or 0-10 scale, giving greater room to distinguish between alternative scenarios. The difficulty with constructing such a system is to develop narrative guidance that characterizes what each score in a five or ten-point range means. In developing the guidance tables, we found that the adoption of four levels represented a manageable (and sometimes challenging) framework for articulating sufficiently distinguishable narrative descriptions of variations in the level of benefits and costs.

MTW should not be considered a stand-alone, end product. As indicated previously, it is possible that use of the tool will throw up recurring themes in relation to which benefit and cost assessments are considered to be of low reliability. This will indicate a need for further research to develop more substantive assessment methods in these areas[21].

[20] Assessments using the MTW tool are ‘qualitative’ in the sense that they require no analysis of numeric data. The method employed by MTW can further be described as “a categorical assessment based on the interpretation of descriptive criteria.”

[21] Refer to the Activating WSUD ‘benefits’ and ‘costs’ reports for comments on further research needs to develop underlying assessment methods.

7 Summary and recommendations

The Activating WSUD project team has developed the More Than Water (MTW) tool for assessing the benefits and costs of WSUD/GI projects. The tool is available as an MS Excel file that can be downloaded from the Activating WSUD website. Use of MTW involves making assessments of the level, importance and reliability of a series of benefits and costs criteria, drawing on guidance information provided with the tool. While assessments can rely on expert judgement, they can also be informed by the results of supporting analyses, such as hydrological modelling, life cycle cost calculations, CIPTED scores, and Stream Ecological Valuation assessments where these are available.

Typically, use of the tool will compare an assessment of the benefits and costs of a WSUD project with those of an alternative, such as a 'business as usual' scenario employing conventional development practices. This approach has been demonstrated through the application of the MTW tool in three case studies: Kirimoko Park residential subdivision, the AMETI transport project and Talbot Park Community Renewal project. In all three cases, the use of the tool demonstrated that a GI approach delivers a greater range and level of benefits and performs better across a range of cost outcomes.

MTW can also be used in collaborative planning exercises to help stakeholders identify objectives and prioritise the features that they would like a GI project to deliver.

The current version of MTW (MTW 1.0) should not be considered an end-product. It has yet to be critically peer reviewed (outside of the Activating WSUD team) or used in real-world applications. While we have begun to explore how the tool can be developed further to provide for assessments to consider Te Ao Māori values, this remains a work in progress. We therefore make the following recommendations for its use and further development:

(1) The tool should be promoted as part of the Activating WSUD Phase 3 dissemination workshops.

(2) The real-world utility of MTW should be assessed by WSUD practitioners trialing the use of the tool in WSUD projects.

(3) A mechanism for feedback on the tool should be provided. Users could then make recommendations on the tool, including its performance, functionality, appearance and limitations. In the short-term this will be via the Activating WSUD website (however current funding concludes July2019).

Subject to further resourcing (i.e. beyond the completion of the research activities currently contracted to the BBHTC Science Challenge):

(4) Building on the findings of the Activating WSUD 'Te Ao Māori' workstream, the MTW tool should be further developed so that assessments can explicitly consider how well WSUD projects well recognize and provide for the values of Māori stakeholders.

(5) the Activating WSUD project team should explore opportunities to lead the application of the MTW tool in, for example, WSUD business case and collaborative planning projects.

(6) Revisions to the tool and supporting guidance material should be made to reflect feedback provided by WSUD practitioners, particularly landscape architects/urban planners to identify metrics and qualitative measures for terrestrial, non-water social benefits .

(7) Evidence on recurring themes, for instance on the most challenging aspects of making an assessment of benefits and costs, should influence the setting of priorities for research to develop underlying assessment methods.

Appendix A – Assessment tables

See the following pages for:

Table A1 – More Than Water (MTW) benefits assessment guide

Table A2 – More Than Water (MTW) costs assessment guide

Table A1 – More Than Water (MTW) benefits assessment guide

For each benefit, the assessment involves:

1. Determining the **LEVEL** of the benefit. The text under the column headings 'None' to 'High' is intended to help guide this assessment.
2. Determining the **IMPORTANCE** of the benefit. This is a subjective choice of the individual, communities or stakeholders making the assessment. Where assessments do not have access to information on the values of communities and/or stakeholders, 'importance' can be held constant for all benefits.
3. Determining the **RELIABILITY** of the assessment. The text in *italics* under the heading 'Benefits and assessment methods' provides guidance on methods that could be used to provide a high (evidence-based) level of reliability.

			Assessment Guide – Level of Benefit			
Domain		**Benefit** *and assessment methods**	**None**	**Low**	**Medium**	**High**
Water	**Environmental**	**Hydrology** *Quantitative methods:* • *Monitoring of stream water levels/flows for comparison of post-development and pre-development hydrology and/or comparison with control catchment.* • *Continuous simulation hydrological modelling.* • *Rainfall-runoff design event modelling.* *Qualitative methods:* • *Inference from stream geomorphology.* • *Inference from catchment land cover and design of stormwater infrastructure.*	Highly impacted hydrology: runoff volume and stormwater/stream peak flows much increased, while time-to-peak, groundwater recharge, low flow and, flow variability much reduced compared to undeveloped site or catchment. Likely to be the case in any conventional development. Exacerbating factors include highly compacted or shallow replaced soils, removal of trees/plants, removal of wetlands/seeps/ephemeral waterways, extensive imperviousness, a reticulated stormwater network and little or no volume control.	Limited mitigation of development impacts on hydrology: larger, bottom of site or catchment volume controls such as detention ponds and infiltration basins. Fails to manage surface flooding, stream base flows, or protect stream headwaters including ephemeral areas.	Comprehensive use of devices for volume reduction and detention, rather than avoidance at source by WSUD design. While extreme effects of urban development may be avoided, hydrological characteristics such as flow variability, groundwater recharge and low flows may be markedly different from an undeveloped site or catchment.	Runoff volume, stormwater/stream peak flows, time-to-peak, groundwater recharge, low flows and flow variability largely the same as in an undeveloped site or catchment. Likely to only be the case where soil compaction has been avoided, and/or soils enhanced to provide >600 mm rooting depth and 300 mm topsoil depth with organic matter additions (compost), imperviousness is very low (<10%) or disconnected from streams and widespread use of GI mimicking natural infiltration processes.
		Water quality *Quantitative methods:* • *Stream / receiving water body monitoring for comparison of post-development and pre-development water quality and/or comparison with control catchment.* • *Inference from stormwater/wastewater discharge quality monitoring.* • *Inference from biological metrics (e.g. MCI).* • *Continuous simulation water quality modelling.* • *Contaminant load modelling.* *Qualitative methods:* • *Inference from catchment land cover and design of stormwater infrastructure.*	Site runoff contains high concentrations of contaminants relative to undeveloped site. Highly impacted water quality in receiving water bodies through any one of: high concentrations of suspended solids, metals, nutrients and microbes relative to background water quality; spikes in summer water temperature; acute pollution (spill) events entering stream with regular frequency. Likely to be the case in any conventional development with a reticulated stormwater network and little or no treatment.	Limited mitigation of development impacts on water quality: bottom of site or catchment treatment only. Fails to protect stream headwaters, if present. Sediment reduced but metals or temperature spikes occur. Acute pollution (spill) events enter stream occasionally.	Comprehensive use of treatment devices, rather than avoidance at source by WSUD design. While extreme effects of urban development may be avoided, water quality likely to be markedly different from an undeveloped site or catchment.	Concentrations of suspended solids, metals, nutrients and microbes in site runoff and receiving water bodies largely the same as in an undeveloped site or catchment. Likely to only be the case where imperviousness is very low (<10%) and/or unconnected to streams and widespread use of source control and green technologies providing treatment.

		Aquatic habitat quality *Quantitative methods:* • *In situ habitat assessment methods (e.g. SEV, Riparian Function Assessment).* • *Inference from biological metrics (e.g. MCI).* *Qualitative methods:* • *Inference from stream geomorphology, riparian condition.* • *Inference from catchment land cover and design of stormwater infrastructure.*	Highly impacted habitat quality in water bodies, if present: streams piped, straightened and/or lined/reinforced and riparian vegetation absent or of low diversity and/or low height (e.g. mown grass). No overhanging vegetation.	If present, stream channel largely open and unmodified but unstable (slumping banks and/or incised areas). Overhanging riparian vegetation absent or providing little shade or leaf litter, no wood input, poor instream habitat with few deep pools or flood refuges.	If present, stream channel largely open and unmodified and stable. Riparian vegetation present but <10 m wide or providing limited shading and often of limited diversity with non-native and weed plants prevalent. Leaf input but little wood input; instream habitat has deep pools.	If present, stream channel geomorphology (channel form, pool & riffle sequences) and bed substrate largely the same as in an undeveloped site or catchment. Stream banks largely lined with diverse native riparian vegetation, providing shade and woody debris to stream.
		Drainage network and aquatic ecosystem connectivity *Quantitative methods:* • *In situ habitat assessment methods (e.g. SEV).* • *Stream mapping.* *Qualitative methods:* • *Water body visual screening assessments.* • *Analysis of aerial photographs/GIS layers.*	Disconnected drainage system and ecosystems, if present: open stream sections isolated by extensive piping and/or physical/chemical barriers to fish passage. Areas of intact aquatic habitat/riparian vegetation isolated by extensive sections of poor quality habitat. Headwaters absent.	If present, main stem of stream network largely open and connected, headwaters present but poorly connected to main stem due to extensive piping and/or physical/chemical barriers to fish passage. Areas of intact aquatic habitat/riparian vegetation isolated by extensive sections of poor quality habitat.	If present, main stem of stream network largely open and connected, but poorly connected to headwaters due to some piping and/or physical/chemical barriers to fish passage. Stream connected to wetlands and seepages within floodplain (i.e. providing flood zone habitat). Connected stream largely has good habitat quality.	Natural drainage network largely intact from headwaters to stream/river mouth and from stream to floodplain wetlands/seepages, if present, with little or no artificial barriers to fish passage and good habitat quality (instream and riparian, see above) maintained throughout.
		Natural character (water bodies) *Quantitative methods:* • *Geomorphological assessments* • *Vegetation surveys* • *Water quality monitoring* *Qualitative methods:* • *Water body visual screening assessments.* • *Analysis of aerial photographs/GIS layers.*	Highly impacted water bodies and riparian margins, if present: modified channels, poor water clarity, riparian vegetation absent, or featuring high proportion of introduced/pest species. Frequent rubbish in the stream; stream may have algal growths in summer and periodic oil slicks/evidence of pollution.	If present, stream channel largely open and unmodified. However, water clarity poor and riparian vegetation unhealthy, weedy or of low diversity (e.g. mown grass). Occasional rubbish/supermarket trolley.	If present, stream channel largely open and unmodified. Water clarity may be good but riparian vegetation of limited width and/or diversity and weedy non–native species prevalent.	Characteristics of water bodies and riparian margins largely the same as in undeveloped and unfarmed site or catchment: channel form and sinuosity, water clarity, riparian vegetation highly natural and not weedy, no rubbish present.
	Social	**Supplementary water supply** *Quantitative methods:* • *Metering and analysis of water usage from reticulated and harvested water sources.* *Qualitative methods:* • *Household/business water use surveys.* • *Inference from analysis of water supply network plans/as-builts.*	No water re-use: all stormwater and wastewater discharged to waste. Most landscaping areas are above grade and irrigated from potable water supply.	Limited rainwater capture and/or greywater re-use on a minority of individual residential properties. Many landscaped areas are below grade so stormwater runs from adjacent impervious surfaces into them, avoiding need for irrigation.	Rainwater capture and/or greywater re-use common on residential properties, but absent from public and commercial facilities (or vice versa). Landscaped areas treated to capture water, or reduce water use, e.g. mulching, use of meadows (not regularly cut lawns), water-harvesting within landscaping.	Widespread harvesting and use of stormwater and wastewater: rainwater tanks widely installed for domestic potable and non-potable uses; abstraction of detained stormwater from ponds/wetlands for landscape irrigation; recycling of household and commercial grey water for non-potable uses: e.g. toilet flushing.
		Reduced wastewater/CSO loading *Quantitative methods:* • *Monitoring of overflow frequencies and volumes.* • *Continuous simulation wastewater/stormwater network modelling.* *Qualitative methods:* • *Inference from catchment land cover and design of 3-waters infrastructure.* • *Inference from household/business water use surveys.* • *Inference from analysis of 3-waters network plans/as-builts.*	All wastewater discharged to reticulated network. In areas of combined systems, all stormwater discharged to reticulated network, resulting in frequent overflows of untreated sewage during commonly-occurring rain (more than monthly overflows).	Limited reduction in wastewater discharge as a result of grey-water recycling and/or water conservation and water use efficiency measures on a minority of individual residential properties. In areas of combined systems, all stormwater discharged to reticulated network, resulting in overflows of untreated sewage during commonly-occurring rain (more than quarterly).	Grey-water recycling and/or water conservation and water use efficiency measures common on residential properties, but absent from public and commercial facilities. Use of devices for stormwater volume reduction managed reduces frequency of combined sewer overflows to less than 2 times per year on average.	Much reduced discharge of wastewater as a result of grey-water recycling and/or water conservation and water use efficiency measures in domestic and commercial settings. Stormwater loading of combined systems avoided by source control, retention and volume control. No wastewater or combined sewer overflows.

		Drainage & flood management *Quantitative methods:* • *Monitoring of stream water levels/flows for comparison of post-development and pre-development hydrology and/or comparison with control catchment.* • *Measurement of surfacing flooding levels.* • *Continuous simulation hydrological and hydraulic modelling.* • *Rainfall-runoff design event modelling.* • *Analysis of flood incident reporting.* *Qualitative methods:* • *Inference from stream geomorphology.* • *Inference from catchment topography, drainage network, land use zoning and design of stormwater infrastructure.*	Frequent surface flooding due to runoff in excess of network capacity. If streams present, frequent out-of-bank flows and erosion-causing flows due to lack of volume control in network. Residential and commercial properties subject to repeated flood-related damage and/or transport connectivity interrupted.	Some management of flooding by bottom of site or catchment detention and/or stop banks, rather than by controls on floodplain development. Largely fails to deal with surface flooding and upper site or catchment flooding.	Surface flooding avoided or restricted to designated overland flow paths and flood storage basins/reserve land. Some management of flooding by bottom of site or catchment detention, rather than by controls on floodplain development.	Surface flooding avoided or restricted to designated overland flow paths and flood storage basins/reserve land. If streams present, out-of-bank inundations of natural floodplains at around the same frequency as undeveloped site or catchment, but with no impact on private property. Likely to only be the case where the natural functioning of floodplains is respected by avoiding incursion of the built environment.
		Climate change adaptation *Quantitative methods:* • *Continuous simulation hydrological and hydraulic modelling, using climate change scenario inputs (e.g. increased rainfall intensities, raised sea levels).* • *Rainfall-runoff design event modelling, with increased rainfall intensity.* *Qualitative methods:* • *Inference from catchment topography, drainage network, coastal characteristics, land use zoning and design of 3-waters infrastructure.* • *Inference from household/business climate-change readiness surveys.*	No consideration of changed rainfall intensities, drought frequency or sea level considered in the planning and design of urban development and water management. Gives rise to elevated risk of: under-capacity stormwater networks, under-sized stormwater management devices, water shortages, flood incidence (riverine and coastal), drought and heat-stressed landscaping with increased water demand.	Limited consideration of climate change implications in engineering design, for example in determining minimum habitable floor levels.	Climate change implications broadly considered in engineering design, for example in sizing stormwater systems as well as determining minimum habitable floor levels. Locations for potential additional treatment devices identified and protected. But lack of comprehensive wider planning for climate change (e.g. development zoning set back to avoid wider flooding, drought resilience).	Planning and design of the built environment incorporates additional set back reflecting forecast sea level rise and flooding extent. Stormwater systems (networks and devices) designed with spare capacity/redundancy to accommodate increased rainfall intensity. Widespread use of rainwater tanks for supplementary water supply.
		Recreation *Quantitative methods:* • *Stream / receiving water body monitoring.* • *Inference from stormwater/wastewater discharge quality monitoring.* • *Continuous simulation wastewater/stormwater network modelling.* *Qualitative methods:* • *Recreational use surveys.* • *Water body visual screening assessments.* • *Inference from catchment land cover and design of 3-waters infrastructure.*	If present, receiving waterbodies unsuitable for full or partial contact recreation, often with public signage: very high risk of human health effects from water contact due to poor microbial water quality (Concentrations of *E. coli* and/or *enterococci* indicator bacteria routinely above guidelines). More generally, water bodies unappealing for recreation, e.g.: poor water clarity, muddy bed sediments, excessive algal blooms/growth, gross pollutants present.	If present, receiving water bodies often suitable for partial contact recreation, but generally unsuitable for full contact because of frequent microbial contamination following rainfall.	If present, receiving water bodies generally suitable for full contact because of low level of microbial contamination. However, water bodies may be unappealing for recreation, e.g.: poor water clarity, muddy bed sediments, excessive algal blooms/growth, gross pollutants present.	If present, receiving waterbodies well suited to contact recreation: very low risk of human health effects from water contact due to excellent water quality (Concentrations of *E. coli* and/or *enterococci* indicator bacteria virtually always well below guidelines). Water bodies and riparian areas appealing for wide range of recreation, e.g.: good water clarity, sandy to pebbly bed sediments, limited algal blooms/growth.

		Provisioning (e.g. fishing, collection of plant-based foods and materials) *Quantitative methods:* • *Fisheries surveys.* • *Market and non-market economic based assessments of ecosystem service provision: prices in comparable markets, benefit transfer, contingent valuation, choice experiments[a].* *Qualitative methods:* • *Recreational and cultural use surveys.* • *Inference from water quality and biological metrics.*	If present, receiving water bodies represent poor wild food sources: e.g. fish, shellfish and water cress and materials such as reed and rush fibres absent or in very low abundance. Very high risk of human health effects from consumption of shellfish, watercress due to poor microbial water quality. Waterbodies unappealing for provisioning, e.g.: poor water clarity, muddy bed sediments, excessive algal blooms/growth, gross pollutants present.	If water bodies are present, wild foods and materials are present and either largely safe to collect and consume but only in very low abundance so harvesting is not practical or responsible, or moderate risk of human health effects from harvesting due to poor microbial quality or elevated toxicant concentrations.	If water bodies are present, wild foods and materials are safe to collect and consume and reasonably abundant, but water bodies may lack appeal for provisioning, e.g.: poor water clarity, muddy bed sediments, excessive algal blooms/growth, gross pollutants present.	If present, receiving water bodies represent sources of abundant wild foods and materials. Very low risk of human health effects from consumption of e.g. shellfish, watercress. Waterbodies appealing for provisioning, e.g.: good water clarity, sandy bed sediments, limited algal blooms/growth.
		Connectedness with nature (water bodies) *Quantitative methods:* • *Public surveys.* • *Market and non-market based economic assessments of ecosystem service provision: avoided costs in public health treatment processes; human capital approaches - lost contribution to regional and national economies; choice experiments and contingent valuation studies, hedonic spatial econometric studies of price formation in real estate markets[a].* *Qualitative methods:* • *Water body visual screening assessments.* • *Analysis of aerial photographs/GIS layers.* • *Inference from catchment topography, drainage network, coastal characteristics, land use zoning and design of 3-waters infrastructure.*	If present, water bodies hidden from public view and/or with very limited access: restricted by private property rights and/or little or no provision of safe/easy accessways within public reserves. Water bodies and riparian margins typically highly impacted: modified channels, poor water clarity, riparian vegetation absent, or featuring high proportion of introduced/pest species.	If present, water bodies informally accessible within public reserves but typically highly impacted: modified channels, poor water clarity, riparian vegetation absent, or featuring high proportion of introduced/pest species.	If present, water bodies accessible within public reserves, including via formal tracks/footpaths, with combination of natural and modified characteristics: for instance good water clarity but exotic riparian vegetation.	If present, water bodies celebrated as community assets and easily accessed: stream and coastal margins in public ownership with wide provision of footpaths and accessways. Characteristics of water bodies and riparian and coastal margins largely the same as in undeveloped site or catchment: channel form and sinuosity, water clarity, riparian vegetation composition.
Non-water	Environmental	**Preservation of natural soils, soil hydrological function and plants** *Quantitative methods:* • *Measurement of earthworks extent (area/volume).* • *Measurements of retained natural land cover, tree canopy and topsoil volume.* • *Assessments of rooting depths/volumes, infiltration rate,soil permeability and soil moisture storage.* *Qualitative methods:* • *Visual assessments of soil properties (depth, structure) and heterogeneity.* • *Inference from plans/design drawings of extent to which terrestrial hydraulic connections between topsoils and subsoils, and subsoils and groundwaters, seepage zones and surface waters are present and functional.*	Land development features widespread removal of plants, leaf litter layers and topsoil and/or reinstatement of 100 mm or less of topsoil over earth-worked subsoils. Removal of trees >8 m height or >40 years old. Significant loss of soil physical quality (water storage capacity, air capacity and permeability) and heterogeneity. Alteration/removal of natural water flows between topsoils, subsoils, aquifers and seepages. Natural nutrient and water cycling replaced by fertilizer- and irrigation-based regime.	Retention of some older plants (especially trees) and/or ecosystems (especially wetlands,seepages and riparian zones) with buffer zones that are at least to edge of the plant dripline. Soils in green spaces have around 400 mm rooting depth of which around 200 mm is topsoil from on-site.	Retention of most older plants (especially trees) and/or ecosystems (especially wetlands, seepages and riparian areas) with enhanced buffer zones (larger or soil-amended). Soils in green spaces have around 600 mm rooting depth of which around 200 mm is topsoil and/or these topsoils are amended with around 100 mm depth of compost, arborist mulch or leaf litter to enhance hydrological function. Most green spaces are below grade to reduce irrigation needs and allow passive irrigation.	Land development retains significant areas of remnant native ecosystems where present and avoids widespread removal of topsoil. Most likely to be achieved by minimising the built footprint. Topsoils and suitable soil from excavated areas retained for reuse on-site in greenspaces and enhanced to deliver deep rooting depths, minimise irrigation, allow trees to reach full potential heights, especially trees over 8 m height. Connections between topsoils and subsoils, and subsoils and groundwaters, seepage zones and surface waters are present and functional.

		Microclimate management (UV, temperature, air quality) *Quantitative methods:* • *Meteorological and air quality monitoring for comparison of post-development and pre-development microclimate and/or comparison with control sites.* • *Microclimatic and air quality modelling.* *Qualitative methods:* • *Inference from land use zoning, urban design and extent of tree cover, species and canopy characteristics (e.g. height, spread, density, seasonality and relationship to built infrastructure).*	Trees and 'bulky' (shrub and climbing plant) green space virtually absent from the built environment and public spaces. Absence of shading and screening properties from tree and/or vine canopies contributes to high rates of UV exposure, elevated summer temperatures and circulation of atmospheric particulate matter, elevating the risk of a range of adverse human health effects.	Limited provision of isolated green spaces and small trees (<6 m height), and/or green spaces mainly private with public spaces in hard infrastructure or regularly mown grass with minimal shelter provided by vegetation; trees largely absent at street scale. Trees are placed in hard surfaces or mown grass, not perennial unmown vegetation.	Well distributed green spaces or connected larger green spaces with high proportion of complex vegetation (high leaf surface and volume) in public spaces, especially those where people spend most of their time or visible from public spaces. Moderate proportion of regularly mown grass with significant areas of shrubs, meadows, wetlands and other more complex vegetation. Trees also present at street scale, but mainly at low density or at higher density but less than 6m height at maturity. Trees mainly underplanted with perennial vegetation that is not mown.	Trees widespread throughout the built environment including large trees (>10 m height at maturity and with root volume to support this height). Tree and/or vine canopies provide shading and screening to reduce UV exposure, moderate high summer temperatures and intercept atmospheric particulate matter. Abundant, well distributed green spaces provide 'oases' of moderated climate and better air quality. Meadows or perennial groundcovers dominate over regularly mown grass. Landscaping complements water-related features of WSUD in contributing to climate change adaptation.
		Carbon sequestration and mitigation *Quantitative methods:* • *Carbon budget assessments.* *Qualitative methods:* • *Inference from land use zoning, transport networks, urban design and extent of tree and wetland cover.*	Bulky vegetation and/or wetlands virtually absent from the built environment; most plants are in limited monocultural form (mown lawns or terrestrial groundcover <1 m height). Carbon uptake by plants insignificant relative to output from transport, heating, industry etc.	Areas of shrubs, hedging, vines and small trees in isolated green spaces and street scale provide for limited carbon sequestration.	Areas of shrubs, hedging, vines and trees in well distributed green spaces provide for carbon sequestration. Large trees and/or significant areas of wetlands also present, but mainly at low density.	Widespread vegetation, especially large trees and/or vines or wetlands (including mangrove wetlands), acts as significant sink of carbon. Complements water-related features of WSUD in contributing to climate change adaptation.
		Terrestrial habitat quality *Quantitative methods:* • *Vegetation and habitat surveys (presence of key features such as tall trees, dense shrubby vegetation, structural dead wood, accessible water supply or unmown grass), dominance of native plant species, especially trees.* • *Inference from biological metrics (e.g. bird surveys, insect surveys).* *Qualitative methods:* • *Inference from catchment land cover, urban design, extent of tree cover and species used, connectivity with existing natural areas, and proposed maintenance – particularly the frequency and degree of disturbance.*	Vegetation virtually absent from the built environment, or present in limited and/or regularly disturbed monocultural form (e.g. conventionally mown lawns). Non-native and weed species dominate landscaping and/or 'green' areas. No guidance to new owners on complementary planting or maintenance, especially in developments containing, or adjacent to, natural ecosystems.	Isolated, small green spaces provide limited terrestrial habitat, but often highly modified, regularly disturbed and poor quality (e.g. dominated by exotic plant species and lacking plant species and structural complexity). Absence of pest control (particularly rats).	Well-distributed green spaces, including one or more larger areas dominated by native plant species. Limited areas of natural vegetation provide mixed quality terrestrial habitat, including areas that have complex plant structure (including tall plants or vines with high density of cover), and infrequent disturbance. Input or accumulation of logs and leaf litter. Weeds are controlled.	Presence of significant areas of relatively undisturbed and/or rehabilitated native vegetation with deliberate enhancement of habitat features for native fauna (e.g. dead wood/wood piles, vines and epiphytes, provision of specific plant species that provide food, rock piles that create refuges and deep leaf-litter layers. Sustained removal of weeds and pests. Remnant areas are well-buffered.
		Terrestrial ecosystem connectivity *Quantitative methods:* • *Vegetation and habitat surveys.* • *Inference from biological metrics (e.g. bird surveys, insect surveys).* *Qualitative methods:* • *Inference from catchment land cover, urban design and extent of tree cover.* • *Analysis of aerial photographs/GIS layers.*	Green space largely absent from the built environment.	Lack of perennial vegetated corridors. Scattered refuges (at ground level or as tree or vine canopy) and/or 'habitat stepping stones' unlinked to adjacent or site green spaces.	Well-distributed green spaces linked by green corridors of permanent vegetation with refuges in places, or by 'habitat stepping stones', for example low density tree planting with underplanted raingardens along the street network.	Widespread green space is linked by habitat stepping stones and a variety of vegetated corridors to maintain or restore a network of connected and complementary ecosystems, including following the margins of the natural drainage network.

		Natural character (land) *Quantitative methods:* • *Geomorphological assessments* • *Vegetation surveys* *Qualitative methods:* • *Visual screening assessments.* • *Analysis of aerial photographs/GIS layers.*	Predominantly built environment with highly modified landforms, for instance regular cut and fill / terracing. Perennial, unmown vegetation virtually absent from the built environment. Materials used in construction and landscaping do not reflect local geology. No reference to broader landscape or site histories.	Some pre-development land forms and large trees/outcrops retained but elsewhere natural character obscured by the built environment. Isolated green space and vegetation. Materials used in construction of public places may reflect local geology; some landscaping uses plants from local ecosystems and/or heritage but often as understorey (not trees) or individual species are planted alone - without their 'natural' community.	Pre-development land forms and large trees are largely retained and visible from public areas. Views to significant external landforms are retained (e.g. mountains, cliffs, watercourses). Elsewhere natural character remains obscured by the built environment. Most materials used in construction reflect local geology; most visually-dominant landscaping reflects local ecosystems (including trees), particularly in public areas.	Presence of areas of relatively undisturbed or enhanced natural landforms and vegetation. Sympathetic urban planning and design maintains natural character throughout built areas. Views to significant external landforms are retained (e.g. mountains, cliffs, watercourses). All materials used in construction reflect local geology; all landscaping reflects local ecosystems ad uses groups of plants in their natural context.
	Social	**Reduced building material consumption** *Quantitative methods:* • *Comparative quantity surveys (pre-development and/or as-built).* *Qualitative methods:* • *Inference from catchment land cover and infrastructure design.* • *Analysis of aerial photographs/GIS layers.*	Use of conventional development practices to maximum extent allowed by zoning rules: sprawling single storey buildings, wide roads and large areas of other paving, maximising the use of concrete and asphalt. Construction activities generate a large amount of waste. Stormwater conveyance uses extensive networks of concrete pipes.	Limited reduction in building materials use achieved on public land, for instance by preservation of limited areas of greenspace. Property development generally follows a conventional approach, in terms of building design and generation of construction waste.	Narrower roads and footpaths in some areas results in reduced use of concrete and asphalt. Some private property development adopts efficient design principles (e.g. multi-storeys, shorter/narrower driveways and paved areas).	Widespread efficient design of buildings (e.g. multi-storeys, clustering) and narrow street design limits use of concrete and asphalt, relative to what is allowed by zoning rules. Construction waste minimised through efficient procurement and recycling. Widespread use of green technologies (swales) for stormwater conveyance avoids need for pipe networks.
		Infrastructure resilience *Quantitative methods:* • *Continuous simulation network modelling, using natural disaster scenario inputs (e.g. partial failure of network).* *Qualitative methods:* • *Inference from catchment natural hazard assessments (type, scale and location) and infrastructure design.*	Use of conventional infrastructure which is highly susceptible to damage and disruption. Lack of diversity or redundancy likely to lead to system failure in event of a natural disaster.	Use of conventional infrastructure, but with greater provision of redundancy/spare capacity (e.g. sizing of pipes, design of pump stations) than allowed for by a conventional 'safety margin'.	Resilience considered in urban design, but focuses on response to natural disasters. Locations for backup infrastructure, transport routes etc identified and protected. But lack of comprehensive wider planning for response to gradual (chronic) drivers of change.	Infrastructure designed in accordance with a range of resilience principles, e.g.: multifunctionality, redundancy, modularity and diversity, providing for operational reliability under changed conditions – with both acute (sudden) events and chronic (slowly-building) pressures addressed. Infrastructure continues to function well during natural disasters such as floods and earthquakes. Adaptive management enables urban systems to evolve and perform well in response to gradual pressures such as population growth and environmental change.

		Food and fibre production *Quantitative methods:* • *Measurement of food producing area or capacity (e.g. class 1 soils).* • *Measurement of earthworks extent (area/volume).* • *Measurements of retained topsoil and quality.* • *Assessments of rooting depths/volumes, infiltration rates and soil permeability.* • *Market valuation, factor income assessments, contingent valuation, choice experiments, benefit transfer[a].* *Qualitative methods:* • *Inference of potential for food production from catchment land cover, soils maps, earthworks plans and building plans.*	Lack of green space limits opportunities for food production within the urban environment. Ad hoc planning and management of land resources enables development of productive soils, resulting in their loss for food production.	Poor quality soils in green space means food production requires large investments in importing suitable soils and/or intensive interventions such as drainage, de-compaction, irrigation, amendments with organic materials and/or chemical fertilisers). Perennial trees requiring physically fertile soils cannot be grown.	Annual and perennial food production possible in public and/or private spaces. Perennial trees and vines requiring fertile, free-draining soils and full sun can be grown in limited areas. Suitable foraging spaces are available that support pollinator and predator insects throughout the year. Riparian areas, wet swales and/or wetlands have native species that can be safely harvested for fibre (kuta, raupo, ti kouka, flax); on coastal areas pingau is grown; in forests kiekie vines are established. Medicinal (rongoa) plants are healthy and safe to use.	Multifunctional green spaces on roofs, walls and between buildings provides a range of suitable, accessible food and fibre growing options. Ground-level areas have deep, free-draining soils that support trees and large vines (e.g. kiwifruit, hops, grapes). Composting and mulching used to recycle nutrients. Most watering uses harvested stormwater. Runoff and leachate from high fertility areas is mitigated in raingardens. Urban planning optimises the use of land resources avoids development of productive soils, preserving their use for food production.
		Public safety *Quantitative methods:* • *Avoided costs in treatment and recovery processes; lost production assessments; restitution costs; human capital losses; willingness to pay, i.e. contingent valuation, choice experiments, benefit transfer[b].* *Qualitative methods:* • *Assessments against Crime prevention through environmental design (CPTED)[b] attributes.* • *Inference from land use zoning and urban/street design.*	Vehicle dominated street design creates poor environment for safety of pedestrians/cyclists. Poor urban design delivers unappealing, unused public spaces creating potential for crime by failing to meet majority of CPTED attributes. Areas of green space poorly maintained and used for waste disposal, creating hazardous environments for access, recreation etc.	Street design accommodates conventional measures for pedestrian safety (marked crossings etc) but no traffic calming provisions. Public spaces may meet some (2-3) CPTED attributes.	In places, street design (narrower road widths, traffic calming measures) promotes safety for pedestrians/cyclists. Many public spaces meet most (4-5) CPTED attributes.	WSUD street design (narrower road widths, traffic calming measures) promotes safety for pedestrians/cyclists throughout road network. High quality urban design delivers appealing, well used public spaces minimising crime potential by meeting all 6 CPTED attributes: (1) Safe access, movement and connections; (2) Surveillance and sightlines that enable people to see and be seen, but with 'refuges and privacy' in some areas; (3) Clear and logical layout; (4) Public spaces that encourage surveillance; (5) Sense of cared-for space (amenity) that is maintained and tidy; (6) Physical, active security to discourage access to sensitive/private areas, and encourage access to public areas.
		Connectedness with nature (land) *Quantitative methods:* • *Public surveys.* • *Market and non-market based economic assessments of ecosystem service provision: hedonic spatial econometrics studies of price formation in real estate markets, contingent valuation, benefit transfer[a].* *Qualitative methods:* • *Visual screening assessments.* • *Analysis of aerial photographs/GIS layers.* • *Inference from land use zoning and urban design.* • *Green Factor weighting (Seattle)*	Predominantly built environment with very limited access to green space: restricted by private property rights and limited views from public spaces, and/or little or no provision of accessways within public reserves. Green space typically highly modified, lacking diversity and featuring high proportion of non-native and/or pest plant species.	Isolated green spaces/parks, often with only limited formal accessways and typically highly modified, lacking diversity. A high proportion of non – native species in landscaped areas.	Public greenspace widespread and with good access via formal tracks/footpaths, but lacking significant areas of relatively undisturbed, restored natural vegetation or naturalistic plantings. Moderate to high proportion of private greenspace visible or boundaries are planted (i.e. not hard walls), so contributes to connectedness. Opportunities to see or hear local birds or desirable insects/lizards – or their signs seasonally.	Green space celebrated as community assets and easily accessed: abundant, well distributed green spaces in public ownership with wide provision of footpaths and accessways. Incorporates significant protection of natural elements especially along boundaries (as hedges and other vegetation), feature trees and/or geology. Areas where people can regularly see or hear 'desired' native birds and animals (e.g. tui, fantail, skinks, native bees or butterflies)

		Community health and wellbeing *Quantitative methods:* • *Market and non-market based economic assessments of ecosystem service provision: hedonic spatial econometrics studies of price formation in real estate markets, contingent valuation, benefit transfer[a].* *Qualitative methods:* • *Visual screening assessments.* • *Analysis of aerial photographs/GIS layers.* • *Inference from land use zoning and urban design.*	Lack of green space and motor vehicle dominated street design limit opportunities for active recreation and release from the daily grind. Urban living involves exposure to multiple physical and mental health hazards: high levels of noise, dust, UV, light, temperatures and wind.	Predominantly built environment but with some provision of isolated green spaces/parks for informal recreation.	Greenspace reasonably widespread and provides for organised and informal recreation but connectivity limited. Well planted road corridors, especially where using trees, contribute to some moderation of physical and mental health hazards: noise, dust, UV, light, temperatures and wind.	Urban design effectively moderates multiple physical and mental health hazards: noise, dust, UV, light, temperatures and wind. Multifunctional green space, such as sports fields and walking/cycling tracks provides plentiful opportunities for organised and informal active recreation. Connectivity of green spaces and street design (e.g. designated shared biking/walking routes, traffic calming measures) encourages active transport modes. Mental well-being derives from connectedness with nature (see above) with access to abundant green space encouraging relaxation, intellectual stimulation and effective stress management.
		Property values *Quantitative methods:* • *Spatial econometric analyses of real estate sales data[d].* *Qualitative methods:* • *Interviews and surveys.*	Lack of natural character and poor public safety make this an undesirable place to live, reflected in relatively low residential property values (sale prices below market average and/or rental turn over above average for the area).	Property values (sale prices and/or rental turn over) are at or around the market average, as the very limited 'green' characteristics of the area offer little to distinguish this from surrounding neighbourhoods.	Property values (sale prices and/or rental turn over) are slightly above the market average, as characteristics such as natural character and public safety give the area some advantages over surrounding neighbourhoods.	Characteristics such as a strong sustainability performance, natural character and public safety make this a highly desired location to live, work and play, with knock-on effects for residential property values (sale prices well above market average – by around 5% or greater; rental turn over well below market average).

*While these methods are generally listed in order of decreasing assessment quality, the competent application of any of them is consistent with an assessment reliability rating of 'high'.

References
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b. EU Commission,2019, Mobility and Transport Safety: Monetary Valuation of Road Safety https://ec.europa.eu/transport/road_safety/specialist/knowledge/measures/monetary_valuation_of_road_safety_en, accessed 28 January, 2019.
This study also includes valuations for: environmental impacts (noise and air quality effects; health impacts: insecurity in road crossing, insecurity in walking and cycling, short term illness effects, and serious injury effects.
c. http://www.cpted.net/
d. Mazzotta, M.J.; Besedin, E.; Speers, A.E. A Meta-Analysis of Hedonic Studies to Assess the Property Value Effects of Low Impact Development. *Resources* **2014**, *3*, 31-61. http://www.mdpi.com/2079-9276/3/1/31

More Than Water (MTW) costs assessment guide

For each cost criterion, the assessment involves:

4. Determining the **LEVEL** of the cost criterion. The text under the column headings 'None' to 'High' is intended to help guide this assessment.
5. Determining the **IMPORTANCE** of the cost criterion. This is a subjective choice of the individual, communities or stakeholders making the assessment. Where assessments do not have access to information on the values of communities and/or stakeholders, 'importance' can be held constant for all criteria.
6. Determining the **RELIABILITY** of the assessment. The text in *italics* under the heading 'Criterion and assessment methods' provides guidance on methods that could be used to provide a high (evidence-based) level of reliability.

			Assessment Guide – Level of Criterion			
Domain		**Criterion** *and assessment methods**	**None**	**Domain**	**Benefit** *and assessment methods**	**None**
Project	**Cost effectiveness**	**Influence on housing affordability** (i.e. a measure of the proportion of take home pay needed vs property holding costs – the current level of affordability for New Zealand homeowners is a mortgage of 40% of the "family" take home pay and existing property holding costs[a]. An increase in property holding costs leads to a decrease in housing affordability) *Quantitative Assessment Methods:* • *Life cycle costing of stormwater management system (for both the development proposal and what the "BAU")* • *Associated assessment of change in property holding costs.* *Qualitative Assessment Methods:* • *Inference from the proposed stormwater management methods to determine whether or not they would be additional to a "BAU" approach or would replace a traditional piped system.*	N/A – this selection is not available for this criteria. For neutral effect on housing affordability refer to 'medium'.	The effect on affordability is negative. The stormwater management approach is expensive and therefore increases property holding costs thereby having an adverse effect on housing affordability. For example, stormwater management mitigation includes a mix of at source devices such as rain gardens, permeable paving and rain tanks for treatment as well as a pipes to convey stormwater to attenuation wetlands. $1,900 - $2,600 /ha/ year LCC (based on 60 - 90% impervious cover and 75% TSS removal)[b]. There is little space at grade and/or ground conditions (high water table) make excavation for rain gardens expensive and swales impractical. There are no reductions in the piped network, nor impervious areas or earthworking costs. Existing landscaped/ natural areas are destroyed and new ones created.	Effect on affordability is around neutral. This could be done via: (1) Traditional approach to development – no change to current housing affordability and does not affect the accepted affordability of a mortgage of 40% of the "family" take home pay and existing property holding costs[a]. (2) The stormwater management approach includes a mix of pipes and swales to convey stormwater to treatment wetlands or infiltration "soft" rain gardens. $1,400 - $1,600/ ha/year LCC (based on 60 - 90% impervious cover and 75% TSS level)[b]. The stormwater management approach is cost efficient and has the potential to reduce property holding costs, or only increase them very slightly (1% decrease to less than 1% increase in holding costs). For example, stormwater management mitigation includes a mix of at source devices such as swales, rain gardens, permeable paving and rain tanks. The devices work in series to reduce surface area requirements and costs. Reduced costs from the reduced piped network. In some areas landscaping is integrated with green infrastructure devices.	Effect on affordability is positive (i.e. it leads to a decrease in holding costs of >1%). A water sensitive urban design approach is used and all stormwater infrastructure is above ground. No (minimal) piped network and stormwater is conveyed via swales to infiltration 'soft' rain gardens or wetlands. Use of green roofs[c]. All landscaping is fully integrated within the green infrastructure, leading to a zero-additional maintenance approach. Significant remnant or landscaped spaces within lower areas of development can easily be designed to incorporate green infrastructure, e.g. wetlands and wet forests. Reduced earthworking, impervious area and pipe costs. Protection of natural aquatic and terrestrial habitats. At source stormwater management reduces the need for construction of large-scale wastewater/ combined sewer upgrades as stormwater input into the wastewater system is reduced and reduces CSOs.

		Influence on development yield *Quantitative Assessment Methods:* • *Assessment of allowable yield under relevant district plan standards vs assessment of yield to be achieved based on an alternative layout.* • *Inference based on the proposed lot layout design.*	Traditional approach to development – no effect on development yields.	The proportion of overall development site available for dwelling placement and construction is similar to (<1% increase in yield[d]) or less than that achieved via a traditional approach. This is as a result of restrictive codes of practice requiring wide road areas. Space is needed for large scale treatment and attenuation devices such as wetlands and ponds which can reduce lot yield.	Slight increase in dwelling density (1 – 4% increase in yield[d]) as a result of the use of at source green infrastructure, rain tanks and permeable paving, and pro-active incentives which allow for: • bonus 'additional floor' grants for living roofs. • reduced reserve contributions offset by green infrastructure areas.	Dwelling density increases by >4%[d] as a result of flexible codes of practice which allow for clustering impervious areas, reduced road widths and use of 'at source' green infrastructure. Non-buildable areas (such existing native vegetation and required landscaped areas) can be used as part of an integrated green infrastructure system and "medium" level incentives applied.
		Cost effectiveness on the public purse – public infrastructure delivery and maintenance *Quantitative Assessment Methods:* • *Determination of the ownership status of the proposed stormwater infrastructure.*	N/A – this selection is not available for this criteria. For neutral effect on housing affordability refer to 'medium'.	The infrastructure delivery is not particularly cost effective for the public operator. Infrastructure delivery maintains a focus on high-profile public infrastructure upgrades to solve/ reduce CSOs or flooding of high-value infrastructure. Ongoing maintenance of infrastructure is generally undertaken by the public purse (e.g. pipes, wetlands, ponds).	Ongoing infrastructure maintenance and delivery is shared between the public operator and private property owners. This combined approach to infrastructure delivery uses both at source green infrastructure and large scale, high profile public infrastructure upgrades. There is a split between the public and private share of ongoing maintenance (e.g. swales which discharges to wetlands; rain tanks; permeable paving and rain gardens connected via piped networks).	Infrastructure delivery and maintenance is generally under private ownership, reducing costs to the public operator. Covenants are used to protect and require money to be set aside to maintain green infrastructure in perpetuity. At source green infrastructure offsets additional upgrades to the public stormwater, water supply and wastewater network, especially where additional discharges to public network result in CSOs, or where new development exacerbates flooding of high-value infrastructure.
		Influence on health and wellness affordability *Quantitative assessment methods:* • *Treatment train configuration cost assessment of cost efficiency of combinations of: wastewater overflows; road safety metrics; frequency and duration of "nature dose"; vegetation generated changes in air quality parameters* *Qualitative assessment methods:* • *Resident opinion survey*	Traditional approach to development – no effect on personal healthcare affordability.	Health and wellness is slightly more affordable due to one of these criteria being present in the development approach: • a reduction in wastewater overflows leading to greater levels of outdoor activity and safer contact recreation environments. • increased road safety by using narrow roads and green infrastructure as traffic calming devices – promotes increased pedestrian and cycle activity. • Increase frequency and duration of nature dose[e] as a result of green corridors facilitated by green infrastructure connecting urban road corridors with urban parks, natural landscaped areas and receiving environments. • Improved urban air quality from green infrastructure corridors which include a mix of low-lying vegetation and trees[f].	Health and wellness is moderately more affordable due to two of these criteria being present in the development approach: • a reduction in wastewater overflows leading to greater levels of outdoor activity and safer contact recreation environments. • increased road safety by using narrow roads and green infrastructure as traffic calming devices – promotes increased pedestrian and cycle activity. • Increase frequency and duration of nature dose[e] as a result of green corridors facilitated by green infrastructure connecting urban road corridors with urban parks, natural landscaped areas and receiving environments. • Improved urban air quality from green infrastructure corridors which include a mix of low-lying vegetation and trees[f].	Healthy and wellness is more affordable due to three or more of these criteria being present in the development approach: • a reduction in wastewater overflows leading to greater levels of outdoor activity and safer contact recreation environments. • increased road safety by using narrow roads and green infrastructure as traffic calming devices – promotes increased pedestrian and cycle activity. • Increase frequency and duration of nature dose[e] as a result of green corridors facilitated by green infrastructure connecting urban road corridors with urban parks, natural landscaped areas and receiving environments. • Improved urban air quality from green infrastructure corridors which include a mix of low-lying vegetation and trees[f].

	Avoided Costs	**Avoided earthworking costs** *Quantitative assessment methods:* • *Determination of earthwork volumes under differing urban development scenarios.* • *Estimating of costs associated with earthwork volumes.* *Qualitative assessment methods:* • *Inference from land contours/ slopes as per the low, med and high categories (site visits, topographical maps, aerial photos)*	Traditional approach - no reduced earthwork volumes. Where geotechnically unstable soils and/ or steep slopes or terraced landforms are wanted, significant earthworks are needed to facilitate development.	Site slope is 1% or less and relatively small amount of earthworking needed for either a traditional and a WSUD development. Average avoided cost is 15%[g].	Site slope is greater than 5%. Reasonable level of earthworks is needed to facilitate development. Savings can be gained by designing roadways along contours where possible, but retaining still likely due to natural topography and steeper slopes. Average avoided cost is around 24%[g].	Site slope between 1 and 5%. Significant savings can be achieved by designing roadways along contours and using stepped rather than flat building platforms. Average avoided cost is 35% or greater[g].
		Avoided hard infrastructure costs (pipes, kerbs, catchpits, wastewater upgrades, etc) *Quantitative assessment methods:* • *Determination of pipe length and associated infrastructure under differing urban development scenarios.* • *Estimating of costs associated with piped infrastructure.* *Qualitative assessment methods:* • *Inference from soil types and stormwater measures as per the low, med and high categories.*	Traditional development approach with a fully reticulated piped network.	Areas with high water tables (< 1 to 1.5 m depth), geotechnically unstable soils and/or low permeability that limits subsoil exfiltration (such as Hydrologic Class 1, onerahi chaos breccia and most Ultic Soils, Podzols and fine-textured Gley Soils). Subsoil pans, cemented or compact layers or rock present that impedes drainage. Average avoided cost is from the reduced pipe network is 10%[g].	Soils with moderate subsoil permeability, particularly in climates with low rainfall intensities and volumes; may have some subsoil mottling; many Brown Soils and Pallic Soils, silt-textured Recent Soils and some Allophanic Soils (especially in Auckland). Average avoided cost from the reduced pipe network is 18%[g].	Highly permeable, deep soils which allow for infiltration and exfiltration of stormwater at rates such that a piped conveyance system is not needed. These will generally have no soil mottling or gley features (e.g. Recent and Raw Soils with sandy and gravelly subsoils, Pumice Soils, many Allophanic and Granular Soils, some Brown Soils). AND/ OR in areas where recharge is needed (peat soils, aquifer recharge). Average avoided cost resulting from a predominantly above ground swale network is 50%[g]. Source control of stormwater volumes, as well as at source use of green roofs, re-use rain tanks and rain gardens avoid the need for and cost of large scale wastewater treatment upgrades in brownfields areas with combined sewers or separate systems with high levels of stormwater ingress to the wastewater network. Avoided cost savings is 15 – 23%[h].

		Avoided impervious area costs *Quantitative assessment methods:* • *Determination of paved areas under differing urban development scenarios.* • *Estimating of costs associated with roading/ paving areas.* *Qualitative assessment methods:* • *Inference of the potential reductions in impervious areas as per the low, med and high categories.*	Traditional approach to site development, road widths, road/drive layout, means there are no reduced impervious areas.	Restrictive codes of practice dictate minimum road widths with little room for innovation and clustering. Average avoided cost is 10%[g]. Potential reduction in impervious area could be in the order of 2 - 5%[i].	Enabling codes of practice allow for varied and narrow road widths and use of permeable parking and green infrastructure as traffic calming devices. Average avoided cost is 13%[g].	Enabling codes of practice allow for varied and narrow road widths as well as varied densities which facilitate clustering. Average avoided cost is 17%[g]. Potential reduction in impervious area could be in the order of 14 – 18%[Error! Bookmark not defined.].
		Avoided landscaping costs *Quantitative assessment methods:* • *Cost estimation of the landscaping design.* *Qualitative assessment methods:* • *Inference from the landscaping plan and likely costs.*	A traditional development approach leads to increased landscaping costs as landscaping is undertaken separately from and over and above the traditional piped stormwater system.	Low level of avoided landscaping costs from: • use of highly resilient vegetation avoids high maintenance costs associated with deciduous trees and less resilient plants which require regular watering, picking up of leaves, fertilizing, etc.	Moderate level of avoided landscaping costs from: • use of native vegetation; • use of low maintenance grass species to reduce ongoing costs associated with mowing of green open spaces/ parks. • some landscaping aspects integrated as part of the stormwater management approach for the site and/ or green infrastructure devices.	High level of avoided landscaping costs from: • use of native vegetation. • use of low maintenance grasses. • zero additional landscaping over and above the enhancement of existing natural areas and green infrastructure. • zero additional maintenance over and above green infrastructure maintenance costs.
		Avoided property operation costs (& reduced risk) of the built environment that can be delivered by GI *Quantitative assessment methods:* • *Life cycle costing of building stormwater management, landscaping and energy system.* *Qualitative assessment methods:* • *Inference from building layout, design, energy systems and stormwater management plan.*	No avoided costs - Traditional development with little consideration of external building environment, or orientation to sun. All climate control using building fixtures (blinds, screens) and energy pumps, etc. Landscaping irrigated in summer with potable water and under-drained.	Property operation costs are reduced slightly through the use of landscaping. Conventional landscaping uses trees, climbers and hedges to shelters buildings from wind, sun and extreme weather, Conventional landscaping is below grade to reduce irrigation costs, and soils at least 600 mm depth and surface 300 mm amended with compost to reduce watering requirement.	Avoided property operation costs are moderately reduced as green infrastructure is selected and located to contribute to cooling of buildings in summer (shade) and warming in winters (shelter): • reduces the heat island effect in summer by shading W-and N-facing concrete; • H-VAC inlets and solar power units placed with living roofs to improve efficiency (lower summer peak temperatures); • landscaping uses rain gardens and bioswales (watered and fertilised from runoff) that do not need mowing (saving a large cost); • in low-humidity environments raingardens/living walls used at air intakes to help cool buildings.	Low operational costs and therefore high avoided costs are realised via the use of green infrastructure features described in the “medium” category, but GI that also: • harvest and reuse stormwater (and other waters), reducing use of potable water for landscape, toilet flushing, etc., as well as energy; • uses trees, green screens and living roofs placed to reduce UV impacts on building, particularly roof membranes, exterior trims; • enhances enhance building security and prevents tagging/vandalism (e.g. access prevented by rain gardens; green walls).

Environment	Cost effectiveness	**Water quality cost effectiveness**
		
		Quantitative assessment methods:
		• *Contaminant load modelling coupled with life cycle cost modelling.*
		
		Qualitative assessment methods:
		• *Inference from design of the stormwater management system and associated landscaping.*
			A traditional kerb, channel and pipe approach to development means that there is no stormwater treatment.
			
			No source control of Cu and Zn-releasing materials), no capture or re-use of stormwater , landscaping conventionally drained and irrigated with potable water.
			
			Large-scale wastewater network upgrades to reduce CSOs.
				Costs to remove contaminants are very high as stormwater infrastructure focusses on volume conveyance with little capture and treatment of contaminants. Examples of these types of systems include:
				• oversized catchpits, pipes are expensive to build and maintain but provide very small (around 10 – 20% TSS removal) water quality benefits. Treatment costs could be in the order of[i]:
				  ○ LCC $150/kg/yr of TSS captured
				  ○ LCC $2,500/g/yr of Zn captured
				  ○ LCC $5,700/g/yr of Cu captured
				• rain tanks that do not re-use water
				• designated ponds/ infiltration basins providing treatment
					Stormwater infrastructure which is relatively expensive to build and maintain, but provides a good level of water quality treatment (metals and sediments) and provides for source control of contaminants. Examples include:
					• rain gardens supported by a piped network that prevent direct discharge of spills. Treatment costs could be in the order of:
					  ○ LCC$50/kg/ yr of TSS captured
					  ○ LCC $150/g/ yr of Zn captured
					  ○ LCC $800/g/yr of Cu captured
					• Wetlands supported by a piped network.
					• green roofs with low organic levels and low disturbance
					• source control of building materials (avoiding use of copper and galvanised zinc)
						Stormwater infrastructure that works within a treatment train to provide a high level of water quality treatment at lower costs. Examples include:
						• treatment via swales which drain to small rain gardens or wetlands. Treatment costs could be in the order of:
						  ○ LCC $35/kg/ yr of TSS captured
						  ○ LCC $120/g/ yr of Zn captured
						  ○ LCC $750/g/ yr of Cu captured
						• cluster development reduces impervious areas
						• integrated below-grade landscaping
						• multi-use detention areas
						• reduction of wastewater overflows via control of stormwater at source (e.g. full re-use rain tanks, GI).
						• use and protection of existing natural areas (e.g. established areas of bush and trees)

		Hydrological cost effectiveness *Quantitative assessment methods:* • *Cost estimation of the engineering design of the stormwater management system to meet hydrological planning requirements coupled with life cycle cost modelling.* *Qualitative assessment methods:* • *Inference from design of the stormwater management system and associated landscaping.*	No stormwater attenuation or volume control, i.e. use of kerb and channel with pipes connected to surface water.	Stormwater infrastructure which may provide a small degree of attenuation through the piped network (undersized culverts/ storage) but is expensive to build and maintain. Landscaping is below grade, reducing additional impact of these areas. Downpipes are separated from the piped network by small water-butts or small rain-planter boxes. Wide roads are expensive to build and create the need for more expensive stormwater infrastructure to mitigate downstream flooding or stream erosion.	Stormwater infrastructure which can be relatively expensive to build and maintain, but provides a good level of stormwater attenuation (e.g. ponds/ wetlands supported by a piped network). Residual greenspace that is below grade to receive runoff and where the soils are amended to enhance rooting depth, moisture storage and exfiltration.	The development approach is highly cost effective via clustered development which reduces impervious areas (and pipes) and protects natural areas from being earthworked thereby reducing compaction of soils. The stormwater infrastructure provides both volume control as well as peak flow attenuation, such as larger water re-use rain tanks and green roofs.

		Receiving aquatic habitat quality/ stability cost effectiveness *Quantitative assessment methods:* • *Cost estimation of the proposed stream management system.* *Qualitative assessment methods:* • *Inference from stream geomorphology, riparian condition.* • *Inference from site land cover and design of stormwater infrastructure.*	A conventional approach to development which leads to degraded habitat quality and the need for expensive 'constructed' solutions to reduce habitat instability (e.g. retaining walls, concrete channels).	Expensive retaining, concrete channels, stream modification and on-line treatment devices are used to mitigate effects of development. It combines a traditional piped stormwater system with reduced impervious areas so that whilst runoff volume and peak flow are decreased to some extent, degradation occurs as impervious areas and pipes are connected to surface waters.	Combines reduced hard infrastructure and impervious areas with stormwater practices that provide water quality treatment and peak flow and base flow attenuation of stormwater, and disconnects impervious areas from pipes to protect receiving environment from spills. Treatment train approach is used and design with drought refugia allows wetlands to support native fish, invertebrates.	Stream modification and intervention approaches are minimal (and use vegetation or natural materials) or are not required and are therefore relatively inexpensive. The stormwater management and development approach combines reduced hard infrastructure and impervious areas with source control of contaminants with a reduction of stormwater volumes (e.g. green roofs, zinc roofs with rain tanks, swales, wetlands which provide for water reuse) and complements this with terrestrial habitat protection (e.g. shaded riparian zones).
		Terrestrial habitat quality/stability cost effectiveness *Quantitative assessment methods:* • *Life cycle costing of the proposed landscaping and stormwater management design, coupled with vegetation and habitat surveys.* *Qualitative assessment methods:* • *Inference from catchment land cover, urban design and the proposed stormwater management system, extent of tree cover, connectivity with existing natural areas, and proposed maintenance.*	Traditional development: landscaping may not contribute to connectivity or buffer remnant areas, and is not linked with green infrastructure/ stormwater management.	Species used in landscaping are not weeds and instead complement nearby/natural areas rather than increasing costs of weeding / management downstream. Marginal use of green infrastructure is used in isolated areas, allowing for a slight reduction in "additional" landscaping costs.	Green infrastructure is located and designed to buffer remnants and riparian areas and enhance connectivity, e.g. practices containing coarse wood and boulder features to allow lizard movement.	The green infrastructure practices are regenerative by adding significant habitat, enhancing or 'filling' physical or temporal/seasonal gaps in food supply for local species (e.g. nectar or fruit for native birds) and increase connectivity of green corridors. Existing areas of native trees and bush are protected. Zero additional maintenance of green infrastructure devices is incorporated into the design.
	Avoided costs	**Avoided environmental remediation costs** *Quantitative assessment methods:* • *Comparative analysis of cost effectiveness of treatment train alternatives for contaminant removal.* *Qualitative assessment methods:* • *Inference from the proposed stormwater management system*	Traditional approach to development and therefore no costs associated with environmental remediation have been avoided.	May make a significant contribution to environmental remediation costs as a result of no source control or green infrastructure. Whilst ponds provide some degree of treatment they also create effects which could lead to increased remediation costs.	May make a medium contribution to environmental remediation costs as a result of using stormwater practices which provide a "minimum bottom-line" level of treatment. Little or no source control.	Makes a low, or even no contribution to environmental remediation costs as a result of source control and use of green infrastructure – a WSUD approach to site design (clustering, protection and integration of natural features, reduced earthworking, etc.) as well as infrastructure provision.

		Avoided property remediation and storm damage costs (flood related) *Quantitative assessment methods:* • *Hydrological and hydraulic modelling* • *Flood loss estimation modelling* • *Life cycle costing* *Qualitative assessment methods:* • *Inference from site topography, drainage network, land use zoning and design of stormwater infrastructure.*	Traditional approach to development and therefore no costs associated with flood remediation and storm damage have been avoided.	Potentially very high property remediation and/ or storm damage costs as a result of filling in floodplains or overland flow paths and providing for no attenuation. Aim to achieve[j]: • 10 year zero damage and remediation cost threshold (greenfield development) • no change in current flood remediation costs for brownfield areas	Medium level of property remediation and/ or storm damage costs as a result of filling in floodplains. Stormwater ponds/ wetlands are used to provide attenuation. Aim to achieve[j]: • 50 year zero damage and remediation cost threshold (greenfield development) • 5 year zero damage and remediation cost threshold (brownfield areas)	Low property remediation and/ or storm damage costs as development is prohibited within floodplains, stormwater volumes are reduced through water reuse and/ or infiltration to ground, and attenuation is provided via stormwater ponds/ wetlands. Aim to achieve[j]: • 100 year zero damage and remediation cost threshold (greenfield development) • 10 year zero damage and remediation cost threshold (brownfield areas)
		Avoided costs of future proofing (climate change; resilience)	No avoided costs of future proofing the stormwater management approach - conventional development with little consideration of future proofing stormwater infrastructure or building resilience into the network. No consideration of changed rainfall intensities, drought frequency or sea level (if relevant) considered in the site planning and design of site.	Low level of avoided costs due to <u>two</u> of these criteria being present in the stormwater management approach: • the system is designed to cater for future rainfall levels incorporating climate change. • consideration is given to building redundancy and modularisation into the stormwater system to reduce costs of repair from natural hazards such as earthquakes or increasingly intensive storms. • provision in the design has been made for maximum probable development, accounting for infill or increases in impervious surface.	Medium level of avoided due to <u>three</u> of these criteria being present in the stormwater management approach: • the system is designed to cater for future rainfall levels incorporating climate change. • consideration is given to building redundancy and modularisation (e.g. rain gardens) into the stormwater system to reduce costs of repair from natural hazards such as earthquakes or increasingly intensive storms. • Provision in the design has been made for maximum probable development, accounting for infill or increases in impervious surface. • Modular systems (rain gardens) are integrated with below-grade landscaping so that additional new areas can be brought on line as required. • Design all roofs that have <5 degrees slope, especially ballast roofs over membranes, to have defined safe access points, areas of higher weight loading and edges that allow retrofit of green roofs.	High level of avoided due to <u>four or more</u> of these criteria being present in the stormwater management approach: • the system is designed to cater for future rainfall levels incorporating climate change. • consideration is given to building redundancy and modularisation (e.g. rain gardens) into the stormwater system to reduce costs of repair from natural hazards such as earthquakes or increasingly intensive storms. • Provision in the design has been made for maximum probable development, accounting for infill or increases in impervious surface. • Modular systems (rain gardens) are integrated with below-grade landscaping so that additional new areas can be brought on line as required. • Design all roofs that have <5 degrees slope, especially ballast roofs over membranes, to have defined safe access points, areas of higher weight loading and edges that allow retrofit of green roofs. • Trees are used as an integral part of the stormwater system. These take 10 to 30 years to develop an effective canopy (it is noted that NZ stormwater guidance may take 10 years to build trees into calculations).

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g. Percentages are based on a literature review undertaken in 2015 (referenced below), and updated as part of the research, cost data collection and case studies analyses undertaken for this project.
- Ira, S. 2015. Quantifying the cost differential between conventional and water sensitive design developments – A literature review. Report prepared for NIWA and the Cawthron Institute as part of the MBIE funded "Urban Planning that Sustains Waterbodies" research initiative.
h. Based on a 2015 literature review (reference g) of case studies sites in the USA and UK.
i. Costs and/ or impervious areas are based on LCC modelling of different development and treatment scenarios using Kirimoko Park in Wanaka as a case study.
j. Concept of "zero damage threshold" design storms taken from a 2015 USEPA Report: Flood Loss Avoidance Benefits of Green Infrastructure for Stormwater Management. Contract No. EP-BPA-13-C-003 - https://www.epa.gov/sites/production/files/2016-05/documents/flood-avoidance-green-infrastructure-12-14-2015.pdf