Understanding the value of meeting the requirements of environmental legislation for roading improvement projects

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The NZ Transport Agency is a Crown entity established under the Land Transport Management Act 2003. The objective of the Agency is to undertake its functions in a way that contributes to an efficient, effective and safe land transport system in the public interest. Each year, the NZ Transport Agency funds innovative and relevant research that contributes to this objective.

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Contents

Executive summary

Through understanding the cost of meeting the requirements of environmental legislation and the resulting benefits for roading improvement projects, this research project aimed to provide insights into value that would assist transport decision makers over the long term.

The research project responded to the Government Policy Statement on Land Transport 2015/16 – 2024/25 (GPS 2015), which sets out the Government's strategic and policy objectives for land transport, guiding investment by the NZ Transport Agency and local authorities. GPS 2015 reflects the Government's understanding that:

> *The land transport sector has stewardship of a significant proportion of our national wealth, and needs to ensure that public expenditure delivers the right infrastructure and services to the right level and at the best cost. There are high user and societal expectations for increases in levels of service across the whole transport network. Users express this in terms of reduced levels of congestion, a safer system, greater resilience, and mitigation of environmental impacts. Transport decision-makers need to take account of those expectations, and ensure that transport makes a broad positive contribution to the economy and society.*

The GPS 2015 provided important context for the project and guided the project scope to focus on the value of meeting the requirements of environmental legislation as it relates to adverse effects and measures taken to avoid, remedy or mitigate these in the project process.

The New Zealand Transport Domain Plan (Transport Knowledge Hub 2016a) contains enduring question EQ7.1, which asks what regulations apply to transport services operating in New Zealand, what are the costs and benefits of different regulations, how effective are different regulatory frameworks, and how are these things changing, including modally, regionally and temporally? The recommended initiative R7.1 is a project to improve monitoring and evaluation of transport regulatory effectiveness. This research project aligned well with the Domain Plan's R7.1, with a narrower focus on just environmental legislation. It was appropriate to consider environmental legislation, in particular, as it has a major and unique impact on transport projects primarily through the Resource Management Act (RMA).The RMA is New Zealand's main piece of legislation that determines how the environment is managed and was the focus of this research.

For this study, value was taken to be the difference between costs and benefits.

The research concluded that current approaches to information capture by roading authorities do not enable the value of meeting the requirements of environmental legislation, for the following reasons:

- The isolation of costs arising from meeting the requirements of environmental legislation is a very focused question. It does not align with typical drivers for cost capture such as capitalisation of assets or the payment for construction activity.
- There is no consistent structure for cost data capture. Roading authority project managers can use their discretion in setting up cost codes within financial systems and other de-centralised cost tracking systems (spreadsheets).
- Changes in staff through the project mean that information is lost. It is normal for a roading improvement project to be managed by multiple project managers from development through to delivery. This is often due to changes in the expertise required to deliver the project phases as well as staff turnover. As a result, complete knowledge about project value may not be retained within organisations through the full project lifecycle.

- Currently, roading authorities focus on capturing information about benefits that can be monetised. This study has concluded that international best practice is to accept not all benefits can be adequately monetised, and the capture of benefits through a wider set of indicators is appropriate.

The research project has developed a framework for capturing the costs and benefits arising from environmental legislation for roading improvement projects, which if fully implemented would enable the value of meeting the requirements of the legislation to be determined. Reflecting the conclusion that not all benefits can be adequately monetised at present, the framework captures:

1 Qualitative information – as a rich narrative about the scheme and the benefits arising through meeting the requirements of environmental legislation

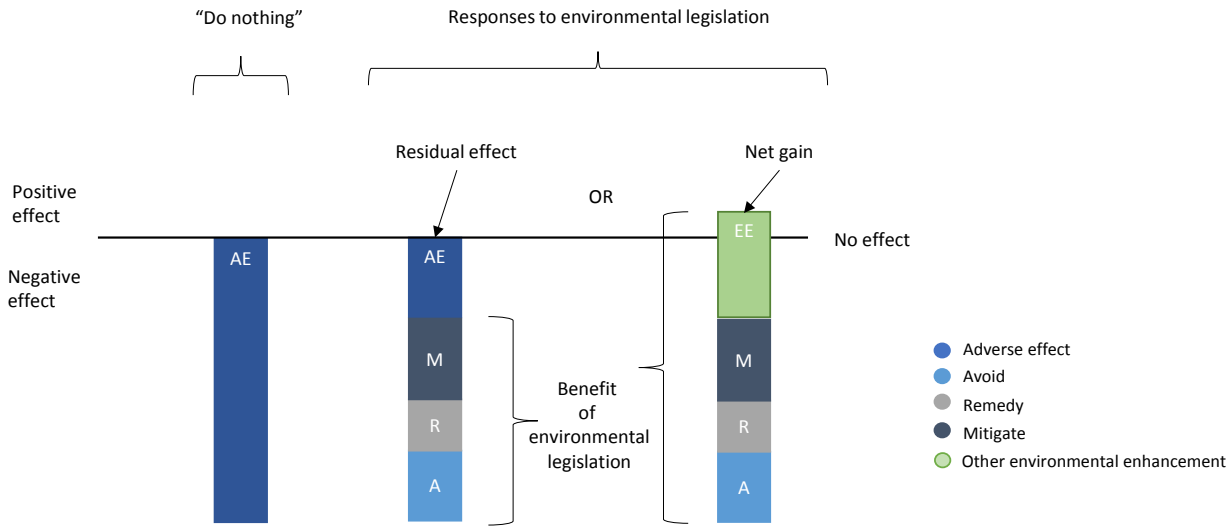
2 Quantitative information – using non-monetary units such as numerical measures to capture the magnitude of the value delivered by environmental legislation, for example, length of watercourse diverted or naturalised or area of planting for landscape impact mitigation

3 Monetary terms – where possible the benefits are monetised and project costs are recorded to enable consideration of costs and benefits using a common currency.

Cost for this study refers to all capital and operating costs of a roading project, including pre-development costs, which relate to meeting the requirements of environmental legislation.

The framework focused on the assessment of environmental effects (AEE) process arising from the requirements of the RMA. The AEE process requires a structured approach to the expected effects (actual and potential) of a scheme, followed by the application of measures to avoid, remedy and mitigate adverse effects. Figure ES.1 illustrates this process, focusing on adverse effects. Adverse effects can be avoided, remedied or mitigated, potentially leaving residual adverse effects or net gains. A consent may still be granted if residual adverse effects that have been identified during the consenting process are reduced to an acceptable level.

Figure ES.1 Benefits attributable to meeting the requirements environmental legislation due to responding to adverse effects



Source: Modified from the Business and Biodiversity Offsets Programme (2009)

The modern paradigm for the design and construction of roads does not consider the 'do nothing' or 'without meeting the requirements of environmental legislation' premise shown in figure ES.1. The concept of constructing a road without giving due consideration to protecting the receiving environment is

no longer considered by design engineers. It is therefore necessary to carefully determine this counterfactual or 'do nothing' situation to ensure the outcomes of meeting the requirements of environmental legislation are fully valued.

This research recommends supporting the development of a benefits measurement approach by implementing a benefits register; applying the philosophy that benefits should be measured and reassessed throughout the project lifecycle. Embedding these practices into current roading authority processes is expected to improve the overall identification of benefits. This recommendation is aligned with NZ Treasury's work on managing benefits (The Treasury 2016b).

Decisions can be made very early in the scheme development or options appraised that result in significant costs or benefits. This research has concluded that current NZ Transport Agency processes at the early stages of project planning do consider environmental and social impacts, eg avoidance of areas of ecological value, but these values are not articulated later in the project's development. The focus becomes the benefits added to the scheme later in the project process, for example measures that mitigate any negative effects remaining. This research project recommends capturing value from the project's commencement using the benefits register, to ensure that the full value from implementing environmental legislation is captured, including value delivered by 'avoiding' impacts through early project choices.

The research recommends the development of a value database to capture basic information about schemes, along with the benefits realised and associated costs. This would enable, in time, the identification of areas where value is consistently realised through meeting the requirements of environmental legislation. Another recommendation of this research is that as a database of scheme 'value' is developed, the NZ Transport Agency considers whether to engage further primary economic research (willingness-to-pay studies, for example) to assist it in monetising benefit to a fuller extent.

The benefits register and value database concepts could also be applied to determine and demonstrate 'value' in other outcome areas beside the implementation of environmental legislation. Obvious examples where this framework could be adapted and applied include safety and journey management outcomes.

The recommendations made within this report have resourcing implications for roading authorities and could be undertaken in a staged manner and/or by pilot studies for a limited set of roading improvement projects. The recommendations should also be considered in the context of other initiatives to collect information and measure performance that the NZ Transport Agency and other roading authorities may be considering.

Abstract

This research developed a framework to enable roading authorities to understand the value of meeting the requirements of environmental legislation for roading improvement projects.

The Resource Management Act 1991 (RMA) is New Zealand's main piece of legislation that determines how the environment is managed and was the focus of this research. Government and roading authorities are seeking an understanding of the costs and benefits of environmental mitigation in particular, which meant this research sought to understand the outcomes of the 'avoid, remedy, mitigate' process set out in section 5 of the RMA.

Value was determined to be the difference between costs and benefits. The research recognised that not all benefits can be adequately monetised at this point in time, so the framework captures qualitative information, quantitative information and monetary measures.

The framework was tested on three case studies, and the research concluded it can be applied across the full project lifecycle and can be facilitated by adopting a project benefits register.

The study found that, to better inform decision making around the value of meeting the requirements of environmental legislation, a consistent approach to cost and benefit capture is required across roading authorities, which links costs with activities and outcomes arising from the implementation of environmental legislation.

1 Introduction

1.1 Project background

The NZ Transport Agency (the Transport Agency) is a Crown entity established under the Land Transport Management Act 2003. The Transport Agency's objective is to undertake its functions in a way that contributes to an efficient, effective and safe land transport system in the public interest.

Each year the Transport Agency invests a portion of its funds in innovative and relevant research (including the publication of that research) to contribute to this objective. This research report is a part of the 2015/2016 research programme. The Transport Agency (2015c) is aware that the:

> *costs and benefits of meeting environmental legislation (for roading improvement projects) are not fully understood by Road Controlling Authorities or Government Agencies as they are not measured systematically using an established methodology. This leads to assumptions around the costs of environmental mitigation and its value; and a lack of understanding of how the intent of the environmental legislation can be met in a cost effective way.*

This project has developed a framework for capturing the costs and the benefits arising from environmental legislation, which if fully implemented would enable the value of meeting the requirements of the legislation to be determined. While this report refers to the Transport Agency throughout, other roading authorities have been considered in the development of the framework, which was tested using case studies from Auckland Transport.

1.2 Policy context

The *Government policy statement on land transport 2015/16 – 2024/25* (GPS 2015) (Ministry of Transport 2014) sets out the Government's strategic and policy objectives for land transport, guiding investment by the Transport Agency and local authorities. The GPS 2015 reflects the Government's understanding that:

> *The land transport sector has stewardship of a significant proportion of our national wealth, and needs to ensure that public expenditure delivers the right infrastructure and services to the right level and at the best cost. There are high user and societal expectations for increases in levels of service across the whole transport network. Users express this in terms of reduced levels of congestion, a safer system, greater resilience, and mitigation of environmental impacts. Transport decision-makers need to take account of those expectations, and ensure that transport makes a broad positive contribution to the economy and society.*

This research project sought to understand both the cost of meeting the requirements of environmental legislation and the benefits delivered in doing so, to provide insights into value that will assist transport decision makers over the long term. Amongst other things, this might assist in ensuring that transport infrastructure investments are 'at the best cost', which we interpret to mean a level of investment at which the net benefits of investment are maximised.

The GPS 2015 also provides objectives to guide investment in land transport. Of most relevance to this research project is the objective that New Zealand will have 'a land transport system that mitigates the effects of land transport on the environment'.

The Government's long-term result for this objective is described as mitigation of environmental effects. This is further detailed in the GPS 2015:

> *Land transport investment can have positive as well as negative impacts on the environment. Investment in motorways or expressways that removes traffic from suburban streets can significantly improve the living environment for many people within the transport catchment. Investment that reduces fuel use by enabling shorter trips or smoother traffic flow can reduce the national or global impacts of land transport.*
>
> *However, improvements can have adverse impacts on those living closest to the new facilities. These local impacts are addressed in the course of securing Resource Management Act 1991 approvals to enable benefits to wider society to be unlocked.*
>
> *We need to get to a position where the total investment in environmental mitigation is better understood. The level of investment in environmental mitigation needs to be known to support well informed decisions that get the best returns from our investment (*Ministry of Transport 2014).

It is within this context that the Transport Agency commissioned this research project 'Understanding the value of meeting the requirements of environmental legislation'. The outcomes of the project will enable roading authorities to capture the costs and benefits of meeting the requirements of environmental legislation and to develop, over time, an appreciation of the value delivered through its related investment. The GPS 2015 provided important context for the project and further guided the project to focus on the value of environmental legislation as it relates to adverse effects and measures taken to avoid, remedy or mitigate these in the implementation of a roading scheme.

The strategic directions for research in the transport sector have been set by the *New Zealand transport research strategy 2016-2010* (Transport Knowledge Hub 2016b) and the *New Zealand transport domain plan* (the Domain Plan) (Transport Knowledge Hub 2016a). These were developed by the Transport Knowledge Hub and endorsed by the relevant central and local government agencies including the Ministry of Transport and the Transport Agency.

The Domain Plan contains enduring question EQ7.1, which asks what regulations apply to transport services operating in New Zealand, what are the costs and benefits of different regulations, how effective are different regulatory frameworks, and how are these things changing, including, modally, regionally and temporally? The recommended initiative R7.1 is a project to improve monitoring and evaluation of transport regulatory effectiveness. The activities anticipated by this project included reviewing or improving current methods and processes and/or developing new methods. Therefore, this research project aligned well with the Domain Plan's R7.1, but had a focus solely on environmental legislation. It was appropriate to consider just environmental legislation as it has a major and unique impact on transport projects primarily through the Resource Management Act (1991) (RMA).

1.3 Purpose

The stated purpose of this research was to:

- understand the value of meeting the requirements of environmental legislation
- develop a tool or methodology for road controlling authorities and other government agencies to determine the costs and benefits to be captured and analysed, at a project, regional and national level.

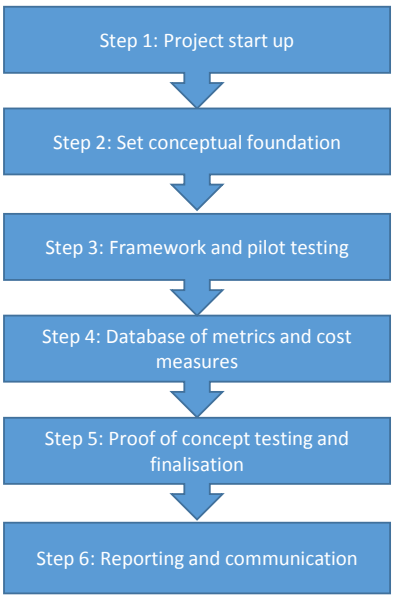
In its Request for Proposal the Transport Agency identified a number of underlying or associated aims and questions, as follows:

- The research will need to provide an understanding of the value, including tangible and intangible costs and benefits of meeting the requirements of environmental legislation for roading improvement programmes.
- What is the value of meeting the intent of environmental legislation for roading improvement projects relative to other project costs and benefits?
- Compliance with environmental legislation imposes various costs at different stages of project lifecycles, but is intended to avoid other (environmental costs) that would otherwise be borne by society.
- Costs incurred include avoiding pursuing options; finding design solutions; regulatory costs; mitigation works (such as noise barriers, storm water treatment, the implementation of erosion and sediment control measures during construction) and environmental monitoring and offsetting.
- How is value currently determined, and what is the most appropriate systematic method to specifically attribute the costs and benefits of meeting environmental legislation in the future?
- Understanding the costs and benefits of meeting environmental legislation will help inform investment decision making at the national and regional programme level.

1.4 Methodology

The methodology for this project is summarised in figure 1.1. Following the establishment of the project Steering Group, the research team spent a period developing the conceptual foundation of the project – formulating definitions for key terms including 'value' and 'environmental legislation'. The literature review considered possible assessment frameworks and approaches. Also within the conceptual phase the team reviewed a number of historical Transport Agency projects to determine whether current practices enabled the capture of the cost and benefit of environmental legislation.

Figure 1.1 Project methodology



The project then moved into a framework development and pilot testing phase. The pilot case study identified that the framework was appropriate, while highlighting the challenges in applying it.

Wider testing on two further case studies followed, along with the development of additional metrics to capture value.

1.5 Report structure and audience

This research report has been structured as follows:

- Chapter 2 provides a summary of the project scope, including key definitions.
- Chapter 3 presents the framework for capturing the value of environmental legislation.
- Chapter 4 provides the outcomes of three case studies used for this research project.
- Chapter 5 sets out the conclusions of the research, recommendations for implementation and for future work in this area.

References are included in chapter 6, while the appendices include:

- a review of monetary valuation methods in the international roading sector
- the literature review and alternative options considered
- a summary of current Transport Agency project practices
- framework user guide
- case study detail
- recommended improvements to the *Economic evaluation manual* (EEM[1]) (NZ Transport Agency 2016a).

In compiling this report the researchers have focused on the practitioner, charged with implementing a framework for capturing the value of meeting the requirements of environmental legislation. As such, detail on alternative approaches considered, current processes and practices, and case study outcomes are included as appendices. It is assumed readers of this report have a working knowledge of the New Zealand environmental planning and regulatory system.

[1] Unless otherwise indicated, the abbreviation EEM throughout the report refers to the 2016 version of the manual.

2 Project scope

This research focused on designing a structured method that captures the value delivered through roading projects by meeting the requirements of environmental legislation based on the Resource Management Act 1991 (RMA). The method is sufficiently flexible to be applied to identify value delivered by other environmental legislation, again in the context of roading project delivery. This chapter details environmental legislation in the context of New Zealand roading projects, how value has been defined and the application of value in the context of meeting the requirements of environmental legislation.

2.1 Defining environmental legislation

2.1.1 The Resource Management Act 1991

The RMA is New Zealand's main piece of legislation that determines how the environment is managed. It is the primary guiding legislation through which roading authorities exercise their environmental responsibilities. The primacy of this legislation in the context of environmental management meant it was the focus of this research.

The RMA is an enabling statute with the underpinning purpose of sustainable management as set out in section 5:

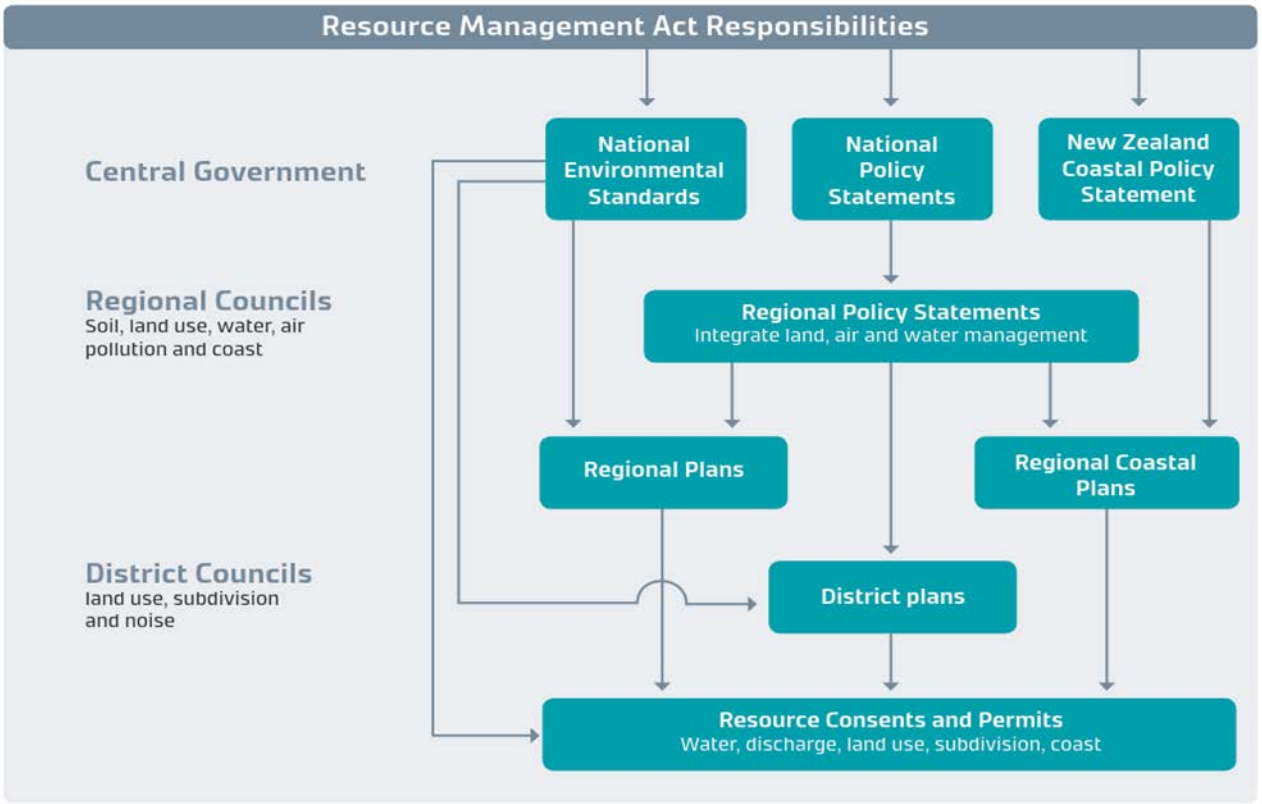
> *(1) The purpose of this Act is to promote the sustainable management of natural and physical resources.*
>
> *(2) In this Act, sustainable management means managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural well-being and for their health and safety while—*
>
> *(a) sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and*
>
> *(b) safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and*
>
> *(c) avoiding, remedying, or mitigating any adverse effects of activities on the environment.*

The RMA establishes functions and duties for central and local government agencies (regional, district, city or unitary councils). For central government, this includes issuing national policy statements and national environmental standards. The purpose of national policy statements is to address matters of national significance that are relevant to achieving the purpose of the RMA. For local government, councils have a number of functions (as outlined in sections 30 and 31 of the RMA) for the purpose of giving effect to the RMA. These include establishing objectives, policies and methods:

- to achieve integrated management of natural and physical resources, where there are regionally significant actual or potential effects associated with the use, development, or protection of land (in the case of regional councils)
- to achieve integrated management of the effects of the use, development, or protection of land and associated natural and physical resources of the district (in the case of territorial authorities).

These functions establish a hierarchy of policy statements, standards and plans to achieve the purpose of the RMA as show in figure 2.1.

Figure 2.1 Resource Management Act and the national and local planning framework



The hierarchy ensures consistency between plans as it flows down from the national, to regional, and district level, with increasing detail at each stage. At the district level, network utility operators who are approved as requiring authorities (including the Transport Agency as a constructor and operator of roads) can include designations in district plans to give effect to their requirements.

The RMA operates in practice by establishing a set of duties and restrictions on the use of land, the coastal marine area, rivers and lake beds and water; and on discharges of contaminants into the environment. Generally, these restrictions apply to activities unless they are permitted by rules in regional or district plans (or national environmental standard) or authorised by a resource consent.

Applications for resource consents and notices of requirements for designations are made in the context of the hierarchy of plans and the objectives, policies and rules they contain. They are required to be accompanied by an assessment of environmental effects (AEE). The AEE must assess the proposal against the relevant objectives, policies and rules in the hierarchy of policy statements, plans and standards; and assess the effects of the proposed activities on the environment. Consistent with the meaning of effect in the RMA, the AEE is required to assess positive as well as adverse effects.

The provisions of the relevant policy statements, plans and standards and the AEE are considered by consent authorities in their decisions on whether to grant consent and setting conditions on any consent granted. The consent authority may consider other matters it considers relevant and this may enable requirements of other regulatory or non-statutory document to also be considered in the consenting process.

2.1.2 Other relevant environmental legislation

A non-exhaustive list of other environmental statutes relevant to roading projects includes:

- Heritage New Zealand Pouhere Taonga Act 2014
- Hazardous Substances and New Organisms Act 1996
- Biosecurity Act 1993
- Wildlife Act 1953
- Reserves Act 1977
- Marine Reserves Act 1971
- Marine Mammals Protection Act 1978
- Conservation Act 1987
- Local Government Act 2002
- Health Act 1956.

The detailed requirements of many of these statutes are triggered by location-specific aspects of a scheme, for example whether the roading corridor traverses an area of Department of Conservation land, adjoins a marine reserve or impacts on an area with heritage or cultural value. Other location-specific legislation can also be influential, for example river settlement legislation influencing the Waikato and Waipa Rivers in the Waikato region. The Marine and Coastal Area (Takutai Moana) Act 2011 may also be a relevant for marine and coastal areas.

Often the impacts of the scheme and the requirements of the other statutes are considered alongside the resource consenting processes.

This research focused on designing a structured method that would capture the value delivered by roading projects through meeting the requirements of the RMA. The framework and approach, complemented if necessary by key reference documents, is sufficient to enable practitioners to consider the value of meeting the requirements of other environmental legislation where it is applicable to a scheme.

2.1.3 What does 'meeting the requirements of environmental legislation' mean?

The purpose of the RMA, as set out in section 2.1.1 of this report, is broad and holistic. However, the value this project sought to understand related to actions taken to address the requirements of part 2(c) of the purpose of the RMA as set out in its section 5:

> *Avoiding, remedying, or mitigating any adverse effects of activities on the environment.*

In the context of this research 'meeting the requirements of environmental legislation' relates to the matters that are considered for the resource consenting of a scheme. The research did not primarily seek to capture other issues such as safety or travel time improvements.

The RMA definition of environment is broad, including:

> *a) ecosystems and their constituent parts, including people and communities; and*
>
> *b) all natural and physical resources; and*
>
> *c) amenity values; and*

d) the social, economic, aesthetic, and cultural conditions which affect the matters stated in paragraphs (a) to (c) or which are affected by those matters.

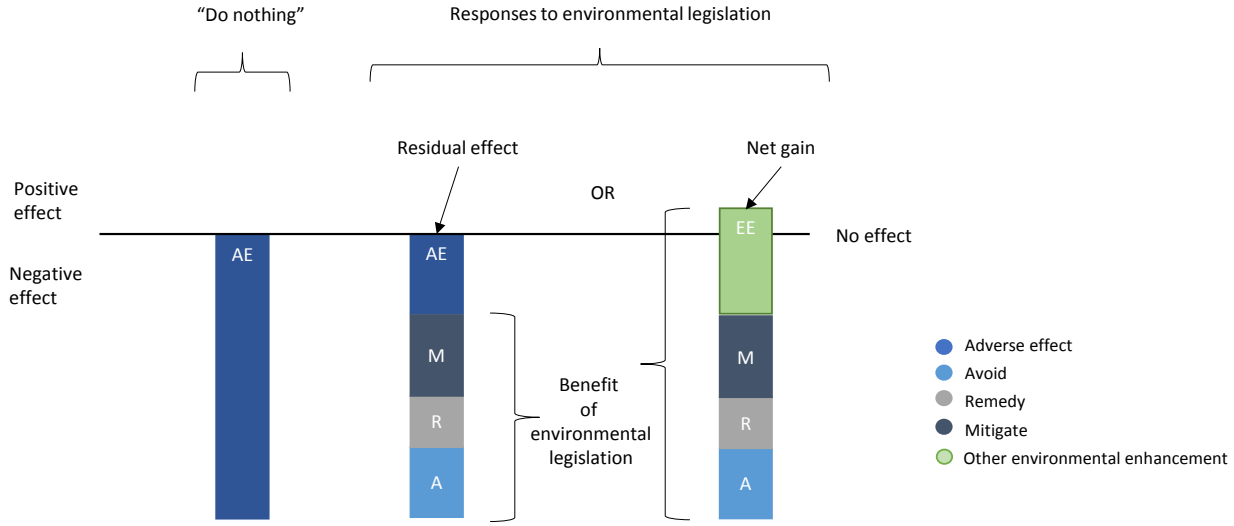
This project applied an interpretation of the environment, based on those adverse effects normally considered by a project in the development of an AEE and consenting process (and as outlined in clauses 6 and 7 of schedule 4 of the RMA).

Schedule 4 of the RMA sets out the requirements for a resource consent application, which must include:

- a description of the activity and site
- an assessment of the activity against the purpose and principles of the RMA (part 2) and relevant policy statements, environmental standards and plans
- an assessment of the environmental effects.

The AEE process requires a structured approach to the expected effects (actual and potential) of a scheme, followed by the application of measures to avoid, remedy and mitigate adverse effects. Figure 2.2 illustrates this process, focusing on adverse effects. Adverse effects can be avoided, remedied or mitigated, potentially leaving residual adverse effects or net gains. A consent may still be granted if residual adverse effects that have been identified during the consenting process are reduced to an acceptable level, for example through consent conditions.

Figure 2.2 Benefits attributable to meeting the requirements environmental legislation due to responding to adverse effects



Source: Modified from the Business and Biodiversity Offsets Programme (2009)

2.1.4 Beyond mitigation

The authors had the opportunity to speak to many roading project managers over the course of this study, many of whom assumed the focus lay on isolating the costs and benefits of environmental *mitigation*. Mitigation measures, for example stormwater treatment or fish relocation, are often the most obvious environmental components at the scheme delivery stage. However, the greatest environmental benefit could be delivered at the scheme selection phase, by avoiding an alignment that traverses environmentally sensitive areas for example.

A key conclusion of this report is that environmental and social benefits considered early in the project development are not always carried into subsequent stages when the approved scheme is refined. This means some of the greatest value delivered through implementing environmental legislation associated with 'avoiding' effects, eg by route selection, are not captured or articulated later in the project development, which focuses on the mitigation measures added to the scheme.

2.1.5 Exceeding the legislative requirements

A key challenge that arose during this study was how to delineate between the requirements of environmental legislation and components of enhancement that might be delivered within a scheme.

As outlined in section 2.1.3 of this report, the purpose of the RMA is to promote the sustainable management of natural and physical resources. Section 5(2)(c) of the purpose states sustainable management must be undertaken while 'avoiding, remedying, or mitigating any adverse effects of activities on the environment'. The RMA is also clear in its obligations on regional councils in section 30 to both maintain and enhance aspects of the environment such as water quality and quantity, and ecosystems. The *New Zealand coastal policy statement 2010* (NZCPS) (Department of Conservation 2010) and the *National policy statement for freshwater management 2014* (Ministry for the Environment 2014) also require environmental improvements. There are Environment Court and Supreme Court cases where the application of these obligations has been tested in the context of resource consent applications. Notably these include *Puke Coal Limited v Waikato Regional Council* [2014] NZEnvC 223 (23 October 2014) which specifically addresses both betterment and mitigation, and *Environmental Defence Society Inc v The New Zealand King Salmon Co Ltd* [2014] NZSC 38 which interpreted the implementation of the NZCPS.

The term *mitigation* is not defined in the RMA. For the purposes of this project, we have adopted the following commonly used concepts:

- mitigation relates to the reduction of an acknowledged adverse effect
- enhancement generally relates to an improvement on the existing state.

A 'minimum' or 'maximum' mitigation is not required by legislation but is determined by assessment including evaluation against policies and identifying effects on the existing environment.

We determined that enhancement above the requirements of legislation (net gain) could not easily be identified for the following reasons:

- As noted above, the RMA and national policy statements envisage that regional councils will enhance or improve the existing environment.
- Value required to meet (or exceed) the requirements of environmental legislation is often determined through consultation with affected parties – who have their own context of worth – or by a Commissioner, who will form a view of worth, based on technical evidence and arguments presented (often with competing views). In short, the location of the 'no effects' line may be perceived differently by the varying parties.
- Benefits may also arise through the implementation of a roading authority's own practices, such as the Transport Agency's social and environmental responsibility policies.
- Enhancements to one area of a project may be intended to counter residual adverse effects in another, forming part of an overall package of mitigation.
- It is often difficult to isolate any enhancement from the legislative requirements (as they are established in individual resource consenting processes).

- It is difficult to answer the hypothetical question 'would this scheme have been granted a consent if we hadn't provided an enhancement?' It is not possible to construct this counterfactual.

In many instances components not strictly required by environmental legislation (including associated plans and policies) form part of the 'contract' (the resource consents and designations) with local communities in exchange for, or to mitigate, the overall effects of road construction. This reflects that roading projects often deliver benefits to a wider community – national, regional or district-wide populations and economies while any negative effects, whether these are short or long term in duration, are typically most acute for local communities.

Examples of enhancement could include:

- a landscape and urban design framework – providing outcomes such as scheme specific art or architecturally designed bridges
- the provision of areas of planting greater than those calculated through any 'offset' method. Triggers for this can be as simple as land availability, or a recognition of the wider ecosystem and amenity outcomes provided by the tree planting
- cycleways, footpaths and public amenities greater than those required to mitigate any severance or other similar issues.

Figure 2.3 shows how legislation and Transport Agency policy is interlinked, including specialist guidelines and the environmental and social responsibility standard.

Figure 2.3 New Zealand Transport Agency guiding environmental and social legislation and policies

This project took a pragmatic approach to responding to the challenge of identifying enhancement. It encourages those following the framework to identify all the environmental benefits of the scheme and proposes the collection of sufficient information to enable the development over time of a value database. By interrogation and inspection, it should be possible with time to compare schemes and environmental benefits.

2.2 The concept of value

Value is defined from the perspective of the whole community and encompasses all things that result in changes in wellbeing. As a government objective, maximising the total wellbeing of society over time stems from utilitarianism. This is a philosophy that defines the ethically best choice in any situation as that which most improves wellbeing (or utility). A fuller discussion of economic value is included in appendix A. Cost-benefit analysis (CBA) is the practical application of the utilitarianism theory and attempts to measure, quantitatively where possible, all factors that affect wellbeing. Within the CBA context, economic value is the difference between costs and benefits.

CBA is central to Transport Agency decision making. It is embedded in Treasury methodologies (The Treasury 2015c) and the *Economic evaluation manual* (NZ Transport Agency 2016a). For the purpose of this project, costs are determined to be the capital (and where possible) operating costs of a scheme. As such this study has sought to convert as many benefits as possible into monetary benefits, which enables them to be most readily expressed in current Transport Agency processes and practices.

There are a number of reasons why it is not always possible to monetise benefit, including:

- a paucity of detail, for example at the early stages of a scheme design
- no relevant or sufficiently local primary research in relation to the monetisation of a component of benefit
- lack of base data required to consider the impact on society, for example forecast changes in visitor numbers to an area.

The Natural Capital Protocol (Natural Capital Coalition 2016) approach adopted by this project intends to overcome some of these barriers. The concept of natural capital is gaining increasing traction with policy makers and business leaders in other parts of the world (UKWIR 2016). The Natural Capital Coalition (2016) defines value as 'the importance, worth, or usefulness of something' and valuation as the process of estimating the importance, worth or usefulness of natural capital to people. It includes qualitative, quantitative and monetary approaches, or a combination of the three.

A qualitative approach describes impacts or dependencies and may rank them as high, medium or low. The capture of the value of meeting the requirements of environmental legislation in qualitative terms is expected to form a 'rich narrative' relating to the scheme. By succinctly 'telling the story' of consultation and consenting and the benefits and costs identified at that stage, a record is created. Repeating this facilitates knowledge capture over the lifecycle of a scheme and the comparison with other schemes will enable the value of meeting the requirements of environmental legislation to be better understood.

The quantitative approach uses non-monetary units such as numbers to capture the magnitude of the value delivered by environmental legislation, for example the length of watercourse diverted or naturalised, or the area of mass planting for landscape impact mitigation.

Monetary valuation is encouraged, where possible and meaningful, to enable consideration of costs and benefits using a common currency.

A more detailed discussion of the natural capital approach is included in appendix C2.

Some commentators also argue there is an intrinsic value – part of the essential nature of a thing (Merriam-Webster Dictionary) – which sits outside an anthropocentric view. Eppink et al (2016) provide an accessible and helpful discussion of different value paradigms including intrinsic value. Intrinsic value may have relevance in the context of cultural value considerations, but is not contemplated in this study.

2.3 How to value meeting the requirements of environmental legislation

The RMA requires an AEE to be carried out when applying for a resource consent. The process for compiling an AEE typically:

- determines the baseline environmental condition (the existing environment and permitted development envelope)
- models or predicts the environmental effects of the scheme, both during construction and during its operation
- develops measures to avoid, remedy or mitigate adverse environmental effects.

This project has sought to capture the value delivered through this process.

To capture this value in full requires consideration of a 'do nothing' environmental scenario. For example, the 'do nothing' earthworks scenario could be excavation across the full site with no phasing, erosion or silt control measures. Discussions with practitioners indicate current practices do not always contemplate a 'do nothing' scenario, as council and societal expectations require the implementation of good or best practice measures to avoid, remedy or mitigate effects. The case studies in chapter 4 demonstrate the challenge of identifying this 'do nothing' or 'counter factual' scenario.

A key conclusion of this research is that insufficient consideration of the 'do nothing' scenario may mean the incremental benefits associated with environmental legislation are under estimated.

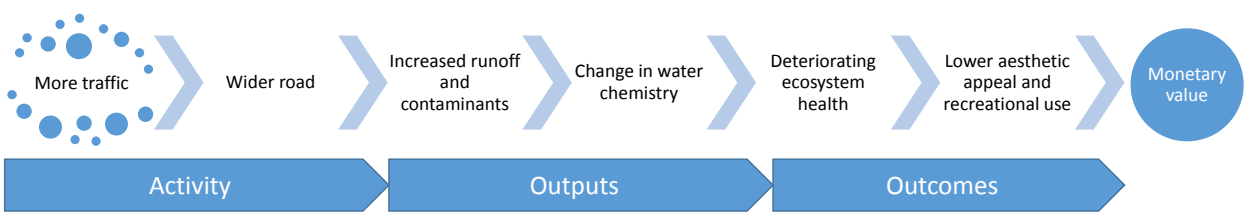
Capturing the full value of meeting the requirements of environmental legislation also requires consideration of how decisions made very early in a project scheme have delivered benefits and influenced costs. For example, a road alignment may have been selected to avoid an area of conservation land, watercourses, or site of cultural or social significance. The effort required to monetise the associated costs and benefits could be considerable, as it would require an alternative design for the 'do nothing' scenario, but inclusion of this in a qualitative rich narrative enables a more complete assessment.

Applying a method where value is described qualitatively, and quantified and monetised where possible, leads to consideration of both outputs and outcomes from meeting the requirements of legislation.

Roading projects will have environmental effects, some of which will be factors of significance to people, which can be considered outcomes or things that provide them with wellbeing. Others effects will be outputs, or intermediate effects, which may be easier to capture or quantify.

For example, an increase in traffic volumes and road runoff results in a change in river chemistry (an output), which in turn results in changes to ecosystem health and the suitability of the river for recreation, its aesthetic appeal etc (outcomes). Any wellbeing impacts result from changes in the factors valued directly by communities, such as recreation and aesthetic appeal and these can be monetised, as shown diagrammatically in figure 2.4.

Figure 2.4 Activities, outputs, outcomes



Both the AEE and the natural capital approach lead to consideration of environmental value in a structured manner, addressing individual components of an ecosystem or wider environmental context. For example, an AEE will normally address impacts on water quality, ecology, air quality, noise, landscape etc.

It was beyond the scope of this research to develop a detailed methodology for each 'component' of value delivered by meeting the requirements of environmental legislation. The research team focused on key information that would enable the social, ecological and water-related benefits to be captured more fully. Further work beyond this study is required to consider benefits relating to other aspects such as landscape and visual effects or other project specific needs. It is envisaged these frameworks can be developed by experts in each discipline applying the Natural Capital Protocol approach – qualify, quantify and monetise. Specialist economists will be needed to develop these monetary values.

A recommendation of this research is that as a database of scheme 'value' is developed, the Transport Agency considers whether to engage further primary economic research (willingness-to-pay studies, for example) to assist it in monetising benefit to a fuller extent.

3 Framework

3.1 Introduction

This chapter focuses on the recommended framework for understanding the value of meeting the requirements of environmental legislation. The framework is based on a literature review of possible assessment frameworks and approaches. The researchers also reviewed a number of historical Transport Agency projects to determine whether current practices enable the capture of the cost and benefit of meeting the requirements of environmental legislation. The literature review of benefits approaches is detailed in appendices B and C.

The reviews of Transport Agency projects found the Transport Agency does not currently collect information in a manner that enables the value of meeting the requirements of environmental legislation to be determined. The review of current practices and processes is included in appendix D. Three primary reasons for this are:

- This value is not a key driver for data development or collection.
- While benefits are determined by and articulated in the environmental planning process (primarily in the AEE document), they can be difficult to distil from the comprehensive scale of documentation and are not captured consistently between roading projects.
- Current processes do not require detailed or consistent capture of costs that relate to meeting the requirements of environmental legislation.

A more comprehensive discussion of current processes and practices is included in appendix D.

In response to these information gaps, a framework was developed, along with key output and outcome measures, to enable the collection of consistent data accompanied by a sufficient narrative through the project lifecycle to identify value. Essentially this comprises a project benefits register as promoted by Treasury (2016b) and as such this term has been used to describe a recommended output of this project. It also includes recommendations for the capture of costs linked to activities carried out to implement environmental legislation as a key output of cost management systems.

It should be noted the focus of this research project has been on capturing the value delivered by meeting the requirements of environmental legislation. Transport schemes inherently deliver safety and/or economic benefits and inherently incur costs. These benefits, and others outside of the remit of environmental legislation, should be added to a benefits register if this concept is adopted by the roading authorities.

The framework and metrics were designed to capture the value realised at each stage of the project lifecycle – from the programme business case through to scheme implementation. Ongoing operations and maintenance, including capital maintenance schemes, fell outside the scope of this study.

It is useful to briefly consider what this project did not set out to achieve. Its purpose was not to enable comparison of the environmental benefits of different options within a scheme selection process, nor was it intended to improve environmental outcomes. CBA, multi-criteria analyses and other established techniques can be used to compare different scheme options. Nor was the purpose to improve environmental outcomes as these can be delivered through the application of existing tools such as Greenroads (Greenroads Foundation 2015) or IS rating scheme (Infrastructure Sustainability Council of Australia nd) methodologies, or via the identification and capture of environmental opportunities through the scheme development process.

3.2 Principles

The literature review provided a number of possible frameworks for the consideration of environmental value. A series of principles were established to guide the development of the framework:

4 The information collected must be relevant. The data captured must align with the GPS 2015 objective to deliver a 'land transport system that mitigates the effects of land transport on the environment' and to understand the costs and benefits associated with this.

5 The time and effort expended on capturing data should focus on areas where there are material benefits and costs.

6 The assessment of value should be rigorous and repeatable.

7 The level of detail available will increase as a project proceeds. The framework must be sufficiently flexible to support this.

8 To be efficient and effective the framework must align with existing Transport Agency and roading authority processes and requirements, but may require augmentation of these processes.

3.3 Process

The framework adopts the methodology recommended by Eppink et al (2016) to the Transport Agency for assessing the benefits of cultural and historic heritage. Eppink et al (2016) enables the cultural value of a project, one component of value delivered through meeting the requirements of environmental legislation, to be assessed using the Heritage Economics Benefits Framework.

Figure 3.1 summarises the four-step process, which is expected to be applied iteratively through the project lifecycle.

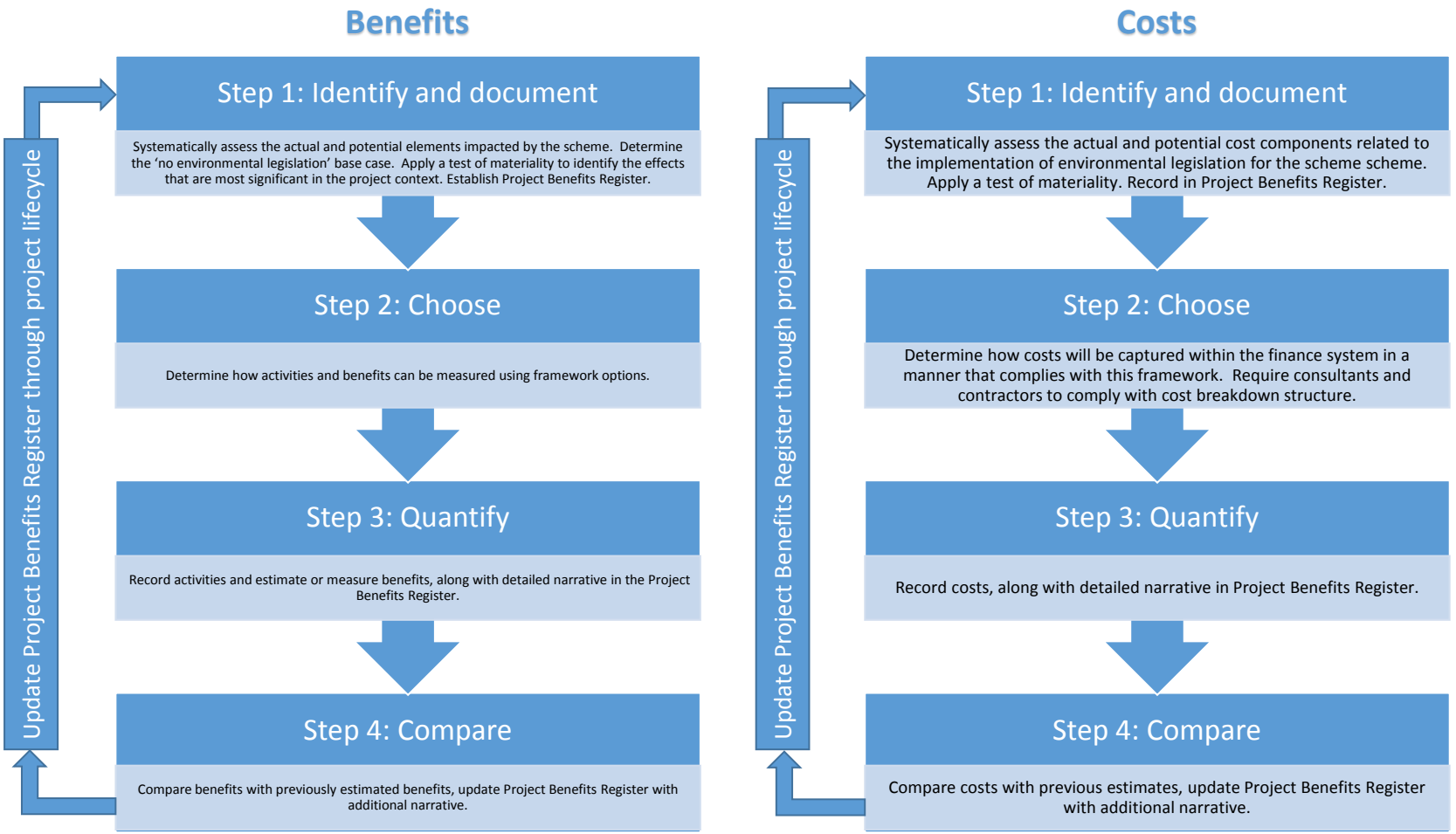
The recommended process for capturing the benefits of meeting the requirements of environmental legislation is for the creation of a project benefits register as a separate project document. The capturing of benefits is described in more detail in section 3.5.

A key conclusion of this research is that the coherent capture of data by updating the *Cost estimation manual* (CEM) (2015a), EEM and reporting requirements in finance and performance or asset management systems could enable much of the required information to be captured through existing channels. The capture of costs is described in detail in section 3.6.

There are wider gains from the project benefits register than to support this project, such as the benefit of storing and retaining the intellectual property of the project for use in subsequent stages, as the project reviews revealed these can be lost over the project lifecycle due to changes in key staff and suppliers. Also, the concept of a project benefits register (or a benefits realisation plan as promoted by Treasury (2016b)) could potentially be widened to capture all project benefits.

The activities required at each stage of the framework application are outlined in the following subsections.

Figure 3.1 Process for understanding the value of meeting the requirements of environmental legislation



Adapted from Eppink et al (2016)

3.3.1 Identify and document

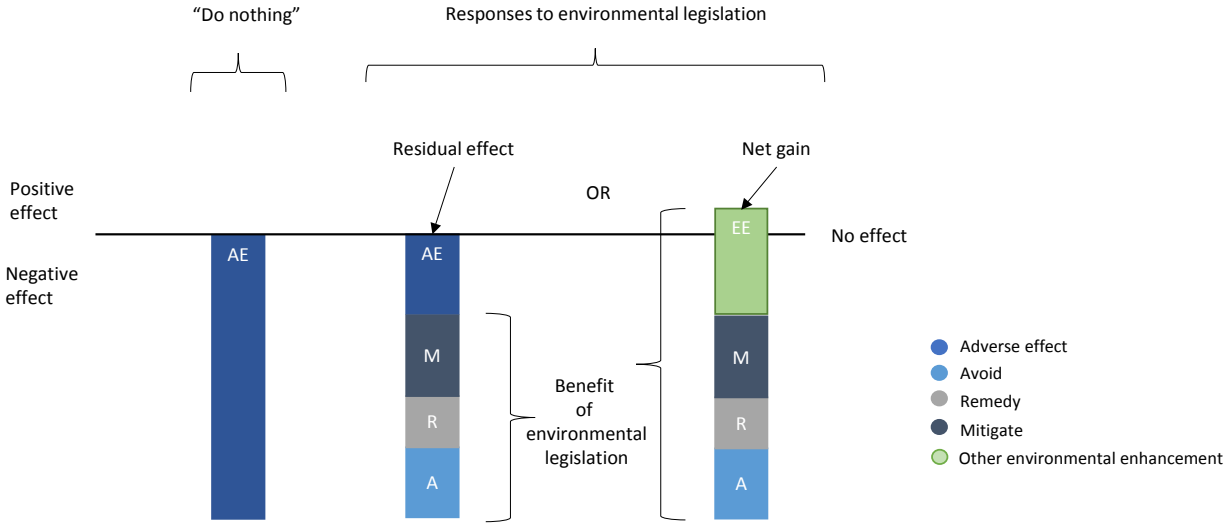
Systematic identification of potential costs and benefits associated with meeting the requirements of environmental legislation can be carried out using existing screening tools and processes, including:

- applying the Transport Agency's *Environmental and social responsibility screen*
- considering the Transport Agency's *Environmental and social responsibility policy*
- the consent and notice of requirement process and documentation including AEEs
- the user guides included in appendix E developed for the project to support the framework
- reference to case studies as there can be similar costs and benefits for different projects.

When considering costs and benefits, it is useful to refer again to the RMA and where benefits are delivered through section 5(2)(c) of the RMA, which is 'avoiding remedying or mitigating the adverse effects of activities on the environment'. This is diagrammatically presented in figure 3.2.

Central to the success of identifying costs and benefits is to consider the 'without meeting the requirements of environmental legislation' scenario or counterfactual situation. This scenario is often not captured by current consent processes and supporting documentation, as a 'do nothing' scenario for managing the effects of road construction on the environment does not align with current norms so is not examined. Examples would include practices seen in earlier decades such as end tipping material in the coastal environment or large scale earthworks without any silt or erosion control measures. Careful definition of the counterfactual is required to correctly identify the value delivered through meeting the requirements of environmental legislation.

Figure 3.2 Benefits attributable to meeting the requirements of environmental legislation due to responding to adverse effects



Core to the success of this process is the collation of sufficient information to capture value, without creating a disproportionate burden on resources. A wealth of information is included in an AEE, but with AEE documents running to hundreds if not thousands of pages it becomes very difficult to distil benefits. In populating the project benefits register practitioners should aim to present the most meaningful information in the most concise manner. A key conclusion of this research was that the capture of the value of implementing environmental legislation is not a fundamental aim of the current processes.

To identify the components of cost and benefit that should be included in the assessment, four key questions were proposed to establish the materiality of the component:

1 What is, or is expected to be important to stakeholders?

2 What are, or are expected to be significant issues in the planning process?

3 What are, or are expected to be, significant areas or items of worth impacted by the scheme?

4 What are, or are expected to be, noticeable costs linked to meeting the requirements of environmental legislation?

These questions could be supplemented or assisted by existing environmental screening and scoping criteria, and user guides, where they exist.

Costs should be considered where they are material to:

1 A proportion of the scheme cost, particularly for smaller schemes

2 A capital cost, relative to the total roading agency spend.

It was not appropriate for this research project to determine an absolute threshold for cost as a materiality test, as this would vary by roading authority and capital programme size and project size.

3.3.2 Choose

The components of cost and benefit can be measured using the three framework options:

1 Qualitative (or rich narrative) – this is a narrative description of the costs and benefits and should be populated for all items

2 Quantitative – this is a quantitative, but non-monetary measure of value, eg a numerical measure of the scale of the benefit or cost. This research project proposes key quantitative measures for benefits associated with water and ecology and social impacts, being areas where transport schemes have an effect and the RMA delivers a benefit at a cost. If quantitative measures are not currently detailed here the reader is referred to the Natural Capital Protocol (Natural Capital Coalition 2016) for useful guidance on identifying appropriate qualitative indicators

3 Monetary – expressing costs and benefits in monetary terms. The EEM sets out processes for monetising value where possible. This project further developed the monetisation of benefits in the streamworks and freshwater ecology environmental sub-categories as set out in appendix G. Proposed refinements to the monetisation of air quality-related impacts are also proposed, set out in appendix F. Costs are often recorded in engineering estimates for projects and can be used or derived.

3.3.3 Quantify

Develop the qualitative, quantitative and monetary measures. The projects reviewed for this research demonstrated that at the early stages of the project development (prior to the design completed for a detailed business case) there is little documented information that describes the benefits delivered by meeting the requirements of environmental legislation. However, from the reviewed projects it was apparent that critical project decisions such as route selection were being made at early stages based on environmental issues and consent risks. Hence a full narrative is required to identify benefits, especially for those realised in early stages, such as avoiding important ecological sites.

Once a sufficiently detailed design is prepared, it should be possible to record more quantitative information such as length of stream diverted and volume of runoff treated in stormwater devices. This information should be revisited at the completion of the detailed design and again following scheme construction. Where benefits have been assumed over the operation phase, such as water treatment benefits, measurement of actual outputs could significantly assist future value assessments.

Once a design has a business case and/or the design developed and estimates are updated then the monetary aspects can be recorded.

Through the project process the benefits register can be updated at project stage gates. The register can easily become a complex matrix, so care should be taken in its use across the project lifecycle. The research team concluded that meaningful determination of value (cost and benefit) can only be achieved by staff close to the project, such as the project manager and technical experts.

3.3.4 Compare

By comparing costs and benefits identified at each stage of the project, it will be possible to understand whether early assumptions around costs and benefits were correct, when and where costs have been incurred through the project lifecycle and where and when the most significant benefits arise.

This project recommends comparison between projects, which will enable a more in-depth understanding of the value of meeting the requirements of environmental legislation and how value can be maximised for future roading projects.

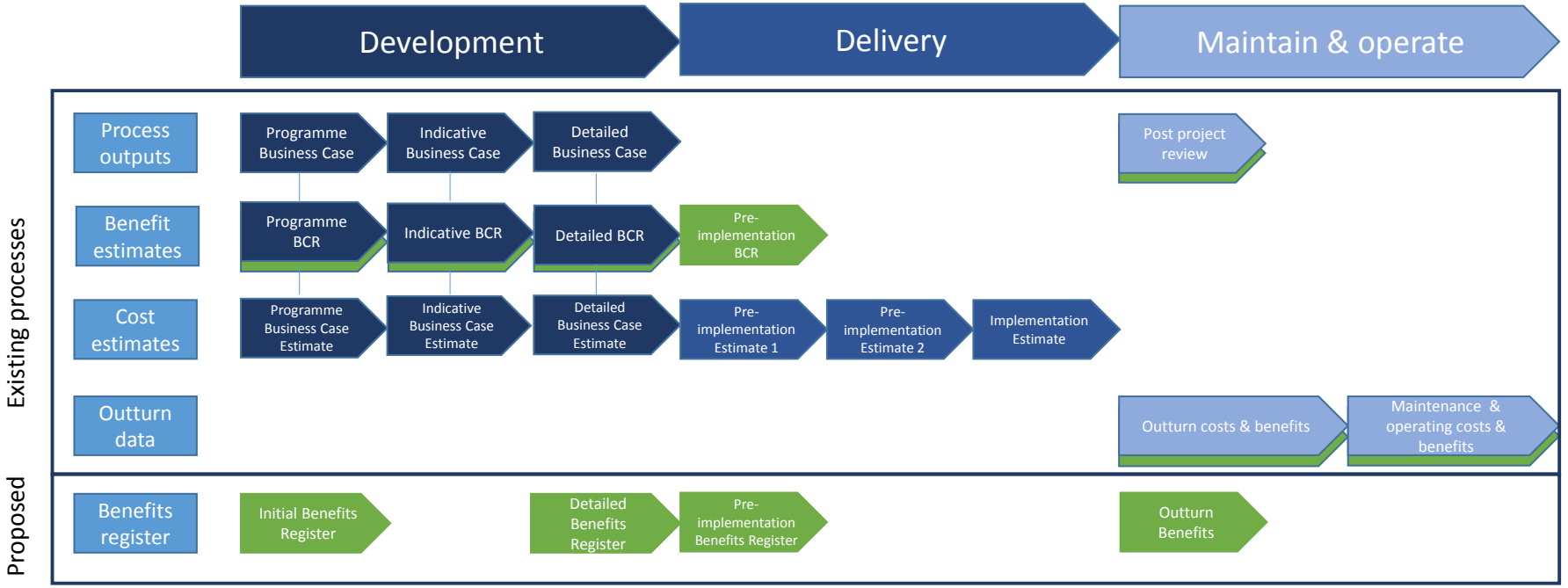
3.4 Applying the framework across the project lifecycle

The framework was primarily designed to capture information at the project level and it is expected it will be most usefully applied from the point of the detailed business case onwards for the purpose of this study. Notwithstanding this, the establishment of a project benefits register should occur early in the project lifecycle, at the programme business case phase, as indicated by the green box in figure 3.3. This enables early consideration of the interaction of the scheme with the environment and resultant opportunities and risks.

Figure 3.3 also illustrates how a project benefits register would be used through the ‘development’ phase through to the end of the detailed business case and revisited at the ‘delivery’ phase to capture value arising from the options appraisal phase, resource consent process, detailed design and construction. Any change in cost arising from the consent (such as amended design details) and benefit (such as improved outcomes for stakeholders) would be captured through the delivery phase. Finally, at the start of the ‘maintain and operate’ phase, the outturn costs and realised benefits following construction should be measured to capture changes through the delivery process, along with benefits over the operational period, which are typically estimated or assumed at the time of the consenting process.

Our findings from our review of Transport Agency processes were that post project reviews were not focused on the environmental benefits and costs, so considerable effort may be required at this stage to quantify and record information.

Figure 3.3 Framework overlaid with existing Transport Agency processes and cost and benefit documentation



Note: new documents / processes are shown in green boxes. Augmented processes (additional information capture) is shown by green shading

3.5 Capturing benefit

A structured matrix is proposed for the project benefits register as summarised in table 3.1. Qualitative information should be populated for each of the main phases of figure 3.3:

- the baseline situation, to define the current environment
- the predicted effects, assuming no environmental legislation were in place
- the benefits delivered through the 'avoid, remedy, mitigate process'
- the benefits delivered by enhancements
- residual effects.

The scale of each of these components should be quantified where possible.

Monetisation requires considerably more effort and is normally carried out by an expert economist. For the purpose of capturing the value of environmental legislation, monetisation of the benefits realised through the avoid, remedy, mitigate process is where this effort should be directed.

This project foresees the development of a database of scheme cost and benefit information across multiple projects, enabling the value of meeting the requirements of environmental legislation to be understood more completely with time. To promote the capture of a consistent dataset this research developed key questions to consider for the qualitative information, and data to seek when populating the quantitative information for the framework. These are set out in detail in appendix E.

The EEM sets out approaches for monetising many project benefits. However, it has gaps for methods to monetise benefits relating to many environmental aspects. This research focused on further developing methods for monetising benefits realised in the water environment. The development of these methods for the water environment and the application of the approach are detailed in appendix G.

Table 3.1 Standardised matrix for benefits capture

	Baseline	Effects	Meeting the requirements of environmental legislation	Residual effects
Quantitative	✓✓	✓✓	✓✓	✓✓
Qualitative	✓	✓	✓✓	✓
Monetise			✓✓	✓

Key: ✓✓ Complete for all indicators
✓ Complete where possible / time and cost effective

3.6 Capturing cost

To enable costs arising from meeting the requirements of environmental legislation to be isolated, the research concluded a new standardised cost breakdown structure to capture actual costs needed to be implemented.

The current situation is that the *Cost estimation manual* (NZ Transport Agency 2015a) requires project costs to be estimated in a detailed and structured manner prior to the tender and award of contract works. However, the research has shown that each tender has a different structure and that project managers are not required to record costs in a detailed or structured manner within the Transport Agency's financial system.

Any new cost structure would need to have the capture of the value of meeting the requirements of environmental legislation as one of its core objectives, to avoid costs being rolled up into categories broader than the legislative requirements.

To achieve such cost capture the Transport Agency or roading authority will need to contractually require its consultants and constructors to comply with a more comprehensive cost breakdown structure than at present. This may require some estimation of the balance of effort between environmental and engineering or other planning and legal considerations, but the degree of difficulty in doing this is considered moderate.

Practitioners seeking to capture the cost of meeting the requirements of environmental legislation should be aware of the following:

- Unless a bespoke estimate is carried out for the purposes of identifying the cost of meeting the requirements of environmental legislation at each stage gate, it will be difficult to capture changes in cost arising from this driver. For example, the cost of land or the cost of capital may change more significantly over the planning period than any costs imposed by the resource consenting process.
- To fully identify the cost of meeting the requirements of environmental legislation, the cost of constructing the scheme without doing so needs to be estimated. This would include practices that may be significantly cheaper (for example, without the controlled disposal of contaminated soil, stormwater systems designed only for conveyance, rather than for combined conveyance and treatment outcomes etc) but which have not been designed. This requires a bespoke design and cost estimate of a non-feasible scenario to be developed, which may not be attractive to funders and project managers.
- A more manageable approach is to isolate the extra components attributed to environmental mitigation such as erosion and sediment control measures, stormwater treatment devices and noise walls. Care is required to capture the enabling costs of the environmental mitigation such as additional land area or earthworks and the time cost of any construction programme difference due to these items. However, this approach will exclude the costs arising from ‘avoiding’ adverse effects. Capturing operations and maintenance costs is an area this research project was not required to address.

4 Case studies

During the process of setting the conceptual foundation of the framework seven projects were reviewed in detail. This enabled the development of the framework presented in this research report. Appendix D2 presents the finding of these reviews. The overall conclusion was that environmental values for the projects were not well captured and are difficult to extract from current processes/records. Information articulated by Transport Agency and council project managers or consultants provided a clearer insight to the value of implementing environmental legislation than any available quantitative data.

Significant effort was invested in identifying suitable case studies for the conceptual and assessment phases. Three case studies were finally identified to first trial the framework then to apply it. A component of the Waterview Connection was selected for the trial, and the Mill Rd and Te Atatu Rd projects were used to demonstrate how the final framework can be applied. The selection of these projects was determined by:

- timing – underway or relatively recent at the time of the trial and final framework testing
- availability of key staff with a detailed working knowledge of the scheme.

The framework was applied at a single point in time for these case studies using documentation prepared for other purposes. This was necessary due to the project timescales and scope. The process detailed in section 3.3 was therefore not applied in full to these case studies.

4.1 Waterview Connection – Board of Inquiry phase

4.1.1 Description

The Waterview Connection is a segment of the Western Ring Route, which links Manukau, Auckland, Waitakere and North Shore by connecting SH20, SH16 and SH18 in a 48km long motorway route. The Western Ring Route enables people to bypass the city centre when travelling around Auckland, reducing the reliance on SH1 and the Harbour Bridge and increasing connectivity within the city with positive economic growth and productivity results.

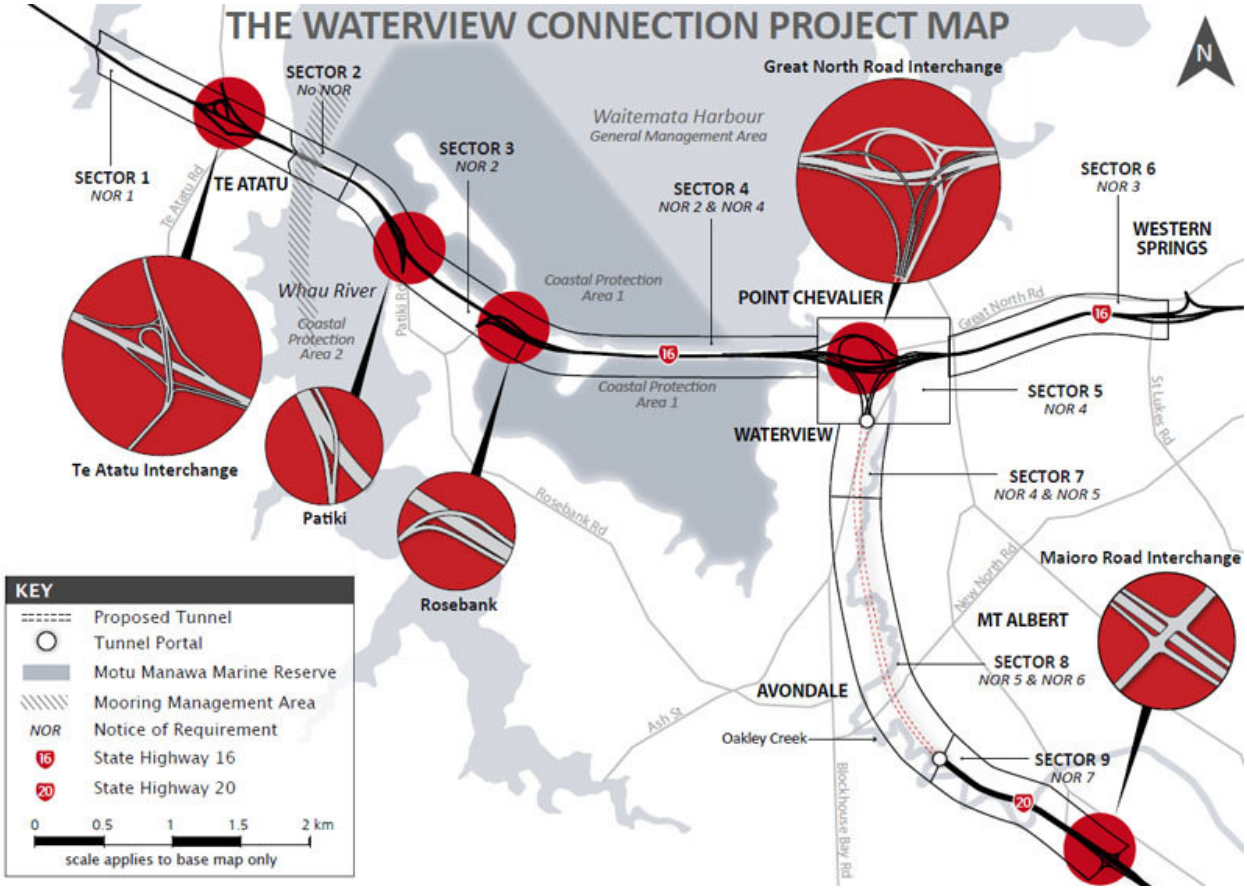
A Board of Inquiry gave consent to a suite of five ‘Western Ring Route’ projects, which included the Waterview Connection project.

The Waterview Connection links SH16 and SH20 through the suburbs of Mt Albert, New Windsor, Waterview and Point Chevalier in a 4.5km long new section of motorway with deep tunnels. The cost of the Waterview Tunnel was around $1.4 billion, of a total Western Ring Route cost of $2.4 billion. The tunnel opened as this report was finalised.

The freshwater ecology and streamworks components of the Waterview Connection projects were used as a pilot study to test this framework. The Board of Inquiry phase (delivery, pre-implementation phase in figure 3.3), was used for the assessment prior to finalising the methodology and the more comprehensive case studies.

The extent of the scheme in shown in figure 4.1. This case study primarily relates to the works linked to sectors 5, 7, 8 and 9, as the most significant freshwater and ecology impacts and benefits were on the Oakley Creek.

Figure 4.1 Scheme extents, Waterview Connection



Source: nzta.govt.nz/projects/wrr/docs/waterview-connection-graphic-map.pdf

4.1.2 Planning approvals and key issues

The applications for designations and resource consents for the five project components of the Western Ring Route were received by a Board of Inquiry, the first project to do so in New Zealand. In June 2011 the Board of Inquiry approved the designations and resource consents with some changes including additional mitigation measures.

Key issues as determined by the Commissioners (Board of Inquiry: Waterview Connection Proposal 2011) are briefly summarised here:

- property – land loss, values, compensation, compliance with district plan standards, vibration, stability, subsidence and the adequacy of the risk assessment for tunnelling
- marine environment – marine life, native flora and fauna, chenier beaches, extension of Motu Manawa Marine Reserve, effects of reclamation and discharges, tidal flows, increased sedimentation, climate change, sea level rise, peak oil, access for recreational users
- Oakley Creek – potential for flooding, discharge of heavy metals, native flora and fauna, loss of historic/archaeologically or culturally significant sites

- community effects – health effects of ventilation stacks and untreated emissions, effects on community facilities, school and crime, demolition of residential property, loss of and reduced quality of green space and recreational areas, severance of community and facilities, loss of open space connectivity, loss of social housing and reducing school rolls, counselling/support for residents, community consultation processes, construction timelines, combined effect of road and rail corridor
- amenity effects – light, height, noise, dust, visual effects and mitigation, construction hours
- transport – urgency to complete ring road, reliability of modelling data, consideration of alternatives, continuity of bus lanes and cycle ways, wider network effects, additional connectivity to SH20 or Waterview interchange, additional pedestrian/cycle connections, construction yard traffic, 2006 alternative route AR1, design requirement for heavy goods vehicles, alternative routes for dangerous goods, tunnel safety, emergency procedures, benefits relative to public transport
- process and regulatory – methods, timeframes, information and consultation, project aims and objectives, existing plans and strategies, overlap with rail designation, robustness of benefits assessment, amendments to provide clarity, protection of assets and operations, ongoing monitoring and reporting – noise, air, stormwater, safeguard options for rail, management plans and stakeholder involvement
- cultural – heritage of Oakley Creek and Motu Manawa, heritage and culturally significant sites, iwi processes and practices
- other – tourism impacts, basaltic exposures, effects on water quality for Mt Albert residents, leachate from contaminated soils, concrete slurry.

This summary provides a useful overview of the scale, detail and inter-relationship of the issues surrounding the consenting of a major roading project in an urban area.

4.1.3 Case study summary

The Waterview Connection case study is presented in more detail in appendix G, including cost build up, freshwater and ecology benefits. The appendix also details the development of an approach to monetising water quality and ecological outcomes, which was subsequently applied to the Waterview Connection, but which could also be applied to other roading projects.

Key observations from this case study are presented here and outputs of the assessment are presented in section 4.1.4.

4.1.3.1 Observations

1 The massive scale of the project and associated documentation means the capture of concise and relevant information around benefits is possible, but challenging.

A key source of information detailing the benefit of meeting the requirements of environmental legislation for any roading scheme is the AEE. The components of the AEE relating to just the stormwater, streamworks and freshwater ecology effects ran in excess of 1,000 pages. Distilling concise but still meaningful information from such a massive quantity of data is challenging but can provide useful results.

The use of images and photographs provides a very quick and tangible means of demonstrating value. The photographs in figure 4.2 were taken upstream of the Waterview Connection restoration area, and in an area restored by the project. These photographs are a succinct means of summarising the value – environmental and aesthetic – delivered by the scheme.

Figure 4.2 Photographs showing the Oakley Creek upstream of (left) and within the Waterview Connection project restoration area (source: LEARNZ)


2 People with a detailed working knowledge to the scheme need to be involved to accurately estimate costs and benefits

Cost data was obtained from the Transport Agency (AEE costs) and Bond CM (construction cost estimates). To estimate costs relevant to meetings the requirements of environmental legislation, and within this the stormwater, streamworks and freshwater ecology components, required the involvement of staff who had been embedded in the Waterview project team at the time of the AEE preparation and submission. This was because the description of costs was insufficient for others to determine their relevance, in whole or in part.

When determining benefits, the framework presented in this study provides a methodology for benefit capture in a structured and consistent manner. While a third party could populate the matrices provided, the most reliable information would come from experts with a detailed understanding of the scheme and the materiality of the various issues, who were well briefed on the framework.

3 Costs are not developed for the purpose of considering the value of meeting the requirements of environmental legislation.

The construction cost estimate for the Waterview Tunnel prepared at the time of the AEE focused on the tunnelling components of work, as the tunnel and ancillary works comprised the majority of the overall $1.4 billion scheme cost. The environmental costs were determined for this project on a pro-rated basis using estimates for other major roading projects or nominal sums. No detailed bottom up estimate was developed.

The accuracy was appropriate for the purpose of the cost estimate at that phase in the project lifecycle. However, the cost estimate for the works required to meet environmental legislative requirements was carried out a high level and a large level of uncertainty in costs exists as a result.

Furthermore, costs developed for construction activities or components may include items and activities required by environmental legislation, and item and activities that have other drivers. For example, cost estimates for drainage works could include kerb and channel, catch pits, pipework, swales (which provide both drainage and treatment), and other treatment devices. Depending on the granularity of the cost estimate it may not be possible to isolate costs that can be solely attributed to the requirements of environmental legislation.

To gain a reasonable estimate of the cost of meeting the requirements of environmental legislation, the project estimate and accounts would have to be established to meet this specific objective. This would require, for example, stormwater design consultants to estimate the proportion of their design time spent addressing the requirements of the RMA, local, district or regional plans and the design of stormwater

treatment devices. This is possible, but would need to be communicated to the consultant at the outset of the project, possibly in the contract documents.

Finally, for this pilot study no proportion of the project overhead was assigned to the environmental cost. We considered it was appropriate to include these costs at a percentage rate, or as a proportion of scheme cost, as it was not possible to construct any environmental mitigation measures (or other relevant scheme components) without some setup, project management costs.

4 Attempting to assign cost and benefit into environmental sub-categories results in values with a high degree of uncertainty.

Sub-categorisation of the environment (for example, into categories such as fresh water and social impact) may be a convenient way to examine value as it aligns to AEE subject/discipline areas. However, the research team found attempts to draw boundaries between environmental sub-categories was artificial and there were inevitably cross overs.

An attempt was made to identify only those costs and benefits that related to the streamworks, stormwater treatment, flood detention and freshwater ecology. The intent of this was twofold:

- to manage the scale of information processed for the pilot study
- to ascertain whether it was possible to identify the value of each 'sub-category' of the environment.

The pilot study determined it is possible to broadly estimate the costs of the mitigation works for the environmental sub-category, subject to the caveat on costs noted above. In this case costs included:

- the Board of Inquiry, including council costs, legal costs and consultancy costs
- stream restoration capital works, including removing artificial channel lining and improving stream morphology, habitat and planting
- the design of streamworks and associated flood detention to reduce the effects of flooding
- the treatment of existing stormwater runoff volumes, in addition to the increased volumes created by the scheme.

However, the environmental benefits arising from these works existed beyond the immediate benefits evident in the freshwater environment. Other benefits included social benefits (amenity, for example) and benefits to the downstream marine environment from improved freshwater quality.

Indeed, the intention of the treatment of existing road runoff (not required by the relevant council organisations at the time of the Board of Inquiry) and a higher standard of treatment was to partially compensate for the reclamation of the coastal area for the widening of the causeway section of the road.

Due to these challenges, determining value at a sub-category level provided an indicative output, at best.

5 The 'no environmental legislation' or counterfactual scenario is not considered in current practice.

It is difficult for engineers and environmental practitioners designing and operating under current practices to consider a 'no environmental legislation' or counterfactual scenario.

For example, the causeway which was widened as part of the Waterview Connection project was constructed by end tipping material into the coastal marine environment. Conversely, the starting point for modern acceptable practices was:

> *To manage erosion and sediment control in this marine environment the Project needs to be constructed sympathetically; consideration must be given to, firstly, reducing the potential*

for sediment generation and, secondly, managing any suspended material generated from the earthworks (Ridley and Moulder 2010).

Similarly, designing a stormwater conveyance system without consideration of treatment or flood detention requirements is not a paradigm that is considered in design philosophies.

As another example, many potential effects from the project were avoided by tunnelling for most of the alignment, but these benefits are not clearly quantified in the AEE, although were considered in more detail at the scheme assessment phase.

To fully capture the benefit of meeting the requirements of environmental legislation, practitioners need to at least contemplate what the design would look like without any consideration of the environment. This could include, for example:

- more direct alignments, crossing areas of environmental or cultural significance
- no erosion and silt control or stormwater treatment measures.

It may be difficult to quantify and monetise such scenarios, but a qualitative summary should be able to compare the outcome with the counterfactual, at least conceptually.

6 Insufficient information exists to monetise benefits.

A literature review was carried out to determine how to monetise benefits to the freshwater environment in the Waterview context. This approach can be applied to other similar projects.

The review highlighted possible methods for monetisation, but required detailed information that was not captured or modelled as part of the existing AEE process. Notably, this included current and expected future visitors to the Oakley Creek location, which was not counted or estimated for the Waterview project.

7 Overall the framework provides insight into the value delivered by meeting the requirements of environmental legislation.

While limitations exist in terms of the familiarity of the research project team with the scheme and the information available to monetise benefits, overall the conclusion of the pilot study was that the information captured was useful in terms of delivering an improved understanding of the value of meeting the requirements of environmental legislation.

4.1.4 Outputs of assessment

The information here summarises the outputs of the assessment, which are provided in more detail in appendix G.

In monetary terms, the total cost of meeting the requirements of environmental legislation was identified as $12.7 million (assumed 2016 cost base). The associated benefits that could be monetised were $1.94 million (2016 cost base). This would indicate a negative value associated with meeting the requirements of environmental legislation of $10.7 million. However, as clearly shown in table 4.1, the benefit value used in this calculation was incomplete – excluding recreation and amenity benefits.

Table 4.1 Monetary benefits analysis – Oakley Creek

Category	Missing data	Value ($/annum)	Value (PV $million)	Range (PV $million)
Recreation (less active)	Change in visitor numbers			
Amenity	Change in vegetation + its significance Number of households who visit			
Existence		$141,000	$1.94	$1.11 – $2.77

Further, the tables in section G3 give a wider indication of the value of the scheme value, notably:

- Improved water quality treatment compared with the existing motorway resulting in a net reduction in discharge of contaminations to the environment. There are 23.31 ha of additional impervious surfaces resulting in an approximate total impervious area of 56.83 ha across the project area. Water quality treatment will be provided for 99.4% of the additional impervious areas. Of the 33.52 ha of existing impervious motorway surfaces within the project area water quality treatment is currently provided for only 3.30 ha (9.8% by area). The proposed treatment devices for the project will significantly increase the area of existing motorway treatment to 30.40 ha (90.7% by area), achieving 80% treatment efficiency over the majority of this area [compared with the Proposed Auckland Regional Plan: Air Land and Water (PARP:ALW) required 75% treatment efficiency].
- The project streamworks will provide a net benefit in terms of peak flood levels and extents. The minor effect of increased peak water levels upstream of the Bollard Avenue culverts is mitigated by reductions in flood risk for two houses, and the reduction in total flood extent within the project area.
- The proposed stream realignments and rehabilitations will have a positive effect on the environment as 1.3 km of natural channel form will replace the existing manmade basalt rock wall channel. This compares to a required environmental compensation area of 1,305 square metres. The project streamworks will have net ecological, environmental and recreational benefits by providing greater access to the stream, better ecological habitats and more vegetation than currently exists in these reaches. No adverse effects are anticipated to the stream bed morphology, flow hydraulics or sediment.

These benefits indicate the amenity value of the restored stream could be considerable as there is a significant improvement in stream habitat, and the value of reduced flooding is also not currently monetised. By collecting this qualitative and quantitative information, and juxtaposing it with the cost and monetised benefits, the gaps in the monetary analysis of benefits become clear.

4.2 Mill Road – designation phase

4.2.1 Description

The components of the Mill Road project at the designation phase (delivery – pre-implementation phase in figure 3.3) were used as a case study for this framework.

This project spans an 8.9km section of arterial road from the off-ramps at SH1 onto Redoubt Road in Manukau, running east along Redoubt Road and Mill Road to the Mill Road and Popes Road intersection in Alfriston as shown in figure 4.3. This section of road currently has safety issues, with 283 crashes and four fatalities reported between 2009 and 2013, and there are also some areas with congestion issues.

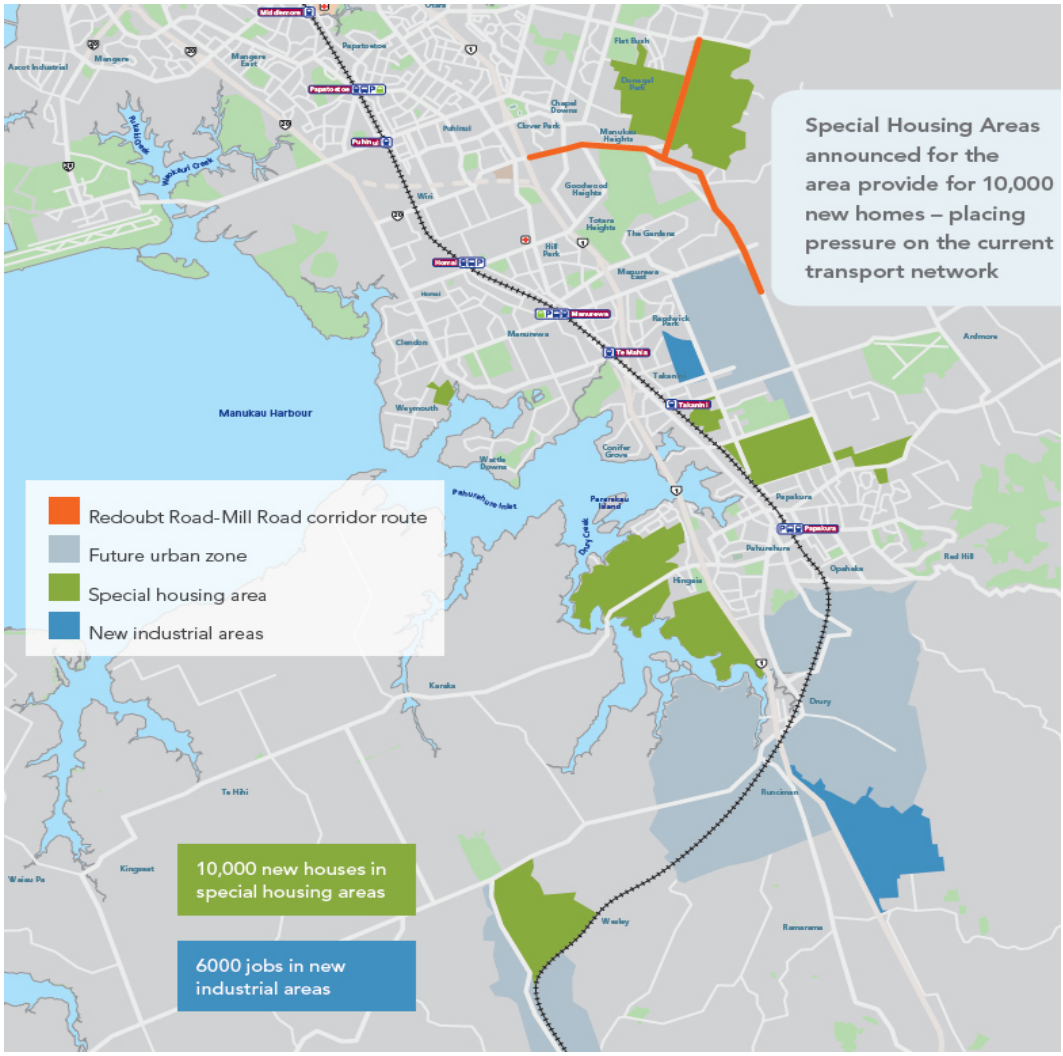
The surrounding area has been earmarked for residential and industrial development, with 22,000 new houses planned for the area and 6,000 new jobs available in the industrial developments. The upgrade aims to address these safety issues while providing transport access for this area to support future growth, including public transport, cyclist and pedestrian facilities. The scheme also provides some resilience to the north-south transport routes in case of interruption to the current arterial routes, mainly SH1. The upgrade includes widening the corridor to accommodate a four-lane road with an extra bus only lane along Redoubt Road, improving the alignment where required, cycle lanes, shared use path and footpaths with improved intersections and increased pedestrian crossing opportunities.

The upgrade has been split into two sections. The northern section goes from SH1 at Manukau to the intersection of Mills Road and Popes Road and is currently at the Notice of Requirement (NOR) stage, with the NORs accepted in April 2016. The upgrade to this section is predicted to cost around $300 million.

The southern section continues upgrades through to Papakura and Drury and is expected to cost an extra $172 million. Finalisation of this route and associated construction is expected to start in 2025 depending on the growth of the surrounding area.

The current arterial roadway passes through an urban environment from SH1 to Totara Park and serves as an urban arterial for the surrounding land uses, including the medium density residential development. The road then passes into a predominantly rural environment with lower density countryside living development and Totara Park. The section of the road around Murphy's Road is planned for urban development that will be mostly complete by 2025.

Figure 4.3 Redoubt Road – Mill Road upgrade route (source: Auckland Transport)



4.2.2 Planning approvals and key issues

The NOR applies to the northern section and was split into three designation applications. NOR 1 is the urban section of the corridor commencing at Redoubt Rd SH1 on/off ramp to east of Hilltop Road/Redoubt Road intersection. NOR 2 is from the Hilltop Road/Redoubt Road intersection to the Redoubt Road/Murphys Road intersection, including Totara Park. NOR 3 includes the remainder of the corridor. The application requested a 10-year designation for NOR 1 and 15-year designations for NORs 2 and 3.

The NORs were approved by a board of independent planning commissioners in February 2016 with 10-year designations for NORs 1 and 2 and a 15-year designation for NOR 3.

Issues identified during public consultation included the effect on the rural landscape, noise and vibration concerns about loss of native biodiversity, social concerns around disruption and anxiety caused by the prolonged planning process and concerns about accessibility.

4.2.3 Outcomes of assessment

Details of the assessment of environmental benefits and related scheme costs are provided in appendix H of this report.

No project cost information was available for this research.

In terms of benefits, the AEE for this NOR or designation phase of the project is generally not developed in detail. The designation sets the roading envelope, but actual effects and design of mitigation measures will be determined at the scheme design phase.

Of note is the avoidance of an area of significant native bush by the construction of a viaduct. The length of this viaduct was increased following consultation with interested parties. The project manager for the scheme noted the increased cost of land purchase over the period of the consent consultation was more significant than the increased viaduct costs.

4.3 Te Atatu Rd – construction phase

4.3.1 Description

The components of the scheme at the construction (delivery – implementation phase in figure 3.3) were used as a case study for this framework.

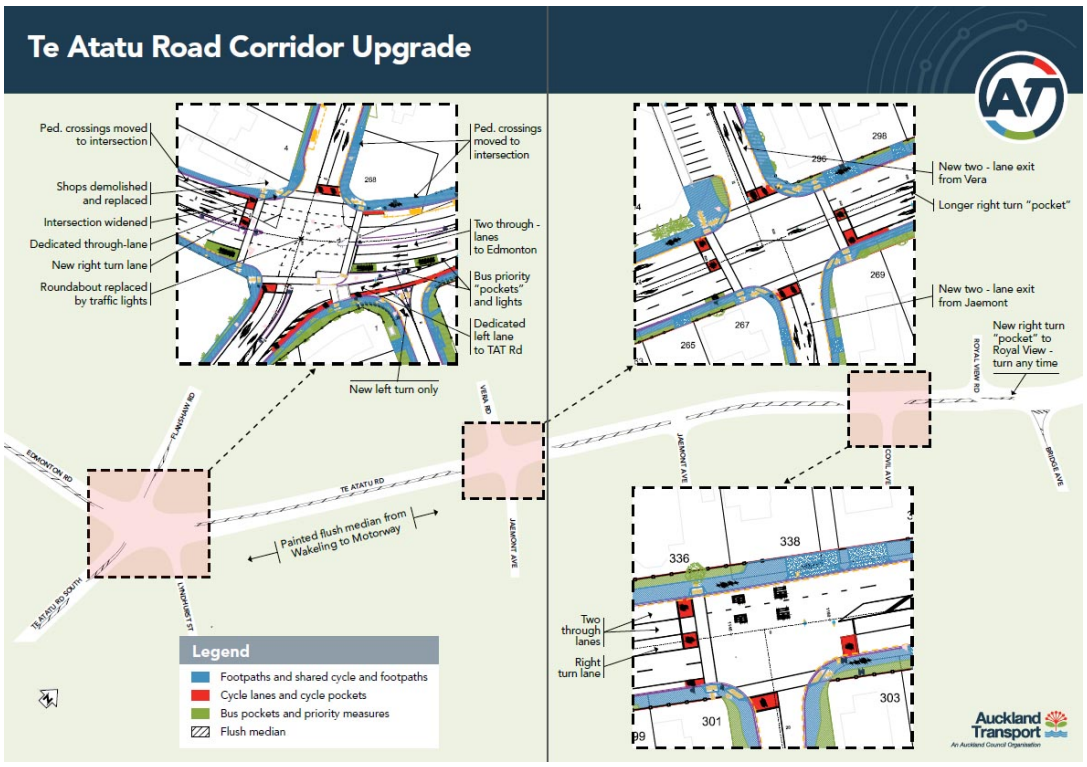
The Te Atatu Corridor Improvement Scheme is an upgrade to sections of Te Atatu Road, Edmonton Road, the Te Atatu Road intersection and associated side streets. Currently Te Atatu Road is one of the most travelled roads in Auckland, with 38,000 vehicles a day getting on or off the Northwestern Motorway at this point, creating significant congestion and safety issues. The scheme will improve traffic flow for vehicles, provide capacity for future growth, improve road safety for all road users and provide facilities for buses, cyclists and pedestrians with a 1.4km upgrade.

The improvement includes widening the road to include bus priority measures, cycling facilities and improved footpaths, replacing roundabout with traffic lights, synchronising traffic lights, levelling the road, removing some right turn options and adding dedicated turn lanes.

The project is expected to cost $30 million and it was substantially complete in mid-2017.

Prior to this development Te Atatu Road was a four-lane regional arterial road that connected west Auckland suburbs with the Northwestern Motorway. Te Atatu Road remains largely surrounded by residential properties with some commercial and home business activity. The upgrade requires the partial acquisition of 111 properties.

Figure 4.4 Te Atatu Road corridor upgrade – intersection layouts (source: Auckland Transport)



4.3.2 Planning approvals and key issues

Resource consent was applied for in 2014. Key consent issues were related to stormwater discharge, construction effects, contaminated land, and noise and vibrations.

4.3.3 Outcomes of assessment

Details of the assessment of environmental benefits are provided in appendix I of this report.

With respect to stormwater discharge and treatment, the project involved an increase in impervious area of 6,900 m^2. A significant proportion of the runoff (from 22,890 m^2) was to be diverted to a Transport Agency swale constructed as part of the Waterview Connection project. This would remove 80% of suspended solids (more than the required 75% total suspended solids (TSS)). 10,500 m^2 of impervious area was to be treated with cartridge filters and discharged into Pixie Stream (then Henderson Creek) and 20,100 m^2 of impervious area treated with cartridge filters and discharged into Whau River. Due to the proposed stormwater treatment devices and limited additional catchment the overall effect on the water environment was not assessed in detail. No stream ecological valuation (SEV) calculation was carried out and it was not possible to monetise any benefits.

Overall, the costs attributable to meeting the requirements of environmental legislation were not significant in comparison to the scheme capital cost, at approximately 5%. This excluded property reinstatement costs, as it was assumed the Public Works Act (1981) governed these requirements. However, it is noted that ongoing maintenance costs for the stormwater treatment devices may form a noticeable component of annual operating expenditure.

5 Conclusions and recommendations

5.1 Conclusions

This research concluded current approaches to information capture by roading authorities do not enable the value of meeting the requirements of environmental legislation to be determined.

- There is a lack of structure for cost data capture – roading authority project managers can use their discretion around how they set up cost codes within financial systems and other de-centralised cost tracking systems (spreadsheets).
- The isolation of costs arising from meeting the requirements of environmental legislation is a very focused question and does not align with typical drivers for cost capture such as capitalisation of assets or construction activity. Further, contractors' actual costs are not always reflected in the schedule of works, so isolating specific costs is difficult.
- Changes in staff through the project means that information is lost. It is normal for a roading improvement project to be managed by multiple project managers from development through to delivery. This is normally due to changes in expertise and staff turnover. It means knowledge about project value is seldom retained by staff through the full project lifecycle. Also, organisational structures separate planning and delivery from operations and maintenance.
- The current approach by roading authorities is to capture benefit within the project business case, which primarily focuses on benefits that can be monetised. This study concluded international best practice is to accept that not all benefits can be adequately monetised at this point in time, and the capture of benefit through a wider set of indicators is appropriate.

Other key conclusions from this study include:

- The Transport Agency's existing systems provide appropriate tools for the adequate capture of value arising from meeting the requirements of environmental legislation, although these tools need to be developed further and supplemented by a benefits register.
- A substantial quantity of information about the value of meeting the requirements of environmental legislation lies within the AEE documentation for road improvement projects. However, due to the scale of the documentation and its structure for responding to planning process requirements, it is difficult to readily distil this information for the purpose of understanding the value of meeting the requirements of environmental legislation.
- Current Transport Agency processes at the early stages of project planning do consider of environmental and social impacts, but these considerations are not always carried into subsequent stages when the approved scheme is refined. This means some of highest value items associated with 'avoiding' effects, eg by route selection, are not articulated later in the project development, which focuses on the mitigation measures added to the scheme.
- The modern paradigm for the design and construction of roads does not consider a 'without meeting the requirements of environmental legislation' premise. The concept of constructing a road without giving due consideration to protecting the receiving environment is no longer considered by design engineers. It is therefore difficult to fully value the outcomes of meeting the requirements of environmental legislation, as the counterfactual or 'do nothing' situation is not considered.

5.2 Recommendations

This research has proposed a framework to determine the value of meeting the requirements of environmental legislation. This framework enables the structured capture of information but requires a shift in the mindset of roading authorities to be effective, along with more detailed data capture. Specific recommendations relating to the implementation of this research are set out in sections 5.2.1 to 5.2.7.

5.2.1 A benefits measurement approach

Current processes require the capture of benefit information to complete a CBA for funding purposes. The EEM provides details of how to complete this benefit assessment, which focuses on monetary outputs. Key benefits delivered by roading schemes – safety improvements and transport travel time improvements – are well represented in this methodology.

Complementing the EEM is the Transport Agency's framework for investment performance (NZ Transport Agency 2016b), which seeks to measure investment outcomes and to determine whether expected benefits are realised.

This study recommends that the principle of benefits measurement through the project lifecycle is adopted, as recommended by the New Zealand Treasury's work on managing benefits (The Treasury 2016b).

Applying the philosophy that benefits should be measured and reassessed throughout the project lifecycle is recommended, along with the implementation of an associated benefits register to enable this. Embedding these practices into current roading authority processes is expected to improve the overall identification of benefits and enable the value of meeting the requirements of environmental legislation to be captured.

5.2.2 Value identification through the project lifecycle

The capture of benefits and costs throughout the project lifecycle enables the full value of meeting the requirements of environmental legislation to be understood. It will also help with business cases, consenting and post project verification. Decisions can be made very early in the scheme development or options appraised that result in significant costs or benefits. During the 'maintain and operate' phase, the outturn costs and benefits following construction should be measured to capture changes through the delivery process, along with benefits over the operational period, which are typically estimated or assumed at the time of the consenting process.

5.2.3 Creation of a value database

This research recommends the adoption of the work of the Natural Capital Coalition (2016), comprising the consideration of value in a 'qualitative, quantitative, monetise' framework. Capturing basic information about a scheme, along with the benefits realised and associated cost, in a central 'values database' is recommended. This would enable, with time, the identification of areas where value is consistently realised through meeting the requirements of environmental legislation. This, along with quantitative information and cost data would direct areas for future studies, for example primary research into willingness to pay (WTP), enabling monetisation of benefits.

This database would also serve to summarise the value of meeting the requirements of environmental legislation.

5.2.4 Cost capture

Current practices for capturing cost vary between projects, even within a single transport authority. To better inform decision making around the cost of meeting the requirements of environmental legislation a consistent approach to cost capture is required, with costs specifically linked to activities delivered and/or outcomes arising from environmental legislation. This should cover staff costs, consultant costs, constructor costs, and operations and maintenance costs.

There may be wider benefits in implementing such an activity-based costing schedule to capture costs for other activities or outcomes that roading authorities are interested in monitoring.

5.2.5 Monetising benefits

For some benefits, opportunity exists to improve the current approaches to monetisation based on more recent information and international good practice. Detailed methodologies relating to the monetisation are included for:

- air quality (appendix F)
- freshwater environment, including ecology and amenity (appendix G)
- noise (appendix J).

5.2.6 Resourcing

In developing an approach to determining the value of meeting the requirements of environmental legislation, the researchers have been mindful of the challenge of applying any method in terms of both total resource requirements and the skills required by personnel involved.

For smaller projects, where the impact of environmental legislation is limited, the application of this methodology could likely be achieved by the client project manager, with support from key specialists as required.

For larger projects, the recommendations of Treasury (2016b) that similar levels of resource are committed to benefits realisation as to other project controls such as cost and risk, are noted and this level of resource recommended to improve benefit information capture.

The implementation of the proposed framework could be done in a staged manner and/or via key pilot studies, to further refine the framework and get early reports on understanding the value of meeting the requirements of environmental legislation.

5.2.7 Future research areas

It was beyond the scope of this research to develop a detailed methodology for each ‘component’ of value delivered by meeting the requirements of environmental legislation. The research team focused on key information that would enable the social, ecological and water-related benefits to be captured more fully. Further work is required to consider benefits relating to other aspects such as landscape and visual effects.

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Appendix A: Monetary valuation

A1 The wellbeing perspective

The purpose of this research (NZ Transport Agency 2015c) was to:

> *Provide an understanding of the value, including tangible and intangible costs and benefits of meeting the requirements of environmental legislation for roading improvement programmes.*

Value is defined from the perspective of the whole community and encompasses all things that result in changes in wellbeing. As a government objective, maximising the total wellbeing of society over time stems from utilitarianism, the theory that defines the ethically best choice in any situation as that which most improves wellbeing (or utility). Cost-benefit analysis (CBA) is the practical application of the theory and attempts to measure, quantitatively where possible, all factors that affect wellbeing.

In the absence of environmental regulation, it is assumed roading projects would have engineering costs, and benefits resulting from improvements in the movement of people and goods, such as reduced travel times and improved safety. However, residual environmental effects would be expected, including from road run-off, noise and amenity effects. Environmental legislation requires road developers to avoid, remedy or mitigate these effects. The interest in this report is focused on the absolute effects of environmental legislation – how the application of environmental legislation has changed total costs and benefits for individual projects.

A2 Total economic value

CBA assesses all effects of a policy or project. This is consistent with the concept of total economic value (TEV) which is used to identify and classify the full range of values that people derive from the environment or a specific resource (see figure A.1). It can be used as a way to ensure all effects are taken into account within a CBA.

TEV includes:

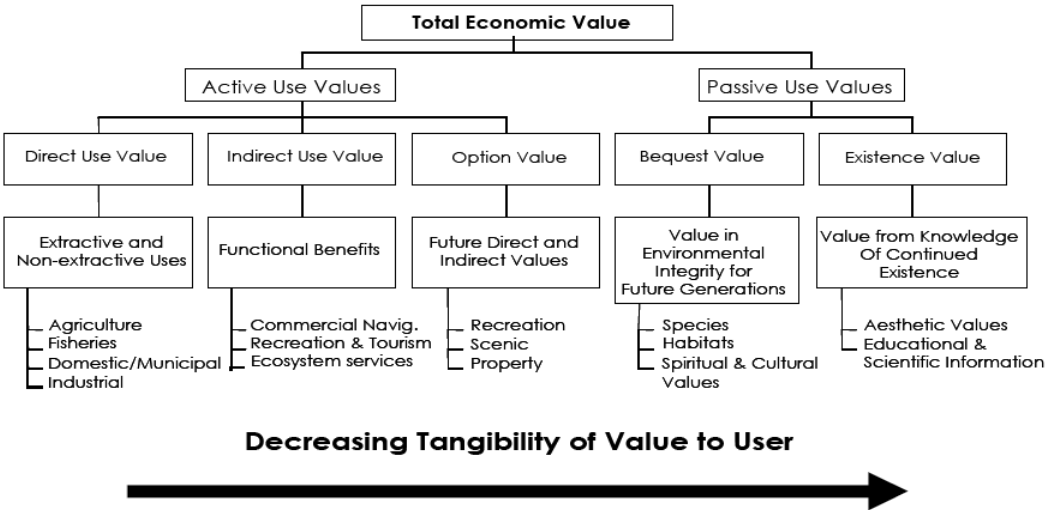
- active use values that involve direct interaction with the resources, eg the impacts of flooding on properties that are occupied or used for business activities, and the benefits (eg expressed as a WTP) of recreational uses of the environment
- passive use (or non-use) values that pertain more to the fact of existence (the value from knowing that a particular environmental asset exists even if you never visit it) or its value for future generations (the value arising from the desire for certain resources to be available for one's heirs or future generations in general, eg notable landscapes).

The TEV diagram is a useful reminder that values accrue to people who do not visit a natural area but who benefit from knowledge of its existence, and that there are values in retaining options for future use, where this future use may be any one (or combinations) of the other uses.

The concept of ecosystem services (see appendix C1 for more explanation) is often used in environmental valuation literature (Pascual et al 2010). It is consistent with the TEV concept but applies values at an earlier stage in the process, in that it seeks to measure the contribution of ecosystems to producing wellbeing (figure A.1). Ecosystem services are descriptive of what ecosystems do, while TEV outlines the type and (ideally) the value of these services.

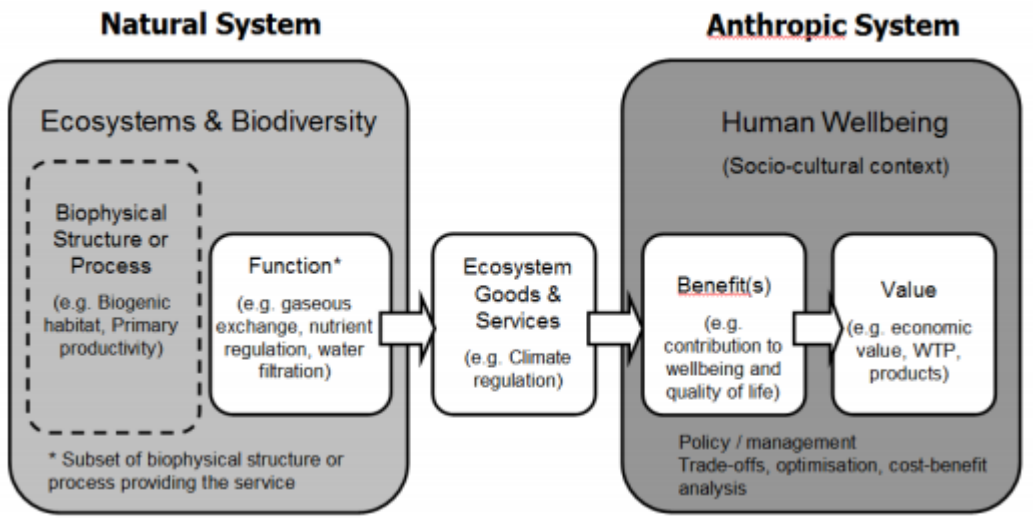
In this research, we used the TEV concept as the basis for identifying available data on the value of environmental legislation for roading projects. We used it to ensure we examined a wide set of literature.

Figure A.1 Total economic value



Source: Nimmo-Bell (2009)

Figure A.2 Ecosystem services in an impact pathway



Source: Thrush et al (2010)

A3 Non-market valuation

A3.1 Valuation methods – an economic perspective

In this study we convert value monetary value where possible. Monetary valuation of the environment is distasteful to many people, so it is important to understand why it is being undertaken. The fundamental aim of this approach is not to put a dollar value on the environment, but to express the impact of changes in environmental quality in terms of the trade off against other things that people value (Turner et al 2003): what would people be willing to give up to gain improved environmental quality?

The reason for doing this is that we have limited resources. As a society (and as individuals) what we want is greater than we can obtain; we are limited by time or money or other resources, so we must make choices amongst limited resources. And, in very general terms, if we want more environmental quality, we divert resources that otherwise could be used for other things. We measure how much people would be willing to give up to obtain more environmental quality.

Valuation techniques for non-market values of the environment use a mix of revealed and stated preference techniques to estimate relative values.

- revealed preference techniques observe how people behave and use the results as a measure of relative preferences. For example, we measure how far people will travel and how much they expend, to visit a site with high aesthetic value, and we measure how much more they spend to visit a site with higher quality than another
- stated preference techniques rely on surveys in which people are asked to state their relative preferences, often in terms of WTP. The more sophisticated approaches use choice experiments in which a clear payment method is shown and trade-offs are demonstrated, ie having more of one thing means having less of another.

Some studies have noted differences in expressions of WTP for something and willingness to accept (WTA) compensation for its loss (Pearce and Turner 1990). The appropriate approach to use depends on the distribution of property rights, with WTP appropriate where an individual has no right to the benefits from a resource and WTA appropriate when rights exist (Pearce et al 2006). The approach matters because studies suggest large differences between results in stated preference studies depending on whether questions are eliciting WTP or WTA.

However, in most environmental policy decisions, the decisions being made are regarding an improvement in environmental quality for which, arguably, there is no current right. For this study the Transport Agency has posed the question of the value of environmental protection relative to some other state of the world (counterfactual – see below) that would not require any environmental protection. On this basis, it can be argued that WTP is the most appropriate measurement approach.

A3.2 Distribution of costs and benefits

The efficiency argument widely used in public policy economics (the Kaldor-Hicks efficiency criterion (Kaldor 1939; Hicks 1939) is that who gains and who loses because of a policy or investment decision (its distributional effects) does not matter; what matters is that the nation (or region) is better off.

If a project design has lower costs but damages the environment more, the cost savings could be redistributed and all people could be better off. For example, all those who valued the environment could be compensated for their losses. However, the principle does not state compensation must be paid, only that it *could* be paid (Johansson 1991). The underlying assumption is there may be numerous policies and projects, all of which will make some people better off and others worse off, but in aggregate across all projects/policies, all are made better off.

This approach does not differentiate between types of distribution, ie between environmental and financial costs and benefits, or whether distribution has occurred afterwards. In contrast, adopting an approach that requires all policy interventions are of benefit to everyone, or at least not detrimental, can lead to a stalemate in which there are few projects or policies that can ever be adopted. Indeed, this kind of stalemate was the background to the adoption of the Kaldor-Hicks efficiency criterion in the first place, rather than the stricter Pareto criterion (no one can be made worse off).

The benefits of environmental improvements may be less widely distributed across the community than their costs when funded by taxes. If road projects over several years are narrowly distributed geographically, the balance of costs and benefits may vary significantly. These distributional considerations may be an appropriate additional consideration by decision makers, but not at the level of the individual project. Roads will often be part of an integrated network in which benefits may be widely distributed, and over time, most communities receive road improvements. However, for some local projects the costs may be distributed quite differently from the benefits.

A3.3 Community values

Studies that obtain estimates of WTP for environmental attributes are measuring the stated preferences of individuals. Arrow (1963) noted the problem of aggregating wellbeing across individuals, especially when the ranking of preferences might be quite different. Sagoff (1988) and others have suggested people might state different levels of preference if responding as members of a group rather than as individuals. This can reflect the greater WTP if others face the same cost, thus ensuring no change in relative net wealth. Suggestions have been made for studies to use values derived through collective discussions, rather than surveys of individuals (see for example Wilson and Howarth 2002; Lo and Spash 2011), although there are methodological difficulties, including that of obtaining representative samples of people (Turner 2006).

The absence of community values is a possible limitation to the analysis, and this is based on the infancy of the discipline and the absence of studies. We have not, for example, identified studies that show the difference between community and individual values. We note this issue for completeness but have not addressed this issue explicitly.

A3.4 Benefit transfer

If valuation studies have not been undertaken for specific sites, eg using WTP surveys, values are obtained from studies in different locations and often with different ecosystems. To do so means the data provides only very stylised values that may only be correct at the order of magnitude.

The work under this study did not develop new (primary) data on values of the environment but made use of results in existing studies. We used non-market values estimated at study sites to identify values that can be used more generally. This is known as the benefit transfer approach and is generally accepted as providing order of magnitude estimates of values (Sharp and Kerr 2005; Barbera 2010).

Kerr and Sharp (2003b) estimated the errors associated with benefit transfer in a study of the valuation of urban stream mitigation in Auckland. They concluded there are ‘large potential errors from benefit transfer, even under close to ideal conditions’. Marsh and Mkwara (2013) reviewed recent literature on non-market values for freshwater as an input to a study of the costs and benefits of improvements in water quality for the Waikato River. The authors suggest the values compiled are ‘estimated for specific changes at particular sites’ but ‘none of the values ... are suitable for transfer to assess the impact of different central and regional government water quality policies on non-market values in the Waikato’, let alone other rivers in other locations.

These conclusions are of obvious concern to this and other studies seeking to use benefit transfer as the basis for values. However, the expectation is that when including values for environmental effects, the estimation of impacts is improved over assuming the effects are zero, ie the actual effect is closer to the transferred value than to zero. The assumption is the values suggested are at least order-of-magnitude correct.

Improvements can be made to the data over time through additional studies that more directly address the impacts relating to road projects.

A3.4.1 Benefits transfer methods

Sharp and Kerr (2005) define three principal methods of transferring benefits from a study site to a policy site:

- direct transfer — the specific values are transferred
- benefit function transfer — the valuation function is transferred
- meta-analysis — where many study cases are available, regression analysis can be applied to the results to identify statistically the relationship between site attributes and value.

The direct transfer approach is the crudest and simplest method. It involves taking the mean values estimated at the sites of the original study and applying them to the new site – no adjustment is made to these values to reflect site characteristics (Sharp and Kerr 2005). For example, the estimated recreational value per visit from a study conducted at one New Zealand location could be directly applied to a visit in another catchment. To do so assumes all factors of importance that determine that value are the same or very similar, eg the aesthetic value of the site, the amenities that are present and the same or similar socio-economic characteristics.

In contrast, the benefit function transfer and meta-analysis methods involve the transfer of a function (or equation) rather than a value. This equation would then be populated with local parameter values, eg the value of a fishing trip might be a function of the number of fish in the river (and thus the chances of catching a fish), water visibility and some other aesthetic parameters. As such, these approaches are regarded as more accurate than a direct value transfer.

In practice the difference between direct transfer and benefit function transfer is not straightforward. Direct transfer may simply be transfer of a benefit function with a very simple functional form (equation). Thus, what is transferred may sit on a continuum of complexity, depending on the existing understanding of the factors that determine value and the availability of input values to solve any equation.

A3.5 Maximum willingness to pay

Because the assessment of benefits will have significant uncertainty, it is useful to examine whether constraints can be set on environmental values in a way that provides some guidance to the values that are appropriate in this report.

Clough (2010) attempts to estimate the total WTP for environmental protection by New Zealand households as a way to set a maximum WTP for an individual project. He estimates current total expenditure by households on environmental protection in the form of central government expenditure for the Department of Conservation, the Nature Heritage Fund and QEII Trust, local government expenditure on biodiversity and landscape conservation, the opportunity cost of land held in the conservation estate, subscriptions and donations to environmental non-profits and several other items. He suggests this provides the basis for an aggregate estimate of household WTP for the environment, eg if households were willing to pay more, this would result in higher levels of government funding of the Department of Conservation or higher levels of charitable giving. Using this approach, Clough estimates the WTP for biodiversity and landscape protection at approximately $200 per person per annum or $560 per household per annum. He uses this to suggest some values for individual ecosystems in the literature are too high, eg he cites values that include $325/household per annum to avoid native birds from becoming absent from Lake Rotoiti.

It is not obvious that such strong conclusions can be drawn. The payments examined by Clough are largely those of national organisations on conservation throughout the country. Any individual or

household contributing to this funding (and thus expressing a WTP) would have no certainty it would lead to enhanced biodiversity or landscape that was geographically close to that individual or of importance to them. Many of the results found in studies are values expressed for specific areas or habitats with which a person will interact or be familiar. These values from Clough may be more like a maximum estimate of existence value, ie the WTP for the ongoing existence of natural areas which a person may never see.

A4 The counterfactual

All studies of costs and benefits involve the comparison of two scenarios. Typically, this is with the project (the factual) and without it (the counterfactual).

Our task in this study was to examine the value of meeting the requirements of environmental legislation. This means we compared the impact on the total net benefits of a project between two scenarios:

1 the factual: the project as currently required, including all measures taken to avoid, remedy or mitigate adverse effects

2 the counterfactual: the project if it were to proceed with no requirement to meet environmental legislation, ie a pure transport project intended to improve the movement of people and goods at least cost.

A finding of this research was the counterfactual is difficult for practitioners to envisage, as the outcomes that could result are not considered acceptable in current New Zealand society. This is discussed further in section 4.1.3.

Appendix B: Literature review of transport sector benefits approaches

B1 *Economic evaluation manual*

The NZ Transport Agency's (2016a) *Economic evaluation manual* (EEM) 'provides procedures to help approved organisations evaluate the economic efficiency of their investment proposals in line with the Transport Agency's Assessment Framework'.

Economic efficiency is assessed using social cost-benefit analysis (CBA) and generally by means of the benefit-cost ratio (BCR) which is one output of CBA.

The primary function of the EEM is to provide consistency, transparency and comparability between the analyses of different projects or activities. The purpose of the EEM is defined as:

- presenting economic evaluations in a consistent format
- presenting the costs and benefits, and their relative magnitude, of alternatives and options clearly and consistently
- ensuring that any assumptions are standardised across activities, as far as possible
- ensuring that the appropriate level of data collection and analysis will be undertaken for economic efficiency evaluation
- assessing the monetised and non-monetised impacts, business benefits and equity impacts as an input to the effectiveness assessment factor of the allocation process.

The EEM includes standardised values, procedures and worksheets for several impacts. It also provides guidelines on appropriate data collection and analysis.

The manual includes different types of benefit:

- market benefits, eg reductions in vehicle operating costs
- non market (standardised), eg value of statistical life combined with lives saved
- non-market (non-standardised), eg the value of reduced ecological impacts.

The EEM provides methods for monetising a range of benefits. This research project was concerned with a limited number of the total benefits listed in the EEM, namely:

- vehicle emission reduction benefits
- other external benefits
- walking and cycling health benefits.

Some benefits arising from roading schemes can be adequately monetised, for example vehicle operating cost savings from more efficient alignment selection can be modelled using geometric design software then costed using unit operating costs and forecast traffic flows. The EEM provides monetary values and methodologies for four categories of benefit of relevance to this study:

1 local air pollutants

2 carbon dioxide emissions

3 traffic noise

4 health benefits of cycling and walking.

However, other environmental, social and cultural benefits are typically difficult to adequately capture in monetary terms and the EEM suggests categories of benefit, but does not provide guidance on the valuation methods other than to require a CBA. Table B.1 summarises the relevant benefit valuation approaches in the EEM and comments on where values could be updated and further guidance provided. Further discussion of each of these components is provided below.

Table B.1 Summary of benefit valuation approaches in the *Economic evaluation manual*

Effect	Valuation method	Comment
Emissions		
Local air pollutants	0.001 × ΔPM10 concentration × population exposed × normal death rate × value of life	The approach and factors used have not been updated to take account of new available information
CO_2	$40/tonne	Based on a 2006 estimate – it is recommended this value is updated
Other external effects		
Traffic noise	$350/yr/dB change/household affected	Based on a fixed average house price ($450,000) and evaluated over 40 years
Vibration	Descriptive	Opportunity to develop valuation method
Water quality	Descriptive+ CBA of mitigation measures	Opportunity to develop valuation method
Special areas	Descriptive+ CBA of mitigation measures	Opportunity to develop valuation method
Ecological impact	Descriptive+ CBA of mitigation measures	Opportunity to develop valuation method
Visual impact	Descriptive+ CBA of mitigation measures	Opportunity to develop valuation method
Community severance	Descriptive+ CBA of mitigation measures	Opportunity to develop valuation method
Overshadowing	Descriptive+ CBA of mitigation measures	Opportunity to develop valuation method
Health benefits of walking and cycling	$2.60/pedestrian km and $1.30/cyclist km	These are 2008 values as also used in the 2010 EEM. The derivation of these values is unclear.

Source: NZ Transport Agency (2016a)

B1.1 Vehicle emission reduction benefits

The EEM provides methods for estimating changes to emissions of CO_2, NOx, PM_{10} and volatile organic compounds using emission factors which change with speed for light and heavy vehicles. Monetary valuation guidance is provided for PM_{10} and CO_2 only.

B1.1.1 PM_{10}

The value of emission reductions are estimated for PM_{10} on the basis of changes to concentrations and exposure to those concentrations. The EEM does not provide guidance on how to estimate changes in concentrations. It notes some potentially useful references, but all are more than 10 years old; this section of the EEM has not been updated since the original version (Land Transport NZ 2006) and has not taken account of recent developments. It does note that contacting the appropriate regional council may be useful 'as they sometimes carry out air pollution analysis, eg using emission inventory techniques'.

The monetary value of changes in concentrations is estimated on the basis of changes to mortality. Mortality impacts have been estimated as a 0.101% increase in daily death rates for a 1 $\mu g/m^3$ increase in PM_{10} (which is lower than values used in most recent studies (see Kuschel et al 2012)). The cost is then estimated using the following formula:

$$0.001 \times \Delta PM_{10} \text{ concentration} \times \text{population exposed} \times \text{normal death rate} \times \text{value of life} \quad \text{(Equation B.1)}$$

The value of life used is that for crashes and is updated periodically by the Ministry of Transport, most recently in 2016 (Ministry of Transport 2016).

B1.1.2 CO_2 emissions

The EEM suggests reductions in CO_2 emissions are estimated using a value of \$40/t of CO_2 (in 2004 dollar values), which it notes equates to 12 cents per litre of fuel or approximately 5% of total vehicle operating costs. It states one of these values shall be used in project evaluations. The \$40/t value is based on a value of \$30/t estimated in the Ministry of Transport (1996) *Land transport pricing study* and has been inflated.

Elsewhere in the EEM, it suggests the value of CO_2 reductions can be estimated as 4% of vehicle operating costs.

B1.2 Other external benefits

External benefits (or disbenefits) affect parties other than those formally included in the transport decision for example, the wider public, particularly those living close to a road. Because CBA takes the national viewpoint in which all effects in New Zealand are considered, external impacts must also be considered.

The EEM includes:

- traffic noise and vibration
- impacts on water quality
- impacts on special areas, defined for reasons that include cultural, archaeological, ecological or social/recreational
- ecological impacts
- visual impacts and overshadowing
- community severance and or isolation.

B1.2.1 Traffic noise

Based on international research using hedonic price valuations (studies of impacts on house prices), modified to reflect missing impacts or market failures, the EEM suggests the impacts of noise are 1.2% of the value of properties affected per decibel (dB) of noise increase.

Using an average value of urban property of $450,000 and occupancy of 2.9 persons, this suggests an impact of $5,400/dB per property and $1,860/dB per resident affected. This is used to estimate an impact of $350 per household or $120 per person per annum. This appears to be based on a rounding of the values obtained using the standardised values of a 6% discount rate (EEM, section 2.5) and a time period of 40 years (EEM, section 2.6).

Thus the suggested formula for estimating noise impacts is:

$$\$350 \text{ per year} \times \text{dB change} \times \text{number of households affected} \quad \text{(Equation B.2)}$$

B1.2.2 Vibration

The EEM suggests vibration is highly site-specific but it does not provide data or methodologies for monetary valuation of impacts. It suggests that 'the number of buildings exposed to significant vibration (and an estimate of the numbers of people affected) shall be identified and recorded on maps'. It divides the impacts into those that require a level one or level two assessment, with a level two assessment requiring an assessment of whether minor (2–5 mm/sec) or major (≥ 5 mm/sec) impact levels are exceeded.

B1.2.3 Water quality impacts

Water quality impacts are defined to include those associated with:

- physical modifications of river channels and other water bodies, or changes to water levels
- release of sediment from physical works
- increased discharges from paved surfaces.

The EEM requires the expected construction-phase and long-term effects to be reported. It notes that the incremental costs and benefits of measures taken to mitigate water quality effects should be reported but does not provide guidance on how to do this.

B1.2.4 Impacts on special areas

Special areas include those with particular cultural, historical, ecological, social/recreational, amenity and other values. Projects can have direct physical effects on these sites or affect the values through the proximity of the project. The assessment of values are expected to be site-specific and the EEM suggests that the assessment might include expert evaluation and public consultation; it notes that Māori values will often be involved. A descriptive valuation is required which should include mapping of the special areas.

B1.2.5 Ecological impact

Ecological impacts include:

- direct habitat loss
- fragmentation and isolation, eg a road separates two parts of a population or biological community
- change in microclimate (light, moisture, wind)
- facilitation of dispersal, eg vehicles dispersing invasive species
- impacts on local physical and chemical conditions, eg from pollution
- impacts of humans following increased accessibility of vulnerable areas.

The EEM suggests it is not possible to assess all impacts, so records of impacts will include general as well as specific information. It suggests a descriptive approach but 'Where projects have been modified to protect or enhance components of ecosystems, the incremental costs and benefits shall be reported'. Again, no guidance is provided on how to determine these costs and benefits.

B1.2.6 Visual impacts

Visual impacts include:

- obstruction, eg a road blocks the view
- intrusion, eg the road jars with the surroundings
- views from the road, which might be positive when those for non-road users are negative.

The EEM suggests description of the impacts, including artist's impressions and the numbers of people affected. It also states 'Where projects have been modified to protect or enhance their visual impact, the incremental costs and benefits of these measures shall be reported'. Again, no guidance is provided on how to determine these costs and benefits.

B1.2.7 Community severance

In the same way as biological communities can be severed by roads, so can human communities. This can impact on security and mobility, particularly for pedestrians and cyclists, affecting movement patterns and interactions.

The EEM suggests a physical description of these effects, including crossing points and so on. As with other effects, where measures are taken to reduce the impacts, costs and benefits should be analysed. This should include the benefits of reduced travel time and crash savings, using methods specified elsewhere in the EEM.

B1.2.8 Overshadowing

Overshadowing is the shadow cast by a structure associated with a road project, eg an embankment or a bridge. The EEM suggests the properties should be identified and a physical description provided. As with other effects, where mitigation measures are taken, the costs and benefits should be analysed.

B1.3 Walking and cycling

Health benefits for walking and cycling are estimated in the EEM (2008 values) as $2.60/pedestrian km and $1.30/cyclist km (NZ Transport Agency 2010a). These benefits apply to pedestrians and cyclists using a new facility, or to disbenefit when a new facility reduces walking and cycling activity. The reason for these values is not provided either in the 2016 or 2010 versions of the EEM (NZ Transport Agency 2010a, 2016a).

B2 Economic benefits of cultural and historic heritage

In 2014 the Transport Agency commissioned a research report on the cultural, social and economic benefits of cultural and historic heritage (Eppink et al 2016).

The report provides a detailed and accessible discussion of value concepts and their particular application to cultural and historic heritage. The report accompanies a forthcoming framework and tool, which are described at an outline detail.

The proposed framework has the following attributes:

- It can be applied across the project lifecycle.
- It recommends quantification methods where they are available.
- It applies appropriate monetary valuation techniques, with the use of a rich narrative recommended where none is available.

It is consistent with the work of The economics of ecosystems and biodiversity (TEEB) and the Natural Capital Protocol in that it recommends a combination of qualitative, quantitative and monetary indicators. The 'rich narrative' methodology proposed intends to emphasise building relationships with tangata whenua and enables the capture of detail underlying the benefits assessment, which more fully informs it.

B3 Performance indicators

Denne et al (2013) reviewed possible performance indicators for the Transport Agency, which have subsequently been incorporated into a framework for investment performance measurement. The framework is closely aligned with the EEM, and where possible requires the user to provide a quantitative measure of the outcome, for example travel time delay, deaths and serious injuries. The intent is to require schemes to predict outcomes and to measure these following implementation, to provide evidence of delivery and value for money. The performance indicators will be tracked in an updated version of TIO.

The framework includes a number of outcome classes where the 'user is to describe' the benefit, including biodiversity, community cohesion and other categories where quantification is inconsistent or not possible.

B4 Austroads *Guide to project evaluation*

The Austroads (2012a) *Guide to project evaluation part 2* includes a three-stage evaluation process for evaluation of transport projects:

1 Test strategic fit (ie assessment against broader strategies, policies and plans)

2 Investigate and analyse project options (solutions) that pass the strategic fit

3 Develop a business case for the preferred option.

Austroads (2012a) provides guidelines for conducting benefit-cost analysis (BCA) and multi-criteria analysis (MCA) on public transport infrastructure projects, policies and programmes. Its aim is to foster good practice, consistency and transparency in the evaluation of transport projects. A tool (Risk ExplorerTM software) used for identifying, assessing and analysing risks related to uncertain factors impacting on project benefits and costs is included to help the practitioner perform a risk assessment and analysis.

Austroads comments on the decision criteria to be used in a CBA (box B.1). In contrast to the Transport Agency and the EEM, the suggested decision criterion is net present value rather than the BCR, which it notes only works well when costs and benefits are correctly identified.

Box B.1 Decision criteria

Net present value

Net present value (NPV) is unquestionably the most fundamental discounted cash flow (DCF) criterion. It can be used in all decision contexts. Indeed, little would be lost if it were the only decision criterion. Because of its importance in decision making, NPV should be reported for all evaluations. If it has one disadvantage, it is that it is not readily explained to a non-technical audience.

Benefit–cost ratio

Benefit–cost ratio (BCR) is perhaps the most widely used DCF criterion in the transport sector, especially for small projects. It is readily understood by non-experts. It is also universally used to rank projects for inclusion within capital budgets. Although ranking by BCR is widely accepted as the right way to get the most out of a constrained capital budget, it should be noted that it is an approximation that only works well when certain important conditions are satisfied [The BCR is especially sensitive to the definitions of costs and benefits, for example, if cost reductions are defined as benefits].

Internal rate of return

Internal rate of return (IRR) has intuitive appeal to a non-technical audience: it resembles the interest earnings on a loan, and is widely (and not incorrectly) understood that way. However, it is also the least helpful measure for the decision-maker, as it can only be used where budgets are unconstrained and projects are independent – a rare occurrence. For this reason, IRR should only ever be reported as an adjunct to other DCF measures, and then to aid comprehension, not decision making.

Source: Austroads (2012a)

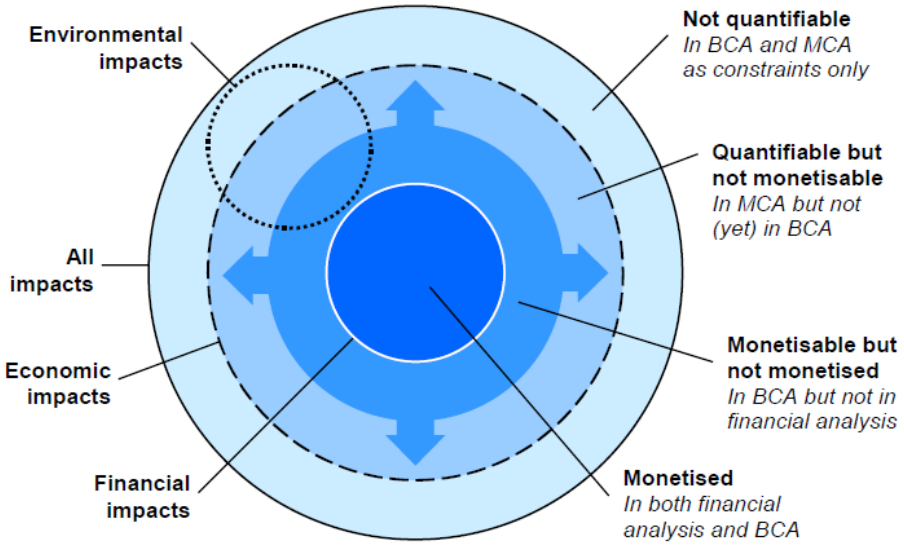
Austroads recommends using MCA as an adjunct to CBA for factors that cannot be monetised, although it also notes the criticisms levelled at MCA, ie that the weights attached to the non-monetary objectives

> *Are necessarily arbitrary and subjective; if they were not, it would be possible to conduct BCA in the normal way by treating weights as conversion factors to translate non-monetary objectives into monetary ones.*

Austroads suggests that it is always preferable to use CBA/BCA but that where this is not possible, MCA can be provided alongside to assist in decision making.

Austroads suggests that environmental impacts are often not quantifiable in monetary terms.

Figure B.1 Impacts classified by monetisability and quantifiability



Source: Austroads (2012a)

Austroads identifies a number of categories of impact of road projects. Environmental categories and the associated valuation method are included in table B.2. These valuations have been used to develop a simple set of values expressed in cents per vehicle kilometre travelled (vkt) (table B.3). Many of the values used by Austroads are adjusted from European values in studies of the external costs of transport (INFRAS/IWW 2000).

Table B.2 Valuation methodologies used for environmental effects from Austroads

Category	Methodology
Air pollution	Values are based on control/avoidance costs and health benefit values using the results of a European (ExternE) study reporting $/tonne estimates, converted to Australian dollars using population-weighted average population densities for urban areas. Rural impacts assumed to be 1% of urban impacts
Greenhouse gases	Emission reduction costs using bottom-up models, updated using the consumer price index (CPI)
Noise	WTP studies and a valuation of health effects of noise exposure. Rural areas assumed to have zero noise impact.
Water	WTP and mitigation cost methodologies. Mitigation costs include vegetation, sedimentation tanks, combined catchments and treatment of storm water run-off) over entire road networks or on a per vehicle-kilometre basis. New Zealand estimates included: 0.3c/vkt (range = 0.1-0.5 cents) (Ministry of Transport 1996)
Nature and landscape	Based on repair and compensation/restoration methodology and a unit cost per area of affected land. The sensitivity of the loss is assumed to be higher for rural areas therefore the urban passenger car and bus values are set at 10% of the rural value.
Urban separation	Time loss due to separation for pedestrians, lack of non-motorised transport provision and visual intrusion

Source: Austroads (2012b)

Table B.3 Externality unit costs for passenger vehicles and buses (cents per vehicle kilometres travelled)* from Austroads

	Vehicle/units	Urban		Rural	
		Passenger cars	Buses	Passenger cars	Buses
1	Air pollution	2.78 (2.71–2.84)	31.26 (22.12–34.77)	0.03 (0.02–0.03)	0.00 (0.00–0.35)
2	Greenhouse gas emissions	2.19 (1.93–2.45)	12.88 (n/a)	2.19 (1.93–2.45)	12.88 (n/a)
3	Noise	0.91 (0.64–1.16)	2.19 (1.2–3.09)	0.00 (0.00)	0.00 (0.00)
4	Water	0.42 (0.40–0.43)	4.69 (3.32–5.21)	0.04 (0.04–0.04)	0.05 (0.03–0.05)
5	Nature and landscape	0.05 (0.05–0.19)	0.14 (0.14–0.66)	0.51 (0.51–1.80)	1.42 (1.42–6.57)
6	Urban separation	0.64 (0.38–0.90)	2.07 (1.29–2.84)	0.00 (0.00)	0.00 (0.00)
7	Upstream and downstream costs	3.74 (3.22–4.25)	19.32 (15.45–23.18)	3.74 (3.22–4.25)	19.32 (15.45–23.18)

* Austroads adjusts all values from 2007 Australian dollars to 2010 Australian dollars using the change in CPI for all groups' index numbers – weighted average of eight capital cities.

Source: Austroads (2012b)

The overall costs of air pollution emissions, as used by Austroads, are shown in table B.4.

Table B.4 Unit values of emissions in $/tonne

Gas	$/tonne
Carbon dioxide equivalent (CO_2-e)	$52.40
Carbon monoxide (CO)	$3.30
Oxides of nitrogen (Nox)	$2,089.2
Particulate matter (PM10)	$332,505.9
Total hydrocarbons (THC)	$1,046.8

Source: Austroads (2012b)

B5 UK transport analysis guidance (TAG)

The UK DfT (2017a) *Transport analysis guidance: WebTAG* is a transport-specific guide for project appraisal, first published in 2013 and based on HM Treasury's (2011) *The green book*, which in turn sets out the framework for appraisal and evaluation for all policies, programmes and projects. *The green book* constitutes binding guidance on all departments, including the Department for Transport. DfT (2017) is further implemented via spreadsheets and additional guidance in a toolkit available online as WebTAG.

TAG Unit A1.1: Cost-benefit analysis (DfT 2017b) covers CBA building on HM Treasury's *The green book*. CBA is only one element of the appraisal process that also includes economic, environmental and social impact appraisal in what is effectively an MCA. Table B.5 shows the impacts that are typically monetised and those that are not.

As with the EEM, the UK government provides standardised values for assessing the impacts of noise, air pollution and greenhouse gases.

Table B.5 of impacts in TAG Unit A1.1

Category of impact	Impacts that are typically monetised	Impacts that can be monetised but are not reported	Impacts that it is currently not feasible or practical to monetise
Economy	Business users and private sector providers (including revenues)	Reliability impact on business users Regeneration wider impacts	
Environment	Noise Air quality Greenhouse gases	Landscape	Townscape Historic environment Biodiversity Water environment
Social	Commuting and other users Accidents Physical activity Journey quality	Reliability impact on commuting and other users Option and non-use values	Security Access to services Affordability Severance
Public Accounts	Cost to broad transport budget Indirect tax revenues		

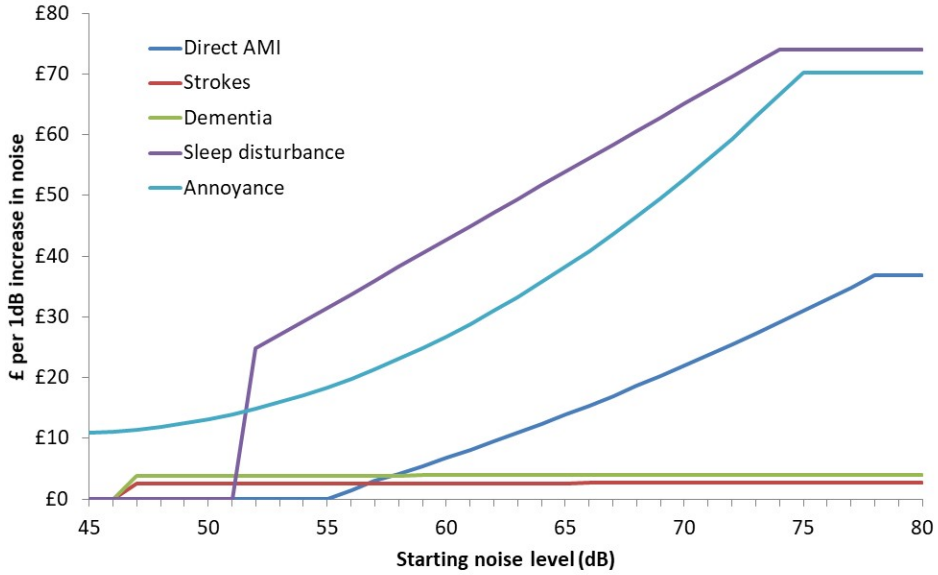
Source: DfT (2017b)

Sections B5.1 to B5.5 provide more detail on the environmental and social values assessments set out in TAG Unit A1.1 (DfT 2017b).

B5.1 Noise impacts

The impacts of noise are included in the WebTAG based on research by Dickens et al (2014). The values are shown in figure B.2.

Figure B.2 WebTAG table 3.1 Noise – road traffic noise marginal values £ per household per dB change (2017 values)



Note: AMI = acute myocardial infarctions

Source: DfT (2017c)

The direct acute myocardial infarctions (AMI) impacts were estimated using the Babisch curve (IGCB(N) 2010) which links noise levels to AMI incidents and is derived from studies in Germany.

In the UK it was combined with the following assumptions (IGCB(N) 2010):

- an average probability of AMI of 0.0084% per person, derived from the number of cases of AMI in London in 2006
- the cost of a single instance of AMI is estimated based on the recommended quality adjusted life year (QALY) value of £60,000 (see below)
- evidence that 72.4% of cases of AMI lead to immediate mortality (with an estimated life expectancy loss of 10.8 years) and a disability weight of survival from AMI of 0.40532 (consistent with World Health Organisation figures)
- an average of 2.4 persons per household.

A QALY is essentially a life year in perfect health and is estimated to have a value of £60,000 in the UK (Dickens et al 2014). In New Zealand, one approach used has been to set gross domestic product (GDP) per capita as a threshold for the maximum amount to pay to achieve a QALY (Webber-Foster et al 2014). GDP per capita in New Zealand is currently approximately $53,000 (Statistics New Zealand 2015) . Detailed methods for calculating the health impacts of noise can be found in the transport noise modelling tool available at www.gov.uk/guidance/noise-pollution-economic-analysis (Defra 2014).

Similar approaches are used for estimates of the impacts on strokes and dementia.

B5.2 Amenity impacts

Sleep disturbance values are based on results in Janssen et al (2011). Self-reported sleep disturbance values (as a percentage of highly sleep disturbed = %HSD) were used to derive exposure-response functions. The function road travel was defined with respect to the noise level at night (L_{night}):

$$\% HSD = 20.8 - 1.05 (L_{night}) + 0.01486(L_{night})^2 \quad \text{(Equation B.3)}$$

This equation was used with disability weights.[2] The disability weight recommended by Janssen et al (2011) for sleep disturbance was 0.07; in effect this means being highly sleep disturbed due to environmental noise reduces a completely healthy individual's health by around 7%. This was combined with the above equation to derive a value specified in disability-adjusted life years.[3] To produce a monetary value, the UK workers then used a QALY value of £60,000.

The calculation is as follows for the cost for a change in night noise level from L1 to L2:

$$Cost\ of\ sleep\ disturbance\ per\ household = (\%HSD_{L2} - \%HSD_{L1}) \times 0.07 \times QALY \times PPH \quad \text{(Equation B.4)}$$

Where: $\%HSD_{L1}$ = percentage of households that are sleep disturbed at night noise level L1 calculated using the formula in equation B.4

QALY = quality adjusted life year

PPH = average number of people per household.

B5.3 Air quality

The UK's approach to estimating the damage costs of air pollution are noted in *TAG Unit A3: Environmental impact appraisal* (DfT 2015a). It refers to the methodology used by the Air Quality Subject Group of the Interdepartmental Group on Costs and Benefits (IGCB(A) 2011), which in turn relies on a methodology originally developed by Watkiss et al (2006) for the IGCB in the context of the CBA of the air quality strategy (Defra et al 2007).

B5.3.1 PM_{10}

The main pollutant examined is PM_{10}. The damage costs are estimated per household resulting from a 1µg/m^3 increase in concentration. It uses a central estimate of effects of a 6% increase in premature deaths per 10µg/m^3 increase in concentrations, with lower and upper bounds of 1% and 12% respectively. The analysis includes different assumptions on lagged benefits between zero lag and a 40-year lag.

To analyse the effects Watkiss et al (2006) use lifetables to track deaths over time, explaining (p12) that 'we analyse over 100 years to see when the deaths 'saved' in year 1 actually occur later, because necessarily they will occur'.

These calculations were used to estimate the costs shown in table B.6 which are the base values applied in the analysis. These have been updated for more recent years using GDP per capita.

[2] A disability weight lies on a scale between 0 (indicating the health condition is equivalent to full health) and 1 (indicating the health condition is equivalent to death).

[3] Disability-adjusted life years are the sum of the potential years of life lost due to premature death and the equivalent years of 'healthy' life lost by virtue of being in states of poor health or disability.

Table B.6 Marginal annual air quality cost (£ per household per 1µg/m³)

Lag assumption	2010 prices	2017 prices
Central	£93	£115
Low (40-year lag)	£49	£60
High (zero lag)	£105	£130

Source: Watkiss et al (2006); DfT (2017c)

B5.3.2 NOx

Values for NOx are included in the TAG both as damage costs and the costs of abatement (table B.7).

Table B.7 Damage cost and marginal abatement cost values (2017 values) (£/tonne)

	Central value	Low value	High value
NO_x damage costs	£1,165	£908	£1,324
NO_x marginal abatement costs	£32,511	£30,268	£81,837

Source: DfT (2017c)

B5.4 Greenhouse gases

Different approaches are taken depending on whether emissions are included in the European Union Emissions Trading Scheme (the 'traded' sector) or not (the 'non-traded' sector) (European Commission 2017). Where emissions are covered by the traded sector, emission costs are assumed to be internalised and included in commodity prices; where they are not covered by the traded sector, the emissions are estimated and costed separately.

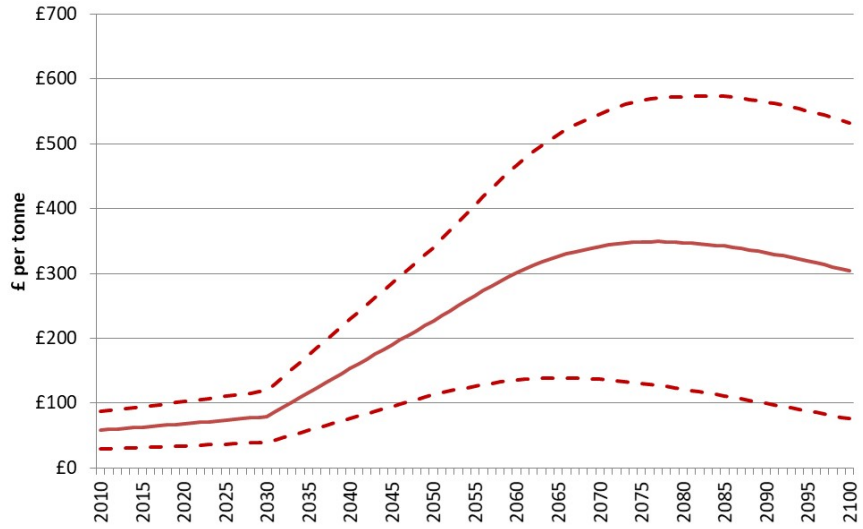
The traded sector covers emissions from power and heat generation, energy-intensive industry and aviation. Thus, emissions from electricity consumption in transport are in the traded sector. However, conventional transport fuels, including petrol, diesel and gas oil, are in the non-traded sector.

The analysis suggests that embedded emissions in materials imported from countries with no carbon pricing should be taken into account within the appraisal in line with Department for Energy and Climate Change guidance. For major transport schemes such as the High Speed Two rail network, such embedded carbon analyses are being undertaken (A Ainsworth, pers comm).

The UK values emissions in the non-traded sector based on emission abatement curves, ie the costs of emission reductions required to meet emission targets. The central values and the high and low range are shown in 5.2.

Note, in New Zealand, vehicle emissions are in the 'traded' sector so CO_2 costs are (partially) internalised in fuel prices.

Figure B.3 CO_2 prices included in the TAG for transport project appraisal (2017 prices)



Source: DfT (2017c)

B5.5 Other environmental impacts

A standard approach has been developed in the TAG for assessing other environmental effects. It describes the effects and classifies them in terms of their magnitude, but does not use monetary values (DfT 2015a). The approach applies to the impacts on:

- landscape
- townscape
- historic environment
- biodiversity
- water environment.

The approach taken is to use 'a qualitative "environmental capital" style approach', although alternative approaches based on identifying impacts on ecosystem services are being explored for the future. Ecosystem services are discussed in appendix C, section C1 if this report.

The concept of environmental capital is used in the TAG to assess what matters and why it is important. The current environmental capital is defined, along with an assessment of how the environmental capital may change over time in the absence of the proposal. This provides the baseline level of environmental capital against which the impact of the proposal can be appraised. A five-step approach is used that includes:

- Step 1: Scoping and identification of the study area
- Step 2: Identifying key environmental resources and describing their features
- Step 3: Appraise environmental capital
- Step 4: Appraise the proposal's impact
- Step 5: Determine the overall assessment score.

We examine this for some examples below.

B5.5.1 Landscape

The environmental capital of landscape is defined in terms of:

- pattern – the relationship between topography and form, eg small fields in a confined valley
- tranquillity – remoteness and sense of isolation, including noise and/or absence of development
- cultural – how historic or traditional elements contribute to the character
- landcover – how land use contributes to the landscape.

The analysis of impacts is defined using a table: the TAG landscape impacts worksheet, included here as table B.8.

Table B.8 TAG landscape impacts worksheet

	Step 2	Step 3				Step 4
Features	**Description**	**Scale it matters**	**Rarity**	**Importance**	**Substitutability**	**Impact**
Pattern						
Tranquillity						
Cultural						
Landcover						
Summary of character						

Source: DfT (2015b)

The overall assessment score uses the descriptions included in table B.9. This provides an impact score, but does not monetise the effect.

Table B.9 Landscape: definitions of overall assessment scores

Score	Comment
Large beneficial (positive) effect	The scheme provides an opportunity to greatly enhance the landscape because it: • greatly enhances the character (including quality and value) of the landscape • creates an iconic high-quality feature and/or series of elements • enables a sense of place, scale and quality to be restored in an area formerly of high landscape quality. Note that very few, if any, schemes are likely to merit this score.
Moderate beneficial (positive) effect	The scheme provides an opportunity to enhance the landscape because: • it fits very well with the scale, landform and pattern of the landscape • there is potential, through environmental design measures, to enable the restoration of characteristics, partially lost or diminished as the result of changes resulting from intensive farming or inappropriate development • it will enable a sense of place and scale to be restored through well-designed planting and environmental design measures, that is, characteristics are enhanced through the use of local materials and species used to fit the scheme into the landscape • it enables some sense of quality to be restored or enhanced through beneficial landscaping and sensitive design in a landscape which is not of any formally recognised quality • it furthers government objectives to regenerate degraded countryside.
Slight beneficial (positive) effect	The scheme: • fits well with the scale, landform and pattern of the landscape • incorporates environmental design measures to ensure they will blend in well with surrounding

Score	Comment
	landscape • will enable some sense of place and scale to be restored through well-designed planting and environmental design measures • maintains or enhances existing landscape character in an area which is not a designated landscape, nor vulnerable to change • avoids conflict with government policy towards protection of the countryside.
Neutral effect	The scheme iswell designed to: • complement the scale, landform and pattern of the landscape • incorporate environmental design measures to ensure it will blend in well with surrounding landscape characteristics and landscape elements • avoid being visually intrusive or have an adverse effect on the current level of tranquillity of the landscape through which the scheme passes • maintain existing landscape character in an area which is not a designated landscape, that is, neither national or local high quality, nor is it vulnerable to change • avoid conflict with government policy towards protection of thecountryside.
Slight adverse (negative) effect	The scheme: • does not quite fit the landform and scale of the landscape • although not very visually intrusive, will impact on certain views into and across the area • cannot be completely integrated because of the nature of the scheme itself or the character of the landscape through which it passes • affects an area of recognised landscape quality • conflicts with local authority policies for protecting the local character of the countryside.
Moderate adverse (negative) effect	The scheme is: • out of scale with the landscape, or at odds with the local pattern andlandform • visually intrusive and will adversely impact on the landscape • not possible to fully integrate, that is, environmental design measures will not prevent the scheme from scarring the landscape in the longer term as some features of interest will be partly destroyed or their setting reduced or removed • will have an adverse impact on a landscape of recognised quality or on vulnerable and important characteristics or elements • in conflict with local and national policies to protect open land and nationally recognised countryside.
Large adverse (negative) effect	The scheme is very damaging to the landscape in that it: • is at considerable variance with the landform, scale and pattern of thelandscape • is visually intrusive and would disrupt fine and valued views of thearea • is likely to degrade, diminish or even destroy the integrity of a range of characteristics and elements and their setting • will be substantially damaging to a high quality or highly vulnerable landscape, causing it to change and be considerably diminished in quality • cannot be adequately integrated • is in serious conflict with government policy for the protection of nationally recognised countryside
Very large adverse (negative) effect	The scheme would result in exceptionally severe adverse impacts on the landscape because it: • is at complete variance with the landform, scale and pattern of thelandscape • is highly visual and extremely intrusive, destroying fine and valued views both into and across the area • would irrevocably damage or degrade, badly diminish or even destroy the integrity of characteristics and elements and their setting

Score	Comment
	• would cause a very high quality or highly vulnerable landscape to be irrevocably changed and its quality very considerably diminished • could not be integrated: there are no environmental design measures that would protect or replace the loss of a nationally important landscape • cannot be reconciled with government policy for the protection of nationally recognised countryside

Source: DfT (2015b)

B5.5.2 Biodiversity

Biodiversity is described in terms of the area and features. Judgemental indicators are then developed covering:

- the scale at which the feature matters – international, national, regional or local
- importance – a descriptive assessment of the biodiversity and earth heritage importance of the feature
- trend – the abundance of the habitat or natural feature relative to its target level, and its trend
- substitution possibilities – if it is replaceable.

The value of the biodiversity capital at risk is defined using criteria shown in table B.10.

Table B.10 Guidance on describing the biodiversity and earth heritage value of features

Value	Criteria	Examples
Very high	High importance and rarity, international scale and limited potential for substitution	Internationally designated sites
High	High importance and rarity, national scale, or regional scale with limited potential for substitution	Nationally designated sites Regionally important sites with limited potential for substitution
Medium	High or medium importance and rarity, local or regional scale, and limited potential for substitution	Regionally important sites with potential for substitution Locally designated sites
Low	Low or medium importance and rarity, local scale	Undesignated sites of some local biodiversity and earth heritage interest
Negligible	Very low importance and rarity, local scale	Other sites with little or no local biodiversity and earth heritage interest

Source: DfT (2015b)

Table B.11 shows the criteria used in defining the size of the impact.

Table B.11 Criteria for determining the magnitude of the impact

Magnitude	Criteria
Major negative	The proposal (either on its own or with other proposals) may adversely affect the integrity of the key environmental resource, in terms of the coherence of its ecological structure and function, across its whole area, that enables it to sustain the habitat, complex of habitats and/or the population levels of species of interest.
Intermediate negative	The key environmental resource's integrity will not be adversely affected, but the effect on the resource is likely to be significant in terms of its ecological objectives. If, in the light of full information, it cannot be clearly demonstrated that the proposal will not have an adverse effect on integrity, then the impact should be assessed as major negative.
Minor negative	Neither of the above apply, but some minor negative impact is evident. (In the case of Natura 2000 sites a further appropriate assessment may be necessary if detailed plans are not yet available.)
Neutral	No observable impact in either direction.
Positive	Impacts which provide a net gain for wildlife overall.

Source: DfT (2015b)

B5.5.3 Water environment

The water environment at risk is defined with respect to its quality, a measure of the physical condition, considering also:

- scale, eg where the resource is of great value to a community for providing a significant proportion of local employment
- rarity – whether the water attribute is commonplace or scarce
- substitutability.

Water resources are considered by resource type (river, floodplain, groundwater, estuaries etc) and feature (or use), for example water supply, transport or dilution of pollutants, biodiversity, conveyance of flood flows. The full tables can be found in *TAG Unit A3: Environmental impact appraisal* (DfT 2015a). The size of the effect is measured using the classifications in table B.12.

Table B.12 Criteria for determining impact magnitude

Magnitude	Criteria	Example
Large adverse	Results in loss of feature	Loss of important fishery Change in water framework directive (WFD) classification of river reach Compromise employment source Loss of flood storage/increased flood risk Pollution of potable source of abstraction
Moderate adverse	Results in adverse impact on integrity of feature or loss of part of feature	Loss in productivity of a fishery Contribution of a significant proportion of the effluent in the receiving river, but insufficient to change its WFD classification Reduction in the economic value of the feature
Slight adverse	Results in minor adverse impact on feature	Measurable changes in feature, but of limited size and/or proportion
Negligible	Results in an impact on feature but	Discharges to watercourse but no significant loss in quality,

Magnitude	Criteria	Example
	of insufficient magnitude to affect the use/integrity	fishery productivity or biodiversity No significant impact on the economic value of the feature No increase in flood risk
Slight beneficial	Results in minor beneficial impact on feature or a reduced risk of adverse effect occurring	Measurable changes in feature, but of limited size and/or proportion
Moderate beneficial	Results in moderate improvement of feature	Enhanced productivity of a fishery Reduction in a significant proportion of the effluent in a receiving river, but not sufficient to change its WFD classification Moderate reduction in flood risk
Large beneficial	Results in major improvement of feature	Removal of major existing polluting discharge to a watercourse Major reduction in flood risk

Source: DfT (2015a)

B6 US TIGER BCA resource guide

The TIGER BCA resource guide (US DOT 2015) is used to provide guidance on the appraisal of TIGER grants. TIGER stands for the Transportation Investment Generating Economic Recovery Grant programme. It is a means by which US DOT invests in road, rail, transit and port projects that promise to achieve national objectives.

US DOT receives hundreds of applications to build and repair pieces of freight and passenger transportation networks. Applicants must detail the benefits their project would deliver for five long-term outcomes: safety, economic competitiveness, state of good repair, quality of life and environmental sustainability. US DOT also evaluates projects on innovation, partnerships, project readiness, BCA and cost share.

The BCA resource guide provides technical information that applicants for TIGER grants need for monetising benefits and costs in their BCA, as well as guidance on methodology. The guide includes some recommended monetised values (table B.13).

Table B.13 Monetary values included in the TIGER resource guide

Cost/benefit category	Recommended monetised value	
Value of statistical life (VSL)	\$9.2 million (US$$_{2013}$)	
Value of injuries		
Minor	0.003 of VSL	
Moderate	0.047 of VSL	
Serious	0.105 of VSL	
Severe	0.266 of VSL	
Critical	0.593 of VSL	
Unsurvivable	1.000 of VSL	
Property damage only crashes	\$3,927 per vehicle (US$$_{2013}$)	
Value of travel time	**Local travel** (US$2013/person-hr)	**Intercity** (US$2013/person/-hr)
Personal	\$12.42	\$17.39
Business	\$25.53	\$24.44

Cost/benefit category	Recommended monetised value	
All purposes	$12.98	$44.24
Value of emissions	**Emission type**	**$/tonne (US$$_{2013}$)**
	Carbon dioxide (CO_2)	Varies[(a)]
	VOCs	$1,999
	NO_x	$7,877
	PM	$360,383
	SO_2	$46,561

[(a)] Based on social cost of carbon (3%) (see below)

Source: US DOT (2015)

The analysis should be undertaken using a discount rate of 7% based on OMB circulars A-4 (Office of Management and Budget 2003) and A-94 (Office of Management and Budget 2011). Applicants should provide an alternative analysis with a real discount rate of 3%.

B6.1 Social cost of carbon

The federal Interagency Working Group on Social Cost of Greenhouse Gases (2016) guidance states the value of carbon dioxide emissions changes over time and should be discounted at the lower discount rates of 2.5%, 3% or 5%. The TIGER programme recommends use of 3% values. All other benefits and costs are discounted at 7% (or 3%) while carbon values are based on a 3% discount rate.

B7 California life-cycle benefit/cost analysis model

The California Department of Transportation (Caltrans) uses the California life-cycle benefit/cost analysis model (Cal-B/C) to conduct investment analyses of projects (Caltrans 2007). It is a spreadsheet-based tool that can prepare analyses of highway, transit (public transport) and passenger rail projects. Users input data defining the type, scope and cost of projects. The model calculates life-cycle costs, net present values, benefit-cost ratios, internal rates of return, payback periods, annual benefits and life-cycle benefits.

The model measures, in constant dollars, four categories of benefits that result from highway or transit projects:

- travel time savings (reduced travel time and new trips)
- vehicle operating cost savings (fuel and non-fuel operating cost reductions)
- crash cost savings (safety benefits)
- emission reductions (air quality and greenhouse gas benefits).

Appendix C: Literature review of other benefits approaches

New Zealand and its roading sector are not alone in finding it difficult to assign value to less tangible benefits, such as environmental, social and cultural aspects of a scheme. There has been significant international effort expended on developing approaches to quantify these benefits and also on developing approaches to monetise them. Three key approaches, ecosystem services, natural capital and matrix based methods, are considered in sections C1 to C3.

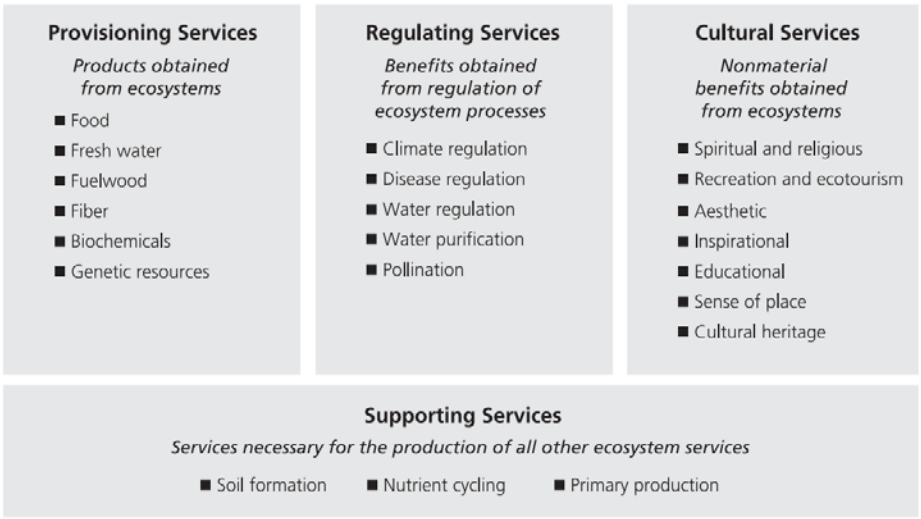
C1 Ecosystem services

The concept of ecosystem services considers the various goods and services that humans derive from their natural surroundings. Landmark studies like Costanza et al's 1997 valuation of US$16–$54 trillion per year of global natural capital popularised the concept. The authors defined ecosystem services as follows:

> *Ecosystem goods (such as food) and services (such as waste assimilation) represent the benefits human populations derive, directly or indirectly, from ecosystem functions.*

Later the Millennium Ecosystem Assessment (MEA) embedded ecosystem services in the language of environmental management by categorising the services into four groups (see figure C.1) (MEA 2005). The MEA simplified the definition of ecosystem services to be 'the benefits that people obtain from ecosystems'.

Figure C.1 Ecosystem services



Source: (MEA 2005)

The ecosystem services concept can be used to identify the services/benefits the natural environment produces. The provisioning, regulating and cultural services are valued because they affect 'final' products (using the language of economists), such as clean water, whereas the supporting services do not affect wellbeing directly but enable the production of the other services.

The Economics of Ecosystems and Biodiversity (TEEB) is further developing the ecosystem services approach. Work presented in Russi et al (2013) suggests different approaches and tools can provide complementary information for assessing the value of water and wetlands. Four methods of capturing and measuring information are outlined:

1 Qualitative analysis – recognising that capturing information in a narrative form in itself provides definition and clarity in relation to a benefit

2 Quantitative data – measuring physical stock and flow indicators, such as river minimum and maximum flows, or species populations, can provide a meaningful basis for measuring impacts and change

3 Geospatial mapping – spatial consideration of quantitative data

4 Monetary valuation – noting that the three most commonly used methods comprise market-based assessments, revealed preference assessments and stated preference methods.

A New Zealand example is referenced, where the water supply services provided by Te Papanui Conservation Park (Lammermoor Range) were valued in terms of the costs that would be incurred by Dunedin City Council, hydro-electricity generators and farmers needing water for irrigation if the water supply ceased to exist. The estimated value of the water is $136M (2005 net present value (NPV)) (Department of Conservation 2006).

TEEB acknowledges monetary valuation has a significant role to play, but argues that a single methodology cannot reflect all values, and suggests a range of methods are required. It also refers to participatory methods.

C1.1 Ecosystem services and TEV

The New Zealand Ministry for the Environment (MfE) has initiated the mapping of the relationship between ecosystem services and the TEV framework in the context of water quality, including table C.1 and figure C.3.

Table C.1 Aligning ecosystem services with the TEV framework

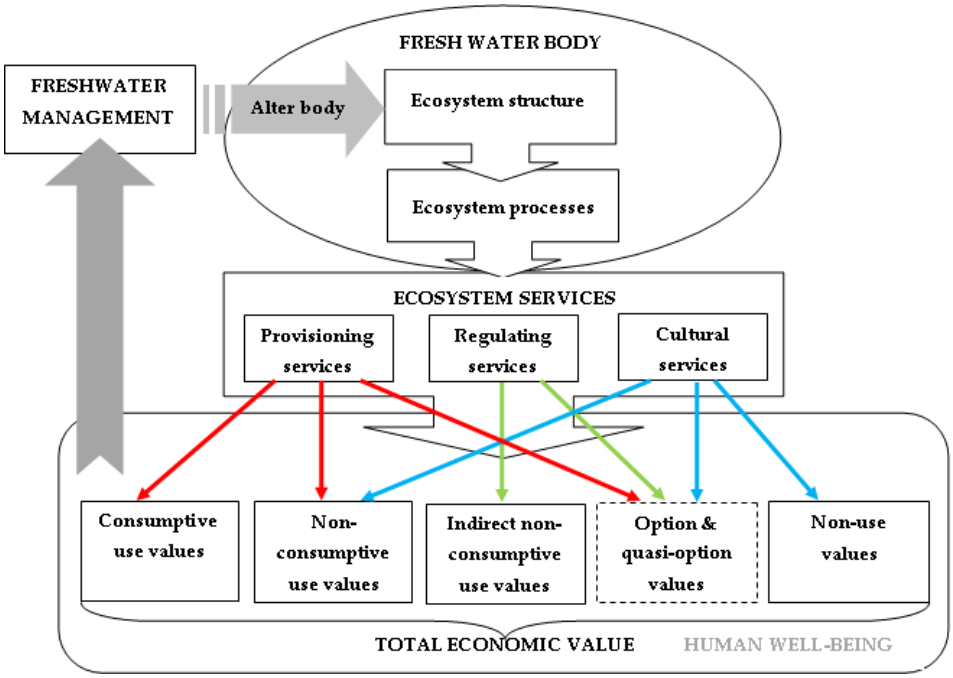
Ecosystem service		Activity of value	TEV class
Provisioning	Food	Aquaculture	Direct consumptive use
		Sport fish	
		Mahinga kai	
	Fibre	Flax	
		Driftwood	
		Fibre for decorative handicraft	
	Fresh water supply	Irrigation	
		Municipal water	
		Industrial water	
		Hydroelectricity	Direct non-consumptive use
		Commercial transport	
	Abiotic products	Gravel extraction for concrete	Direct consumptive use
		Stones for decorative handicraft	
	Genetic and medicinal resources	Pharmaceuticals	
Regulating	Disease regulation	Parasite and toxic algae regulation	Indirect use
	Fresh water regulation	River flow regulation	
	Fresh water purification	Removal of pollutants	
	Pest regulation	Mitigation of invasive non-native species	
	Erosion control	Stabilisation of river/lake banks	
	Natural hazard regulation	Flood and drought protection	

Ecosystem service		Activity of value	TEV class
Cultural	Education	Historical interest	Direct non-consumptive use
		Scientific knowledge systems	
		Archaeological interest	Direct consumptive use
	Conservation	Charismatic endangered species & wild landscapes	Direct non-consumptive use
		Existence of endangered species & biodiversity	Non-use
	Aesthetic	Perceived beauty	Direct non-consumptive use
	Spiritual & cultural	Inspiration	
		Tranquillity	
		Māori site of significance	
		Taonga species	
		Wahi tapu	Non-use
	Recreation	Ecotourism, fishing, hunting, kayaking, swimming	Direct non-consumptive use

Source: Covec (2013)

MfE's conceptual model was adapted from Hein et al's (2006) ecosystem valuation framework which illustrates the role of the MEA's ecosystem services classifications in such valuations. MfE's adaptations made it more specific to water and included management of water bodies and their inputs and outputs. The latter addition describes how feedback on changes in the TEV can be used as a stimulus for policy tools to manage the quantity and quality of the water, thereby altering the ecosystem and the services it provides.

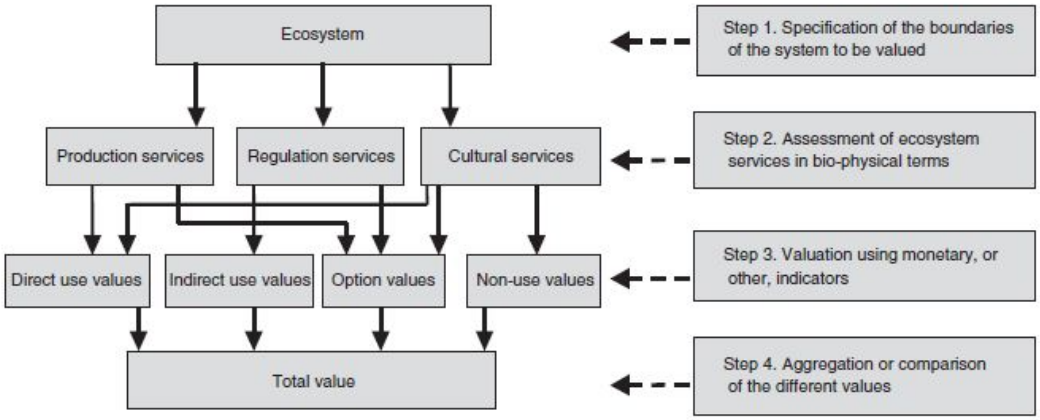
Figure C.2 A conceptual model of MEA ecosystem services and the TEV framework



Source: Covec (2013)

MfE's adapted model excludes a key feature of Hein et al's (2006) original model (figure C.3): the principal steps in the valuation of an ecosystem. Here, in step 2, the authors outline that the MEA's classifications are valuable in the 'assessment of ecosystem services', and the use of these classifications does not extend further into the valuation process – the TEV framework takes over at the next step. The implication is that the relationship between the ecosystem services framework and the TEV framework is simple: the ecosystem services framework aids in identifying the services the ecosystem provides, while TEV outlines the type and (ideally) the amount of value these services have.

Figure C.3 Hein et al's ecosystem valuation framework



Note: The solid arrows represent the most important links between the elements of the framework. The dashed arrows indicate the four principal steps in the valuation of ecosystem services

Source: Hein et al (2006)

C2 Natural capital protocol

A similar structured approach is provided by the Natural Capital Protocol (2016) (Natural Capital Coalition 2016). The Natural Capital approach seeks to support better decisions by considering interactions with nature – or natural capital – within decision-making processes. It has a focus on decision making by businesses but can be broadly applied. In addition to considering how an element is impacted by business activities/operations, it also considers how the environment impacts on business – encouraging consideration of components such as climate change on future business operations.

The protocol discusses value and monetisation:

> *To value something means to understand what it is worth to us. In the Protocol, valuation refers to the process of estimating the relative importance, worth, or usefulness of natural capital to people, in a particular context.*
>
> *In financial accounting terms, valuation is understood to mean monetization, but in environmental economics and this Protocol, valuation means more than just monetization. It includes qualitative, quantitative, and monetary approaches, or a combination of these*

It separately defines economic value:

> *The importance, worth, or usefulness of something to people—including all relevant market and non-market values. In more technical terms, the sum of individual preferences for a given level of provision of that good or service.*

The protocol is structured in four steps:

1 Frame – determine why the assessment is being carried out

2 Scope – define the objectives, scope the assessment, determine material impacts and dependencies

3 Measure and value – identify what can be measured, measure change, value the impacts and dependencies

4 Apply – interpret results and take action.

Focusing on the measure and value step, the protocol encourages the identification of components that can be quantified where possible, such as water volumes. It identifies that consideration should be given to impacts on the business, the impacts of the business on society and the dependencies of the business and that for the latter two components the specialist expertise of environmental and welfare economists may be required.

Similarly to the ecosystem services approach, the protocol differentiates between qualitative, quantitative and monetary valuation approaches. Figure C.4 is extracted from that document and provides qualitative and quantitative examples of indicators by impact driver category (or environmental element).

Figure C.4 Qualitative and quantitative indicators of impact

Impact driver category	**Example qualitative indicators** according to set criteria	**Example quantitative indicator** (for a given location and over a given period of time)
Energy	Large to small ↑ High to low ↑ Severe to minor ↓ Essential to superfluous ↓	Kilowatt hours of energy
Water		Cubic meters or turbidity of water
Nutrition		Joules of energy consumed
Materials		Tons or cubic meters of wood
Regulation of physical environment		Hectares of habitat providing water filtration; cubic meters /day of water filtered by vegetation
Regulation of biological environment		Risk level of incident (e.g., flood frequency); resilience against diseases (e.g., in trees or crops)
Regulation of waste and emissions		Grams of pollutant assimilated per kilometer of river
Experience		Estimation of time required for ecosystem restoration based on previous experience
Knowledge		Importance of particular species for the resilience of ecosystems (e.g., threshold at which services cease)
Well-being and spiritual/ethical values		Mental or physical health benefits of access to green space or clean air and water (e.g., change in productivity).

Source: Natural Capital Coalition (2016)

C3 Matrix approaches

Recognising the difficulty in quantifying value, an alternative qualitative, or semi-quantitative, approach using matrix-based assessment has been adopted by organisations including the UK Department of Transport and the Environment Institute of Australia and New Zealand.

The 2015 'EIANZ guidelines for use in New Zealand terrestrial and freshwater ecosystems' (Environment Institute of Australia and New Zealand Inc 2015) provides a consistent basis for the consideration of effects on these elements of the environment. It follows a process of description, evaluation, assessment, impact management and monitoring, providing options for good practice where appropriate. For the assessment of effects it presents a single approach, the use of a matrix system with supporting information.

Development of the matrix goes through three steps:

1 Assign ecological value

2 Describe the magnitude of effects

3 Describe the level of effects.

Consideration of value at different spatial and ecosystem scales is addressed.

This type of matrix decision is similar to that used in the UK TAG documentation (Department of Transport 2015b).

Specific consideration was given to cost-utility analysis (CUA) following feedback from the Steering Group.

CUA is a form of MCA. It assesses the quantity of benefit per dollar using some non-monetary scale. However, like all MCAs it suffers from a weighting problem, eg how much do we value impacts on water quality vs those on air quality? The answer is generally provided via the subjective values of experts or stakeholders. Furthermore, CUA cannot address some questions such as whether the benefits of environmental requirements on road projects exceed the costs

The results of this work are expected to provide data relevant to the EEM which takes a CBA approach and which already uses monetary values for some environmental effects.

C4 HM Treasury *The green book*

HM Treasury's (2011) *The green book* provides general guidance on CBA for all government appraisals and evaluations. It is equivalent to the NZ Treasury's (2015c) CBA guidance document. Of note, *The green book* includes guidance that goes beyond that provided in the NZ Treasury guidance on non-market values and on discount rates.

C4.1 Non-market values

The green book does not provide any specific values for use in analysis, but notes the importance of including non-market values and the preference for using estimates based on people's WTP or WTA a project's outputs or outcomes. HM Treasury (2011) notes (p57):

> *Willingness to pay is the maximum amount of money an individual is willing to give up in order to receive a good. WTA is the minimum amount of money they would need to be compensated to forego or give up a good. The amount consumers are willing to pay depends to a large extent on the levels of income available to them, so valuations are usually obtained by averaging across income groups.*

The green book discusses methodologies for evaluating health costs and benefits, including crash costs. Other specific comments it makes include recommending the use of a social cost of carbon in valuing the costs of greenhouse gas emissions (this is different from the recommendations in the TAG, as discussed

above). For other environmental impacts, eg on air quality, water and landscape, it notes ongoing research is addressing these issues.

C4.2 Discount rates

The green book addresses the discount rate issue and recommends the use of a rate based on the social rate of time preference. For the UK this is estimated to be 3.5% real. The guide also discusses the implications of future uncertainty for discount rates, and suggests the use of a rate that declines over time – to 2.5% at 100 years and 1% for effects beyond 300 years in the future.

C5 New Zealand Treasury guidance

The Treasury (2016b) *Managing benefits from projects and programmes* defines benefit as 'A measurable gain from an investment which is perceived to be advantageous by a stakeholder'. It provides four attributes for benefits in the context of an investment proposal:

1 There is a beneficiary (eg society, a group or an individual)

2 There is a gain

3 They are attributable

4 They are discernible.

It recognises measurable benefits may be both monetary and non-monetary. It notes benefits should be attributable to the investment and measurement should be meaningful, i.e. there should be a direct relationship between the achievement of the measure/s and the achievement of the benefit.

The guidance suggests measures should be established early, but recognised that for all benefits, whether monetary or non-monetary, there are limits as to what can be measured, and to what is cost effective to measure. However, it also suggests at least one measure per benefit is necessary.

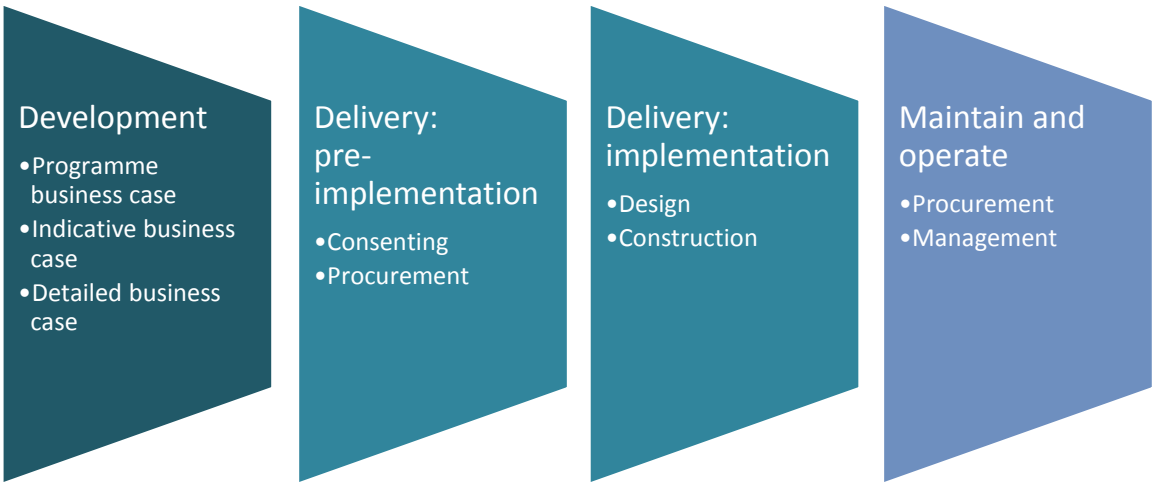
Treasury promotes the use of a benefits realisation plan, which should be updated when there is a change in project scope, timing or cost. The guidance suggests benefits management should be assigned the same standards of management and level of resource as other scheme components such as risk, scheduling or health and safety.

Appendix D: Current practices and processes

D1 Project lifecycle

The Transport Agency and Auckland Transport have both adopted the New Zealand Treasury's better business case model for the delivery of capital works (The Treasury 2015b). An overview of the phases of a project lifecycle is shown in figure D.1.

Figure D.1 Transport Agency project development and delivery lifecycle



Benefits are calculated using the EEM (NZ Transport Agency 2016a) for the indicative business case and detailed business case, to enable the development of a BCR. The EEM is focused on monetising benefits and limited guidance is provided on approaches to the monetisation of environmental benefits. The BCR is only recalculated after the detailed business case if there are adjustments to funding during the delivery phases. BCR data are held in the Transport Investment Online (TIO) database system, which primarily captures scheme cost information.

Cost estimates are calculated in accordance with the *Cost estimation manual* (CEM) (NZ Transport Agency 2015a). Prior to the indicative business case and detailed business case stage gate cost estimates, a programme business case estimate is developed, and the following delivery phase cost estimates are also required:

- pre-implementation estimate 1 – update of estimate to include any hearing or Environment Court conditions
- pre-implementation estimate 2
- implementation estimate.

The required report that compares the detailed business case estimate and pre-implementation estimate 1 should in theory provide a high-level overview of any additional costs that can be attributed to environmental legislation that have arisen through the consenting or Board of Inquiry process. However, this study has found limited documentation in relation to historical costs and BCR.

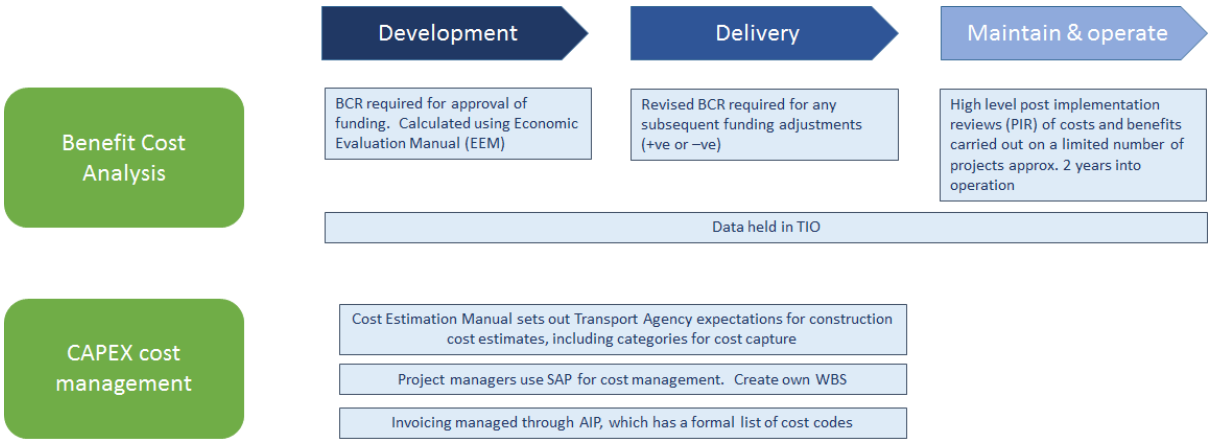
Actual project costs are recorded in the Transport Agency and Auckland Council's SAP financial system. Project managers set up their own work breakdown structures for the capture of costs. For large projects

these may be comprehensive. However, for many smaller projects very high-level cost types are used, for example, consultant, contractor and council.

Post project reviews are carried out on a small number of projects each year. These reviews recalculate the benefits arising from safety and reduced travel time. No post implementation reassessment of environmental benefits is currently carried out.

Figure D.2 provides an overview of how benefit and cost data are structured and captured through the Transport Agency's systems.

Figure D.2 Benefit and cost data capture in Transport Agency systems



D2 Project review

To determine current processes and practices for capturing data on the cost and benefits of environmental legislation, and hence to design an appropriate framework, a sample of seven roading projects was reviewed. The aims of the review were to:

- understand the project narrative in the context of environmental legislation, particularly the consenting/Board of Inquiry process
- identify when benefits were identified, how they were measured and what BCRs were calculated during the project lifecycle
- establish how project costs are captured and disaggregated, with specific focus on those arising from environmental legislation
- ascertain whether it is possible to determine the value of environmental legislation from historical roading projects.

The project review process adopted was to request key project documentation (scheme appraisal reports, business case documentation, BCR reports etc) to prepare for structured interviews with roading authority project managers. For the Transport Agency Waikato schemes the research team was referred to key consultants for the interview process.

The projects that were reviewed are summarised in table D.1. The overall finding was the environmental values are not being well captured and are difficult to extract from current processes/records. The story articulated by Transport Agency project managers was much more valuable than any available quantitative data.

Table D.1 Projects reviewed for this study

Project title	Location (key dates)	Scale of project	Commentary
NZ Transport Agency projects			
Akerama curves	Northland – rural (consented 2015, under construction)	Large ($5–20 million)	The Akerama Improvements Project covers a section of State Highway (SH) 1 near Hukerenui, 35 km north of Whangarei, from Barnes Road to Rusk Road. More passing lanes are being built and tight corners are being removed as part of the safety improvement work.
Waikato Expressway – Huntly section	Waikato – rural (consented 2009, under construction)	Very large ($100 million +)	Road of National Significance. The Waikato Expressway project will improve safety and reliability and reduce travel times and congestion on SH1 by delivering a four-lane highway from the Bombay Hills to south of Cambridge. The expressway is being built in seven sections of which this is one.
Ruby Bay Bypass	South Island – rural (consented 2008 constructed by 2012)	Large ($20–100 million)	The Ruby Bay Bypass creates a more direct route between Motueka and Nelson. It realigns SH60 inland away from the Mapua/Ruby Bay townships and resolves the existing issues of the road having multiple speed limits, being prone to erosion and having no less than 145 access points.
SH1/SH5 intersection	Waikato – rural	Medium ($0–$5 million)	A roundabout replacing the intersection of SH1 and SH5, just south of Tirau
Victoria Park Tunnel	Auckland – urban (consented 2010 constructed by 2012)	Very large ($100 million +)	Road of National Significance. The Victoria Park Tunnel addressed the bottleneck on the Auckland motorway system between Newmarket and the Auckland Harbour Bridge, resulting in safer and more reliable trips for 150,000 vehicles a day.
Auckland Transport projects			
Albany Highway upgrade	Auckland – urban	Large ($5–20 million)	An upgrade from two to four lanes of an extended stretch of the Albany Highway between Albany town centre and the motorway connection.
Matakana seal extension	Auckland – rural	Small (<$1 million)	Short length of seal extension in the Matakana Valley. Part of a programme of upgrade works.

D2.1 Project narrative

At present there is no means of capturing the full project narrative regarding the value of environmental legislation.

The narrative sits informally with those involved in the project. It is captured to some greater or lesser degree through key documents, such as the SAR and business case documents, and perhaps more fully in the AEE and documents determining the outcome of the consent or Board of Inquiry process. These

documents also focus on the changes made at the stage of the project development and the benefits realised at previous project changes (such as route selection) are not consistently carried through the documentation. However, at present these documents have proven difficult to access within the Transport Agency's systems as hard copies only are held on file. Standard practice has been to contact consultants for electronic versions.

The TIO system also holds a limited project narrative and is currently being updated to have sufficient server capacity to also hold documentation. For a number of projects reviewed for this research study there were significant changes in Transport Agency project staff through the project lifecycle, so the full capture of a narrative is not possible within the organisation. In some instances consultants hold this intellectual property, but in others, where there have also been changes in consultants, the narrative becomes piecemeal.

There would appear to be an opportunity to use the TIO upgrade to more fully capture information about benefits and the project narrative.

D2.2 Project costs

Project costs are estimated at a number of phases through the project lifecycle using the CEM framework. Actual costs are captured in the SAP finance system using the project manager's own cost structure. TIO records annual costs and the reason for any variance, but insufficient detail to be able to attribute costs arising due to environmental legislation, or other drivers.

D2.3 Cost estimation manual

The CEM provides a structure for estimating costs that focuses on the source of cost. The cost breakdown structure is summarised in figure D.3.

There are some cost components that can be clearly allocated entirely or substantially to the requirements of environmental legislation, for example, Pre-implementation 2.5 Hearing costs and 2.6 Environmental court costs. However, other cost components are more complex to disaggregate. For example, Pre-implementation 2.2 Consultants costs would include a wide range of consultants, such as traffic modelling experts and road designers, along with ecologists, planners and stormwater designers.

Similarly, within implementation costs the '1. Environmental compliance' cost allocation includes environmental mitigation related to the permanent works (eg noise walls and stormwater treatment) but mitigations for the temporary works are allocated elsewhere, for example sediment control costs are allocated to '2. Earthworks'.

Figure D.3 Cost allocation categories in the *Cost estimation manual* (NZ Transport Agency 2015a)

Pre-implementation costs

1. Consultancy Fees
    1. Contract management
    2. Design and documentation for construction
    3. Construction drawings
    4. Statutory applications
    5. Additional geotechnical testing
    6. Provisional sums
2. NZTA Managed Costs
    1. Tendering costs
    2. Consultants costs
    3. Safety audit costs
    4. Peer review costs
    5. Hearing costs
    6. Environmental Court costs
    7. Public relations costs
    8. Legal costs
    9. Miscellaneous other costs

Implementation costs

1. Environmental compliance
2. Earthworks
3. Ground improvements
4. Drainage
5. Pavement and surfacing
6. Bridges
7. Retaining walls
8. Traffic services
9. Service relocations
10. Landscaping
11. Traffic management and temporary works
12. Preliminary and general
13. Extraordinary construction costs

There is an opportunity to refine the CEM to estimate costs arising from environmental legislation. However, it is likely a focus on actual costs will be more useful in the longer term.

D2.4 SAP finance system

The finance system used by Transport Agency and Auckland Council project managers to monitor project budgets and to record project spend is SAP. This assigns budgets against agreed purchase orders for awarded contracts. Other local authorities will use a range of different financial systems.

At present Transport Agency project managers are typically at liberty to structure their cost capture in SAP in any form. This can be as simple as 'consultants, contractor, fees, other' or similar, for the duration of the project life. The outcome of this is that for many projects it is difficult to disaggregate project actual costs.

For very large projects, such as the Victoria Park Tunnel or the Waikato Expressway – Huntly Section, project managers or their cost controllers typically use much more detailed systems for cost capture, which appear to comprise spreadsheets that are held separately to SAP. This means the detailed cost data, including actual versus budget estimates and contractors' quotations, is captured though not in a central database.

Project managers also noted that contractors assign costs to varying categories. For example, one tender was viewed where the environmental compliance, health and safety and quality site overheads had the same value – the cost of the employee who would be providing these was divided evenly across the categories. While this example is not material in the context of this research, it does highlight that capturing actual cost, compared with contractors' allocated cost, could be difficult.

D2.5 Project benefits

The capture of project benefits is limited. BCRs are recorded in TIO and at times the supporting spreadsheets or breakdown of the components of these benefits (in monetary terms) is available. However, the detailed reports underlying the BCR are not always held, due to system limitations, and these reports align with the EEM, which does not provide a detailed approach for the capture of the full range of project benefits.

Appendix E: Structured framework for value capture with a benefits register

E1 Overview

The body of this research report sets out the framework for the consideration of costs and benefits arising from meeting the requirements of environmental legislation. This appendix provides more information on environmental benefits that can be quantified and suggests methods that may contribute to estimating monetary values, beyond those presented in the EEM and appendices F and G of this report.

Effort has been directed into three areas of benefit delivered by meeting the requirements of environmental legislation:

1 Ecology (freshwater, marine, terrestrial)

2 Stormwater, flooding, stream works and erosion and sediment control value

3 Social benefits.

These have been selected as:

- They are common to most, if not all, roading improvement schemes. Other areas of environmental consideration, for example coastal processes, contaminated land or groundwater effects, may occur for some projects.
- Together these areas of benefit cover most of the outcome classes in the Transport Agency's framework for investment performance measurement that are currently left as 'user to describe' in the *Economic evaluation manual* (EEM) (NZ Transport Agency 2016a). Amenity investment benefits are partially captured within the social benefits framework herein. These could be more fully captured if this work was extended to cover landscape and visual effects.

The remaining benefits where description is not prescribed are resource consumption, access to key destinations and pricing efficiency. These benefits are not core to the requirements of environmental legislation.

The matrices provided consider the qualitative, quantitative and monetary information that would be the most useful to compare the benefits of different roading projects. The user is encouraged to consider each component of benefit/cost in a structured manner:

- baseline – a description of the current environment
- effects – the impact of the 'do nothing' scenario in terms of avoiding, remedying or mitigating effects. As noted in the introduction to this report, this may not be a paradigm that practitioners are used to considering, but without contemplating this, the full benefit of meeting the requirements of environmental legislation cannot be determined
- outcomes of environmental legislation – the 'avoid, remedy, mitigate' process, along with any additional environmental enhancements
- residual effects/net gain – any residual adverse effects, or a measure of any net gain.

When considering the effects of the scheme, consider:

- the type of effect (direct or indirect)
- the likelihood of occurrence (actual or potential)

- the magnitude of effect (severe through to minor)
- the permanence of the effect (permanent or temporary).

When commenting on the value delivered through the avoid-remedy-mitigate-offset process, consider benefits delivered by reducing both the scale and magnitude of effects.

When populating the matrices it may be practical to consider each component in relation to the baseline environment characteristics. It is suggested that any such detailed or 'bottom up' assessment is subsequently considered at scheme level, to summarise material outcomes.

A detailed structure for cost capture is included in section E5.

E2 Ecology

As indicated in section 3.3.1 of this document, it is important to determine a materiality (or significance) criteria to ensure key information is captured for this assessment of value. Typical questions that can help test materiality in relation to ecological benefits are:

1 What are, or are expected to be, areas of significant ecological worth impacted on by the scheme?

2 What is, or is expected to be, important to stakeholders?

3 What are, or are expected to be significant issues in the planning process?

4 What are, or are expected to be, noticeable costs linked to meeting the requirements of environmental legislation?

It is likely a screening exercise using the Transport Agency's *Environmental and social responsibility screen* (or similar equivalent), or the AEE process, will identify the material ecological issues of relevance. Tools such as the EIANZ (2015) ecological significance matrix provide a guide to assessing the significance of ecological effects and can be used in the qualitative assessment. Professional judgement or expert opinion is also often sought to provide separation of effects that are considered significant in both an ecological and planning context from those that are not.

It is expected the ecology framework would be completed for components of freshwater, terrestrial and marine ecology. Project teams may seek to record value in more detail, for example by 'natural value criteria' but this would create a large and complex matrix. A more pragmatic approach has been used for the case studies presented in this report.

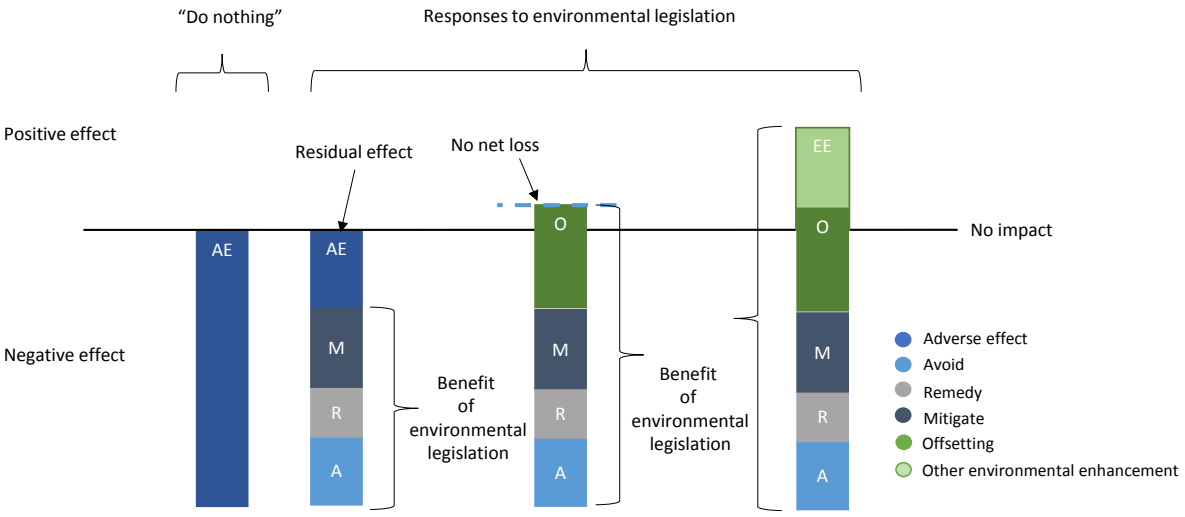
When describing and measuring the effects of the scheme, for the purpose of this benefit assessment it is necessary to consider (or create) a scenario where there is no environmental legislation in place. The effects of this could be, for example:

- significant sediment deposition in waterways due to no erosion and sediment control measures
- extirpation of species or destruction of rare habitat.

It is accepted that such a scenario would not be a realistic outcome as our society values our environment and generally wants to protect it, but the instrument for delivering environmental protection is environmental legislation, and this analysis is seeking to determine the value of what the environmental legislation achieves.

In the context of ecology, the conceptual diagram presented in figure E.1 is further developed, to recognise the specific area of biodiversity offsetting.

Figure E.1 Benefits attributable to meeting the requirements of environmental legislation due to responding to adverse effects – ecology



No net loss is shown above the 'no impact' line, due to uncertainties in the outcomes of offsetting benefits – for example, whether translocation of species will be successful. This uncertainty is built into the offsetting 'calculation' and is discussed further below.

In the ecology context, avoid, remedy, mitigate and offset have the following meanings:

- Avoid – conserve ecological areas and maintain ecological integrity and ecological services.
- Remedy – replacement of values at sites within the development footprint from which ecological values have been temporarily removed, for example, reinstatement of native scrubland or lizard habitat following completion of physical works.
- Mitigate – minimise the magnitude of effect by, for example, salvaging and relocating wildlife and rare plants, using retaining walls to reduce batter slopes and vegetation clearance, using bridges instead of embankments to minimise stream loss, or providing control of on-site erosion and sediment to minimise indirect effects of contaminants on downstream ecosystems.
- Offset – a form of environmental compensation that creates a positive benefit to address unavoidable residual adverse effects on significant ecological values, and which is similar in type to the value affected. Offsets are often supported by quantitative analyses of values lost and gained, and adhere to a set of offset principles, chief of which include equivalence of biodiversity traded, permanence of protection of values used as the offset and the offset benefits are additional to management already occurring. No-net-loss of impact is often set as an aspirational goal of offsetting; in New Zealand there is no imperative under the RMA to provide offsetting at a no-net-loss level at present. The required threshold or test is set by local plan documents.
- Other environmental compensation – and compensation proposed in addition to offsetting.

Quantifying the benefits delivered through the process of avoiding, remedying, mitigating or offsetting can also be achieved using the following methods:

- Avoid – the area of habitat or community not impacted and the average state score of indicators of ecological health in that area.

- Remedy – the area of habitat restored to a similar target state as one or more of the habitat impacted on at the site, and a measure of the predicted ecological maturity of species or populations in that area as measured over a reasonable timeframe (usually the period of resource consent). This may result in less 'value' being achieved and counted for in a restored area compared with a similar area from which the original values were removed. For example, 10 ha of replanted native forest, even after 35 years, does not have the same complexity and capacity to support diverse biodiversity as does a 10 ha area of 100-year-old forest. Replanting 10 ha of forest within a project disturbance footprint may therefore contribute only part of the replacement (remedy) that may be required for the loss of a 100-year-old forest.
- Mitigate – the numbers of a species (usually) or communities (if relocation of whole plant communities is proposed) salvaged and successfully relocated within or outside of the site.
- Offset calculations include as a standard, an estimate of loss at the development site, a prescribed management programme to provide ecological benefits at an offset site and an estimate of the benefits achievable relative to those removed at the development site. A multiplier is applied to the area proposed for restoration to acknowledge risk of failure, uncertainty of outcome and time lag effects that characterise the delivery of benefits from most such restoration projects. This means that, often, a larger area is required for restoration at the offset site to balance residual losses within the development site.

These rely upon measuring the state (current 'ecological health') of the ecological value using the indicators outlined in table E.1.

Where sufficient relevant information is available, qualitative and quantitative information can be captured following the MEA's categorisation of services into provisioning, regulating and cultural services and benefits that people derive from ecological values.

It is possible to monetise some of the ecological benefits of meeting the requirements of environmental legislation, as set out in the case study in appendix G of this report.

Table E.1 Ecological benefits matrix

Outcome type	Measurement	Baseline	Effects	Benefits of meeting the requirements of environmental legislation	Residual effects
Natural values	**Qualitative**	Describe the existing environment in relation to natural values following commonly used criteria for assessing ecological values: representativeness, rarity/ distinctiveness, diversity and pattern, sustainability and ecological context.	Describe the impact of the scheme on each natural value criteria, where material. Consider the effect if no environmental legislation were in place.	Describe the actions taken to avoid, remedy and mitigate effects, including the outcomes of such actions. Comment on any offsetting that could be relevant, its nature and intent.	An assessment of the importance of the site and residual adverse effects not avoided, remedied or mitigated. Comment on any additional ecological compensation. Comment on whether residual effects result in a risk of not obtaining the consent.
	Quantitative	Area within the project footprint (including potential indirect effects) of discrete community types or species as identified by classification tools such as DOC's Threat Classification System for native species, LENZ (land environments classification), historically rare environments (Landcare Research), FENZ (freshwater environments classification) or MEC (marine environments classification).	Area of each item identified in the baseline quantitative assessment (discrete community types etc) affected by the proposed scheme.	Area of each item identified in the baseline quantitative assessment (discrete community types etc) where impacts have been avoided, remedied or (if possible and relevant, mitigated) by the proposed scheme. Area with unacceptably high residual effects to be addressed by offsetting. Detail of offsetting calculation.	Area of each item identified in the baseline quantitative assessment (discrete community types etc) where there will be residual effects.
		Across all ecological components where habitat is occupied, numbers or density of individuals of species of conservation concern (listed in DOC's Threat Classification System) or of ecosystem, social or cultural importance (eg snapper for coastal marine communities, rare plants for tussocklands, rare birds for	Where it can be expressed in quantitative terms, the likely effects of the scheme on the number or density of species, plant species diversity etc. If this cannot be quantified, it should be limited to a qualitative assessment. The proportional loss or degradation of the ecological	Likely effects of the measures proposed to avoid, remedy, mitigate or offset the effects of the scheme where they can be expressed in quantitative terms on the number or density of species etc. If this cannot be quantified, it should be limited to a qualitative assessment.	Quantification of the residual effects on the number and density of species. The residual effects in terms of the proportional loss or degradation of the feature.

Outcome type	Measurement	Baseline	Effects	Benefits of meeting the requirements of environmental legislation	Residual effects
		wetlands, kereru or bats for forests).	feature compared with local, regional and national extent as derived from spatial analysis tools such as the threatened environments classification, FENZ, MEC or (for species) judgement of an appropriate expert where spatial databases do not exist.	Detail of offsetting calculation. The impact of any actions taken to avoid, remedy, mitigate or offset effects in terms of the proportional loss or degradation of the feature.	
		For terrestrial and wetland communities, percentage cover of vegetation tiers, indigenous plant species diversity, exotic plant species diversity and coverage, native bird richness, counts of pest animal presence browse, catches or sign.	-	-	-
		For freshwater communities, macro-invertebrate index, fish index of biotic integrity (IBI), percentage riparian cover-, semi-quantitative scoring of instream habitat diversity and complexity, water clarity and turbidity. In some regions, the stream ecological valuation (SEV) method measures 16 key indicators of stream state and provides one aggregate state score by which to assess health.			
		For marine communities, key indigenous species diversity and abundance, exotic species diversity and abundance, water clarity and turbidity.	-	-	-

Outcome type	Measurement	Baseline	Effects	Benefits of meeting the requirements of environmental legislation	Residual effects
	Monetise	**Existence value:** Freshwater – nearby stream $200 to $600/household/year Freshwater – regionally important stream $15–$35/household/year Marine – nearby coastal area/swimming beach $200–$500/household/year Marine (other) $75–$150/household/year **Effects:** Native fish – increase of 1 or more species $13/household/year for the whole stream Vegetation – change from a little to a large amount $100 household/year for the whole stream **Note** More detail provided in appendix G			
Ecosystem services	**Qualitative**	Describe the existing environment following the MEA's categorisation of services into provisioning, regulating and cultural services and benefits that people derive from ecological values.	Consider the effects of the scheme on the services provided – for example, water regulating functions may be compromised if streams are culverted or water filtering functions may be reduced if the stream is partly channelised.	Describe how the avoid, remedy, mitigate process has impacted the overall effects.	Expected state of provisioning, regulating and cultural services following road construction.
	Quantitative	Based on natural values, above.			
	Monetise	The public's economic value attributed to continuation of the ecosystem services derived from that element or component of biodiversity and ecology.			

E3 Stormwater, flooding, stream works and erosion and sediment control value

As indicated in section 3.3.1 of this document, it is important to determine a materiality (or significance) criteria to ensure key information is captured for this assessment of value. Typical questions that can help test materiality for freshwater-related impacts are:

1 What are, or are expected to be, significant changes to the water environment resulting from the scheme?

2 What is, or is expected to be, important to stakeholders including iwi?

3 What are, or are expected to be significant issues in the planning process?

4 What are, or are expected to be, noticeable costs linked to environmental legislation and/or to mitigate environmental effects?

It is likely that a screening exercise using the Transport Agency's *Environmental and social responsibility screen* (or similar equivalent), the AEE process or planning documents and technical documents, will identify the material water-related issues of relevance. Interactions with other specialists, for example ecologists, may also identify key issues to consider.

When describing and measuring the effects of the scheme for the purpose of this benefit assessment it is necessary to consider (or create) a scenario where there is no environmental legislation in place. If no environmental legislation were in place effects could be, for example:

- significant sediment deposition in waterways due to no erosion and sediment control measures
- deteriorating water quality due to increased vehicle-derived contaminants and increase runoff volumes, without treatment.

It is accepted that such a scenario would not be a realistic outcome as our society values our environment and generally wants to protect it, but the instrument for delivering environmental protection is environmental legislation, and this analysis is seeking to determine the value of what the environmental legislation achieves. The intent of this assessment is to capture values arising through choices to:

- Avoid sensitive areas, for example by the choice of road realignment.
- Remedy any damage, for example by reinstatement of streams diverted during construction.
- Mitigate any likely effects, for example by designing storage to attenuate peak flows or water treatment devices to remove pollutants from runoff.
- Enhance, for example treat existing road runoff where not required by planning documents.

Table E.2 Water outcomes

Outcome type	Measure	Baseline	Effects	Benefits of meeting the requirements of environmental legislation	Residual effects
Stormwater treatment	**Qualitative**	Summary of existing watercourses. Description of any stormwater management areas or other relevant planning overlays. Soil type in relation to infiltration. Description of baseline receiving water quality. Description of any existing stormwater management.	Description of how the scheme impacts stormwater volumes and quality, how these in turn impact the receiving environment. Consider the effect if no environmental legislation were in place.	A description of measures taken to avoid, remedy or mitigate effects on the environment. This should include a description of any road alignment changes, stormwater treatment, flood detention etc. It should include consideration given to outfall locations and energy dissipation and erosion protection measures.	Describe any expected residual effects linked to stormwater.
	Quantitative	Area of road surface currently receiving or not receiving water quality treatment. Current standard of treatment (total suspended soils (TSS) removal).	Change in pollutant load (based on expected traffic volume). Change in road impervious surface area. Change in flows for frequent flows (stream erosion flows). Change in maximum flood flows for key events (50%, 10%, 1% annual exceedance probability (AEP)).	Modelled load of pollutants captured within treatment devices.	Modelled loads to the environment Change in flows for frequent flows (stream erosion flows). Change in maximum flood flows for key events (50%, 10%, 1% AEP).
	Monetise	Water clarity – improvement from muddy to clear $75/household/year for the whole stream. Linked to ecological outcomes, refer table E1.			
Stream works	**Qualitative**	Overview of state of existing watercourses (natural, channelised, culverted etc).	Consider the effect if no environmental legislation were in place.	Description of any proposed naturalisation, or where streams/ rivers have been avoided through the choice of road alignment, wider bridges etc.	
	Quantitative	Length of stream within project footprint.	Length of stream affected by the project – diverted, culverted etc.	Length of stream avoided, naturalised or otherwise benefitting from meeting the requirements of environmental legislation.	Length of stream culverted, channelised etc.

Outcome type	Measure	Baseline	Effects	Benefits of meeting the requirements of environmental legislation	Residual effects
	Monetise	Stream channel – artificial to natural 90/household/year for the whole stream.			
Flooding	**Qualitative**	Description of any current known or modelled existing flood risk (likelihood and magnitude) in the subcatchments upstream and downstream of the road.	Impact of the scheme on peak flows, how road and structures could affect flooding, change in frequency, duration, magnitude of flood risk. Consider effect if no environmental legislation were in place.	Description of modifications to design to avoid or mitigate flood effects. May include change to bridge design, road alignment modification or flood storage.	Description of the likelihood and magnitude of any residual flooding.
	Quantitative	Maximum flood flows for key events (20%, 5%, 1% AEP). Number of habitable floor areas flooded at present within scheme footprint/relevant hydrological boundaries.	Modelled peak flow rate (20%, 5%, 1% AEP). Number of habitable floor areas flooded at present within scheme footprint/relevant hydrological boundaries.	Volume of flood detention. Number of habitable floor areas which are protected through design.	Modelled peak flow rate (20%, 5%, 1% AEP). Number of habitable floor areas flooded within scheme footprint / relevant hydrological boundaries.
	Monetise				
Erosion and sediment control	**Qualitative**	Summary of existing watercourses. Description of baseline receiving water quality focussed on sediment. Description of soil type, rainfall characteristics, erosion potential.	Describe the effect of the scheme if no environmental legislation were in place.	Describe the expected benefit of the erosion and sediment control works.	Describe the expected outcomes of the erosion and sediment control works, including short and long-term outcomes.
	Quantitative	Annual catchment sediment yield (tonnes/annum).	Expected total sediment yield without any erosion or sediment control or scheme phasing (tonnes/annum).	Expected total sediment yield with erosion or sediment control and scheme phasing (tonnes/annum). Number and size of treatment devices. Maximum area exposed. Limit of earthworks season (months).	Expected total sediment yield arising from scheme (tonnes/annum).
	Monetise	Water clarity – improvement from muddy to clear $75/household/year for the whole stream.			

E4 Social

The following principles should be followed in developing metrics to understand the social value created via the implementation of environmental legislation:

- Measuring outputs *versus* outcomes: consideration of both outputs (such as improved recreation opportunities) and outcomes (such as improved health and wellbeing). Current practice focuses on measuring outputs. Outcomes often need to be measured over the long term or predicted based on outputs. Capturing any short-term outcomes or information to confirm outcome trends has value. It may be appropriate to include these in the narrative rather than seek full quantification.
- Operation versus construction: it is recommended more effort is placed on articulating and measuring permanent impacts. As with outputs *versus* outcomes, measuring direct construction impacts, such as noise or air quality may be within the scope of the project timescale, but it is the long-lasting costs or benefits that are the real legacy (such as reducing the gradient of the road will reduce the amount of noise associated with vehicle acceleration/deceleration as well as vehicle emissions). Communities may be more willing to accept short-term loss of amenity value if they understand the negative impacts of operation will be minimised and there will be other lasting positive environmental or social impacts.
- Recognising co-benefits: it is recognised there may be overlap in environmental and social costs and benefits (such as improved amenity value as a result of an ecological restoration of a local stream). It is recommended these outcomes are captured in full though the narrative and quantified where possible with the interdependencies identified.
- Leveraging other programmes/frameworks: where possible, the metrics seek to reference existing programmes and frameworks used in New Zealand, including the better business case and EEM, as well as voluntary frameworks that measure environmental and social performance in the development and delivery of infrastructure (including the IS tool[4] and Greenroads). This is to maximise integration and to leverage data which is likely already being (or increasingly) being collected for projects.

When using the potential measures outlined below, initial consideration must be given to which measures are important (or material) for the development and delivery of an asset. For example, if there is no tunnelling or significant pilling being undertaken as part of the scope of works, then the impact of vibrations should not need to be considered.

It is also important to understand the community context and baseline in order to measure the effects of environmental legislation. For example, in a community which is generally disengaged, and unlikely to participate in the consenting process, survey return rates would be expected to be lower than in a community where the population are able and willing to be actively engaged. In the former case, participation rates of 30% may be considered a success, *versus* in the latter scenario that level of participation may be considered sub-optimal.

There are a number of additional indicators that should be included in a social outcomes assessment which are included elsewhere in the business case, these include:

- Visual amenity: Does the project alter visual amenity value during construction or when in operation?
- Community safety: Does the project result in safety risks during construction or when in operation?

[4] Developed and administered by the Infrastructure Sustainability Council of Australia

There are also several emerging social impacts the construction sector globally is considering which may be considered in the planning process, but which are less likely to be a consequence of environmental initiatives *per se*:

- Workforce training and diversity: the positive benefits that result from having a diverse construction workforce, and the positive legacy that can be made through purposefully seeking to support the development of trainees or apprentices.
- Social procurement: the positive impacts that can be made by purposefully weighting organisations that create positive social outcomes as part of their business model. For example, assuming levels of service and cost were equivalent, a tender to provide landscaping services would be awarded to a company that invests its profit into training and mentoring at-risk-youth as part of its operations team over a standard for-profit landscaping firm. Engaging in social procurement may be linked to environmental considerations in procurement such as low embodied energy materials.

In determining the value of meeting environmental legislation in a social context, it is important to be cognisant of the community of interest when making the assessment. In the context of this study, a wide view has been taken – thinking of communities that are impacted by, or depend on, specific (transport) infrastructure assets/systems. This could be local, regional or national. This wide interpretation also extends to consideration of stakeholder groups, for example community interest groups or environmental organisations.

Section 36A of the RMA is clear that this legislation does not create a duty to consult on resource consent applications and notices of requirement. This research recognises that, in practice, consultation is carried out for most if not all roading improvement projects.

Table E.3 Social benefits

Outcome		Baseline	Effects	Benefits of meeting the requirements of environmental legislation	Residual effects
Community connectivity and accessibility (movement or flows)	**Qualitative**	Current levels of connectivity and accessibility to: Non-essential services[5] Essential services[6] Critical services[7]	Any temporary decrease or increase in connectivity for some or all of the community? Any permanent decrease or increase in connectivity for some or all of the community? Any temporary or permanent decrease or increase in congestion for some or all of the community?	Measures taken to avoid disruption (eg relocating road), remedy effect (reinstate connectivity after the project) or mitigate (programming works to minimise disruption). Any increase in connectivity as a result of the project, including also bridges, intersection improvements, cycle ways and footpaths.	Long-term impact on community cohesion? Residual change in connectivity. Increase in connectivity, eg removing restrictions on access to services.
	Quantitative	Degree of route accessibility or level of redundancy. Availability/frequency of high occupancy vehicles, public transport and active transport modes. Volume of users of local services. Congestion of local roads.		Change in route accessibility or level of redundancy. Change in availability/frequency of high occupancy vehicles, public transport and active transport modes. Change in volume of users of local services. Congestion of local roads.	
	Monetise	International Finance Corporation (IFC) social cohesion methodology where applicable, focus on quantifying avoid, remedy, mitigate Reduced journey times, as per the EEM (NZ Transport Agency 2010a)			
Provision of community spaces/ facilities	**Qualitative**	Availability of community spaces including: • Recreation areas (parks, sportsfields, playgrounds etc) • Community buildings (libraries, community halls, pools etc).	Any temporary or permanent decrease or increase in availability of community spaces for some or all of the community?	Provision of refurbished, relocated or new community spaces/ facilities.	Long-term impact on community health and wellbeing. Long-term impact on community cohesion.

[5] Non-essential services include retail (excluding lifeline utilities), places of worship, recreational facilities. Note that this could be extended to include sites of cultural or heritage significance if these are not included the cultural indicators.

[6] Essential services include educational facilities, financial institutions and insurance providers.

[7] Critical services include health and wellbeing services (GP, hospital) and lifeline services.

Outcome		Baseline	Effects	Benefits of meeting the requirements of environmental legislation	Residual effects
	Quantitative	Current visitor numbers/usage. Number or m^2 of spaces/facilities.	Change in number or m^2 of spaces/facilities. Change in visitor numbers/usage.	Number of area of spaces refurbished, relocated or newly provided.	Post project visitor numbers/ usage. Post project number or m^2 of spaces/facilities.
	Monetise	Social Return on Investment (SROI) and/or IFC social cohesion methodology where applicable Recreational benefits – see appendix G, section G4.4.			
Impacts on the community's physical environment	**Qualitative**	Description of current physical environment with regard to visual amenity, influenced by noise, vibration, light, overshadowing, air quality etc. Discussion of the sum of the impacts and resultant effects on the aesthetic and neighbourhood sense of place.	Does the project impact the amenity value of the local community (temporarily or permanently) due to physical environmental changes including: • noise • vibration • light • overshadowing • air quality (dust) • visual impact. How does this impact the overall neighbourhood sense of place?	Activities including: • noise walls • vibration monitoring and thresholds, selection of equipment • lighting choices • realignment or property purchase to avoid overshadowing • dust control • tunnelling.	Description of the post-construction physical environment with regard to visual amenity, influenced by noise, vibration, light, overshadowing, air quality etc. Discussion of the sum of the impacts and resultant effects on the aesthetic and neighbourhood sense of place.
	Quantitative	Measurements of: • ambient noise • existing lighting • natural environment and amenity (area, age, scale) • air quality etc.	Modelled noise effects. Modelled air quality effects. Number of properties affected. Area of natural environment reduced. Development and execution of a management plan. Number of exceedances (consented limits or project targets). Number of complaints during project construction and operation (lag).	Expected change (reduction) in: • noise effects • air quality effects • number of properties impacted • number of exceedences • number of complaints arising from the benefits of meeting the requirements of environmental legislation. Area of natural environment avoided, or new environment created.	Residual Noise effects Air quality effects Number of properties impacted Number of exceedences Number of complaints Amenity outcomes.

Outcome		Baseline	Effects	Benefits of meeting the requirements of environmental legislation	Residual effects
	Monetise	Partly covered by EEM. See also appendix G4; MRCagney et al (2016); Nunns and Denne (2016)			
Community engagement (licence to operate)	**Qualitative**	What is the current position of the community with respect to the issues the scheme intends to address? Supportive, neutral, opposed to the scheme itself?	Compare activities with a 'no consultation' scenario: How and when are impacts discussed with the community? How are the impacts of construction and operation (both positive and negative) communicated to the community?	Does the community have the chance to participate in developing options to avoid, remedy, mitigate? What degree of engagement do they have in agreeing mitigation approaches to negative impacts? How engaged is the community are engaged on negotiable issues? Non-negotiable issues? Is there a social licence to operate created? Does community reach acceptance of negative impacts?	Final position of community with respect to the scheme – supportive, neutral, opposed. Does a social licence to operate extend beyond this project?
	Quantitative	Frequency of mention of relevant issue in media (for example, complaints about travel time or congestion)		Community engagement plan developed and executed. Engagement level (as determined by IAP2 framework). Information and engagement occur within timeframes that allow participation. Number of attendees at engagement sessions. Time to address community complaints (target and actual). Community survey of the degree of satisfaction with information provided and engagement (lead). Number of complaints during project construction and operation (lag).	
	Monetise	May follow			

E3 Cost information

The capture of project costs linked to meeting the requirements of environmental legislation has been structured to align with the Transport Agency's elemental costing model (NZ Transport Agency 2015a).

To enable comparison of cost and benefit data, and hence the consideration of value by scheme, key information about a scheme is also required. Key qualitative and quantitative data for comparison purposes is linked to the structure in the elemental costing model, augmented where appropriate.

A practical approach to the capture of cost data is proposed – where costs *could* be attributable to meeting the requirements of environmental legislation, these costs should be included for simplicity.

A detailed structure for cost capture is set out below.

Project narrative/qualitative information
Brief description of the project extent and location with a particular focus on significant environmental, cultural and social locations, designations, species and issues associated with the project and its location. As relevant to the project phase: • Overview of consultation and consenting strategy, description of nature of consultation and scale of engagement, commentary on significance of objections, any hearing and/or referral to the Environment Court and whether there were any Court proceedings. • Nature of changes to the design required as a result of consultation and/or consent conditions.
Quantitative information
Commencement and practical completion dates (design and construction phases). Project type: X lane motorway, X lane expressway X lane highway, Xm long passing lane, Xm long road reconstruction. Actual duration and planned duration (investigation and reporting (I&R), design and project documentation (D&PD) and construction phases). Period of time from submission of resource consent application to granting of consents (including any Environment Court Hearing). Number of consents required. Number of submissions on the consent applications, for, neutral and against. Project length, excluding side roads and accommodation works. Earthworks: the greater of either a) or b): a) Total m^3 of cut material + borrow material + imported material. b) Total m^3 of fill material + cut to waste.
Financial information
Total scheme cost
Development (non- construction) costs
Planning and consent costs: • all costs directly attributable to planning and consents, including roading authority's own costs, specialist consultants – legal, planning and designers and environmental experts • exclude council and legal fees as these are captured below • may include costs for any necessary permits or consents for investigations including ground investigations • include the proportion of design costs relating to environmental aspects of work • collection and mapping of planning and environmental information • surveys, such as ecological (flora and fauna, terrestrial, marine and freshwater). • assessments of effects • caucusing of experts

- any other relevant costs.

Iwi:

- all iwi consultation costs.

Designation and resource consent preparation and lodgement, including hearings:

- any related costs not captured under planning and consent costs, above.

Fees (designation and environment court):

- all fees related to the designation and environment court.

Legal costs (including environment court):

- all legal costs relating to meeting the requirements of environmental legislation. Exclude legal advice relating to other matters, such as land purchase, Public Works Act.

Mana Whenua, Waahi Tapu, Kōiwi and Mauri fees and costs:

- all costs.

Reviews and audits:

- any peer reviews of matters relating to meeting the requirements of environmental legislation.

Geotechnical elements:

- contaminated land investigations
- permeability investigations if linked to the design of infiltration drainage systems
- any other investigations related to the design of environmental mitigation.

Public relations:

- all public relations costs.

The consultants input before contract award (D&C contracts only)

- The design of those components relating to the requirements of environmental legislation, including but not limited to:
  - stormwater treatment devices
  - landscape design
  - design changes to accommodate consent conditions.

Council costs/expenses:

- all costs relating to environmental legislation.

Heritage costs:

- all costs.

Mitigation costs:

- all costs.

Supplementary investigations during the investigation phase:

- any environmental investigations or investigations required for the design of works required to meet environmental legislation.

Detailed design

Design:

- detailed design of scheme components required to meet the requirements of environmental legislation, for example landscaping or stormwater treatment, fish passes etc
- design of any offset scheme.

Mana Whenua, Waahi Tapu, Kōiwi and Mauri fees and costs:

- all costs.

Professional fees:

- peer review of aspects linked to the requirements of environmental legislation.

Resource consent costs, including fees:

- all costs.

Public relations:

- all costs.

Contractors detailed design (D&C only):

- as per design.

Advertising:

- all costs.

Economic assessments:

- costs related to environmental benefits.

Heritage costs:

- all costs.

Mitigation costs:

- all costs.

Supplementary investigations during detailed design:

- any environmental investigations or investigations required for the design of works required to meet environmental legislation.

Management, surveillance and quality assurance (MSQA)

Consultant surveillance during the construction phase:

- of matters relating to meeting the requirement of environmental legislation, which could range from monitoring for the presence or absence of species during construction, overseeing planting programmes, or ensuring the design of stormwater treatment devices meets specification, for example.

Legal:

- if related to meeting the requirements of environmental legislation.

Iwi liaison during construction:

- all costs.

Regional council monitoring:

- all costs.

Archaeological fees:

- all costs.

Reviews and audits:

- if related to meeting the requirements of environmental legislation.

Public relations:

- all costs.

Contractors input following contract award (D&C only):

- as per design.

Advertising:

- all costs.

Newsletters:

- copying and delivery.

Noise monitoring:

- all costs.

Complaints:

- all costs.

Heritage costs:

- all costs.

Mitigation costs:

- all costs.

Supplementary investigation during the construction phase:

- any environmental investigations or investigations required for works required to meet environmental legislation.

Construction
Environmental compliance: • all costs. Earthworks: • any earthworks costs required to construct components of the scheme that are required due to environmental legislation, including bunds, stormwater treatment ponds, landscaping batters. Also any cost savings resulting from being able to balance on site cut and fill via these structures • foreshore works, where costs are incurred because of the requirements of environmental legislation • construct, maintain and remove temporary sediment control measures, temporary sediment control ponds, including temporary hydro-seeding, rock check dams and silt fencing • archaeological. Ground improvements: • site decontamination. Drainage: • stormwater drainage – swales • surface water channels constructed for the purpose of meeting the requirements of environmental legislation (not solely for conveyance) • erosion control. Pavement and surfacing: • if, for example, surface type was specified to meet noise requirements under environmental legislation. Landscaping and urban design: • all costs. Traffic management: • all costs. Preliminaries and general: • apply as a percentage, or in proportion to the costs of the project attributable to environmental legislation.
Extraordinary project costs
Tunnels, other significant project expenditure that can be confirmed to arise due to the requirements of environmental legislation

Appendix F: Air quality improvements to the EEM

F1 Emission costs

The values and approach used in the EEM have not been updated since the original Land Transport NZ (2006) version, despite significant air quality impact research in New Zealand, including that funded by the NZ Transport Agency.

F1.1 General approach

The EEM approach follows the approach to health valuation used elsewhere, eg in the HAPiNZ studies where the approach used is (Kuschel et al 2012a):

Health effects (cases) = Exposure × Exposure-response function × Population exposed

And the costs are estimated as:

Social costs = Health effects (cases) × Cost per case

F1.2 Mortality impacts of PM_{10}

The guidance on economic valuation of the health effects of air pollution is limited to PM_{10}. This is consistent with other analyses to date in New Zealand, including the CBA of the air quality standards (NZIER 2009), recent analyses for the Ministry of Transport (Denne and Atkins 2015) and the HAPiNZ research (Kuschel et al 2012a) that underpins both of these other studies.

The values for the exposure response function in the EEM (0.1% increase in mortality rate per 1µg/m^3 increase in PM_{10}) is considerably less than that used in Kuschel et al (2012a) (table F.1). The exposure response functions in Kuschel et al (2012a) are expressed as multipliers, such that a multiplier of 1.07 per 10µg/m^3 change in PM_{10} concentration is equivalent to a 0.7% increase in mortality rate per 1µg/m^3, eg seven times the value used in the EEM.

Table F.1 Exposure response functions used in updated HAPiNZ research

Health outcome	Exposure response functions (Relative risks per 10µg/m^3 PM_{10})
1 Premature mortality, all adults, all ethnicities	1.07 (1.03 – 1.10)
1a Premature mortality, all adults, Māori-only	1.20 (1.07 – 1.33)
2 Premature mortality, babies, all ethnicities	1.05 (1.02 – 1.08)
3 Cardiac hospital admissions, all ages, all ethnicities	1.006 (1.003 – 1.009)
4 Respiratory hospital admissions, all ages, all ethnicities	1.01 (1.006 – 1.017)
4a Respiratory hospital admissions, children all ethnicities, aged 1–4 years	1.02 (1.01 – 1.04)
4b Respiratory hospital admissions, children all ethnicities, aged 5–14 years	1.03 (1.00 – 1.05)

Source: Kuschel et al (2012)

The most recent HAPiNZ research (Kuschel et al 2012a and 2012b) is not officially endorsed as the way to undertake health impacts analysis, but it is widely used, including as inputs to government policy proposals.

The HAPiNZ team has made a model available for analysing exposure and health impacts (www.hapinz.org.nz (It would make sense for the EEM to refer to such resources available for health effects modelling.

Denne and Atkins (2015) have raised additional issues based on international approaches. These include:

- the use of lagged benefit values
- the inclusion of estimates of effects on life years lost, in addition to premature mortality.

We discuss these in turn below.

F1.2.1 Lagged benefits

Lagged benefits have been used in policy studies in the US and Europe for several years to reflect the fact that reductions in emissions and concentrations will not result in all the health benefits of reducing pollutant concentrations being obtained immediately. Because people are made 'frail' from living in elevated concentrations of pollutants (Seethaler et al 2003), the cessation of emissions stops additional frailty and would be expected to allow some repair. However, even if all pollution is eliminated, it might take many years without pollution for the full benefits to be realised. Reduction in emissions, without eliminating them, will reduce the rate at which frailty increases.

Kuschel et al (2012b) measure the impacts of current levels of pollutant concentrations on total premature mortality. This is appropriate to the extent that current concentrations have been relatively stable. However, policy studies and impact assessments are looking at the effects of changes in emissions, for which it is appropriate to measure lagged benefits.

The delay issues have been recognised in international studies for some time. In the US, the UK and elsewhere in Europe, studies of the costs and benefits of air pollution use lagged benefits. This reduces the present value of benefits because of the impacts of discounting. The approaches used are still developing and there is increased focus on studies that are testing the extent of lag, including some US studies that suggest a significant proportion of the benefit is gained soon after a reduction in emissions (Lepeule et al 2012). Against this, the UK Committee on the Medical Effects of Air Pollutants (COMEAP 2009) suggests 'the US cohort studies do not, and cannot, lead to any clear conclusion on the likely latency between a change in average pollution levels and the appearance of effects', while also noting 'current thinking suggests that the exposure in the weeks, months and short number of years prior to death is the most biologically relevant time period of exposure for deaths from cardiovascular (or cardiorespiratory) causes, whereas the effect of exposure on lung cancer is likely to have a longer latency'.

F1.2.2 USA

In the US, prior to 2004, the Environmental Protection Agency (EPA) and the Health Effects Subcommittee used a weighted five-year time course of benefits in which 25% of the PM-related mortality benefits were assumed to occur in the first and second year, and 16.7% were assumed to occur in each of the remaining three years (EPA 2004a).

Subsequently, following a suggestion from the EPA (EPA 2004b), the Science Advisory Board noted that considerable uncertainty remained but recommended that a lag structure is used in which 30% of the mortality reductions occur in the first year, 50% are distributed equally (12.5% per year) in years two through five and the remaining 20% are distributed equally over years six through 20 (Cameron and Ostro 2004).

This approach is still used as the primary assumption, although in recognition of the uncertainty, several alternative lag structures have been used also (EPA 2011): a five-year distributed lag (20% per year over five years) and an exponential decay model based on analysis by Roosli et al (2005).

F1.2.3 EU

Work for the European Commission has examined the effects associated with a one-year pulse change, ie a sudden reduction in pollution for one year, as a way to understand the marginal effects (AEA Technology Environment 2005). Here, in contrast to a 6% increase in mortality for a 10 μg/m^3 increase in $PM_{2.5}$ concentrations otherwise used, they assumed a 2.4% increase in year one, followed by 0.36% increases in years two to 11, followed by reversion to the original mortality rate.

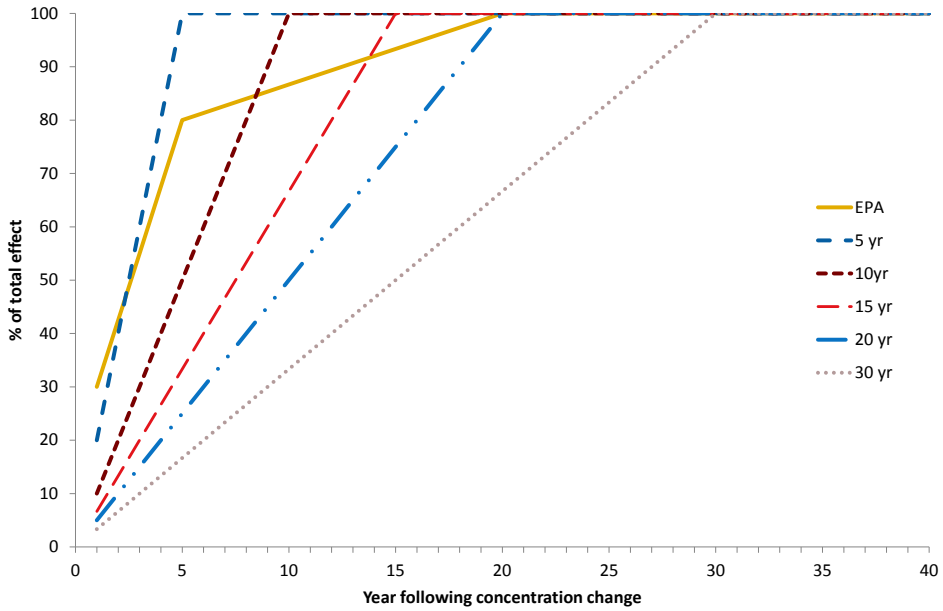
An analysis relating to the National Emissions Ceiling Directive adopted the US EPA's lag structure (Miller et al 2011).

F1.2.4 UK

In the UK, Walton (2010) analysed the issue of cessation lag for COMEAP and identified a range of possible lag structures (F1.2).

Subsequently COMEAP used lag options that included no lag and 5, 10, 20 and 30-year phased-in lags in addition to the US EPA suggested lag structure (COMEAP 2010). Table F.1 shows the implications of these different lag structures on damage estimates in relative terms, using different discount rates. At an 8% discount rate, usually used for public policy analysis in New Zealand, a 30-year lag reduces the impact to 41% of what it would be with no lag.

Figure F.1 Selection of lag structures examined by Walton (2010)



Source: Walton (2010)

Table F.1 Implications of lag structures for impact estimates (index: no lag = 100)

Discount rate	No lag	EPA	5 yr	10 yr	15 yr	20 yr	30 yr
0.0%	100	100	100	100	100	100	100
3.0%	100	91	94	88	82	77	67
5.0%	100	86	91	81	73	65	54
8.0%	100	80	86	72	62	53	41
10.0%	100	77	83	68	56	47	35

Denne and Atkins suggest the US EPA lag structure is used as the primary assumption, consistent with international practice.

F1.2.5 Premature death or life years lost

The EEM, along with most impact studies in New Zealand, has characterised the mortality impacts of particulates as increases in premature mortality. This has been used as a simple shorthand to explain the nature of impacts, but may be somewhat misleading when the impacts of a project or policy will not eliminate pollution but reduce emissions and concentrations to a lower level. People may still die prematurely, but not **as** prematurely; premature mortality is not so much reduced as is the prematurity of the mortality (Denne and Atkins 2015).

The issues are discussed in more detail in annex 4 of Denne and Atkins (2015), including an explanation of the alternative approaches using a value of statistical life (VoSL) and the value of a life year (VoLY) lost. The approach reflects the way in which mortality impacts are characterised:

- The VoSL approach assumes the mortality effect can be characterised as a reduction in the risk of death for people of all ages.
- The VoLY approach assumes the mortality impact is an extension to life expectancy. Life is extended at the end of life, possibly many years in the future.

Many policy agencies in other countries are adopting either a VoLY-based approach or are presenting results using both VoSL and VoLY.

In the UK, the economic analysis to inform the air quality strategy (Defra et al 2007) has used a VoLY-based approach, building on recommendations of COMEAP. In the US, the practice has been more to use premature deaths and VoSL rather than life years lost and VoLY, eg in Industrial Economics (2006). However, the government's 2003 guidance on regulatory impact analysis suggests it is 'appropriate to consider providing estimates of both VSL and VSLY, while recognizing the developing state of knowledge in this area' (Office of Management and Budget 2003). Consistent with this, the 2011 CBA of the Clean Air Act Amendments included results in terms of avoided premature mortality, life-years lost and changes in life expectancy (EPA 2011).

In the EU, a 2005 CBA of the Clean Air for Europe programme recommends 'years of life lost as the most relevant metric for valuation' (AEA Technology Environment 2005). However, in response to peer review recommendations, they include estimates of 'the number of deaths per year attributable to long-term exposure to ambient $PM_{2.5}$' despite their acknowledging it will over-estimate the impact; they argue it has computational problems but is easy to understand.

F1.3 Recommendation

Given the ongoing uncertainty in this research and practice, we suggest studies use both approaches and provide the range of results reflecting this.

The simplest way to measure life years lost is using the approach of COMEAP. It estimates life years lost by multiplying the number of additional deaths at each age by the average life expectancy at that age. Life expectancy by age can be estimated from life tables. COMEAP found that, across several different coefficients (change in mortality per unit change in PM concentration), its results expressed in terms of life years lost (or gained) were 11.8 – 12.2 times the estimated number of attributable deaths (COMEAP 2010).

Note, this is not suggesting each estimated premature death has its life shortened by 12 years. The assumption is still that lives are shortened by a few months. Rather the headline figure of premature lives lost (or saved) masks the true number affected within the population. Indeed, COMEAP (2010) estimates

that for England and Wales, a population-weighted average concentration of $PM_{2.5}$ of 9.46µg/m^3 throughout their life results in approximately 6.5 months lower life expectancy for those born in the year (2008) of evaluation. Multiplying additional deaths by life expectancy is a simple way of estimating the increase in life years; a more complex way would be to estimate the change in life expectancy for all people in an age class, rather than simply for those who are estimated to have died 'prematurely'.

F2 Greenhouse gas emissions

The EEM suggests the use of a value of \$40/t of CO_2 (in 2004 dollars), or its equivalents of 12 cents per litre of fuel or 5% of total vehicle operating costs (VOC). The \$40/t value is inflated from the \$30/t value estimated in the 1996 Land Transport Pricing Study (Ministry of Transport 1996). If CO_2-equivalent (CO_2-e) emissions are going to be explicitly measured and valued, these values should be updated. The cost of emissions is currently included in the price of transport fuel and this might be the appropriate way to take it into account in analysis (as of January 2016 the obligation for producers or importers of liquid fuels is to surrender one emission unit per two tonnes of CO_2-equivalents). This is particularly the case as the Ministry of Business, Innovation and Employment (MBIE) produces regular forecasts of fuel prices that include the price of emissions. However, taking this approach assumes that the price of emission units is the correct way to place a price on CO_2-e emissions in a CBA. We discuss this issue first.

F2.1 Social cost of carbon vs emission unit price

There are two possible ways to estimate a cost of carbon: the social cost of carbon, ie an estimate of the damage costs attributable to CO_2–e emissions, or the cost of emission units used by New Zealand to bring itself into compliance with international commitments to limit emissions. We discuss these different options below.

In most circumstances the social cost of a pollutant is equivalent to the marginal damage cost of one more unit of pollutant (Baumol and Oates 1988). For CO_2 and other greenhouse gases, the complicating factor is they have global effects; because they are very long-lived (CO_2 is in the atmosphere until it is absorbed by the ocean or through photosynthesis), greenhouse gases mix thoroughly in the atmosphere and the emissions from New Zealand will be widely distributed adding to global concentrations. The damage costs associated with one more tonne of CO_2–e emitted from New Zealand will be experienced by all countries. This is relevant to CBA because a national perspective is taken in the EEM and for most other policy decisions: effects outside New Zealand are not considered. So just as we do not count as a benefit to New Zealand the profits made by foreign-owned companies, a national CBA does not include the environmental damage costs borne by other countries. From this perspective, the costs to New Zealand of emissions from New Zealand are very small: a small fraction of any estimates of the global social costs of carbon, estimated as US\$12–\$123/tonne of CO_2 in 2020 (Interagency Working Group on Social Cost of Greenhouse Gases, United States Government (2016)).

This does not mean New Zealand's climate change policy is developed with no account taken of the effects on other countries, or that these are unimportant; quite the opposite. However, precisely because emissions from all countries have largely global rather than local effects, climate change policy has developed via international agreements under the United Nations Framework Convention on Climate Change, including the recent Paris Agreement (FCCC/CP/2015/L.9/Rev.1(United Nations Framework Convention on Climate Change 2015)). New Zealand has agreed to limit its emissions (its nationally determined contribution under the Paris Agreement) to some absolute level. In this context, the cost of each additional (marginal) tonne of emissions is the cost of coming in to compliance with the agreed limit, ie the cost of New Zealand reducing emissions by one tonne or of purchasing emission units from the

international market in a way that would be consistent with the international obligations. Given full information, rational decision making and an economically efficient international regime to limit emissions which included full international trading of emission units allowing global emissions to be limited at least cost, we might expect the price of emission units to reflect the marginal damage cost. However, in the absence of such an ideal market, it is still the price of emission units that reflects the social cost to New Zealand of every additional tonne of emissions. In contrast, to use a social cost of carbon is to take a global perspective for analysis and, to be consistent, this would also include all impacts on foreign companies and individuals.

F2.2 Direct measurement or fuel price

Accepting first that the price of emission units is the correct way to value CO_2-e emissions, the argument for separate measurement of emission costs versus inclusion in the fuel price depends on the following issues:

- if fuel sales have a full obligation to surrender emission units
- if there is a readily available projection of fuel prices including the cost of emission units
- if all road-related CO_2-e emissions are from fuel combustion.

We examine these issues in turn below.

F2.2.1 Full obligation

At the time of writing (November 2016), liquid fossil fuel participants in the Emissions Trading Scheme (ETS) are only required to surrender one New Zealand unit (NZU) for every two tonnes of emissions, and they can buy NZUs from the government to meet their obligations at a fixed price of $25 per NZU (www.climatechange.govt.nz/emissions-trading-scheme/participating/fossil-fuels/obligations/). This means the current price of fuels only includes the cost of CO_2-e to some extent and estimating the full cost would require separate measurement of emission costs. However, The Climate Change Response (Removal of Transitional Measure) Amendment Act 2016 is phasing out the one-for-two transitional measure starting from 1 January 2017 (Ministry for the Environment 2016). The current 50% unit cost will increase to 67% from 1 January 2017, to 83% from 1 January 2018, with all sectors in the ETS paying the full market price from 1 January 2019 (Climate Change Minister 2016). From 2019 the cost of CO_2-e emissions will be fully incorporated into the fuel price and there will be no need for additional account to be taken. Until then, some adjustments will need to be made reflecting the percentage obligation under the ETS.

F2.2.2 Available projections

MBIE produces projections of fuel prices as part of its Energy Outlook publication. The latest version (MBIE 2012) includes a reference scenario that projects prices for petrol and diesel with a zero emissions price and an emissions price of $100/t of CO_2 from 2020. One approach is to use this as the basis for fuel projections in roading projects, although the approach used appears to be more an attempt to measure the implications of a wide range of effects, rather than $100/t being a best guess of future prices. Estimating a price projection with a different carbon price can be undertaken by using the $0/t fuel price projections, emission factors for CO_2-e emissions (see table F.2) and a projection of carbon prices (see below). This requires a projection of future carbon prices (see below).

Table F.2 Emission factors for CO_2- e

Fuel	Emission factor (tonnes CO_2e/'000l)
Regular petrol	2.310
Premium petrol	2.367
Automotive diesel	2.685

Source: New Zealand Government (2008)

F2.2.3 Carbon price projections

NZ Treasury estimates the expected costs of emission units as part of its estimate of fiscal liabilities, eg where it has agreed to supply free emission units and might need to purchase units to meet this obligation. This is a useful basis for estimating a cost of CO_2 emissions in any year. The latest estimate is $17.75/tonne at 30 June 2016 (The Treasury 2016a).

F2.3 Recommendation

For analysis of roading projects, an estimate of the future cost of emission units will be required. There is no official projection, but possible sources include (Covec 2010):

1 Futures markets – sales of contracts to deliver emission units in the future

2 Bottom-up modelling – estimates using models that incorporate detailed technical information

3 Top-down modelling – estimates from models that are based on historical relationships between prices (typically of energy fuels) and consumption

4 Backstop technology cost – the costs of major technologies that might be used in a widespread way and set a ceiling on price

5 Social cost of carbon analysis – estimates of the damage costs of greenhouse gases, on the assumption that the level of international commitments will result broadly in the price of carbon equalling estimates of the social damage cost.

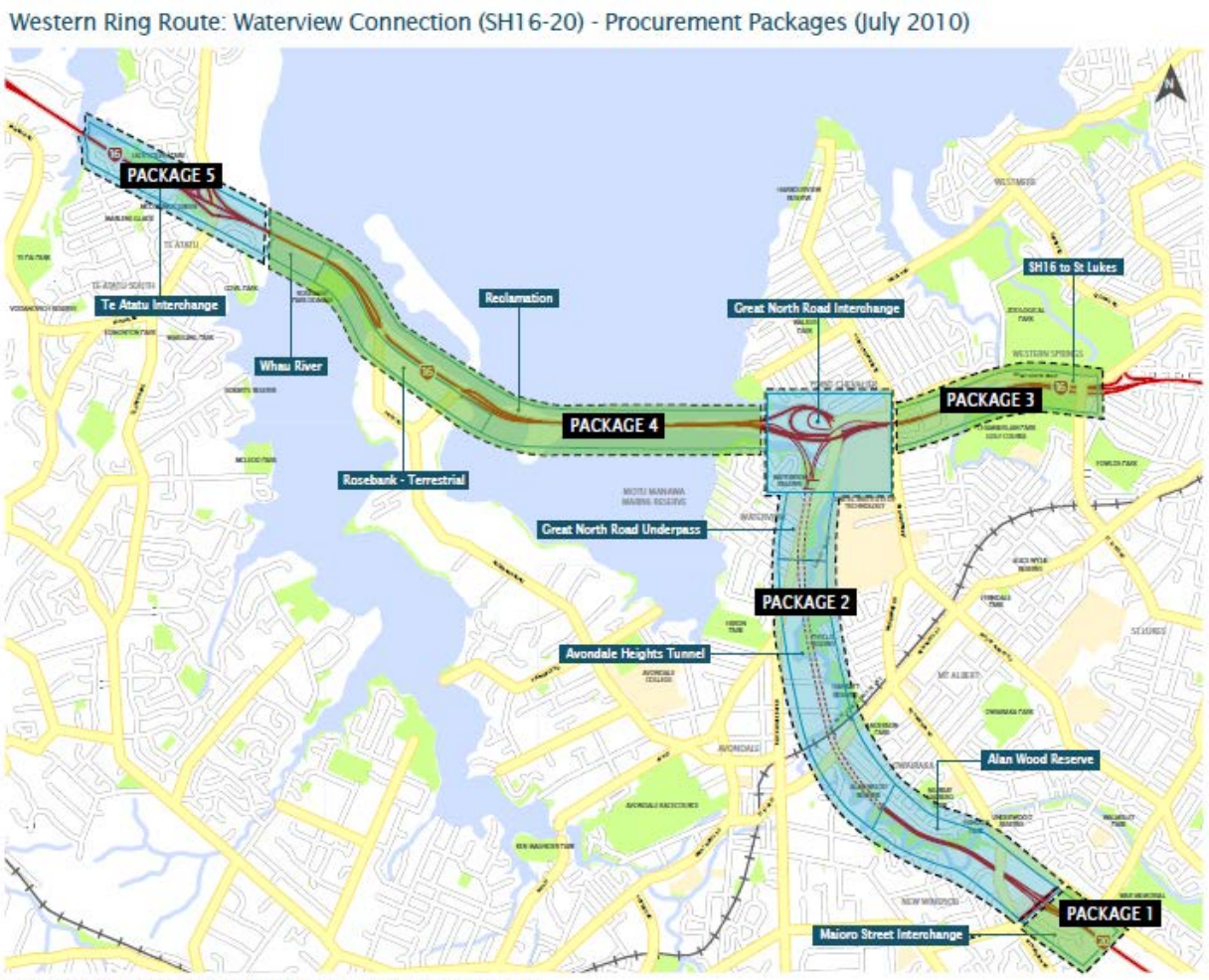
6 Expert opinion – using surveys of people with emission market expertise.

Appendix G: Waterview Connection case study

G1 Overview

Section 4.1 provides an overview of the Waterview Connection project and the outcomes of the assessment, including key conclusions of the assessment. This appendix provides further detail on the case study, including cost build up, and freshwater and ecology benefits. It also details the development of an approach to monetising water quality and ecological outcomes, which is subsequently applied to the Waterview Connection, but can also be applied to other roading projects. The extent of the scheme is shown in figure G.1 and described in section 4.1. This case study primarily relates to the works linked to package 2 as the most significant freshwater and ecology impacts relate to the Oakley Creek.

Figure G.1 Scheme extents, Waterview Connection 2010



Source: Bond Construction Management

G2 Cost

Bond Construction Management (BondCM) provided the build-up of the environmental costs of the SH16 and SH20 Waterview Connection projects at the Board of Inquiry stage to assist in the development of this research. In particular, BondCM was requested to provide the following costs:

- all temporary erosion and sediment control works
- all permanent water quality treatment/detention ponds and wetlands
- all permanent swales, biofilters, proprietary water quality devices
- works to naturalise Oakley Creek
- all ecological and water quality monitoring work.

In providing an estimate for this work in 2010, BondCM derived these environmental related costs using data from then current, related projects (with the exception of the noise walls). This was due to the small percentage of overall costs these would provide and our estimating efforts were largely directed elsewhere – tunnels, earthworks etc.

Sub-total costs for environmental compliance, drainage and landscaping/urban design have been shown to provide some level of detail. It is assumed the 'stream diversion' noted under Richardson Road was for naturalising Oakley Creek.

The overall cost effect of meeting the requirements of environmental legislation is very low – less than 1%. Where noise walls are provided, the walls account for most (approximately 80%) of the environmental costs for a particular 'package'. Only those values relating to water and ecology are tabulated here, as these were of interest for this case study.

The values shown reflect direct costs and also exclude margin, property, I&R, D&PD, MSQA, contractor's design and risk contingency, as does the overall $1.4 billion scheme cost estimate ($1.1 billion for package 2).

Table G.1 Capital cost estimates

Cost component and description	Total cost $ million	Proportion of total scheme cost
Environmental compliance • Limited to erosion and sediment control, stormwater treatment	$2.25	0.19%
Drainage • Stream diversion costs only	$1.66	0.14%
Landscaping and urban design • Planting costs only	$5.26	0.45%
Total	$9.17	0.78%

Consultant and legal costs related to the freshwater and ecology benefits were derived on a pro-rated basis, based on cost records from the Transport Agency and Tonkin + Taylor. No Transport Agency staff costs were included in the detail cost breakdown provided by them.

Costs included pro-rata were management, design, AEE planning, EPA planning, sundry costs, legal costs, expert witness costs and consenting costs.

The total costs attributed to the freshwater and ecology components of the scheme were $3.5 million.

No operations and maintenance cost estimates were included in the documentation reviewed.

G3 Qualitative and quantitative benefit information

Table G.2 Stormwater benefits

		Baseline	Effects	Benefits of meeting the requirements of environmental legislation	Residual effects
Water quality, streamworks and flooding	**Qualitative**	The environment affected by the project includes Oakley Creek, Meola Creek and Pixie Stream catchments as well as the coastal marine area including the Waterview Estuary, Oakley Inlet, Waitemata Harbour, Whau Creek and Henderson Creek. Parts of the Waterview Estuary, Waterview Inlet, Waitemata Harbour and Whau Creek are covered by the Motu Manawa Marine Reserve. Oakley Creek is an urban stream that is highly modified where it passes through Alan Wood Reserve and the upstream section. The Pixie Stream is highly modified. The Meola Stream is also modified in the area that will be affected by the project. Flooding occurs in the Oakley catchment and this can be attributed to urbanisation and the associated increase in impervious surfaces and dwellings.	The stormwater generated from the motorway contains vehicle pollutants including suspended solids, heavy metals and hydrocarbons. These contaminants can have effects on the ecology of the streams and marine receiving environments. The increase in impervious area associated with the project has the impact of increasing the volume and potentially the peak flow of stormwater runoff during flood events. Oakley Creek and Stoddard Road Tributary had to be realigned to accommodate the motorway corridor. The streams are diverted with an associated reduction in length and loss in floodplain volume that can be stored and conveyed during a flood event.	The effects from stormwater are mitigated by the collection and treatment of stormwater prior to it being discarded to the environment. Stormwater treatment is proposed by a combination of devices including wetlands, bio-filter strips, swales and proprietary cartridge filters. The stormwater treatment devices will provide treatment to meet the requirements for sediment removal of ARC TP10. Where there are discharges into the stream the stormwater devices will provide extended detention and peak flow attenuation for the 100 year ARI event. The treatment of stormwater is higher than required by PARP:ALW and ARC TP10 targets and serves to mitigate coastal reclamation and the associated loss of habitat for marine biology . Constructing a tunnel rather than an overland motorway corridor for the extension of SH20 significantly reduces the stormwater produced as a result of the project as these	There is a net benefit in water quality of stormwater discharges as increased stormwater discharge is mitigated by the treatment of existing impervious areas. There are net ecological, environmental and recreational benefits by providing greater access to the stream, better ecological habitats and more vegetation from the proposed streamworks to Oakley Creek. Streamworks result in lower maximum water level in the project area, reducing the extent of flooding. The extent of flooding reduces for properties Valonia Street, Whittle Place, Methuen Road and Hendon Avenue. Overall, there is a net benefit in terms of peak flood levels and extents compared with the existing environment.

		Baseline	Effects	Benefits of meeting the requirements of environmental legislation	Residual effects
				areas will not contribute additional impervious surface areas to the catchment. The streamworks proposed for Oakley Creek will replace the existing manmade basalt rockwall channel with a naturalised channel for with meanders, riffle-run-pool features, biotechnical engineering of banks and riparian planting. Benefits are expected for stream bed morphology, flow hydraulics or sediment. The streamworks will realign areas of Oakley Creek to lower flood levels and extents within the project area. They will also preserve floodplain storage that would otherwise have been lost during a nearby development. These works will mitigate the decrease in length and volume of the streams impacted by the motorway corridor. Construction treatment devices will be used to mitigate construction stormwater effects and will be used for construction yards, new sections of the motorway prior to use (including SH20 and widened sections of SH16) and the causeway sections of SH16 while staged construction is carried out.	

		Baseline	Effects	Benefits of meeting the requirements of environmental legislation	Residual effects
	Quantitative	33.52 ha of impervious surfaces Water quality treatment provided for 3.30 ha (9.8% by area)	23.31 ha of additional impervious surfaces 56.83 ha total impervious surfaces. Discharges from sectors 7 and 9 could potentially increase the volume of stormwater runoff in Oakley Creek by up to 6% during construction.	Removal of TSS at 75% for sectors 6–9. Removal of TSS at 80% for sectors 1–5. Water quality treatment provided for 99.4% of the additional impervious area. Water quality treatment provided for 90.7% of the existing impervious area. Realignment and rehabilitation of 1,318 m of Oakley Creek.	Reduction in TSS (typically 80%), Zn (typically 80%) and Cu (typically 60%) loads to the Waterview Inlet. Peak flow in a flood event downstream of site increases by 3.3% following the project. Increase in water levels during a 100 year ARI flood event of 150 mm upstream of Bollard culverts. The streamworks reduce flood risk for two habitable floors and leaves it unchanged for the remaining four vulnerable habitable floors already at risk of flood.
	Monetise			Refer section G5	

G3.2 Ecology benefits – Oakley Creek[8]

G3.2.1 Baseline

Outcome type: Natural values

Measurement: Qualitative

Oakley Creek is the main stream within the project footprint, transecting four sectors (sectors 5, 7, 8 and 9).

Ecological investigations have indicated existing environmental conditions within Oakley Creek are poor, probably due to low water quality. The primary indicators of this poor water quality were the macro-invertebrate communities, which were characterised by low numbers of taxa and the absence of pollution-sensitive taxa.

In particular, Oakley Creek near New North Road provided physical habitat conditions favourable to a range of sensitive species (eg stony substrate and oxygenated water), and their absence therefore suggested water quality was the main limiting factor. Other sites sampled within the Creek also lacked pollution-sensitive taxa, and generally had few insect taxa of any sort.

Relatively high abundance of midge larvae and axehead caddis larvae at the Oakley Creek sites suggested the presence of productive algal slimes on the rocky substrate, which indicates nutrient enrichment.

In terms of physical habitat, Oakley Creek is a large stream with a large volume of habitat, deep pools suitable for large eels and permanent flows.

Freshwater fish communities within Oakley Creek above the waterfall are of very low diversity, with only shortfin eels (in super-abundance) and (less commonly) longfin eels, and the introduced pest mosquitofish being recorded. Given this, it is evident that the waterfall in Oakley Creek near UniTec (downstream of the Phyllis Street reserve) is a significant barrier to migrating native fish. Other sites sampled within the creek also lacked pollution-sensitive taxa, and generally had few insect taxa of any sort.

Overall, Oakley Creek within the Waterview Project footprint has relatively low ecological health, particularly in terms of its physical habitat modification and low diversity and sensitivity of macroinvertebrates. Water quality here is also low, but is similar to other urban catchments**.**

Measurement: Quantitative

The Oakley Creek catchment has a total area of approximately 1,231ha and has 84% urban surface cover. This indicates a total impervious surface area of approximately 1,033ha.

The National Institute of Water and Atmospheric Research (NIWA) has estimated that the current or baseline annual load of zinc (Zn) is 729 kg per year and copper (Cu) is 87 kg per year for the entire Oakley Creek catchment.

[8] For this report, the study has been formatted for an A4 page; however, anyone planning to carry out an assessment like this may wish to use a landscape table, similar to the tables on previous pages, but in A3 format.

Table G.3 Sector 9 long- term operational sediment and contaminant loads

Sector	Annual load kg year					
	2016			2026		
	TSS	Zn	Cu	TSS	Zn	Cu
9	1,671	36	4	1,920	42	5

Pre-works Oakley Creek surveys:

Table G.4 Results of the Boffa Miskell 2008, 2003 and 2001 macroinvertebrate surveys

	Sector 7 and 8 Waterview to New North Road			Sector 9 Alan Wood Reserve			
	2001	2003	2008	2001	2003	2008	2009 (mean)
Taxonomic richness	15	11	12	12	11	11	7
No. of insect taxa	6	5	6	7	5	4	3
EPT	1	0	2	1	0	0	0
MCI (Macroinvertebrate Community Index)	50	50	70	62	50	65	56
SQMCI (Semi Qualitative Macroinvertebrate Community Index)	2.2	2.1	2.9	3.2	2.1	3.2	3

Source: Boffa Miskell (2010a)

Table G.5 Comparison of water quality results to ANZECC guidelines

		NIWA (2004)	ANZECC/MFE	
		50% percentile value	Guildelines level	Exceedance
Dissolved copper	g/m^3	0.0043	0.0014	YES
Dissolved zinc	g/m^3	0.01	0.008	YES
E. coli	Per 100ml	7450	550	YES
Total dissolved nitrogen	g/m^3	0.79	0.614	YES
Total dissolved phosphorus	g/m^3	0.04	0.033	YES

Source: Boffa Miskell (2010a)

Table G.6 Results of the fish surveys in 2008 and 2001

	Downstream				Upstream			
	2008		2001		2008		2001	
	No.	Size range (mm)	No.	Size range (mm)	Density per m^2	Size range (mm)	Density per m^2	Size range (mm)
Common bully	2	58–115	1	75	-	-	-	-
Elvers	-	-	-	-	-	-	0.10	50–250
Gambusia	-	-	-	-	0.02	-	-	-
Giant bully	-	-	1	150	-	-	-	-
Inanga	46	50–100	16	50–75	-	-	-	-
Longfin eel	3	400–700	-	-	0.08	280–500	-	-
Redfin bully	-	-	1	55	-	-	-	
Torrentfish	-	-	2	25–80	-	-	-	-
Shortfin eel	-	-	2	50–600	0.28	140–520	0.25	250–650
Total abundance	51	-	23	-	0.38	-	0.36	-
Diversity	3	-		-	3.00	-	1.00	-

Source: Boffa Miskell (2010a)

Table G.7 SEV results for representative sites within Oakley Creek

Ecological function	Relative importance	Site 1	Site 2	Site 3
		Stoddard Road	Hendon Park	Lower Oakley Creek
Hydraulic functions				
Natural flow regime maintained	High	0.05	0.08	0.00
Connectivity to flood-plain maintained	Medium	0.60	0.05	0.05
Connectivity for species migrations exists	Low	0.05	1.00	1.00
Connectivity to groundwater maintained	Low	0.90	0.50	1.00
Hydraulic function mean score		**0.40**	**0.41**	**0.51**
Biochemical functions				
Water temperature	High	0.42	0.30	0.50

Ecological function	Relative importance	Site 1	Site 2	Site 3
		Stoddard Road	Hendon Park	Lower Oakley Creek
control maintained				
Dissolved oxygen levels maintained	Medium	0.42	0.61	0.65
Organic matter input maintained	Medium	0.12	0.02	0.26
In-stream particle retention maintained	Medium	0.08	0.08	0.08
De-contamination of pollutants maintained	Medium	0.81	1.00	0.76
Flood-plain particle retention maintained	Low	0.59	0.13	0.29
Biogeochemical function mean score		**0.41**	**0.36**	**0.42**
Habitat provision functions				
Fish spawning habitat intact	High	1.00	0.50	0.50
Habitat for aquatic fauna intact	High	0.30	0.26	0.38
Habitat provision function mean score		**0.65**	**0.38**	**0.44**
Biotic provision functions				
Fish fauna intact	High	0.17	0.47	0.47
Invertebrate fauna is intact	High	0.00	0.03	0.03
Aquatic biodiversity intact	High	0.25	0.39	0.54
Riparian vegetation intact	High	0.45	0.03	0.77
Biodiversity function mean score		**0.22**	**0.23**	**0.45**
Sum of scores (maximum value 16)		**6.20**	**5.45**	**7.26**
Overall mean SEV score (maximum value 1)		**0.39**	**0.34**	**0.45**

Source: Boffa Miskell (2010a)

Monetise: Refer appendix G4.

G3.2.2 Effects

Outcome type: Natural values

Measurement: Qualitative

The proposed construction phase works within the Oakley Creek catchment include surface earthworks and structures in sector 5 (linking the northern portals of the cut-and-cover tunnels with the Great North Road Interchange); tunnelling in sectors 7 and 8; and surface earthworks (connecting the Waterview Connection to the existing SH20 Mt Roskill extension at the Maioro Street Interchange), structures (the southern portals of the driven tunnels and the Oakley Creek bridge) and stream diversions in sector 9.

The surface works have the potential to generate large volumes of sediment, in particular the earthworks but also the excavations associated with constructing the tunnel portals and constructing the stream realignments.

The stream is a contained environment in that there is no lateral dispersal of sediment, with all sediment discharged increasing the creek's base load and potentially affecting the downstream environment all the way to the stream mouth.

The biological communities in the stream are characterised by common, pollution-tolerant macroinvertebrate taxa and low fish diversity above the waterfall. These communities will generally have a low sensitivity to the predicted increases in suspended sediment.

Effects are likely to be limited to localised decreases in abundance of some species, but there are not expected to be any significant decreases in taxonomic richness or changes in characteristic fauna within Oakley Creek.

The existing biological communities in the creek are adapted to fluctuating flows and water quality, and are expected to have a high resilience or capacity to recover from the predicted (or even worse) increases in suspended sediment.

Instream works will be undertaken in sector 9. These consist of:

- stream realignments in Alan Wood Reserve/Hendon Park that are necessary to physically accommodate the new highway here
- stream realignments between Richardson Road and the Maioro Street Interchange that are necessary to physically accommodate the new highway here
- stream realignments at the confluence of Oakley Creek with the Stoddard Road tributary that are necessary to physically accommodate the new highway and the future rail alignment here.

Stormwater generated by the motorway will contain pollutants from vehicles such as heavy metals, suspended solids and hydrocarbons. The change in land use will increase the impervious surface area, increasing the volume of runoff from the catchment and potentially the peak flow during flood events unless mitigation is provided.

Drawdown of groundwater in the vicinity of Oakley Creek to facilitate tunnel and portal construction might alter the contribution of groundwater that naturally flows towards Oakley Creek. This may result in changes to the base flows in Oakley Creek. It might also increase the volume of water that naturally discharges through the floor of the creek to recharge the underlying groundwater system.

Measurement: Quantitative

The new motorway will be approximately 12 ha in extent, and will represent approximately a 1% increase in impervious surface area discharging to the creek.

The total length of stream potentially affected is approximately 6 km.

The future stormwater contaminant load from sector 9 represents approximately 6% of the current load.

790 m of Oakley Creek will be realigned + 219 m of Stoddard Road tributary. Total loss of stream length estimated at 137 m.

Table G.8 Length of Oakley Creek realignments and calculated loss of streambed habitat area

Stream realignment	Existing creek length (m)	Proposed stream length (m)	Net stream length loss (m)	Stream width (m)	Streambed area lost (m^2)
Stoddard Tributary realignment	138	127	11	1.7	19
Stoddard Tributary realignment to accommodate railway alignment	79	71	8	1.8	14
Oakley Creek realignment under the bridge	125	124	1	2.4	2
Oakley Creek realignment A	148	114	34	2.1	71
Oakley Creek realignment B	230	214	16	2.1	34
Oakley Creek realignment C	287	220	67	2.1	141
Total	**1007**	**870**	**137**	-	**281**

Source: Boffa Miskell (2010a)

The project requires 343 m of riparian rehabilitation, which will be undertaken within Alan Wood Reserve, Hendon Park and the Goldstar Block.

G3.2.3 Benefits of meeting the requirements of environmental legislation

Outcome type: Natural values

Measurement: Qualitative

All stormwater runoff from areas disturbed by construction activities will be managed in accordance with the Erosion and Sediment Control Plan, which sets out the principles and specific methods that will be applied in each sector.

These stream realignments avoid the need for any new culverts within Oakley Creek. They have furthermore been designed to minimise loss of stream length, as well as to maintain fish passage and enhance instream habitat quality.

It is considered the ecological attributes added into the design of these realignments represent good environmental practice and will offset any temporary adverse effects likely to occur during construction and establishment. They will also deliver a net ecological benefit by improving upon the existing degraded

freshwater habitat in this part of Oakley Creek, which in itself is sufficient mitigation for the disturbance of the stream during construction.

The net loss of stream habitat due to stream realignment needs to be compensated by way of stream rehabilitation at another appropriate location.

The restoration of Oakley Creek will improve riparian and in-stream habitat, providing benefits to the fish and macroinvertebrate communities present in these creek reaches. Riparian vegetation is beneficial for aquatic macroinvertebrates. Overhanging vegetation, leaves and fallen wood provide substrate on which macroinvertebrates feed, live and lay their eggs. It provides shade to the stream, reducing summer water temperatures and improving dissolved oxygen levels. Sensitive EPT taxa are more common in bush-lined streams for these reasons. Riparian vegetation also provides suitable habitat for the adult stages of aquatic insects, which often require damp, humid conditions to survive and reproduce.

Increased macroinvertebrate density and diversity also has flow-on benefits for fish fauna which prey on these species as food.

All stormwater discharges to Oakley Creek will be treated as per table G.2.

Measurement: Quantitative

75% removal of suspended solids and associated contaminants via treatment in pond and swale systems.

Table G.9 Environmental compensation (EC) calculation

Stream realignment	Streambed area lost (m^2)	EC ratio	EC area (m^2)
Stoddard Tributary realignment	19	3.9	73
Stoddard Tributary realignment to accommodate railway alignment	14	3.9	56
Oakley Creek realignment under the bridge	2	4.6	11
Oakley Creek realignment A	71	3.9	278
Oakley Creek realignment B	34	3.9	131
Oakley Creek realignment C	141	3.9	549
Total	281	-	1,098

Source: Boffa Miskell (2010a)

The project requires 343 m of riparian rehabilitation, which will be undertaken within Alan Wood Reserve, Hendon Park and the Goldstar Block.

Table G.10 Stream rehabilitation lengths

Stream rehabilitation	Existing stream length (m)	Proposed stream length (m)
Oakley Creek Realignment A	49	48
Oakley Creek Realignment B	135	141
Oakley Creek Realignment C	228	228
Oakley Creek Realignment D	31	31
Total	443	448

Source: Boffa Miskell (2010a)

G3.2.4 Residual effects

The proposed stream realignments and rehabilitations will have a positive effect on the environment as a natural channel form will replace the existing manmade basalt rock wall channel. The project streamworks will have net ecological, environmental and recreational benefits by providing greater access to the stream, better ecological habitats and more vegetation than currently exists in these reaches. No adverse effects are anticipated to the stream bed morphology, flow hydraulics or sediment.

G4 Monetisation of water and ecological benefits

G4.1 Impacts on values

Ecological impacts occur through a cascade of effects within ecosystems, but the effects of interest for this analysis are those factors valued by people. A literature review of the ecological impacts of stormwater options in the Auckland region identified the effects of modification to waterways as summarised in table G.11.

Table G.11 Ecological impacts of modified waterways

Issue	Effect
Concrete-lined channels	Disconnected from the groundwater system, provide virtually no habitat function, and potentially impede fish migration.
In-stream structures, eg culverts and weirs	Impair ecological function, impede the upstream migration of freshwater fish.
More impervious surfaces	More frequent, larger and flashier floods that increase streambank erosion and reduce natural character.
Higher stream temperatures	Result from lack of shade and hot impervious surfaces. They are harmful to temperature sensitive invertebrates and fish.
Sediment runoff	Reduces water clarity, light levels, food quality and the feeding efficiency of animals. Harmful to some fish species and can smother food supply. In the marine environment sediment can kill benthic macrofauna or lead to reduced species diversity and abundance; it can lead to increased mangroves and reduced extent of other habitats.
Solid waste/plastics	Plastics kill marine species through ingestion and entanglement, and act as a vector for the transport of invasive organisms. Toxic additives which are used in the manufacture of some plastics, and organic contaminants which become concentrated on plastics, may also affect organisms that are intimately exposed to plastics.
Heavy metals	Metal and organic contaminants accumulate in the tissues of shellfish, fish, birds and other invertebrates. They can compound the effects of other environmental stressors and differentially affect rare species and large species.

Source: Summarised from Kelly (2010)

In the absence of environmental requirements for the Waterview Connection project it would be expected that the Oakley Stream adjacent to the new road would be channelled to avoid flooding effects on the road. Instead, measures have been taken which will avoid some of the impacts shown in table G.12 and will improve the form and ecological function of the stream.

This is, in turn, expected to affect:

- the physical amenity of the stream, valued by recreational users

- the ecological functioning of the stream, valued by those who do (amenity values) or do not (existence values) visit the stream area
- the extent and nature of run-off to the marine environment which will, in turn, affect recreational and existence values pertaining to the marine environment.

We examine these impacts in turn below, but first discuss further the effects on the marine environment.

G4.2 Marine impacts

The Waterview Connection project is expected to improve the water quality of runoff from the causeway to the marine reserve. Batstone et al (2008) reported the results of an expert workshop which identified the impacts of runoff in the coastal environment (table G.12) and examined the effects of heavy metals and sediment. They estimated all had a high probability of occurrence, except for harmful algae and bacteria (low to medium).

Table G.12 Impacts of runoff in the coastal environment

Dimension	Effect	Cause
Turbidity	Reduced water clarity Visual and sensory effects for contact recreation	Fine sediment Suspended solids
Harmful algae and bacteria	Closed beaches Human health effects	Various species Sewer overflows
Estuarine muddiness	Community succession to mangrove habitat Visual effects Benthic fauna effects	Fine sediment
Visual amenity	Erosion Structures Plumes litter (detritus or dead material added to the top layer of soil)	Sediment Suspended solids Solid waste
Unsafe/reduced quality of swimming		Pathogens Fine sediment Turbidity
Shellfish contamination	Loss of recreational harvesting	Fine sediment Harmful algal blooms Pathogens Metals
Mangrove expansion	Change of coastal environment in estuaries Visual effects Use effects Loss of shellfish habitat	Fine sediment Nutrients

Source: Batstone et al (2008)

These effects will be expected to improve because of the project, but it is not clear if they can be quantified. This includes the flow-on effects on recreational use of the marine environment, amenity impacts or the ecosystem function that contributes to existence values.

G4.3 Non-market value data

This section provides the results of a review of literature on monetary valuation of the environment relating to water bodies and associated environments. This includes:

- recreational use of water and areas close to water bodies
- amenity values, ie the aesthetic value of certain, generally more natural, assets
- existence values that reflect values arising from the environment without requiring direct use.

Table G.13 shows a selection of estimates of non-market values of freshwater from studies in New Zealand. These provide an estimate of total values for several broad categories of benefit, eg the average household WTP for river swimming and so on. WTP for activities at individual locations would be expected to be less than these amounts as there are likely to be substitute sites. The highest values are associated with active use of water bodies for recreational purposes, eg swimming or rowing. Less active uses (landscape/aesthetic) and passive use values are lower. These values provide a broad understanding of the limits to which values for individual streams, or other elements of the environment, might rise.

Table G.13 Non- market values of freshwater – median and range (low – high)

Category	Values (2012$)	Values (2016$)
Swimming/household/year	$101 ($72 – $129)	$104 ($74 – $133)
Rowing/person/year	$205 ($173 – $236)	$212 ($179 – $244)
Fishing/person/year	$67 ($67 – $67)	$69 ($69 – $69)
Fishing/angler/trip	$31 ($5 – $125)	$32 ($5 – $129)
Fishing/household/year	$25 ($2 – $603)	$26 ($2 – $623)
General recreation /household/year	$93 ($6 – $236)	$96 ($6 – $244)
Landscape/aesthetic/household/year	$55 ($1.2 – $160)	$57 ($1 – $165)
Biodiversity/ household/year	$12 ($5 – $31)	$12 ($5 – $32)
Ecosystem health/ household/year	$43 ($0.5 – $269)	$44 ($1 – $278)
Water quality/ household/year	$73 ($1.4 – $222)	$75 ($1 – $229)
Ecosystem services/household/year	$56 ($31 – $80)	$58 ($32 – $83)
Non-use (passive use) values/household/year	$25 ($19 – $30)	$26 ($20 – $31)
Traditional food gathering/household/year	$39 ($17 – $61)	$40 ($18 – $63)

Note: All values inflated from 2012 (Q2) values to Q3 2016 values using CPI: Statistics New Zealand (2012) Infoshare database: CPI index all groups for New Zealand. Traditional food gathering/household/year comprises willingness to pay for the opportunity to gather traditional food (koura, eels, etc).

Source: Adapted from Marsh and Mkwara (2013)

The values are not straightforward to use:

- For fishing there are three expressions of value: per person, per trip and per household and the differences are not clearly explainable, eg a greater WTP per (average) person per year than per household per year and a higher value per person than per angler;
- More general environmental values include the value of biodiversity, ecosystem health and ecosystem services. These are likely to be measuring similar things. And non-use (passive use) values may include some of these ecosystem health values also.

Below we explore in more detail how these and other valuation data might be used to provide data for the analysis of the benefits of measures taken to limit the impacts of road projects.

G4.4 Recreational use

G4.4.1 Value of recreational visits

Recreational use of water bodies appears to offer the greatest potential benefits amongst those activities and values not normally measured in monetary terms. Studies in New Zealand include those that have valued:

- the benefits of recreational activity, eg the consumer surplus of a day's recreation (WTP minus the costs of travel)
- the change in recreational benefits as a result of changes in some water attribute, eg increased WTP for recreation when the water is clearer.

In addition to the summary values in table G.13, table G.14 shows a selection of recreational values for freshwater bodies. It includes the original values from the study cited and in 2016 dollars, inflated using a CPI (Statistics New Zealand). The values are very high for recreation at unique and picturesque sites, eg Whanganui River (over $100/visitor/day), and lower for more generalised recreation, even at regionally significant sites, eg $120/household/year for Lake Rotorua for Rotorua residents and $38/year for households elsewhere in the Bay of Plenty (BoP).

Table G.14 Recreational values of freshwater bodies

Study location	What was valued	Value (original)	Value (2016)	Author(s)
Whanganui & Whakapapa Rivers, Manawatu-Whanganui	Recreational canoeing benefits	$43–$58 per visitor/day	$103–$139 per visitor/day	Sandrey (1986)
Lake Tutira, Hawke's Bay	General recreational benefits	$8 per visitor/day	$33 per visitor/day	Harris and Meister (1981)
Upper Whanganui and Whakapapa Rivers, Manawatu-Whanganui	Recreational rafting, kayaking, canoeing benefits	$104 per visitor/day	$165 per visitor/day	Cocklin et al (1994)
Artificial lake, Methven, Canterbury	General recreational benefits	$37–$80 per household/year	$59–$127 per household/year	Meyer (1994)
Lakes Rotorua and Rotoiti	All recreation: motorised boating, jet skiing, yachting, kayak/rowing, wind sailing, trout angling, swimming, picnicking, traditional food, walking/ photography, bird watching, shooting and scenic driving.	$93.22/household/year (Rotorua residents); $29.81/household/year (BoP residents)	$120/household/year (Rotorua residents); $38/household/yr (BoP)	Bell and Yap (2004)

Some published data is available for the value of marine areas, particularly for fishing.

Kerr and Latham (2011) identified the value of a recreational fishing day from several US studies and values per marine recreational fishing trip, while noting that the values reported differed by more than an order of magnitude, particularly as a result of differences in methodology used. They also noted that the availability of substitutes is an important determinant of site value.

In New Zealand:

- Wheeler and Damania (2001) provide estimates of the value of sea fishing on a per fish caught basis. They include values on a marginal ($6–20/fish in 1999 of $8–28/fish in 2016$) and average basis ($24–$181/fish or $35–$260/fish in 2016$). Changes to water quality might change the number of fish caught, although to predict this it would be necessary to estimate the impacts of a series of steps from road runoff through to fish catch probabilities.
- Kerr et al (2003) estimated benefits per fisher for marine fishing of just over $100 per annum (in 2002$ or $134 in 2016$).
- Kaval and Yao (2007) compared the value of freshwater and saltwater-recreation, finding that freshwater-based recreation was valued at approximately $95/person/day ($111 in 2016$) compared with $59/person/day ($69 in 2016$) for saltwater-based recreation (largely sea fishing).
- Schischka and Marsh (2008) estimated a WTP for recreational marine fishing of $48–60/trip (2007 values) or $56–$70 (2016$).

The comparative study (Kaval and Yao 2007) suggest freshwater fishing has a higher value than marine fishing, although this is based on a review of other studies rather than applying the same methodology to the participants in different activities. We also note the very wide range of values for freshwater fishing in table G.13. It is unlikely strong conclusions can be drawn on relative value from their analysis. Here we assume the same values apply to marine and freshwater sites.

Other improvements in recreational values of marine sites would be associated with swimming and other contact recreation, including surfing and water skiing.

G4.4.2 Value of substitute sites

The values summarised here might be relevant to sites that were made available for recreation as a result of environmental improvements or reduction in flooding. However, the values may not be suitable where there is the potential for substitution between recreation sites. For example, if a stream is cleaned up and attracts more recreational visitors, these may be people who otherwise would go to a site further away. They may go to the new site to add variety to their recreational experience, because it is closer or because it is better in some way. In these circumstances the full value of the recreational visit cannot be associated with the specific site, because other sites would provide (possibly lower) benefits also. The benefit is the WTP for the *change* in recreational opportunities. This is typically not what has been measured.

Measuring the value associated with a specific site is complicated by the numerous possible recreational decision options, eg Scarpa (2003) discusses the recreational use value of woodlands in the UK, noting that:

> *Household decisions are often not simply framed around the issue of 'what woodland site shall we go and visit?'. More frequently they are framed on a broader set of alternatives. For example, around the issue of 'what outdoor site shall we go and visit?', or even a more generic 'what shall we do with this nice day?'*

Similarly, the clean-up of a stream that provides recreational opportunities might be providing more choice amongst a very wide range of 'things to do'. This limits the potential usefulness of the published values and means the value of any individual site may be relatively low in the context of many other recreational options.

Sites such as Lake Rotorua (as included in table G.14) might be dominant recreational sites for local residents with no real substitute, whereas local streams in Auckland may have several substitutes. Swimming beaches affected by stormwater discharges (following wastewater overflows) may have

significant value, but they will have some substitutes also, eg if one beach is unsuitable for swimming, others may still be swimmable. That said, it is likely some sites that are thought of as 'local' to some residents, eg the local beach, can be regarded as having effectively no beach substitutes, although even these may have substitutes consistent with the 'what shall we do with this nice day?' question.

In using published values, a key issue is whether the project will lead to an increase in the total number of recreational days or just the location of recreation that would happen anyway. If it is recreation that would have happened anyway, the value of the new site might be the reduction in transport costs (people go to the new site because it is closer) or some value associated with variety or diversity. Regardless of the reason, if some people go to a closer site and obtain the same level of gross benefit (eg before travel costs are netted off), then the travel cost saving is a benefit of the new site.

For additional recreation, the following values are thus relevant:

- For replacement sites (no additional recreation in total), the value should be based on the value of reductions in distance travelled.
- For additional recreational activity, the value should be based on the marginal values for recreational visits.

Transport cost savings include savings in time and in vehicle costs. Estimates of these are provided in box G.1. We summarise these values at the end of this section. We examine the value of additional recreation in the next section.

Box G.1 Estimate of value of travel savings

Travel savings are estimated based on savings in time and of vehicle costs.

Time savings

Time savings can be estimated using the value of time in the NZ Transport Agency's *Economic evaluation manual* (EEM) (NZ Transport Agency 2016). It uses a composite value of time for all occupants of a vehicle and for all vehicle types of $14.10/hour (in 2002$ values) (table A4.3 in EEM) or $18.90/hour (2016$ values). This could be combined with an estimated number of kilometres of travel reduced and a speed of travel, as follows:

$$VTS = KM/Speed * VT$$

Where:	V_{TS}	= value of time saving
	KM	= change in kilometres
	Speed	= average speed of travel in km/hour
	V_T	= value of time ($18.90/hour)

Average speeds will need to be assumed based on the location and speed limits that apply.

Vehicle cost savings

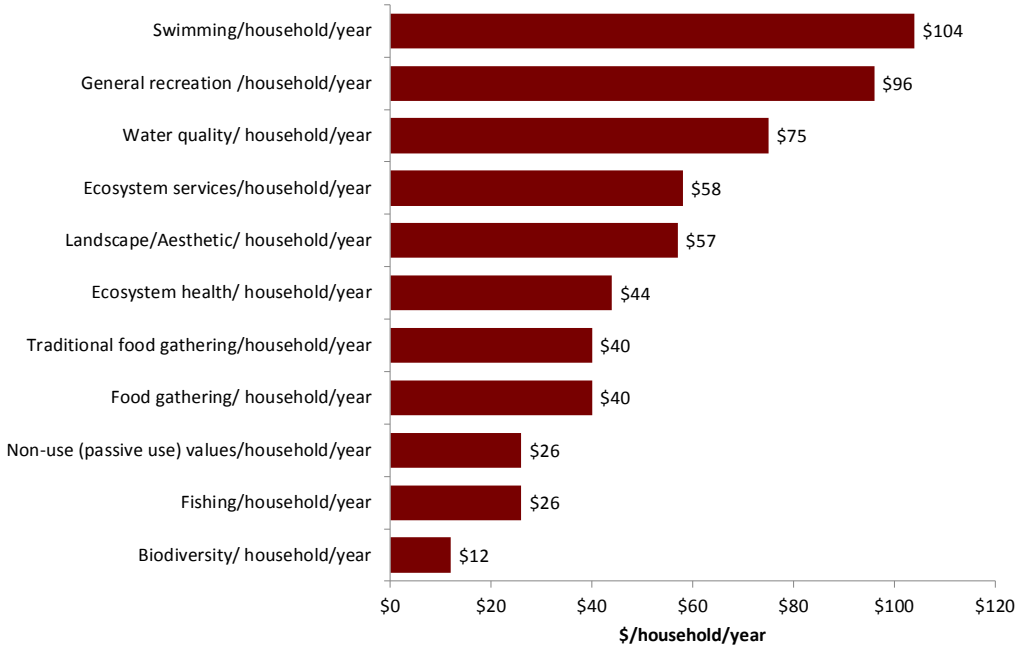
VOC includes costs of fuel and vehicle depreciation. Cost assumptions are from the EEM.

G4.4.3 Value of additional recreation

The value of additional recreational trips can be assessed using the marginal values of recreational trips. The value varies with the type of recreation.

In figure G.2 we present the values from table G.13 in a graphic format. We use these to develop some broad estimates of recreational values.

Figure G.2 Non- market values of freshwater – median ($/household/year) (2016$)



Source: Adapted from Marsh and Mkwara (2013) – updated to 2016$ using CPI (Statistics New Zealand)

The highest values in figure G.2 are for active recreation, eg swimming ($104/household/year) and for 'general recreation' ($96/household/year), which is a composite measure where a value was estimated for more than one type of recreational activity, eg recreational fishing and boating (Marsh and Mkwara, 2013) In table 7 of that document general recreation benefits at an artificial lake in the South Island are valued at $58 – $125/household per annum and Lakes Rotorua and Rotoiti at $38 – $120/household per annum, depending on how nearby they are. The value of $26/year for fishing is somewhat anomalous, and we note it is lower than the value for fishing per person per trip (table G.13), and that this is lower than values cited for sea fishing (see marine sites above) for which values per household per year varied from $69 – $134.

At the lower end are values for passive or non-use of freshwater areas. These are amounts people are willing to pay for sites they do not necessarily visit. We examine these in more detail below under existence value.

In the middle are values associated with the qualities of the aesthetic or ecological values of the site that might be associated with visits.

The annual $/household values might be useful where a project results in a new site becoming available for recreational use. For the values to be useful this would need to apply to households for which there are few current opportunities so the values are truly marginal.

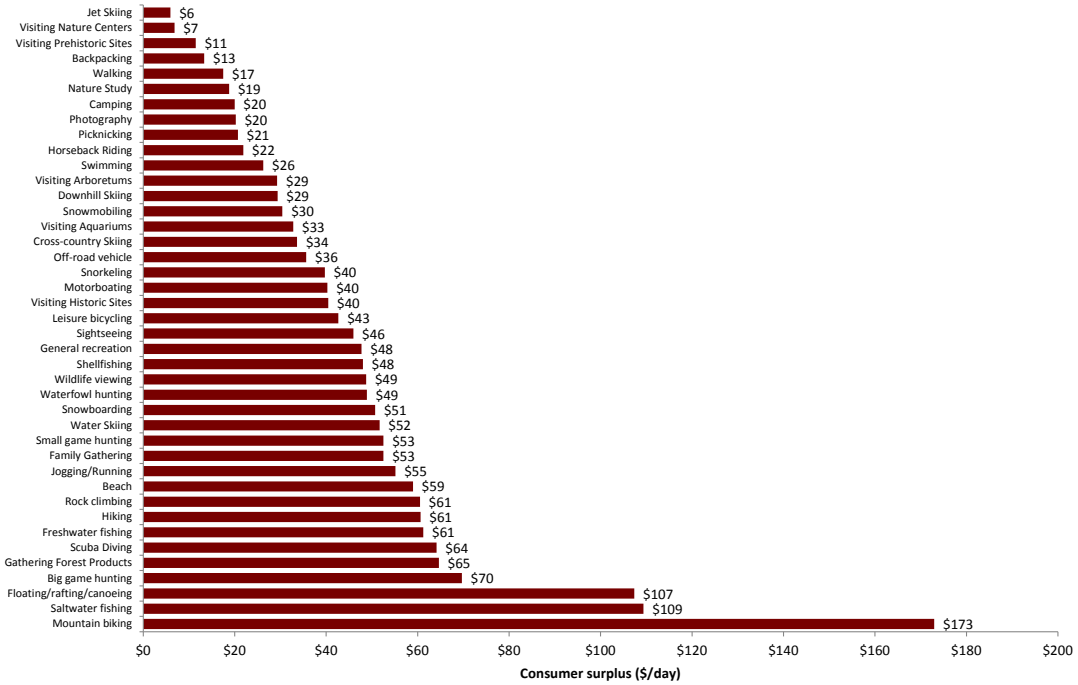
It is useful to convert these $/household values into values per visit, especially where the improvement of a site leads to additional recreational trips rather than extending recreation to additional households.

Table G.14 includes values of $33/visitor/day for general recreation and $103–$165/visitor/day for active recreation (canoeing, kayaking etc). If people visit once per year, the value per visit should be equal to the value per annum. The high per visit values noted in table G.14 appear to be for unique sites with uncommon experiences, eg the Whanganui River ($103–$139/visitor/day); these values are likely to be higher than for single visits to Auckland sites, particularly given the number of substitute sites.

To find a way to convert $/household per annum numbers into values per trip, we use data from international studies to develop ratios of values between recreational types. Figure G.3 shows values from

a wide range of US studies compiled into a database by Oregon State University, College of Forestry (Oregon State University 2016).

Figure G.3 Recreational values in US studies



Source: Oregon State University (2016); Covec analysis

The recreational values we are interested in might be classified as active or inactive, and land or water-based, in addition to specialist activities such as fishing and/or food gathering. For New Zealand, we have some estimates of the value of day trips for fishing, in addition to values per household per year. To convert $/household values to $/trip, one approach is to use the ratio between fishing trip values and values for these other activities. Table G.15 shows average values for a number of activities and the ratio of these values to the value of a fishing day. In general, we might split the values into: (1) active values, that include fishing and active water- and land-based activities, and (2) relaxed activities that include walking and picnicking. The WTP for active recreation is approximately double that for relaxed recreation.

Table G.15 Value of individual recreational activities in US studies

Category	Activities	Value ($/day)	Ratio (Fishing = 1.0)	N
Fishing	Fishing	$67.57	1.00	932
Relaxed	Walking, pick-nicking, visiting sites (arboretums, visitor centres etc)	$34.92	0.52	71
Active water-based	Canoeing, rafting, boating, scuba diving	$74.28	1.10	170
Active land-based	Mountain biking, hunting, off-road vehicle	$64.95	0.96	801
Food gathering	Shellfishing, gathering forest products	$63.54	0.94	15
Swimming	Swimming	$26.24	0.39	14

Source: Oregon State University (2016); Covec analysis

Swimming has a high per household value (table G.13) but this is likely to reflect multiple trips. Hence, although it is a relatively active recreational type, the value per visit in the US data is closer to the less active recreational values.

We use the value per fishing day from table G.13 ($33/day) to suggest the following values for recreational values of freshwater bodies in Auckland:

- fishing and active recreation: $33/visit
- less active recreation (walking, picnicking) and swimming: $16.50/visit.

These values would apply to additional trips as opposed to the relocation of visits.

As a check on these numbers, we note:

- the price for swimming pool entry in Auckland is approximately $3.50–$7.50 for adult casual entry (Auckland Council 2017)
- a day pass for Mountain Biking at Woodhill Forest is $10 (Woodhill Mountain Bike Park 2017)
- adult prices to the Auckland Zoo are $28 ($12 for children) (Auckland Zoo 2017)
- a day pass at Snow Planet is $68 (or $45 for two hours) and to Rainbow's End (Superpass) is $56 (Rainbow's End 2017).

It might be assumed the ticket prices give a broad estimate of the economic surplus (WTP less the costs incurred) for people having recreational visits for which they do not have to pay.

There are some reasons why ticket prices might be different from recreational surpluses, including that stream values are more likely to be those enjoyed by nearby residents, whereas the commercial prices take account of the costs of travel also, eg if people did not need to travel so far, the entrance price might be higher – we assume prices are set at a level that would maximise revenues for site owners).

This could suggest a potential greater surplus for a closer site as the gross benefit of the recreational visit would not be offset by such significant costs of travel. And there may be some other costs associated with commercial recreation facilities, including crowding (congestion) that could reduce the comparative value also. However, the sites that charge will also have unique features that increase the WTP; this might suggest the ticket prices could over-estimate economic surpluses of recreation for non-paying activities.

Despite these uncertainties, in both directions, the ticket prices suggest the values assumed for recreational activities are in the right order of magnitude.

One significant challenge in estimating the benefits of environmental improvement is projecting how many additional total recreational visits might be made as a result of the environmental improvements (or avoided environmental degradation). This is unlikely to be predictable from any existing dataset as there is no breakdown of visitor numbers at a fine enough level to develop a site-specific predictive model. Thus the input data will require some judgement on the expected change in visits.

Some data is collected on the number of visits to recreational facilities in Auckland. However, these are limited to specialist sites that include swimming pools and recreation centres (table G.15). These are easier to count than trips to outdoor recreational sites for which there is no entry price.

Table G.15 Visits to Auckland swimming pools and other facilities

Visit type (per capita)	Actual (2012/2013)	Target (2014/2015)
Average number of visits to swimming pools	7.51	7.6
Average number of visits to other facilities	6.75	6.85

Source: Auckland Council (2014)

There is some data on walking trips from the Ministry of Transport's household travel survey. It notes that overall, people in New Zealand spend 205 million hours per year walking and walk an estimated 807 million km per year and 987 million walking trips (Ministry of Transport 2015). For recreation there are approximately 108 million trips per year for which walking is the travel mode; this is about 30% of all recreation trips (although less on a kilometre basis) and an average of approximately 64 per household per year (or over one per week).

A domestic travel survey used to be conducted by the Ministry of Tourism/MBIE, but this has been discontinued. It only accounted for trips that were greater than 40km in one direction.

Given the absence of data on recreational trips, some assumptions will need to be made about the frequency of visits to any sites in question.

G4.4.4 Quality of recreational visits

A number of studies have addressed the change in the value of recreational visits as a result of changes in the quality of the recreational site. This has included some aspects of site amenity, whether the water is of swimmable quality, and water clarity. The swimmability issue will not often be of concern for changes in water quality in Oakley stream, which is too shallow or small for swimming. Swimmability becomes an issue in the marine environment, the final destination of water from Oakley stream, where faecal coliforms and sediment (deposited and suspended) can make beach areas un-swimmable, at least temporarily.

Water clarity affects the value of recreational visits to streams, whether or not people enter the water.

We address issues relating to aesthetics of the site in section G4.6 below). This includes measures that increase the aesthetic quality of water bodies (eg riparian planting), that make recreational experiences more pleasurable and of higher value. Here we limit our analysis to the issues of swimmability and water clarity. These may be of limited relevance to Oakley Stream but may be relevant to effects in the marine environment.

G4.4.5 Swimmability

Suitability for swimming is estimated on the basis of enterococci or *E coli* counts in marine and fresh waters respectively (see table G.16). Predicted changes in these counts in receiving environments that are currently used for swimming would be required.

Table G.16 Suitability for swimming

Test	Marine waters (enterococci/100 mL)	Freshwaters (E coli/100 mL)	Result
No single sample greater than:	140	260	Surveillance/green mode very safe for swimming
Single sample greater than:	140	260	Alert/amber mode satisfactory for swimming
Two consecutive single samples greater than:	280	550	Action/red mode could be health risk for swimming

Source: Ministry for the Environment (2003)

These changes could be combined with values for changes in water quality to (or away from) a swimmable level. Table G.17 has values expressed in terms of the impacts per household per year, and reflects the change in values for those who do or do not visit the site. These are therefore not pure recreational values, but some combination of values for active recreational use and passive (existence) use. This does not make these values redundant, but means we are less able to classify values in terms of the TEV categories.

Table G.17 Impacts of changes in water quality on recreational value ($/household/year)

Location	What was valued	Value (original)	Value (2016)	Author(s)
Karapiro, Waikato	Water quality improvements Risk of algal bloom (for swimming):	$39 to $190 (2009)	$42 to $207	Marsh (2010)
Lower Waimakariri, Canterbury	Improving water quality to swimmable standard (D to C)	$72 to $153 (1993)	$114 to $242	Sheppard et al (1993)
Orakei Basin, Auckland	Improvement in water quality	$11 (2003)	$14	Williamson (1998)
Selwyn River, Canterbury	Safe to swim Predominantly clear water: 25 days no flow in summer:	$68 to $299 (2003) -$2 to $183 -$2 to -$62	$89 to $390 -$3 to $239 -$3 to $81	Kerr and Swaffield (2007)
Hurunui River	Suitability for swimming changing from satisfactory to good from water quality improvement	$33 (2011)	$34	Marsh and Phillips (2012)

One difficulty with using these values to apply to improvements in marine water is that closure of beaches because of faecal contamination is not permanent; it is a phenomenon that happens occasionally, and the costs will differ depending on whether or not they occur during summer months when swimming is more prevalent.

The most straightforward approach is to estimate the change in the number of total recreational visits, combined with the estimated value for an additional visit. Additional values relating to the cleanliness of the environment itself, eg the value of a higher quality environment are examined in section G4.7 below.

G4.4.6 Water clarity

Studies have estimated the impacts of changes in visibility on the recreational value of water bodies. These values have been expressed in terms of making water clear rather than muddy, or marginal improvements in visibility as the distance (in metres) that a dark object can be seen (table G.18). Stream visibility is affected by sediment levels and levels of eutrophication/biological growth.

Table G.18 Value of water visibility improvements ($/household/year unless otherwise stated)

Location	What was valued	Applicability	Original value (year)	Current value (2016)
Auckland urban streams [(a)] a) Natural (avoided degradation) b) Degraded (improvement)	Clear rather than muddy	Locals	(2003) a) $67 ($46–$96) b) $60 ($42–$85)	 $88 ($60–$125) $78 ($55–$111)
Karapiro Catchment [(b)]	Improve water clarity to 4 m (from <1 m)	Catchment residents	$82 ($18–$110) (2010)	$89 ($20–$119)
North Canterbury Rivers [(c)]	Improve water visibility by 1 m (generic river)	Anglers visiting river	$9 (2008)	$10

Location	What was valued	Applicability	Original value (year)	Current value (2016)
Rotorua lakes [(d)]	Improve water visibility by 1 m	Anglers visiting lakes	All values $/angler/year $23 (Rotorua) $26 (Rotoiti) $0.04 – $3.90 (other lakes)	All values $/angler/year $23 (Rotorua) $27 (Rotoiti) $0.04 – $4 (other lakes)
Waikato river and streams [(e)]	Improve water clarity	Catchment residents	User (non-user) 2014 0.2 m: $4 ($4) 0.6 m: $15 ($12) 1.1 m: $33 ($26) 1.6 m: $54 ($43) 2.5 m: $103 ($81) 3.5 m: $172 ($136)	No change in values

Source: [(a)] Kerr and Sharp (2003a; 2003b); [(b)] Marsh (2010); [(c)] Beville and Kerr (2009); [(d)] Marsh and Mkwara (2013); [(e)] Phillips (2014)

There is some consistency between the results, eg the value of improving a stream from muddy to clear is very similar to that for a 4 m improvement in water clarity ($88 and $89 per household per year respectively) (a 4 m improvement in water clarity means that it is possible to see something underwater that is 4 m away). The per metre improvement ($10/m) is in the same order of magnitude, although it applies to a potentially narrower group of people – those who fish in the river being valued. It is likely this latter value is the more useful number as it is a value of a small improvement. The marginal values derived from Phillips (2014) are significantly higher, eg $69 to improve visibility from 2.5 to 3.5 m ($55 for non-users) (She notes she found no statistically significant relationship with revealed preference data, but has used a combination of revealed and stated preference data).

Of the values above, the numbers derived from studies on Auckland streams (see Kerr and Sharp's study results in table G.18) would appear to be most relevant. These are annual values per household and appear to be associated with streams in general rather than a particular stream, eg they are a WTP for a generalised improvement in all Auckland streams. Improving any individual stream would be expected to be less than this, or for the affected population to be much smaller.

The $/metre data is unlikely to be useful directly, because it is unlikely water clarity impacts will be assessed with such precision. However, we can use this data with some broad assumptions about improvements, eg by using data for a 4 m improvement to represent the value of a significant increase in clarity. The value of a significant increase might be taken as $20 per household per annum for those local to the river. We use the same percentage range as used for recreation days (6% – 254%) to derive a range of $1 to $51.

G4.5 Values for analysis

Building on the discussions above, we suggest the following values are used for analysis in this report with respect to recreational uses of streams and the sea in the Auckland region.

Table G.19 Values for analysis of recreational benefits (2015$)

Activity	Activity change	Value	Range (low–high)
Active recreation (eg fishing, boating)	Number of additional trips in the region as a whole (net of substitutions) as a result of the project or policy.	$33/additional trip	$2 – $84
Less active recreation (eg walking, picnicking)	Number of additional trips made in the region as a whole (net of substitutions) as a result of the project or policy	$16.50/additional trip	$1 – $42
Swimming	Number of additional trips made in the region as a whole (net of substitutions) as a result of the project or policy	$16.50/additional trip	$1 – $42
Water visibility	Will there be a significant change in the visibility in any stream for which visibility could be valued? (ie does not apply to very shallow streams). The value would apply to all those regarded as local to this stream (catchment population)	$20/household/year	$1 – $51

Source: Kerr and Sharp (2003a; 2003b)

G4.6 Amenity value

Amenity or aesthetic value is an expression of what people value about the environment for its appeal to their senses; this might include the look, sound, smell, taste or feel of a location. Amenity value is the term used in New Zealand legislation to capture the concept of aesthetics; the RMA (section 2) defines the concept as 'those natural or physical qualities and characteristics of an area that contribute to people's appreciation of its pleasantness, aesthetic coherence, and cultural and recreational attributes'.

It is difficult to isolate amenity values, as they commonly modify the value of more direct uses. For example, the benefit a swimmer derives from a water body depends on amenity attributes such as clarity, odour and pollution levels. There is also likely to be a high correlation between the aesthetic value of a water body and the extent to which it is in a pristine or natural state, although this is not certain and may differ between people. Amenity values have been included in several valuation studies, particularly those associated with existence value, eg the value of a natural site, regardless of whether it is visited. As with recreational studies, often there are difficulties with separating out aesthetic values of active users from values for passive users (Jay et al 2007; Lansford and Jones 1995). For example, the aesthetics of a site are part of the reason for a recreational visit, and it is difficult to separate the contribution to total value of aesthetics and that of the activity itself. Given this, it is likely that amenity value is incorporated into estimates of recreation (above) and existence value (below).

Below we discuss some studies that have addressed aesthetic value and we examine the extent to which these can be separated out from other values.

Kerr and Sharp (2008) assessed the benefits of a series of improvements to Auckland streams that included improvements in water clarity, the introduction of fish species and increased levels of vegetation (table G.20). The results suggested greater benefits from improving from little to moderate vegetation than to plentiful vegetation. This cannot be used to suggest that a reduction in vegetation (from plentiful to moderate) has a positive value as both were derived from estimates of the value from increasing vegetation; it reflects more the level of uncertainty in the results. Baskaran et al (2009) examined the benefits of improved scenic views from 30% more trees, hedges and plantations; they suggested values of $16/household/year (in 2009$ or $18/household/year in 2015$).

Table G.20 Benefits of increased vegetation by Auckland streams ($/household per annum) 2003$ (2016$ in brackets)

	Little to moderate	Little to plentiful
Natural stream	$42 ($55)	$35 ($46)
Degraded stream	$66 ($86)	$26 ($34)

Source: Kerr and Sharp (2008); Covec conversion to 2015$

Bell et al (2012) assessed the benefits of natural character associated with three rivers (Takaka, Matakitaki and Lee-Wairoa-Waimea) in the Tasman District (table G.21). These are for changes to vegetation alongside the rivers that affect their naturalness, but the estimates are likely to include those of visitors as well as those who do not visit.

Table G.21 Willingness to pay for natural character

River	Current state	Change to	WTP ($/yr) (2011)	WTP ($/yr) (2016)
Matakitaki	Mainly natural	Mixed vegetation	-$152 (-$76 – -$210)	-$157 (-$78 – -$217)
		Highly modified	-$198 (-$398 – $112)	$204 (-$410 – $115)
Takaka	Highly modified	Mixed vegetation	$57 ($28 – $85)	$59 ($29 – $88)
		Mainly natural	$100 ($80 – $129)	$103 ($82 – $133)
		Natural species	$189 ($96 – $296)	$195 ($99 – $305)
Waimea	Highly modified	Mixed vegetation	$85 ($64 – $118)	$88 ($66 – $122)
		Mainly natural	$135 ($22 – $281)	$139 ($23 – $290)
		Natural species	$159 (-$26 – $344)	$164 ($27 – $355)

Source: (Bell et al 2012)

Tapsuwan et al (2009) examined the amenity value of urban wetlands in Perth, Australia. Wetlands were in decline because of increased extractions of groundwater that recharged the wetlands and climatic conditions. They used hedonic pricing to estimate that house sales prices were significantly related to the distance to the nearest wetland and the number of wetlands within 1.5km of a property. They found the value of being 1 m closer to a wetland was A$42.40 and the existence of a wetland within 1.5 km of a property was close to A$7,000. The value placed on wetlands will reflect local preferences for different components of the environment and it is unlikely these values can be directly transferred to Auckland, even if adjusted for house prices. It is more likely that Auckland house prices will reflect proximity to beaches/the sea than urban wetlands.

The work on Auckland streams would be most relevant to this work. However, these values are also discussed under the existence value section below, as Kerr and Sharp's study (2003a) included a mix of use and non-use (passive use) values.

We use small values as estimates of the benefit of smaller increases in vegetation quantity (table G.22); a range of values is derived using the same ranges as for recreation. These would apply to sites not visited for recreational purposes, but appreciated aesthetically, eg by locals who can see the site or by people driving past.

Table G.21 Values for analysis of amenity benefits

Question	Value ($/household/year)	Range (low–high)
Number of local (catchment) households that have a member who visits the stream regularly	$50 for significant increase in vegetation $25 for moderate increase $10 for small increase	$3 – $127 $2 – $63 $1 – $25

G4.7 Existence value

Within total economic value (TEV), passive use values include:

- existence value – the value of knowing that an environmental asset exists even if you never visit it
- bequest value – WTP to bequeath resources to the future.

However, in practice it may not always be possible to separate out the different categories (Sharp and Kerr 2005), so passive uses are often combined into a single existence value category and some researchers have noted that people often cannot distinguish between option and bequest values (David et al 2007).

Sharp and Kerr (2005) examined 'values that citizens perceive to be embodied in the environment ... independent of use of that environment'. Terms used to define these values include 'existence', 'passive use' and 'non-use' values. In general existence values are greatest when the environment is least disturbed relative to its natural state and are lowest when the environment is most modified; however, this is not always the case; modified environments can be valued, especially when they have qualities that enhance their aesthetic appeal.

Existence values have been examined for Auckland urban streams in a study by Kerr and Sharp (2003a; 2003b; 2008). They surveyed the WTP of Auckland residents to improve degraded streams or to prevent the degradation of natural streams. The survey asked respondents to express their WTP for changes in ecological value using a conceptual model which imagined different possible states of streams amongst which respondents were to choose their preferred option (table G.22). Each option had a cost attached to it.

Table G.22 Conceptual model of ecological value

Attributes	Degraded state	Moderate ecological value	High ecological value
Flow	Flow high peak/low	Modified hydrology	Normal hydrology
Riparian zone	0–5 m either side 0–100m long	5–15 m either side 100–300 m long	>15 m either side > 300+m long
Temperature	> 25°C	20°C – 24°C	< 20°C
O_2 saturation	<50%	50–80%	>80%
Nutrient levels	High	Medium	Low
Shade	0–50%	50–70%	≈ 70%
Fish taxa	≤ 2	3–5	>5
Stream cover	Little	Adequate	Optimal
Complexity	Low	Medium	High

Source: Kerr and Sharp (2003a)

The study used statistical techniques to estimate the changes to total existence value because of changes in different components of environmental quality; we show the values for site enhancement (as opposed to

degradation) in table G.23. The total row is estimated as the value of enhancement of a stream from low to high value; it includes an increase of five native fish species ($15–$40/household per annum).

These overall estimates might be compared with estimates of existence value for other natural environments. Existence values identified in Sharp and Kerr (2005) are presented in table G.24. These include values for those who do and do not use the river. Genuine existence (passive use) values may be best estimated using the values expressed by non-users, eg those who do not visit the river ($15–$32/household/year). Marsh and Mkwara (2013) did not identify any more recent studies for New Zealand.

Table G.23 Components of existence value for Auckland urban streams

Attribute	Explanation	Value ($/household per year)	
		2003$	2016$
Water clarity	Muddy (or low visibility) to clear	$56 ($35–$104)	$73 ($46–$136)
Native fish	One more species	$10 ($0–$28)	$13 ($0–$37)
Vegetation	Little or no vegetation to moderate vegetation Little or no vegetation to high vegetation	$66 ($23–$154) $26 ($7–$61)	$86 ($30–$201) $34 ($9–$80)
Stream channel	Stream channel from straight to natural form	$69 ($44–$126)	$90 ($57–$165)
Total (estimated)	Improvement from degraded to high ecological value	$227 ($109–$473)	$296 ($142–$618)

Source: Kerr and Sharp (2008); Covec estimates of total

Table G.24 Existence values ($/household/year) 2003$ values (2016$ values in brackets)

Value	River	All regional households	River users	Non- users
Preserve in existing state	Waimakariri	$42 ($54)	$51 ($66)	$12 ($15)
Improve quality[(a)]		$34 ($44)	$40 ($52)	$14 ($18)
Preserve in existing state	Rakaia	$43 ($56)	$77 ($99)	$25 ($32)
Prevent pollution returning to 1960s levels	Waikato	$93 ($120)		
Preserve river flows	Ashburton	$70 ($90)[(b)]		

[(a)] Improve water quality from D to C standard (eliminate health risk to recreational users); [(b)]Value expressed by Ashburton residents (rather than Canterbury households) was $118 ($152)/households/year

Source: Original (December 2003) values taken from Sharp and Kerr (2005)

These values pertain to the preservation of the river in its existing state relative to some other state in which it had a lesser value, ie they are an estimate of the change in total value as a result of a change in some attributes of the river. However, the change in state is not as clearly defined as it is for the Auckland stream values.

A number of studies have estimated the value of ecosystem services provided by freshwater systems. Patterson and Cole (2013) estimated the value of ecosystem services provided by wetland, estuarine, mangrove, lake and river ecosystems. Clarkson et al (2013) estimated values provided by wetlands specifically. These values are expressed on a per ha basis. The values that build largely on the work undertaken globally by Costanza et al (1997) are less relevant than the local studies cited above.

The analysis here is based on the Auckland stream values (table G.23) to the extent possible. Making use of these values requires:

- the identification of a suitable population to which the values apply
- a basis for relating the values for change in quality to some physical variables that can be measured
- a way to translate these values to values for the marine environment in the absence of specific studies.

G4.7.1 Relevant population

For the Kerr and Sharp (2003a) study the questions were phrased to obtain responses relevant to a stream (either degraded or natural) near the respondent's home (Dr Geoff Kerr, Lincoln University, personal communication, July 2015). This recognised that streams are widely distributed in Auckland and existence value is most likely to be expressed for a nearby stream rather than for one that is further away.

For freshwater, unless the waterbody is regionally significant, the relevant population is the number of households within the catchment area of the stream being examined.

For marine habitats for which the catchment concept does not apply, existence values are likely to be expressed by a much wider proportion of the Auckland population. However, it is unlikely that the same level of existence value will be expressed by the whole region for all coastal areas. There are two approaches to addressing this: either to assume a smaller existence value for the whole region or to assume a smaller population is relevant for each marine area improved.

In practice, no single approach is likely to be relevant to all locations. Some coastal areas will be widely valued whereas others will be valued by a much smaller number of residents.

G4.8 Value of changes in quality

The values in table G.23 are expressed either as:

- the benefits of improving individual characteristics of a stream that contribute to total existence value
- for improving the aggregate environmental quality and thus total existence value.

We discuss the two values in turn below.

G4.8.1 Individual characteristics

The characteristics of the stream that contribute to total existence value, and that have been included in the existence value studies of Sharp and Kerr, are water clarity, native fish species, vegetation and stream channel shape. The values are derived from studies in which people have expressed their WTP relating to the improvement of whole streams. However, often projects will only provide improvements to part of a stream.

Existence values apply regardless of visitation, so to some degree this might not matter. However, we need some way to take account of the fact that improving part of a stream has less value than improving the whole. The options are to:

1 Use a lower value for a change in environmental quality, or

2 Apply the change in value to a smaller population.

Effectively they can be used to reach the same outcome. Because the relevant population is already being used as an input to the analysis it is simpler to vary this. The implication is that those assumed to express an existence value relating to a particular water body are assumed to be those households for which the reach of stream that has been improved is closer than other streams or unimproved parts of the stream in question.

We make suggestions for values to use in analysis below building off the values for Auckland streams in table G.23.

G4.8.2 Aggregate environmental quality

The alternative approach to valuing individual elements of existence value is to combine:

- an estimate of the total existence value with
- some measure of the change in total ecological value of the stream.

The estimates of total existence value in table G.23 are relevant to the clean-up of a degraded stream. What is not clear, however, is whether the absence of a stream, eg it is diverted to a concrete pipe, is better or worse than a degraded stream. Our assumption here is that it is worse, eg there is some ecological value and some existence value for a stream with some natural qualities, even if degraded. Using the total values in table G.23 for improving a degraded stream, our assumption is that the total existence value for a pristine stream is $350/household per year, relative to a pipe.

Different values might apply to improvements to regionally significant water bodies as opposed to the local stream or water body. For these instances, we use the regional values identified by Sharp and Kerr (2005) as presented in table G.24. As a true expression of existence value, we use the value for non-users of $25/household per year.

The next required component of analysis is a way to measure the change in total ecological value of the stream or other water body. It is likely to be achievable across broad categories of change only, eg conversion from pipe to open stream (daylighting) or vice versa.

In Auckland, a system has been developed for quantifying changes in the ecological quality of streams. This is SEV, which was developed as a method for quantifying the ecological values of streams in a consistent manner based on the performance of their key ecological functions (table G.25) to inform resource management decisions. Greater detail about SEV is provided in the technical report and the user's guide published by Auckland Council (Storey et al 2011; Neale et al 2011).

SEV has not been developed with existence values in mind, but in the absence of any other aggregate measure of ecological value it may provide a useful indicator of change in factors that affect total existence value. Changes in SEV have been used in the assessment of some Transport Agency projects, including Waterview Connection.

Using SEV as the basis for determining changes in environmental qualities valued by the community, the total ($350/household – see discussion above) would be the value associated with a SEV score of 1. Changes in existence value would then be measured as:

$$\Delta EV = EV_t \times \Delta SEV \qquad \text{(Equation G.1)}$$

Where: ΔEV = the change in existence value at the stream

EV_t = the total existence value (assumed to be $350/household per year)

ΔSEV = the change in stream ecological value

Table G.25 Ecological functions used in the stream ecological valuation

Ecological function	
Hydraulic functions	• Natural flow regime • Floodplain effectiveness • Connectivity for natural species migrations • Natural connectivity to groundwater
Biogeochemical functions	• Water temperature control • Dissolved oxygen levels • Organic matter input • Instream particle retention • Decontamination of pollutants
Habitat provision functions	• Fish spawning habitat • Habitat for aquatic fauna
Biodiversity provision functions	• Fish fauna intact • Invertebrate fauna intact • Riparian vegetation intact

Source: (Storey et al 2011)

An equivalent methodology for the marine environment needs to be developed also.

G4.9 Including the marine environment

Batstone et al (2008) note that many studies clearly show that urban runoff is contaminating urban estuaries with heavy metals, as well as persistent organic pollutants such as hydrocarbons, dichloro-diphenyl-trichloroethane (DDTs) and polychlorinated biphenyls (PCBs). They also noted the potential for bio-accumulation in marine organisms and for accumulation in sediments, and that sediment itself was a contaminant.

A later study by some of the same authors examined the WTP of Auckland residents for improvements in the marine environment resulting from stormwater system alternatives (Batstone and Sinner 2010); (Batstone et al 2010). As part of this work they attempted to develop linkages between urban stormwater and the functioning and health of the marine environment. For example, they examined stressors such as sediment that had primary effects that included changing levels of light in the water, smothering of organisms and changes in habitat. These effects resulted, in turn, in reductions in primary production, nutrient recycling and losses of habitat. The outcomes included loss of biodiversity, loss of ecosystem resilience and reduced carbon storage.

They found people had a higher WTP for environmental quality in an outer zone, consisting primarily of beach locations, than for other parts of the Auckland coast, eg the upper harbour (table G.26). Correspondents also showed higher estimated WTP for water quality than for other environmental quality attributes in the outer zone. Two personal characteristics proved statistically significant when interacted with environmental quality/location variables: income and broad residential location.

Table G.26 Household willingness to pay ($/year) for environmental quality using 2 models

Harbour location	Attribute	Level change	Average	2016$
Outer	Ecological health	Low – medium	$144.27	$159.22
		Low – high	$189.25	$208.86
	Water quality	Low – medium	$213.67	$235.81
		Low – high	$303.87	$335.35
	Underfoot conditions	Low – medium	$131.78	$145.43
		Low – high	$186.09	$205.37
Middle	Ecological health	Low – medium	$88.65	$97.83
		Low – high	$116.39	$128.45
	Water quality	Low – medium	$57.91	$63.91
		Low – high	$98.53	$108.74
	Underfoot conditions	Low – medium	$61.05	$67.38
		Low – high	$61.81	$68.21
Upper	Ecological health	Low – medium	$65.00	$71.73
		Low – high	$86.67	$95.65
	Water quality	Low – medium	$43.39	$47.89
		Low – high	$102.92	$113.58
	Underfoot conditions	Low – medium	$60.89	$67.20
		Low – high	$64.34	$71.01

Source: Batstone et al (2010); Batstone and Sinner (2010); Batstone (2009

The results were expressed as household WTP for environmental quality improvements from low to medium or high levels. In table G.26 we summarise the results as the average of two (statistical) models used in the study. These were combined with total numbers of households in the Auckland region to estimate the value of improvements. Diagrams are included to provide clarity to the definitions of outer, middle and upper harbour zones.

An alternative approach is that used by van den Belt and Cole (2014) who estimated the value of the ecosystem services provided by marine areas on a ha basis (Thrush et al (2013) identified ecosystem services associated with estuarine ecosystems but did not value them). This built on aggregate numbers used by Costanza et al (1997) in valuing ecosystem services for the world. We have more confidence in using the New Zealand-specific data based on WTP studies as this affects elements of TEV.

G4.10 Proposed values for analysis

We propose values for analysis when estimating changes in individual elements of ecological value and for estimating changes in total ecological value.

G4.10.1 Individual characteristics

Table G.27 summarises the suggested values for incorporating existence value into the analysis and relating to improvements in individual components that contribute to existence value. These are based largely on the values from the Auckland stream analysis (tables G.23 and G.24), with some rounding. For vegetation improvements we take values within the range, noting the relatively high value of shifting from little to moderate vegetation and the lower value (diminishing marginal benefits) from shifting to plentiful vegetation. For simplicity, and because the interest is in some percentage change in total vegetation we

have assumed an amount that represents the total value of moving from no vegetation to some large and optimal amount.

Table G.27 Suggested values for components of existence value

Attribute	Change	Value per household per year (whole stream)
Water clarity	Muddy (or low visibility) to clear	$75
Native fish	1 more species	$13
Vegetation	Little to large amount	$100
Stream channel	Straight to natural	$90

G4.10.2 Aggregate environmental quality

To make these values usable we propose they are combined with measures of change in total ecological value using some aggregate indicator. For the marine environment, an equivalent approach would need to be made to measure changes in total ecological health.

The values are shown in table G.28. These are multiplied by the change in ecological value score (or marine equivalent) (from 0 to 100%) and the relevant population. The marine areas are reclassified to a simpler split between swimming beaches and other coastal areas.

Table G.28 Suggested values for analysis of existence values

Ecosystem	Value at maximum ecological health ($/household/year)	Range (low-high)
Freshwater (nearby stream)	$350	$200 – $600
Freshwater (regionally important stream)	$25	$15 – $35
Marine (nearby coastal area/swimming beach)	$350	$200 – $500
Marine (other)	$125	$75 – $150

G4.11 Māori values

Taking account of the Māori perspective on environmental values is part of understanding the full effects on the community. Separately identifying Māori values is a statutory requirement in the RMA, the Conservation Act and the Local Government Act. And the specific relationship of tangata whenua to local environs is increasingly being recognised in Treaty Settlements via Statutory Acknowledgements.

Māori values are perhaps best understood through the idea of connection. A group (iwi/hapū) has a relationship of belonging to a river, water body or another component of the local environment. This relationship may be expressed via stories, including creation stories, but the underlying sense is one of interdependence in which people rely on the environment and should look after it. This may be achieved via reciprocity in which anything taken (food or other resources) is balanced by giving, eg restoration to ensure the ongoing functioning and wholeness of the environment and for the benefit of current group members and for future generations.

The approach is different from but not completely alien to the pakeha view of the world. The nature of obligations is often expressed through policy and legislation, eg standards for water quality that define the obligations for mitigation and restoration. Obligations arise because of trade-offs between values, recognising that reduced environmental quality reduces the extent to which the environment can provide a

range of values. Where things differ is with respect to the equilibrium position. Whereas for pakeha, an equilibrium might be reached in which the costs to environmental quality might be offset by gains in some other value derived from the resource, for Māori, although such costs and benefits still apply, the benefits on one side of the ledger cannot be fully used to offset the other.

Māori values are accounted for to the extent that the values cited here are based on surveys and other techniques that included Māori participation. However, these values are not isolated and given separate expression.

G4.12 Summary of values

The values suggested for analysis are summarised below.

Table G.29 Suggested values for benefits analysis

Category	Description	Change	Relevant population	Value	Range
Recreation	Active	# of additional trips	Participants	$33/extra trip	$2 – $84
	Less active	# of additional trips	Participants	$16.50/extra trip	$1 – $42
Amenity	Water visibility	Significant increase	Regular visitors to stream	$20/household/year	$1 – $51
	Vegetation increase	Significant increase Moderate increase Small increase	Regular visitors to stream	$50/household/year $25/household/year $10/household/year	$3 – $127 $2 – $63 $1 – $25
Existence	Freshwater (nearby stream)	Full value[(a)]	Local residents	$350/household/year	$200 – $600
	Freshwater (nationally important stream)	Full value[(a)]	Regional residents	$25/household/year	$15 – $35
	Marine area (swimming beach)	Full value[(a)]	Local residents	$350/household/year	$200 – $500
	Marine area (other)	Full value[(a)]	Local residents	$125/household/year	$75 – $150

Notes:[(a)] Full value represents the benefit from changing from pipe-enclosed waterway to fully natural stream

G4.13 Application

The Waterview Connection project has several effects. To illustrate the analytical approach, we use the example of Oakley Creek. The project includes some realignment and rehabilitation of the stream. The potential components of analysis are summarised in table G.30 and discussed further below.

Table G.30 Analysis – Oakley Creek

Category	No of units	Value per unit	Range	Calculation
Recreation (less active)	A = estimate of additional visitors/year	B = $16.50/ additional visitor	$1 – $42/visit	Value = A × B
Amenity	C = vegetation increase (significant/moderate/small) D = total number of households experiencing the vegetation change	E = $50/25/10 per household/year (depending on level of perceived change: significant/moderate/ small)	$3 – $127 $2 – $63 $1 – $25	Value = D x E (value depending on C)
Existence	F = population (household numbers) of adjoining meshblocks G = estimated improvement (SEV change)	H = $350/household/year	$200 – $500	Value = F × G × H

The recreation value can be estimated for less active recreation, eg Oakley Creek involves activities that are based around walking by the stream rather than active pursuits (swimming or fishing). To estimate the change in value would require an estimate of the change in the total number of annual visitors as a result of the changes. This change in visitor numbers could be multiplied by $16.50/visit.

Amenity values may increase for visitors. The main measurable change will be any change in vegetation levels as experienced by visitors. The values expressed are for households, which we assume to be the households from which there are regular visitors to the site. This might be assumed to be some percentage of the population of the local area, eg those within a short walk of Oakley Creek.

Existence values are assumed to be held by all those living within a short distance of the stream. For simplicity, we assume all occupied dwellings in the Waterview area unit (1,182 in the 2013 census) (Statistics New Zealand 2013). Boffa Miskell (2010b) estimates the current SEV for Oakley stream to be 0.34 and that without realignment the value would be reduced to zero. Given that the maximum score is 1.0, we can calculate the effect as:

$$1{,}182 \times \$350 \times 0.34 = \$140{,}658 \text{ within a range of } \$80{,}376 - \$200{,}940 \quad \text{(Equation G.2)}$$

This can be converted to a present value by discounting these annual values over 30 years (the assumed project life) using a discount rate of 6% (as used in the EEM).

The overall results are shown in table G.31. Current missing data does not enable us to place a value on the recreation or amenity benefits, but we have data to place a ball-park estimate of the benefits relating to existence value.

Table G.31 Analysis - Oakley Creek

Category	Missing data	Value ($/annum)	Value (PV $million)	Range (PV $million)
Recreation (less active)	Change in visitor numbers			
Amenity	Change in vegetation + its significance Number of households who visit			
Existence		$141,000	$1.94	$1.11 – $2.77

G5 Comparison of costs and benefits – value

In monetary terms, the total cost of meeting the requirements of environmental legislation has been identified as $12.7 million (assumed 2016 cost base). The associated benefits that can be monetised are $1.94 million (2016 cost base). This would indicate a negative value associated with meeting the requirements of environmental legislation of $10.7m. However, as clearly shown in table G.31, the benefit value used in this calculation is incomplete – excluding recreation and amenity benefits.

Further, the tables in section G3 give a wider indication of the value of the scheme value, notably:

- Water quality: There are 23.31 ha of additional impervious surfaces resulting in an approximate total impervious area of 56.83 ha across the project area. Water quality treatment will be provided for 99.4% of the additional impervious areas. Of the 33.52 ha of existing impervious motorway surfaces within the project area, water quality treatment is currently provided for only 3.30 ha (9.8% by area). The proposed treatment devices for the project will significantly increase the area of existing motorway treatment to 30.40 ha (90.7% by area), achieving 80% treatment efficiency over the majority of this area (compared with the 75% treatment efficiency required by the Proposed Auckland Regional Plan: Air Land and Water).
- The project streamworks will provide a net benefit in terms of peak flood levels and extents. The minor effect of increased peak water levels upstream of the Bollard Avenue culverts is mitigated by reductions in flood risk for two houses, and the reduction in total flood extent within the project area
- The proposed stream realignments and rehabilitations will have a positive effect on the environment as 1.3 km of natural channel form will replace the existing manmade basalt rock wall channel. This compares with a required environmental compensation area of 1,305 square metres. The project streamworks will have net ecological, environmental and recreational benefits by providing greater access to the stream, better ecological habitats and more vegetation than currently exists in these reaches. No adverse effects are anticipated to the stream bed morphology, flow hydraulics or sediment.

These benefits indicate the amenity value of the restored stream could be considerable as there is a significant improvement in stream habitat, and the value of reduced flooding is also not currently monetised. By collecting this qualitative and quantitative information, and juxtaposing it with the cost and monetised benefits, the gaps in the monetary analysis of benefits become clear.

Appendix H: Mill Road case study

Capture of the following benefits was undertaken:

- stormwater quantity and quality
- ecology
- social impacts.

These were considered the most material effects of the scheme as aligned with this research. Detailed assessments of effects will be included with future consent applications and the Outline Plan of Works and will further inform the capture of value.

Table H.1 Stormwater benefits, Mill Rd scheme

		Baseline	Effects	Benefits of meeting the requirements of environmental legislation	Residual effects
Stormwater	**Qualitative**	The existing Redoubt Road and Mill Road are two-lane rural roads. Proposed Auckland Unitary Plan designated stormwater management area flow (SMAF 1), which seeks to protect and enhance Auckland's streams and aquatic biodiversity in urban areas. This SMAF is based on the high-value Puhinui Stream that has relatively low levels of existing impervious areas in its catchment. The PAUP also identified a high use stream management area which is based on streams that are under pressure from demands for water takes. This applies to Totara Park and extends for approximately 1.2 km in an easterly direction. Soils are unsuitable for infiltration. The section from SH1 to Totara Park has existing SW infrastructure and new networks will connect to these. Elsewhere the existing roads do not have stormwater infrastructure (other than roadside drains).	The creation of a four lane road creates more impervious surface area in the catchment and higher vehicle movements than the existing situation. The impact of the road upgrade is to increase the generation of stormwater contaminants in the runoff from the road surface which will include gross pollutants, sediment and metals (zinc and copper in particular have environmental effects). These contaminants can have effects on the ecology of the stream and marine receiving environments. The impact is to also increase the volume and peak flows of stormwater from the road area. This extra stormwater volume can have effects on the stream environment due to erosion and depletion of stream baseflows (due to less infiltration and reduced groundwater flows to the stream). The impact of the increased stormwater volume is also to increase peak flows during flood events (eg 100-year ARI flood event). The effect of this can create an increased flood risk to properties and buildings lower in the catchment.	The effects from stormwater are mitigated by the collection and treatment of stormwater prior to it being discarded into the environment. Stormwater treatment is proposed by a combination of devices including proprietary (filter) devices, raingardens, vegetated swales and wetlands. The stormwater treatment devices will provide treatment to meet the requirements for sediment removal of ARC TP10 as well as the SMAF 1 requirements for retention and detention (where this is possible) and peak flow attenuation for the 100-year ARI event.	The residual effects are not documented. The project documentation is for the Notice of Requirement and does not have a detailed assessment of effects that would be expected for the later consent application stage. The residual effects are likely to be from the residual stormwater contaminants (after treatment) and any hydrological effects on streams from areas not receiving retention and detention. The mitigation mostly meets the intention of the PAUP, so achieves the council's expected levels of mitigation.

		Baseline	Effects	Benefits of meeting the requirements of environmental legislation	Residual effects
	Quantitative	No stormwater treatment for existing Redoubt and Mill Roads.		Stormwater treatment for all 34 ha of impervious surfaces for 8.95 km of road for: • 75% TSS removal • retention and detention (where practicable) • attenuation of 100-year ARI peak flows to predevelopment levels. Stormwater treatment devices include: • 8 wetlands • 1–2 proprietary (filter) devices • 4 areas with vegetated 'wet' swales.	
	Monetise	Project insufficiently developed to enable monetisation of benefits			

Table H.2 Ecology benefits, Mill Rd scheme

Note: Residual effects are not addressed in the AEE.

		Baseline	Effects	Benefits of meeting the requirements of environmental legislation
Natural values	**Quantitative**	**Vegetation** The preferred alignment lies within the Manukau Ecological District. **Murphy's Bush**, through which the proposed road corridor (and existing Murphy's Road) passes, is one of the largest remnants of indigenous forest remaining in the northern part of Manukau Ecological District. This forest, which regenerated following logging in the 1880s, is regarded as the best remaining example of dense kahikatea forest in Auckland and the flora has been well documented for vascular plants, liverworts, lichens and fungi. **146 Mill Road Bush** The bush is an example of old growth podocarp-broadleaved forest with a canopy height of 18–20 m. The gully system is dominated by taraire and puriri, interspersed with rimu, rewarewa, karaka, pigeonwood, tawa tanekaha and occasional matai. Kahikatea, nikau, cabbage tree and scattered pukatea occupy the gully floor, while kanuka is locally dominant on steep, drier slopes above the watercourse, with associated canopy species including totara, lancewood and titoki. Mapou, mahoe, ponga, wheki and mamaku are common throughout the subcanopy. **Watercare bush and scrub** Within the designation the Watercare bush comprises a stand of mature kahikatea (approximately 18 m or more tall) on the stream terrace and the adjacent hillslopes. The stand is interspersed with rewarewa and a single mature rimu and matai. Cabbage trees, nikau and kanuka are also present. The wider site includes broadleaved forest dominated by taraire and puriri, but this forest type is outside of the designation. High botanical conservation values within the footprint of the bridge. Identified in PAUP as an SEA.	**Vegetation** Using the Institute of Ecology and Environmental Management (IEEM) approach: • Direct loss of bush at 146 Mill Road due to bridge abutments and span of bridge. The bush is rated as being of high ecological value, while the magnitude of effects is assessed as low (due to relatively small portion of bush located within the works footprint). Overall effects assessed as low. • Removal of mature emergent trees in Watercare bush. The value of the bush has been assessed as high and the magnitude of effects as moderate therefore the significance of effects is classed as medium. • Minor tree removal in Murphy's Bush; predominantly exotic trees and woody weeds. Ecological values of Murphy's Bush assessed as very high but the magnitude of effects assessed as negligible and therefore significance of effects evaluated as low. • There will be temporary fragmentation in Watercare bush since some clearance is necessary to construct haul road(s) to build the bridge piers. • As well as physical habitat removal, road construction creates extended linear	**Vegetation** The use of the bridge to cross the Watercare gully substantially reduces the extent of vegetation loss compared with works utilising placement of fill material. Avoiding the old growth forest remnant at 134 Mill Road and at Murphy's Bush by bridging over (rather than traversing through) the two other areas of old growth indigenous forest at 146 Mill Road and on the Watercare property. In addition amendments to the alignment of the bridge over the Watercare bush in mid-2014 resulted in the retention of several mature kahikatea trees. The temporary fragmentation of the Watercare bush can also be ameliorated by way of approaching the pier construction sites from both sides of the creek, thereby retaining a habitat linkage beneath the bridge that connects the bush on either side while the pier construction is underway. Remedy the loss of native trees by legally protecting native bush located within properties that will remain within the Mill Road designation. The obvious candidate for this form of remedial action would be the Watercare forest. Providing guaranteed protection of this old growth forest will deliver excellent remedial outcomes in exchange for (limited) adverse ecological

		Baseline	Effects	Benefits of meeting the requirements of environmental legislation
		Freshwater ecology **Site One – Murphy's Bush** - This site is located on a headwater branch of the Otara Creek, which discharges into the Tamaki Estuary. The stream on the west of the culvert is located in a native forest reserve, being Murphy's Bush. The upstream catchment is predominantly pasture but vegetation has been retained along much of the stream length, including the headwaters near Redoubt Road. The stream at this site has high-quality native riparian vegetation and low channel modification, and appears to have good water quality. Fishes recorded here are shortfin and longfin eel, bully (not identified) and koura (freshwater crayfish), which are very abundant. **Site two – Totara Park** – This site is located on the northern branch of the Puhinui Stream within Totara Park, the catchment for which extends towards Redoubt Road (the main stream continues west and passes under Mill Road, and was sampled at site 3). The Puhinui Stream ultimately discharges into the Puhinui Inlet in the south-east Manukau Harbour. The stream catchment is predominantly pasture with riparian planting along some of its upstream tributaries. Fish communities consist of shortfin eel and common bully. Macroinvertebrate communities have a moderate abundance and richness. Biodiversity scores are relatively low, but overall integrity is relatively high compared with the other sites. **Site 3 – Watercare Gully** This site is located on a branch of the Puhinui Stream on the eastern side of Mill Road. Upstream habitats are largely unmodified and have an extensive corridor of riparian forest. Macroinvertebrate communities have a relatively low abundance and richness, but a high proportion of EPT (E= Ephemeroptera,	edges through the habitats they traverse. Habitat edges alter the microclimate of the surrounding area via increased exposure to light. Changes in microclimate create shifts in flora and fauna communities, thus altering associated ecosystem processes such as leaf litter composition and nutrient recycling (Saunders et al 1991).	effects on 1,100 m2 of old growth forest at this same location. Mitigation for loss of native trees could also be achieved by undertaking compensatory planting of native vegetation in the local area. Mitigation planting could be undertaken either within or potentially away from the designation (with the latter being contemplated if the results of doing such would deliver a better ecological outcome than planting within the corridor). Implementation of designation conditions 34–37. **Freshwater ecology** Where loss of intermittent or permanent stream reaches cannot be avoided then such an effect needs to be mitigated or compensated for. This compensation usually takes the form of riparian restoration of a nearby stream, in recognition that such vegetation plays an important role in regulating the environmental variables that directly influence stream health (eg providing shade, preventing stream bank erosion and providing both woody debris and leaf/insect inputs to feed aquatic communities). Erosion and sediment controls during earthworks will be managed according to methods and procedures described in Auckland Regional Council (1999). These factors should keep adverse freshwater effects to minor (or less) levels. In terms of managing the operational phase

		Baseline	Effects	Benefits of meeting the requirements of environmental legislation
		P= Plecoptera, T= Tricoptera) taxa. The five EPT taxa recorded here are Deleatidium, Neozephlebia and Zephlebia, Triplectides and Pycnocentrodes. Other taxa include snails and beetle larvae. Biodiversity functions are sub-optimal, but overall functional integrity is high. **Site 4 – 146 Mill Road Gully** The stream within 146 Mill Road is a headwater tributary of the Papakura Stream, which discharges into the Pahurehure Inlet in the south-east Manukau Harbour. The macroinvertebrate community has a moderate abundance and low richness, but a high proportion of EPT taxa. The EPT taxa here are Deleatidium, Zephlebia, Polyplectropus, Pycnocentrodes and Triplectides. Other taxa include snails, beetles and dobsonflies. The fish community recorded here comprises shortfin eels and one banded kokopu. **Site 5 – Lower Mill Road** This site is located on a tributary of the Papakura Stream. Riparian vegetation is primarily willow trees, which produces root mats and contributes leaves and woody matter. There is a high abundance of orange iron bacteria, probably indicating anaerobic groundwater inflows. Macroinvertebrate communities have a relatively high abundance and moderate richness, but EPT taxa are absent. **Site 6 – Ranfurly Road** This site is located on a tributary of the Papakura Stream. Macroinvertebrate communities show a high abundance with a moderate level of taxa richness, including two EPT taxa, the caddisflies Oxyethria and a single high scoring Psilochorema. This classifies the stream as poor, with probable severe pollution due to the absence of abundance of higher scoring Taxa and the low abundance of the EPT taxa found within. This could either mean stream pollution or the lack of available habitat for species richness or both.		potential effects on freshwater, stormwater runoff from the road will be treated and attenuated in a total of seven treatment wetlands, which will be designed to meet the treatment criteria recommended by Auckland Council in TP10. This will provide removal of 75% of suspended solids and associated contaminants.

<table>
<tr><th></th><th></th><th>Baseline</th><th>Effects</th><th>Benefits of meeting the requirements of environmental legislation</th></tr>
<tr><td></td><td></td><td>Site 7 –Alfriston Road
Macroinvertebrate communities show a moderate species abundance with a moderate taxa richness. Probable severe pollution due to the absence of abundance of both EPT taxa and other non EPT taxa. Macroinvertebrate communities at this site have the lowest distinctiveness relative to the other survey sites.
Site 8 – Mill Road (South)
Macroinvertebrate communities show a high abundance with a moderate level of taxa richness. Two EPT taxa were found, including a large number of stone flies and a single Psilochorema. Likely severely polluted. The large abundance of ostracods and Orthocladiinae is also an indication of water quality issues.
Site 9 – 125 Murphy's road
Macroinvertebrate communities (sampled and assessed using hard-bottomed methods) have a relatively low abundance but a high level of taxaonomic richness.</td><td></td><td></td></tr>
<tr><td></td><td>Quantitative</td><td>Freshwater ecology
Macroinvertebrate community metrics and fish IBI scores
<table>
<tr><th></th><th>Site 1 Murphys</th><th>Site 2 Totara Park</th><th>Site 3 Watercare</th><th>Site 4 146 Mill Rd</th><th>Site 5 Lower Mill Rd</th></tr>
<tr><td>1 Total abundance</td><td>92</td><td>228</td><td>96</td><td>147</td><td>387</td></tr>
<tr><td>2 Number of taxa</td><td>13</td><td>10</td><td>8</td><td>8</td><td>16</td></tr>
<tr><td>3 Number of EPT taxa*</td><td>4</td><td>2</td><td>5</td><td>5</td><td>0</td></tr>
<tr><td>4 MCI score</td><td>63</td><td>82</td><td>116</td><td>122</td><td>64</td></tr>
<tr><td>5 QMCI score</td><td>3.8</td><td>2.8</td><td>2.8</td><td>3.6</td><td>2.2</td></tr>
<tr><td>6 Taxonomic distinctness indices</td><td>4.6</td><td>4.9</td><td>4.6</td><td>4.8</td><td>4.6</td></tr>
<tr><td>7 Fish IBI</td><td>26</td><td>22</td><td>26</td><td>32</td><td>0</td></tr>
</table></td><td>Vegetation
• 1,500 m² (3.6% of entire bush feature) of Mill Road bush will be directly lost as a result of the bridge abutments.
• Only approximately 12 trees and shrubs affected at Murphy's Bush.
• Approximately 1,100 m^2 (11%) of the Watercare Bush as described above is within the bridge footprint. Approximately 1,700 m^2 degraded scrub vegetation (Watercare bush) is located within the bridge footprint.
• In addition 1,200 m^2 (37%) of better quality scrub (Watercare bush) is also within the bridge footprint, located adjacent to the kahikatea forest. This scrub is dominated by a 3–5 m high</td><td>Freshwater ecology
The Environmental Compensation Ratio was used as presented in Storey et al 2011.. Given the culvert lengths and the habitat quality there would be a need to restore approximately 160–400 m² of aquatic habitat in a nearby stream.</td></tr>
</table>

		Baseline	Effects	Benefits of meeting the requirements of environmental legislation

	Site 6 Ranfurly	Site 7 Alfriston	Site 8 Mill Rd (south)	Site 9 125 Murphy's Rd
1 Total abundance	1,501	445	1,837	198
2 Number of taxa	15	12	17	25
3 Number of EPT taxa*	1	1	2	6
4 MCI score	71	57	69	90
5 QMCI score	2.4	2.4	2.5	3.3
6 Taxonomic distinctness indices	4.0	3.7	4.3	3.9
7 Fish IBI	24	14	14	32

* excluding Oxyethira and Paroxyethira

Summary of SEV scores, mean scores for function classes and overall mean score

	Site 1 Murphys	Site 2 Totara Park	Site 3 Water care	Site 4 146 Mill Rd	Site 5 Lower Mill Rd
Hydraulic function	0.92	0.96	0.96	0.67	0.87
Biogeochemical function	0.91	0.78	0.91	0.56	0.43
Habitat pro- vision function	0.67	0.74	0.82	0.40	0.46
Biodiversity function	0.45	0.48	0.54	0.44	0.23
Overall mean SEV score	0.78	0.76	0.83	0.54	0.52
SEV Range	Good	Good	Exc- ellent	Mod- erate	Mod- erate

canopy of ponga.

Freshwater ecology

The extent of instream and stream bed habitat loss at the Murphy's Bush site is in the order of 10 m, due to the extension of an existing culvert. Loss of 70 m of instream and stream bed habitat at Mill Road South due to construction of new culvert.

<table>
<tr><th></th><th></th><th>Baseline</th><th>Effects</th><th>Benefits of meeting the requirements of environmental legislation</th></tr>
<tr><td></td><td></td><td>
<table>
<tr><th></th><th>Site 6 Ranfurly</th><th>Site 7 Alfriston</th><th>Site 8 Mill Rd (south)</th><th>Site 9 125 Murphy's Rd</th></tr>
<tr><td>Hydraulic function</td><td>0.75</td><td>0.65</td><td>0.64</td><td>0.68</td></tr>
<tr><td>Biogeo-chemical function</td><td>0.34</td><td>0.28</td><td>0.29</td><td>0.67</td></tr>
<tr><td>Habitat provision function</td><td>0.23</td><td>0.23</td><td>0.24</td><td>0.42</td></tr>
<tr><td>Biodiversity function</td><td>0.31</td><td>0.21</td><td>0.23</td><td>0.42</td></tr>
<tr><td>Overall mean SEV score</td><td>0.43</td><td>0.36</td><td>0.37</td><td>0.58</td></tr>
<tr><td>SEV range</td><td>Moderate</td><td>Low</td><td>Low</td><td>Moderate</td></tr>
</table>
</td><td></td><td></td></tr>
<tr><td></td><td>Monetise</td><td colspan="3">Project insufficiently developed to enable monetisation of benefits</td></tr>
</table>

Ecological report recognises the existence of the current busy two-lane arterial route along Redoubt Road and Mill Road and therefore that any road-related ecological effects have already manifested.

Wildlands report did not recommend an overall preferred option but identified the adverse effects associated with each option. They attended a MCA workshop and considered all options poorer than the do nothing option with the exception of Northern A which was neutral.

Table H.3 Social benefits, Mill Rd scheme

		Baseline	Effects	Avoid/remedy/mitigate	Residual effects
Community connectivity and accessibility	**Qualitative**	**Non- essential services:** The most prominent community facility in the NOR 1 is the Church of Jesus Christ of Latter-day Saints Meeting House. The location of the facility provides a high level of visibility for visiting members as well as connectivity to the airport and Hamilton (nearest temple). There are two motels in NOR 1 – the Manukau Heights Motor Lodge and the Redoubt Motel. Both motels are marketed on their close proximity to the airport, Manukau Shopping Centre, Rainbows End theme park, Auckland Botanical Gardens and Vodafone Events Centre. Vehicle movement in and out of Totara Park Equestrian Centre is varied as the centre is largely seasonal, with minimal winter usage. However, planning is underway to build a roof over one of the areas which is expected to result in an increase of usage at the centre and thus an increase in traffic during the wet seasons. Riding for the disabled generates a high level of traffic to the site as each rider is accompanied by three volunteers. It has also been noted by users that it is difficult to turn right to access or exit the Totara Park Equestrian Centre due to visibility issues. There are a number of Housing New Zealand Corporation properties within the area. This population has been identified as vulnerable due to their low income and reliance on public transport infrastructure. **Essential services:** There are two state primary schools in NOR 1. Both schools are located away from the Redoubt Road	There will be disruption during construction to access to community facilities such as schools, the Church of Jesus Christ Latter-day Saints, two motels, Totara Park Equestrian Centre, Manurewa Assembly of God and the Buddhist Foundation. Temporary closure of sections of road means residents may be unable to access private properties and there may be an effect on emergency services and public transportation in terms of travel delay. Due to access restrictions, there may be an increase in congestion on certain roads during construction phases. Construction areas may reduce accessibility for cyclists. Construction may result in the temporary relocation of nearby bus stops, which could potentially affect accessibility for vulnerable populations.	Alternative local road routes will be identified to reduce access restrictions during construction phases. Alfriston School will gain access from the old section of Mill Road, rather than the main corridor. This will provide a safer traffic environment for school children during the construction phase. When full property access is unable to be remediated to an appropriate design standard, then full property acquisition is a likely outcome. The cycling community will be informed of areas affected and of changing road conditions to minimise the construction accessibility for cyclists.	Improved road design, including medians, street lighting and improved intersection controls will increase traffic safety and reduce crashes. These provisions will also address the issues of access and visibility to Totara Park Equestrian Centre. The road corridor upgrade will provide an increase in modal choice between major land use destinations, thus increasing connectivity and sustainability. Public transport provision is expected to increase which will have positive implications for the community (particularly vulnerable populations) by reducing isolation and promoting social inclusion. Improved safety and accessibility for cyclists and pedestrians through the provision of dedicated infrastructure, including pedestrian crossing phases at traffic signals,

		Baseline	Effects	Avoid/remedy/mitigate	Residual effects
		corridor on residential feeder roads. • Redoubt North Primary School – the majority of students either walk or are driven to school. There is no formal walking school bus and no current student cycle/scooter activities to or from school. Approximately five students use public transport to access the school. • Everglade Primary School is located at Everglade Drive. NOR 2 has one early childhood education facility – Edukids, located on Arranmore Drive, off Flat Bush School Road, and one state primary school – Chapel Downs, located on Dawsons Road. A private/independent school – Tyndale Park Christian School is located on Murphy's Road. In NOR 3, Alfriston School has two school bus routes servicing Brookby and Redoubt Road. The majority of students either walk or are driven to education facilities in the corridor. There is no walking school bus or current scooter/cycle activities to and from these schools. **Critical services:** The Manukau Super Clinic is to the west of the proposed upgrade and provides a patient shuttle bus; however, there is no direct public transport provision from Redoubt Road. Buses from Hollyford Drive and Redoubt Road can connect to buses and trains servicing this facility. Those wanting primary healthcare of emergency medicine must travel to Middlemore Hospital. **General connectivity issues in the area:** There is significant traffic congestion in NOR 1, especially during peak hours (see the traffic flows table below), which impacts on the accessibility of			new footpaths, new cycle lanes (on-road), dedicated cycle paths (off-road) and shared pedestrian-cycle paths.

<table>
<tr><th></th><th></th><th>Baseline</th><th>Effects</th><th>Avoid/remedy/mitigate</th><th>Residual effects</th></tr>
<tr><td></td><td></td><td>the services described above. NOR 1 has a much larger traffic volume than the rest of the corridor. This is due to people using Redoubt Road to access the motorway as there is no southbound on ramp at Te Irirangi Interchange, and there is also public transport in this area. There is public transport in the form of buses connecting to the Manukau Station, Otahuhu, East Tamaki, Howick and Downtown. The four bus stops in the route are located in NOR 1. There are no existing public transport routes on the latter Mill Road section of the upgrade.
Cycling is considered dangerous and the majority of cycling appears to be in prearranged cycling groups during the weekends. There are safety risks at the Redoubt Road – Mill Road Intersection.</td><td></td><td></td><td></td></tr>
<tr><td></td><td>Quantitative</td><td>Congestion of local roads
Traffic flows:
<table>
<tr><th>Location</th><th>2011 AADT (vpd)</th></tr>
<tr><td>Redoubt Road East of SH1</td><td>22,000</td></tr>
<tr><td>Redoubt Road East of Hollyford Drive</td><td>10,000</td></tr>
<tr><td>Mill Road South of Redoubt Road</td><td>13,500</td></tr>
<tr><td>Mill Road North of Alfriston Road</td><td>9,000</td></tr>
<tr><td>Mill Road South of Alfriston Road</td><td>11,000</td></tr>
<tr><td>Murphy’s Road North of Redoubt Road</td><td>10,500</td></tr>
</table></td><td colspan="3">The improved corridor will allow for reductions in journey time and will assist in easing of severe congestion (refer table below).
<table>
<tr><th>Peak</th><th>Design year</th><th>Travel time savings (mins)</th></tr>
<tr><td>AM northbound</td><td>2026</td><td>6–7</td></tr>
<tr><td>PM northbound</td><td>2026</td><td>6–7</td></tr>
<tr><td>AM southbound</td><td>2026</td><td>No significant difference over current corridor</td></tr>
<tr><td>PM southbound</td><td>2026</td><td>6–7</td></tr>
<tr><td>AM northbound</td><td>2041</td><td>10</td></tr>
<tr><td>PM northbound</td><td>2041</td><td>10</td></tr>
<tr><td>AM southbound</td><td>2041</td><td>No significant difference over current corridor</td></tr>
<tr><td>PM southbound</td><td>2041</td><td>8</td></tr>
</table></td></tr>
</table>

<table>
<tr><th></th><th></th><th>Baseline</th><th>Effects</th><th>Avoid/remedy/mitigate</th><th>Residual effects</th></tr>
<tr><td></td><td></td><td>Frequency and operational hours of current bus services
<table>
<tr><th>Service</th><th>Hours of operation</th><th>Frequency</th></tr>
<tr><td>457/457X Otahuhu, Downtown via Otara</td><td>6.25am–10pm, 3.05pm–6.30pm</td><td>10–45 min</td></tr>
<tr><td>466 Manukau City Centre to Manurewa via Everglade Terrace and the gardens</td><td>6.25am–7.20pm</td><td>30 min</td></tr>
<tr><td>497/497X Otahuhu, Downtown via Otara</td><td>5.30am–11.10pm</td><td>20–60 min</td></tr>
<tr><td>566 Wattle Downs to East Tamaki via Wiri, Manukau City and Chapel Road</td><td>6.25am–7:20pm</td><td>30 min</td></tr>
<tr><td>580 Manukau City Centre to Howick via Stancombe Road and Botany Town Centre</td><td>6.10am–7.10pm</td><td>15–35 min</td></tr>
</table></td><td></td><td></td><td></td></tr>
<tr><td></td><td>Monetise</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Provision of community spaces/facilities</td><td>Qualitative</td><td>Church of Jesus Christ of Latter-day Saints Meeting House is used for Sunday services and holds monthly conferences, as well as providing accommodation for visiting missionaries. There are three additional places of worship in the area, including the Manurewa Assembly of God and St Elias Catholic Church. There is also the Dharmmapark Suandham Rightview Buddhist Foundation which has 5 on-site monks and an adjoining shed used for events.
There are two motels, the Manukau Heights Motor</td><td>Temporary effects during construction to Church of Jesus Christ Latter-day Saints, the two motels, Totara Park Equestrian Centre, Manurewa Assembly of God and Buddhist Foundation as there will be interruption to access points, leading to a loss in patronage and</td><td>Access to Totara Park will be maintained during construction with changes communicated.
There will be collaboration with Parks and Reserves and Totally Totara to advise park users during construction and remedy affected mountain bike trails. The project spoils can be used to enhance existing trails in the park.</td><td>There will be increased recreational space for cyclists on the abandoned section of Mill Road.
There will be a land addition to St Johns Redoubt Reserve, including more than doubling its road frontage. This will allow</td></tr>
</table>

		Baseline	Effects	Avoid/remedy/mitigate	Residual effects
		Lodge and the Redoubt Motel, both located in NOR 1. Guiding New Zealand's Taha-Whaia Woodside Hall is a meeting house and serves as accommodation for the region's Girl Guides. Totara Park Equestrian Centre is shared by Riding for the Disabled, Totara Park Pony Club and Totara Park Adult Riding Club. There is a council-owned hall which is used for a weekend community market and for other community activities. Alfriston School provides the school community with access to their swimming pool over summer. It also has an all-weather turf sporting facility which is used by the community. There are two primary schools in NOR 1 (Redoubt North Primary School and Everglade Primary School), both of which are located away from the Redoubt Road corridor on residential feeder roads (further information in section above). Healthcare facilities include the Manukau Super Clinic, a Family Service Centre and Dental Hub at Chapel Downs School in NOR 2, the Ormiston Hospital and Totara Hospice. There is also the Counties Manukau Police (District Headquarters), Manukau Fire Station and St John Ambulance station close to NOR 1. The Manukau Super Clinic does not offer primary healthcare or emergency medicine and these patients typically travel to Middlemore Hospital. St Johns Redoubt is a reserve that contains the remains of a fort from the 1863–64 Waikato Wars. Totara Park is the significant recreation resource in the area and spans all NOR packages. It includes walking tracks, mountain biking trails, equestrian bridle trails, an adventure playground, swimming pool and tennis court. There are informal recreation	associated income. One of the motels will be acquired as part of the project which will result in a loss of visitor accommodation. Access for horse riders, pedestrians and mountain bike trail users will be impacted during construction, potentially leading to a reduction in usage. Some mountain bike paths in Totara Park will be removed and/or altered by the road widening and development of wetlands. A section of the 'Pony Express' mountain bike track will be permanently lost.	Potential for land acquisition outside of Totara Park and adding it to the park to retain the size of the park. A social impact and business disruption delivery work plan and social impact management plan will be finalised in detailed design of project. They will be developed as the project progresses to respond to the project's impacts.	the development of off road parking space and greatly increase the recreational amenity value of this area. Once construction has been completed, access to community facilities will be restored which will ensure usage of facilities is back to normal.

		Baseline	Effects	Avoid/remedy/mitigate	Residual effects
		activities including orienteering, boot-camps and running groups at the Wairere Road entrance. Murphy's Bush is located in NOR 2 and is a recreational reserve for families and school groups. However, this is a known area for inappropriate behaviour and Police surveillance has been increased alongside urban design measures to increase safety.			
	Quantitative	Church of Jesus Christ of Latter-day Saints Meeting House accommodates up to 1,000 people every Sunday (groups of up to 300 people in 3-hour blocks). Up to 1,000 people attend the monthly conferences. There are up to 40 missionaries on the property at a time. The Dharmmapark Suandham Rightview Buddhist Foundation is 12 acres and has at least 10 vehicles visiting the site each morning and regular events can attract up to 100 cars to the site. The Manurewa Assembly of God has a congregation of 160 parishioners. The Manukau Heights Motor Lodge has 21 rooms and the Redoubt Motel has 12 rooms mostly inhabited by long-term occupants. The Totara Park Equestrian Centre leases 30 acres of Totara Park from the council. The Dental Hub in NOR 2 is expected to treat 4,400 patients per year. St Johns Redoubt has an area of 0.419 ha – 11,000m^2 according to recreational assessment. Totara Park has an area of around 216 ha. There are 10–12 km of mountain bike trails with a long-term plan of increasing this to 30 km.	Acquisition of 77,690 m^2 of land within Totara Park	Return of 14,933 m^2 to Totara Park post-construction.	Permanent acquisition of 66,150 m^2 of Totara Park (2.91% of total). The size of St Johns Redoubt Reserve will be increased by 20%, 2,000 m^2.
	Monetise				

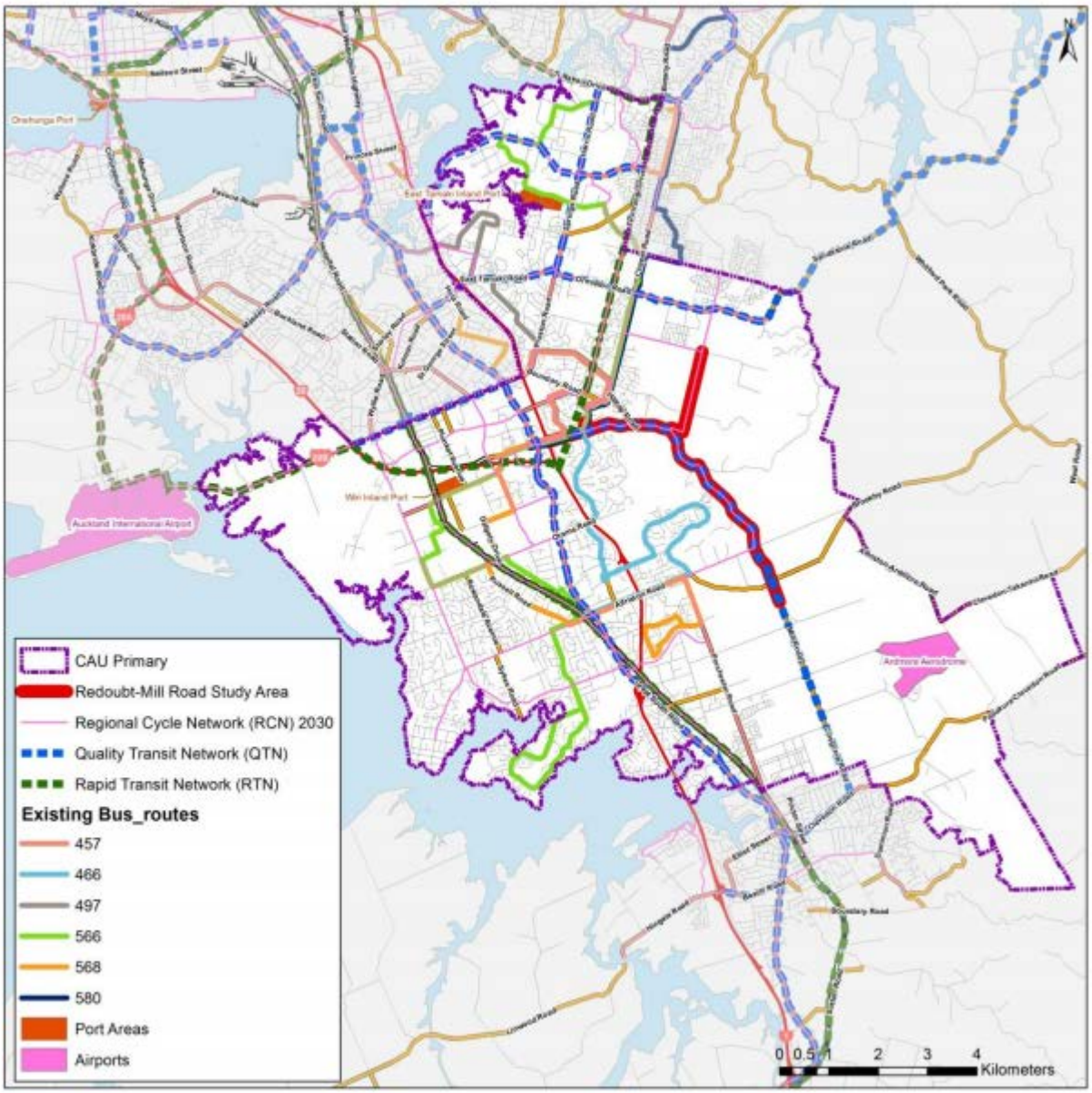
		Baseline	Effects	Avoid/remedy/mitigate	Residual effects
Impacts on the community's physical environment	**Qualitative**	NORs 2 and 3 are predominantly rural areas with low density housing and significant areas of vegetation, including Totara Park. There is no/minimal street lighting on these sections. NOR 1 is a predominantly urban area with moderate density housing and street lights.	There will be vegetation clearing, especially at the intersection of Murphy's Road and in the areas of new alignment. This also includes a loss of native vegetation. There will be some changes to property boundaries, property acquisitions and the subsequent demolition of dwellings that will impact on the visual amenity of the area. There will be increased impacts for people who live near the corridor with retaining walls and batter slopes visible from their property and potentially impacting views. The new road alignment, including the bridges will change the existing visual landscape. Street lighting will be introduced in NORs 2 and 3. This can cause additional stress and sleep deprivation for affected residents. Construction noise may disrupt residents and business owners especially if night works are carried out. Operational noise due to vehicle movement on the	There will be early replanting of vegetation and landscaping screens where possible to mitigate changes to the rural outlook. This will include an early planting programme that will occur prior to physical works occurring. Replanting of native vegetation, which is required as part of the designation conditions. There will be communication with affected landowners to mitigate changes to visual amenity specific to individual properties. Construction noise will be managed through designation conditions and management plans. Stakeholders sensitive to night works will be identified and construction staged to limit night works around these stakeholders. Operational road noise will be mitigated by the detailed design, which may include traffic calming options and low noise surfacing and will comply with noise standard NZS6806:2010. A contact person will be available 24/7 during construction to respond to public queries regarding community health. Air quality and noise will be considered in the methodology and sequencing of construction.	Lighting along the new route will increase safety for multi-modal users and reduce crash risks. Replanting of vegetation (and native vegetation) will ensure there are minimal adverse residual effects in regards to the visual amenity of the area. The design has been carefully considered so it will accommodate the future urban and rural character of the corridor, as well as the natural and topographical landscape features. New landscaping within the urban section will visually narrow and reduce the dominance of the road to improve the amenity for residents and users. The boundary with Totara Park has been kept as open as possible to maintain views into the park and towards the Manukau Harbour/ Manukau Heads.

		Baseline	Effects	Avoid/remedy/mitigate	Residual effects
			road may also disrupt residents and business owners in close proximity to the road. Dust will be generated during construction with the potential to adversely impact the health of the surrounding community. There is also a perception that increased vehicle emissions may have an adverse impact on the health of the community. Dwellings in close proximity to the construction works will be affected by vibration. The time frame of the construction will mean there are long periods of construction effects in all NOR corridors.	A social impact and business disruption delivery work plan and social impact management plan will be finalised in detailed design of project. It will be developed as the project progresses to respond to the project's impacts. A construction environmental management plan will be prepared and implemented during the construction phase.	
	Quantitative		There will be permanent acquisition of 66 residential dwellings and permanent acquisition of 226 portions of land parcels.		
	Monetise				
Community engagement (licence to operate)	**Qualitative**	Community engagement began in August 2008 when open days by the Papakura District Council and Manukau City Council were held. Stakeholder consultation was carried out in 2009 and 2010 but a preferred route was not adopted and designation did not occur. The current scheme assessment began in February 2012.		The consultation plan says the purpose of consultation is to inform affected parties, gather knowledge, understand views and take them into account, respond to concerns and reduce misinformation. It is not required under the RMA but it is	Consultation and community engagement is an ongoing process and will be dealt with through the social impact and business disruption delivery work plan and in

		Baseline	Effects	Avoid/remedy/mitigate	Residual effects
		There were public perceptions that a route had been confirmed and designated in 2009. This created confusion and anxiety for many property owners when a different alignment was presented in October 2012. Some residents believe the prolonged planning phase is impacting on future plans for some property owners who await certainty and accurate timeframes for property acquisition. Many residents have expressed concern that the planning phase is having a negative impact on property values and has ruined the area. A number of residents oppose the project on social, environmental and economic grounds. Opposition to the project centres on the high cost, the number of properties affected and the rationale for the project. Frustrations with the residents that the construction of the project will take 20 years to be completed and will not be finished within their lifetime. Concerns were also expressed by residents in regards to operational noise, loss of vegetation, loss of security and privacy and a reduction in safety. Comments from a number of attendees at the public information days expressed positive feedback about the increased capacity on the urban section, noting current increased traffic delays at peak times. Provision of a high frequency westbound bus corridor received positive feedback.		important as it can lead to better relationships with the community and can lead to consideration of alternative alignments. Communicate information about the Public Works Act rights to homeowners. Communicate with cycling associations and shops to inform them of road works schedule as well as use of text messages and websites to advertise changes tor road conditions. Require contractor to conduct stakeholder management during construction. Liaise with clubs affected by works and maintain a subscription service to keep motorists aware of construction effects. Neighbourhood BBQs to be hosted by the project during construction to bring residents together over the project. Use Church of Jesus Christ of Latter-day Saints Meeting House database to inform members of changes to access to the church. Keep community informed about interruptions to access to community facilities and explain mitigations and design solutions. Communicate property acquisition to neighbours of affected properties.	accordance with the consultation plan. This will ensure that the community is kept up to date with the proposal throughout the duration of works.

		Baseline	Effects	Avoid/remedy/mitigate	Residual effects
				Collaboration with affected residents on revegetation plans. Communicate conditions related to noise, vibration and air quality and proposed mitigation measures to property owners. Maintain engagement with iwi in case of disturbance of unknown cultural sites. Collaborate with Parks and Reserves and Totally Totara to communicate with park users about impact on Totara Park and work with community to restore trails. Provide a community liaison staff member to alleviate concerns regarding contractors. Develop noise complaint protocols. Community was consulted on proposed alignments for feedback and used to test the MCA developed. Communicate with motorists to indicate clear timeframes for construction works through additional signage and advertising. Communicate access to Totara Park with park users.	
	Quantitative				
	Monetise				

Figure H.1 Transport patterns and community connections: public transport provision



Source: AECOM New Zealand (2014)

Appendix I: Te Atatu Road case study

Capture of the following benefits was undertaken:

- stormwater quantity and quality
- social impacts

These were considered the most material effects of the scheme as aligned with this research. The requirement to gain a consent for contaminated land is noted, although we were informed that no contaminated material (coal tar) was found on site during construction.

Table I.1 Stormwater benefits, Te Atatu Rd

		Baseline	Effects	Benefits of meeting the requirements of environmental legislation	Residual effects
Stormwater	**Qualitative**	The existing Te Atatu Road is a four-lane urban arterial road which follows a natural ridgeline. This narrows to a two-lane road at the roundabout with Edmonton Road and Flanshaw Road which are both two-lane urban arterial roads. Stormwater flows discharge to the north or south-east of the road. The existing stormwater management system is a network of council owned and managed reticulated stormwater system serviced by kerb and channel drainage. This project passes through 3 catchment areas, which are defined as mainly medium density residential development. The Te Atatu South Stormwater Catchment covers an area of 589 ha and drains in the southerly direction to the receiving environment, which is the tidal reaches of the Whau River. The Te Atatu Peninsula Stormwater Catchment is around 478 ha and drains to the north to Pixie Stream and ultimately the tidal reaches of the Henderson Creek. The Henderson Creek Stormwater Catchment is around 193 ha and includes Edmonton Road. The receiving environment is Henderson Creek.	The widening of the road creates a more impervious surface area in the catchment. The impact of this is to increase the volume and peak flows of stormwater in the road area. This extra stormwater volume can have effects on the receiving environment by downstream channel erosion. This can also increase the amount of stormwater contaminants received by the environments including gross pollutants, sediment and metals with associated impacts on the ecology of the stream and coastal environments.	The works will use existing stormwater infrastructure as much as possible. The stormwater management proposed will treat not only the additional impervious surfaces created during the project but the existing impervious surfaces in the subcatchments that include the project area to mitigate any incremental or adverse cumulative effects. Stormwater from the westbound ramp onto SH16 to the intersection of Te Atatu Road and Jaemont Ave will be diverted and treated in the Transport Agency Treatment Swale constructed for the Waterview Project. This will then be discharged in Pixie Stream via Transport Agency system permit No. 38324. Stormwater360 Stormfilter Tanks (cartridge filters) in the road reserve of Vera Road and Lyndhurst Road will be used to treat stormwater to be discharged into the existing council stormwater outfall into Pixie Stream then to Henderson Creek and Whau River respectively. The catchment area that currently discharges directly into Henderson Creek has a very small increase in impervious area and additional treatment to the existing stormwater management was not required. Flow from the subcatchment that currently discharges into Pixie Stream will be diverted to the subcatchment that discharges into Whau River to more than offset the increase in discharge into Pixie Stream and ensure the volume discharged into Pixie Stream does not increase.	Outcome is a stormwater design to meet council expectations as set out in PAUP and TP10, which is deemed adequate to protect stream ecology.

		Baseline	Effects	Benefits of meeting the requirements of environmental legislation	Residual effects
		Pixie Creek is a Type 4 (highly disturbed) urban stream due to the high amount of impervious land in the catchment and is not a significant corridor for fish passage. It is of moderate ecological value. Henderson Creek and Whau River are scheduled as Coastal Protection Area 2 under the Regional Coastal Plan and are located in the Upper Waitemata Harbour Area of Significant Conservation Value.			
	Quantitative	The existing impervious area is 58,604 m^2 in the affected sub catchment areas. The project area affects 1.4 km of road.	The project involved an increase in impervious area of 6,854 m^2. The total catchment area treated is 65,456 m^2.	22,890m^2 (3,033m^2 increase) will be treated at the Transport Agency treatment swale. This will remove 80% of suspended solids (more than the required 75% TSS). 10,545 m^2 (1,323 m^2 increase) will be treated with cartridge filters and discharged into Pixie Stream (then Henderson Creek). 20,066 m^2 (2,129 m^2 increase) will be treated with cartridge filters and discharged into Whau River. The increase in impervious area for the Henderson Creek Stormwater Catchment was 369 m^2 (of 11,955 m^2 total) so the impacts were minor and no change in treatment system is required. Approximately 2,000 m^2 of piped flows will be diverted from the subcatchment that discharges into Pixie Stream to discharge into Whau River. 2 cartridge filter systems.	
	Monetise	Not possible			

Source: MWH (2014b); MWH (2014c)

Table I.2 – Social benefits, Te Atatu Rd

		Baseline	Effects	Benefits of meeting the requirements of environmental legislation	Residual effects
Community connectivity and accessibility	**Qualitative**	**General connectivity/ accessibility:** Te Atatu Road is a four-lane (two in each direction), arterial route for persons travelling from west Auckland suburbs to the north-western motorway (SH16) via the adjoining local road network. Delays and congestion are major issues along Te Atatu Road and at the motorway interchange. Bus stops are located along Te Atatu Road and Edmonton Road, which are significant thoroughfares for west Auckland public bus services. There are existing footpaths on both sides of Te Atatu Road; however, there are no existing on or off road cycle facilities. The majority of properties along Te Atatu Road have access via the front boundary and include on-site parking.	One or more road lanes may be closed during construction, which will cause inconvenience for road users and cyclists, and may create traffic delays. There will be a delay when turning right into Covil Avenue due to the phasing priority given to Te Atatu Road. There will also be a delay on Vera Road and Jaemont Avenue. There will be delay at SH16's westbound off-ramp which will create additional queues and delays on the motorway. The lane width will be reduced to less than 3m wide and reduce the accessibility of the road for cyclists during construction. Small impacts to public transport operations during construction as works will occur through existing bus stops. Pedestrian access to Te Atatu Road will be affected during construction. Use of water filled barriers to separate the construction works from the travel could severely impact access to private properties along Te Atatu Road.	A traffic management plan will be prepared and implemented to mitigate accessibility issues. This will include guidelines for construction hours, personnel parking, construction sequencing and restrictions on construction traffic movements. It will also include a comprehensive project communication plan. Variable messaging boards and other communication mediums, for example radio advertisements will be used to advertise alternative routes to avoid traffic delays. Most construction-related trips will occur outside of commuter peak hours and most of the required equipment will remain on-site, as well as any suitable excavated material. This will reduce the need for traffic movements to and from the site. Reduce speed limit to 30 km/h with lane width reduction so the speed of cyclists and vehicles is similar and it is therefore safer for the cyclists and reduces delay. At the Countdown Supermarket a right-turn pocket will be	Increase in connectivity for cyclists as a cycle path is constructed on the northbound side of Te Atatu Road and a shared path elsewhere. The cycleway facilities provide a direct connection to the north-western cycleway along SH16, connecting west Auckland to the Auckland Isthmus. Installation of central flush median to increase safety of access into private properties along the road. This will also alleviate traffic delays and congestion, as a vehicle waiting to turn right will remain clear of the traffic. Improved traffic efficiency with improved intersection arrangements (ie 2 lanes of traffic not hindered by buses or turning vehicles and installation of traffic lights to replace roundabout). Enhanced public transport infrastructure will provide

		Baseline	Effects	Benefits of meeting the requirements of environmental legislation	Residual effects
				provided for the main entrance along Te Atatu Road South to retain access to this service. Temporary bus stops will be installed and continuous monitoring of public transport services in the construction area will be carried out. Pedestrian access will be maintained during construction on at least one side of Te Atatu Road. Vehicular access to properties will be maintained as much as possible. However temporary bridges may be used to ensure access is retained. If this is not possible, temporary parking for the owner will be arranged. Contractor will be required to communicate with property owners who will have restricted access to indicate the timeframe of effects to their property. Access will be re-established for private property owners, with earthworks to ensure the slope of the driveway is acceptable for vehicle access. Car ports will also be replaced.	better connectivity and accessibility for the community. There will be improved pedestrian facilities at intersections to increase pedestrian accessibility to the area.
	Quantitative	The Te Atatu Road corridor carries approximately 37,000 vehicles per day (as of 2012) Expected maximum number of construction delivery trips to be 134 delivery trips per day or 18 delivery trips per peak period.		Proposed 1.5 m on road southbound cycleway and a 2.5 m to 3.0 m shared use path on the north side of Te Atatu Road.	

		Baseline	Effects	Benefits of meeting the requirements of environmental legislation	Residual effects
		10 minute increase in delay turning right into Covil Avenue (which carries 156 cars in morning peak) and up to 7 minute increase in delay at Jaemont Avenue and Vera Road during construction. SH16's westbound off-ramp expected to have additional delay of 31 seconds.			
	Monetise				
Provision of community spaces/ facilities	**Qualitative**	A commercial centre, including a supermarket and other small businesses is located at the intersection of Te Atatu Road with Flanshaw and Edmonton Roads.			
	Quantitative				
	Monetise				
Impacts on the community's physical environment	**Qualitative**	Te Atatu Road and Edmonton Road are defined as regional roads in the district plan and are therefore high noise routes. The properties have adapted to the fact they are situated on a regional arterial road and therefore the majority of dwellings are setback approximately 5–10 metres from the road boundary. Many of the properties have shrubs, hedges or trees planted in the front yard, with many containing fences along the front boundary. There are sections of grass	The required construction, both during day and night-time, has the potential to exceed the relevant noise criteria. The construction will involve the use of heavy machinery operating in close proximity to dwellings which may be affected by construction vibration. The road/property boundary line is expected to change as a result of the new widening of the road. Due to this, a number of properties require new retaining walls, reinstatement of fences, a change in driveway gradient and the installation/ reconfiguring of existing vehicle crossings. Temporary loss of vegetation along property boundaries and removal of generally protected trees and some native vegetation will change the visual appearance of the Te Atatu Road corridor. There is potentially contaminated land that may be disturbed during construction. The effects of	There will be a construction noise and vibration management plan developed and implemented by the contractor. There is potential to exceed the noise criteria, which will need to be avoided through a consultation process and mitigation of construction noise. This will include notification of residents within 50 m of construction of the proposed works and providing a contact number. Construction activities will be staged to avoid creating excess noise at night-time. Avoidance of unnecessary noise such as installing mufflers onto trucks and quietening	Pedestrian facilities and landscaping along the entirety of the corridor will be upgraded, creating positive, long-term effects on the overall pleasantness and amenity of the corridor. There will be increases in operational noise for properties close to the widened road but this is considered to be mainly due to increase in traffic volumes over time which may have occurred independently. The character of the noise will

		Baseline	Effects	Benefits of meeting the requirements of environmental legislation	Residual effects
		berm and street trees, which are generally protected within the road reserve area. The road was built prior to 1980 and Auckland Council considers these roads often use coal tar in construction, which means this land may potentially be contaminated.	discharging coal tar contaminants could contaminate non-sealed land and soils, as well as discharging into water. This contaminant includes polycyclic aromatic hydrocarbons, which are toxic and can persist in the environment with impacts on human health. A requirement of works is that the corridor will remain lit during construction, leading to relocation of existing streetlights and installation of new street lights parallel to construction. Construction machinery and equipment will have an effect on the visual amenity of the area during the construction period. There is potential for the drift of unmanaged dust during the earthworks phase to cause nuisance to surrounding residential properties.	reversing alarms will also be carried out. There will be replanting of native vegetation. Loss of vegetation within individual properties will be mitigated through consultation with individual landowners, whereby replanting specifications and arrangements are being made in accordance with the landowner's preferences and specifications. A methodology will be developed to manage the disturbance and removal of soil that is potentially contaminated. Where possible, street lighting will be combined with traffic lights to reduce number of the poles in the corridor. An erosion and sediment control plan has been developed to mitigate dust and sediment effects. The proposed staging of construction will also assist in minimising the amount of exposed soil at any one time. Contingency measures have been put in place in the event of finding cultural or archaeological material during the construction. However, there are no known archaeological sites or waahi tapu within the area.	not change.

<table>
<tr><th></th><th></th><th>Baseline</th><th>Effects</th><th>Benefits of meeting the requirements of environmental legislation</th><th>Residual effects</th></tr>
<tr><td></td><td>Quantitative</td><td>Daytime sound levels vary from 62 dB to 75 dB LAeq and night-time sound levels vary from 60 dB to 71 dB LAeq.</td><td>Removal of 22 generally protected trees and works within the rootzone of 2 generally protected trees.
Three street lights were relocated prior to construction and 18 existing street light poles will be relocated during construction. 12m high poles.
Sound level predictions and assessment of effects
<table>
<tr><th>Position</th><th>Existing scenario</th><th>Do minimum scenario</th><th>Sound level difference</th><th>Adverse effect/ impact</th></tr>
<tr><td></td><td>Year 2012</td><td>Year 2026</td><td></td><td></td></tr>
<tr><td></td><td>$dBL_{Aeq(24h)}$</td><td>$dBL_{Aeq(24h)}$</td><td>Decibels</td><td>rdf</td></tr>
<tr><td>257 Te Atatu Rd</td><td>67</td><td>69</td><td>+2</td><td>Negligible</td></tr>
<tr><td>267 Te Atatu Rd</td><td>68</td><td>70</td><td>+2</td><td>Negligible</td></tr>
<tr><td>301 Te Atatu Rd</td><td>68</td><td>70</td><td>+2</td><td>Negligible</td></tr>
<tr><td>303 Te Atatu Rd</td><td>67</td><td>69</td><td>+2</td><td>Negligible</td></tr>
<tr><td>304 Te Atatu Rd</td><td>68</td><td>70</td><td>+2</td><td>Negligible</td></tr>
<tr><td>4 Fanshaw St</td><td>66</td><td>68</td><td>+2</td><td>Negligible</td></tr>
<tr><td>237 Edmonton Rd</td><td>67</td><td>69</td><td>+2</td><td>Negligible</td></tr>
<tr><td>241 Edmonton Rd</td><td>67</td><td>69</td><td>+2</td><td>Negligible</td></tr>
</table></td><td>Restoration planting, including:
• 33 pohutakawa trees
• titoki
• 6 cabbage trees.</td><td></td></tr>
</table>

<table>
<tr><th></th><th></th><th>Baseline</th><th>Effects</th><th>Benefits of meeting the requirements of environmental legislation</th><th>Residual effects</th></tr>
<tr><td></td><td></td><td></td><td>
Recommended construction noise criteria
<table>
<tr><th rowspan="2">Period</th><th colspan="6">Sound level (dB)</th></tr>
<tr><th colspan="2">Weekdays</th><th colspan="2">Saturdays</th><th colspan="2">Sundays and public holidays</th></tr>
<tr><th>L_{Aeq}</th><th>L_{Amax}</th><th>L_{Aeq}</th><th>L_{Amax}</th><th>L_{Aeq}</th><th>L_{Amax}</th></tr>
<tr><td>6.30–7.30</td><td>55</td><td>75</td><td>45</td><td>75</td><td>45</td><td>75</td></tr>
<tr><td>7.30–18.00</td><td>70</td><td>85</td><td>70</td><td>85</td><td>45</td><td>75</td></tr>
<tr><td>18.00–20.00</td><td>65</td><td>80</td><td>45</td><td>75</td><td>45</td><td>75</td></tr>
<tr><td>20.00–00.00</td><td>60</td><td>75</td><td>45</td><td>75</td><td>45</td><td>75</td></tr>
<tr><td>00.00–6.30</td><td>45</td><td>75</td><td>45</td><td>75</td><td>45</td><td>75</td></tr>
</table>
Shading: Dark grey – increased noise limit for night-time construction works.
</td><td></td><td></td></tr>
<tr><td></td><td>Monetise</td><td colspan="4"></td></tr>
<tr><td>Community engagement (licence to operate)</td><td>Qualitative</td><td>A consultation strategy was established, which identified key stakeholders, directly affected parties/ adjacent landowners and other stakeholders.
A consistent theme from the consultation phases was the support for an off-road</td><td>The results of the consultation (feedback forms, online submissions) were used where possible to modify the detail of the project design. For example, there was significant support for an off-road cycleway and this has been included into the project in the form of the shared path facility.</td><td>Both the contractor and Auckland Transport will provide representatives who are responsible for ensuring public information and landowner liaison meet the requirements of this upgrade. The contractor is required to notify all residents of the planned timeframe of construction works including</td><td>Ongoing consultation will continue to occur between Auckland Transport representatives and affected parties to keep them informed about the project.</td></tr>
</table>

		Baseline	Effects	Benefits of meeting the requirements of environmental legislation	Residual effects
		cycle way. Auckland Transport has undertaken consultation with iwi groups having potential interest in the proposed works. None of the seven iwi groups asked for a cultural impact assessment to be done for this project.		contact details and access information. Information boards will be erected at undetermined locations to inform the public of major changes to the corridor, such as traffic management plans. Residents will be notified when individual private property reinstatement works will be carried out and Auckland Transport will obtain resource consents for the works. It is planned that Auckland Transport will undertake further consultation before project construction begins. It is also planned that Auckland Transport and the contractor will keep the general public, road users and residents informed about the project.	
	Quantitative				
	Monetise				

Appendix J: Review of valuing noise impacts

J1 Review of valuing noise impacts

Advice on taking account of noise costs is provided in the EEM and in the Transport Agency's (2016d) *Guide to assessing road-traffic noise using NZS 6806 for state highway asset improvement projects*.

J1.1 EEM

The approach used in the 2016 EEM to value noise impacts is the same as that used in the original version (Land Transport NZ 2006), updated for changes in average property values. Based on international research using hedonic price valuations (studies of impacts on house prices), modified to reflect missing impacts or market failures, the EEM suggests the impacts of noise are 1.2% of the value of properties affected per decibel (dB) of noise increase (or decrease).

The property values used are national averages, rather than regionally specific values. This is because 'there is no reason to suppose that noise is less annoying to those in areas with low house prices' (EEM).

Using an average value of urban property of $450,000 and occupancy of 2.9 persons, this suggests an impact of $5,400/dB per property and $1,860/dB per resident affected. This is used to estimate an impact of $350 per household or $120 per person per annum. This appears to be based on a rounding of the values obtained using the standardised values of a 6% discount rate (EEM, section 2.5) and a time period of 40 years (EEM, section 2.6).

Thus the suggested formula for estimating noise impacts is:

$$\$350 \text{ per year} \times \text{dB change} \times \text{number of households affected}$$

J1.2 NZS 6806

The Transport Agency has adopted New Zealand Standard NZS 6806 (Standards New Zealand 2010) for assessing noise from new and altered state highways. The standard provides criteria and a mitigation design process, and where noise levels would exceed the criteria, NZS 6806 requires the Transport Agency to investigate options for reducing noise levels. Appendix D of the standard includes guidance on undertaking a CBA of noise mitigation options.

The NZS 6806 approach is slightly different from the EEM.

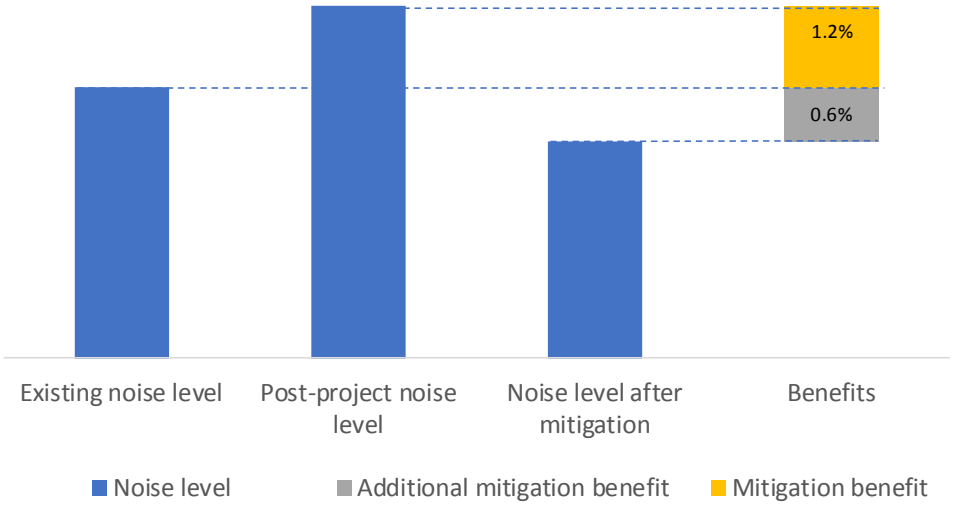
- It suggests using a median house price, rather than average, and suggests values are taken from the Real Estate Institute of NZ.
- The noise mitigation benefit is calculated as the sum of:
  - The noise mitigation benefit (a_i) is the benefit derived from mitigating the external noise effects which are also found in the base case. This is evaluated using the 1.2% of property value as suggested in the EEM
  - The additional noise mitigation benefit (b_i) is the benefit from mitigating the external noise effects which result from the new project, as opposed to the base case. This is to be estimated as 0.6% of the national median house price per dB and assumes there is a diminishing marginal return to noise improvement

- Internal noise mitigation benefit (c_i) is the benefit derived from mitigating the internal effects of a new or altered road in cases where building modification mitigation is necessary. It is suggested this is calculated using 0.3% of the national median house price.

Appendix D of the standard shows how the methodology applies under different circumstances, eg whether noise levels with the project and after mitigation are greater than or equal to the existing (pre-project) levels. The approach is shown in figure J.1. The analysis includes estimating a counterfactual scenario, with the project (new road or altered road) but with no mitigation; the difference between this and current noise levels is valued as the mitigation benefit using 1.2% of median property values. The difference between current noise levels and improved post-mitigation noise levels is valued using 0.6% of median property values. The internal noise mitigation benefit is calculated separately and, depending on whether other mitigation actions are taken, is 0.3% times the median house price times either:

- no other mitigation – the difference between the counterfactual noise level and noise levels with internal mitigation, or
- with other mitigation – the difference between the noise levels with other mitigation measures only and with internal mitigation.

Figure J.1 Mitigation benefits measurement approach in NZS 6806



In addition to guidance on benefit valuation, NZS 6806 provides indicative costs for noise mitigation measures including low-noise road surfaces, noise barriers, noise bunds and acoustic insulation. This is useful.

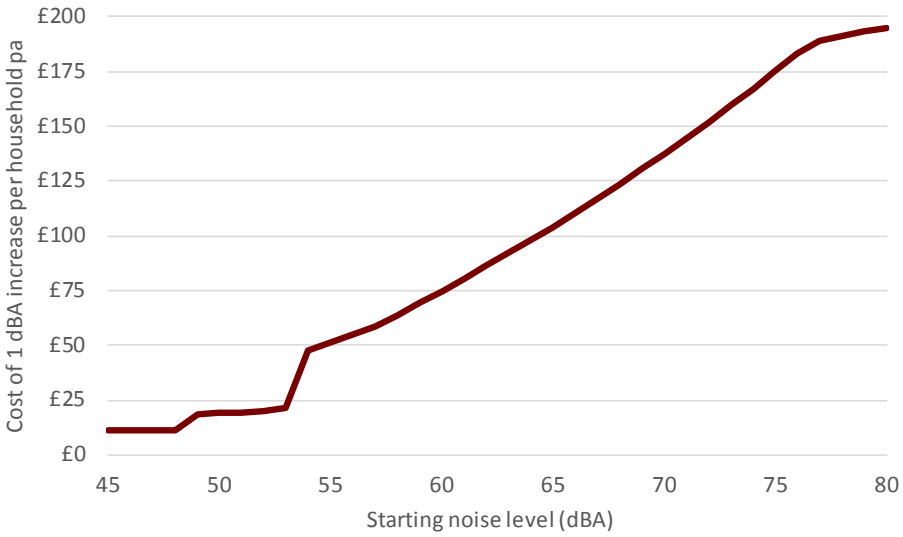
J1.3 Review of approaches

Whereas the 1.2% of house prices is derived from the literature, the basis for the 0.6% and 0.3% factors appears to be that of declining marginal benefits of noise reduction. This is consistent with the international literature (see figure B.2 in appendix B). However, unlike the UK approach which takes account of the starting noise level (see figure J.2 below), NZS 6806 simply assumes that preventing noise from getting worse than it is currently is worth twice as much (per A-weighted decibel (dBA)) as improvements in noise levels, no matter what the starting position.

Another question raised by the UK approach is that of the link to median house prices. Currently, the New Zealand approach will change the value of noise with changes in median (or average) house price. This

means recent increases in house values will change the marginal value of noise, and government policies to address housing affordability, if they result in lowering median house prices, will change the marginal value of noise also. Under the EEM (using average house prices), the estimated value of noise has increased by 84% between 2006 and 2016 (from $190 to $350 per household/dB). In contrast, the CPI has increased by only 21% over this period. If the marginal value of noise was indexed to the CPI it would be $230/household/dB in 2016 dollars.

Figure J.2 Marginal road noise values (2014 £/dBA) – cost of a 1dBA increase/benefit of 1dB reduction



Source: Data from www.gov.uk/guidance/noise-pollution-economic-analysis (accessed August 2017)

A full review of noise literature to understand these issues in more depth is beyond the scope of this report. However, it would appear that some aspects of the UK approach could usefully be adopted in New Zealand.

J1.4 Recommendation

We suggest the following:

- The value of noise reduction is measured on the basis of a marginal value at each decibel level, rather than differing depending on whether the end point (post-project) is above or below current levels.
- The marginal value is fixed at some time historically and is varied with CPI rather than house prices.

Appendix K: Glossary

AEE	assessment of environmental effects
AEP	annual exceedance probability
AMI	acute myocardial infarctions
ARC	Auckland Regional Council
ARI	annual recurrence interval
BCA	benefit-cost analysis
BCR	benefit-cost ratio
Benthic	The Benthic Community is made up of organisms that live in and on the bottom of the ocean floor
BondCM	Bond Construction Management
BoP	Bay of Plenty
Caltrans	California Department of Transportation
CBA	cost-benefit analysis
CEM	*Cost estimation manual* (NZ Transport Agency)
CO_2	carbon dioxide
COMEAP	Committee on the Medical Effects of Air Pollutants
CPI	Consumer Price Index
Cu	copper
CUA	cost utility analysis
DCF	discounted cash flow
Defra	Department for Environment, Food & Rural Affairs (UK)
D&PD	design and project documentation
dB	decibel
EC	environmental compensation
EEM	*Economic evaluation manual* (NZ Transport Agency)
EIANZ	Environment Institute of Australia and New Zealand Inc
ETS	Emissions Trading Scheme
EPA	Environmental Protection Agency (US)
EPT	E= Ephemeroptera, P= Plecoptera, T= Tricoptera, sensitive taxa
EV	existence value
FENZ	freshwater environments classification (New Zealand)
GPS 2015	Government Policy Statement on Land Transport 2015/16 – 2024/25
ha	hectare/s
IBI	index of biotic integrity
IFC	International Finance Corporation
IGCB	Interdepartmental Group on Costs and Benefits (UK)
IEEM	Institute of Ecology and Environmental Management
IRR	internal rate of return
IS	infrastructure sustainability
I&R	investigation and reporting
MBIE	Ministry of Business, Innovation and Employment
MCI	Macroinvertebrate Community Index

MCA	multi-criteria analysis
MEA	Millennium Ecosystem Assessment
MEC	marine environment classification
MfE	Ministry for the Environment
MSQA	management, surveillance and quality assurance
NIWA	National Institute of Water and Atmospheric Research
NOR	Notice of Requirement
NOx	nitrogen oxide
NPV	net present value
NZCPS	*New Zealand coastal policy framework 2010*
NZEnvC	Environment Court of New Zealand
NZSC	Supreme Court of New Zealand
NZU	New Zealand unit
PAUP	Proposed Auckland Unitary Plan
Plumes Litter	detritus or dead material added to the top layer of soil
PM	particulate matter
PARP:ALW	Proposed Auckland Regional Plan: Air Land and Water
QALY	quality adjusted life year
RMA	Resource Management Act 1991
SEV	stream ecological valuation
SMAF	stormwater management area flow
SQMCI	Semi Qualitative Macroinvertebrate Community Index
SROI	Social return on investment
TEEB	the economics of ecosystems and biodiversity
TEV	total economic value
TIO	transport investment online
TP10	Technical Publication Number 10
Transport Agency	NZ Transport Agency
TSS	total suspended solids
VOC	vehicle operating costs
VoLY	value of a life year
VoSL	value of statistical life
WFD	water framework directive
WTA	willingness to accept
WTP	willingness to pay
Zn	zinc