

Guide to using nature-based solutions in transport engineering

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1 Introduction

1.1 Purpose of this guide

This document provides guidance on the integration and application of nature-based solutions (NbS) in Waka Kotahi NZ Transport Agency engineering practices. Currently Waka Kotahi has a large programme of projects underway to improve the resilience of the state highway network, and the intent is that NbS are incorporated into the design process. This is intended to be a temporary guide until a comprehensive green engineering handbook is published by the Waka Kotahi Environment and Sustainability team.

1.2 Audience

As this document is a temporary guide, its intended audience is for internal teams and suppliers working on relevant projects which could incorporate NbS to meet Waka Kotahi environmental and resilience targets.

1.3 Definitions

The following are terms used in this guide.

Term	Definition
Nature-based solutions (NbS)	<p>Encompasses both green infrastructure and green engineering, as well as other approaches that use natural systems and processes to address environmental challenges. This includes, for example, using natural habitats to reduce the risk of flooding, or restoring degraded ecosystems to enhance their capacity to sequester carbon.</p> <p>NbS are defined in Te Mana o te Taiao – Aotearoa New Zealand Biodiversity Strategy 2020 as ‘Solutions that are inspired and supported by nature, cost-effective, and simultaneously provide environmental, social and economic benefits and help build resilience.’</p> <p>For the purposes of this document the term nature-based solutions is an umbrella term that encompasses all approaches that aim to address environmental challenges in sustainable ways. However, there are distinction between terms and practices which differentiate those approaches which in their totality support nature, from those that simply mimic or utilise natures services for example.</p>
Green engineering (GE)	The use of engineering principles and practices to design sustainable solutions. This can include techniques such as life cycle assessment, green chemistry, and sustainable materials.
Green infrastructure (GI)	Natural or nature-based features, such as planting, sand dunes, wetlands and green roofs, that provide multiple environmental benefits, such as water quality improvements, emissions reduction and reduced resource use, air quality improvement, or biodiversity conservation.
Grey engineering or hard infrastructure/engineering	Traditional, man-made structures and systems, often using concrete, steel, and other conventional materials, designed to address engineering challenges. These solutions typically do not contribute to the natural environment (ecological benefits) and often require high maintenance over time.

1.4 Background

NbS are actions that protect, manage, and restore ecosystems to address societal challenges while benefiting human well-being and biodiversity. They mimic natural systems and offer resilience to environmental changes. NbS aim to conserve nature, support infrastructure systems, reduce disaster risk, and achieve sustainable development goals.

NbS can be categorised into infrastructure, issue-specific, restorative, management and protection approaches. Waka Kotahi can drive infrastructure and issue-specific approaches, while restorative, management, and protection approaches require stakeholder collaboration through GE and GI as a pathway to more NbS.

Implementing NbS, GE, and GI in engineering practices is aimed at leading to value for money, environmental benefits, and social advantages, supporting infrastructure, disaster risk reduction, adaptation, and resilience goals. Proper classification (of NbS, GI, GE), and partner and stakeholder involvement are crucial for successful of NbS, GE and GI outcomes and awareness.

The process Waka Kotahi is seeking to follow to embed these concepts involves four steps:

1. publication of this guide
2. pilot projects and opportunities to realise and trial NbS, GI, and GE solutions, seeking examples of adaptive, staged and permanent examples – this guide and the projects implemented will be used to support the development of a *Green engineering handbook*
3. publication of a *Green engineering handbook*
4. updates to wider standards and guidelines.

2 When and how to use nature-based solutions

Nature-based solutions (NbS) are increasingly recognised by Waka Kotahi as effective and sustainable methods to address environmental challenges. NbS simulate or enhance natural processes using natural materials and vegetation, providing cost-effective and long-term solutions compared to traditional engineering approaches. By incorporating NbS, Waka Kotahi achieves improved environmental outcomes, reduced costs, and resilience to climate change, while enhancing the aesthetic value of infrastructure

At Waka Kotahi, we recommend implementing hybrid engineering solutions. These innovative approaches serve as sustainable alternatives to traditional hard engineering systems. By blending the best aspects of green engineering (GE) and green infrastructure (GI), we aim to create more environmentally friendly and resilient solutions for various projects.

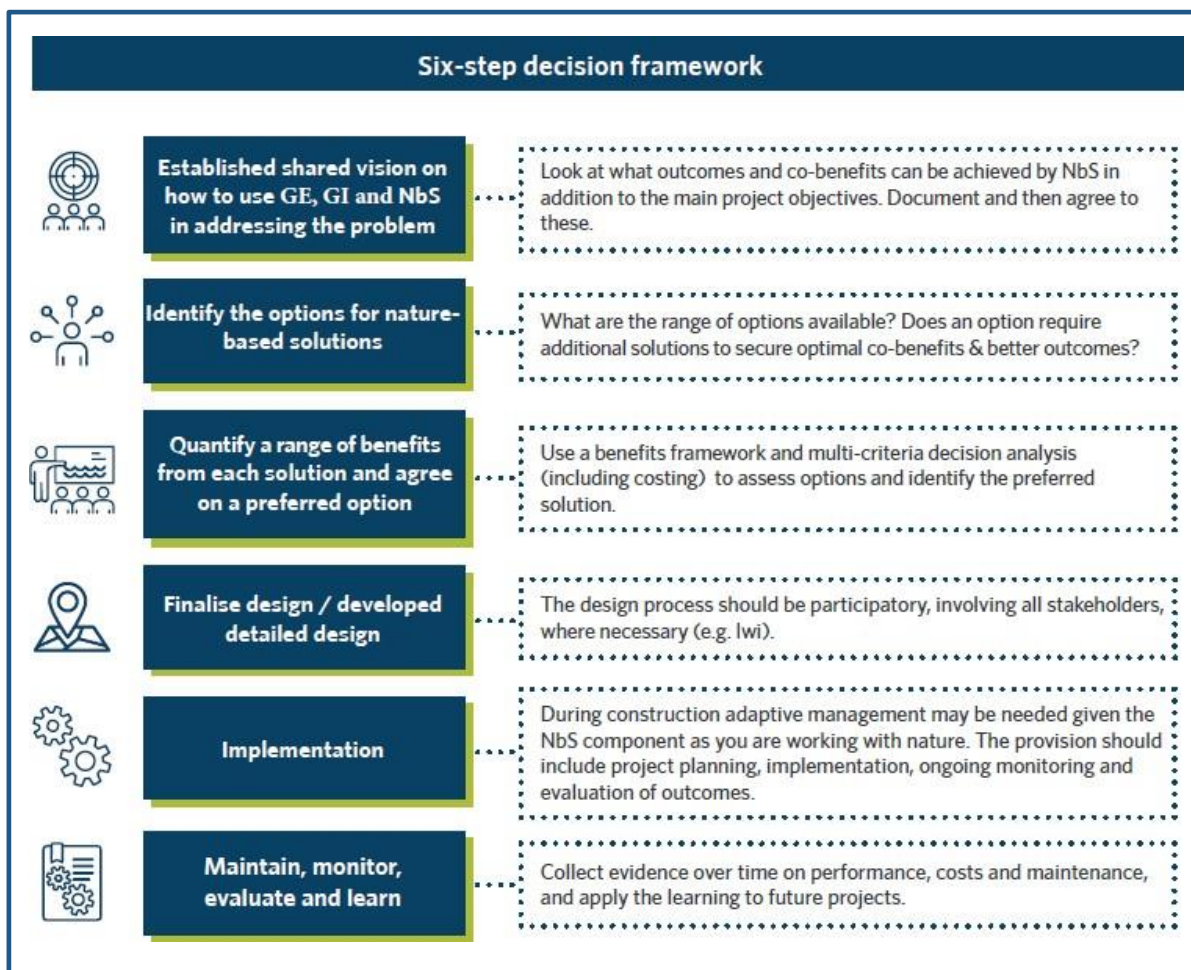
These solutions can be particularly useful:

- in isolated locations
- where permanent engineering solutions may be ineffective
- as part of water sensitive design
- where adaptive management such as flexibility and collaboration to address complex environmental challenges is necessary, and
- where the number of sites or likely events restricts the deployment of hard engineering.

Activities such as retaining walls, stormwater management, vegetation systems, erosion and slope protection can benefit from NbS, GE, and GI. Waka Kotahi is also developing guidelines (*Green engineering handbook*) for integrating NbS, GE, and GI into projects, further promoting their use as alternatives to hard engineering and promoting sustainable systems.

2.1 Design and selection decision framework

Our six-step decision framework for NbS, GE and GI is a comprehensive approach that integrates nature considerations throughout the project cycle. It ensures the early incorporation of nature or nature services into investment planning, maximising co-benefits and providing increased confidence in performance, costs, and maintenance.



2.2 Typical solutions

Waka Kotahi expects that NbS, GI and GE solutions to be considered and evaluated alongside other grey engineering options in determining emergency works, response, and recovery designs. This includes both in tactical and adaptive solutions, staged solutions, and for permanent solutions.

The following tables show NbS solutions as compared to grey engineering solutions in different areas.



Coastal Areas

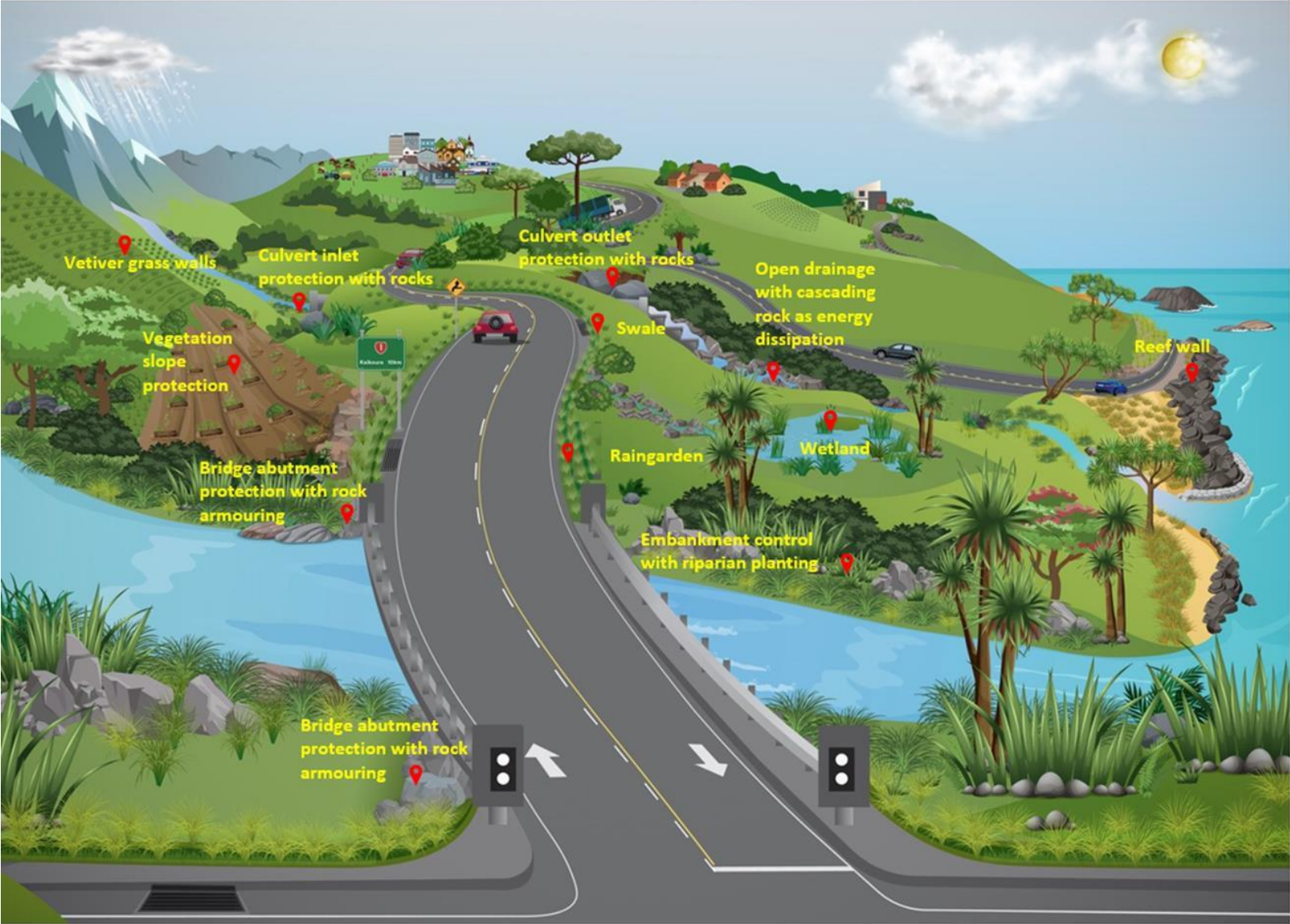
Solutions		Objective
NbS	Gray	
Restoration of inter-tidal flats and natural vegetation, mangrove where they exist	Combined with rock revetments and/or dykes	Protection from coastal erosion and coastal flooding (storm surge and sea level rise)
Dune restoration and beach nourishment	Combined with detached breakwaters or groynes system	Protection from coastal erosion and coastal flooding (storm surge and sea level rise), facilitate sediment accumulation
Marsh/mangroves restoration and reefs restoration	Combined with road elevation, breakwaters construction	Added protection of road and bridges from impact of wave energy
Pavement edge protection with rock armoured and/or vegetated swales	Combined with gabion baskets installed lower than the base layer	Protection of pavement edge erosion
Create reefs off-shore via local rock	Combined with traditional revetment wall structures	Hard shore reef development to break wave energy



Mountainous / General Areas

Solutions		Objective
NbS	Gray	
Slope drainage and revegetation (eg: restoration of grasslands and/or forests)	Combined with anchored mesh systems or check dams	Slope protection for erosion and landslide prevention, manage runoff
Planting of local plant species with root systems hold the soil materials together without compromising the overall soil structural stability. Wooden retaining walls/fences to stabilise soils	Anchored mesh systems and/or erosion control mats	Roadside stabilization and erosion and flood protection – co-benefits improve biodiversity / aesthetics as well
Upper slope: horizontal, vertical, and complementary drainage system slope re-profiling so that vegetation can grow and reduce slumping	Complemented by a system of protective barriers along the road and anchored mesh systems	Slope protection for erosion and landslide prevention and mitigation against the impact of rock falls.
Lower slope: Compacted embankment forming green terraces and vegetated retaining walls (eg: Flex MSE Vegetated Wall System, Vetiver Grass Technology)	Protected with geotextile, geogrids and Flex MSE	Slope protection for erosion control and road base scouring
Side of the road: swales (vegetated/rock etc), raingardens, wetlands, detention areas	Combined with associated structures with inlet/outlet structures (inlet manholes/catchpit/wing walls etc); where possible consider NbS solutions (eg: erosion protection with rock armoured)	Protect natural landscapes to minimize flood damages, improve water quality, and reduce erosion from stormwater runoff
Rock armoured around inlet and outlets of cross/side culverts as energy dissipators and protection around bridge footings	Combined with wing walls or protection mattresses around inlet/outlet areas and engineered solutions that allow vegetation growth (mesh systems, products with growing cells e.g. Geoweb(R))	Erosion protection within inlet/outlet of drainage system, protection to bridge piers and protecting the road edge from erosion
Cascading drainage pathway instead of pipe systems for sloping areas	Concrete steps or stone steps	Erosion protection using energy dissipating pathways and lower maintenance of open drainage pathways. Improve visual appeal
Pavement edge protection with rock armoured and/or vegetated swales	Combined with gabion baskets installed lower than the base layer	Protection of pavement edge erosion

Can nature help you solve problems and to achieve multiple outcomes? The figure below shows some examples.



3 Further information

Waka Kotahi has several guides, specifications, standards, articles, and discussions that provide examples of NbS. These include:

- [Stormwater treatment standard for state highway infrastructure – chapters 7–8](#)
- [Landscape guidelines](#)
- [Stormwater management](#)
- [P46 Stormwater specification](#)
- [Coastal effects assessment guideline for transportation infrastructure](#)

Further useful resources on this topic include:

- [United States Federal Highway Administration Nature-based solutions for coastal highway resilience: an implementation guide](#)
- [The Australian guide to nature-based methods for reducing risk from coastal hazards](#)
- [Multi-criteria analysis](#)