



Nature-based Solutions for Flood Mitigation: Summary Report

**Lessons learnt from Aotearoa New Zealand
feasibility studies**

29 May 2026

Prepared by WSP New Zealand

EXECUTIVE SUMMARY

The report synthesises lessons from 21 feasibility studies on nature-based solutions (NbS) for flood mitigation across Aotearoa New Zealand. The studies were funded by the Ministry for the Environment through the Jobs for Nature programme and delivered by 15 councils and unitary authorities. They cover rural, urban, and coastal contexts. Together, they explore how working with natural or modified ecosystems can reduce flood risk while delivering wider environmental, cultural, and community benefits.

The report summarises assessment approaches, stakeholder engagement, and mana whenua partnership across the studies. It identifies key findings and outlines next steps to move from feasibility to implementation. WSP reviewed project reports, catalogued key information, and interviewed project teams to confirm scope, methods, and outcomes. A Bay of Plenty Regional Council memorandum was also reviewed to provide additional insight on the benefits and limitations of NbS.

Key findings:

- **NbS can reduce flood impacts under certain conditions.** Multiple studies demonstrate measurable reductions in peak flows, delays in flood timing, and reductions in flow velocity. These benefits are most evident during smaller and more frequent flood events.
- However, **NbS are not a silver bullet for flood mitigation.** Their effectiveness varies across catchments and scenarios. Performance typically reduces during more severe flood events. Engineered flood protection remains one of a series of intervention strategies to be considered – but NbS can play a role as an alternative, complementary, or hybrid approach.
- **NbS are highly context-specific.** Effectiveness depends on catchment characteristics, scale, and NbS type. Cultural, social, ecological, and economic factors also influence feasibility. The location and design of interventions within the catchment are critical to performance.
- **Assessment methodologies vary widely.** Methods differ across studies, reflecting a wide range of technical, cultural, and economic considerations. Across the feasibility studies, NbS were most often assessed using hydrological and/or hydraulic modelling, complemented by GIS suitability analysis, geomorphic and soil assessments, multi-criteria analysis, and economic assessments.
- **Scale and integration are critical.** Catchment-wide implementation and combinations of NbS provide the greatest benefit. Individual interventions are unlikely to fully mitigate flooding during less frequent and more severe events.
- **NbS deliver multiple co-benefits.** These include environmental, cultural and community outcomes. Co-benefits are central to the value and business case for NbS.
- **Meaningful stakeholder and mana whenua engagement is essential.** Early and well-resourced engagement improves assessment quality and supports future implementation. Approaches ranged from limited consultation to co-governance and iwi-led delivery. Effective engagement builds confidence, supports decision making, and aligns outcomes with community and cultural priorities.

Most of the feasibility studies have not yet progressed to detailed design or delivery. Councils are using the findings to refine priorities, improve datasets, and explore funding pathways. Progress will require sustained funding, long-term monitoring and maintenance planning, and clear governance arrangements and allocation of responsibilities.

Key concerns and constraints raised about NbS implementation include funding, capacity, land availability, governance clarity and mandates, and uncertainty about performance. While the interdisciplinary nature and scale of NbS increase complexity compared to more traditional engineered solutions, many of these challenges affect the wider flood management sector, particularly during ongoing legislative reform to both resource management and local government.

Next steps for the sector

The studies show growing momentum for NbS in Aotearoa. To move from feasibility to implementation, further sector development is required. Priority actions include:

- **Strengthen the evidence base.** Analyse existing NbS studies and related interventions to improve confidence in their effectiveness (through investment in post-implementation monitoring) and better understand co-benefits.
- **Support policy uptake.** Use emerging evidence to influence resource management reform and guide councils in the evolving policy environment.
- **Unlock funding pathways.** Enable pilot projects and implementation through public, private, and alternative funding mechanisms. Quantifying costs and multiple benefits will strengthen business cases.
- **Develop Aotearoa-specific guidance.** Provide consistent, evidence-based frameworks for NbS assessment and implementation that reflect local conditions and contexts.

1. INTRODUCTION

ABOUT THE NbS FEASIBILITY STUDIES

The Ministry for the Environment funded 15 regional councils and unitary authorities to undertake a total of 21 feasibility studies on the use of nature-based solutions (NbS) for flood mitigation. The \$5 million in funding, part of the Government's Jobs for Nature initiative, supported these councils to explore how nature-based interventions can be used to mitigate river or coastal flood risk in partnership with mana whenua and local communities. While led by councils, nearly all projects used external support, mostly via consultants but also from universities, Crown Research Institutes, and trusts. Multiple projects were carried out in partnership with mana whenua or other organisations. The two-year projects were completed in June 2025.

As detailed in this summary report, the projects used a diverse range of methodological approaches to explore the potential of NbS for flood mitigation in local catchments, from quantitative hydraulic and hydrological modelling of effectiveness to investigations of broader feasibility through Mātauranga frameworks, community and landowner engagement, spatial and economic assessments, and other approaches. Most focused on rural catchments (eighteen studies) with others targeting urban contexts (three studies). The maps on pages 5-6 provide an overview of the feasibility studies and Appendix A includes a list of the projects and associated councils.

Each of the studies is applicable to a specific location, inclusive of the soils, topography, and climate of that location. Individual study findings are not necessarily transferable to other locations.

ABOUT THIS REPORT

This summary report synthesises the approaches and findings across the NbS feasibility studies. It summarises the methodologies, engagement, and results from the cohort of studies with high level commentary, and highlights three case studies to showcase the breadth of approaches taken. While not a good practice guidance document, this review identifies emerging common practices and themes from the studies.

WSP, with support from the River Managers Special Interest Group, contacted council project teams to obtain the final or near-final project reports between November 2025 to February 2026. The project reports were then reviewed and catalogued for analysis. WSP scheduled interviews with most of the project teams, including council leads and staff and/or their consultants to confirm key project information. Bay of Plenty Regional Council (BoPRC), which has tested the feasibility and implementation of NbS through various projects separately from the MfE-funded cohort of feasibility studies, developed a memorandum on the *Limitations of Nature-based Solutions for Long-Term River Flood Mitigation* (December 2025) which it provided to WSP. WSP also considered BoPRC's memo for high level commentary on the benefits, effectiveness, and limitations of NbS in developing this summary report.

This summary report follows the post-workshop summary report (June 2025) of the national mid-project workshop held in Blenheim in March 2025 to capture and exchange preliminary insights and experiences from the feasibility studies as they entered the final stages of project delivery. The post-workshop report documented lessons learned up to March 2025 about project approaches, delivery of the feasibility studies, and implementation needs, and issued recommendations to further support NbS for flood mitigation in Aotearoa.

It should be noted that this current report is not a comprehensive compendium of all of the approaches and findings from the feasibility studies. Accordingly, we encourage interested readers to explore projects relevant to their unique context through the individual project reports or by reaching out to the corresponding council for further information. Specific findings from each study should be considered in the context of the local catchment and the limitations of the methodological approach undertaken. Publicly available materials from the feasibility studies will be listed on the Resilient River Communities website.



Note that for consistency, this summary report uses the project titles confirmed by project teams at the mid-project workshop in March 2025 for the one-page overviews in the post-workshop summary report (June 2025). Formal project names may differ.

For two studies (Horizons Regional Council and Waikato Regional Council blue carbon), only prior publicly available information was used in the review due to lack of access to the final reports during analysis.

1. INTRODUCTION

ABOUT NbS

Nature-based solutions (NbS) are “actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services, resilience and biodiversity benefits.”

– UNEP-UNEA 5.2

As per the UNEP definition above, NbS constitute working with nature to address challenges (like flood mitigation) while providing a range of benefits. A variety of types of NbS can be used to support flood mitigation, with a range of options across upper, middle, and lower catchments as well as different ecosystem contexts (see Figure 1).

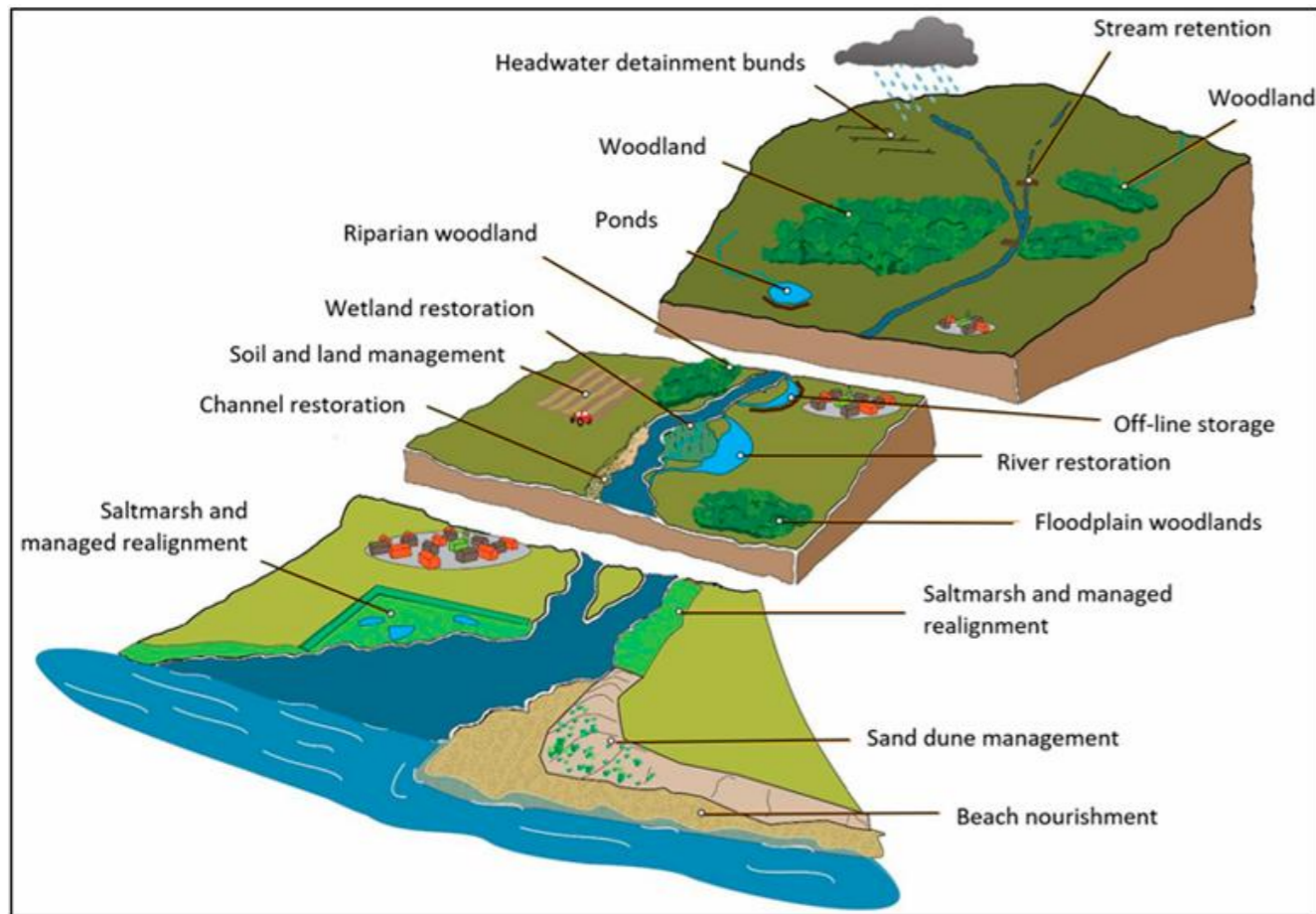


Figure 1. Illustration of different landscape features for flood mitigation in upper, middle, and lower catchments. Source: UK Environment Agency 2018 in Griffiths et al. 2024.



Categorisation of NbS interventions can vary widely. In the NIWA [literature review](#) commissioned to support the MfE-funded feasibility studies, Griffiths et al. 2024 adopted World Bank (2021) nomenclature to group NbS for flood mitigation into the following categories:

- retention and detention systems, e.g., ponds, lakes, reservoirs, detainment bunds, swales, dry ponds, and leaky barriers
- bioretention systems, e.g., rain gardens and bioswales
- landcover and soil management, e.g., forests, pasture management, tillage reduction
- river naturalisation and restoration, e.g., making room for rivers, stream daylighting, reestablishment of riparian corridors, removal of concrete embankments, and riverbed and bank revegetation
- and natural and constructed wetlands.

Across the feasibility studies, similar terminology of NbS types was used, but there were inconsistencies with some terms being used interchangeably or without sufficient differentiation (e.g., leaky barriers vs leaky weirs vs leaky dams). A source such as Griffiths et al. 2024 could be used as a reference guide for naming and categorisation of NbS types and scenarios to standardise a national approach and allow for better industry comparability and analysis of NbS assessment and implementation for flood mitigation. However, adopting or developing standardised classification of NbS for flood mitigation in Aotearoa should consider the unique characteristics of the country’s whenua and awa as well as differences between rural and urban contexts.

2. OVERVIEW OF FEASIBILITY STUDIES | Te Ika-a-Māui North Island

Auckland Council

Compaction of urban soils: Understanding the feasibility of potential solutions for the amelioration of urban soils to reduce flood risk

Study area: Two urban Auckland catchments: Te Auaunga – Oakley Creek (13 km²) and Te Ararata – Māngere Creek (18 km²)

Project approach: Monitor urban soil properties and use stormwater models to test soil amelioration scenarios

NbS types assessed: Deep soil loosening; rebuilding sponge layer; protecting high-quality soils; managing water tables; enhancing infiltration and permeability

Waikato Regional Council

Understanding coastal wetland hydrology and the effects of extreme events on land-use transition and blue carbon storage

Study area: Coastal wetland restoration site (~0.2 km²) in Pūkorokoro/Miranda on the Firth of Thames

Project approach: Hydrodynamic modelling of site management and inundation scenarios, field data collection, vegetation surveys and modelling, partnership with restoration project partners

NbS types assessed: Coastal wetland restoration

Taranaki Regional Council

Kia manawaroa Waitōtara, kia whakaritea te tangata - Let Waitotara be resilient, let the people be adaptive

Study area: Waitōtara River catchment, large forested rural catchment from Matemateonga Range, 1200 km²

Project approach: Hydraulic modelling of NbS in TUFLOW to assess feasibility in flood mitigation

NbS types assessed: Slope afforestation, riparian afforestation buffers, leaky barriers

Horizons Regional Council

Ōroua and Pohangina catchments nature-based flood mitigation solutions

Study area: Sections of the Ōroua and Pohangina River catchments – tributaries of the Manawātū River

Project approach: Develop a flood protection model to support Horizons' flood resilience planning

NbS types assessed: Room for the river, riparian margin integrity, channel adjustment

Note the HRC report was not received within summary report preparation timeframes; project information is based on publicly available information (i.e. the mid-project report).

Greater Wellington Regional Council

Nature-based solutions feasibility study – Waipoua River

Study area: Waipoua River catchment upstream of Masterton, rural floodplain valley, 149 km²

Project approach: Hydrological and hydraulic modelling and valuation of key NbS approaches

NbS types assessed: Indigenous afforestation and land retirement; channel realignment/Room for the River; small-scale distributed retention storage; floodplain re-engagement

Northland Regional Council

Taumāreke Catchment Nature-Based Solutions Feasibility Study

Study area: Taumāreke River catchment, steep hill country and narrow valleys draining to Bay of Islands, 490 km²

Project approach: Whole catchment hydrological analysis, GIS multi-criteria risk mapping to prioritise NbS and funding; extensive landowner engagement

NbS types assessed: Native forest revegetation; steep-slope erosion control; leaky barriers; silt traps; riparian planting; floodplain reconnection; wetland and intertidal wetland restoration; catchment management

Waikato Regional Council

Waikato and Waipā River Nature Based Solutions Feasibility Investigations

Study area: Waikato and Waipā River catchments

Project approach: Identification of impediments to implementing NbS for flood resilience based on organisational experience and knowledge, through interviews with WRC staff and Waikato River Authority representatives

NbS types assessed: While no specific NbS types were assessed, the scope includes wetlands (engineered or natural), river naturalisation and floodplain restoration, landcover and soil management, detention systems, and bioretention systems

Gisborne District Council

Maunga to Motu – Embracing the Waimata Awa

Study area: Upper Waimatā River catchment, highly erodible hill country above Gisborne, 370 km²

Project approach: Develop GIS based predictive toolbox to assess NbS for tackling erosion, sedimentation and woody debris

NbS types assessed: Afforestation (agroforestry, dense native bush); narrow and wide riparian planting; small–large floodplain detention/retention storage; linear vegetative debris belts; debris traps

Hawke's Bay Regional Council

Heretaunga Plains nature-based solutions for flood management

Study area: Ngaruroro River from Kaweka Range to Heretaunga Plains, 1923 km²

Project approach: Model NbS for flood peak reduction and groundwater recharge benefits using hydrological, 2D and groundwater modelling

NbS types assessed: Afforestation; wetland restoration; floodplain retention/detention; river naturalisation and stopbank removal; floodplain reconnection; combined NbS options

Hawke's Bay Regional Council

Upper Tukituki nature-based solutions for flood management

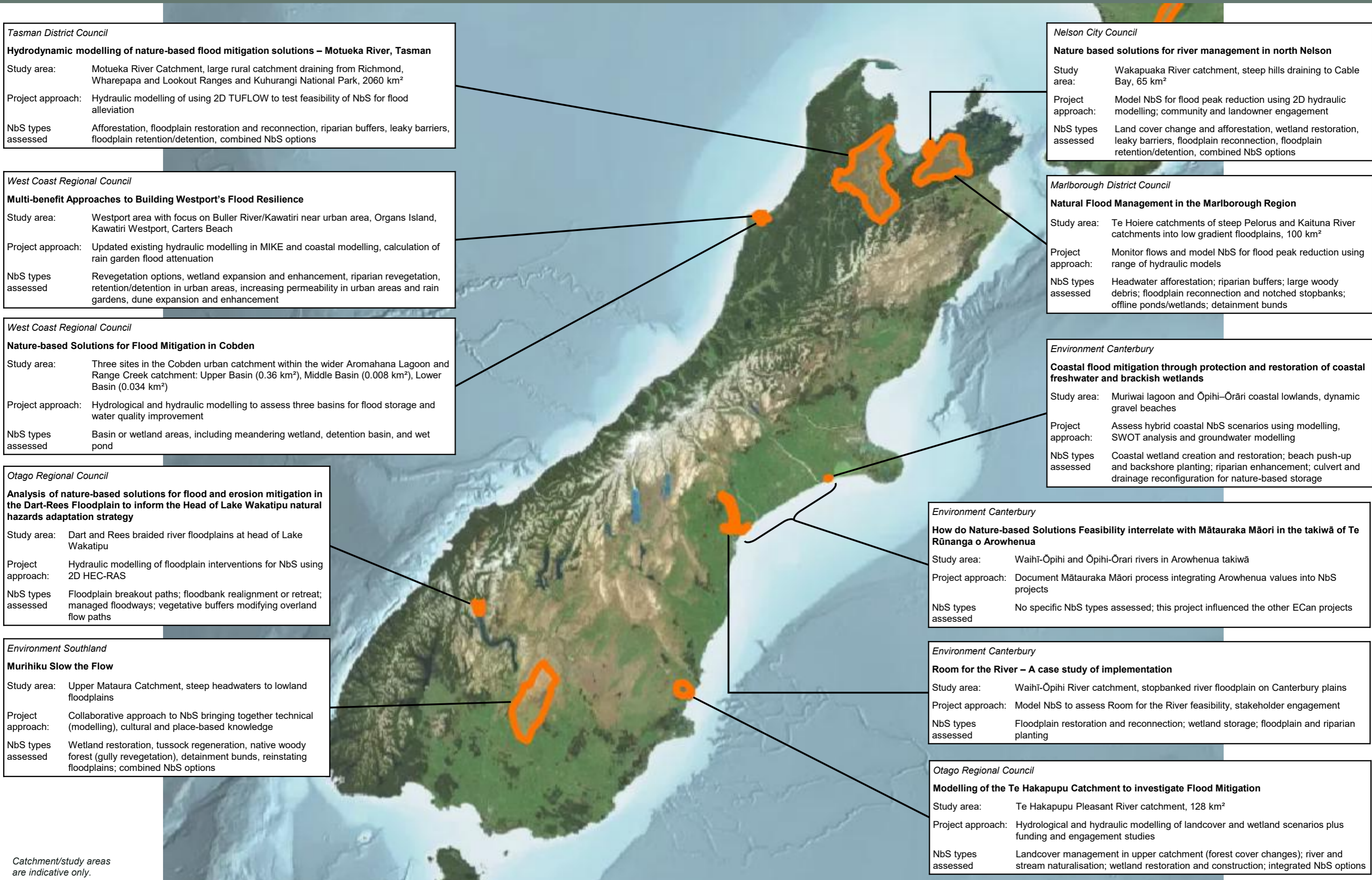
Study area: Upper Tukituki Waipawa River catchment, rural catchment from Ruahine Range to floodplain, 670 km²

Project approach: Model NbS for flood peak reduction using 2D hydraulic modelling

NbS types assessed: Afforestation; wetland restoration, river naturalisation and stopbank removal; floodplain reconnection, combined NbS options

Catchment/study areas are indicative only.

2. OVERVIEW OF FEASIBILITY STUDIES | Te Waipounamu South Island



Tasman District Council
Hydrodynamic modelling of nature-based flood mitigation solutions – Motueka River, Tasman
 Study area: Motueka River Catchment, large rural catchment draining from Richmond, Wharepapa and Lookout Ranges and Kuhurangi National Park, 2060 km²
 Project approach: Hydraulic modelling of using 2D TUFLOW to test feasibility of NbS for flood alleviation
 NbS types assessed: Afforestation, floodplain restoration and reconnection, riparian buffers, leaky barriers, floodplain retention/detention, combined NbS options

Nelson City Council
Nature based solutions for river management in north Nelson
 Study area: Wakapuaka River catchment, steep hills draining to Cable Bay, 65 km²
 Project approach: Model NbS for flood peak reduction using 2D hydraulic modelling; community and landowner engagement
 NbS types assessed: Land cover change and afforestation, wetland restoration, leaky barriers, floodplain reconnection, floodplain retention/detention, combined NbS options

West Coast Regional Council
Multi-benefit Approaches to Building Westport’s Flood Resilience
 Study area: Westport area with focus on Buller River/Kawatiri near urban area, Organs Island, Kawatiri Westport, Carters Beach
 Project approach: Updated existing hydraulic modelling in MIKE and coastal modelling, calculation of rain garden flood attenuation
 NbS types assessed: Revegetation options, wetland expansion and enhancement, riparian revegetation, retention/detention in urban areas, increasing permeability in urban areas and rain gardens, dune expansion and enhancement

Marlborough District Council
Natural Flood Management in the Marlborough Region
 Study area: Te Hoiere catchments of steep Pelorus and Kaituna River catchments into low gradient floodplains, 100 km²
 Project approach: Monitor flows and model NbS for flood peak reduction using range of hydraulic models
 NbS types assessed: Headwater afforestation; riparian buffers; large woody debris; floodplain reconnection and notched stopbanks; offline ponds/wetlands; detainment bunds

West Coast Regional Council
Nature-based Solutions for Flood Mitigation in Cobden
 Study area: Three sites in the Cobden urban catchment within the wider Aromahana Lagoon and Range Creek catchment: Upper Basin (0.36 km²), Middle Basin (0.008 km²), Lower Basin (0.034 km²)
 Project approach: Hydrological and hydraulic modelling to assess three basins for flood storage and water quality improvement
 NbS types assessed: Basin or wetland areas, including meandering wetland, detention basin, and wet pond

Environment Canterbury
Coastal flood mitigation through protection and restoration of coastal freshwater and brackish wetlands
 Study area: Muriwai lagoon and Ōpihi-Ōrāri coastal lowlands, dynamic gravel beaches
 Project approach: Assess hybrid coastal NbS scenarios using modelling, SWOT analysis and groundwater modelling
 NbS types assessed: Coastal wetland creation and restoration; beach push-up and backshore planting; riparian enhancement; culvert and drainage reconfiguration for nature-based storage

Otago Regional Council
Analysis of nature-based solutions for flood and erosion mitigation in the Dart-Rees Floodplain to inform the Head of Lake Wakatipu natural hazards adaptation strategy
 Study area: Dart and Rees braided river floodplains at head of Lake Wakatipu
 Project approach: Hydraulic modelling of floodplain interventions for NbS using 2D HEC-RAS
 NbS types assessed: Floodplain breakout paths; floodbank realignment or retreat; managed floodways; vegetative buffers modifying overland flow paths

Environment Canterbury
How do Nature-based Solutions Feasibility interrelate with Mātauraka Māori in the takiwā of Te Rūnanga o Arowhenua
 Study area: Waihi-Ōpihi and Ōpihi-Ōrari rivers in Arowhenua takiwā
 Project approach: Document Mātauraka Māori process integrating Arowhenua values into NbS projects
 NbS types assessed: No specific NbS types assessed; this project influenced the other ECan projects

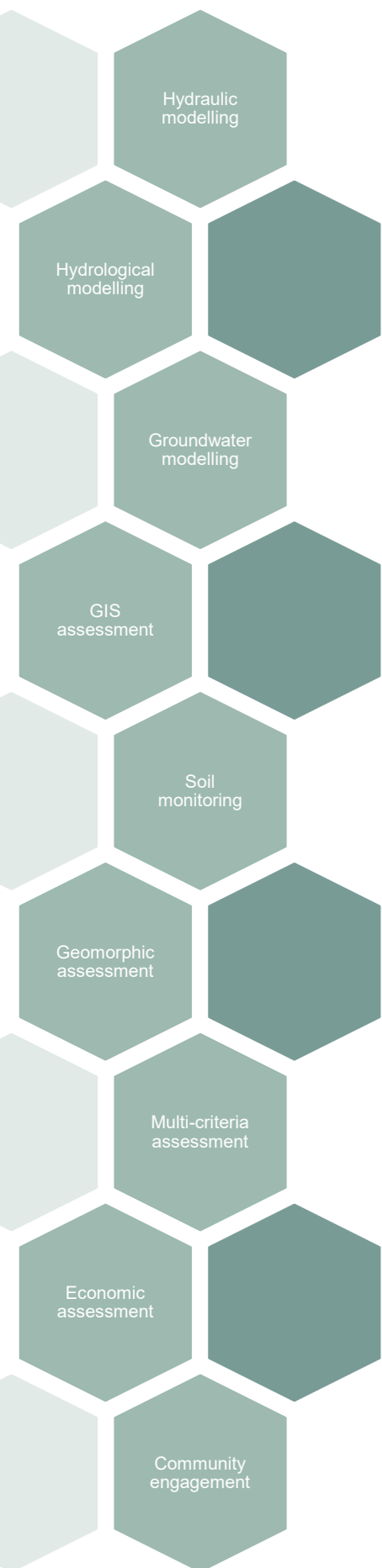
Environment Southland
Murihiku Slow the Flow
 Study area: Upper Mataura Catchment, steep headwaters to lowland floodplains
 Project approach: Collaborative approach to NbS bringing together technical (modelling), cultural and place-based knowledge
 NbS types assessed: Wetland restoration, tussock regeneration, native woody forest (gully revegetation), detainment bunds, reinstating floodplains; combined NbS options

Environment Canterbury
Room for the River – A case study of implementation
 Study area: Waihi-Ōpihi River catchment, stopbanked river floodplain on Canterbury plains
 Project approach: Model NbS to assess Room for the River feasibility, stakeholder engagement
 NbS types assessed: Floodplain restoration and reconnection; wetland storage; floodplain and riparian planting

Otago Regional Council
Modelling of the Te Hapakupu Catchment to investigate Flood Mitigation
 Study area: Te Hapakupu Pleasant River catchment, 128 km²
 Project approach: Hydrological and hydraulic modelling of landcover and wetland scenarios plus funding and engagement studies
 NbS types assessed: Landcover management in upper catchment (forest cover changes); river and stream naturalisation; wetland restoration and construction; integrated NbS options

Catchment/study areas are indicative only.

3. ASSESSMENT APPROACHES



DIVERSITY OF ASSESSMENT APPROACHES

Each feasibility study approached the fundamental question of exploring NbS for water and flood management in a different manner and therefore a range of assessment approaches was used, both qualitative and quantitative.

In addition to the technical assessments and modelling discussed in this section, mana whenua and community engagement were central to many project approaches; these are discussed in Section 4.

The extent of existing work in each study catchment informed the approach chosen by each council. While some project teams used the MfE funding as an opportunity to investigate a new catchment or establish a baseline hydrological or hydraulic model, other project teams built upon foundations of previous analyses and assessments within the catchment/study area to investigate if NbS could be used to reduce impacts of flooding. Project teams drew upon a range of global and Aotearoa-based sources to inform their understanding of and assessment approaches to NbS for the feasibility studies, from international frameworks and guidance to previous work and experience undertaken by consultants both locally and overseas; the literature review by Griffiths et al., 2024; and topic-specific research papers.

Out of the 21 studies, 15 used hydrological or hydraulic modelling (surface and groundwater) to aid their assessment. Some projects made use of existing models in the area, whereas some re-ran the models for various NbS scenarios and others built new models for these studies. Other approaches used included GIS assessments (both simple and complex), on-site monitoring of soils, geomorphic condition analysis, multi-criteria analyses, and economic assessments.

The level of detail on methodologies, parameters, and results provided in the summary reports varied depending on the type of assessment undertaken. Some reports provided detailed assessment methodologies and specific hydraulic modelling methodologies, including information on specific NbS representations within the analytical tools. There were varying levels of detail in the approaches taken for both methodology and analysis, and we have based our summary on the information available on the results and findings from the studies. Given the variety of approaches, not all nuances and details in the study results have been captured; for future analyses in this space, guidance on standardised communication of project findings would support comparability.

DIVERSITY OF CATCHMENT SCOPE AND SCALE

The studies also varied significantly in geographic location, scope, and scale (see the project overviews on pages 5-6). Some studies had a very specific scope and study area, while others were less constrained and took a whole of catchment approach to investigate if NbS could have any benefits on flood risk in the catchment. The studies covered mostly large and small rural catchments (study areas from less than 1 km² to 2060 km²), with a few investigating coastal and estuarine areas, and a few focused on urban areas by looking at benefits of green roofs and effects of soil compaction in new developments.

SELECTION OF NbS OPTIONS FOR ASSESSMENT

Feasibility studies that assessed specific NbS types took varying approaches to identifying and selecting NbS options for assessment. Some projects underwent a multi-step optioneering process which included long-list and short-list refinement through discussions with the project team and project partners. Other councils began the project with certain NbS options in mind that were specific to local interests, conditions, or constraints, and in some cases built on previous project findings.

Pros and cons of different NbS types were captured from project teams through the mid-project workshop and compiled in Appendix D of the subsequent [post-workshop report](#).



3. ASSESSMENT APPROACHES

APPROACHES USED:

- Computational hydrological modelling and hydraulic modelling covering fluvial, pluvial, coastal, and groundwater models
- Events: 50% AEP to 0.1% AEP with range of events assessed across the studies, most focussing on one to two events (including a focus on flooding events in the past few years), future impacts of climate (rainfall and flow increases, and sea level rise) were included and assessed in 11 studies
- GIS assessments for catchment overviews and NbS suitability determination of areas and parcels, through to two bespoke machine learning GIS toolboxes and models, and in one case were combined with an MCA process
- Soil monitoring in one study, and modelling of different infiltration parameters in some hydraulic and hydrological modelling in several studies
- Geomorphic assessments, where a couple of studies mentioned undertaking a geomorphic assessment of either riverine or coastal systems, and several other studies recommended undertaking a geomorphic assessment in any future NbS feasibility stages
- Multi-criteria assessment (MCA) was used in several studies to determine areas at risk and to determine NbS suitability
- Approximately 25% of studies undertook economic assessments, including some studies focusing on costing, high level cost-feasibility considerations, assessment of funding and financing pathways, simple cost-benefit analyses, semi-quantitative valuation, willingness to pay, importance rating, and preference ranking benefit analyses. Two studies used the More than Water tool to compare different NbS options and also to compare NbS options with grey infrastructure.
- Qualitative assessments using a baseline hydraulic model to inform possible future studies.

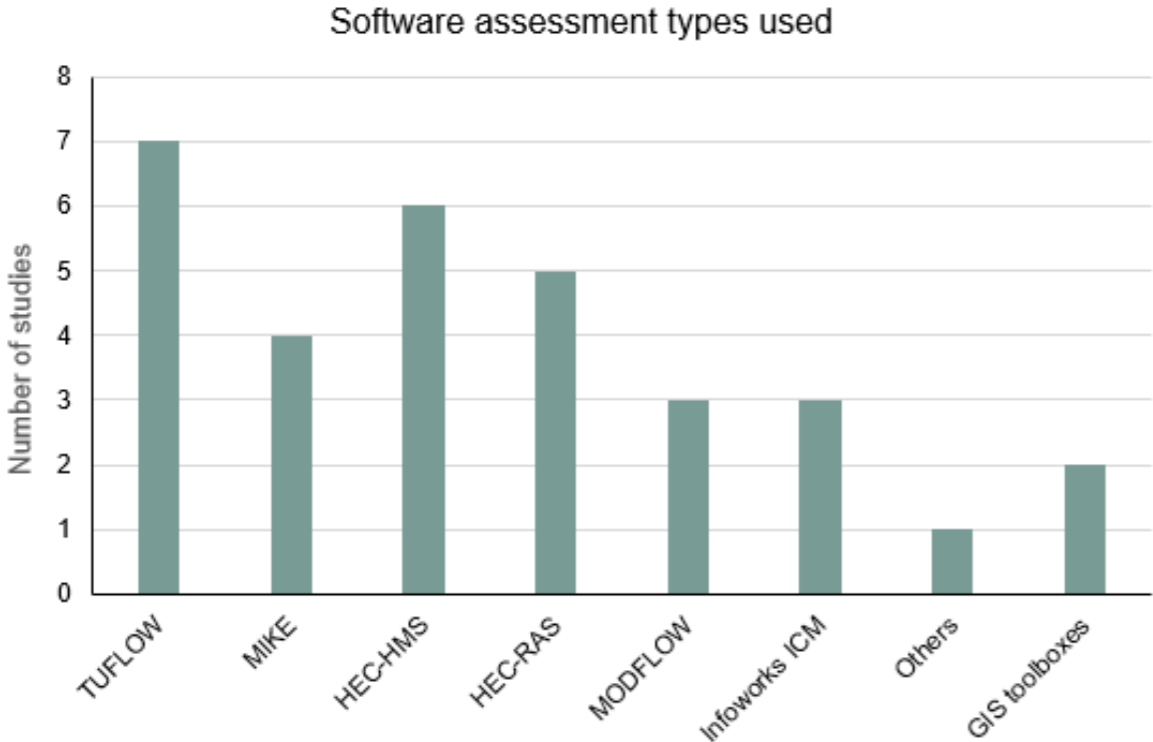


Figure 2. Common software types used for assessment. Many studies used multiple software types, resulting in the graph summing to more than 21. Some studies conversely did not use any software.



3. ASSESSMENT APPROACHES

REPRESENTATION OF NBS IN MODELLING

The NbS types that were represented in the hydraulic models varied in scale, spatial extent, and number. For some catchments with existing modelling and a known focus for NbS locations and types, the hydraulic modelling was refined specifically for those areas to improve the resolution of the analysis. In some catchments that were newly assessed, there were no noted constraints or focus area and the NbS testing covered whole catchments. Multiple studies looked at combination of NbS options to understand the benefits of multiple NbS options working together to identify the largest flood attenuation benefits.

The suitability of different types of NbS for the study catchments and reaches of the catchments is detailed in the reports. Most studies with hydrological and hydraulic modelling looked at land use changes in the upper catchment, in particular by modelling restoration of native forest and afforestation. In coastal studies, the NbS types were mainly tested alongside grey infrastructure, either for direct comparison or for testing grey-green options.

The scale of the NbS testing depended on the type of NbS and catchment context, with more urban focussed studies looked at property level options such as rain gardens, green roofs, and making use of local greenspaces, while more rural catchments looked at hectares of land use change into wetlands and revegetation options, with the largest revegetation test looking at over 90,000 hectares. In some catchments, the tested scale of afforestation or revegetation with indigenous forest covered a majority of the catchment area (>50%).

When looking at vegetation and land use changes, NbS were predominantly modelled in the upper reaches and headwaters of the catchments and study areas. These were mainly modelled across large areas but some studies focussed on small sections of vegetation change, others modelled whole sub-catchments and catchments, and some investigated the impacts of numerous vegetation types on flood levels and flows within the study area. Within the hydrological and hydraulic models, vegetation changes were represented through changes to roughness, with several studies also accounting for losses and infiltration changes expected after afforestation with indigenous species (see table at right for the ranges applied).

Multiple studies looked at “Room for the River” approaches of river naturalisation and reconnection, with sections of stopbank removal or step-back on small and large scale river reaches. Several studies modelled complete removal of existing stopbanks on both sides of the river to better understand its natural flow.

Leaky barriers, bunds, and debris traps were tested across several studies, for either reducing flood flows or lowering velocity to aid with sediment run-off and erosion. Modelling of these NbS types represented them through either geometry changes or roughness changes. The modelled features ranged in scale and size, from small 1 metre size elements to larger grey-green interventions to protect a key area of interest, e.g., by using large scale erosion protection measures with enhanced planting.

Within the detailed GIS studies to understand the catchment response, a range of NbS were assessed and information from international and Aotearoa specific studies was used to inform the changes and parameters.

The table below shows a summary of the different approaches taken to represent the NbS using analytical tools, within the hydrological, hydraulic and groundwater models across a range of software. The values listed in the table are presented as a range to show the broad nature of the assessment types and scenarios assessed. No review or assessment has been undertaken on these as they are all catchment, reach and NbS specific, and in each study are being compared to baseline conditions, which also have a range of values. From the ranges shown below, Aotearoa specific guidance could be recommended to support application and to provide confidence that the outputs are based on robust inputs.

Roughness parameters – Manning’s n values (12 studies)

Vegetation changes predominantly represented through roughness changes. Some reports provided Manning’s values, others mentioned vegetation changes were represented through a change to roughness.



- Forest roughness/afforestation: ranges applied for restoration to native forest and bush between 0.1-0.4,
- Wetland roughness: ranges applied between 0.05-0.3
- Leaky barriers: tested using roughness – from 0.1 and up to 0.65 in one study
- Riparian planting - increases of 0.02 relative to baseline, with bank planting tested with roughness values from 0.12 to 0.2

Infiltration parameters and Curve Number changes (11 studies)



Increased infiltration and changes in CN values in land use change scenarios to represent possible increased infiltration



Geometry changes (15 studies)

Representation of leaky barriers, bunds, weirs – incorporated as x,y,z in the digital elevation model (DEM)

Representation of sediment bunds,

Removal of stopbanks or structures from the topography / DEM.



Model parameter changes (one study with multiple models)

e.g., Interception losses increased for some scenarios, such as to determine the impact of afforestation with native or other species as a change from forestry or grasses and cropland

3. ASSESSMENT APPROACHES

COMMON ASSESSMENT PRACTICES

While this summary report isn't a best practice guide, we have identified emerging common practice among the feasibility studies. These include:

- **HYDRAULIC MODELLING** | Using hydraulic models was the most common approach, opted for by 15 of the 21 studies. This enables quantification of benefits.
- **GIS ASSESSMENTS** | Most studies used a GIS based approach for assessing catchment characteristics and undertaking a catchment overview. A couple of studies developed bespoke GIS toolboxes for their assessment approach, and multiple studies developed StoryMaps for sharing their findings with the community.
- **ASSESSMENT REFINEMENT** | Where available, councils made use of existing models and studies and known limitations of the models and adapted their NbS assessment approach accordingly. In some cases with existing models, new small scale models were built to help assess NbS effectiveness with simpler and faster tools.
- **NbS REPRESENTATION** | Some studies represented the same NbS features in different ways to understand the model effectiveness and sensitivity to different parameter changes. More research and guidance on appropriate methods and values would allow for more detailed testing and better comparisons between studies across the country.
 - Manning's roughness coefficients were a common choice, but as detailed in the NbS representation section, the range of values varied significantly depending on the scenario or feature tested. Guidance would facilitate consistency of approaches and comparability of findings; for example:
 - With afforestation, while this would vary naturally around the country, the indigenous bush and forest was represented as anything from 0.1 to 0.4.
 - For wetlands, roughness values ranged from 0.05 to 0.3 – seemingly based on original representation of the wetland area, the possible depth of ponding, and vegetation within the wetland area.
 - Leaky barriers/bunds were represented in multiple ways: as roughness changes ranging from 0.1 to 0.65, geometry changes, and modelling as structures with an outlet. While the software type seemed to determine the choice of approach for projects, some studies undertook the additional step of sensitivity testing each method and then used the most appropriate representation based on how the NbS slowed and held back the water.
 - Geometry changes were used to represent NbS like detainment bunds, storage features and removal of stopbanks.



CHALLENGES AND CONSIDERATIONS FOR ASSESSMENT

Project teams noted a range of challenges, uncertainties, and considerations in their assessments and modelling approaches. Development of future guidance could further analyse and identify good practice for addressing these. Key challenges included:

- Data gaps and uncertainty; outdated datasets; and gaps in spatial coverage
- Sensitivity of models to missing parameters or data
- Appropriate representation of NbS through the assessment approaches using GIS toolboxes or hydrological/hydraulic modelling
- Consistent modelling representation across large catchments with varying subcatchment dynamics
- Calibration challenges with available hydrometric data and historical flooding data within the catchments
- Complexity of geomorphic dynamics (e.g., sediment, woody debris)
- Reliance on international literature for values, guidance, or criteria given uncertainty of or gaps in Aotearoa-specific ones (e.g., resistance values, roughness values for native vegetation, soil infiltration rates, attenuation factors)
- Use of large cell size for modelling in some cases to avoid conflict with property-level flood mapping (which reduced resolution of results)

4. STAKEHOLDER AND MANA WHENUA ENGAGEMENT

THE CENTRALITY OF ENGAGEMENT

Stakeholder and mana whenua engagement at the feasibility study stage are important to integrate community and iwi perspectives at the assessment stage, build support, and facilitate future implementation. Engagement helps to:

- Ensure respect for mana, mauri, whakapapa, and kaitiakitanga
- Build relationships between councils and community and mana whenua, both for NbS as well as more generally
- Increase community interest and buy-in
- Increase shared understanding of risk and future readiness
- Engage in constructive dialogue to explore options, community interests and needs, and practical considerations
- Improve transparency and community confidence in data and modelling outputs

There was a range of stakeholder engagement and mana whenua partnership, from limited outreach (often constrained by time, availability or consultation fatigue) through examples of moderate engagement activities sharing findings at key project stages, to strong partnership or co-leadership of projects. For some projects, the key focus was to build on existing partnerships with mana whenua and work with them on NbS initiatives, while other catchments had limited prior community engagement so the project was used as initial starting point for future work.

TYPES OF STAKEHOLDERS ENGAGED

Stakeholders engaged from local and central government, communities, Māori, industry, and the broader research and flood management community:

- Internal council staff from other departments
- Councillors and elected members
- Other councils (i.e. regional/district council)
- Mana whenua (including representatives of iwi, rūnanga, hapū, trusts)
- Industry stakeholders
- Researchers and universities
- Local residents and community members
- Community groups
- Catchment groups
- Landowners and property owners, including from the farming and forestry sectors
- Central government agencies such as DOC and Fish & Game
- Restoration project partners



ENGAGEMENT METHODS

Engagement approaches ranged in depth and breadth, from formal governance structures to online or in-person meetings to visual communication tools and storytelling. Methods included:

- Co-governance structures
- Establishment and meetings of governance, steering, or advisory groups,
- Wānanga, workshops, and hui
- Hīkoi and Site visits
- Surveys
- Modelling demonstrations, map visualisations, and GIS walkthroughs
- Collaborative scenario development
- Webinars and Conference presentations
- Community discussion and feedback sessions
- Online engagement materials, such as StoryMaps
- Targeted follow-up engagement (e.g., via email, tailored discussions)

4. STAKEHOLDER AND MANA WHENUA ENGAGEMENT

MANA WHENUA ENGAGEMENT AND PARTNERSHIP

Nearly all projects engaged mana whenua throughout the project. Engagement ranged from limited or none to strong partnership-based and iwi-led approaches. Overall, the feasibility studies demonstrate both the growing recognition of the importance of meaningful partnership with mana whenua in NbS and flood risk management work, and the practical challenges of achieving this consistently when constrained by time, funding, and capacity.

Some projects included mana whenua as full project partners or co-leads, ensuring continuous engagement and enabling mātauranga Māori to meaningfully shape project design or assessment. Engagement on some projects involved collaborative integration of cultural frameworks and mātauranga Māori. On other projects, mana whenua perspectives were actively sought and incorporated through workshops, interviews, wānanga, or representation on governance groups, but without full co design or shared leadership. Limited engagement was most often of a consultative nature or associated with time pressure, capacity constraints on both councils and iwi, and a desire to avoid consultation fatigue in already heavily engaged communities.

Project experiences showed that mana whenua engagement is most effective and meaningful when it is planned early, adequately resourced, and embedded as a core component of project design and delivery rather than an adjunct to technical assessment.

ENGAGEMENT OUTCOMES AND FINDINGS

Stakeholders were generally supportive of the feasibility projects and NbS for flood risk mitigation potential demonstrated through assessments and modelling. While conceptual interest in NbS was generally high across projects, readiness to implement varied more widely and was often linked to practical considerations and level of confidence in the real or perceived absence of best practice or design guidance. High interest or strong willingness was evident in many projects, particularly amongst council staff, technical experts, mana whenua, catchment groups, and environmentally active community members. In several cases, stakeholders actively sought updates, offered land for trials, or expressed a desire to pilot NbS interventions. Despite overall strong interest in NbS, a few communities favoured traditional engineered solutions and viewed the value of NbS more in terms of other benefits such as erosion control, water quality, soil conservation, or biodiversity outcomes rather than for flood mitigation alone.

Engagement also surfaced stakeholder concerns about future NbS implementation, which would need to be considered and addressed as councils progress to further development of options and eventual on-the-ground operations. Stakeholders across the projects raised concerns that reflect both technical uncertainties as well as broader social, economic, and institutional challenges. While there was generally strong interest in NbS as part of larger holistic and adaptive flood management approaches, willingness or readiness to progress NbS to implementation was influenced by key concerns such as:

- funding uncertainty and limited institutional capacity
- questions around landowner implications, land availability, and land-use impacts,
- desire for clarity around roles, responsibilities, and governance for implementation and maintenance,
- managing expectations about what NbS can realistically achieve for flood mitigation, effectiveness and resiliency in severe events, and how they can be integrated with hard engineering or hybrid solutions.

Among the most frequently cited concerns were land availability and land-use impacts; funding, costs, and economic viability; limits on the effectiveness and performance of NbS, such as in extreme events or specific catchment conditions; maintenance requirements and long-term responsibility; liability concerns, such as downstream impacts of woody debris from leaky dams after flood events; resourcing constraints, including council staff capacity; and the practical challenges of implementing large-scale NbS across settled floodplains. Other concerns included landowner willingness and uptake; regulatory complexity and uncertainty; technical uncertainty and evidence gaps; trade-offs and unintended consequences; equity and cost-sharing; management of expectations around NbS performance given the need for a comprehensive hybrid approach to flood mitigation; and potential cultural misalignment.

Many of these concerns about NbS might also apply to other flood mitigation options. Evaluation of NbS acceptability and attractiveness to community, stakeholders and partners should also take into account concerns about alternative options.

5. SUMMARY OF FINDINGS

The findings of the feasibility studies demonstrated benefits of NbS for flood mitigation in some cases, but also highlighted variations in local conditions, NbS types, scale, and positioning within catchments. These summary findings are based on a review of the reports supplied by each council, along with some surveys and discussions with the council and technical teams. No individual project findings have been noted within this report (aside from in the case studies). Findings from across the studies have been grouped and summarised so that key learnings can be highlighted and documented. The project overviews in Section 2 and case studies in Section 6 allow the reader to understand project specifics.

As discussed in Section 3, the feasibility studies employed a wide range of approaches. The choice of assessment methodology, NbS options and representation, intervention scale, catchment characteristics, positioning within the catchment, and other aspects affects the results and conclusions of each study. We therefore acknowledge that findings must be interpreted individually in the context of each study's methodology and limitations, and encourage practitioners to further investigate studies relevant to your specific context. Context-specificity notwithstanding, this section captures key themes that have emerged from findings across the feasibility studies based on the reports and interviews.



DEMONSTRATED FLOOD MITIGATION POTENTIAL

In many catchments, modelling indicates NbS can deliver measurable peak flow attenuation, slow the flow of water, and reduce velocities, especially:

- in smaller/more frequent events (e.g., 50% to 20% AEP)
- when deployed at scale (both number of interventions and size of area covered by intervention)
- when using large scale vegetation-based interventions and land use restoration
- in both floodplain reconnection and floodplain storage-based interventions
- when combining NbS interventions across the catchment



CATCHMENT CHARACTERISTICS AND MORPHOLOGY

Catchment characteristics and morphology influence feasibility and effectiveness: steep or highly confined catchments as well as large main-stem rivers showed limited benefit with limited scope for NbS options, whereas broad floodplains and headwater tributaries appeared to show more meaningful impact. Studies that looked at whole catchments mainly found greater flood mitigation benefits, highlighting that a range of NbS applied across the catchment provided the most benefit.



COMBINATIONS OF NBS OPTIONS

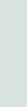
Multiple studies noted support for integrated catchment management or a whole of catchment approach as combined scenarios were found to provide a greater benefit for flood mitigation than individual NbS.

Several studies also noted that a combination of NbS with grey infrastructure might be a better long term solution, particularly mentioned and assessed in the coastal studies.



SCALE OF FLOOD EVENTS

Though several studies found that some NbS were effective in larger more severe events, most studies showed that in large less frequent, more severe AEP events (e.g., 1% AEP and larger), NbS at a tenable scale and intensity were rarely sufficient in reducing the flood risk in key areas of interest. In the catchments and studies that showed little to no benefits from NbS in large severe events, it was indicated that even grey interventions may not be effective for flood reduction in the infrequent events. This indicates that the scale of intervention (whether NbS or other) required is greater than assumed for the study, and that a more 'transformational' intervention may be required to mitigate flooding.



POTENTIAL FOR ADVERSE EFFECTS

In some cases, results demonstrated that certain interventions could increase peak flows in key downstream locations or cause adverse effects upstream like increased water levels – which is a consideration for any type of flood mitigation option, whether grey infrastructure or NbS. Several studies found that NbS can shorten response times, when modelling a reconnection to the floodplain, the high flows bypassed the main channel and flowed across a shorter distance and therefore quickened the response time and increased conveyance downstream. These findings highlight the need to carefully plan and understand the study area and hydrodynamic behaviour of the catchment.

5. SUMMARY OF FINDINGS – NbS TYPE SPECIFICS



RETENTION AND DETENTION SYSTEMS

Leaky barriers:

When implemented at scale, leaky barriers and weirs were found to be beneficial across both watercourses and flowpaths to attenuate peak flows and divert water into the floodplain. Modelling indicates that leaky barriers and bunds were effective in reducing peak flows and velocities in a few studies when looking at numerous features within a reach or catchment (200+), compared to studies which modelled smaller quantities of leaky barriers. The effectiveness of the leaky barriers was mainly shown to decline for the more severe events due to the scale of them compared to the peak flows.

Unsurprisingly, numerous studies found that the greater the number of leaky barriers and weirs, the greater the flow reduction. Several studies showed that several strategically placed leaky barriers were found to have significant impacts on peak flows. The location, scale (size and number) and overall catchment morphology seemed to determine the response to leaky barriers and weirs.

Attenuation and detention features:

When modelling and testing attenuation and detention features – such as bioretention systems, detainment bunds/basins, and infiltration areas – the results on flow reductions were mixed. On projects that assessed relatively small-scale features, no benefits were found, whereas in some studies modelling showed large peak flow reductions at both a localised and larger scale. One feature was shown to have a 40% reduction immediately downstream of the NbS, and two studies found 12 – 14 % reductions in peak flows in the catchment as a result of using combined NbS options which included attenuation and detention features for multiple return periods, including a 2% event.

Impacts on velocity:

Modelling indicated that leaky barriers, silt traps and debris retention were effective in smaller events at reducing peak velocities, both through GIS based analyses and hydraulic modelling. This finding, from multiple studies, showed leaky barriers, bunds and silt traps could be used to manage sediment runoff and mitigate erosion issues within specific problem areas, reaches or across whole catchments when deployed at scale.



INFLUENCE OF EXISTING LAND USE & LAND USE CHANGE

Existing planted forestry land use was shown to be beneficial in reducing river flows when compared to the land represented as either harvested or grasses/crops, on both small and large scale projects. Through these tests and studies, this highlighted the need for careful management of harvesting in future as the planted areas are providing benefits to the catchment for erosion and peak flows. We found no specific reference to modelling of slash impacts in the work carried out, but the implications of this warrant further consideration in support of this finding.

Several studies undertook some modelling and testing of changes to infiltration parameters as a result of land use change. One study specifically investigated soil parameters in different locations across a study area, and found reduced runoff with greater soil health, shown through both physical testing and modelling. The other studies focussing on literature information and conceptual models found that significant flood reductions were recorded in the areas modelled where greater infiltration was incorporated with a land use change.



VEGETATION CHANGES – AFFORESTATION

The largest reductions in peak flows were found to be from vegetation changes in the upper catchments, some studies found small 1-3% decreases in flows, others found moderate decreases in flows of 5-10% and several large-scale catchment studies found decreases of 25-40% for medium size events (10% to 5% AEPs). As well as flow reductions, hydrograph peak delays of several hours were found in multiple catchments. Supporting this finding, the BoPRC memo documented that they have physically recorded these benefits in areas of land that have been retired from planting trees in some of their catchments. On the whole, the impacts of vegetation changes were shown to be linked to existing land use, area of land use change and slope. Some of the catchments studied were already predominantly forested (indigenous or exotic forestry), and a further increase to forest cover was shown to reduce peak flows in most cases through several modelling scenarios.



WETLANDS

Wetlands, which were tested at a range of scales and locations, were shown to be beneficial in some of the studies. In one study, wetland areas were tested using the Manaaki Whenua Landcare Research and LINZ historical wetland layer as a first pass (approximately 5-10% of catchment area) and showed an 8 – 12% reduction in peak flows at the downstream end of the catchment for both the 5% and 1% AEP events. When refined further using local research data, flow reductions were 1-12%, but with a delayed flood peak. Other studies also found some benefits of re-introducing wetlands, and these studies covered a range of different geomorphologies and habitats, and flood benefits were also found in studies testing a combination of NbS options which included wetlands. In a few studies, the tested wetlands were shown to have no flood reduction benefit.

5. SUMMARY OF FINDINGS – CO-BENEFITS

CO-BENEFITS

By definition, NbS provides multiple benefits in addition to addressing a primary challenge – in this case, flood mitigation. Co-benefits of NbS were discussed in all of the feasibility study reports. As noted in the wider literature and the feasibility study reports, co-benefits are central to the attractiveness of NbS. Several studies highlighted that where the modelled flood mitigation benefits alone may not be sufficient to justify the investment in NbS, co-benefits are central to making the economic case for NbS implementation.

Co-benefits frequently mentioned in the feasibility study reports included:

- **Environmental benefits**, such as water quality improvement, stormwater and runoff treatment, biodiversity enhancement, habitat creation and restoration, sediment control and retention, carbon sequestration, and slope stability or erosion control.
- **Cultural and community benefits**, including strengthening cultural values and connections, mahinga kai and food gathering and harvesting access, community well-being and resilience, enhancement of landscape amenity, recreational access, and economic benefits. Studies which integrated mātauranga Māori viewed NbS as an opportunity to uplift the mauri of the awa and whenua in the catchments through their support of natural hydrological and ecosystem processes.

Even where not specifically identified as co-benefits, hydrological indicators associated with flood mitigation – such as slower runoff and increased infiltration rate – can improve the soil stability, growth and health of vegetation, support groundwater recharge, and increase drought resilience, providing wider benefits to the catchment. Restoring natural floodplain function and hydrological dynamics can support local ecosystem health and richer biodiversity, which provide broader environmental, community, and cultural benefits.



Examples of co-benefits mentioned in feasibility study reports

While all of the feasibility studies mentioned co-benefits, fewer studies assessed these co-benefits either quantitatively or qualitatively.

- Quantitative assessment of co-benefits took place through a few studies' hydrological and hydraulic modelling, including modelling of groundwater metrics.
- Two studies investigated the potential for certain types of NbS to allow for groundwater recharge across a wide floodplain area using conceptual models. One study found mixed results from the range of NbS tested, with some options resulting in increased groundwater levels and others resulting in reduced groundwater levels. The second study found large increases in groundwater levels for some NbS options which might replicate things like Managed Aquifer Recharge.
- Other studies explored or assessed co-benefits qualitatively, such as through hui, Mātauranga frameworks, and the More than Water tool.

6. CASE STUDIES

The following pages contain three case studies from the feasibility studies:

UPPER KAWAKAWA CATCHMENT
DETENTION
Northland Regional Council

MURIHIKU SLOW THE FLOW
Environment Southland

HYDRODYNAMIC MODELLING OF
NATURE-BASED FLOOD MITIGATION
SOLUTIONS – MOTUEKA RIVER
Tasman District Council

These case studies were selected to demonstrate the diversity of project approaches and outcomes.

Project phases

Community engagement and hydrological understanding

Financial feasibility and funding Strategy

Spatial analysis and NbS prioritisation

Aim: To understand the opportunities and constraints for implementing NbS and restoration to address flooding and water quality issues, with an overarching ambition to provide a foundational blueprint to guide future restoration.

Context and need: Recurrent flooding is affecting roads, communities, and low lying farmland. Other issues and context in the catchment include water quality degradation, loss of aquatic habitat, highly erosion prone soils in hill country, extensive drainage modification, and significant sediment, nutrient, and pathogen pressures.

Project approach: Whole catchment spatial mapping and MCA to identify priority locations for NbS implementation building on community engagement and financial and strategic reviews. The project made use of spatial datasets and suitability logic for the GIS analysis to determine NbS opportunities within the catchment. The MCA used attributes including hydrological factors, ecological values, land-use considerations and cultural and social importance, in order to determine the relative importance for the overall NbS analysis. As part of a proof of concept, a 2D HEC-RAS model was developed for a sub-catchment to test the proposed NbS identified in the GIS analysis to baseline conditions.

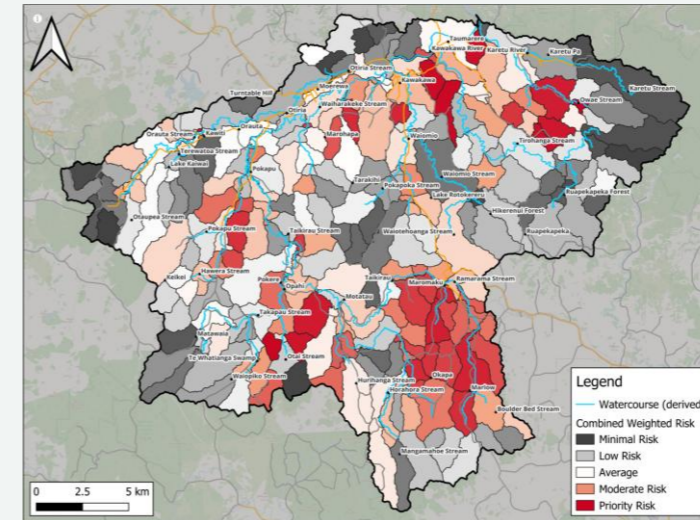
Key findings:

- Hydrological analysis showed the sensitivity of the catchment to high rainfall events, in particular to address flashiness, sediment mobilisation, habitat disconnection and water quality concerns.
- Hydraulic modelling in a specific sub-catchment demonstrated measurable peak velocity and flow reductions (15-20% for the 1% AEP event) at downstream road locations using NbS.
- Silt traps and hill country erosion planting were identified as the most cost effective and readily adoptable measures, particularly for sediment reduction and downstream flood risk mitigation.
- Financial feasibility improves markedly when NbS are targeted to marginal land and linked to alternative revenue streams (e.g., carbon, rongoā, nurseries).
- Wetland restoration and floodplain reconnection offer high flood attenuation benefits but face feasibility challenges on productive farmland.

Takeaways:

- Catchment wide NbS adoption and planning is required to achieve meaningful flood reduction outcomes.
- Assessment of NbS potential and suitability serves as an enabling tool rather than a prescriptive solution; real-world feasibility and delivery depends on local context, aspirations, operational constraints, wider resilience considerations, and buy-in from landowners, iwi, and the wider community.
- NbS mapping at catchment scale is feasible and transferable to other Northland catchments.
- Data limitations constrain precision but do not undermine strategic value.

➔ [View the StoryMap](#)



Study area:

Large, predominantly rural catchment (~490 km²) draining towards the Taumāreke estuary and into the Bay of Islands, with steep hill country upstream and narrow alluvial valleys downstream.

Current land use includes native and commercial forestry, pastoral farming, wetlands, and small townships (e.g., Ōtiria, Moerewa, Kawakawa).

Partnership:

Ngāti Hine were partners throughout the project, contributing mātauranga Māori, site knowledge, and strategic direction. This collaboration informed NbS selection, spatial prioritisation, monitoring design, and alignment with iwi aspirations for kaitiakitanga, mahinga kai, and long term catchment restoration. A case study was developed in more detail with one landowner for a proof of concept.

Status of next steps

Community, iwi and landowners are interested in pursuing the work further but require more guidance from council. Constraints to future work currently include a lack of allocated funding – with no allocation in the current LTP, landowners require guidance from council for funding applications, and no funds available for supporting the work.

Why this case study?

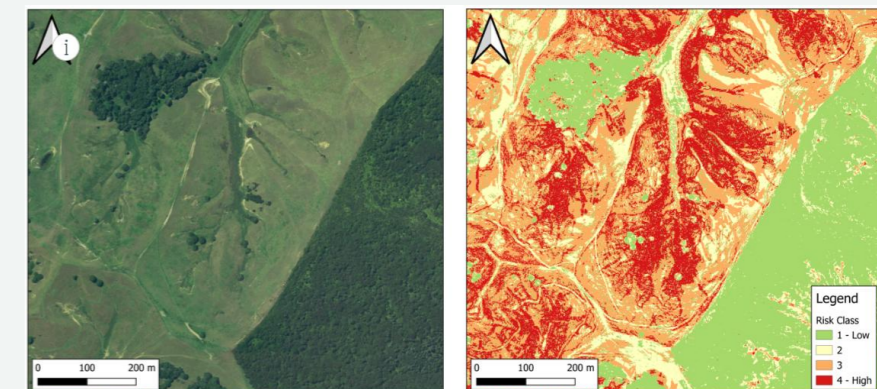
NRC's study exemplified the diversity of assessment approaches undertaken to understand different facets of feasibility, from hydrological analysis to a complex GIS spatial analysis, multi criteria assessment, investigation into financial feasibility and funding pathways, and extensive consultation with landowners and community, through to development of a sub-catchment case study.

NbS types assessed:

- Native forest & vegetation restoration
- Steep slope erosion control
- Leaky barriers
- Silt traps
- Riparian planting
- Floodplain reconnection
- Wetland restoration
- Intertidal wetland restoration (īnanga focus)
- Catchment management (non-spatial, inferred from risk mapping)

Engagement:

Engagement was also undertaken from project initiation with landowners, community groups, catchment committees, and multiple NRC teams through hui, workshops, and one on one discussions. A risk-based mapping approach and GIS StoryMap proved effective for communicating issues and opportunities, supporting constructive conversations and voluntary participation.



Programme components

Mātauranga Māori approach

Modelling and scenario analysis

Decision support and integration

Engagement and community of learning

Aim: The phrase ‘Slow the Flow’ reflects the aim to lessen and delay peak flood flows and reduce contaminant run-off by enhancing the catchment’s natural ‘sponge function’. The work produced a draft ‘blueprint’ for a catchment approach to floodplain management in Murihiku Southland.

Context and need: The urgency for this work increased after the February 2020 floods, which led to the evacuation of over 4,500 people across the Mataura catchment. The river’s degraded condition and over-allocated waters further underscore the need for whole-of-catchment flood and river management to reduce risk and lift river health.

Project approach: The project tested how a collaborative approach – bringing together technical, cultural and place-based knowledge – could assess the potential for NbS to reduce flood risk and support catchment health. In this project, Environment Southland and Te Ao Mārama Inc. each developed a feasibility baseline using their own approaches, one grounded in Mātauranga Māori, the other in western science. Working these side by side confirmed, in a very practical way, how complementary they are for the region, showing that bringing cultural values, lived experience, scientific evidence and pūrākau together can create a shared picture that better supports decisions. A scenario was developed involving all NbS interventions and tested across a range of flood events.

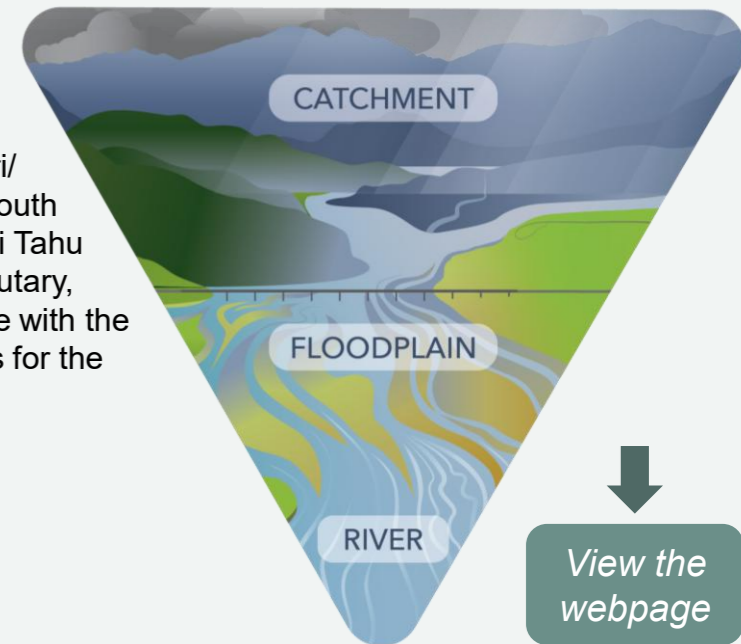
Key findings:

- Early desktop modelling suggests that a well-designed combination of NbS can reduce peak flood flows across a range of flood scenarios.
- The magnitude of the potential reductions, and resultant exposure of populations, property and infrastructure depends on the scale of deployment (coverage), location, design and sequencing. For example, floodplain reconnection without added roughness/vegetation can increase peak flows by allowing water to move more quickly across the floodplain.
- Post-project engagement has reinforced that effectiveness lies in a portfolio of many relatively simple, distributed interventions — often using tools already available in the region (such as detention bunds). Each additional measure generally contributes incremental benefit, and cumulative gains increase as these measures are applied more widely and in the right places.
- Flood mitigation benefits alone may not justify the combined investment. However, broader environmental and cultural co-benefits (explored qualitatively through the rural More Than Water prototype) add further value.
- Scenario modelling and decision-support tools were most useful when paired with on-the-ground context and cultural insight. Building internal alignment within council teams proved critical to sustaining external trust and has laid groundwork for future floodplain management conversations.

Why this case study? | The Murihiku Slow the Flow project emphasised the importance of iwi partnership, featured the use of Mātauranga frameworks to inform a methodology for place-based analysis alongside quantitative modelling, and developed a blueprint for a catchment approach to flood management.

Study area:

The study focused on the upper Mataura catchment, which spans high-altitude uplands through to lowland floodplains, extending from the Eyre Mountains near Whakatipu Waimāori/Lake Whakatipu, and extends to Toetoes Estuary along the south coast. It includes landscapes of particular significance to Ngāi Tahu ki Murihiku. An initial baseline assessment of the Waikaia tributary, which contributes roughly half of the flow above its confluence with the main Mataura River, was extrapolated to inform the scenarios for the upper Mataura catchment.



Package of five NbS interventions assessed:

1. Wetland restoration
2. Tussock regeneration
3. Native woody forest (gully revegetation)
4. Detainment bunds
5. Reinstating floodplains

Partnership:

Murihiku Slow the Flow operated under shared leadership, co-led by Environment Southland and Te Ao Mārama Inc. on behalf of Ngāi Tahu ki Murihiku. Shared leadership arrangements strengthened the relevance and depth of the work. While full end-to-end weaving of Mātauranga Māori and western science was not achieved, contributions at each step improved the assessment approach for Murihiku Southland and set direction for future co-design.

Status of next steps

Recently confirmed funding for flood resilience work in Murihiku Southland provides a practical opportunity to put this learning into action. The draft blueprint for a catchment approach to floodplain management can now be applied in parallel with current practice in selected projects.

Shared leadership with Ngāi Tahu ki Murihiku will be central to this next phase. Maintaining and clarifying roles, resourcing and capacity will support the continued development of feasibility baselines and cultural monitoring alongside technical work. Ongoing, structured engagement and communication will also be critical. Dedicated resourcing for participation, storytelling and knowledge transfer will help connect communities, practitioners and decision-makers, and support the wider uptake of nature-based approaches across Murihiku Southland.

Finally, applying the blueprint should be treated as an iterative learning process. Checkpoints can be used to refine packages, assumptions and tools as new evidence and whānau insights emerge. Over time, this will allow application of the approach to extend beyond the upper Mataura into other parts of Murihiku Southland, as system-wide, sequenced packages that work with natural hydrological cycles — slowing, storing and filtering water from the mountains to the sea.

Engagement:

A Steering Group supported the work, alongside participation from council teams and national peers. Hīkoi, workshops and briefings connected both workstreams and shared insights with mana whenua, the Waikaia Catchment Group, the Regional Climate Change Working Group, and Councilors and staff from the Regional Council, and Gore and Southland District Councils.

Assessment approach

Baseline model

NbS optioneering

Testing of NbS scenarios

Aim: To test the feasibility of using different NbS options to alleviate flooding within the Motueka River catchment.

Context and need: Multiple towns within the catchment are at risk of flooding, in particular Motueka, Brooklyn, Riwaka, and Tapawera, most of which have no flood protection assets. Motueka is protected by stopbanks on the lower Motueka River from Peach Island to the SH60 bridge. Recent flood events in 2021 and 2025 have highlighted the risk of flooding to the Motueka catchment and the need to investigate flood alleviation options, including NbS.

Project approach: The project conducted a catchment-scale feasibility assessment using a 2D TUFLOW rain-on-grid hydraulic model of the whole catchment in order to create a baseline model from which to test NbS effectiveness. Numerous NbS tests were conducted at catchment- and reach-scale resolutions in order to understand the potential flood reduction potential of NbS relative to baseline conditions. Baseline conditions were compared against the 16 NbS scenarios across 1–10% AEP events (with emphasis on 5% AEP), including sensitivity testing for vegetation density, land-cover change, and saturated catchment conditions. Individual and combined NbS scenarios were tested to assess cumulative effects.

Key findings:

- Increasing native vegetation density in upper and mid-catchments produced the largest flood mitigation benefits, reducing peak flows by up to ~27% and delaying flood peaks by more than two hours in responsive sub-catchments.
- Retaining existing forest cover is critical: conversion of forest to grassland increased peak flows by up to ~30% and accelerated flood peaks.
- Floodplain reconnection and restoration reduced peak flows locally (up to ~14%) and delayed flood peaks, but benefits were strongly location-dependent and diminished under saturated catchment conditions.
- Retention and detention systems, especially when combining in-channel leaky barriers with floodplain storage, provided large reductions in peak flows, particularly in smaller tributaries.
- Combined NbS scenarios demonstrated the greatest benefits, with peak flow reductions of up to ~36% in the most responsive sub-catchments and ~9% at the downstream site of Motueka River at Woodstock, with significant delays in peak timing across the catchment.
- Leaky barriers were most effective in smaller tributaries, with peak flow reductions typically up to ~5–6%, and performance driven more by placement than number.
- Analysis highlighted strong spatial variability in flood response, with smaller sub-catchments (e.g., Motupiko, Tadmor, Stanley, Sherry) and areas with wide floodplains showing the greatest sensitivity to nature-based interventions.

Takeaways:

- NbS performance is highly dependent on catchment geomorphology, land cover, and available floodplain space. Interventions should be tailored to the specific characteristics of each sub-catchment or area of interest.
- Strategic combinations of NbS types provide substantially greater benefits than single interventions alone.

Why this case study? | The Motueka study undertook an in-depth catchment-scale feasibility assessment. Hydraulic modelling was used to test NbS across the diverse study area and test the sensitivity of catchment responsiveness to specific NbS. The study demonstrated that multiple NbS scenarios delivered measurable benefits compared to baseline conditions across sub-catchments.

Study area:

Whole Motueka River catchment (~2,060 km²), with analysis focused on key tributary sub-catchments

NbS types assessed:

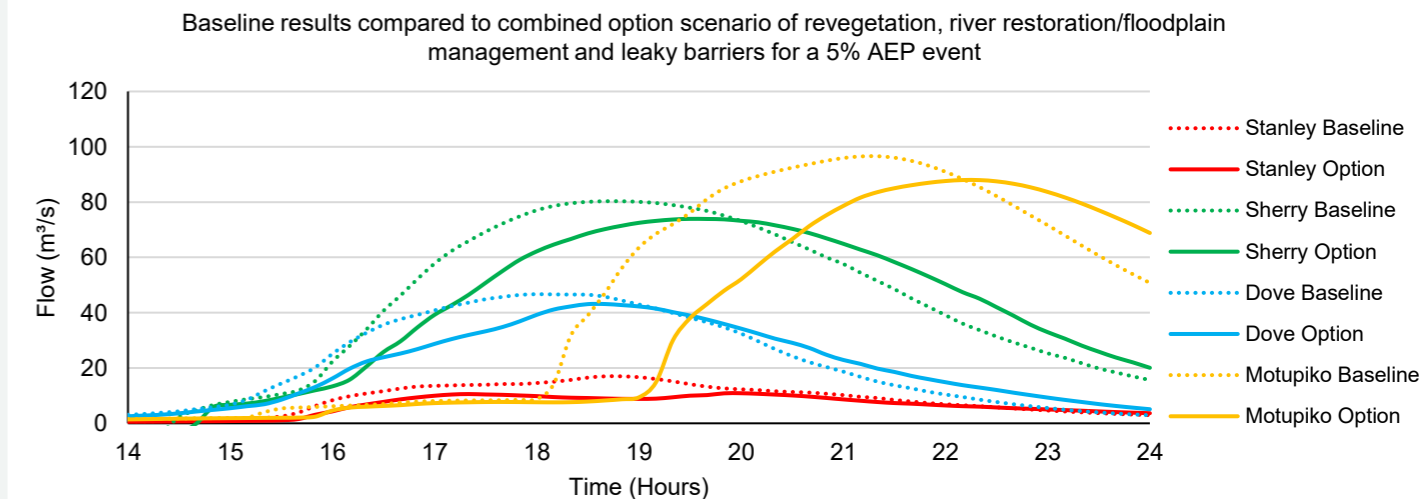
- Revegetation, land-cover and soil management (e.g., afforestation, changes in forest density)
- River restoration and floodplain reconnection (e.g., floodplain lowering, reconnection of paleo-channels, floodplain storage, and vegetated floodplain storage)
- Retention and detention systems (e.g., in-channel and floodplain leaky barriers, offline storage)

Number of NbS options tested:

- ~16 core scenarios, plus multiple sensitivity tests
- Options tested both individually and in combined scenarios
- Tested across all three NbS types

Scale of NbS tested:

- Catchment-wide vegetation changes
- Tributary catchment-scale interventions
- Localised river reaches and floodplain storage areas



Status of next steps

Recommended next steps include prioritising the most responsive sub-catchments for more detailed assessment, strengthening mana whenua and landowner engagement, undertaking cost-benefit analysis, and progressing targeted NbS trials where funding and community support allow.

No funded implementation phase has yet been confirmed as part of this study, but the NbS modelling outcomes may inform alternative funding pathways are being investigated for small pilot studies.

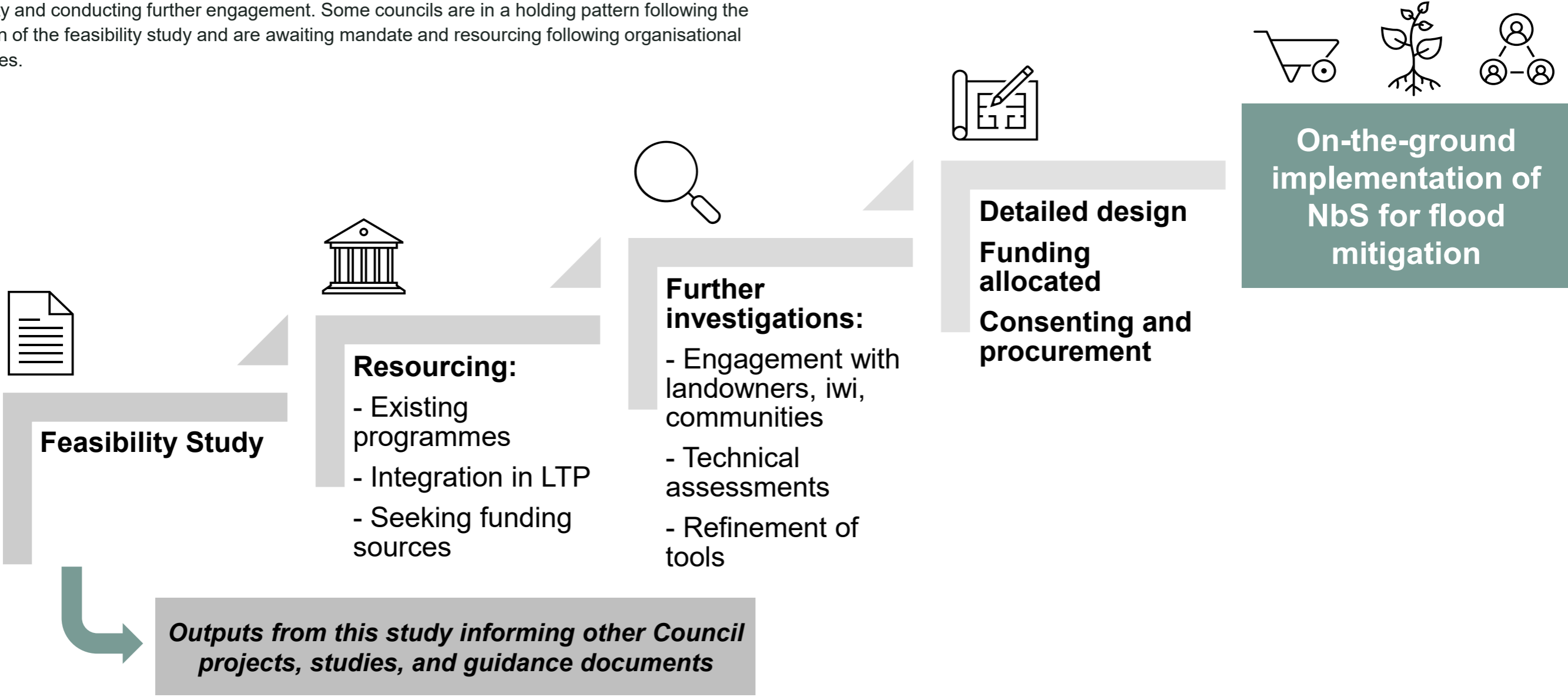
7. NEXT STEPS FROM THE FEASIBILITY STUDIES

While all of the projects were feasibility studies of a desktop nature, the status of their next steps varies. The diagram below provides a simplified representation of the various stages that the feasibility projects are at on their journey to on-the-ground implementation, reflecting that feasibility depends not only on technical assessment but also availability of funding, internal resourcing, buy-in from local communities and partners, and practical logistics.

As of the time of the interviews, few projects are concretely progressing to detailed NbS design options or on-the-ground implementation, with only one council having allocated funding for a project plan. Several are focused on strengthening evidence before committing to implementation, including through planned field trials, updates to guidelines and asset data, validation and refinement of modelling, further research, and identification of trial sites. A number of projects are using the feasibility study outputs, both assessment findings as well as tools, frameworks, and blueprints developed through the studies to inform wider flood risk and water environment strategies and influence future decision-making, including as inputs to LTP processes and broader catchment, floodplain, and river management programmes. A few councils are exploring further funding opportunities for investigations alongside partners, while others are socialising findings with the community and conducting further engagement. Some councils are in a holding pattern following the conclusion of the feasibility study and are awaiting mandate and resourcing following organisational restructures.

As identified in the stakeholder engagement findings, many councils expressed in interviews that uncertainty about internal resourcing and funding availability were key barriers to progressing towards NbS implementation. These challenges do exist across the stormwater and flood management sectors more broadly, however some are accentuated in NbS. Organisational restructures, staff turnover, and capacity constraints limit councils' ability to undertake further investigations, on-the-ground trials, and engagement and in some cases leave NbS initiatives without a clear departmental allocation or "home". Meanwhile, regulatory uncertainty, including RM reform and the shifting responsibilities between councils and Central Government raises questions about mandates for and prioritisation of different flood risk management activities and associated funding, whether from ratepayers or Central Government. Several councils also identified the need for more Aotearoa-specific guidance on NbS to help facilitate further assessment and implementation.

With clear council, community, and iwi interest in testing NbS for flood risk mitigation on the ground, timely support for council resourcing, funding, and guidance is key to enable councils and their partners to build on the momentum from the feasibility studies.



8. CONCLUSION

REFLECTION ON KEY FINDINGS

In this report, we have summarised the approaches and findings of the MfE-funded feasibility studies on NbS for flood mitigation. Across a diverse range of assessment methodologies and engagement approaches, the feasibility studies demonstrated that NbS have a role to play in flood mitigation across different catchment contexts, but that their effectiveness and feasibility are context-specific.

Opportunities for NbS may also be limited in some circumstances, such as in places with limited land availability and in urban areas with widespread impervious surfaces. Most studies focused on rural settings, so this finding is not unexpected; however, outside of this review, transformational urban catchment programmes globally and nationally, such as Auckland Council's Making Space for Water programme, are showing significant benefits from urban greening and water sensitive urban design initiatives.

In the same vein, individual findings need to be examined in light of assessment limitations and the local context. Where studies found that the tested NbS were insufficient for addressing flooding, this may indicate that alternative mitigation options are needed, including traditional grey or hybrid infrastructure. However, this could also point to inherent and unmitigable flood risks in the catchment that require consideration of alternative management pathways to address the exposure of people and property. Climate change adaptation and resilience needs require transformational thinking, including around the opportunities and scale of nature-based approaches to flood mitigation.

Furthermore, we note that assessment findings are not static. As land use and risk conditions change and broader resilience needs come to the forefront, the suitability and feasibility of NbS for local conditions may change as well.



RECOMMENDATIONS FOR SECTOR NEXT STEPS

The feasibility studies add to the growing body of knowledge on and momentum for NbS for flood mitigation in Aotearoa. To build on this foundation and promote uptake to address the country's evolving flood resilience needs, the sector needs to continue advancing the evidence base for NbS and progress supportive policy, funding avenues, and guidance. The following recommendations build upon the prior recommendations captured in the June 2025 post-workshop summary report targeted at practitioners, policy makers, and decision makers and funding sources.

- **EVIDENCE BASE** | While NbS and adjacent concepts such as blue-green networks have gained traction in recent years, there is a long history of working with nature to manage flood risks and enhance community resilience, if not by name. Studies specifically on NbS are essential, but an analysis documenting the effectiveness and raising awareness of previous NbS-adjacent applications could help serve as proof of concept for NbS implementation. Evaluation of NbS interventions' multiple benefits will help to communicate their value.
- **POLICY** | Evidence from the feasibility studies and other work in this space can support policy advocacy and influence into ongoing reforms in resource management and local/regional government. While the current legislative uncertainty raises challenges for council resourcing and mandates to apply NbS, it also presents an opportunity to shift the dial on NbS uptake for the years and decades to come. In the meantime, policy guidance would also support local government to use existing and upcoming planning levers to promote NbS investigation and deployment and identify clearer resourcing pathways to implementation.
- **FUNDING** | Councils also expressed the need for further funding support to resource on the ground pilot projects. Funding programmes could come from a range of sources including central government as well as the private sector and alternative funding mechanisms. Policy settings for biodiversity and carbon credits could prompt significant uptake, but this requires further analysis into strategic approaches and wider implications to facilitate positive outcomes for local communities and ecosystems. Quantification of costs and benefits of NbS, including valuation of co-benefits through assessment frameworks such as the More Than Water Tool, can support business case development and funding decisions.
- **GUIDANCE** | To further support the expansion and implementation of NbS for flood mitigation in Aotearoa, we recommend the development of good practice guidance for assessing the feasibility and suitability of NbS for flood mitigation in the Aotearoa context. This guidance could build on the findings of the feasibility studies to further analyse the methodologies and results of the studies in the context of each study's individual parameters and limitations to produce insights on good practice and considerations for undertaking such assessments and applying them to progress the selection and implementation of NbS in catchments throughout the motu.

Standardised categorisation and classification of NbS types could also support comparability of projects across the sector. In addition, guidance on standardised reporting or communication of project findings would support comparability. Such guidelines could include a template for key information such as the number and scale of NbS interventions, study area size, and percent change in catchment response from baseline conditions. Evidence-based standards, methodologies, and reporting of findings would promote a more consistent yet context-specific approach to NbS and improve capacity in the industry.

8. CONCLUSION

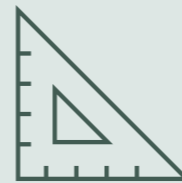
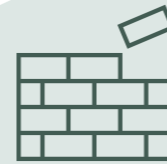
KEY TAKEAWAYS

NbS can reduce flood impacts under certain conditions. Multiple studies demonstrate measurable reductions in peak flows, delays in flood timing, and reductions in flow velocity. These benefits are most evident during smaller and more frequent flood events, though a few studies showed effectiveness even in severe events.

NbS are highly context-specific. Effectiveness depends on catchment characteristics, scale, and selection of suitable NbS types. Cultural, social, ecological, and economic factors also influence feasibility. The location and design of interventions within the catchment are critical to performance.

Assessment methodologies vary widely. Methods differ across studies, reflecting a wide range of technical, cultural, and economic considerations. Across the feasibility studies, NbS were most often assessed using hydrological and/or hydraulic modelling, complemented by GIS suitability analysis, geomorphic and soil assessments, multi-criteria analysis, and economic assessments. The tools and modelling approaches can be adapted to the level of detail required for each study and adapted to different scopes.

Meaningful stakeholder and mana whenua engagement is essential. Early and well-resourced engagement improves assessment quality and supports future implementation. Approaches ranged from limited consultation to co-governance and iwi-led delivery. Effective engagement builds confidence, supports decision making, and aligns outcomes with community and cultural priorities.



However, **NbS are not a silver bullet for flood mitigation.** Their effectiveness varies across catchments and scenarios. Performance typically reduces during more severe flood events. Engineered flood protection remains one of a series of intervention strategies to be considered – but NbS can play a role as an alternative, complementary, or hybrid approach.

Scale and integration are critical. Catchment-wide implementation and combinations of NbS provide the greatest benefit. Modelling indicates widespread and large scale (in terms of number of interventions as well as spatial footprint) implementation would be required to have a significant impact. Individual interventions are unlikely to fully mitigate flooding during less frequent and more severe events. Taking a systems approach and planning sequencing of different interventions along flow paths and tributaries can be important components of designing for scale.

NbS deliver multiple co-benefits. These include environmental, cultural, and community outcomes beyond flood mitigation. Co-benefits are central to the appeal and overall value of NbS, and play a key role in their feasibility from the perspective of supporting community and iwi aspirations as well as bolstering the business case for investing in NbS.

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This report was compiled by WSP authors Annika Min, Isabelle Farley, and Liam Foster with review by James Reddish.

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APPENDIX A: LIST OF FEASIBILITY STUDIES

FEASIBILITY STUDY	COUNCIL
Compaction of urban soils: understanding the feasibility of potential solutions for the amelioration of urban soils to reduce flood risk	Auckland Council
Coastal flood mitigation through protection and restoration of coastal freshwater and brackish wetlands	Environment Canterbury
How do Nature-based Solutions Feasibility interrelate with Mātauraka Māori in the takiwā of Te Rūnanga o Arowhenua	Environment Canterbury
Room for the River – A case study of implementation	Environment Canterbury
Murihiku Slow the Flow	Environment Southland
Maunga to Motu – Embracing the Waimata Awa	Gisborne District Council
Nature-based solutions feasibility study – Waipoua River	Greater Wellington Regional Council
Heretaunga Plains nature-based solutions for flood management	Hawkes Bay Regional Council
Upper Tukituki nature-based solutions for flood management	Hawkes Bay Regional Council
Ōroua and Pohangina catchments nature-based flood mitigation solutions	Horizons Regional Council
Natural Flood Management in the Marlborough Region	Marlborough District Council
Nature based solutions for river management in north Nelson	Nelson City Council
Upper Kawakawa Catchment Detention	Northland Regional Council
Modelling of the Te Hikapupu Catchment to investigate Flood Mitigation	Otago Regional Council
Analysis of nature-based solutions for flood and erosion mitigation in the Dart-Rees Floodplain to inform the Head of Lake Wakatipu natural hazards adaptation strategy	Otago Regional Council
Kia manawaroa Waitōtara, kia whakaritea te tangata - Let Waitotara be resilient, let the people be adaptive	Taranaki Regional Council
Hydrodynamic modelling of nature-based flood mitigation solutions – Motueka River, Tasman	Tasman District Council
Understanding coastal wetland hydrology and the effects of extreme events on land-use transition and blue carbon storage	Waikato Regional Council
Waikato and Waipa River Nature Based Solutions Feasibility Investigations	Waikato Regional Council
Multi-benefit Approaches to Building Westport’s Flood Resilience	West Coast Regional Council
Nature-based Solutions for Flood Mitigation in Cobden	West Coast Regional Council

This appendix compiles a selection of key resources on NbS and related concepts from Aotearoa New Zealand and the international community.

RESOURCES RELATED TO THE NbS FEASIBILITY STUDIES

Foster, L. & Min, A. (2025). **Post-Workshop Summary Report: Ministry for the Environment Nature Based Solutions for Flood Mitigation Projects – National mid-project workshop.** [\[link\]](#)

As part of the Ministry for the Environment’s ongoing programme of council-led feasibility studies on nature-based solutions (NbS) for flood mitigation across Aotearoa, a mid-project workshop was held in March 2025 to capture insights and experiences so far from the pilot studies. This report summarises lessons learned to date as shared by the participants via the in-person workshop and a pre-workshop survey.

Griffiths, J., Semadeni-Davies, A., Borne, K., & Tanner, C. (2024). **Nature-based solutions for flood management: Literature review.** NIWA Client Report No. 2024141CH; NIWA Project ELF24502. National Institute of Water & Atmospheric Research (NIWA). [\[link\]](#)

This literature review was undertaken to inform the 21 MfE-funded flood mitigation feasibility studies undertaken by councils. The aim of the review was to provide an up-to-date and in-depth analysis of the existing literature, case studies, and best practises related to the use of nature-based approaches for mitigating and managing fluvial floods.

AOTEAROA NEW ZEALAND RESOURCES

Boffa Miskell Limited (2024). **Nature-based Solutions for Climate Adaptation: Roadmap for scaling use in Aotearoa New Zealand.** Report prepared for Ministry for the Environment. [\[link\]](#)

This Roadmap for Scaling Nature-based Solutions for Climate Adaptation in Aotearoa New Zealand sets out the key actions required to equip New Zealand with the information, tools, and resources required to scale the use of NbS. The roadmap seeks to scale the use of NbS through the implementation of actions that will grow the understanding, financing, and technical application of NbS to address a range of climate change risks.

Pedersen Zari, M., G.L Kiddle; V. Chanse; S. Bloomfield; A. Latai-Niusulu; M. Abbott; P. Blaschke; S. Mihaere; O. Brockie; M. Grimshaw; A. Platje; K. Varshney; S. Ershadi (2024). **NUWAO Nature-based Solutions Design Guide.** Auckland: NUWAO. [\[link\]](#)

The NUWAO Nature-based Solutions Design Guide for Te Moananui Oceania is a tool for those involved in urban design, planning, policy-making, and community engagement, who aim to create urban spaces that work with nature to enhance the health and wellbeing of people, other living beings, and ecosystems. It features a database of approximately 100 practical NbS strategies, offering guidance and inspiration for the design of NbS initiatives. The strategies range from internationally recognised to those unique to the Te Moananui Oceania region.

Forest and Bird (2025). **Nō te ao tūroa ngā rongōā | Choose nature-based solutions.** [\[link\]](#)

Forest & Bird has worked with local councils, private landowners, and iwi throughout the country to publish a new resource showcasing a selection of nature-based projects throughout Aotearoa New Zealand. Each case study featured in the report looks at the problem being solved, what has been achieved, and how the mahi offers multiple co-benefits for local communities.

Helen Clark Foundation & WSP (2023). **Sponge Cities – Can they help us survive more intense rainfall?** [\[link\]](#)

The concept of sponge cities advocates for harmonious water resource management through innovative measures such as 'daylighting' streams, reducing impervious surfaces, enhancing green spaces, and implementing green infrastructure. The report emphasises crucial actions, such as excluding vulnerable flood-prone areas from development and incorporating mātauranga Māori to achieve comprehensive flood management solutions that enhance biodiversity and promote human well-being.

Manaaki Whenua – Landcare Research Group (2019). **Activating Water Sensitive Urban Design for Healthy Resilient Communities** (National Science Challenge for Building Better Homes, Towns and Cities). [\[link\]](#)

As part of this research programme, the following research outputs on Water Sensitive Urban Design (WSUD) and NbS are available:

- The 'More Than Water' WSUD Assessment Tool, which provides for the evaluation of a wide set of benefits and costs criteria using a simple qualitative assessment method. The tool generates graphical outputs that can be used to demonstrate how benefit and cost outcomes may vary under different development scenarios.
- Understanding the long term costs and maintenance responsibilities of NbS and WSUD approaches to site development in New Zealand.
- An international literature review of financial incentives and funding mechanisms for the implementation of WSUD in New Zealand.
- Research into the Te Ao Māori worldview and linkages to WSUD.
- New Zealand-based WSUD case studies.

Resilient River Communities [\[link\]](#)

Resilient River Communities is a joint initiative between Kānoa - the Regional Economic Development & Investment Unit, regional councils and unitary authorities to promote vital river management and flood protection schemes in New Zealand. It provides resources about river management and flood protection schemes in Aotearoa, including reports, webinars, and case studies.

International resources >>>

INTERNATIONAL RESOURCES

Cado van der Lely A, van Eekelen E, Honingh D, Leenders J, McEvoy S, Penning E, Sterk M, Voskamp I, Warren A and van Zelst V (2021). **Building with Nature: a future proof strategy for coping with a changing and uncertain world**. Ecoshape White Paper. [\[link\]](#)

This white paper informs practitioners of Building with Nature about the concept of uncertainty in relation to the decision and implementation process of Building with Nature, and how to use it as a strength.

Chausson, A., Turner, B., Girardin, C. A. J., Seddon, D., et al. (2020). **Mapping the effectiveness of nature-based solutions for climate change adaptation**. *Global Change Biology*, 26(11), 6134–6155. [\[link\]](#)

In order to enable NbS policy and practice to be better informed by science, this paper produced the first global systematic map of evidence on the effectiveness of nature-based interventions for addressing the impacts of climate change and hydrometeorological hazards on people.

CIRIA (2022). **The natural flood management manual**. 423p. CIRIA, London, UK. ISBN: 978-0-86017 945-0. [\[link; license required\]](#)

CIRIA's natural flood management (NFM) manual brings together evidence and case studies from the delivery of natural flood management projects. It provides a step-by-step guide to natural flood management measures from identification through to implementation.

CIRIA (2023). **ciriabest (CIRIA's Benefits ESTimation Tool)**. [\[link; license required\]](#)

ciriabest (CIRIA's Benefits ESTimation Tool) provides a structured way to estimate the value of the multiple benefits of blue-green projects. ciriabest is an online, spatial tool which guides the user to estimate the monetary value of a range of benefits that are not normally quantified. The main goal of ciriabest is to enable robust business cases to be made to give confidence to decision makers in the value of such projects to society, the environment and the economy.

Global Green-Gray Community of Practice [\[link\]](#)

The Global Green-Gray Community of Practice brings together designers, engineers, policymakers, funders, and communities to advance infrastructure that integrates traditional "gray" solutions with green, nature-based approaches — building more sustainable and resilient systems for people and nature. Published resources include:

- **Practical Guide to Implementing Green-Gray Infrastructure (2020):** A tool for identifying, funding, planning, designing, constructing, and monitoring green-gray infrastructure projects to increase the resilience of vulnerable cities, communities, and assets around the world.
- **Green-Gray Infrastructure Funding and Finance Playbook (2022):** The Playbook defines the roles, responsibilities, and replicable funding and financing models required to develop green-gray infrastructure at scale.
- **Guidance for Policymakers: Enhancing Resilience With Green-Gray Infrastructure (2026):** This report identifies policy instruments and governance processes that play a role in hindering or enabling GGI [green-grey infrastructure], outlines the process for conducting a national policy analysis for GGI solutions, and provides case studies that offer a glimpse into real-world contexts from around the world.

Institute of Public Works Engineering Australia (IPWEA) (2025). **The Green Infrastructure Management Manual (GIMM)**. [\[link\]](#)

The manual provides best-practice guidance on a range of GI assets, including street trees, green roofs and walls, parks and gardens, urban forests, community gardens, living shorelines, hybrid reefs, seagrasses, saltmarshes, mangroves, and water-sensitive urban design features such as constructed wetlands, bioswales, and rain gardens.

IUCN (2020). **Global Standard for Nature-based Solutions**. A user-friendly framework for the verification, design and scaling up of NbS. First edition. Gland, Switzerland: IUCN. [\[link\]](#)

IUCN's Global Standard for Nature-based Solutions is a comprehensive framework to inform and assess NbS across eight criteria and 27 indicators environmentally appropriate, socially beneficial, and economically viable across all sectors and geographies. The Nature-based Solutions Global Standard includes 8 criteria and 27 indicators.

OECD (2020). **Nature-based solutions for adapting to water-related climate risks**. OECD Environment Policy Papers, No. 21, OECD Publishing, Paris. [\[link\]](#).

This paper provides an overview of the use of NbS to date in OECD countries and finds that in most cases ambition for NbS does not match practice. Focusing on the application of NbS for addressing climate-related flood and drought risks, this paper explores why prevailing decision making frameworks may fail to adequately consider NbS. It sets out a policy evaluation framework that supports the identification of, and proposed ways to address constraints on the use of NbS to address water-related climate risks.

UK Environment Agency (2025). **Working with natural processes to reduce flood risk 2024**. Flood and Coastal Erosion Risk Management Research and Development Programme. [\[link\]](#)

The research report and literature review of this UK government programme brings together the updated evidence base for working with natural processes to protect, restore and emulate the natural functions of catchments, floodplains, rivers and the coast to reduce flood risk.

UNEP & IUCN (2021). **Nature-based Solutions for Climate Change Mitigation**. Nairobi & Gland. ISBN: 978-92-807-3897-1. [\[link\]](#)

This report analyses the state of knowledge regarding the role of Nature-based Solutions (NbS) in climate change mitigation. It shows that in order to keep temperature rising to 1.5 degrees and achieve net zero by 2050 a significant contribution from NbS is both necessary and possible, provided the necessary finance is made available.

UNEP-UNEA (2022). Resolution adopted by the United Nations Environment Assembly on 2 March 2022. **Nature-based solutions for supporting sustainable development**. UNEP/EA.5/Res.5. [\[link\]](#)

This 2022 UN resolution defines nature-based solutions and recognises their potential to support sustainable development.

INTERNATIONAL RESOURCES (continued)

US Army Corps of Engineers, various authors (2018, 2021, 2024). **Engineering with Nature: An Atlas**, Volumes 1, 2, and 3. Vicksburg, MS: U.S. Army Engineer Research and Development Center. [\[link\]](#)

The EWN Atlas Series highlights projects and partnerships that showcase the multifaceted benefits of integrating natural processes into engineering solutions. The three volumes present case studies of constructed projects, methodologies, and success stories, with each structured around four essential elements: using science and engineering to produce operational efficiencies; using natural processes to maximize benefit; increasing the value provided by projects to include social, ecological, and economic benefits; and using collaborative processes to organize, engage, and focus interests, stakeholders, and partners.

USACE (2021). **International Guidelines on Natural and Nature-Based Features for Flood Risk Management**. Engineering With Nature. [\[link\]](#)

The International Guidelines on Natural and Nature-based Features (NNBF) for Flood Risk Management provide practitioners with the best available information concerning the conceptualisation, planning, design, engineering, construction, and maintenance of NNBF to support resilience and flood risk reduction for coastlines, bays, and estuaries, as well as river and freshwater systems.

Vigerstol K., N. Karres, S. Kang, N. Lilly, M. Massey-Bierman (2023). **Accelerating Adaptation: the promise and limitations of Nature-based Solutions in the race to adapt to increasing floods and droughts**. The Nature Conservancy, Arlington, VA, USA [\[link\]](#)

This Nature Conservancy (TNC) report offers disaster risk planners and adaptation funders guidance on where and how to effectively harness nature to adapt to both a wetter and drier future.

Woods Ballard, B, Wilson, S, Udale-Clarke, H, Illman, S, Scott, T, Ashley, R, Kellagher, R (2015). **The SuDS Manual** (C753). CIRIA. ISBN: 978-0-86017-759-3. [\[link\]](#); [license required](#)

This publication covers the planning, design, construction and maintenance of Sustainable Drainage Systems (SuDS) to assist with their effective implementation within both new and existing developments. The guidance provides a framework for designing SuDS with confidence and to maximise benefits.

World Bank (2017). **Implementing nature-based flood protection: Principles and implementation guidance**. Washington, DC: World Bank. [\[link\]](#)

This document presents five principles and implementation guidance for planning, such as evaluation, design, and implementation of nature-based solutions for flood risk management as an alternative to or complementary to conventional engineering measures.

World Bank (2021). **A Catalogue of Nature-based Solutions for Urban Resilience**. Washington, D.C. World Bank Group. [\[link\]](#)

The catalogue of nature-based solutions for urban resilience has been developed as a guidance document to support the growing demand for NbS by enabling an initial identification of potential investments in nature-based solutions.

