POST-WORKSHOP SUMMARY REPORT

Ministry for the Environment Nature-Based Solutions for Flood Mitigation Projects – National mid-project workshop

FINAL VERSION

June 2025

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Contents

Ka ora te wai,

Ka ora te whenua.

Ka ora te whenua,

Ka ora te tangata.

If the water is healthy,

The land will be nourished.

If the land is nourished,

The people will be provided for.

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Executive summary

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 New Zealand, 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.

Documented lessons learned so far span findings about the project approach and delivery, insights into the various NbS options being tested, and implementation needs identified by participants. Project teams shared their experiences with procurement and project set up, stakeholder engagement and partnerships, and modelling and tools used in the pilot studies. Participants discussed key factors for NbS optioneering and site selection and gave preliminary indications of which NbS types seemed to have the most potential for flood mitigation. Implementation needs focused on supportive policies and regulations, dedicated and sustained funding, and best practice guidance.

Key recommendations include:

- Form communities of practice to share knowledge and experiences.
- Compile guidance on best practice, from technical modelling methodology and design standards to stakeholder engagement and strategy integration.
- Establish supportive policies and regulations at the national and regional levels.
- Continue partnerships and community outreach.
- Communicate the multiple benefits of NbS and set appropriate expectations about their limitations.
- Seek and establish funding from a range of sources, including blended public and private mechanisms.
- Continue collecting further information and examples, but do not wait for perfect evidence to implement NbS for flood mitigation.

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1. Introduction

1.1 Purpose

This report summarises the findings from the March 2025 mid-project workshop and pre-workshop survey on the projects underway in the Nature Based Solutions for Flood Mitigation programme funded by the Ministry for the Environment. The report captures lessons learned and suggests next steps, including recommendations for guidance to aid future project implementation.

The purpose of the workshop was to bring project teams from across the country together to share their experiences of running nature-based solutions (NbS) pilot studies, discuss successes and learnings, identify common challenges, and build a community of learning around NbS for flood mitigation. The workshop also identified emerging good practice for NbS feasibility studies, and its outputs will inform the development of a good practice guide as a starting point for the industry.

1.2 Background

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

The Ministry for the Environment has 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, which is part of the Government's Jobs for Nature initiative, is supporting 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. The two-year projects are due for completion in June 2025.

While specific regional or local outcomes vary, overall intended outcomes of the projects include:

- Practical recommendations and implementation of road maps
- Enhanced understanding of flood risk and effectiveness of NbS
- Supporting community/stakeholder consensus
- Informing policy and securing funding
- Informing national guidance and frameworks

The March 2025 workshop was a mid-project opportunity for collation of learnings between councils across the country as they entered the final stages of project delivery.

Name of 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 Pilot	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

Name of feasibility study	***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 Hakapupu 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

The 12 March 2025 workshop. (Annika Min, WSP)

2. Approach

The collation of mid-project findings comprised two stages: a pre-workshop online survey and a full day in person workshop.

2.1 Survey

An online survey was disseminated to workshop participants in advance of the workshop to gather information about the projects and to collect insights into project findings.

The survey covered two parts. Part 1 consisted of a project synopsis, including basic project details such as project name, location, local context, and key objectives and activities. This information was compiled into a one-page summary of each project, which can be found in *Appendix F. Project 1-pagers*. Part 2 of the survey covered emerging lessons, successes, and challenges from the project, including across project set up and procurement, approaches and software, stakeholder engagement and communication, and other aspects of project delivery.

See *Appendix B. Survey questions* for the survey questions and *Appendix E. Survey responses* for an anonymised transcript of the survey responses.

2.2 Workshop

The workshop was held in Blenheim on 12 March 2025 and was supported and attended by the Ministry for the Environment. MfE authorised the costs for up to four attendees from each pilot project, and project teams were encouraged to include representation of a range of expertise covering project management, modelling, communication and engagement, policy implications, and contractors for the project. In addition to the facilitators, a total of 54 attendees participated in the workshop.

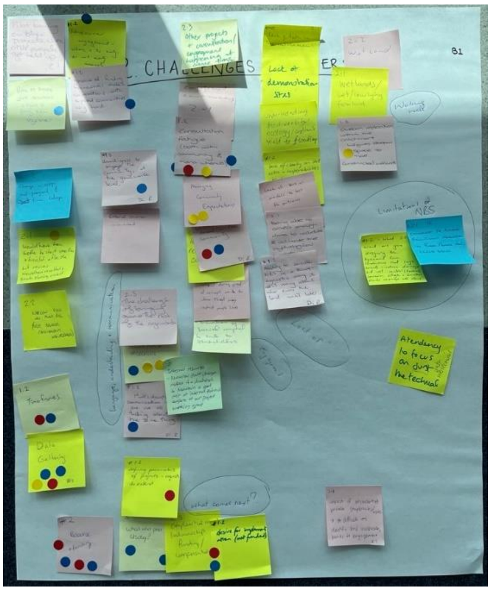
The mid-project workshop was designed to collect lessons from councils across the country from their projects to date. The purpose of the workshop was for participants to:

- Share experiences, discuss common challenges, and learn from other projects.
- Build a community of learning in relation to NbS.
- Expand their network with colleagues working on similar projects.
- Identify emerging good practice based on lessons learned from the NbS pilot studies and inform the future development of a good practice guide for the industry.

The workshop included plenary sessions, elevator pitches (brief presentations of each project), and three breakout sessions to facilitate small group discussions. The breakout sessions focused on key themes and questions to capture and consolidate attendees' experiences from running the pilot studies:

Breakout one	Breakout two	Breakout three
Lightning round: Key themes	**Technical & implementation stream**	**Successful practice application of NbS options**
Participants rotated in rapid-fire rounds to contribute to all key themes. Key themes: 1. Successes – what is going well 2. Challenges & barriers 3. Stakeholder/engagement 4. Optioneering 5. Process for site selection and how to improve. 6. Tools and lessons 7. Opportunities for NbS and flood risk management 8. Implementation needs	*Participants each chose one theme for in-depth discussion.* Key themes: 1. Technical 2. Funding, Implementation and Policy 3. Partnerships, engagement, and stakeholders.	*Each group received the same prompts*. Breakout 3 looked at successful practical application of NbS options using the groups experience from the pilot and initial findings and application against each NbS options. The purpose was to share which of the options are feasible and showing promise for flood management across the region.

See *Appendix A. Workshop agenda* for the workshop agenda and *Appendix C. Attendee list* for the list of attendees.



Photos from the 12 March 2025 workshop. (Annika Min, WSP)

3. Project approach and delivery findings

Participants shared their insights into procurement and project set-up, modelling and tools, and stakeholder engagement and partnerships. Project teams shared a mix of successes and challenges. As projects are ongoing, these findings focus on experiences to date.

3.1 Overview of successes and challenges from project approach and delivery

Key successes	Key challenges and barriers
• Enabling collection of evidence of the value of NbS for flood mitigation • Generating community conversations about catchment management approaches • Increased awareness and understanding of flood risk and potential benefits of NbS • Relationship building between councils, iwi, and consultants	• Managing community expectations • Time constraints • Data gathering • Limited resourcing and capacity • Consultation fatigue • Siloed nature of council • Complexities around land ownership and compensation • Desire for implementation unmet due to funding uncertainty

Successes

Crucially, the MfE funding has enabled the NbS pilot studies to take place for various catchments across the country. These trials will provide vital evidence of the potential value of NbS for flood mitigation in the national and local context.

Overall, there has been a positive response and engagement from district and local councils and good buy-in from partners and stakeholders. Within councils, pilot projects have increased awareness and understanding of potential benefits of NbS across different council sectors. Participants noted that support from other teams has been fundamental to delivering the projects in a short period of time as well as being flexible throughout delivery to let the work dictate.

Externally, the pilot projects have facilitated conversations with communities and iwi about catchment management approaches, bringing flood risks and NbS to the forefront, generating excitement for nature-based approaches, and highlighting other environmental outcomes beyond risk reduction. The projects have contributed to building relationships between councils, communities, iwi, and consultants and laid the groundwork for further collaboration. Projects teams highlighted that geospatial story maps have been an excellent way of communicating complex information.

Challenges and barriers

Challenges and barriers identified by participants span internal, external, and technical aspects of the projects.

Internally, participants highlighted the siloed nature of councils in the multidisciplinary context of NbS as a challenge for communication and collaboration, especially when it could be unclear whether they were all talking about the same things. Some projects found that staff turnover has made it challenging to maintain a good mix of internal technical experts within the working group. Constrained timeframes, delays, and mid-project changes in scope

Externally, councils have had to manage relationships with mana whenua, the wider community, and consultants. They have found that some communities and mana whenua experience consultant fatigue, leading to a lack of engagement. Climate change denial in local communities was also highlighted as a barrier to engagement.

Project teams noted it has been a challenge to manage community expectations around the outcomes of the work given the limited nature of the feasibility studies. In particular, the absence of funding frameworks and uncertainty around future implementation makes conversations with exposed communities difficult.

Participants mentioned that moving on to implementation would land better with community and elected officials.

Questions around the timing of landowner engagement and the complexities around land ownership and compensation also complicate future stages of project implementation. However, some participants noted it may be better to consider NbS in a tenure-agnostic way, i.e. not worrying about who owns the land until later.

On a technical level, data gathering emerged as key challenge. Project teams have found it difficult to collect sufficient catchment data to validate hydrological models.

Current concerns for project delivery include time constraints; staff resource limitations and capacity issues; uncertainty around future funding and the potential for implementation and subsequent long-term maintenance following the feasibility studies; and limitations around modelling.

3.2 Procurement and project set up

Project teams used a variety of procurement methods for sourcing their expertise, including some exclusively internal council teams, blended teams with consultant support, or external expertise secured for specific activities. Participants noted the importance of outsourcing tasks to individuals skilled in their niches as needed.

Multiple projects used a formal procurement process with open tenders on GETS where time allowed, which netted a good amount of interest and expertise with quality, thorough proposals (for example, two technical modelling tenders received 12 and 14 proposals respectively). Others used a closed tender or preferred supplier agreements to ensure location-specific expertise for mātauranga Māori and local relationships. Some projects worked closely with key mana whenua partners to identify specific work streams.

Overall, there appeared to be substantial interest and a high caliber of expertise in this field, but many participants found the availability of staff to be a challenge, especially internally with turnover in core council teams hindering efficient delivery. Participants were pleased that reporting requirements for the projects have been straightforward and not too onerous, saving costs on project administration to focus on actual project work.

Participants identified the following as challenges with procurement and project set up:

- Aligning on common language and understanding of NbS and the project approach among practitioners from different specialties like ecology, hydrological modelling, and engineering.
- Staff turnover and changes to the organisation during the project timeframe caused delays and required an adaptive management approach.
- The open-ended nature of the project created some challenges defining desired outcomes in conversations with consultants.
- Some project teams had difficulties finding adequately experienced practitioners in NbS, including specific expertise in approaches such as Room for the River, or found that those with experience were unavailable due to other contract commitments.

Project teams identified the following as recommendations for future project set up and delivery:

- Establish a clear roadmap with a more defined scope and interim deadlines to increase efficiency.
- Agree on the project plan as early as possible to avoid tight timeframes and ensure detailed work.
- Advocate for longer timeframes from MfE to develop projects, especially where consultation with iwi is required.
- Develop a request for proposals for tendering as early as possible and onboard the provider as soon as possible to get the modelling component of the project underway.
- Engage a project manager to undertake the work, despite the relatively small budget for FTEs, and involve them in the application phase to mitigate issues arising from staff turnover.
- Involve iwi partners in the funding application (e.g. co-application with rūnanga partner) to ensure their input from the start and foster ownership and engagement with the project. However, consideration must be given to how this engagement will be funded.

3.3 Modelling and tools

Project teams have used various approaches and software, including a variety of hydrological and hydraulic modelling packages, geographic information systems, reliance on local technical experts, and on the ground collaboration.

Common modelling tools used in the pilot studies include:	Other tools and data used include:
• QGIS • ArcGIS, including the Surface Volume (3D Analyst) tool in ArcGIS Pro • TUFLOW • HEC-RAS • HEC-HMS • MIKE • Hydstra • Models from consultants (e.g., ESMAX, DBAM) • ESRI's wetland identification • MODFLOW • NIWA's RiskScape • High level Excel-based analysis • Bathymetric Green LiDAR and topographic LiDAR, including for better understanding of geomorphological processes (erosion/accretion) • Delft 3D hydrodynamic modelling • LiDAR surveys for better understanding of geomorphological processes (erosion/accretion) • Council-specific modelling methodology	• ArcGIS StoryMaps • Groundwater data • Urban intelligence • HIRDSv4 rainfall rasters • Vegetation surveys, manual or via drone • eDNA biodiversity survey • HiLo water sensors • Online data from LINZ

Preliminary successes from modelling and use of tools have included generally good availability of data; being on the ground for context-building and collaboration; early indications of good calibration between the model and sample events; green LiDAR availability and application; use of specialist consultants; ArcGIS StoryMaps for communication; incorporating a data-based understanding of natural processes; results from modelling with HEC-RAS that clearly show the effect of NbS on river flows and can be paired with easy-to-understand visuals; and insights from hydraulic modelling into the limitations of NbS for large-scale flood mitigation.

Key challenges have included limited high quality spatial data across catchments; models not accounting for groundwater due to lack of data; inconsistent resolution and availability of data; the need for project workflows to address steep learning curves and room for error; difficulties testing small NbS at scale, e.g. leaky dams; limited data to validate models; and varied confidence in models, with observed mismatches between results and real data during validation. Participants noted that clearer scopes would provide a chance of better outcomes and that projects would benefit from earlier and thorough site assessment in the field. Overall, it was noted that consistency of data and modelling approaches are key areas for improvement going forward. With data updates and constantly evolving software and technology, it is critical for project teams to be aware of the best up-to-date practice tools for future application.

3.4 Stakeholder engagement and partnerships

Many of the pilot studies included stakeholder communication and engagement in their scopes. Several projects focused on positive established relationships with iwi and stakeholders. Overall, projects experienced openness and willingness to engage from iwi, communities, and other stakeholders.

Strategies that have been effective in engaging stakeholders and building strong relationships include:

- Early, proactive, and continuous engagement to build trust
- Forming a governance group at an early stage of the project
- Managing expectations around project outcomes
- Listening to communities' needs and interests and building on those
- Clear communication, transparency, and documentation of assumptions
- Site/place-based hui setting
- Face-to-face discussions

Challenges for community engagement and stakeholder buy-in included consultation fatigue, spread of misinformation about the project which required more proactive public communication, and unavailability of iwi partners. Project teams found it difficult to be based away from the site, as it made in-person meetings less frequent.

Project teams highlighted that sufficient time, budget, and capacity are essential for proper engagement. Time pressure can impact on the availability of partners to engage with the project and can fracture existing relationships if not managed well. Short timeframes hindered the ability to co-design projects in some cases. Participants also noted that the timing of the project – e.g., after a flood event, other issues in the catchment, or according to the season – was important for community engagement.

Participants raised concerns about a 'novel' approach being introduced to the public without any promise of implementation. They emphasised the need for clear messaging around the nature of the pilot as a feasibility study with no funding for implementation of the findings to reduce any chance of misunderstanding about the result of the work. However, some participants saw the hypothetical nature of the feasibility studies as a positive, saying that access to funding for investigating issues and potential solutions—without the immediate pressure of physical works—has fostered more open discussions, with people more willing to explore options when they aren't constrained by the expectation of a tangible outcome.

With NbS being a new subject area, significant advocacy and education will be required to have open and informed discussions with communities. Implementation of pilot sites could also assist with demonstrating to the public how NbS could work.

4. Nature-based solutions options

As noted previously, the United Nations has defined nature-based solutions (NbS) as “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 such, the term NbS spans a broad range of actions. In the flood mitigation context, key NbS types include:

- Floodplain restoration, reconnection, and lowering
- Restoring and reconnection of seasonal streams
- River restoration – remeandering, bed and bank naturalization
- Wetland creation and restoration
- Leaky barriers on watercourses
- Leaky barriers on runoff pathways
- Woody dams in streams and riparian zone
- Offline storage next to watercourses
- Offline storage adjacent to runoff pathways
- Online Storage
- Ponds
- Scrapes
- Bunds
- Floodplain and riparian planting
- Revegetation and habitat management

There are multiple projects undertaking assessment of the majority of these NbS option types, including broad applications being trialled across large catchments. Council participants agree on the need for a combination of multiple NbS options and a whole of catchment approach.

Commonly expressed pros and cons of NbS options encompassed:

Summary of common pros (benefits)	Summary of common cons (challenges)
• Distributed flow reduction and energy dissipation • Increased water retention, infiltration, groundwater recharge • Reduced runoff • Slope stabilisation and erosion control • Flood attenuation and flow reduction • Reduced flow velocities and peak flow generation • Enhanced sediment, debris, and pollutant trapping • Improved water quality • Habitat creation and biodiversity enhancement • Cost-effective, sustainable, and low-tech • Carbon sequestration	• Land availability, requirements, and cost • Public perception, awareness, and acceptance • Maintenance requirements • Potential impact on or conflicts with existing land use, infrastructure, and drainage • Timeframe for establishment and effectiveness • Potential for mosquito breeding (standing water) • Risk of failure and safety concerns • Uncertainty in cumulative hydrological impact or hydrological response, especially at catchment scale • Potential for habitat loss during construction and impact on fish passage if not designed properly

For a more detailed breakdown of best practice application of NbS options, see *Appendix D. Best practice application findings for NbS options for flood mitigation*.

4.1 What is showing promise

Natural processes that show signs of effectiveness for managing water flow or reducing flood risk in pilot areas include wetlands, native and exotic afforestation, riparian planting, vegetated riverbanks / riparian margins, “room for the river” approaches, and community-managed planting.

Types of NbS interventions that have so far demonstrated or are anticipated to have the most promising potential for effective flood management include:

- Wetland detention storage upstream of areas of need
- Widening braid plains by moving stopbanks landward – i.e. Room for the River approaches
- Geomorphic processes to reconnect the river to the floodplains
- Revegetation at large scale
- Increasing roughness to reduce velocity and scour/erosion (in some reaches)
- Storage based downstream
- Conveyance-based NbS

While modelling results are not yet available for pilot projects at this stage, project teams indicated that the scale of the event is significant. The NIWA literature review previously indicated that NbS would be most useful for mitigating the impact of 10–20-year flood events. Most pilot projects noted that modelling so far shows NbS may be less effective for large events, i.e., not expecting significant reductions to 1% AEP flows.

However, NbS are showing promise for reducing the impacts of smaller flood events, and even at 1% AEP flows offer other benefits such as erosion control, stabilisation, sediment development, and water quality improvements. Given these indications, it's important that public expectations be managed around the level of protection that affordable NbS options can provide for a catchment.

Preliminary modelling has shown that if the retired area is big enough, flow attenuation can occur at a meaningful level.

4.2 Optioneering

Participants provided commentary on their optioneering processes – their consideration of various alternatives and options to determine a preferred option – including on challenges they encountered, the criteria or data used, and key factors for determining suitability of different NbS for their specific pilot studies. Longevity of the NbS, affordability and economic viability, impact, cultural significance, availability of data, and the local land ownership context were critical factors in determining the suitability of different nature-based solutions.

Participants highlighted several ways to define the criteria for assessing options. These included defining the level of service for an NbS, determining the cost profile for long term planning and what the community could afford, multi-criteria analysis (MCA), cost-benefit analysis (CBA), and an understanding of ongoing maintenance requirements and costs. Other information considered included natural hazard data, existing flood risk, local topography, existing land use and land ownership arrangements, asset management considerations, information on areas of cultural significance, and economic analysis at different scales (e.g., community, iwi, district). In some cases, project teams evaluated options ranging between biomimicry, restoration aided by engineering, and long-term ecosystem restoration.

Several project teams experienced challenges with optioneering due to the limited options for some sites. At times community interest or priorities were not aligned with the project objectives centred on flood mitigation, resulting in more time needed to reach consensus. A common technical challenge reported was missing data or calibration requirements for suitable assessment around features such as groundwater.

Participants noted that it would have been useful during initial optioneering to know what approaches other councils or projects were taking and whether they were all assessing the same things. They also identified that guidelines on scenario parameters would be helpful to improve the relevance and consistency of use of climate scenarios, timeframes, and corresponding natural hazard data.

4.3 Site selection

Decision-makers involved in the site selection process included council staff, catchment groups, local community, iwi, river engineers, and Runanga.

Key factors for site selection for pilot catchments included:

- High flood risk
- Existing flood protection measures in catchments (either lack or presence thereof)
- Significant exposure or vulnerability of population, homes, marae, and infrastructure
- Priority catchments for iwi/hapu
- Extent of existing data and models for catchments (either lack or abundance thereof)
- Existing relationships with partners and stakeholders

- Co-writing approach with Runanga and capability
- Ability to leverage existing opportunities or advantages
- Availability of land
- Costs and cost-effectiveness
- Funding options
- Opportunity to support mātauranga Māori

Participants noted that key criteria for selecting future NbS trials across a catchment could include sites with established flooding issues (but not necessarily only in a 1% AEP scenario), higher co-benefits, lower environmental effects, potential for replicability, and options where interventions can work alongside nature. Participants said it would be valuable to have an end goal that can be incorporated into existing catchment operations by river managers.

5. Implementation needs

Participants discussed the existing implementation context for councils and identified a range of drivers and factors that would improve their ability to deliver on NbS projects. Key areas include:

- Increased and sustainable funding
- Policy support
- Clear national direction and guidance

Additional areas include enhancing capacity and expertise, working with landowners, and evaluating benefits of NbS.

5.1 Funding

Dedicated and sustained funding is crucial to enabling most project delivery areas, from staffing and procuring project team expertise to running workshops and outreach, covering the costs of tools and operations, and addressing landowner compensation. Funding is also essential for demonstrating commitment, building relationships, and gaining public support.

Participants called for increased and sustainable funding, highlighting the need for dedicated funding streams, flexible funding mechanisms, and national co-funding. They emphasised the need for funding to centre on collaborative resources and benefits and explore avenues for joint funding streams from central government and private sources. Participants identified a range of potential alternative and innovative funding mechanisms, including:

- Cost-Sharing and Incentive Programmes
- Private investment into a system for carbon, biodiversity, and other credits
- National or council rebate or tax breaks for landowners
- Beneficiary-funded mechanisms
- Transfer of general rates from cities
- Streamlining the Public Works Act to open funding sources for NbS
- Green bonds
- Recognition in the Emissions Trading Scheme (ETS) for NbS that improve forest health and improve water retention in soil in addition to sequestering carbon.
- International Visitor Conservation and Tourism Levy and regenerative tourism approaches to support at-risk communities.

Policy changes and integration with other areas could help to unlock new or existing funding. For example, integrating NbS into asset management plans (AMPs) could assist with securing funds to address flooding and climate resilience needs that would otherwise be slated for traditional grey infrastructure solutions. Councils could potentially recognise the value of NbS further by recognising NbS interventions as an asset class as well as assessing the value appreciation of green infrastructure over time, compared to the depreciation of grey infrastructure. Categorising NbS as an asset class warrants a more structured approach to capital expenditures and ongoing maintenance over time and facilitates integration into existing planning, which can unlock funding streams.

Accessing funding also hinges on making a strong business case for NbS. As such, it's important to develop or adapt cost-benefit analysis methodologies to assess the value of natural assets consistently and accurately on both private and public land and quantify the benefits of the broader ecosystem services they provide across catchments. Target levels of service also need to be defined for built NbS, not only for consistency of design but also for communicating the benefits as part of the business case.

Despite the myriad opportunities, funding challenges pose a significant barrier to NbS implementation. As Central Government priorities and approaches shift, river and water management face upcoming policy changes to the Resource Management Act – including specifically on freshwater and Te Mana o te Wai – and a changing policy context, such as with the proposed Regulatory Standards Bill.

Holistic flood risk management in Aotearoa needs more funding to address hazard events in a shifting climate – more research is needed to assess the risk and ascertain just how much funding is needed to deliver on the ground. It is imperative to investigate specific flood risk management activities in parallel, including NbS options. Now that the MfE-funded pilot studies have identified some feasible NbS approaches, the next step is determining how to fund and deliver those in appropriate parts of the catchment. A key aspect is enabling landowners to implement NbS approaches in the right areas, including demonstrating the outcomes – both for flood mitigation as well as co-benefits – that would incentivise them to fund it themselves.

5.2 Policy support

Alongside funding, supportive policy and regulatory changes were identified as critical for promoting and facilitating the wider implementation of nature-based solutions for flood management in Aotearoa.

Supportive strategies and policies

Participants emphasised the need for more supportive policy frameworks at all scales, with a focus on what can be done nationally to set overall direction and momentum and give regions pathways to prioritise NbS where beneficial. Participants called for:

- A clear national strategy and roadmap for expanding the application of NbS in Aotearoa, including agreed outcome, further research and modelling needs, and links to adaptation and risk reduction pathways.
- Prioritisation or preference for NbS in national and regional policy statements.
- Clear definitions for nature-based solutions and different types of NbS to better communicate, capture, and monitor what falls under this umbrella.
- Establishment of a floodplain management policy.
- Alignment and integration with Dynamic Adaptive Policy Pathways (DAPP) and the adaptation community, with a focus on holistic, whole-of-catchment adaptation approaches
- Encouraging the incorporation of NbS in business-as-usual river engineering work where possible, which participants noted as something that has been working well so far.
- Incorporation of NbS into asset management plans (AMPs) where relevant for climate resilience, flood risk mitigation, and addressing other challenges.
- Collective decision-making approaches on how to best manage NbS as an asset in urban and rural environments.

Strategies and policies must be complemented by enabling regulations and adequate funding, planning, and coordination to make broader implementation of NbS a reality. Furthermore, practitioner communities of practice are needed to inform the development of strategies and policies considering the evidence base and to demonstrate the benefits of NbS to gain public support.

Legal and regulatory frameworks

In additional to national strategic direction, permissive and enabling legal and regulatory frameworks are essential to taking NbS from concept to implementation.

Regulatory barriers must be addressed to allow installation of NbS, including through the streamlining of the Public Works Act and resource consenting processes. Implementation pathways need to be established to overcome the hurdle of NbS's multidisciplinary, catchment-scale nature which can make it fall under the jurisdiction of multiple entities or regulations. Confirmation of upcoming changes to the resource management system could help inform future options for NbS. Participants noted that regional policy statements should set the direction for enabling frameworks and promote NbS as credible options for flood risk mitigation.

Legal definitions of NbS and related terms in the flood mitigation and catchment management context, such as river margins and braided rivers, should be clarified.

Since NbS are context-specific and tailored to local environments, communities, and flood risk, councils need discretion to implement activities without being unduly hampered by prescriptive regulations or funding stipulations.

Integrating NbS into the bigger policy picture

Policies and strategies need to position NbS within the larger picture. This is twofold:

1. Promoting NbS as part of a broader suite of solutions.
2. Articulating the multiple benefits of NbS and integrating it across sectors, agencies, and organisations.

As noted in the workshop, NbS offer great potential for flood mitigation but are unlikely to be sufficient against large events in isolation and may not be suitable for all contexts. NbS should be viewed as a credible, effective, locally tailored option within a wider approach that also incorporates traditional built infrastructure, new technologies, social and economic levers, and hybrid options where appropriate.

NbS can be integrated into a range of risk reduction and recovery frameworks across diverse areas such as transport, civil defence, insurance, land use planning, and urban and rural planning as well as at different scales, from local community-led efforts to national adaptation plans.

Linking it to other areas and communicating co-benefits can inspire and garner buy-in from other partners (e.g. Waka Kotahi and large landowners) and identify new opportunities within existing policies and plans (e.g. broadening what types of projects can be covered under the National Land Transport Funding Scheme, or NLTF).

At an organisational or regional level, planners and asset managers should consider how NbS can be recognised as an asset class and integrated with existing or upcoming asset management plans (AMPs) and long-term plans (LTPs) to address identified climate resilience, water management, and flood mitigation needs, as well as other areas that would benefit from NbS.

5.3 Guidance

Participants highlighted the need for clear national direction and guidance to support research, design, implementation, and monitoring for NbS. Various government strategies already point to NbS as an important component of climate adaptation and biodiversity planning. However, establishing a national strategy specifically on NbS would create momentum and could identify areas for integration across agencies and disciplines, broadening awareness, and funding opportunities.

Standardised methodologies and frameworks would facilitate the development of best practice approaches, identify a menu of NbS options, and provide guidance on assessing NbS benefits. This standardisation could extend to representation of NbS interventions within models to improve consistency and replicability. The evidence gathered from the pilot studies should be compiled as a starting point to inform NbS feasibility studies and implementation going forward.

In addition, clear guidance and definitions in the Aotearoa context can support a broader understanding of the work across communities and practitioners and help to set expectations of what projects can and will deliver. Guidance should draw on the existing body of knowledge around best practice approaches from overseas and advise on their applicability to the national context, along with any Aotearoa-specific considerations that practitioners should consider.

5.4 Other implementation needs

Other aspects mentioned by participants which would support NbS project delivery include enhancing project team capacity and expertise, working with landowners, and evaluating wider benefits of NbS.

5.4.1 Enhancing project team capacity and expertise

Designing, implementing, and maintaining nature-based solutions at scale requires sufficient capacity and expertise. Many participants noted a lack of dedicated staff or time within councils and their reliance on technical experts, including consultants. Especially in the context of limited council resources and time, NbS projects would benefit from adequate funding and a sustained ability to:

- Allocate dedicated staff and/or specific funded time to allocate to NbS projects.
- Source internal or external technical expertise.
- Employ local environmental service teams to undertake the physical work of implementation.

Longer project timeframes could help alleviate some of the time constraints of staff as well as support effective engagement with partners and the community.

Recognising the need for ongoing, long-term maintenance of NbS, it would be crucial to identify the "owner" within council who would be responsible for the project, while establishing an integrated project team spanning engineers, ecologists, land management staff, iwi liaisons, and others.

5.4.2 Working with landowners

Engagement with local landowners is often necessary to implement NbS on the ground at a catchment scale. Participants identified the following as key elements for facilitating buy-in from landowners:

- Establishing clear processes and funding mechanisms for landowner compensation.
- Providing guidance on affordability considerations & early decision making.
- Identifying alternative options for landowner compensation, such as swapping land or designating stewardship.
- Having staff as "boots on the ground" to demonstrate capability and commitment.

5.4.3 Evaluating the benefits of NbS

Tools and methods to substantiate the benefits of NbS would support the business case for and help to communicate the value of NbS projects to funders and other audiences. Areas for improvement include:

- Defining and determining the beneficiaries of NbS in the catchment.
- Valuing the ecosystem services provided, including and beyond flood mitigation.
- Assessing the full life cycle of NbS interventions.
- Establishing a consistent framework for evaluating costs and benefits of NbS.

6. Recommendations

Recommendations for practitioners	*Recommendations for policy makers*	*Recommendations for decision-makers and funding sources*
Continue partnerships and outreach. Set appropriate expectations. Communicate benefits beyond flood mitigation. River managers can take a leadership role.	Establish supportive policies and regulations. Emphasise prevention in addition to building NbS.	Compile guidance on best practice. Collect further evidence and examples. Improve support for feasibility and pilot studies.
For all:		
Do not wait for perfect evidence to act. Unlock funding from a range of sources. Form communities of practice.		

Do not wait for perfect evidence to act.

Research and modelling are essential to understanding and communicating the potential impacts and consequences of implementing NbS for flood mitigation in Aotearoa. Similarly to traditional infrastructure, nature-based interventions can have unintended consequences or even exacerbate the problem if not designed or implemented correctly with reference to scientifically based guidelines.[1]

However, there will always be unknowns, and climate change will challenge any approach. Flooding is a significant and increasing problem in Aotearoa that requires innovative, integrated, and diverse approaches, and there is a wealth of international evidence on NbS. The only way to truly know if NbS work in our changing local environment is to build them, monitor the effects, and validate the models developed.

Unlock funding from a range of sources.

Dedicated and sustained funding is essential to supporting delivery of NbS projects. Without an existing funding stream for NbS, and with current regulatory barriers to using public money for multidisciplinary solutions, alternative and blended funding mechanisms could enable councils to seek funding from both Central Government and the private sector. Support for such funding programmes would require demonstrating that such synergies will create public benefit without compromising outcomes.

At the same time, integration with existing processes and policy areas - such as asset management plans, civil defence, and transport - and strong business cases based on the multiple benefits of NbS could help divert funds allocated for addressing flood risk and other resilience needs to NbS interventions.

Form communities of practice.

This workshop brought together over fifty participants from across the country, sparked discussions between councils and consultants, and facilitated knowledge sharing – a good start to forming a community of

[1] Selection, Planning, and Modelling of Nature-based Solutions for Flood Mitigation. Griffiths, J., et al. 2024, Water, Vol. 16, p. 2802. https://doi.org/10.3390/w16192802

practice. Future releases of government funding should provide further opportunities to form communities of practice to facilitate knowledge sharing, create support networks, and cross-pollinate ideas to increase the efficiency and effectiveness of pilot studies and NbS implementation. These communities of practice should also engage and involve mana whenua and rural communities as critical partners of this work. A community of practice can help to collate knowledge, document experiences across different contexts, streamline and avoid duplication of efforts and costs, and contribute to developing strategy for embedding NbS in council processes and linking its benefits to the core work of councils across the motu.

River managers can take a leadership role.

River managers have historically applied various forms of techniques that would now fall under NbS. A key recommendation out of this workshop is to view NbS not as a brand-new concept, but rather to view the interest in NbS as an opportunity to pursue further approaches that incorporate natural features and processes in the management of river catchments. River managers for respective councils should undertake investigation into feasible locations for NbS implementation and seek to assess and communicate co-benefits for flood protection of communities and for ancillary benefits, including biodiversity conservation, carbon sequestration, cultural significance, water quality improvements, and economic outcomes for local sectors.

The River Managers' Special Interest Group should review and take note of this report's findings. It can identify and develop a workstream that seeks to synthesise and share knowledge on nature-based solutions for catchment floodplain management and contextualise NbS within the full suite of flood risk management approaches, for example by providing an approach for assembling a final report on the MfE-funded feasibility studies and developing best practice guidance.

Continue partnership with and outreach to mana whenua and rural communities.

The implementation of many NbS projects hinges on the involvement of rural communities and mana whenua. Continued outreach, active partnership, and building stakeholder consensus are essential to making NbS projects a reality.

Set appropriate expectations.

While NbS can contribute to flood mitigation and offer many co-benefits, they are not a silver bullet. Communication with partners, beneficiaries, and the public should reflect both the high potential of NbS as well as its limitations, particularly around their effectiveness for large scale flood events (e.g., 1% AEP).

Communicate benefits beyond flood mitigation.

Beyond flood mitigation, practitioners need to understand and articulate the wider benefits of NbS to address other societal challenges. Expanding the framing to emphasise the co-benefits of NbS – including for increased resilience, reduced maintenance needs, cost savings, and biodiversity – can help to gain buy-in from partners, communities, funders, and policymakers. Tangible information, such as cost-benefit analysis and comparison of NbS to alternative options, can help drive stakeholder engagement and make the case for NbS.

Collect further evidence and examples.

Continued research and evidence collection are imperative to support our understanding of why, how, and when NbS may be a good option to support flood mitigation and risk reduction in the Aotearoa context. Starting points for this include:

- Consider evidence that may be hiding in plain sight, such as projects that may not be labelled as NbS but are functionally NbS, or older projects that may not have been reported on as NbS. For example, whole-of-catchment approaches that implement interventions high in a catchment to reduce flooding lower in a catchment could include erosion control projects since the 1960s, which also help to mitigate flooding.
- Collaboration between water managers and river managers to get a stock take of where NbS and NbS-related interventions have been built in regional and district council assets.

- Develop and disseminate case studies from this programme, particularly as some become implemented on the ground.

As the effects of climate change intensify, monitoring and evaluation of implemented NbS will be key to understanding their effectiveness over long-term time horizons and under changing conditions.

Proof of concept is especially important to support the choice of NbS in resource-constrained and at-risk communities that are facing multiple natural hazards and affordability issues. Without strong evidence – combined with policy and funding support – communities may default to more familiar grey infrastructure, even when maladaptive outcomes are likely.

Improve support for feasibility and pilot studies.

Workshop participants expressed appreciation for the MfE funding for this programme but noted the limitations of the available funds. Further funding is needed to improve the allocation of dedicated project staffing and support community engagement activities, as well as to progress implementation on the ground. In addition to funding, programmes should provide more time for studies to allow for project completion and account for any delays or staff turnover.

Establish supportive policies and regulations.

Supportive policies and regulatory changes are needed to facilitate the implementation of NbS for flood mitigation in Aotearoa. Participants called for a clear national strategy and roadmap for expanding the application of NbS in Aotearoa as well as the prioritisation of NbS in national and regional policy statements. Establishing a national strategy around NbS would generate momentum, foster collaboration between agencies and sectors, and unlock funding opportunities. Strategies and policies must be complemented by enabling regulations and adequate funding, planning, and coordination to make broader implementation of NbS a reality.

Existing barriers in regulation (such as the Public Works Act) and resource consenting processes must be addressed to create enabling legal and regulatory frameworks that permit the implementation of multidisciplinary, locally specific nature-based solutions. While Government is undergoing resource management reform, policy makers should take the opportunity to improve land and water management practices.

Emphasise prevention in addition to building NbS.

As noted in the UNEA definition, NbS options include protection and conservation alongside restoration and sustainable management of ecosystems. In addition to testing the potential impacts of building NbS in catchments, it is crucial to consider the value of existing natural assets and what might happen if they were removed – not just for biodiversity, but also for flooding. Decisions about the management of natural assets, e.g., whether to cut down a forest, should be weighed considering the ecosystem services these assets provide, including flood mitigation. Conserving natural resources and ecosystems upfront can be much more cost-effective than retroactive intervention, but this often requires a strong, evidence-based business case for early consideration.

Compile guidance on best practice.

Evidence from these pilot studies should be compiled at the conclusion of the programme to serve as a foundation for determining the best practice methodology and approaches for NbS feasibility studies and to inform on-the-ground implementation. Participants viewed the low reporting requirements of the programme favourably to enable them to focus on undertaking the studies themselves; however, more information needs to be collected and collated on the outcomes to enable participants and other users to understand the pilot outputs and progress implementation more quickly. The guidance document could serve as an appraisal of the findings from these feasibility trials.

Participants called for guidance to cover integration of NbS into regional flood mitigation strategies, standardised monitoring frameworks for assessing NbS effectiveness, written design standards, levels of service, consistent modelling methodology, and use of risk and residual risk thresholds.

Whatungarongaro te tangata, toitū te whenua.

As people disappear from sight, the land remains.

This whakatauki speaks to the importance and permanence of land. While people come and go, the land remains. As humans we rely on the land. We must think long-term and see the big picture to ensure the sustainability of the land.

Appendices

Appendix A. Workshop agenda

Nature Based Solutions for Flood Mitigation MFE Projects – National mid project workshop
12 March 2025 | 8:30 am – 4:30 pm | ASB Theatre Marlborough

TIME	AGENDA ITEM
8:30 (30 mins)	**Registration**
9:00 (15 mins)	**Welcome and introductions**
9:15 (10 mins)	**Opening remarks**
9:25 (5 mins)	**Why we are here: workshop objectives, tikanga, and agenda**
9:30 (60 mins)	**Elevator Pitches (Part 1)**
10.30 (20 mins)	***Morning Tea***
10:45 (60 mins)	**Elevator Pitches (Part 2)**
11:45 (20 min)	**What have we heard from you?** *Responding to the data collected before the event.*
12:00 (50 mins)	***Networking Lunch***
12:50 (90 mins)	**Breakout 1 – Lightning round: Key themes** **Key themes** (60 mins) *(key themes are subject to change)* 1. Successes – what is going well 2. Challenges & barriers 3. Stakeholder/engagement 4. Optioneering 5. Process for site selection and how to improve 6. Tools and lessons 7. Opportunities for NbS and flood risk management 8. Implementation needs **Collate inputs & report back** (30 mins)
14:20 (5 mins)	***Switch breakout rooms***
14:25 (45 mins)	**Breakout 2** – **Technical & implementation stream** *Attendees to choose one question.* • Q1: Technical work breakout • Q2: Funding, implementation, policy breakout • Q3: Stakeholder engagement and iwi partnerships
15:10 (15 mins)	***Afternoon Tea***
15:25 (30 mins)	**Breakout 3 – Successful practice application of NbS options** *The outputs from this breakout will inform the need for a compendium/good practice guide.*
15:55 (25 mins)	**Final questions and comments from the group** *Q&A and final thoughts on NbS, including a discussion on strategic planning for NbS implementation in Aotearoa New Zealand.*
16:20 (5 mins)	**Next steps**
16:25 (5 mins)	**MfE closing remarks**
16:30	**Close**

Appendix B. Survey questions

Part 1. Project Synopsis
Project synopses based on the information you provide in Part 1 will be shared with all attendees as part of the workshop package.

1. Council name
2. Project name
3. Project Location: *Please include the catchment area and information on the location(s) being considered to help with the understanding of scale.*

☒ Yes, I have emailed a map of the location(s)/area being considered to the workshop organisers.

4. Project start and end dates
5. Local Context: *What is the key challenge you sought to address with this project? What is the current state of flooding or flood mitigation in the project area?*
6. Local context: *Why were nature-based solutions seen as a good fit to address this challenge?*
7. Project objectives. *Please list the key objectives of the project.*
8. Key project activities. *Please list the key activities of the project*

PART 2. Emerging lessons
This section will not be shared with attribution to specific projects, so please be open and honest with your responses. Themes and common insights will be aggregated for reflection during the workshop. For the following questions, please consider: What has worked well on this project, and do you have any concerns so far? Why? What have you learned, or what can you share, to improve the chances of success for future projects?

PROJECT SET UP AND PROCUREMENT
9. Project set up and procurement: What has gone well?
This could include:

- *Comments on the internal project team and resourcing*
- *Whether you went to market for this project*
- *What was the procurement process? (e.g. formal tender process)*
- *What was the level of interest?*
- *How did you select the provider?*
- *Did you feel the provider options had enough experience and knowledge to deliver on the project?*

10. Project set up and procurement: Do you have any concerns about this aspect of the project? What would you change next time?
11. Project set up and procurement: Any other comments on project set up and procurement?

APPROACHES AND TOOLS
12. Approaches and software: What tools/approaches are being used?
This could include:

- *What tools, software, or other approaches are being used?*
- *How are these tools/approaches performing in comparison to your expectations?*
- *Do you have any tricks or tips to share?*

13. Approaches and software: What has gone well?
14. Approaches and software: Do you have any concerns about this aspect of the project? What would you change next time?
15. Any other comments on tools/approaches

STAKEHOLDER COMMUNICATION AND ENGAGEMENT
16. Stakeholder communication and engagement: What has gone well?
This could include:

- *Have you been able to get the desired stakeholders involved?*
- *How are stakeholders supporting the project?*

- *Do you feel you have the right amount of people involved, or too many or too few?*
- *Whom have you found to be key influencers or stakeholders in this process?*

17. Stakeholder communication and engagement: Do you have any concerns about this aspect of the project? What would you change next time?

18. Any other comments on stakeholder communication and engagement

OTHER ASPECTS OF PROJECT DELIVERY

19. Other aspects of project delivery: What has gone well?

20. Other aspects of project delivery: Do you have any concerns about this aspect of the project? What would you change next time?

21. Other aspects of project delivery: Any other comments. *Please add any additional comments you may have on other aspects of project delivery.*

22. What are your intended outcomes from this pilot work?

E.g. What would you expect to see at the end of the work? What is needed to support the implementation? What national level support is required to build off these pilots?

23. What would you need to improve your council's ability to design, fund, implement, and/or replicate these types of projects?

24. Is there anything further you would like to raise at this time?

25. What question or topic would you most like to hear about from other councils at the workshop?

Appendix C. Attendee list

Name	Organisation
Alastair Clement	Tasman District Council
Andy Brown	GWRC
Anna Ivanova	Environment Canterbury
Anne Bruce	Marlborough District Council
Bertrand Salmi	Water Technology
Charles Chaves	Northland Regional Council
Chris Vicars	Taranaki Regional Council
Cid Shearman	Nelson City Council
Daniel Harrison	Taranaki Regional Council
David Aires	Environment Canterbury
Diana Rossiter	Dextera Ltd
Ella Boam	Greater Wellington Regional Council
Ella Lawton	Environment Southland
Francie Morrow	Greater Wellington Regional Council
Glenn Irving	Dextera Ltd
Graeme Carroll	River Managers SIG
Hannah Watkinson	Environment Canterbury
Ian Wiseman	Jacobs
Ify Ukonze	Otago Regional Council
Isabelle Farley	WSP
Jack Mace	Greater Wellington Regional Council
Jahangir Islam	AECOM New Zealand Ltd
James Mills-Kelley	Marlborough District Council
Jean-Louis Dubois	WSP
Jo Martin	MFE
Jonathan Cousins	NRC

Name	Organisation
Julia Jung	Horizons Regional Council
Katie Coluccio	WSP
Logan Brown	Horizons Regional Council
Maree Willetts	Environment Canterbury
Matt Balkham	Jacobs
Matt Oliver	Marlborough DC
Megan Rowland	Otago Regional Council
Megan Tyler	Northland Regional Council
Melanie White	Otago Regional Council
Melissa Robson-Williams	Environment Southland
Natalie Dixon	Beca
Nathan Anderson	Otago Regional Council
Nicki Davies	Gisborne District Council
Pam Guest	Greater Wellington Regional Council
Paulette Birchfield	West Coast Regional Council
Randal Beal	Environment Southland
Rick Liefting	Waikato Regional Council
Rob Deakin	Greater Wellington
Rob Waldron	HBRC
Ruby Stevens	Horizons Regional Council
Sandy Gorringe	Gisborne District Council
Sarah Yeo	WSP
Saul Gudsell	HBRC
Shaun McCracken	Environment Canterbury
Simeon Long	Marlborough DC /University of Auckland
Sophie South	Davis Ogilvie and Partners
Sue Ira	Koru Environmental
Toby Kay	Nelson City Council
Treena Davidson	Aoraki Environmental Consultancy

Facilitators	
Rachael Armstrong	
Liam Foster	WSP
Annika Min	WSP

Appendix D. Best practice application findings for NbS options for flood mitigation

This appendix summarises commentary on pros, cons, and other considerations for common NbS options for flood mitigation based on workshop discussion and expert input. Descriptions for the NbS options have been drawn or adapted primarily from the CIRIA Natural Flood Management Manual.

The NbS options covered include:

- Floodplain restoration, reconnection and lowering.
- Restoring and reconnection of seasonal streams
- River restoration – remeandering, bed and bank naturalization
- Wetland creation and restoration
- Leaky barriers on watercourses
- Leaky barriers on runoff pathways
- Woody dams in streams and riparian zone
- Offline storage next to watercourses
- Offline storage adjacent to runoff pathways
- Online Storage
- Ponds
- Scrapes
- Bunds
- Floodplain and riparian planting
- Revegetation and habitat management

NbS option	**Floodplain restoration, reconnection, and lowering**
Description	The process of restoring floodplain connectivity (the ability of water to pass between a watercourse and its floodplain), with the aim of encouraging more regular floodplain inundation and floodwater storage. This can reduce flood peaks and downstream flood depths.

Summary of pros	Summary of cons	Summary of other comments
• **Increased Flood Storage**: Restoring floodplains creates natural storage areas for excess water, reducing peak flows downstream. Reconnecting rivers to their floodplains allows water to spread out, decreasing the depth and velocity of floodwaters in the main channel. Lowering floodplain elevations further enhances this storage capacity. • **Flood Attenuation and Flow Reduction**: The increased storage and the greater surface roughness of natural floodplains (due to vegetation) slow down the flow of water. This attenuation spreads the flood hydrograph over a longer period, reducing the peak discharge that downstream areas experience. • **Reduced Downstream Flood Risk**: By storing and slowing floodwaters upstream, these measures can significantly reduce the risk of flooding in downstream communities and infrastructure. This is particularly beneficial for larger, less frequent flood events. • **Groundwater Recharge**: Floodplain inundation can enhance infiltration and recharge local aquifers, contributing to baseflow in rivers during drier periods and improving overall water security at the catchment scale. • **Improved Water Quality**: Floodplains can act as natural filters, trapping sediments, nutrients, and pollutants from floodwaters, thus improving water quality downstream. Wetlands within restored floodplains play a crucial role in nutrient cycling and pollutant removal. • **Enhanced Biodiversity and Habitat Creation**: Restoring natural floodplain ecosystems creates diverse habitats for a wide range of plant and animal species, contributing to overall biodiversity at the catchment level. Reconnecting rivers with their floodplains allows for the exchange of nutrients and organisms, supporting healthier aquatic and terrestrial ecosystems. • **Reduced Erosion and Sediment Loss**: Natural floodplain vegetation helps stabilise riverbanks and the floodplain surface, reducing erosion and the amount of sediment entering the river system. This can improve water clarity and reduce sedimentation in downstream areas and infrastructure. • **Cost-Effective and Sustainable**: In many cases, floodplain restoration can be a more cost-effective and sustainable long-term solution compared to traditional hard engineering approaches like dams and levees, which can have high construction and maintenance costs and negative ecological impacts. • **Carbon Sequestration**: Floodplain vegetation, especially forests and wetlands, can sequester and store significant amounts of carbon, contributing to climate change mitigation. • **Ecosystem Services**: Restored floodplains provide a range of other valuable ecosystem services, such as nutrient cycling, recreation opportunities, and aesthetic benefits.	• **Land Availability and Cost**: Implementing large-scale floodplain restoration requires significant land areas, which may be unavailable or expensive, especially in developed or agricultural catchments. • **Potential Impact on Existing Land Use**: Restoration may require changes in existing land use practices, which can face resistance from landowners and stakeholders (e.g., agriculture, development). • **Timeframe for Effectiveness**: The full benefits of floodplain restoration, especially the establishment of mature vegetation and complex ecosystems, can take a significant amount of time to be realised. • **Complexity of Implementation**: Designing and implementing effective floodplain restoration projects can be complex, requiring a thorough understanding of the local hydrology, geomorphology, and ecology. • **Sediment Management**: Restoring floodplain connectivity can sometimes lead to the deposition of legacy sediments, which may need to be managed. • **Potential for Greenhouse Gas Emissions**: Inundation of floodplains, particularly wetlands, can sometimes lead to the release of methane, a potent greenhouse gas. Careful design and management are needed to minimise this. • **Uncertainty and Climate Change Impacts**: The effectiveness of floodplain restoration can be influenced by future climate change impacts, such as altered rainfall patterns and increased frequency of extreme events. Models and assessments need to consider these uncertainties. • **Upstream-Downstream Dynamics**: While beneficial overall, the localised increase in water storage upstream might have complex and sometimes less beneficial impacts on very immediate upstream areas. Careful modelling is needed to understand these dynamics. • **Maintenance and Management**: While generally low maintenance compared to hard infrastructure, restored floodplains may still require some level of monitoring and management, such as invasive species control or vegetation management. • **Public Perception and Acceptance**: Gaining public support for floodplain restoration projects can be challenging, especially if it involves changes in land use or perceived loss of land.	• Multiple projects undertaking this type of assessment using hydraulic models to support benefit assessment. • Showing promise for more frequent return period flooding events. • Broad applications being trialled across large catchments.

NbS option	**Restoring and reconnection of seasonal streams**
Description	The process of restoring floodplain connectivity (the ability of water to pass between a watercourse and its floodplain), with the aim of encouraging more regular floodplain inundation and floodwater storage. This can reduce flood peaks and downstream flood depths.

Summary of pros	Summary of cons	Summary of other comments
• **Increased Infiltration and Reduced Runoff**: Restoring natural flow regimes and vegetation along seasonal streams enhances infiltration of rainwater into the ground. This reduces the volume of surface runoff that contributes to peak flows in the main river channel during storm events. • **Enhanced Water Storage in Headwaters**: Seasonal streams often drain upland areas. Restoring their natural storage capacity (e.g., through small wetlands, vegetated depressions) can temporarily hold back water, delaying and reducing the peak flow reaching downstream areas. • **Improved Timing of Flows**: Reconnecting seasonal streams to the main network can help regulate the timing of water delivery. A more gradual release of water from these tributaries can contribute to a more sustained baseflow and reduce the intensity of flood peaks. • **Natural Flow Pathways and Energy Dissipation**: Restored seasonal streams with natural meanders and vegetation provide pathways for floodwaters to spread out and slow down. The vegetation and channel roughness help dissipate the energy of floodwaters, reducing their erosive power and downstream impact. • **Reduced Sediment and Debris Delivery**: Healthy riparian vegetation along seasonal streams can filter sediment and debris from runoff before it reaches the main river. This reduces the risk of channel blockage and sedimentation downstream, which can exacerbate flooding. • **Groundwater Recharge Contribution**: Increased infiltration along restored seasonal streams can contribute to groundwater recharge, which can help sustain baseflows in the main river and potentially reduce the impact of prolonged dry periods, indirectly influencing flood risk during subsequent rainfall events. • **Habitat Creation and Biodiversity Enhancement**: Restoring seasonal streams creates valuable habitats for a variety of aquatic and terrestrial species, contributing to overall biodiversity at the catchment scale. Healthy ecosystems are often more resilient to environmental changes. • **Improved Water Quality in Headwaters**: Natural processes within restored seasonal streams and their riparian zones can help filter pollutants and improve water quality in the upper parts of the catchment, which can have downstream benefits. • **Cost-Effective in the Long Term**: Compared to large-scale engineered structures, restoring natural stream processes can be a more cost-effective and sustainable approach to flood mitigation in the long run, with lower maintenance requirements.	• **Land Availability and Fragmentation**: Restoring and reconnecting seasonal streams often requires changes in land use and can be challenging in fragmented landscapes with existing development or intensive agriculture. Securing sufficient riparian buffers can be difficult. • **Potential Impact on Existing Land Use and Drainage**: Restoration efforts might affect existing drainage systems for agriculture or infrastructure, requiring careful planning and potentially compensation for land use changes. • **Timeframe for Ecological Recovery and Hydrological Impact**: It can take time for vegetation to establish and for natural hydrological processes to fully recover in restored seasonal streams. The flood mitigation benefits might not be immediately apparent. • **Complexity of Implementation and Design**: Restoring natural stream morphology and connectivity requires a good understanding of the local hydrology, geomorphology, and ecology. Poorly designed projects can be ineffective or even have negative consequences. • **Sediment Dynamics and Potential for Aggradation**: Restoring natural flow and sediment transport processes might lead to temporary issues with sediment deposition (aggradation) in certain areas, requiring monitoring and potentially management. • **Uncertainty in Effectiveness**: The degree of flood mitigation achieved by restoring seasonal streams can be variable and dependent on factors such as the extent of restoration, the characteristics of the catchment, and the intensity of rainfall events. • **Potential for Increased Evapotranspiration**: Increased vegetation cover along restored streams can lead to higher evapotranspiration rates, potentially reducing overall water yield in the catchment, although this effect is often localised and may be offset by increased infiltration. • **Upstream-Downstream Interactions**: Changes in flow regimes in upper catchment seasonal streams can have complex interactions with the main river channel downstream. Careful modelling is needed to understand these effects. • **Maintenance and Monitoring**: While generally low maintenance, restored seasonal streams may require some level of monitoring to ensure their effectiveness and address issues like invasive species or erosion. • **Public Perception and Acceptance**: Gaining public support for stream restoration projects can be challenging, especially if it involves changes in land management practices or perceived restrictions on land use.	• Multiple projects undertaking this type of assessment using hydraulic models to support benefit assessment • Showing promise for more frequent return period flooding events • Broad applications being trialled across large catchments.

NbS option	**River restoration – remeandering, bed and bank naturalisation**
Description	The process of re-introducing more natural form to previously modified rivers and restoring natural physical process, which can help to slow and store flood water to reduce flood peaks. Re-meandering is the process of creating a new meandering watercourse or reconnecting cut-off meanders, to slow down the river flow, restore natural processes and provide habitat.

Summary of pros	Summary of cons
• **Increased Floodplain Connectivity and Storage**: Remeandering increases the river's sinuosity and length within a given valley, often leading to a wider connection with its floodplain. This allows floodwaters to spread out onto the floodplain more frequently and store larger volumes of water, reducing peak flows in the main channel. • **Reduced Flow Velocities**: The increased length and sinuosity of a remeandered river reduces the overall gradient and thus the velocity of flow, especially during flood events. Slower flows have less erosive power and contribute to a more gradual rise and fall of floodwaters downstream. • **Enhanced Energy Dissipation**: Natural river features like meanders, riffles, and pools, along with natural bank vegetation, increase hydraulic roughness. This roughness dissipates the energy of floodwaters, further slowing them down and reducing their destructive potential downstream. • **Improved Infiltration and Groundwater Recharge**: Natural riverbeds and vegetated banks often have higher infiltration rates compared to straightened and hardened channels. Allowing floodwaters to interact with the floodplain and the riverbed promotes groundwater recharge, which can help sustain baseflows and indirectly influence flood response. • **Sediment Management and Natural Deposition**: Remeandering and naturalising riverbanks can create areas where sediment can naturally deposit during floods (e.g., point bars, floodplains). This reduces the amount of sediment being transported downstream, which can otherwise exacerbate flooding by reducing channel capacity. • **Habitat Creation and Biodiversity Enhancement**: River restoration creates diverse habitats like pools, riffles, wetlands, and vegetated banks, supporting a wider range of aquatic and terrestrial species. Healthy, biodiverse ecosystems can be more resilient to flooding and other disturbances. • **Improved Water Quality**: Natural river processes, including interaction with the floodplain and riparian vegetation, can enhance nutrient cycling and the filtering of pollutants from the water, leading to improved water quality downstream. • **Increased Resilience to Climate Change**: Restored river systems with healthy floodplains are often more resilient to the impacts of climate change, such as more frequent and intense rainfall events, due to their increased storage capacity and ability to dissipate flood energy. • **Aesthetic and Recreational Benefits**: naturalised and meandering rivers are often more aesthetically pleasing and can provide opportunities for recreation, enhancing the overall value of the catchment. • **Reduced Reliance on Hard Engineering**: River restoration can be a more sustainable and cost-effective long-term solution for flood mitigation compared to traditional hard engineering structures like levees and channelisation, which can have negative ecological consequences and require ongoing maintenance.	• **Land Availability and Cost**: Implementing large-scale river remeandering and floodplain reconnection requires significant land areas, which may be unavailable or expensive, especially in developed or agricultural catchments. • **Potential Impact on Existing Infrastructure**: Restoring natural river courses might impact existing infrastructure like bridges, roads, and pipelines, requiring modifications or relocations, which can be costly and complex. • **Sediment Management Challenges During Transition**: The process of remeandering can temporarily destabilise riverbanks and lead to increased sediment mobilization. Careful planning and management are needed to mitigate this. • **Timeframe for Ecological and Hydrological Recovery**: It can take a significant amount of time for a restored river system to fully develop its natural form and function, and for the flood mitigation benefits to be fully realised. • **Complexity of Design and Implementation**: Designing and implementing effective river restoration projects requires a deep understanding of riverine processes, including hydrology, geomorphology, and ecology. Poorly designed projects can be ineffective or even detrimental. • **Uncertainty in Predicting Outcomes**: The exact hydrological response of a restored river system can be complex and difficult to predict with complete certainty, especially under extreme flood events. • **Potential for Increased Inundation in Previously Protected Areas**: Reconnecting rivers to their floodplains will inevitably lead to more frequent inundation of those areas, which might impact existing land uses and require careful management and communication with stakeholders. • **Upstream-Downstream Dynamics**: Changes in flow regimes and sediment transport in a restored section of river can have complex and sometimes unexpected effects on upstream and downstream reaches. Comprehensive catchment-scale planning is crucial. • **Maintenance and Monitoring Requirements**: While generally lower than hard infrastructure, restored rivers may still require monitoring and occasional management, such as invasive species control or bank stabilisation in vulnerable areas. • **Public Perception and Acceptance**: Changes to river courses and increased floodplain inundation can sometimes face resistance from landowners and the public who may have different priorities or concerns about land use and flood risk.

NbS option	**Wetland creation and restoration**
Description	Creation or restoration of wetland areas within a river's floodplain.

Summary of pros	Summary of cons	Summary of other comments
• **Exceptional Water Storage Capacity**: Wetlands act like natural sponges, capable of storing large volumes of floodwater. This storage reduces the peak flow and volume of water that reaches downstream areas, mitigating flood risk. • **Flood Attenuation and Flow Reduction**: The dense vegetation and complex topography of wetlands slow down the flow of water, increasing the time it takes for floodwaters to pass through the catchment. This attenuation spreads out the flood hydrograph, reducing peak discharge. • **Groundwater Recharge**: Wetlands can facilitate infiltration of floodwaters into the ground, contributing to groundwater recharge. This can help sustain baseflows in rivers during drier periods and indirectly buffer against future flood events by increasing the capacity of the aquifer to absorb water. • **Natural Barriers and Energy Dissipation**: Wetland vegetation and their position within the landscape can act as natural barriers, intercepting and slowing down overland flow and floodwaters. The vegetation also increases surface roughness, dissipating the energy of floodwaters and reducing their erosive potential. • **Sediment and Nutrient Trapping**: Wetlands are highly effective at trapping sediments, nutrients, and pollutants from floodwaters. This improves water quality downstream and reduces the risk of sedimentation in river channels and other water bodies, which can exacerbate flooding. • **Habitat Creation and Biodiversity Enhancement**: Wetland creation and restoration provide critical habitats for a wide array of plant and animal species, significantly enhancing biodiversity at the catchment scale. Healthy wetland ecosystems are often more resilient to environmental changes. • **Carbon Sequestration**: Wetlands are highly productive ecosystems that can sequester and store large amounts of carbon in their vegetation and soils, contributing to climate change mitigation, which can indirectly influence the frequency and intensity of extreme weather events. • **Cost-Effective and Sustainable**: Compared to engineered flood control structures, wetland creation and restoration can be a more cost-effective and sustainable long-term solution, often requiring less maintenance and providing numerous co-benefits. • **Ecosystem Services**: Wetlands provide a multitude of other valuable ecosystem services, including water purification, nutrient cycling, and recreational opportunities. • **Resilience to Climate Change**: Wetlands can help buffer against the impacts of climate change, such as increased frequency of intense rainfall and sea-level rise (in coastal wetlands).	• **Land Availability and Cost**: Creating or restoring large wetland areas requires significant land, which may be unavailable or expensive, especially in developed or agricultural catchments. • **Potential Impact on Existing Land Use**: Wetland projects can necessitate changes in existing land use practices, which may face resistance from landowners and stakeholders (e.g., agriculture, development). • **Timeframe for Establishment and Effectiveness**: It can take several years for newly created or restored wetlands to mature and achieve their full hydrological and ecological functions, including optimal flood mitigation capacity. • **Complexity of Design and Implementation**: Successful wetland creation and restoration requires a thorough understanding of local hydrology, soil conditions, and ecological principles. Poorly designed projects can be ineffective or even harmful. • **Potential for Greenhouse Gas Emissions (Initial Stages)**: In the initial stages of wetland creation, particularly if organic-rich soils are inundated, there can be a temporary release of methane, a potent greenhouse gas. Careful site selection and management can minimise this. • **Sediment Management Challenges**: In some cases, restoring wetlands in areas with high sediment loads might require strategies to manage sediment inputs to maintain wetland function. • **Uncertainty in Predicting Hydrological Response**: The exact hydrological response of created or restored wetlands to different flood events can be complex and influenced by various factors. Modelling and monitoring are crucial. • **Upstream-Downstream Interactions**: The placement and design of wetlands within a catchment can influence their effectiveness and may have localised impacts on upstream or downstream areas that need careful consideration. • **Maintenance and Management**: While generally low maintenance, wetlands may require some level of management, such as invasive species control or water level regulation, to ensure their long-term health and effectiveness. • **Public Perception and Acceptance**: Gaining public support for wetland projects can be challenging, especially if it involves changes in land use or perceived loss of productive land. Concerns about pests (e.g., mosquitoes) might also arise.	• Multiple projects undertaking this type of assessment using hydraulic models to support benefit assessment • Showing promise for more frequent return period flooding events • Broad applications being trialled across large catchments.

NbS option	**Leaky barriers on watercourses**
Description	A flow obstacle to slow down and store water in small streams and their immediate floodplain. Also known as 'leaky dams' or 'leaky woody structures (LWS)'. Formed naturally or are installed across streams or their floodplains, using living materials, wood, timber or stone, to reduce flood risk, slow flow and improve floodplain connectivity.

Summary of pros	Summary of cons	Summary of other comments
• **Distributed Flow Reduction**: Numerous leaky barriers across a catchment collectively impede the flow of water in smaller channels and headwaters. This distributed effect can significantly reduce the overall volume and peak flow reaching the main river channel during storm events. • **Increased Water Retention and Infiltration**: By temporarily holding back water, leaky barriers increase the residence time of water within the upper catchment. This allows more time for infiltration into the ground, contributing to groundwater recharge and reducing surface runoff volume. • **Slowing Down Flow Velocity**: The obstructions created by leaky barriers reduce the velocity of water flow in smaller streams. Slower flows have less erosive power and contribute to a more gradual release of water downstream. • **Enhanced Sediment Trapping**: Leaky barriers can effectively trap sediment and debris moving downstream in smaller channels. This reduces sediment load in the main river, which can otherwise decrease channel capacity and exacerbate flooding. • **Nutrient Retention and Water Quality Improvement**: The temporary ponding behind leaky barriers can enhance natural processes that remove nutrients and pollutants from the water, leading to improved water quality downstream. • **Habitat Creation and Enhancement**: The varied flow conditions and small pools created by leaky barriers can provide diverse habitats for aquatic invertebrates, fish, and amphibians in smaller streams. • **Cost-Effective and Low-Tech**: Compared to large, engineered structures, leaky barriers are often relatively inexpensive to construct using locally sourced materials (e.g., wood, stone). They are also generally low maintenance. • **Increased Resilience to Small to Medium Flood Events**: A network of leaky barriers can be particularly effective in mitigating the impact of more frequent, smaller to medium-sized storm events by intercepting and storing runoff in the upper catchment. • **Synergistic Effects with Other NbS**: Leaky barriers can complement other nature-based solutions like riparian planting and wetland restoration, enhancing their overall effectiveness in flood mitigation at the catchment scale. • **Potential for localised Baseflow Augmentation**: Increased infiltration due to leaky barriers can contribute to localised groundwater recharge, potentially leading to a more sustained baseflow in the streams where they are located during drier periods.	• **Limited Impact on Large Flood Events**: While effective for smaller to medium floods, the storage capacity of individual leaky barriers is limited. Their impact on very large, high-intensity rainfall events might be less significant at the catchment scale. • **Potential for Blockage and Failure**: Leaky barriers can become blocked by large debris, reducing their effectiveness and potentially leading to failure or redirection of flow. Regular inspection and maintenance are necessary. • **Impact on Fish Passage (If Not Designed Properly)**: Poorly designed leaky barriers can impede the movement of fish and other aquatic organisms. Careful design that incorporates fish passage features is crucial. • **Sediment Accumulation Upstream**: While trapping sediment is a benefit, excessive accumulation upstream of barriers can eventually reduce their storage capacity and require periodic removal. • **Potential for localised Ponding and Waterlogging**: If not appropriately sized and spaced, leaky barriers could lead to undesirable localised ponding and waterlogging in adjacent areas. • **Aesthetic Concerns and Public Perception**: The appearance of leaky barriers might not be universally appealing, and there could be concerns about their impact on the natural appearance of streams. • **Requirement for Widespread Implementation**: To achieve significant flood mitigation at the catchment scale, many leaky barriers need to be implemented across numerous watercourses, which can be logistically challenging and require landowner cooperation. • **Uncertainty in Cumulative Effect**: Predicting the precise cumulative impact of many leaky barriers on catchment-scale flood response can be complex and require hydrological modelling. • **Maintenance Burden Across a Large Network**: While individually low maintenance, managing and maintaining a large network of leaky barriers across a whole catchment can become a significant logistical and resource challenge. • **Potential for Decomposition and Need for Replacement**: Natural materials used for leaky barriers (e.g., wood) will eventually decompose and need replacement, adding to the long-term maintenance effort.	• Multiple projects undertaking this type of assessment using hydraulic models to support benefit assessment • Limited benefit in steep / high country unless placed with some floodplain alterations

NbS option	**Leaky barriers on overland flow or runoff pathways**
Description	Barriers – using living materials, wood, timber or stone – across overland flow pathways to store and slow water. Leaky barriers can be constructed perpendicular to surface water runoff pathways to slow the surface runoff feeding into watercourses from the surrounding landscape. These designs intercept water closer to the source of runoff and traps sediment before it reaches watercourses.

Summary of pros	Summary of cons	Summary of other comments
• **Distributed Runoff Interception**: A network of leaky barriers across hillsides, agricultural fields, and other runoff-generating areas can collectively intercept and store significant volumes of surface runoff, preventing it from rapidly entering the drainage network. • **Reduced Peak Flow Generation**: By slowing down and temporarily storing overland flow, these barriers reduce the rate at which water reaches streams, thus lowering the peak discharge in the main river channel during storm events. • **Increased Infiltration and Reduced Soil Erosion**: The impounded water behind leaky barriers has more time to infiltrate into the soil, replenishing soil moisture and groundwater. This also reduces the volume of surface runoff and the associated transport of sediment and pollutants. • **Attenuation of Flash Floods**: Leaky barriers on steep slopes and in areas prone to rapid runoff can be particularly effective in attenuating flash floods by slowing down the rapid accumulation of water in downstream channels. • **Water Quality Improvement**: As runoff is held behind the barriers, natural processes like sedimentation and filtration by vegetation can remove pollutants and improve the quality of water entering watercourses. • **Cost-Effective and Flexible Implementation**: Leaky barriers on runoff pathways can often be constructed using relatively simple and inexpensive materials (e.g., logs, straw bales, earth bunds) and can be adapted to various landscape types. • **Synergistic Effects with Land Management Practices**: These barriers can complement sustainable land management practices like contour farming, terracing, and afforestation in further reducing runoff and erosion. • **Potential for Small-Scale Water Harvesting**: In some cases, the water impounded behind leaky barriers can be used for small-scale irrigation or livestock watering, providing additional benefits. • **Habitat Creation and Enhancement**: The small ponds and wetter areas created by leaky barriers can provide habitat for certain types of insects, amphibians, and other small wildlife. • **Reduced Pressure on Downstream Drainage Infrastructure**: By managing runoff at the source, leaky barriers can reduce the burden on downstream drainage systems and the risk of urban flooding.	• **Limited Storage Capacity per Barrier**: Individual leaky barriers on overland flow pathways typically have a limited storage capacity compared to larger structures or natural floodplain storage. Many barriers are needed to achieve significant catchment-scale impact. • **Potential for Failure and Breaching**: Barriers made of less durable materials (e.g., straw bales) can degrade over time or fail during intense rainfall events, releasing stored water rapidly. Proper construction and maintenance are crucial. • **Impact on Agricultural Practices**: Barriers on agricultural land can impede farming operations, requiring careful placement and design to minimise disruption. Landowner cooperation is essential. • **Aesthetic Concerns and Land Use Conflicts**: The appearance of numerous barriers across the landscape might be considered unsightly by some, and their presence could lead to conflicts with other land uses. • **Maintenance Requirements Across a Large Area**: Maintaining a large network of leaky barriers across a catchment can be logistically challenging and resource-intensive, requiring regular inspection and repair. • **Risk of Pest Breeding (Standing Water):** Impounded water behind barriers can potentially become breeding grounds for mosquitoes and other pests if not managed properly (e.g., through vegetation or intermittent drying). • **Uncertainty in Cumulative Hydrological Impact**: Predicting the precise cumulative effect of a widespread network of leaky barriers on catchment-scale flood response can be complex and require sophisticated hydrological modelling. • **Dependence on Topography and Runoff Patterns**: The effectiveness of leaky barriers on overland flow is highly dependent on the local topography and the dominant runoff pathways. They may be less effective in very flat or highly permeable areas. • **Potential for localised Waterlogging**: If barriers are not appropriately designed and placed, they could lead to undesirable localised waterlogging in certain areas. • **Public Awareness and Acceptance**: Educating landowners and the public about the benefits of these barriers and gaining their cooperation for widespread implementation can be a challenge.	• Multiple projects undertaking this type of assessment using hydraulic models to support benefit assessment • Limited benefit in steep / high country unless placed with some floodplain alterations

NbS option	**Woody dams in streams and riparian zones**
Description	Leaky structures made from logs and branches, which mimic naturally fallen trees.

Summary of pros	Summary of cons	Summary of other comments
• **Distributed Flow Reduction**: Numerous woody dams throughout a stream network can collectively slow down the flow of water. Each dam creates small impoundments and increases flow resistance, leading to a cumulative reduction in peak discharge downstream. • **Increased Water Retention and Infiltration**: The small pools formed behind woody dams increase the residence time of water in the upper catchment, allowing more time for infiltration into the streambed and adjacent riparian areas, contributing to groundwater recharge and reducing surface runoff volume. • **Enhanced Floodplain Connectivity**: Woody dams can help to spread floodwaters onto the floodplain more frequently and for longer durations by raising water levels locally. This increases floodplain storage capacity and reduces the volume of water confined within the main channel during larger events. • **Sediment and Debris Trapping**: Woody dams act as natural filters, trapping sediment, organic matter, and large woody debris moving downstream. This reduces sediment load in the main river, which can improve water quality and prevent channel blockage downstream. • **Nutrient Retention and Cycling**: The impounded water and increased organic matter associated with woody dams can enhance nutrient retention and cycling within the stream ecosystem. • **Habitat Diversification and Enhancement**: Woody dams create diverse flow conditions (pools, riffles, backwaters) and provide cover and refuge for fish and other aquatic organisms, enhancing biodiversity throughout the stream network. • **Bank Stabilisation and Erosion Control**: By reducing flow velocity and redirecting flow patterns, woody dams can help stabilise stream banks and reduce erosion, particularly in areas prone to incision. Riparian woody debris can also buffer banks from flood flows. • **Cost-Effective and Use of Natural Materials**: Woody dams can often be constructed using locally sourced wood, making them a relatively cost-effective and sustainable approach compared to engineered structures. • **Resilience and Adaptability**: Woody dams are often flexible structures that can adapt to changing flow conditions and sediment loads. They can also help restore more natural stream morphology over time. • **Synergistic Effects with Riparian Vegetation**: Woody dams work well in conjunction with healthy riparian vegetation, which further enhances flow resistance, bank stability, and habitat benefits.	• **Limited Storage Capacity per Dam**: Individual woody dams typically have a relatively small storage capacity. Achieving significant flood mitigation at the catchment scale requires many strategically placed dams. • **Potential for Blockage and Failure**: Woody dams can become blocked by excessive debris accumulation, potentially reducing their effectiveness or leading to structural failure and sudden release of impounded water. Regular monitoring and maintenance are necessary. • **Impact on Fish Passage (If Not Designed Properly):** Poorly designed or placed woody dams can impede the upstream and downstream movement of fish and other aquatic species. Careful design that incorporates fish passage features is crucial. • **Sediment Accumulation Upstream**: While trapping sediment is a benefit, excessive accumulation upstream of dams can eventually reduce their storage capacity and potentially require periodic removal. • **Aesthetic Concerns and Public Perception**: The appearance of woody debris in streams might not be universally appealing, and there could be concerns about navigation or recreational use. • **Potential for Downstream Scour**: If not properly designed, woody dams can sometimes increase flow velocity and turbulence immediately downstream, potentially leading to scour and erosion. • **Decomposition and Need for Replacement**: Wood is a natural material that will eventually decompose, requiring periodic replacement of the dam structures to maintain their effectiveness. • **Uncertainty in Cumulative Hydrological Impact**: Predicting the precise cumulative effect of many woody dams on catchment-scale flood response can be complex and require hydrological modelling. • **Safety Concerns**: Large accumulations of woody debris, whether natural or engineered, can pose safety hazards during high flows if not properly managed. • **Requirement for Widespread Implementation and Coordination**: Achieving catchment-scale flood mitigation requires the implementation of woody dams across numerous streams and often involves coordination with multiple landowners and stakeholders.	• Multiple projects undertaking this type of assessment using hydraulic models to support benefit assessment • Limited benefit in steep / high country unless placed with some floodplain alterations

NbS option	**Offline storage next to watercourses**
Description	Areas of the floodplain that have been adapted, with a containment, to divert water from the main river channel, temporarily store it, and then slowly release water back to a watercourse after flood levels have receded. The containment may also require an inlet, outlet, and an overflow. An example would be a bund of earth or timber barrier that is built to follow the contour of the slope. They are gravity drained and are usually dry for periods of the year

Summary of pros	Summary of cons	Summary of other comments

• **Significant Flood Volume Reduction**: Offline storage facilities can capture and hold substantial volumes of floodwater that would otherwise contribute to peak flows in the main river channel, leading to a significant reduction in downstream flood risk.
• **Peak Flow Attenuation**: By temporarily storing floodwater and releasing it more slowly back into the watercourse after the peak has passed, offline storage helps to flatten the flood hydrograph and reduce the magnitude of the peak flow.
• **Strategic Placement for Targeted Mitigation**: Offline storage can be strategically located in areas that contribute significantly to downstream flooding, providing targeted flood protection for vulnerable communities or infrastructure.
• **Potential for Multi-Functionality**: These storage areas can be designed to provide additional benefits beyond flood mitigation, such as:
  ○ Water Quality Improvement: Acting as settling basins for sediment and allowing for natural pollutant removal processes (especially in constructed wetlands).
  ○ Habitat Creation: Providing valuable wetland or open water habitats for wildlife.
  ○ Recreation: Offering opportunities for passive recreation like walking, birdwatching, or fishing.
  ○ Water Supply: In some cases, stored water can be used for irrigation or other purposes.
• **Reduced Pressure on Main Channel**: By diverting and storing floodwater, offline storage reduces the hydraulic stress on the main river channel and its banks, potentially reducing erosion and the need for hard engineering solutions.
• **Adaptability to Different Scales**: Offline storage can be implemented at various scales, from small farm ponds to large regional detention basins, allowing for a flexible approach to catchment-wide flood management.
• **Integration with Existing Landscapes**: Offline storage can often be integrated into existing agricultural or open spaces with careful planning and design.
• **Increased Resilience to Climate Change**: By providing additional storage capacity, offline storage can help catchments become more resilient to the anticipated increases in extreme rainfall events due to climate change.
	• **Land Requirements and Cost**: Constructing offline storage facilities requires significant land areas, which can be expensive, especially in densely populated or high-value agricultural regions.
	• **Construction Costs**: The engineering and construction of these facilities can be substantial, involving excavation, embankment construction, and outlet control structures.
	• **Potential for Sediment Accumulation**: Over time, offline storage areas can accumulate sediment, reducing their storage capacity and requiring periodic dredging or maintenance.
	• **Maintenance Requirements**: Regular inspection and maintenance of embankments, inlet/outlet structures, and vegetation (in the case of wetlands) are necessary to ensure the long-term effectiveness and safety of offline storage.
	• **Safety Concerns**: Large offline storage areas can pose safety risks, particularly for young children or during flood events. Proper fencing and signage are essential.
	• **Potential for Habitat Loss During Construction**: The construction of offline storage can lead to the loss of existing habitats, although the resulting storage area can often create new habitats. Careful site selection is important.
	• **Risk of Dam Failure (Embankments):** Poorly designed or maintained embankments can pose a risk of failure during extreme flood events, potentially causing sudden and damaging releases of stored water.
	• **Water Quality Issues (Stagnant Water):** If not properly designed with adequate inflow and outflow, offline storage areas can experience stagnant water conditions, potentially leading to water quality problems like algal blooms or low dissolved oxygen.
	• **Public Perception and Acceptance**: Concerns about land use changes, potential for pests (e.g., mosquitoes), or aesthetic impacts can sometimes lead to public opposition to the construction of offline storage.
	• **Uncertainty in Performance Under Extreme Events**: While designed for specific flood events, the performance of offline storage under extreme, unforeseen conditions may be uncertain.
		• Multiple projects undertaking this type of assessment using hydraulic models to support benefit assessment
		• Promising for a range of return periods but care required to capture flow at peak not on rising limb of storm
		• Broad applications being trialled across large catchments.

NbS option	**Offline storage adjacent to runoff pathways**
Description	Areas that have been adapted to store water by diverting it from a runoff pathway, temporarily store it, and then slowly release water or allow it to infiltrate or evaporate after flood levels have receded. This will likely consist of a pond or earth bund that has runoff diverted into it using either a low/ extended earth bund (that could also be a banked hedge, a swale or cross drains or diverters to divert water from tracks.

Summary of pros	Summary of cons	Summary of other comments
• **Distributed Runoff Management**: Numerous small offline storage features across the catchment collectively capture and temporarily store significant volumes of surface runoff, reducing the amount of water flowing directly into the drainage network. • **Reduced Peak Flow Generation**: By slowing down and holding back runoff at its source, these features reduce the rate at which water reaches streams, thus lowering the peak discharge in the main river channel during storm events. • **Enhanced Infiltration and Groundwater Recharge**: The impounded water in these storage areas has more time to infiltrate into the soil, replenishing soil moisture and contributing to groundwater recharge. This also reduces the overall volume of surface runoff. • **Attenuation of localised Flooding**: These features can be particularly effective in mitigating localised flooding in urban or agricultural areas by capturing and storing excess rainwater close to where it falls. • **Water Quality Improvement**: As runoff is held in these storage areas, natural processes like sedimentation, filtration by vegetation, and biological uptake can remove pollutants before the water reaches watercourses. • **Cost-Effective and Easy to Implement at Small Scales**: Many of these features, like swales and rain gardens, can be relatively inexpensive and easy to implement at individual property or small community scales. • **Integration with Urban and Agricultural Landscapes**: Offline storage adjacent to runoff pathways can often be seamlessly integrated into urban green spaces, road verges, and agricultural fields. • **Increased Awareness and Community Involvement**: Implementing these features at a local level can raise public awareness about stormwater management and encourage community involvement in flood mitigation efforts. • **Habitat Creation and Green Infrastructure Benefits**: Rain gardens and vegetated swales can provide valuable green spaces and habitat for pollinators and other small wildlife, contributing to urban biodiversity and green infrastructure goals. • **Reduced Pressure on Downstream Drainage Infrastructure**: By managing runoff locally, these features can reduce the burden on downstream pipes, drains, and larger flood control structures.	• **Limited Storage Capacity per Unit**: Individual swales, rain gardens, or small detention basins have a relatively small storage capacity compared to larger offline storage next to watercourses. Achieving significant catchment-scale impact requires widespread adoption. • **Maintenance Requirements**: These features require regular maintenance, such as vegetation management, removal of accumulated sediment and debris, and ensuring proper infiltration rates. Neglect can reduce their effectiveness. • **Space Requirements**: Even though individually small, widespread implementation can require significant land area across the catchment, which might be a constraint in densely developed areas. • **Potential for Mosquito Breeding (Standing Water):** If not designed to drain properly or if stagnant water persists for extended periods, these features can become breeding grounds for mosquitoes. Proper design and vegetation management are crucial. • **Uncertainty in Cumulative Hydrological Impact**: Predicting the precise cumulative effect of numerous small, distributed storage features on catchment-scale flood response can be complex and require sophisticated hydrological modelling. • **Dependence on Soil Permeability**: The effectiveness of infiltration-based features like rain gardens and swales is highly dependent on the permeability of the underlying soil. They may not function as intended in areas with low infiltration rates. • **Public Acceptance and Participation**: Achieving widespread adoption requires public awareness, willingness of landowners to implement and maintain these features, and potentially supportive policies and incentives. • **Impact on Aesthetics and Land Use**: Some landowners might have concerns about the appearance of these features or their potential impact on land use. • **Performance Limitations During Extreme Events**: While effective for managing smaller, more frequent rainfall events, the limited storage capacity of individual units might mean they have a less significant impact during very large, intense storms. • **Potential for Clogging**: Infiltration-based features can become clogged over time by fine sediments and organic matter, reducing their infiltration capacity and requiring maintenance.	• Multiple projects undertaking this type of assessment using hydraulic models to support benefit assessment • Promising for range of return periods but care required to capture flow at peak not on rising limb of storm • Broad applications being trialled across large catchments.

NbS option	**Online storage**
Description	Online storage temporarily stores water within the river channel and its floodplain.

Summary of pros	Summary of cons	Summary of other comments
• **Direct Impact on River Levels**: Online storage directly affects the water level and flow within the river channel, providing immediate downstream flood reduction benefits when operated effectively. • **Utilizes Existing Floodplain**: It can maximise the use of the natural floodplain for water storage, potentially reducing the need for extensive land acquisition outside the existing river corridor. • **Gravity-Driven Flow**: Often relies on gravity for both inflow and outflow, potentially reducing the need for pumping and associated energy costs. • **Can Enhance Natural Processes**: Well-designed online storage can mimic or enhance natural floodplain functions, such as nutrient cycling and sediment deposition. • **Potential for Multi-Purpose Use**: Impounded areas can sometimes be used for recreation (e.g., boating, fishing) during normal flow conditions. • **Aesthetic Integration**: If designed with natural materials and landscaping, online storage can be aesthetically integrated into the riverine environment.	• **Impact on Upstream Areas**: Impounding water within the channel and floodplain can increase flood risk and water levels in upstream areas if not carefully managed. • **Sedimentation and Maintenance**: Online storage areas can accumulate sediment over time, reducing their storage capacity and requiring periodic dredging or other maintenance. • **Ecological Impacts within the Channel**: Altering the natural flow regime within the river channel can have negative impacts on aquatic habitats, fish passage, and water quality if not designed sensitively. • **Risk of Downstream Scour**: Control structures within the channel can alter flow velocities and turbulence, potentially leading to increased erosion (scour) downstream. • **Operational Complexity**: Managing water levels and releases from online storage structures often requires careful operational protocols and real-time monitoring, especially during flood events. • **Potential for Dam Failure (if impoundments are large):** Larger online storage projects involving dams or significant embankments carry a risk of failure, which could have catastrophic downstream consequences. • **Limited Additional Habitat Creation Compared to Offline Storage**: While it can enhance existing floodplain functions, it may not create as much new or diverse habitat as dedicated offline storage areas like constructed wetlands. • **Constraints of the Existing River Corridor**: The effectiveness of online storage is often limited by the natural topography and width of the existing river channel and floodplain. • **Potential for Water Quality Issues**: Storing water within the river channel or floodplain can sometimes lead to water quality problems like increased water temperature or reduced dissolved oxygen if flow is significantly restricted.	• Multiple projects undertaking this type of assessment using hydraulic models to support benefit assessment • Limited benefit in steep / high country unless placed with some floodplain alterations • Limited benefit for larger return periods unless significant area available around to support higher flow when peak arrives • Broad applications being trialled across large catchments.

NbS option	**Ponds**
Description	A permanent or near-permanent pond or pool with additional storage capacity to attenuate surface runoff during rainfall events. May be a natural depression, constructed by excavation or by constructing embankments

Summary of pros	Summary of cons	Summary of other comments
• **Distributed Runoff Storage**: Numerous ponds throughout a catchment can collectively capture and temporarily store a significant volume of surface runoff, reducing the amount of water directly flowing into streams and rivers during rainfall events. • **Peak Flow Reduction**: By holding back runoff and releasing it more slowly, ponds can help to reduce the peak discharge in the downstream drainage network. The cumulative effect of many ponds can be noticeable at a catchment scale. • **Enhanced Infiltration**: Ponds can increase the residence time of water on the landscape, allowing more time for infiltration into the ground, which contributes to groundwater recharge and reduces the overall volume of surface runoff. • **Sediment Trapping and Water Quality Improvement**: Ponds act as settling basins, trapping sediment and associated pollutants from runoff before they reach watercourses, thus improving water quality downstream. • **Erosion Control**: By intercepting and slowing down runoff, ponds can help to reduce soil erosion in their contributing areas. • **Habitat Creation and Biodiversity Enhancement**: Ponds provide valuable habitat for a variety of aquatic and semi-aquatic plants and animals, increasing biodiversity within the catchment. • **Aesthetic and Amenity Value**: Ponds can enhance the aesthetic appeal of the landscape and provide recreational opportunities (e.g., fishing, wildlife viewing). • **Potential for Water Harvesting**: Stored water in ponds can potentially be used for irrigation, livestock watering, or other purposes, providing additional benefits beyond flood mitigation. • **Adaptability to Different Landscapes**: Ponds can be integrated into various landscape types, including agricultural land, urban areas (as stormwater ponds), and natural areas. • **Cost-Effective at Small Scales:** Small farm ponds or stormwater ponds can be relatively inexpensive to construct, especially if integrated into existing land features.	• **Limited Storage Capacity per Pond**: Individual ponds typically have a relatively small storage capacity compared to larger offline storage areas or natural floodplains. Achieving significant catchment-scale flood mitigation requires many ponds. • **Maintenance Requirements**: Ponds require regular maintenance, including sediment removal, vegetation management, and ensuring the integrity of their embankments and outlet structures. Neglect can reduce their effectiveness and potentially lead to failure. • **Space Requirements**: While individual ponds might be small, many them across a catchment can require significant land area, which might be a constraint in densely developed or high-value agricultural regions. • **Potential for Mosquito Breeding (Stagnant Water):** Ponds with stagnant water can become breeding grounds for mosquitoes. Proper design with adequate circulation or the introduction of mosquito-eating fish can help mitigate this. • **Risk of Eutrophication**: Nutrient-rich runoff entering ponds can lead to eutrophication (excessive algal growth), which can degrade water quality and harm aquatic life. Proper management of nutrient inputs is essential. • **Potential Safety Hazards**: Ponds, especially those with steep sides, can pose safety risks, particularly for young children. Fencing or appropriate landscaping might be necessary. • **Uncertainty in Cumulative Hydrological Impact**: Predicting the precise cumulative effect of numerous ponds on catchment-scale flood response can be complex and require hydrological modelling that considers their distribution, size, and release rates. • **Dependence on Location and Design**: The effectiveness of ponds for flood mitigation depends heavily on their location within the catchment (e.g., intercepting key runoff pathways) and their design (e.g., storage volume, outlet control). Poorly located or designed ponds might have minimal impact. • **Potential for Habitat Loss During Construction**: The construction of ponds can lead to the loss of existing habitats, although the pond itself can create new ones. Careful site selection is important. • **Public Perception and Acceptance**: Concerns about land use changes, aesthetics, or potential for pests might lead to public opposition to pond construction in some areas.	• Limited benefit for larger return periods unless significant area available around to support higher flow when peak arrives

NbS option	**Scrapes**
Description	A pool or ribbon of shallow water in a depression, which fills in wet weather and then dries slowly in dry conditions.

Summary of pros	Summary of cons	Summary of other comments
• **Distributed Runoff Storage**: Numerous scrapes scattered across a catchment can collectively capture and temporarily store a significant volume of surface runoff, reducing the amount of water flowing directly into streams and rivers during rainfall events. • **Enhanced Infiltration**: The primary function of scrapes is to hold water and allow it to slowly infiltrate into the ground, reducing the volume of surface runoff and contributing to groundwater recharge. This is a key mechanism for flood mitigation. • **Peak Flow Reduction**: By delaying the flow of runoff and promoting infiltration, scrapes can help to reduce the peak discharge in the downstream drainage network. The cumulative effect of many scrapes can be beneficial at a catchment scale. • **Sediment Trapping and Water Quality Improvement**: Scrapes can trap sediment and associated pollutants from runoff, allowing them to settle out and be filtered by vegetation and soil before reaching watercourses. • **Cost-Effective and Simple to Construct**: Scrapes are generally relatively inexpensive and simple to construct, often requiring only basic earthmoving equipment. • **Integration into Various Landscapes**: Scrapes can be integrated into agricultural land, urban green spaces, and natural areas with minimal disruption. • **Habitat Creation and Biodiversity Enhancement**: Even though shallow and often temporary, scrapes can provide valuable habitat for amphibians, invertebrates, and some plant species, contributing to biodiversity. • **Reduced Erosion**: By intercepting and slowing down surface runoff, scrapes can help to reduce soil erosion in their contributing areas. • **Low Maintenance:** Once established with vegetation, scrapes generally require minimal maintenance compared to larger engineered structures. • **Synergistic Effects with Other NbS:** Scrapes can complement other nature-based solutions like buffer strips and reduced tillage in managing runoff at the landscape level.	• **Limited Storage Capacity per Unit**: Individual scrapes are shallow and have a relatively small storage capacity. Achieving significant catchment-scale flood mitigation requires many scrapes. • **Effectiveness Dependent on Infiltration Rates**: The primary flood mitigation benefit relies on infiltration. Scrapes will be less effective in areas with low soil permeability or high groundwater tables. • **Potential for Mosquito Breeding (Standing Water):** Shallow standing water in scrapes can become breeding grounds for mosquitoes, especially if they do not drain or dry out quickly enough. Design considerations to promote drainage or fluctuating water levels are important. • **Space Requirements for Widespread Implementation**: While individually small, many scrapes across a catchment can require a significant amount of land. • **Risk of Sediment Infilling**: Over time, scrapes can become filled with sediment, reducing their storage and infiltration capacity. Periodic maintenance to remove sediment might be necessary in some locations. • **Uncertainty in Cumulative Hydrological Impact:** Predicting the precise cumulative effect of numerous small scrapes on catchment-scale flood response can be complex and require hydrological modelling. • **Potential for Temporary Loss of Land Use**: Implementing scrapes on agricultural land might result in a temporary or permanent loss of productive area. • **Aesthetic Considerations**: The appearance of numerous shallow depressions across the landscape might not be universally appealing. • **Performance Limitations During Extreme Events**: While effective for managing smaller, more frequent rainfall events, the limited storage capacity of individual scrapes might mean they have a less significant impact during very large, intense storms. • **Public Awareness and Acceptance**: Educating landowners and the public about the benefits of scrapes and gaining their cooperation for widespread implementation can be a challenge.	• Multiple projects undertaking this type of assessment using hydraulic models to support benefit assessment • Broad applications being trialled across large catchments.

NbS option	**Bunds**
Description	A low barrier, dam or mound, typically constructed from earthworks, to contain or exclude water

Summary of pros	Summary of cons	Summary of other comments
• **Distributed Runoff Interception**: Numerous bunds across a catchment can collectively intercept and temporarily store significant volumes of surface runoff, preventing it from flowing directly and rapidly into streams and rivers. • **Reduced Peak Flow Generation**: By slowing down the flow of runoff and increasing its residence time on the landscape, bunds help to reduce the peak discharge in the downstream drainage network. • **Enhanced Infiltration**: Bunds create small impoundments that allow more time for water to infiltrate into the soil, contributing to groundwater recharge and reducing the overall volume of surface runoff. • **Erosion Control**: By intercepting and slowing down overland flow, bunds can significantly reduce soil erosion, preventing sediment from reaching watercourses and maintaining soil health. • **Water Quality Improvement**: Bunds can trap sediment and associated pollutants from runoff, allowing them to settle out and be filtered by vegetation and soil before reaching streams and rivers. • **Cost-Effective and Relatively Simple to Construct**: Bunds can often be constructed using locally available materials (earth) and basic earthmoving equipment, making them a relatively inexpensive solution. • **Adaptable to Various Landscapes**: Bunds can be implemented on agricultural land (e.g., contour bunds), hillslopes, and even in urban green spaces to manage runoff. • **Potential for Water Harvesting**: The water impounded behind bunds can sometimes be used for small-scale irrigation or livestock watering in agricultural settings. • **Synergistic Effects with Vegetation**: Bunds often work best in conjunction with vegetation, which further enhances infiltration, slows flow, and stabilises the bund structure. • **Can Help Restore Natural Flow Pathways:** In degraded landscapes, strategically placed bunds can help to re-establish more natural patterns of water flow and infiltration.	• **Limited Storage Capacity per Bund**: Individual bunds are typically low and have a limited capacity to store large volumes of water. Achieving significant catchment-scale flood mitigation requires a large network of well-designed bunds. • **Maintenance Requirements**: Bunds can be susceptible to erosion, especially during intense rainfall events, and may require periodic maintenance and repair to maintain their effectiveness. Vegetation management is also important for stability. • **Potential Impact on Agricultural Practices**: Bunds on agricultural land can sometimes impede farming operations, requiring careful design and placement to minimise disruption. • **Space Requirements for Widespread Implementation**: A large network of bunds across a catchment can require a significant amount of land, which might be a constraint in densely developed or high-value agricultural areas. • **Risk of Failure or Breaching**: Poorly constructed or maintained bunds can fail during large storm events, potentially releasing stored water rapidly and exacerbating localised flooding. • **Potential for Waterlogging**: If not properly designed with adequate drainage, bunds can sometimes lead to undesirable waterlogging in upslope areas. • **Uncertainty in Cumulative Hydrological Impact**: Predicting the precise cumulative effect of many bunds on catchment-scale flood response can be complex and require hydrological modelling. • **Dependence on Soil Type and Slope:** The effectiveness of bunds depends on the soil's infiltration capacity and the slope of the land. They may be less effective on very steep slopes or in areas with low infiltration rates. • **Aesthetic Considerations**: The appearance of numerous bunds across the landscape might not be universally appealing. • **Public Awareness and Acceptance**: Educating landowners and the public about the benefits of bunds and gaining their cooperation for widespread implementation can be a challenge.	• Multiple projects undertaking this type of assessment using hydraulic models to support benefit assessment • Broad applications being trialled across large catchments.

NbS option	Floodplain and riparian planting
Description	Planting of vegetation in the floodplain or riparian areas; this may include tree planting, hedge planting woodland planting, and riparian buffer strips.

Summary of pros	Summary of cons
• **Increased Flow Resistance and Energy Dissipation**: Vegetation on floodplains and riverbanks increases surface roughness, slowing down the flow of floodwaters and dissipating their energy. This reduces flow velocities and the erosive power of floods downstream. • **Enhanced Infiltration and Water Storage**: Plant roots improve soil structure, increasing infiltration rates and the soil's capacity to store water. Vegetated floodplains can act like natural sponges, absorbing and holding floodwaters. • **Bank stabilisation and Erosion Control**: Riparian vegetation helps to stabilise riverbanks with its root systems, reducing erosion and the amount of sediment entering watercourses. This maintains channel capacity and reduces sedimentation downstream, which can exacerbate flooding. • **Interception of Overland Flow**: Vegetation can intercept overland flow, slowing it down and allowing more time for infiltration, thus reducing the volume of surface runoff reaching streams and rivers. • **Sediment and Pollutant Trapping**: Vegetation can filter sediment and pollutants from floodwaters and surface runoff, improving water quality and reducing the transport of contaminants downstream. • **Habitat Creation and Biodiversity Enhancement**: Floodplain and riparian planting creates valuable habitats for a wide range of plant and animal species, contributing to overall biodiversity at the catchment scale. Healthy ecosystems are often more resilient to disturbances. • **Carbon Sequestration**: Vegetation, especially trees and shrubs, can sequester and store significant amounts of carbon, contributing to climate change mitigation, which can indirectly influence the frequency and intensity of extreme weather events. • **Aesthetic and Amenity Value**: Vegetated floodplains and riparian zones enhance the visual appeal of the landscape and provide opportunities for recreation and enjoyment. • **Cost-Effective and Sustainable**: Compared to hard engineering solutions, planting is often a more cost-effective and sustainable long-term approach to flood mitigation, with lower maintenance requirements once established. • **Synergistic Effects with Other NbS**: Vegetation enhances the effectiveness of other nature-based solutions like floodplain reconnection, leaky barriers, and offline storage.	• **Timeframe for Establishment and Effectiveness**: It takes time for vegetation to mature and provide significant flood mitigation benefits. The full effects might not be realised for several years. • **Land Availability and Potential Land Use Conflicts**: Establishing wide vegetated buffers along rivers and on floodplains can require significant land areas, potentially leading to conflicts with existing land uses like agriculture or development. • **Potential for Increased Evapotranspiration**: Mature vegetation can increase evapotranspiration, potentially reducing overall water yield in the catchment, although this effect is often localised and can be offset by increased infiltration. • **Species Selection and Management**: Choosing the right plant species that are adapted to local conditions and can withstand flooding is crucial. Ongoing management, such as invasive species control, might be necessary. • **Impact on Existing Infrastructure**: Planting too close to existing infrastructure (e.g., bridges, culverts) could potentially cause problems with root intrusion or obstruction of flow. Careful planning is needed. • **Uncertainty in Hydrological Response**: The precise hydrological impact of vegetation on flood flows can be complex and influenced by factors like vegetation density, type, and the scale of the flood event. Modelling can help, but uncertainties remain. • **Potential for Debris Accumulation**: While vegetation helps stabilise banks, large woody debris from riparian areas can sometimes accumulate during floods and potentially cause blockages downstream if not managed. • **Vulnerability to Extreme Floods**: Very large and intense floods can damage or destroy vegetation, reducing its effectiveness for future flood mitigation. • **Public Perception and Acceptance**: Some landowners might resist planting on their land due to perceived loss of productive area or changes in landscape aesthetics. • **Initial Establishment Costs**: While generally cost-effective in the long term, there can be initial costs associated with purchasing and planting vegetation.

NbS option	**Revegetation & habitat management**
Description	Conversion of bare peat or sparse vegetation to a well-vegetated condition, or from uncharacteristic vegetation to peat-forming vegetation. Habitat interventions or improvements may need to be ongoing. Plug planting and peatland re-wetting may need to be undertaken to initiate good conditions and enable ongoing improvement to the density of peat-forming vegetation on the surface.

Summary of pros	Summary of cons	Summary of other comments
• **Enhanced Infiltration Across the Catchment**: Revegetation, particularly with native species adapted to local conditions, improves soil structure and organic matter content across the catchment. This leads to increased infiltration rates, reducing surface runoff volume and contributing to groundwater recharge. • **Reduced Overland Flow**: Increased vegetation cover intercepts rainfall and slows down overland flow, giving more time for infiltration and reducing the amount of water reaching streams and rivers rapidly. • **Improved Water Retention in Soils**: Healthy vegetation and soil organic matter increase the water-holding capacity of soils throughout the catchment, acting as a natural buffer against both floods and droughts. • **Stabilisation of Slopes and Reduced Erosion**: Revegetation, especially with deep-rooted plants, helps to stabilise slopes and prevent soil erosion, reducing sediment input into watercourses and maintaining their capacity to convey floodwaters. • **Riparian Zone Enhancement**: Specific revegetation and management of riparian areas (vegetated buffers along waterways) provides all the benefits mentioned earlier (flow resistance, bank stabilisation, sediment trapping, habitat creation) along the critical interfaces between land and water. • **Wetland Restoration and Creation**: Managing and restoring wetlands within the catchment enhances their natural water storage and flow regulation capabilities, significantly contributing to flood attenuation. • **Headwater Management**: Revegetation and habitat management in upland headwater areas can slow down the initial generation of runoff, reducing peak flows in the entire river system. • **Biodiversity and Ecosystem Resilience**: Healthy and diverse ecosystems are generally more resilient to environmental changes, including extreme weather events like floods. Revegetation and habitat management support this resilience. • **Carbon Sequestration**: Vegetation across the catchment, especially forests and wetlands, sequesters and stores carbon, contributing to climate change mitigation, which can have long-term benefits for reducing the frequency and intensity of extreme weather. • **Improved Water Quality**: Vegetation and healthy soils filter pollutants and nutrients from runoff and groundwater, improving water quality throughout the catchment.	• **Long Time Scales for Establishment**: Achieving the full benefits of revegetation and habitat management, especially the development of mature forests or wetlands, can take decades. Flood mitigation benefits may be gradual. • **Large Land Area Requirements**: Implementing significant revegetation across a catchment requires substantial land areas, which may compete with other land uses like agriculture, forestry, and development. • **Potential Conflicts with Existing Land Use Practices**: Changes in land management practices required for effective revegetation and habitat management can face resistance from landowners and stakeholders. • **High Initial Costs and Long-Term Management**: Large-scale revegetation projects can have high initial costs for planting and establishment, as well as ongoing costs for monitoring, maintenance (e.g., invasive species control), and adaptive management. • **Species Selection and Adaptation Challenges**: Choosing the right plant species that are adapted to local conditions, resilient to future climate change, and effective for flood mitigation can be complex. • **Potential for Increased Evapotranspiration (Mature Vegetation):** While generally beneficial, extensive mature vegetation can increase evapotranspiration, potentially reducing overall water yield in the catchment, although this effect needs careful assessment. • **Uncertainty in Hydrological Response at Catchment Scale**: Predicting the precise impact of widespread revegetation and habitat management on catchment-scale hydrology and flood response can be complex and require sophisticated modelling. • **Vulnerability to Extreme Events During Establishment:** Young vegetation can be vulnerable to damage from extreme floods or droughts before it is fully established and resilient. • **Public Perception and Acceptance**: Changes in land cover and management practices can sometimes face public opposition based on aesthetic preferences, perceived loss of productive land, or other concerns. • **Complexity of Coordination and Governance**: Implementing catchment-scale revegetation and habitat management often requires coordination across multiple land ownerships, jurisdictions, and stakeholder groups, which can be challenging.	• Multiple projects undertaking this type of assessment using hydraulic models to support benefit assessment - typically through changes to surface roughness parameterisation • Care required to determine the appropriate measures. Noting need for lower canopy vegetation to support. One team noted the need to work on pest control of deer to enable lower canopy to thrive. • Broad applications being trialled across large catchments.

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Appendix E. Survey responses

Survey responses were received in February 2025. The following is an anonymised transcript of responses from the survey forms. We have redacted specific identifying information for councils, locations, consultants, and partner organisations.

Project set up and procurement

Project set up and procurement: What has gone well?

- While I personally have not been involved directly in the organisation of this project, we are consistently reaching our goals and I think this is due to the outsourcing of various tasks to individuals skilled in their own niche.
- This work order was awarded directly to [redacted] and did not go to open tender are because as this project is taking place in [redacted] takiwā, only [redacted] hold the mātauranga needed to undertake this work. [redacted] holds the mandate and necessary relationships with Te Rūnanga o [redacted] to provide the mātauranga Māori/ te ao Māori cultural advice required to successfully undertake this work. No other entities/ suppliers/ consultants are in this position.
- An open tender was advertised on GETS regarding the technical modelling required to complete two of the three Nature-based Solutions feasibility studies in progress, which are funded by the Ministry for the Environment. These are [redacted]. The tender also identified that the tenderers must have the ability to work alongside the third Nature-based Solutions feasibility study, Mātauranga Māori. Tenders were received from 12 suppliers. An Assessment Panel met and ranked the applications based on proposed solution/methodology, health & safety, capability/skills/experience/track record, and value for money. The four highest ranked proposals were then shared with [redacted] to ensure that Te Rūnanga o [redacted] would be comfortable sharing sensitive information with the preferred supplier (without indicating the assessment scores).
- Resourcing of project team (Council and our partners) has been challenging as changes have occurred with staff internally and externally. An RfP was developed and listed in the GETS system following the formal procurement process. We received 14 proposals for out project. The 14 proposals were assessed on both price and non-price attributes - with the most suitable option selected. With 14 submissions we had a wide range of experience and skill available - several of the submissions would have been suitable.
- Internal project team and resourcing - project management team and technical advisors from both [redacted] Council and [redacted] Council have worked well together, focused on different aspects of [redacted]'s flood vulnerability.
  External experts, already engaged on other flood modelling work for the [redacted], were engaged for some aspects of this work. Preferred supplier agreements were used for other aspects. There was generally good interest from external experts, however, availability was challenging. Expertise was generally at a sound level.
- We have a trusted supplier who can complete and link together different disciplines which support this project. They also have an existing understanding of the catchment and other work occurring in the catchment.
- Key mana whenua partner identified specific work streams to support project
- The project was managed internally within the organisation, with various parts supported using consultants. There was no tender process, instead building on previous relationships. The interest was good given it was a space many of the contractors had not worked in previously. The project was an opportunity to increase knowledge and understanding a grow the Community of Practice.
- Procurement of services has been good. We approached the modelling aspect through selective invite to 3 consultants, we held an open meeting to explain the problem we are trying to investigate & find solutions for using NBS, set a budget of $40k for modelling and asked what each of the consultants could offer us for that price while addressing the objectives. This was a new way of engaging with consultants and allowed us to have more control of the budget and understand what our options were and what we could get for the budget we set.

- The project was initiated by the staff in the Environmental Science section – who submitted the funding application. The region was in the immediate wake of Cyclone Gabrielle, so strategies to reduce peak flows were certainly very topical. Engagement occurred with mana whenua and other local stakeholders, to determine what types of NBS they would be interested in. Work then paused while the national Literature Review was undertaken. During this period, all members of the group that initiated the funding moved on from their roles. This was a challenge as foundational knowledge of the project was not handed over. Following the completion of the national Literature Review the acting manager Environmental Science initiated a formal procurement process via GETS tender to find a consultant to undertake modelling and report on findings. [redacted] received 11 (very thorough) responses. An internal working group was set up to assess tenders – this group was predominantly made up of staff from Environmental Science and also a Flood Modeller from Engineering. Tenders were scored against [] criteria. … The challenge in assessing tenders was that many were of excellent quality, and based on the proposal would have been appropriate. The winning tender was awarded due to the added value / benefits that were highlighted in the proposal. Following the contract confirmation the working group was then expanded to include staff from Environmental Science (x5), GIS, Flood Modeller, Policy & Planning, Catchment Management, and Biodiversity.
- The provider was a direct engagement. Council had worked with [redacted] on an associated flood protection upgrade project and had found them experienced, innovative, and responsive to changes – these were attributes I thought we really required, as I could see the outcome I wanted, but not so clear was what we needed to do to get there. Sophie was recommended as Project Manager and has ensured that the project has run smoothly and enabled that clear path. The level of interest in the project is high, but at this stage all that has been provided is an overview. A full report, including recommendations for the next stage (post project completion) will be provided to Councillors later this year.
- Because this project was delivered by [redacted] in partnership with [redacted], [redacted] procurement policy guided procurement. A tender was prepared and put to market with an evaluation panel to assess the submissions. There were 9 submissions, the level of interest was high and the standard of submissions was very high. The level of experience was varied. NbS is a new term for NZ, but the technical knowledge is more widespread.
- The procurement process for this project was a formal Request for Proposals. We received seven responses which reviewed against Councils internal procurement evaluation process to select the successful candidate. Councils internal project team consists of a project manager, project supervisor and a number of technical experts, including flood engineer and hydrologist. The provider has technical expertise, national and international expertise, a strong project team and innovative ideas.
- We had a great response to our RFP with high caliber of experience in flood modelling, urban nature-based solutions and spatial mapping.
- Due to internal staff constraints we were very late at going to market for a partner to undertake the hydrodynamic modelling. As a result, we only looked at the engineering panel rather than going to the wider market, as we could not afford delays or the time to evaluate potential partners who we had not worked with in the past (this was a risk management consideration). We used [redacted] for our procurement process, which worked well as potential partners described their approach to our project within a few key constraints that we provided, but we otherwise left potential partners with significant latitude to explain their approaches. We received two highly competitive tenders which despite being quite different were hard to differentiate based on our quality factors - we considered this a success.
- The team is a core group of scientists and a dedicated project manager who have worked well together. Procurement has been in several stages, however contractors have so far performed well.
- We were able to procure (direct appointment) existing established and trusted consultants to undertake the work as well as strong internal input. So the process has worked well.

- Project procurement and set up when well and we have developed a good multidisciplinary team to work on the various specialist aspects of the project. Providers were selected based on their previous experience and technical ability in this topic.
- This was a standard BAU contract setup. We do this all the time.
- The majority of the project has been delivered by internal staff. The project employed a freshwater intern to assist with digisation of aerial maps, river lines etc. Recently the intern has moved into another role within Council, whcih has resulted in a slow down in the project. Some compotents of the project we have sought external contractors to assist us with information, reports etc. These reports include the Natural Character Index gravel studies etc. The majority of these reports are small in scope (and budget) and therefore mainly done through diret engagement with suppliers that we know have the expertise, and know the areas in which the work is being completed. To date suppliers have delivered what has been request although recently one supplier pulled out of undertaking works as they didn't have time. This has created a few issues as the supplier had been signed up to complete the work for at least 8 months.

Project set up and procurement: Concerns / what you would change next time

- I personally do not have any concerns, although a clear roadmap with more frequent deadlines could potentially increase efficiency.
- It would have been preferable to co-apply for this funding with our rūnanga partner, to be on the same page sooner. However, due to the way that these opportunities appear and the time/capacity pressures that come with applications, this did not happen on this occasion.
- We would have listed it as a set budget, rather than trying to assess value for money.
- Develop an RfP as early as possible and onboard provider as soon as possible to get modelling component of project underway as it underpins much of the conversation.
- [redacted]'s flood vulnerability is multifactorial – coastal, river, stormwater and pluvial. This project has required us to take a whole of catchment approach to address each risk source, and multiple teams have been established to address lead NBS that seek to address each risk source.
  Key issues encountered include:
  1. Finding common language:
     - NBS sit at the nexus of existing specialities i.e., ecology, hydrological modelling, and engineering.
     - Finding common language and enabling shared understanding amongst practitioners can be challenging.
  2. Finding adequately experienced practitioners:
     - NBS are an emerging field.
     - There is not a mature industry supported by evidential basis and experience.
     - Complicated by lack of shared common understanding.
  3. Finding practitioners that can deliver that are not already overloaded with other contracts
     - Practitioners with NBS experience are often already fully committed on other contracts.
- There were difficulties in co-designing the project plan. The timeframes remaining to get work completed are tight. There is potential that this may result in less detail of certain aspects of the work. Next time: Change tact to agree the project plan as early as possible.
- There were changes both to the organisation and the team during the project.
  The 'adaptive management approach' used was valuable to provide for the changing environment and unforeseen flow-on affects. This also provided our iwi partners with plenty of time to collaborate and identify what would be valuable outcomes the project could deliver for them.
- It was a very open question/feasibility at the start which made for some difficult conversations with consultants around what we wanted and what outcomes we thought would be valuable. I flip flopped a bit between looking large scale catchment approach and small scale site specific approach.
- It was logical to wait for the lit review to be completed, however this caused a delay in procurement, and therefore truncating the time available for the work to be undertaken.

- Next time I we would engage with a Project Manager to undertake this work. However, given the relatively small FTE that may be challenging.
- Project set up went well, despite the finding coming up very quickly. This meant that work programming could not be undertaken in advance and the work falls on top of an existing work load.
- Procurement was a per normal for [redacted].
- I would allow time for iwi partners to be involved in the funding application, so they can have input from the start. This would ensure ownership and engagement with the project.
- Ensuring that the project manager and team were involved during the application phase. This is sometimes tricky at Councils due to the staff turn over, however it is an important step to try and implement
- MfE needs to allow longer time-frames to develop projects like this, particularly where consultation with iwi is required (as it should be). Councils have many competing priorities, and short time frames make delivering projects with successful outcomes much less likely.
- The small pool of people that have the expertise in applying the Room for River concepts was one of the reasons for employing an internal intern for the project. This however, does rely on having clear guidance to allow them to pick up and run with the project. Although the Room for Rivers has a national methodology from recent experience it appears that these are not being applied consistently. This becomes an issue when people say they are using xxxx method however, when somebody else uses it we don't end up with the same answer. Some of this is down to intrepretation of the method however, it does create issues when we are after consistent messaging to relay to the public. If we did have a larger funding pool we might have engaged an external to complete all the reports etc at the same time however, this doesn't allow for as much community engagement, feedback etc which is useful to bring the community along on the project as it is delivered.

Project set up and procurement: Any other comments

- We would bring the technical team together and meet onsite earlier. There was some confusion about the methodology early on that could have been overcome with a day or two face to face, and familiarity with the people and place earlier also would have added value.
- Tenders were of an exceptional quality and were very thorough.
- [redacted] is undertaking a number of projects following Cyclone Gabrielle. It has been difficult to ensure that the information been collected by other teams within council is transferred to the project especially with different timelines and goals for each project. Staff capacity has also been as issue as teams are being pulled into all the recovery projects and may not have had the capacity to give the input that they might have if this was a one-off project as opposed to multiple in the flood modelling, aerial photography, land mapping space.
- Procurement utilised out internal project management office, which has significant experience with procurement processes. I would use the skills of this team again as their expertise was a significant asset to delivering a successful procurement.
- No, was great that the reporting requirements are not too onerous. Quite a bit of cost can be for project admin and not actual project work.

Approaches and Software

Approaches and software: What tools/approaches are being used?

- GIS (Geographic Information Systems) have been vital in this project both for modelling and communication with the public, allowing a clear assessment of the whole catchment to assist in on-ground fieldwork. Open-source software such as QGIS and HEC-RAS have been extremely useful, and are easily accessible for anyone who hopes to take them up.
- No specific tools or software are being used for this project, except for the importance of kanohi ki te kanohi hui and site visits. We are also reliant on the consultant providing data in a palatable format from the other studies, for discussion.
- Our consultants will be able to speak to this at the workshop, but from a non-technical perspective, the modelling and data has been shared in a very user-friendly manner.
- Our consultants will be able to speak to this at the workshop, but from a non-technical perspective, the modelling and data has been shared in a very user-friendly manner.
- Two rain-on-grid flood models are being developed for the project. LiDAR elevation data is being incorporated. River and rainfall data is being incorporated. Bridge/culvert structure data is being incorporated. Our modelling provider is using TUFLOW to develop the flood model - outputs are provided for use in ARC GIS suite.
- Arc GIS, MIKE modelling software, Hydstra
- Tools:
    - [redacted] Flood Risk Model [redacted]
    - ESMAX (Richard Morris and Kirini Associates Ltd)
    - DBAM (Detention Bund Consultancy Ltd)
    - Esri's Wetland Identification
    - Surface Volume (3D Analyst) tool in ArcGIS Pro
- Hydraulic (TUFLOW) modelling, GIS mapping with multi-criteria analysis (MCA) for NbS feasibility assessment, stakeholder engagement workshops.
- HEC-HMS hydrological modelling of the upper reaches of the two study catchments; HIRDSv4 rainfall rasters; TUFLOW 2d hydraulic modelling software; Groundwater modelling of the [redacted]
- HECRAS. Classic hydraulic modelling dilemma of too many options and variables to model and you end up with too much data and confusing the stakeholders and decision-makers. I would limit the modelling scope even more to very specific options (but this hard to know prior). It was helpful having preliminary earthworks models (which can be used to inform landscapers and as visuals in discussions with stakeholders) before doing hydraulic modelling, as this gives them an area and stage-storage relationship to start from.
- The primary tool used for analysis was HEC HMS. The software worked well for its intended purpose.
- HIRDSv4 Rainfall rasters; Bathymetric Green LiDAR and Topographic LiDAR; TUFLOW 2d hydraulic modelling software
- HIRDSv4 Rainfall rasters; Bathymetric Green LiDAR and Topographic LiDAR; TUFLOW 2d hydraulic modelling software
- We have used a range of tools and approaches, including:
    - Manual vegetation survey, drone vegetation image survey
    - Unmanned autonomous boat bathymetry survey
    - eDNA biodiversity survey
    - Sonde water quality monitoring
    - Non-linear numerical model of tidal choke
    - Delft 3d hydrodynamic modelling

  They have performed largely as expected. The use of a UAV for bathymetry survey was new to us, however. It overcame some challenges that would have arisen with traditional survey (difficult site access, dirty water) but introduced others (challenges capturing data in areas with to overhanging vegetation). No tips or tricks to share, sorry.

- TUFLO 2D modelling software being used. Project has not utilised any other software as yet. Would be good to have consistency in datasets and modelling methodology/specification across NZ.
- Monitoring of soils and associated equipment needed was provided by Manaaki Whenua Landcare Research. [redacted] Council's methodology for modelling flows [redacted] has been used for the modelling. This work can be done in excel or HEC-HMS which is are freely available platforms.
- HiLo water sensors, HEC-RAS, ArcGIS Pro and Arc GIS StoryMaps
- Internally the tools that been used are:
    - BeforeUdig was used to collect data, which did not work well for the scale of this project;
    - Online data sources such as LINZ and ArcGIS Online content, which has worked well but did not provide all the data needed; and
    - ArcGIS Pro was used for data compilation, which has worked well.

Approaches and software: What has gone well?

- Modelling using HEC-RAS has gone exceptionally well, with the results clearly expressing the effect of NBS on river flows. The results from modelling can pair up more complex hydraulic processes with easy-to-understand visuals that can be interpreted by anyone.
- Being on the ground in the tākiwa is necessary for context building, and for sharing histories.
- Our consultants will be able to speak to this at the workshop, but from a non-technical perspective, the modelling and data has been shared in a very user-friendly manner.
- Our consultants will be able to speak to this at the workshop, but from a non-technical perspective, the modelling and data has been shared in a very user-friendly manner.
- Early signs are that we have achieved a good calibration between the model and the two flood events we have chosen to calibrate to - this is currently under peer review.
- Suppliers are using software required to get work done which are compatible across disciplines. Have had no specific software issues to date.
- Need to ask the technical team this question...
- The hydraulic modelling has provided clear insights into the limitations of NbS for large-scale flood mitigation. The GIS work is helping to clarify economic viability and prioritisation at a granular level in response to the needs of the local community.
- Good availability of hydrometric data. Can use existing studies, models, and understanding of catchment for early model refinement to increase efficiency
- I have applied some of the benefits-assessment tools identified in the Literature Review 'More Than Water'
- Green LiDAR flown specifically for the project. Use of post 2022 flooding surveys for model calibration
- Response:
    - Good availability of hydrometric data.
    - Green LiDAR availability for much of the main river channel and floodplain.
    - Can use existing studies and understanding of catchment for early model refinement to increase efficiency
- All approaches so far have gone well, however we are only part way through the hydrodynamic modelling.
- Ensuring we used specialist consultants has worked very well.
- All aspects have worked well.
- Arc GIS StoryMaps
- Most things have worked well eventually.

Approaches and software: Do you have any concerns about this aspect of the project? What would you change next time?

- As with all modelling and GIS software, there is a learning curve and a lot of room for error, with the only solution being more time spent focusing on improving the workflow.

- We have had multiple teams working on different NBS with risk that each team will use incompatible software. 1. River flood modelling team; 2. Stormwater flood modelling team; 3. Coastal flood modelling team. Integration of all workstreams in final format.
- There is not currently guidance around software most appropriate for use in assessing feasibility of nature-based solutions.
- An objective of the project is to design a [redacted] approach to this work. There will be significant learnings that will inform the next time. One of the significant tools in the project is the More than Water Tool which is being reworked to better suit rural projects. There has been significant investment in pursuing the use of the tool which we hope will pay-off.
- Response
  - Model doesn't always match what is experienced in the ground, with model appearing to under-estimate flood extent during more frequent event. This needs to be factored in however, the hydraulic model is still useful for relative comparison.
  - High-resolution GIS MCA is complex when looking at several NbS options across entire catchments. Varying resolutions and completeness of data make local decisions challenging.
- Size of catchment, model resolution, and therefore model run times need to be carefully considered
- Size of catchment, model resolution, and therefore model run times need to be carefully considered
- Hydraulic modelling seems to take longer than you expect.
- It wasn't clear to the consultants what the intended approach was and what scenarios were desired. While the software was applied properly, the project could have gone smoother by writing a clearer scope of work where the specific scenarios were described. We may have included additional hydraulic and water quality modelling.
- A more thorough site assessment earlier in the project that included mapping out all hydrological connections would have been helpful. The hydrology of the site is very convoluted and has raised challenges for various project steps.
- see above about available and consistent datasets.
- no this is BAU
- Access to information held by a number of organisations and the format that they all hold it in has been difficult at times. The project relies on understanding infrastructure administered by a number of different parties along the study areas rivers. Data requests have resulted in a range of information being provided in a number of different forms such as pdf's of assets, shapefiles. There appears to be no consistent methodology, data presentation from various groups. These can all be overcome however, does rely on the project needing to convert this information into one consistent format to be used and displayed in the project.

Approaches and software: Any other comments

- Through the process we discovered a number of other tools that could have improved the overall planning process. However, based on the scope that was written, the tools were not applicable as the project had progressed to far to switch tactics. However, they could be useful in the future to identify and quantify potential projects.
- Several site visits were beneficial to gain a deeper understanding of the catchment, identify previous flood indicators, and facilitate effective community engagement across the duration of the study.
- Our tool is still in development stage and therefore it is difficult to comment on this topic. The tool developers are confident that we will get something tangible to help make land use decisions. A challenge we are tackling right now is the weighting of the nature based solutions. We are keeping the weighting decisions to be made by the governance group and [redacted] and external technical experts. Forestry industry was very interested and concerned with not being involved in the weighting but it was decided that to ensure that commercial interests were not key to decision making and the best outcome for the land and awa was explored, that landowners would not be involved in this process. As we get to presenting the tool, there will likely be some hard conversations regarding priorities and cost of implementation.

- Software, data and technology is changing/improving all the time, need to be aware of the 'latest and greatest' and how existing projects can be future proofed.

Stakeholder communication and engagement

Stakeholder communication and engagement: What has gone well?

- Because I am not employed directly by the council, I do not think I am qualified to answer these questions.
- As a feasibility study in partnership with rūnanga, we have not involved any further stakeholders. This would be a critical next step prior to any detailed design, and prior to any implementation.
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- At this stage stakeholder engagement has been limited to the local district councils. We have worked closely with mana whenua to date and are reliant on them for community engagement and continuing the [redacted] project to the reporting stage. We have found key influencers to be Taio staff from our partnership organisation [redacted], hapu and marae reps, and staff from district councils.
- Although originally anticipated as part of this project, stakeholder communication and engagement has not proceeded as planned. This is due to concern regarding consultation fatigue and the potential for community confusion resulting from the multiple workstreams.
- The stakeholders support this project. A key mana whenua partner has identified workstreams they want incorporated into the project
- Almost all those we hope to have been involved, except [redacted] Committee. Ultimately unfortunately this comes down to one personality, but an influential one.
  Other key stakeholders including the TAs have come onboard through the Regional Climate Change Working Group which has greatly improved the uptake and interest.
  Other parts of [redacted] have also become more interested over time.
- Community engagement in this mahi has been strong and well-received. Access to funding for investigating issues and potential solutions—without the immediate pressure of physical works—has fostered more open discussions. People are more willing to explore options when they aren't constrained by the expectation of a tangible outcome.
  An MCA mapping exercise can be more objective, removing emotional attachment and local ideals; however, absolute importance is placed on the wishes and information gathered from stakeholders.
- Stakeholders were engaged with early in the process. There was initial buy in due to the desire to find solutions that relied on less grey infrastructure, and the co-benefits NBS achieves.
  Internal stakeholders are part of the working group. External stakeholders are being asked for feedback on local knowledge and Mātauranga Māori (current question posed is in relation to areas of significance).
  It appears to be a good number of external stakeholders, and this sits at mana whenua or PSGE level. Notwithstanding, because mana whenua represent groups and may need to solicit feedback, the requirement for timely response is not always in line with reality.
  What has gone well: All parties agree that NBS should be investigated.
- I found most stakeholders very supportive and engaged. The consultation was undertaken by the landscape architect which I think worked well as although flood mitigation was the goal, most of the stakeholders I felt were more interested in how the project might look. I have been surprised some stakeholders haven't wanted more input - and it can be difficult when they don't have a clear vision of what they want.
- We are in the midst of interviews, but so far people have been willing to engage and share their thoughts. Because of the existing project, a number of good relationships could be drawn on for the

engagement work. Also catchment advisors have good relationships across [redacted] that have been useful.

- Engagement throughout the duration of this project has been vital to ensure community and iwi priorities and interests are represented in the modelling work and optioneering for NbS.
    - Objectives for engagement include:
        - Get a greater understanding of community priorities and issues in the catchment
        - Help Council understand how landowners in the catchment feel about using Nature-based solutions to help manage flooding, improve water quality and support biodiversity in the region.
        - Understand the barriers for landowners when considering/implementing NbS
        - Understand how Council can work with landowners to implement NbS in the future.
        - Identifying the wider community benefits of NbS and identifying how to address the costs/barriers to this.
    - The engagement outcomes will inform the final report for the project, which will include information on opportunities, benefits and possible risks/limiting factors to the use of NbS in the catchment. This will assist Council with future decisions-making and progressing the project beyond feasibility to implementation.
- We are very lucky to have most of our mana whenua partners engaged in the project as they are on the steering group. This has been beneficial to the project and the project team as it gives us confidence that we are on the right track with the decisions being made for the project.
- Yes, we have engagement from iwi stakeholders, but it has rushed due to the short time to undertake the project - a longer timeframe for the project to work with stakeholders at their pace would be preferable.
  Stakeholders are supporting the project by providing feedback on their vision for the catchment and the types of nature-based solutions that are in keeping with their vision.
  Staff-wise there are too few people involved, and staff capacity is a significant issue.
- We have built good relationships with the Trust that manages the land, over a period of a year and a half now (ongoing). That has been fruitful in ensuring access and support for our studies.
- Not too much stakeholder comms and engagement as yet.
- Our stakeholder engagement has gone well as we were able to use the broad range of contacts within the project team to reach a large number of people across New Zealand. We developed a stakeholder tracking database to track attendance and log interest in the project. We have had a great deal of interest in the project from a wide range of people, geographical areas and roles/ areas of expertise.
- roll of the consultant
- The project has established a Governance Group which has representation from iwi, landowners in the catchments, City and District Councils, Fish and Game, Federated Farmers. This group has been used to guide the project team on communications out to the wider catchments. Letters have been sent to all landowners who own land that borders the rivers, a project webpage has been established on the [redacted] webpage, and a project specfic email address has been established. The Governance Group has been engaging during meetings however, it has been difficult to engage with them outside of these meetings (time poor).
- What has gone well? We have managed to engage with a number of individuals from different aspects of the project to interview. Also have a survey for others to complete.

Stakeholder communication and engagement: Do you have any concerns about this aspect of the project? What would you change next time?

- Further time, budget and capacity would be required to engage more broadly on this project.
- As above, getting the modelling underway earlier would make the stakeholder engagement easier and more productive as completion of the modelling would give people something to talk to at hui - engagement without maps/images can be challenging.

- Natural hazard adaptation planning in a post-disaster setting is highly complex. Following the [redacted] flood events, our wider [redacted] community suffered significant mental distress. This has occurred against the backdrop of endemic social issues and socio-economic deprivation [redacted].
    - There has been a small, but very vocal, part of the community that is publicly critical of both regional and district councils' flood response and protection performance. This has notably undermined the community's trust in the councils.
    - Additionally, there are multiple workstreams and teams that have shared/cross-over responsibility for various aspects of flood hazard identification, management and response, as follows:
    - Teams, groups, and projects include: [redacted]
    - Although engagement with the community and stakeholders was initially scoped during project planning, concern regarding consultation fatigue and the potential for community confusion resulting from the multiple workstreams has meant that engagement has not proceeded as planned.
- [Response with multiple bullet points]
    - Unexpected illness with a key partner has caused delays and difficulties in incorporating mātauranga Māori practices at key point in project
    - Difficulties have arisen with a mana whenua partner as a new settlement trust has been established
    - Originally identified a number of other partners but as project developed, their involvement was shifted to an inform only relationship
    - Next time:
        - Earlier and ongoing partnership with multiple mana whenua representatives
        - Early and clear expectations about relationships between Runanga and post settlement entity groups
- Communication continues to be a struggle. [redacted] isn't proactive in this space and it is difficult to be seen doing something 'different'. Take resource and dedication to be good at this. Definitely a space we can improve. Regular email newsletters would be an easy win. More activity on social media. Getting the []
- That said, communicating the expected physical outcomes of this feasibility study has been challenging. While some residents seek quick solutions to frequent flooding, others prioritise habitat restoration and water quality, and some focus on the economic viability of nature-based solutions (NBS). Ideally, we aim to implement a hard-engineered structure to provide immediate flood relief while simultaneously progressing NBS initiatives.
- Only with the time-scale. As mentioned above, getting feedback quickly is not simple, and may result in discontent if (late) feedback is not incorporated.
- One change might be engaging more with the local Iwi before putting in the original application. Its tricky to do before any funding is approved, but there can be quite a bit of sensitivity.
  One limitation is the team for engagement is physically based away from the project area – meaning it is harder to arrange face-to-face discussions, which are more effective.
- Do you have any concerns about this aspect of the project? Yes, will the approach result in a representative view for [redacted] landowners.
  What would you change next time? Maybe complete a more comprehensive survey using different methods.
- It has been important throughout the engagement process to ensure we are managing community expectations. Clear messaging around this project being a feasibility study only with no funding for implementation of the findings to reduce any chance of miscommunication/misunderstanding of the end result of this piece of work. The findings of the project may show it is not possible to provide flood resilience in the [redacted] using NbS alone.
- There is a knowledge of the project by the wider public, but we are still do communicate the tool as it is still in development.
- Next time I would allow a longer time-frame (3 years) to run the project.

- We have had challenges engaging with some Trustees who are also neighbouring landowners. With hindsight we would have met with them one-on-one early in the project to establish where our interests overlapped and differed.
- Generally no, although we have struggled to actively engage all iwi. Our engagement has been guided by our internal Healthy Waters Māori Outcomes Team and engagement was therefore streamlined with other initiatives. Due to the large number of projects currently being undertaken by Healthy Waters, 'consultation fatigue' was a real issue and therefore we were guided by our [redacted] Engagement Plan.
- There have been times where misinformation has circulated around the project - this lead to a fullpage article in one of the papers which [redacted] then responded to. The webpage has been set up to be the one source of the truth for the project however, it is difficult to stay over all people's thoughts, comments etc on the project when they don't necessarily come through to the project team. I think the challenges with the engagement will be when it comes to the recommendations and we have lines on maps of where management may or may not occur. I guess the difficultly at the moment is that in general people support the concept of Room for the River however, the ultimate response will be when people see how it may affect their land.

Emerging lessons – other aspects of project delivery

Other aspects of project delivery: What has gone well?

- What has gone well? Procurement went well. I feel this new subject area has thrown up a few challenges for both our consultants, and [redacted]. The technical piece went really well.
- The Story Maps produced by the [redacted] has been excellent in communicating what can be quite complex processes, being easily accessible and able to communicate ideas to the broader public.
- The Ministry for the Environment have made the reporting process straightforward.
- The combination of hui, workshops, reviews of reports, and memorandums to ensure agreement throughout the process has ensured that all parties involved feel empowered in their contribution to these projects.
- The combination of hui, workshops, reviews of reports, and memorandums to ensure agreement throughout the process has ensured that all parties involved feel empowered in their contribution to these projects.
- Support from other teams from other councils who are also completing projects using the same funding and working to the same timeframes has been great.
- Adaptable work programme: Maintaining an adaptable work programme through consultation with MfE has meant that we have been able to repurpose the funding initially set aside for engagement. We have been able to expand the scope of the concept development and modelling phase of the project to include six lead NBS options:
    - River flood protection –
        - [redacted]
        - Riverbank revegetation
        - Wetland expansion
    - Coastal flood protection –
        - Coastal dune enrichment and expansion
    - Stormwater and pluvial flooding –
        - Regreening pavements with rain gardens
        - Constructed urban wetlands
- Response
    - Trusted supplier committed to timeframes and managing multiple workstreams
    - Incorporation of different technical disciplines to inform project
    - Direction from mana whenua to incorporate workstreams
    - Relationship with MfE – have received support and helpful advice

- Excited that people mostly inherently 'get it'. They understand the theory that Slowing the Flow will reduce flood risk, they are just worried out what that means to their farm system or infrastructure. The project has evolved from a flood mitigation focus to a broader exploration of sustainable land transitions and environmental restoration.
- Good working relationship between council and consultant. Readily available data from council and provided in timely manner
- Collaboration has gone will between the project team. Council and the various subconsultants have worked well and delivered what has been expected. It worked well having in-person meetings where possible, particularly when reviewing modelling results.
- Response
    - There is a good working relationship between council and consultant.
    - Short weekly meetings and monthly reports ensure clear communication and discussion around the progress of the project.
    - Technical experts at both Council and WSP bring significant knowledge and expertise to the project.
    - Readily available data from council and provided in timely manner
- The contracting of work has gone smoothly. It has allowed us to pull in relevant experts for each piece of work, which is building towards a more interesting holistic picture than we could have established through our own efforts alone.
- Not sure why the focus is on project delivery. The emerging lessons should be about the actual work undertaken.
- Our careful project planning, management and facilitation has meant that our project delivery is on track and is working well.
- General support for the project at a concept level which is promising. We have had other catchments ([redacted]) ask for the same work to be undertaken in the catchment which is promising.
- None
- nothing as yet

Other aspects of project delivery: Do you have any concerns about this aspect of the project? What would you change next time?

- The [redacted] region is vast and does not allow for as much time on the ground in the tākiwa as would be hoped for. Ideally, we would hold all hui on site.
- Delivery of the project has proceeded well.
- Tight timeframes to complete remaining work and deliver final report. Next time: Achieve more engagement from partners to enable earlier initiation of key workstreams
- A team of more people dedicated to the project would have been extremely valuable. It was something I did 'when I could' 'between other projects' and it did suffer at times because of this.
- Identifying ongoing maintenance costs and funding sources for long-term sustainability.
  The modelling, to date, suggests that localised NbS intervention will have limited impact on flooding during extreme events. Funding model will play a critical role in successfully delivering NbS at the catchment scale.
- The timeframe for project delivery is relatively short so can cause added pressure
- Timeframes have slipped, due to more time than expected getting feedback and meetings arranged with stakeholders. The modelling also took longer than anticipated.
- Do you have any concerns about this aspect of the project? That a new approach is being introduced to the public, without any promise of implementation. The implementation of NbS nationwide will require a new collaborative funding approach and a good deal of advocacy. The engagement piece does have challenges, due to the new subject area and a lot of advocacy and education required to discuss the subject matter. Also, maybe funds to deliver a pilot site would assist in showing the public how NbS can work.
- There are some slight concerns that delivery of the Te Ao Maori workstream will not be completed at the timeframe specified. We don't think this should affect the creation of the spatial tool, it will just

mean that some information relating to sites of significance may not be included. We are hoping to get this workstream back on track.

- The short timeframe to deliver the project significantly increases the risk of a non-successful outcome.
- Due to the soil monitoring work being dependent on weather conditions, it would have been better to have had additional time to offset the weather delays we experienced.
- Timeframes - time quickly gets away with these projects especially if you want to do true community engagement and provide time for feedback etc. Also recognising that projects need to have an end date for design so that you can move into implementation. Fine line however, for this project another 12 months would have been great.

Other aspects of project delivery: Any other comments

- Never underestimate the power of strong relationships and values of one-on-one conversations. The [redacted] Hikoi should have been held earlier on, and then replicated at the end of the project. This is something we still hope to do. 25 people in a bus for a day 'getting familiar with people and place'.

What are your intended outcomes from this pilot work?

- It would be great to get a degree of consensus from the wider public, with people willing to consider potential NBS across various catchments.
- Ultimately we hope to have a road map as to how to approach catchment-scale modeling and change as a Treaty partner of excellence in the future. Further below.
- Data and reporting that will support discussions around next steps for implementation of changes at these sites.
- Response
    - Development of strong working relationships with our partnership team and the Waitotara community.
    - Better understanding of the flood risk in [redacted] and across the region for a range of rainfall events and climate change scenarios.
    - Better understanding of the feasibility of NbS to reduce this risk - leverage for funding to implement those that may be suitable and effective.
    - Information on current knowledge gaps - and leverage for funding to address them.
- Following completion of the concept design and modelling phase of the project, we will hold a multi-disciplinary / multi-team workshop with the purpose of sharing each NBS option's: 1. Concept design; 2. Modelling results; 3. Summarising feasibility and confidence in effectiveness; 4. Recommendations for next steps.
  Following completion of this workshop, we will be able to provide recommendations to the Regional and District Councils regarding the implementation of each NBS option. The NBS options that have high confidence in effectiveness would then need to be designed in greater detail and their implementation scoped and costed. This would form the basis of a cost/benefit analysis.
- At the project completion, [redacted] would like to be able to understand whether there are viable nature-based solutions (incorporating mātauranga Māori practices) that could be implemented in the [redacted] catchment which could reduce flood risk to the urban reach. The intention is that this would include a risk and cost benefit analysis to understand the full picture. The reporting needs to be detailed enough (e.g., area required or volume of storage) that this can inform implementation of a solution.
- Highlighting the need to think systematically about flood risk management and the importance of land-use, and land-use change. That the approach of many small structures across a wide area could seem daunting but it is also building on other good practices relating to water quality, biodiversity and climate mitigation. I hope this adds to the bow of NZ needing to take a more joined up approach to solving issues.
- Outcomes
    - Develop a clear workflow for transitioning land into nature-based solutions.

- Provide technical support for [redacted]'s business case on implementation of NBS.
    - Identify funding opportunities and economic viability for landowners to adopt NbS.
- That there is a summary of recommendations to go to Council (supported by reports, benefits, risks, cost estimate) for a decision to be made on whether all or some of the project is viable to be funded to implementation/construction.
- I see that Councils become aware of the questions they need to answer to implement NbS. They have information to enable them to make decisions about implementing.
- Outcomes:
    - Determination of feasibility level options that may reduce flood risk within the catchment.
    - Clear next steps from MfE around how this work/ findings will be used moving forward.
    - National guidance from these studies.
    - Information around planning guidelines, and how future adoption/ funding options for NbS may be available at both national and local govt level as well as at community/ individual level.
    - Using the outcomes from this work to inform the public on NbS and build community support for next steps/ implementation where applicable.
- Outcome: Determination of feasibility level options that may reduce flood risk within the catchment. Next steps / needed to support implementation:
    - Clear next steps from MfE around how this work/ findings will be used moving forward. Are there any plan to publish guidance from these studies, and what is the likely timeframe?
    - Information around planning guidelines, and how future adoption/ funding options for NbS may be available at both national and local govt level as well as at community/ individual level.
    - Using the outcomes from this work to inform the public on NbS and build community support for next steps/ implementation where applicable.
- Quality science advice to the Trust to help inform their restoration actions now and into the future. And a greater understanding within [redacted] of the how coastal land transition projects occur and what the key challenges (scientifically, logistically, and socially) may be.
- Well, this is what our project objectives are.
- At the end of this project we hope to develop a framework for implementing the technical recommendations from this work that can be nationally applied. We also want to identify where further work is needed to refine or calibrate certain recommendations. Additionally, further work regarding quantifying costs and benefits of various soil amelioration options, in the context of wider flood management approaches, would be valuable. This work could be expanded to other urban areas in New Zealand and further funding to extend this work and potentially quantify soil amelioration and modelling guidelines across New Zealand would be beneficial. Funding/ resourcing for these work items could be provided at the national level.
- An understanding of the potential viability of NBS solutions.
- The end result of this work will be a report with a number of different options in terms of river management lines. At some point these will need to be implemented and questions will come into implementation as to whether compensation will be paid for land no longer useable etc. These are all questions that will need to be dealt with catchment by catchment basis. How this will be funded is certainly a question that will arise. Council has invested in undertaken investigations in other catchments in future years, with funding confirmed in Years 2 and out of the current Long Term Plan.

What would you need to improve your council's ability to design, fund, implement, and/or replicate these types of projects?

Responses categorised manually.

Funding

- Increased funding to increase staffing, improve river and rainfall data collection and fund continual development/improvement of flood models.
- Funding is a sizeable challenge for both [redacted] and [redacted]. Both have a small rate-payer base compared to the extensive area over which jurisdiction is held, and extreme climate and natural hazard risk profiles, including a lengthy exposed coastline and multiple settlements located on flood plains. Furthermore, there is no significant unaffected population that could be leveraged to better support vulnerable settlements.
- External funding mechanisms will be required. There is no other alternative.
- Government funding
- Increased funding streams for land-use transition projects.
- More flexible funding mechanisms to support long-term NbS maintenance.
- Quantification of benefits and costs to support justification of funding
- A funding mechanism/program such as cost-share or conservation easements that allow the Council to work with individual land-owners to fund these projects on a voluntary basis while protecting the public investment.
- Funding to undertake feasibility studies and undertake consultation with stakeholders.
- Funding to support this kind of work.
- Funding, no further work will occur otherwise

National direction and momentum

- National direction for co-funding to move from the feasibility phase, through wider engagement and design, to then implement these projects.
- National momentum, if other councils were including them they would be taken more seriously here.
- National direction as to coastal land transition- how marginal coastal land should be dealt with in a changing climate that will see it eventually inundated.

Guidance

- Guidance on integrating NbS into regional flood mitigation strategies.
- Clear national guidance on planning and adopting NbS for flood management.

Standardised methodology, monitoring frameworks, and design practices

- Standardised monitoring frameworks for NbS effectiveness.
- A set of written design standards for individual practices.
- Consistent modelling methodology and application datasets. Also key understanding of risk and residual risk thresholds.

Staffing

- Staff dedicated to the planning, design, and construction (ie watershed coordinator)
- Funding for staff (e.g. time buy outs) to alleviate capacity issues.

Other

- Longer project timeframes - including lead in times at project proposal stage.
- Case studies and examples once they have been implemented.
- Implementation will be the difficult part of this project and will mostly come down to the cost for implementation. This may require the purchase of land needed to allow the river to move, compensation for land that may now be flooded (but used between floods) etc. Although implementation is still a little way of, compensation, land purchase etc have been some of the first questions that the community have asked about in relation to the project. Given the likely areas potentially affected affordability by the proposal afforability to the local community will be a key

consideration for implementation i.e. this is unlikely to be affordable if we rely only on the catchment to fund implementation of the project.

What question or topic would you most like to hear about from other councils at the workshop?

Responses categorised manually.

Selection of sites and types of NbS

- I would be curious to see potential workflows for determining sites for management, as I think this is the most challenging part of the process.
- Types of NbS being considered for different catchments
- Any other large catchments (>1000 km2) being modelled

Partnerships and engagement

- The process that other regional councils followed to engage with rūnanga and what these partnerships look like. Were rūnanga part of the application process for these studies? At what point did they become involved?
- Community engagement for communicating 'scary data'
- How do we get community engagement early in projects?

Modelling

- Modelling for extreme events to judge success rather than smaller, more frequent AEPs - lack of national standard for this modeling and where NBS stacks up at the extreme end of the scale (whereas true success could be more likely in regular occurrences)
- Process applied to confirm confidence in modelling and effectiveness of NBS options
- What types of modelling software other councils have been using?
- Does your modelling show that nature-based solutions can significantly reduce the flood risk in a large event (e.g. 1% AEP)?
- Is anyone looking at integrated surface water and groundwater modelling for NbS optioneering?
- Methodology and results of initial testing

Funding & policy

- How councils are planning on funding priority NBS
- We understand that under this funding that councils are running their own discreet projects. However, are they doing other NBS work outside of this funding? Do they have an overarching strategy/policy around NBS projects?
- Examples of successful funding models for NbS projects.
- Do other Councils see themselves delivering NbS widely?
- How they plan to progress us of NbS, policy, funding, implementation, advocacy?
- How they plan to tackle funding NbS – what ideas do people have.
- If the concept design and modelling confirms feasibility and high confidence in one or more of the NBS, what funding options would be available to councils for detailed design and implementation?

Benefits and costs of NbS

- Are other councils thinking about the wider benefits of NBS for their catchments? Or is the primary focus on flood risk reduction?
- How other councils are quantifying the benefits of NBS (wider than just water quantity/ flood risk benefits).
- How other projects have quantified benefits and costs.

Taking this information forward

- How they intend to use this information going forward, particularly if it will inform their flood risk programme and how?
- What outputs do they want to see from feasibility projects to get them through the decision-making processes within council and into implementation?
- How are councils taking a holistic/systems approach to catchment management and assessing options (NBS and non NBS) to manage current and future CC.

- Disrupting the status quo of patch fixes toward whole-of-catchment solution approaches
- Successes, challenges, next steps.
- We need to raise the importance of how these NBS compliment other engineering solutions, whilst benefitting other regional values.

Other

- How other councils are addressing landowner concerns about economic viability.
- Lessons from other catchment-scale NbS initiatives.

Appendix F. Project 1-pagers

One-page summaries of the projects were compiled from information and images provided by project teams. Project teams reviewed the one-pagers at the mid-project workshop.

AUCKLAND COUNCIL

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

PROJECT DATES

June 2023 to June 2025

LOCATION

Two urban catchments in Auckland – Mangere and Te Auaunga Creek catchments – have been selected for soil monitoring and flood modelling.

PROJECT OBJECTIVES

The project will investigate the potential benefits from an alternative rules framework to reduce flood risk by supporting spongy urban soils by:

- better defining run-off from urbanised soils by monitoring soil infiltration/permeability and profile water storage in 2 sub-catchments with a range of Hydrologic Soil Groups;
- using hydrological modelling to better define the risk of flooding in larger events if run-off from urban soils is underestimated;
- engaging with industry and iwi to recommend industry-focussed solutions;
- testing and recommending options to avoid or minimise soil compaction, and options that ameliorate or mitigate compacted soils.

LOCAL CONTEXT

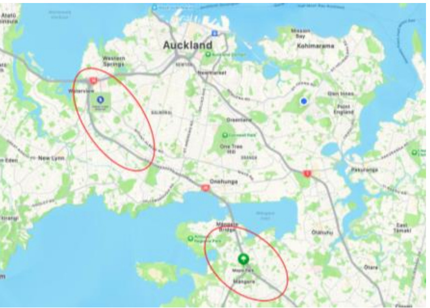
Urbanisation is associated with increased stormwater run-off, largely due to an increase in impervious surfaces and hydraulically efficient pipes connecting impervious surfaces to surface waters. This increased stormwater volume (even from small events) and speed of run-off modifies stream channels and increases flooding risks. However, research indicates that soil infiltration and storage properties are fundamentally altered during subdivision as a result of soil compaction to the extent that pervious areas start functioning more like impervious ones. We identified that more research was urgently needed to characterize runoff from compacted soils within urban green space, lawns and landscaped areas.

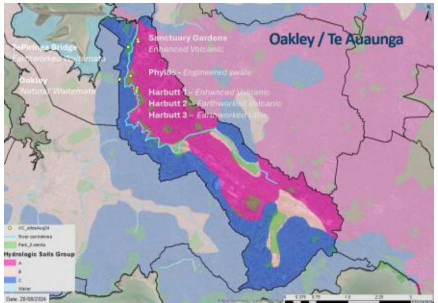
A prior review conducted in Auckland in 2009 concluded that run-off, particularly in winter or during larger rainfall events, may be underestimated given the large reduction in subsoil permeability resulting from compaction during earthworks. A more recent study by the New Zealand Parliamentary Commissioner for the Environment (NZPCE) found that more attention could be given to counteracting the loss of private yards and gardens (resulting from infill development) by improving the natural storage capacity of soils and nearby public green spaces.

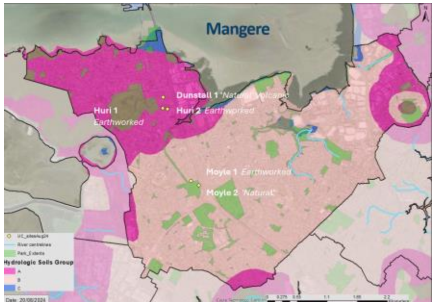
Modern land development practices are fundamentally different to early and mid-twentieth century practices, yet our understanding of the runoff implications of land development are based on the practices of the past. As land development practices continue to evolve, the impact of these changing methods requires assessment techniques which can describe, and potentially mitigate, their impact (complementing 'formal' nature bases solutions such as wetlands, raingardens, swales). Land development practices now include deeper and more extensive cut/fills and high coverage of impervious surfaces that lead to large areas being compacted consistently. However, requirements for replaced topsoil depth vary, and there are no requirements for subsoil or 'permeable' depth.

Soil amelioration in urban areas is an important, yet sometimes overlooked, nature based solution for our cities. This project therefore aims to quantify the impact of earthworks on our urban soils and investigate the feasibility of improving sponginess of such soils.

The key challenge of this project is to assess and quantify the impact of earthworks on hydrological soil groups. The question we asked is whether or not our current modelling approach adequately accounts for the alteration and compaction of urban soils which occurs through the development process, and what the feasibility is of improving sponginess of such soils, i.e. increasing the area of HSGA-equivalent soils, therefore reducing flooding. Both catchments experienced flooding during the Auckland Anniversary Floods.







PROJECT ACTIVITIES

Our project activities include undertaking soil monitoring and hydrological modelling in two distinct catchments in Auckland, along with developing a community of practice and development of policy recommendations.

Soil Monitoring

- We hand-excavated test pits of up to 1m by about 0.5m, which were backfilled after assessment, to carry out the following tests:
  - infiltration and permeability rates (how fast water moves into and through the soil);
  - cores taken up to 60 cm depth (occasionally 80 cm if very deep, permeable soils);
  - soil compaction and soil moisture storage (analyses in laboratory offsite).
- We have used the soil monitoring results to quantify curve numbers for various soils under different compaction scenarios for our modelling of the two case study sub-catchments. Using curve numbers aligns with the current hydrological modelling methodology for the Auckland region (TP108).

Hydrological modelling

- We are using hydrological modelling to quantify the impact of changing the compaction level of Hydrologic Soil Group (HSG) classes on run-off, for flood risk management and the sizing of run-off control devices. We are also modelling potential solutions (such as soil loosening/amelioration within greenspace; increased topsoil depth, building with piles not concrete slabs, enhancing and protecting root zones of trees, etc.) to determine the effect on reducing flood risks. We hope to be able to identify hot-spots within the chosen sub-catchments where maintaining or improving permeability is likely to have the greatest benefit.

Consultation

- We have created a 'community of practice' and hold national workshops to update interested stakeholders on our project progress and disseminate our learnings. We are also consulting with relevant local iwi groups.

Reporting

The agreed study outcomes will involve the development of:

- an initial draft technical guidance document detailing feasibility of potential solutions for implementation by the construction industry and to inform alternative rules frameworks for regional and district plans.
- a draft method which aligns with TP108 to allow the impact of earth worked soils and their amelioration to be explicitly acknowledged and allowed for when assessing flood risk.
- recommendations for next steps and future research.

How do Nature-based Solutions Feasibility interrelate with Mātauraka Māori in the takiwā of Te Rūnanga o Arowhenua

PROJECT DATES

July 2023 - June 2025

LOCATION

Arowhenua Rūnanga

In South Canterbury

LOCAL CONTEXT

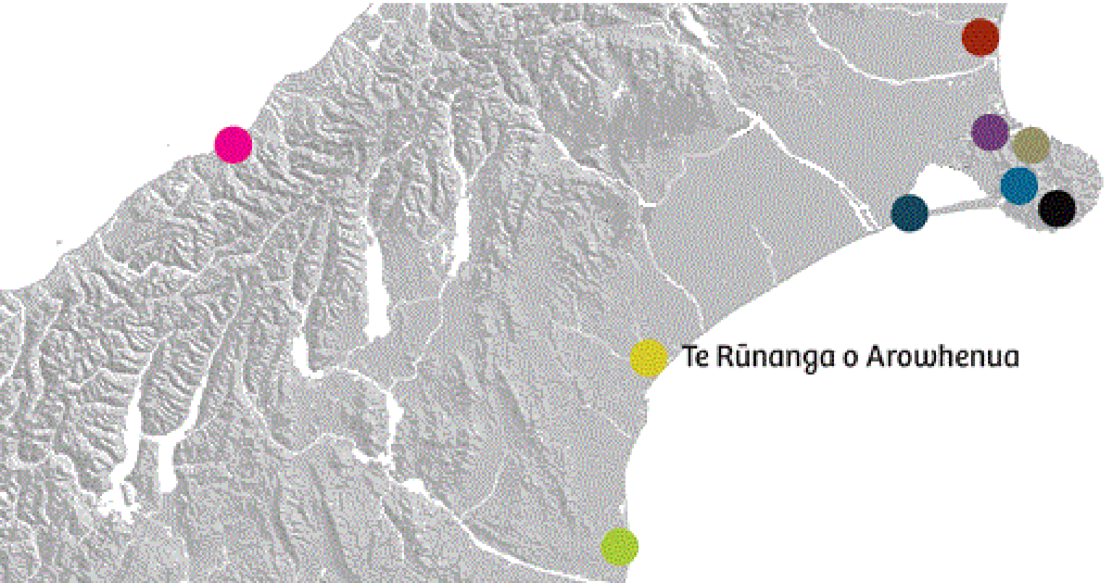
This project investigates "what are nature-based solutions?" and looks at how they resonate with matāuranga Arowhenua. This project investigates what is needed to genuinely incorporate matāuranga into considerations on feasibility of any nature-based solution within the takiwā of Arowhenua.

This project runs in parallel with two other nature-based solution feasibility studies in the Te Rūnanga o Arowhenua takiwā, ‘Room for the River’ and ‘Coastal Flood Mitigation’. It is intended the process and outcomes from each project will inform the other. This project investigates how the matāuranga of Te Rūnanga o Arowhenua can inform and be informed by investigating the feasibility of nature-based solutions to coastal and riverbank erosion.

An increasing focus on resilience planning is required and nature-based solutions is a way to address flood mitigation effects from the coast and rivers. When done with an understanding of matāuranga and the aspirations of Rūnanga nature based solutions have the potential to deliver on multiple Papatipu Rūnanga aspirations. This project intends to enable the exploration of Mātauraka Māori values and how these can inform the design, monitoring and assessment of nature-based solutions for flood mitigation within the takiwā of Arowhenua.

PROJECT OBJECTIVES

Environment Canterbury is exploring the use of Mātauraka Māori to align flood protection programmes with attributes that reflect Papatipu Rūnanga aspirations. We anticipate this report can be used to support the engagement and design of flood protection sites in the Te Rūnanga o Arowhenua takiwā.



PROJECT ACTIVITIES

- Engagement with Te Rūnanga o Arowhenua on the incorporation of mātauraka in nature-based solutions for river and coastal flood mitigation in the Te Rūnanga o Arowhenua takiwā.
- With the consultants, Jacobs, discussions and feedback on how the identified Te Rūnanga o Arowhenua values and raised concerns could be practically incorporated in flood protection planning and works within the takiwā in future.
- Report regarding nature-based solutions and how this should be considered alongside mātauraka within the takiwā of Arowhenua and feedback on adaptation options from Te Rūnanga o Arowhenua.

CANTERBURY REGIONAL COUNCIL – ENVIRONMENT CANTERBURY

Coastal flood mitigation through protection and restoration of coastal freshwater and brackish wetlands

PROJECT DATES

July 2023 – June 2025

PROJECT OBJECTIVES

Collate present-day stock take of coastal wetland ecosystems and their ecological status and health, north of Waitarakao to Orari River and Muriwai to Taumutu.

Develop a suite of adaptation/mitigation options involving coastal wetlands that can be used as a basis for feasibility analyses.

Indicative "non-intervention" wetland evolution analysis (i.e., what would happen to existing wetlands if natural processes were left unfettered). Case study sites: Muriwai/Coopers Lagoon and Spider Lagoon.

Test feasibility of selected options including Mātauranga Māori, physical, environmental and financial implications of each option.

LOCATION

Mid-South Canterbury Coastline, Ōpihi-Ōrāri Rivers and Muriwai-Taumutu

LOCAL CONTEXT

The coastal lowlands of Mid-South Canterbury between Timaru and Banks Peninsula contain a mix of productive farmland and ecologically and culturally valuable coastal wetlands. Despite being located on the coast, most of these wetlands are not normally tidal. Dominant hydrology is freshwater inflows (surface and groundwater) with only occasional sea water incursions. Salinity in these coastal wetlands is variable over space and time, but they are generally fresh or of low salinity (brackish). The coast fronting these coastal lowlands is rapidly eroding (1-2m/year) and prone to significant coastal inundation events. A historic network of coastal stopbanks has mitigated most sea water flooding events, protecting both farmland and the coastal wetlands. However, coastal erosion is now overtaking and engulfing many of these stopbanks rendering the farmland behind unusable in many places and threatening the existence and functionality of the coastal wetlands and lagoons, their biodiversity and mahinga kai values.

We want to explore the feasibility of using/enhancing existing, or creating new, freshwater/brackish coastal wetlands and lagoons to mitigate the environmental and economic effects of severe coastal flooding. The purpose of this project is to better understand the following aspects:

- the ecosystem response and evolution of these freshwater/brackish coastal wetland ecosystems to an encroaching coastline and increasing incidence of saltwater intrusion; how we identify adaptation tipping points for these ecosystems and what options/opportunities for wetland preservation or re-establishment are available;
- whether it is feasible to assist migration of these freshwater/brackish wetlands from the coast i.e., if long-term attempts were made to try to retain and adapt coastal lagoons in the face of erosion/inundation pressures what interventions (engineered, planning or "natural") what would be required to undertake this;
- technical information on how these ecosystems may be incorporated into a buffer zone between the coast and other similar more landward (at risk) ecosystems, and productive land, to maximise the benefits of the space as natural inundation protection and as a functioning ecosystem to improve future management and adaptation decision making.

PROJECT ACTIVITIES

The project delivery approach will involve several key steps, there will be a stocktake of existing coastal wetland ecosystems, ecosystem services, and values (both ecological and cultural). There is also an assessment conducted on existing coastal flood protection assets, including their condition, effectiveness, and remaining lifetimes, based on recent coastal hazard risk assessments. Next, a range of options will be developed for utilising the existing wetland and stopbank systems, or creating a new configuration of wetlands and stopbanks, to form a natural buffer against coastal inundation events and enhance environmental outcomes. This will be followed by modeling the effects of retreat options and developing a financial model to showcase various implementation options and assess their affordability and financial feasibility. Additionally, a model will be considered in relation to sea level impacts on rates of coastal change.

Potential management options may include no intervention, optimising and prioritising productive land management, optimising and prioritising wetland protection and enhancement, or hybrid options that configure a mixture of coastal stopbank systems and wetlands to optimize the buffering capability of the wetland by both protecting productive land and allowing natural wetland evolution. The potential economic and environmental impacts of each option will be explored. This exploration will involve economic modeling of the impacts on farm production and other private land uses, physical impact testing through coastal inundation modeling of incremental sea level rise scenarios against various coastal storm annual recurrence intervals (1-year, 10-year, 50-year, 100-year), using GIS techniques and LiDAR to predict the ability of wetlands and lagoons to migrate inland either naturally or through deliberate intervention, and exploring environmental outcomes in terms of habitat and biodiversity, water quantity and quality, and mahinga kai (cultural impacts).

CANTERBURY REGIONAL COUNCIL – ENVIRONMENT CANTERBURY

Room for the River – A case study of implementation

PROJECT DATES

July 2023 – June 2025

LOCATION

2021 Central and South Canterbury

River Catchments

- Orari River
- Opihi River

PROJECT OBJECTIVES

- Agreement with relevant Runanga partners on River Catchment to focus this study
- Assessment of existing infrastructure and other investments reliant on current river morphology
- 2D flow model to assess current river capacity and use as a benchmark for assessment of how effective each potential mitigation/retreat option may be
- Develop a financial model to assess affordability/feasibility
- List of potential 'room for river' options, indicative costs, barriers to implementation, consultation required, effects to be managed.

LOCAL CONTEXT

At the end of May 2021 Central and South Canterbury received rainfall over 50yr Average Recurrence Interval (ARI) and up to 200yr ARI in many locations. Damage to flood protection infrastructure and private property was severe.

Concurrently, there is a movement growing within the rivers and flood control industry referred to as 'room for the river'. The premise of this movement is that well-intentioned decisions made by past generations have squeezed many of our rivers into narrow corridors. If we can open more space for rivers to both erode vegetative buffers and for floodwaters to spread, the expectation is that future damage will be reduced. 'Room for the river' principles intend to improve spatial quality, providing environmental and social benefits broader than just flood protection.

Making this change, however, is not straightforward. Challenges around environmental permissions, public and private land ownership, capital works, financial compensation, timing of implementation, and integration with other infrastructure all need to be worked through with our communities.

The purpose of this project is to study one river from gorge to sea (proposed to be the Waihi River (Waihi- Temuka- Ōpihi) in South Canterbury) and investigate what would be required to implement a 'room for the river' upgrade to reduce the frequency of flooding from this catchment. Proposed locations include the stretch of the Waihi-Temuka-Opihi Rivers. The locations and scope will be finalised based on discussions with the relevant rūnanga.

It is expected that the investigations will provide a means to gauge the scale and types of impact on flood resilience and ecosystem health of retreating stopbanks landward at both a local scale (e.g., near to the section subject to the retreat) and the cumulative downriver and catchment scale benefits.

PROJECT ACTIVITIES

The initial proposed approach includes the following steps:

- Creation of a 2D Hydraulic model to:
- Determine current flood protection flow capacity;
- Analyse ideal riverbed and vegetative buffer width – primarily for erosion management;
- Identify areas or zones for which stopbank retreat and/or upgrade would be possible and beneficial;
- Identify areas or zones where river berm vegetation should be added to;
- Test the relative sensitivity/benefit of other nature-based solutions to improve flood and erosion resilience (such as offline ponding areas or varied catchment vegetation scenarios).
- Estimation of capital works costs to implement the ideal solution:
- Estimation of the value of land and property acquired by the river under a retreat scenario;
- Development of a financial model to showcase various implementation options and assess affordability / financial feasibility;
- Outline of possible implementation steps and timeframe for Council to consider incorporating into the 30-year infrastructure strategy.
- Consideration and collation of possible impacts including Cultural, Ecological, Recreational/Social, Benefits and impacts of changing from the status quo

Murihiku Slow the Flow Pilot

PROJECT DATES

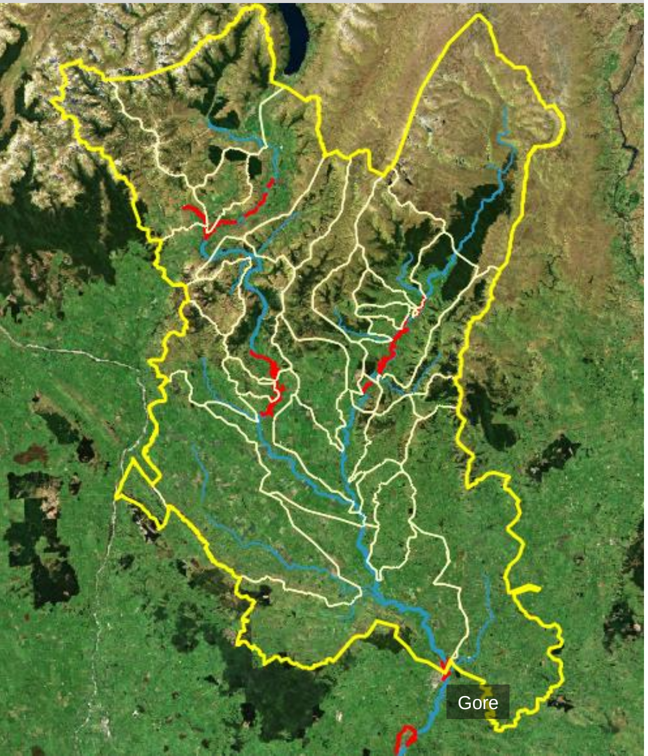
July 2023-June 2025

LOCATION

Upper Mataura and Waikaia Catchment case study area

LOCAL CONTEXT

The Mataura catchment was subject to extensive flooding in early February 2020, which resulted in the evacuation of more than 4500 people from their homes. To reduce the current flood risk to Gore and Mataura, and future increased risk due to climate change, solutions need to reduce the peak flow of the Mataura River. The Mataura River is in a degraded condition and its waters have been overallocated. Long-term integrated solutions are needed to reduce flood risk and reflect qualities of hauora that support the health and well-being of waterbodies within Murihiku Southland, so the environment and people can thrive.



PROJECT OBJECTIVES

1. Foster a collaborative approach between Environment Southland, iwi partners and stakeholders. The project processes and outcomes will be guided by the principles and aspirations set out in the Regional Climate Change Strategy, as agreed by papatipu rūnanga ki Murihiku and the councils of Murihiku Southland.

2. The learnings and outputs from the project will inform future regional climate adaptation planning and decision-making. The project team will use effective ways to capture, share and apply learnings from the project to benefit the whole of Murihiku Southland. Outputs, such as the 'Hauora Framework and Mātauranga', will be tested through the project and all efforts will be made to ensure the outcomes are integrated into future working relationships and programmes. Learnings and application of outcomes, will be highlighted and shared throughout the project, at the Nature Based Solution conference in May 2025, and in the final June 2025 report.

3. Conducting a feasibility study on including nature-based solutions in a catchment approach to flood risk. The study will include the use of hydrodynamic modelling and assessment against various weather events. This assessment framework will be developed by July 2024, the data gathering and processing completed by April 2025, and to pilot the decision-making process by May 2025.

4. By June 2025, the community of learning will represent a broad cross-section of iwi reps and rūnanga, community, local government agencies, industry, and specialist expertise exploring climate adaptation planning and the opportunities, benefits and barriers associated with nature-based solution.It is envisaged that while these steps will collectively be completed by June 2025, these will contribute to the much longer regional adaptation pathway that reflects the development of climate adaptation planning for the region.

PROJECT ACTIVITIES

Create a Team - Initial engagement and discussions with the Councils of Murihiku Southland to gage interest in the project and potential involvement. Confirm collaborative relationship with Te Ao Mārama Inc and rūnanga. Build awareness and understanding of the need for floodplain management and nature-based solutions, with key decision-makers and stakeholders. Confirm pilot location is the Upper Mataura.

Draft the Project Plan - Gather information and case studies showing the benefits of floodplain management and nature-based solutions. Initiate discussions with Project Team and an invitation for their involvement in the pilot, particularly science, science data, policy, and biodiversity. Discuss possible benefits, barriers and opportunities for using nature-based solutions. Initiate the development and design of the Slow the Flow infographic.

Confirm Project Plan - Host a stakeholder workshop check-in on the project plan. Form the Project Steering Group. The workshop includes a review of the problem definition and what success looks like. We will also discuss the possible NBS options for the project, who else needs to be involved and how engagement is carried out. Complete the Murihiku Slow the Flow infographic. Confirm NBS to be explored as part of the project.

Data and Modelling Programme Development - Identify methods for modelling and testing nature-based solutions Identify outcomes to test NBS against. Develop an assessment framework. Form a technical team to undertake the modelling and assessment.

NBS Hauora Framework and Mātauranga – Te Ao Mārama will develop and lead the development of a Hauora Framework and Mātauranga applied to Nature-Based Solutions Options. The final framework will be piloted for use throughout Murihiku Southland to enhance operational decision-making by supporting a partnership approach, providing transparency and robustness.

Upper Mataura Slow the Flow Fieldtrip - Bus trip around Upper Mataura sites of interest to discuss and review possible nature-based solution methods. Share updates on the project including the data and modelling programme, findings from Ministry for the Environment's literature review and initial findings from the NBS hauora assessment criteria. Capture discussions and feedback to inform the next steps.

Testing Nature-Based Solutions - Using the data and information generated through the project, run the findings through the More Than Water Tool to show the outcome of the scenarios tested across all regional values.

Murihiku Slow the Flow Conference – A half-day conference with invited speakers to share knowledge and understanding of nature-based solutions, including the results of the Murihiku Slow the Flow project. Followed by a half-day workshop identifying opportunities to implement the learnings in the Upper Mataura and across the region.

Framework Review Update and Report - Review learnings from the project and update NBS framework. Produce a report and supporting communications summarising findings and sharing next steps. Celebrate.

GISBORNE DISTRICT COUNCIL

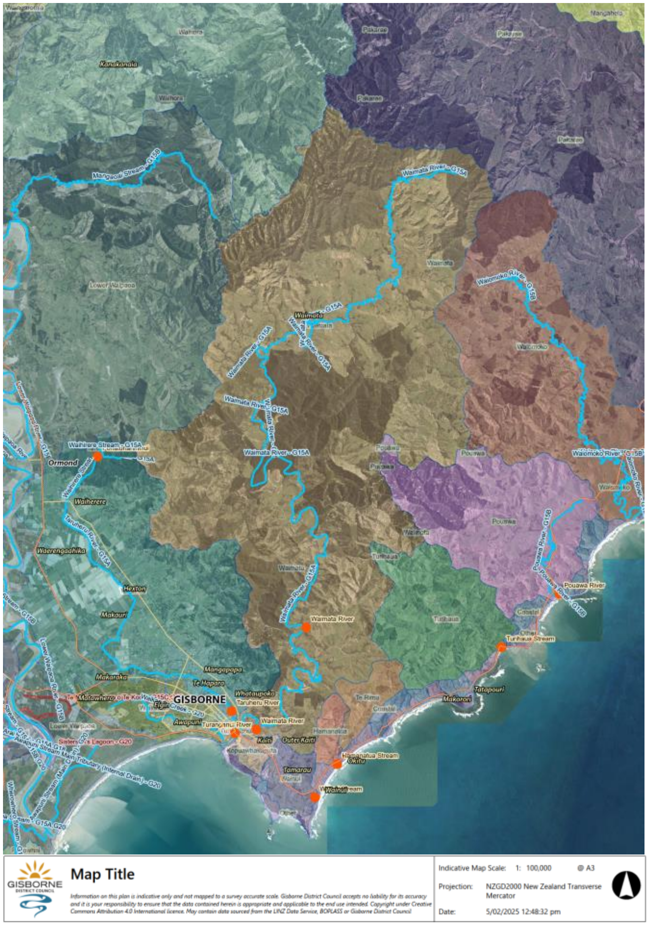
Maunga to Motu - Embracing the Waimata Awa

PROJECT DATES

July 2023 - June 2025

LOCATION

Waimata Awa Floodplain



LOCAL CONTEXT

What is the key challenge you sought to address with this project?
Explore nature-based solutions to work with the natural characteristics of the Waimata Awa and its floodplain to support flood resilience.

What is the current state of flooding or flood mitigation in the project area?
The catchment is highly prone to flooding and because of recent cyclones much of the Waimata river has widened, with dropouts and woody debris common down its 20km length. There is no current flood mitigation strategies in the catchment

Why were nature-based solutions seen as a good fit to address this challenge?
The landscape of the catchment is composed of high, steep sided y-shaped valleys that grade to low relief steep terrain and then into lowland hills. The river acts like a flume, conveying flow, logs and sediment t the coast. There is no room for hard structure flood control due to the nature of the lower catchment.

PROJECT OBJECTIVES

1. Data analysis and consolidation
2. Technical analysis & spatial tool
3. Waimata Historical Context Research

PROJECT ACTIVITIES

1. Data analysis and consolidation - Analysis of a combination of existing data to test the feasibility of a range of NbS to support land use change decisions relating to land stabilisation and reduced sediment, woody debris mitigation and overland flow discharge.
2. Technical analysis & Spatial tool - Create a land use change spatial model for the Waimata Catchment to test NbS, determining intervention locations and their prioritisation to address the inputs of flow, sediment and woody debris inputs into the system. The model should prioritise areas that will provide the most achievable and significant impact on land stability, water quality and flood hazard reduction in the catchment.
3. Waimata Historical Context Research - This workstream will have a specific focus on Mari pre and post-colonial occupation and occupational sites – sites will then be weaved into the spatial tool for protection.

GREATER WELLINGTON REGIONAL COUNCIL

Nature-based solutions feasibility study – Waipoua River

PROJECT DATES

July 2023 – July 2025

PROJECT OBJECTIVES

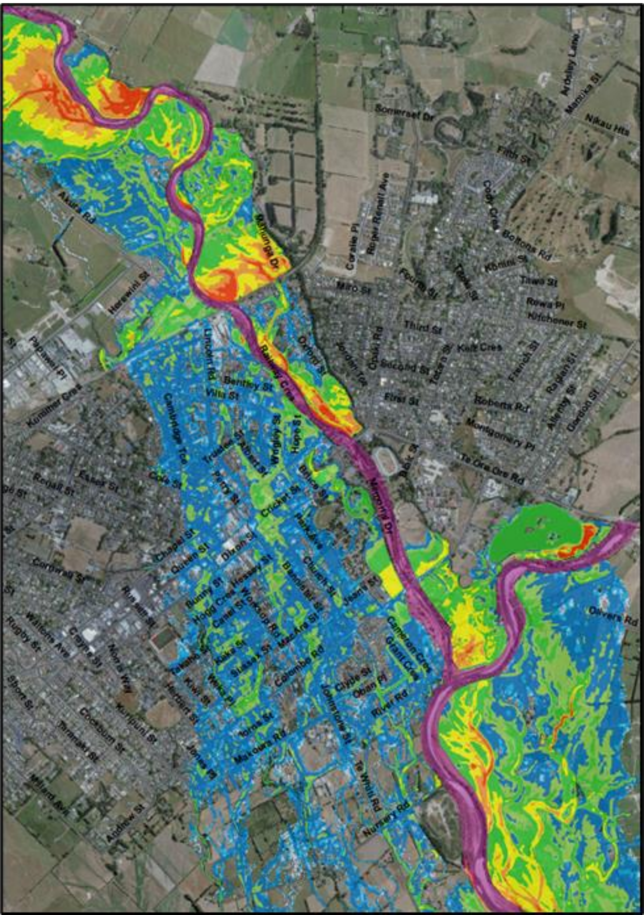
To undertake a feasibility study that will assess and quantify the benefits of a suite of nature-based solutions (including mātauranga Māori practices) for managing flood risk from the Waipoua River under various flood event scenarios

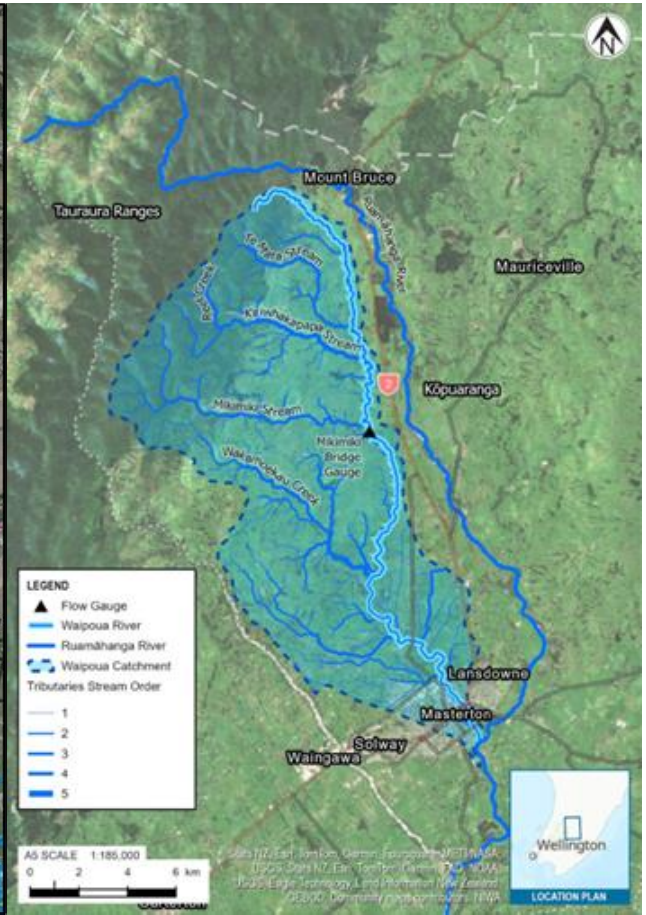
LOCATION

Waipoua River catchment – Wairarapa. The Waipoua River has a catchment area of 149km². The main river channel, from its headwaters to its confluence with the Ruamāhanga River, is 30 km long. The headwaters originate in the Tararua Ranges which are characterised by steep slopes with native forest. A large section of the Waipoua River flows through the lower foothills of the range which is dominated by pasture, before flowing through the urban centre of Masterton. The confluence with the Ruamāhanga River is immediately downstream of the Masterton township.

LOCAL CONTEXT

This project proposes to quantify the benefits of nature-based solutions for managing flood risk to Masterton.





- Flood modelling has been completed for the Masterton urban area. This shows that in a 1% AEP event (+ climate change), flooding is expected to affect a significant area of town.
- There are existing stopbanks within the urban reach, but these are not sufficient for a 1% AEP event.
- At present, little is known regarding how nature-based solutions could be implemented within the Waipoua catchment.
- The project aims to investigate whether nature-based solutions are feasible to reduce the flood risk to Masterton.

PROJECT ACTIVITIES

1. Restoring natural river patterns investigations
2. Improving groundwater recharge and low flow investigation
3. Investigation of indigenous vegetation in the Waipoua catchment
4. Hydrological and hydraulic modelling to quantify the reduction in flooding
5. Quantify/qualify wider benefits of nature-based solutions for catchment

HAWKES BAY REGIONAL COUNCIL

Heretaunga Plains nature-based solutions for flood management & Upper Tukituki nature-based solutions for flood management

PROJECT DATES

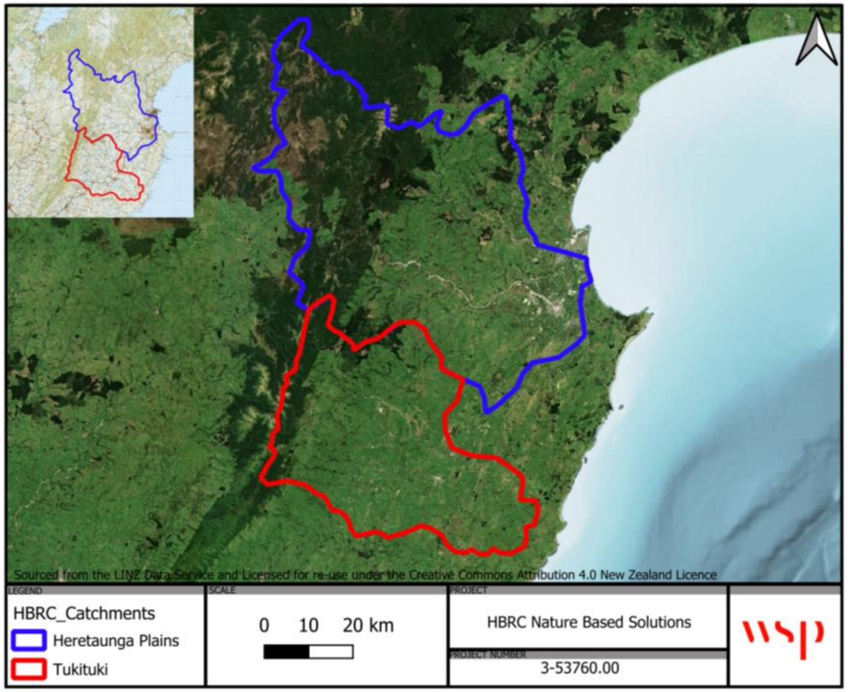
July 2023 – June 2025

LOCATION

Heretaunga Plains (and associated tributaries) & Upper Tukituki catchments

LOCAL CONTEXT

- Key challenge to address was the flood concerns within the catchment and opportunities for alleviation.
- Stopbanks are present in the lower reaches of the Heretaunga Plains catchment and within the Upper Tukituki catchment.
- Large catchment with many tributaries of differing characteristics.
- Predominantly rural – so adequate space to implement solutions.
- Could be an opportunity to combine grey and green infrastructure for flood management and fits within the wider flood resilience review currently being undertaken across Hawkes Bay.



PROJECT OBJECTIVES

- Hydrological and hydraulic models covering the Heretaunga Plains and Upper Tukituki study catchments to identify flood hazard and to be used to test options for mitigating flood hazard using NBS under a range of rainfall events and climate scenarios.
- Areas of higher resolution present within the study to test and refine NBS and impacts on flood alleviation within the catchment-scale models.
- Identification of which NBS from those tested are the most effective, and where such NBS may be situated within the catchment for maximum effectiveness for flood alleviation and to identify co-benefits for the overall health of the catchment.
- Engage with mana whenua and local stakeholders in the Heretaunga Plains and Upper Tukituki catchments throughout the project

PROJECT ACTIVITIES

1. Development of a cross-functional internal working group and engagement with stakeholders
2. Information review and hydrology analysis
3. Hydrological and hydraulic modelling of the study catchments along with localised area groundwater modelling
4. Consider and test Nature Based Solutions for flood alleviation within the catchments

HORIZONS REGIONAL COUNCIL

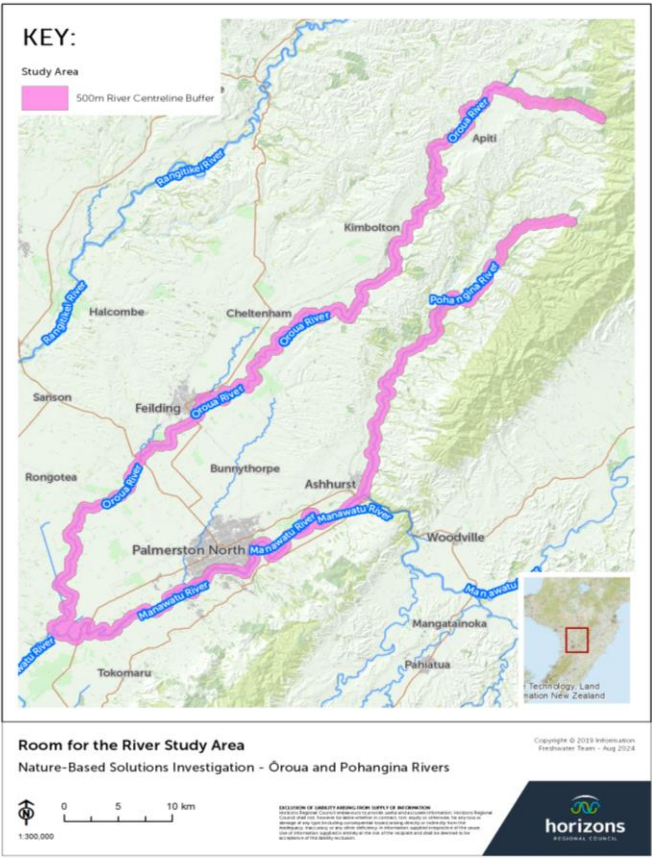
Ōroua and Pohangina catchments nature-based flood mitigation solutions.

PROJECT DATES

July 2023 - June 2025

LOCATION

Sections of the mainstem Ōroua, Pohangina, and Manawatū Rivers, near Palmerston North (North Island).



LOCAL CONTEXT

The Horizons Region has been facing increased flood activity over recent years and substantial changes to the Ōroua and Pohangina Rivers have been observed. The damage caused during recent events has raised questions around the financial and environmental sustainability of the current flood protection schemes.

Recent flood events have resulted in significant damage to flood infrastructure along the lengths of the Ōroua and Pohangina Rivers. This has included damage to soft (tied trees) and hard (rock work) engineered protection. Much of this damage has arisen as a result of the floodwaters not being able to be contained in the designed current active channel and then connecting back with previous floodplains and/or historical flow paths. Many of these flooded areas have now been developed for rural and/or urban land use.

In order to inform future flood protection interventions, the complexity of the Pohangina and Ōroua river corridors and floodplains need to be better understood. This will ensure future flood mitigations and action plans can be drawn up and implemented to allow for more resilient flood protection, and also enable the river to undertake and complete natural processes.

The study's findings will support Horizons' flood resilience planning, allowing Horizons to make informed decisions regarding future flood management. These decisions will safeguard important infrastructure while recognising the innate nature of the Ōroua and Pohangina catchments. Highly restrictive river widths will be unsustainable financially and environmentally in the medium-to-long term. This information will be used to inform changes in river management practices, where development can and cannot occur, and what land use may be appropriate in certain places within the catchments (i.e. rural vs residential).

The aim is to develop a flood protection model that works with the natural environment, minimising the need for engineering interventions and ongoing maintenance.

PROJECT OBJECTIVES

The project has an list of objectives which have been agreed to by the Governance Group established for the project.

These are:

- Prioritising the river's room to move to express her natural character;
- Restoring the integrity of riparian margins, gravel bar habitats and floodplain connectivity;
- Avoiding channelisation of the river corridor, and promoting and enhancing habitat complexity with pools, riffles, runs, meanders and side channels;
- Increasing channel size and capacity to provide for flood flows within defined floodplains;
- Where possible, prioritising the removal of infrastructure from floodplains that are vulnerable to flooding;
- Promoting financial resilience and long-term solutions, minimising maintenance needs over time, and focusing on preventative rather than reactive works;
- Maintaining fish passage and fish habitat;
- Maintaining access to existing recreational areas, and preserving and enhancing the desirable features of those recreation areas;
- Maintaining and promoting access to food gathering, mahinga kai harvesting areas and wāhi tapu, preserving and enhancing the populations of mahinga kai and important characteristics of wāhi tapu; and
- Promoting community, social, economic and cultural connection and resilience.

PROJECT ACTIVITIES

- Engage with partners, consultants, community and iwi, including establishing a governance group
- Gather and consolidate data.
- Develop a holistic and sustainable flood protection model for the Pohangina, Ōroua and Manawatū (between the Pohangina and Ōroua confluences) Rivers.

Natural Flood Management in the Marlborough Region

PROJECT DATES

Through 30 June 2025

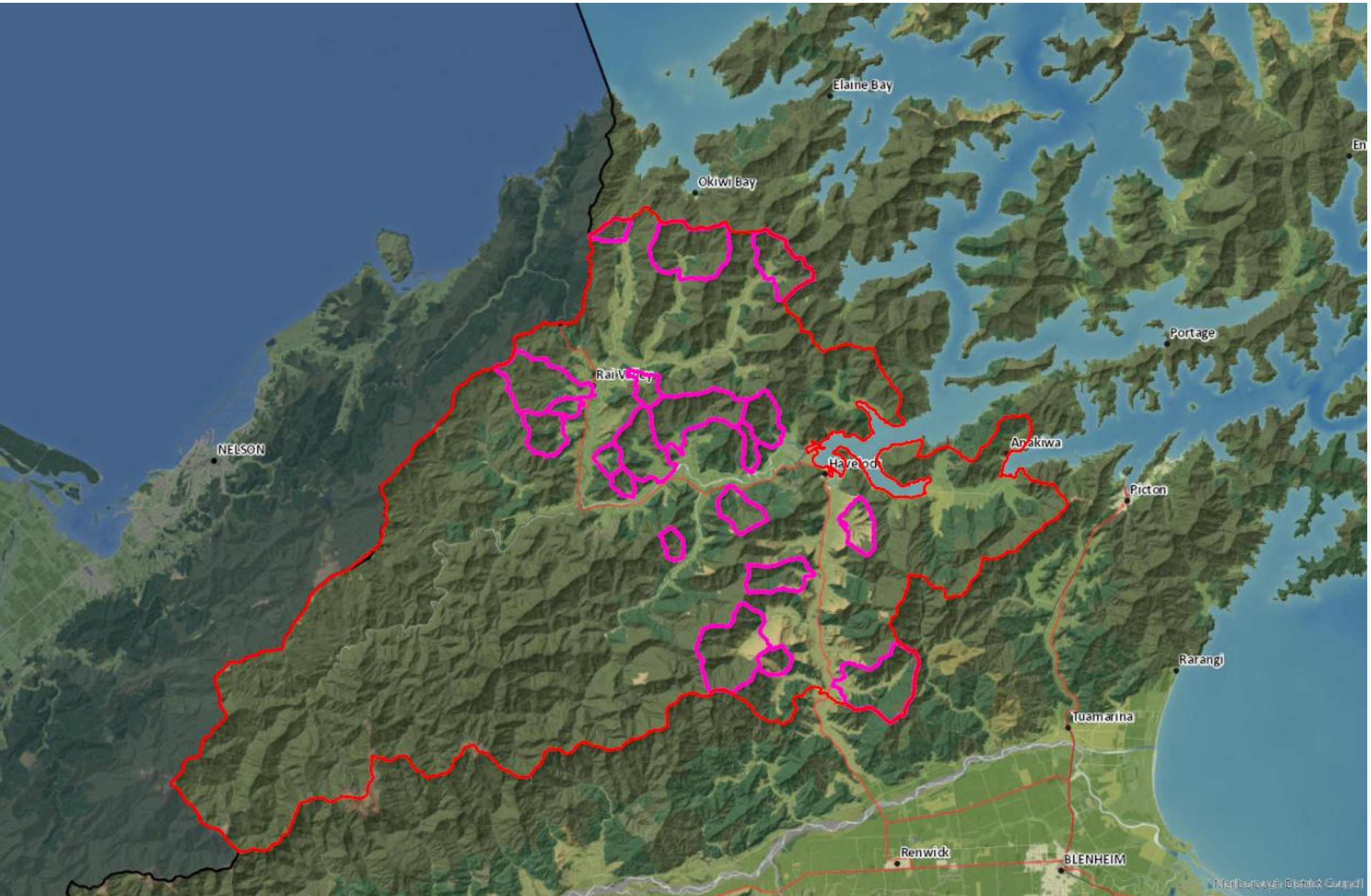
LOCATION

Te Hoiere catchment, with a focus on 21 gauged sub-catchments feeding into both the Te Hoiere (and Rai) and Kaituna rivers.

LOCAL CONTEXT

The immediate issue we want to address is flooding, particularly as climate change increases uncertainty around the magnitude and frequency of rain events. As I understand it, current mitigation techniques primarily act to prevent flooding through channel structures, with this project primarily interested in raising awareness and advocating for management in the upper catchment, intercepting rain and runoff before it reaches the main channel.

I see NBS as a means to combat various consequences of river degradation, not only regarding flooding and sedimentation but also the biodiversity of river ecosystems. NBS not only shifts management toward a more eco-friendly outcome but also focuses more on the health of the wider catchment, starting with the smaller sub-catchments that contribute to broader flooding downstream.



PROJECT OBJECTIVES

Currently, our focus is to communicate NBS to the general public, alongside identifying potential sites for management that are backed by empirical evidence.

PROJECT ACTIVITIES

Personally, I have been undergoing flood modelling across various scenarios which act to display the potential outcomes of management initiatives, alongside communicating the theoretical foundation of NBS.

NELSON CITY COUNCIL

Nature-based solutions for river management in north Nelson

PROJECT DATES

November 2023 - June 2025

LOCATION

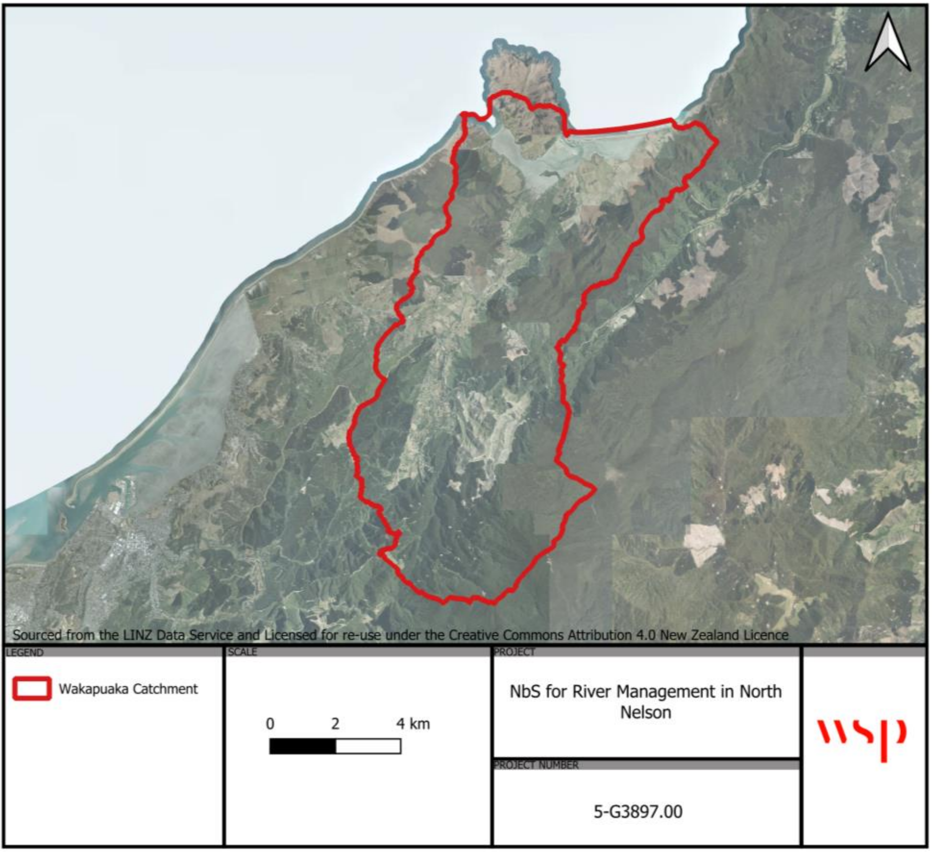
Wakapuaka River Catchment

– North Nelson, 65km²

LOCAL CONTEXT

Key challenge to address was the flood concerns within the catchment and identifying key areas to target for flood mitigation/resilience.
The catchment has been impacted by a number of significant flood events, notable floods were experienced in the catchment in 2022 (February and August).

The geomorphology and land use in the catchment is representative of a number of other catchments in the Nelson region and the intent is that the findings of this project will be transferable across the Nelson region. There is limited funding to support traditional engineered flood protection in the region, and nature based solutions could provide a lower cost, multi benefit solution to some flooding issues. This project will build on existing work and relationships in the catchment, supporting an integrated approach to catchment management, and provide technical information that will provide guidance to Council around diversifying its approach to river management.



PROJECT OBJECTIVES

To develop a hydrodynamic model for the Wakapuaka catchment using historical hydrological data to forecast average weather events, extreme rainfall events, and low river flows.

The model will help Nelson City Council identify options and locations where nature-based solutions may be implemented to help minimise flooding impacts and other environmental impacts within the Wakapuaka catchment.

The catchment flood model may also identify areas where grey-infrastructure options may be required (including but not limited to stopbanks, bank armouring and detention/retention structures) alongside NbS, and to provide recommendations on what flood mitigation techniques are most appropriate in specific locations within the Wakapuaka catchment.

PROJECT ACTIVITIES

1. Information review and hydrology analysis
2. Hydraulic model development and calibration
3. Community engagement
4. Consider and test Nature-Based Solutions

Upper Kawakawa Catchment Detention

PROJECT DATES

July 2023-July 2025

LOCATION

Taumarere hydrological catchment

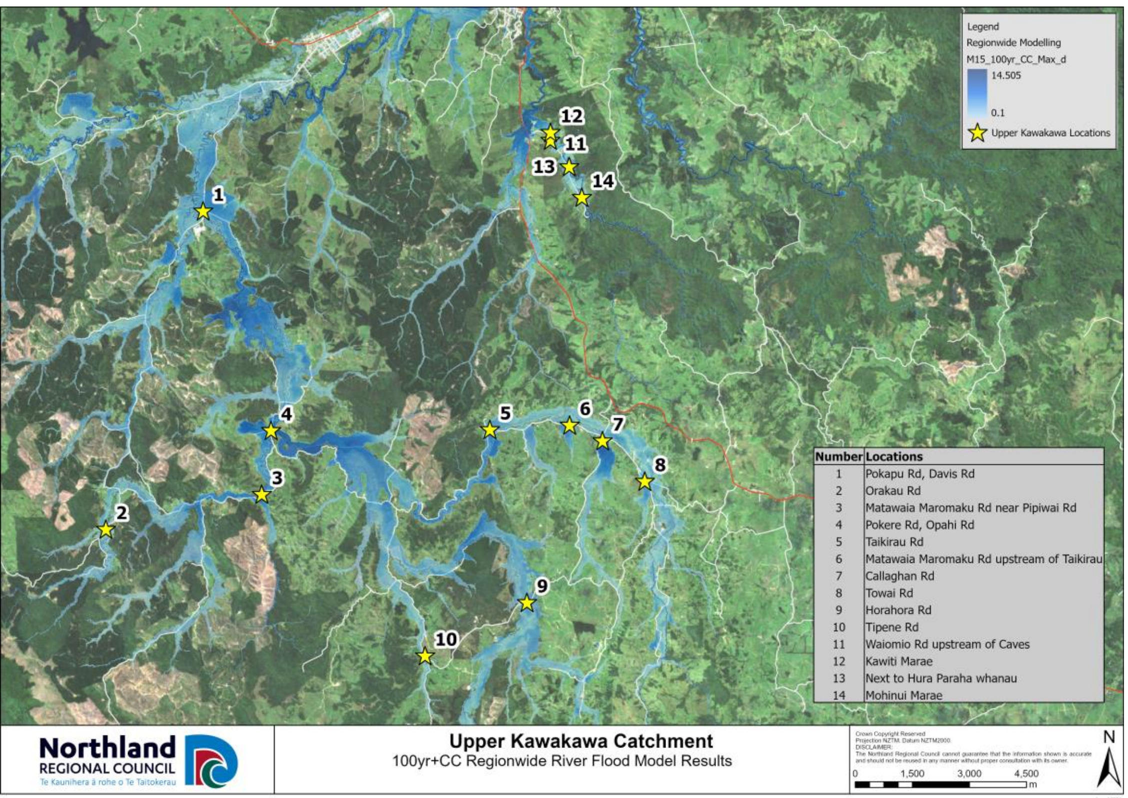
The Taumarere hydrological catchment is approximately 44,000Ha, we are focused on the upper catchment area where detention is typically beneficial. Matawaia, Maromaku, Motatau and Waiomio are the areas of focus in the upper catchment where the roads are frequently flooded.

LOCAL CONTEXT

The primary challenge is frequent flooding over roading infrastructure within the Upper Taumarere Catchment. The project seeks to determine whether nature-based solutions can be used effectively for flood mitigation while also addressing water quality and biodiversity concerns.

Many roads in the upper catchment area run low through the floodplain, in frequent heavy rain events the roads go under and are unpassable an estimated 6-7 times a year, sometimes for 3 or 4 days at a time. The community feedback is that once the rain comes it takes a long time for the water to drain away, noting the flooding as a conveyance issue.

NBS were considered for this challenge because the upper catchment location has extensive existing wetlands, some that are degraded and some that are not. We wanted to see if we could capitalise on the existing wetlands by increasing detention within them and understanding the possibility or feasibility of other NBS types and where they are suitable for implementation, as well as understanding high risk subcatchments.



PROJECT OBJECTIVES

- Understand the hydrology in the upper catchment, what are the attributes of flooding over the roading infrastructure.
- Investigate the effectiveness of NBS in reducing the flooding.
- Develop a workflow for site selection, monitoring, cost estimation, and funding applications to support future implementation of NbS projects.
- Support the Ngāti Hine business case by providing technical expertise on NBS project implementation in the catchment.

PROJECT ACTIVITIES

1. Hydraulic modelling to assess the impact of NbS on flood mitigation and to assess the scale of flooding in the upper catchment.
2. Identification of five degraded sites with cultural and environmental significance, working with Ngāti Hine to investigate them as NBS pilot sites.
3. Development of a GIS-based assessment to map NbS suitability across the catchment and identify economic viability for land transitions.

OTAGO REGIONAL COUNCIL

Modelling of Te Hakapupu catchment to investigate Flood Mitigation

PROJECT DATES

1 July 2023 to 30 June 2025

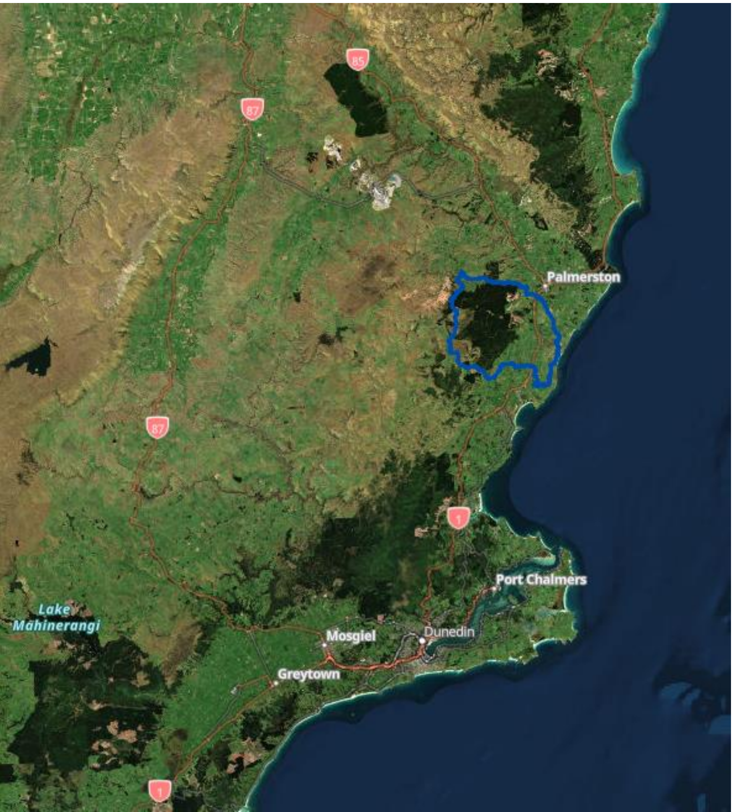
LOCATION

Coastal and wider Otago

LOCAL CONTEXT

The key challenge is the frequency of flash flooding and the flow on effects of those flood events. If ORC are to adopt the NbS approach, it is important it knows where key opportunities and barriers lie.Nearly every year or two, this catchment (an others in East Otago) suffers from heavy rainfall events that result in flash flood type events. These impact on surrounding pastoral lands, stock, fencing and plants as well as water quality and soils losses.

Te Hakapupu/Pleasant River catchment has been the recipient of $4 million of MfE funding through J4N. This was Toitū Te Hakapupu, a water quality improvement project. A lot of information was already available to enable this feasibility study.
One of the findings was that wetlands had played a huge part in the ecosystem services across a large section of the lower catchment area. Additionally, landuse change over the last 20 year has seen the upper half of the catchment converted to forestry from pastoral farming. It is interesting to know what the anticipated effects of forestry may be on the hydrology of the catchment and the risk the harvest cycle impacts have for water quality and flow increase.



PROJECT OBJECTIVES

Feasibility study: Hydrology of the catchment including history of the areas and outputs from running the model to indicate what type of NbS solutions are most effective. Recommendations for the most effective NbS in Te Hakapupu and consideration of future risks and mitigation actions. Recommendations for what key decisions Council need to consider to adopt NbS in future.

Engagement Study: Analysis of landowner perception and willingness to contribute land area for NbS across Otago. Recommendations for mechanisms that could be used to encourage landowners to incorporate NbS on their properties.

PROJECT ACTIVITIES

Feasibility study

1. Modelling various rainfall events in Te Hakapupu, interpreting data and patterns through statistical analysis.
2. Modelling of three different NbS for effectiveness.
3. Prepare a report analysing of the effectiveness of NbS in Te Hakapupu and potential opportunities and barriers.

Engagement Study

1. Prepare a communications and engagement plan including advocacy and education communications.
2. Conduct a survey Otago wide.
3. Prepare a report that identifies opportunities and barriers to ORC implementing NbS on private land in Otago.

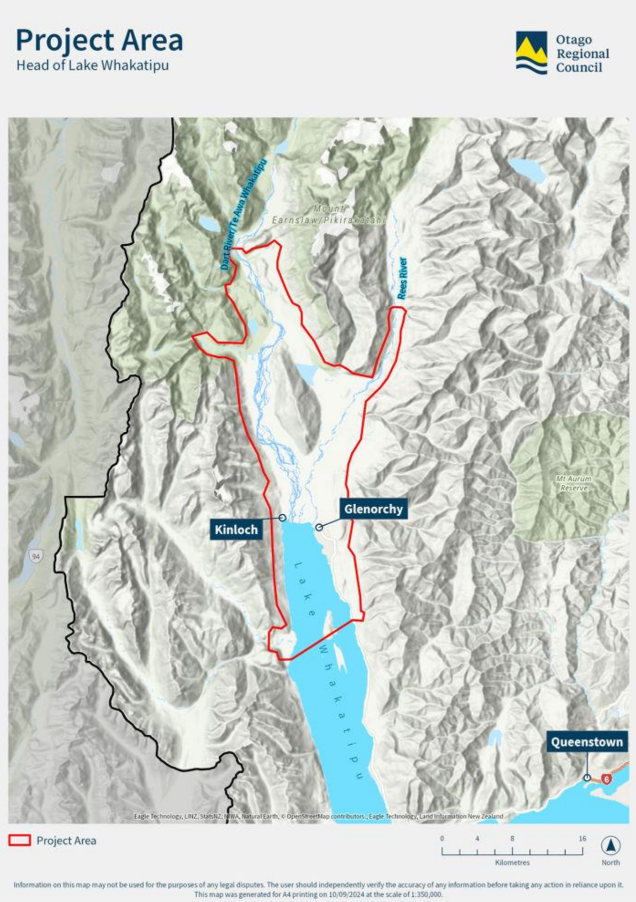
Analysis of nature-based solutions for flood and erosion mitigation in the Dart-Rees Floodplain to inform the Head of Lake Wakatipu natural hazards adaptation strategy

PROJECT DATES

November 2023 – June 2024

LOCATION

Head of Lake Wakatipu (Dart and Rees rivers floodplain), Queenstown Lakes Districts, Otago



LOCAL CONTEXT

The Head of Lake Wakatipu, including Glenorchy, Kinloch, and surrounding rural areas of the Dart and Rees Valleys, Paradise, and Greenstone is a very dynamic environment (alpine catchments, very active braided rivers and deltas) and is exposed to a complex range of flooding (river and lake), slope-related and earthquake-triggered hazard events. This environment has high cultural, recreational and ecological values. These natural hazards are relatively frequent and can be disruptive. Future climate and landscape changes are likely to also increase the potential recurrence. Managing these natural hazard threats presents a difficult challenge. The Glenorchy township is exposed to flooding mainly from Lake Wakatipu, the Rees River, the Buckler Burn and Bible Stream. Bridges and sections of roads can also be affected by flooding and bank erosion from the Dart and Rees rivers. The flooding hazard to Glenorchy township impacts on residential and commercial areas and on infrastructure. The most recent flooding event in the township occurred in February 2020, causing inundation and damages at several houses in Glenorchy township and precautionary evacuations of a number of others.

The very dynamic nature of this environment means that the flooding risks are also not static through time but are modified in response to geomorphic and climatic factors:

- Aggradation and large avulsion of the Dart and Rees riverbeds and the Dart-Rees delta progression into Lake Wakatipu are important influences on changing flood hazard, as river channel capacity is gradually reduced as a consequence.
  - Under the highest greenhouse gases emission scenario (RCP8.5) the magnitudes of 100-year ARI flood events in the Dart and Rees Rivers are projected to increase by ~20%.
- A flood hazard assessment report estimates that the current flood protection structure is providing very limited (only from the Rees River) flood protection and to a standard well below what is usually provided for residential areas. Due to this relatively high flooding likelihood, ORC is assessing all types of hazard management or adaptation approaches which may provide benefit to the community, such as improvements to flood warning systems, potential land-use planning restrictions, and engineered or river management interventions. A screening report focusing on the river engineering and management approaches has identified that there may be benefit in nature-based approaches such as planting of vegetative buffers to modify overland flood water flows, through encouraging trapping of sediments and slowing floodwater flows and an opportunity to develop the original native vegetation in the floodplain.

NbS solutions seem to be a good fit given the relatively unmodified nature of the environment in the Dart and Rees floodplain and the value of this environment to the community and region.

PROJECT OBJECTIVES

The project aimed at progressing the screening study into an investigation and assessment of the feasibility of nature-based approaches for flood and erosion mitigation available for braided rivers in an alpine environment such as the Dart and Rees rivers floodplains. The feasibility study informed the Head of the Lake natural hazards adaptation programme.

PROJECT ACTIVITIES

- Further developing and optioneering the flood mitigation and bank erosion protection interventions based on nature-based solutions. This will include hydraulic modelling (using an existing model)
- Cost benefit and constraints analysis to inform future business cases development
- Community engagement on the findings of the project

Hydrodynamic modelling of nature-based flood mitigation solutions – Motueka River, Tasman

PROJECT DATES

7 October 2024 to 30 June 2025

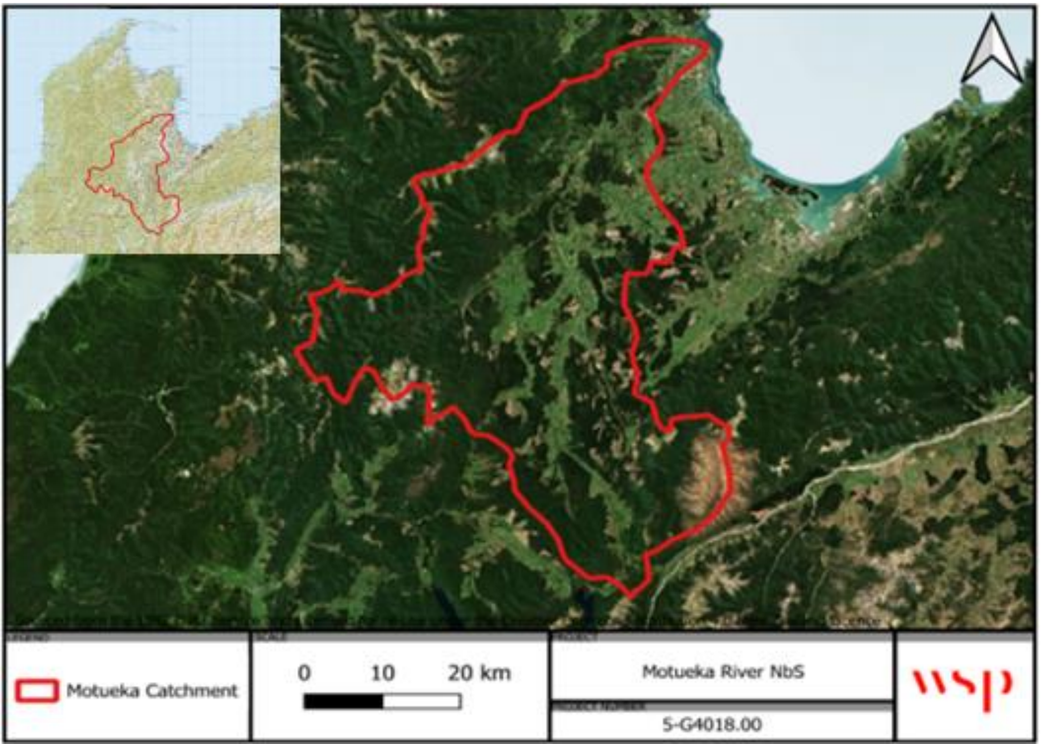
PROJECT ACTIVITIES

- Analysis of catchment hydrology
- Hydrodynamic modelling and validation
- Co-development of nature-based solutions to test with iwi
- Feasibility testing of nature-based solutions.

LOCATION

Motueka River catchment, Tasman District. The Motueka catchment is approximately 2,170 km² in size and encompasses a number of small and medium-sized tributary rivers. As with other New Zealand rivers, the Motueka catchment has experienced significant land-use changes, including native vegetation and wetland loss, the introduction of plantation forestry, and the recent conversion of large areas of orcharding and pasture to high-value hops cultivation.

Development and agriculture have steadily intensified on the extensive flat areas of the Motueka-Riwaka Plain near the coast and the Upper Motueka Plains around Motupiko and Tapawera. Comparison of 1940s aerial photos with today shows that the river corridor has been increasingly constrained by this intensification and encroachment, being narrowed by up to half its original width. Over 90 per cent of the native wetlands in the catchment have been lost. This project is a study exploring the feasibility of Nature-Based Solutions (NBS) for mitigating flood hazard within the Motueka River catchment. The study will evaluate NBS developed in conjunction with Iwi partners.



LOCAL CONTEXT

Key challenges: limited flood protection infrastructure - stop banks only along the lower river, and only built to a 2% AEP level of service. Some communities lack flood protection infrastructure.

Current state of flood mitigation: a network of stop banks along the lower reaches of the river designed to a 2% AEP level of service.

- Large catchment with many tributaries of differing characteristics.
- Predominantly rural – so adequate space to implement solutions
- Historic wetland areas – opportunities for restoration

PROJECT OBJECTIVES

1. An up-to-date whole-of-catchment-scale hydrodynamic model of the Motueka Catchment that can test options for mitigating flood hazard using NBS under a range of rainfall events and climate scenarios.
2. Areas of higher resolution present within the model to test and refine NBS and impacts on flood alleviation within the catchment-scale model.
3. Identification of which NBS from those tested are the most effective, and where such NBS may be situated within the catchment for maximum effectiveness.

TARANAKI REGIONAL COUNCIL

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

PROJECT DATES

July 2023 - July 2025

LOCATION

Waitōtara River catchment (1,196 square kilometres) as well as whole of region component

LOCAL CONTEXT

We want to incorporate a range of existing and new spatial modelling to identify, at the catchment scale, appropriate nature-based solutions to help reduce the effects of flooding and climate change on at-risk communities within Te Awa o Waitōtara (the Waitotara River catchment); with the aim to better inform resilience planning by identifying the most suitable, cost effective and sustainable nature-based solutions and where to deploy them.

The catchment is predominantly rural, consisting of highly developed hill country as well as DOC reserve. The communities living alongside the river in the lower reaches have lived through many floods. There are no flood protection assets associated with the Waitotara River with monitoring, warning and channel management being the key tools to keep the community safe. With a small population and funding challenges, nature based solutions have the potential to provide improved protection, as well as wider benefits, through identifying new options and continuation of works already being carried out across the catchment.

PROJECT OBJECTIVES

Develop a detailed flood model and draft report documenting the feasibility of nature-based solutions for reducing the flood risk in the Waitōtara catchment.

Develop a flood model and draft report documenting the feasibility of nature-based solutions for reducing the flood risk across the Taranaki region.

PROJECT ACTIVITIES

- Partnering with mana whenua to better understand the history and character of the Awa, and to ensure that the appropriate kawa and tikanga are observed and drawn upon in identifying solutions, as well as those insights provided as members of the local community.
- Partnering with the local community, including mana whenua, to better understand the flood history (effects/observations) and effects/observations associated with agricultural development, morphological and ecological changes and climate change.

Undertaking flood inundation modelling within the Waitōtara catchment to:

- identify the areas and people most at risk from flood events now, and with the future effects of climate change.
- identify what the most suitable, cost effective and sustainable nature-based solutions would be and where they are best deployed for optimal benefit according to the priorities identified by mana whenua, the regional council and the local community.

WEST COAST REGIONAL COUNCIL

Multi-benefit Approaches to Building Westport’s Flood Resilience

LOCAL CONTEXT

In July 2021, flooding in the Buller River and, from there, into the Orowaiti River breached Westport’s existing flood defenses and resulted in the evacuation of over 2,000 people, and significant flood damage to 455 homes. In February 2022, a short 6 months later while the community was still reeling from the July event, two unprecedented and intense rainfall events caused widespread damage throughout the Buller district. Many systems and structures that were already weakened by earlier flooding were pushed to the breaking point in places. Westport is recognised in the Hon Kieran McAnulty’s report as one of Aotearoa’s 44 most flood-vulnerable communities. Those identified are currently exposed to significant flood hazard and represent the “bottom 10%” on the New Zealand Index of Deprivation (NZDep, 2018). Additionally, Buller was identified as one of seven territorial authorities with a significant proportion of their population in flood-vulnerable communities.

In May 2023, $22.9M central government funding for flood protection was announced, some of which is being used to fund structural flood protection of Westport’s urban area. Detailed design and feasibility have progressed with construction of some initial elements underway. There is room to consider how Nature Based Solutions could provide further flood resilience to the Westport area, including the protection of flood infrastructure, coastal flooding, and the management of stormwater within the proposed structural flood wall limits. The funding from MfE has been used to investigate the feasibility and usefulness of NBS to augment the Westport area’s resilience to river, coastal, and pluvial flooding events.

PROJECT DATES

19 July 2023 to 31 July 2025

LOCATION

Westport, Buller District. The catchment area is the lower flood plain of the Buller Kawatiri River. See emailed map for the six priority NBS locations. The Buller River drains a catchment 6,350km2 in area.

PROJECT OBJECTIVES

1. Take a whole of catchment approach to assess the potential that NBS have to supporting greater Westport’s flood resilience (coastal, river, and stormwater/ pluvial).
2. Scope potential NB solutions and develop a short-list of lead options that hold the greatest potential.
3. Develop a detailed understanding and conceptual design of the lead NBS options so that future investment decisions are fully informed.

PROJECT ACTIVITIES

The project had 3 parts, High-level NBS scoping, including optioneering and pre-feasibility workshop, Concept design and modelling of priority NBS options and Reporting. The current plan involves a combination of earth stopbanks, ‘planter-box’ stopbanks, concrete floodwalls, wooden floodwalls, and portable flood barriers.

This project takes an integrated, whole of lower catchment approach. Priority has been for approaches where there is opportunity for grey and green flood management infrastructure to work synergistically to achieve the best outcomes for the community.

We see opportunity to not only reduce flood risks by taking an integrated approach, but also accelerate habitat restoration in areas of high ecological and cultural significance, preserve productive farmland, and create usable natural spaces that enrich our lives and create a resilient future.

WEST COAST REGIONAL COUNCIL

Nature-based Solutions for Flood Mitigation in Cobden

PROJECT DATES

Aug 2023 - June 2025

LOCATION

Cobden, Greymouth.

Overall Range Cr catchment approx. 300 ha, with 3 basin locations considered (Upper, Middle and Lower)

LOCAL CONTEXT

Cobden, a suburb of Greymouth on the north bank of the Grey River, is bisected by Range Creek which runs from the foothills of the Rapahoe Ranges to the Cobden/Aromahana Lagoon. The catchment is tidally influenced, adjacent to a significant river (Grey River) which is bounded by stopbanks, and has an existing (modified) lagoon. Presently, when heavy rain occurs in the Cobden catchment whilst the Grey River is high, water backs up into the Aromahana Lagoon, causing floodwaters to inundate nearby properties (on a 1 year ARI). Additionally, in larger (2 - 3 year ARI) rain events, stormwater exceeds the capacity of the upgradient Range Creek channels and flows overland towards the lagoon, flooding upstream properties

The Aromahana Lagoon was once a navigable channel, but since 1988 has been separated from the Grey River by a stopbank with a culvert and control gate. There is the opportunity to provide hydraulic and ecological connectivity to this area which has undergone significant habitat restoration through the input of local community group CASRA. While a changing climate may limit the longevity of built infrastructure, the area can provide myriad other benefits to the community and environment.

PROJECT OBJECTIVES

Investigate:

1. Feasibility to detain floodwaters in a distributed manner within the Range Creek catchment and reduce flooding,
2. Opportunities to restore the urbanised Range Creek channels to improve flood capacity, improve riparian corridors and support biodiversity.
3. Opportunities to improve stormwater discharge quality, through consultation and co-design with Ngati Waewae, integration of stormwater treatment and wetlands
4. Opportunities to incorporate cultural narratives and passive recreation within a Landscape Masterplan for the area.
5. Improvement of community resilience, through considering emergency access and engaging with the existing volunteer base and environmental advocacy groups in the catchment

PROJECT ACTIVITIES

1. Engagement with Ngati Waewae, local Councils and community groups
2. Site suitability investigations; including geotechnical investigation, planning assessment, contaminated land investigation, survey and ecology assessment
3. Hydraulic modelling and Feasibility design; including flood modelling, preliminary earthworks modelling, landscape masterplanning and stormwater design

WAIKATO REGIONAL COUNCIL

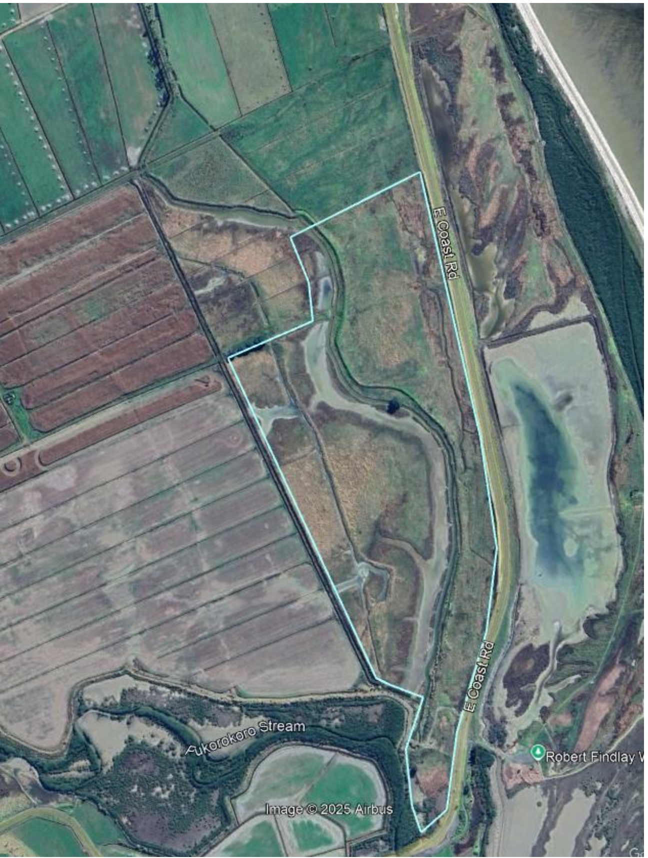
Understanding coastal wetland hydrology and the effects of extreme events on land-use transition and blue carbon storage

PROJECT DATES

July 2023 - July 2025

LOCATION

~20 hectares located on East Coast Road, Pūkorokoro, South Eastern Firth of Thames



LOCAL CONTEXT

Low-lying coastal farmland in the Waikato Region is under threat from sea level rise and extreme weather events. This land is subject to sea-level rise and will eventually be unsuitable for farming. Consequently, hard defences are inappropriate. A transition from coastal farmland to coastal wetland, could offer multiple environmental and social benefits and economic alternatives. There is the potential to support rural communities to transition to alternative land-use – while still supporting the social fabric that are rural communities. To successfully create and maintain coastal wetlands requires an understanding of the hydrological and hydraulic management options, including under extreme conditions.

Our project will partner with an already-establishing restoration project that is restoring a 20ha coastal wetland remnant from farmland. The restoration project aims to realise biodiversity benefits and support habitat for Aotearoa shorebirds, and to assess the feasibility of generating and commodifying blue carbon as a means of funding similar restoration projects.

PROJECT OBJECTIVES

Our project aims to understand the implications of hydrological and hydraulic management options for this site on:

- the impact of extreme weather events on blue carbon persistence;
- protection of adjacent farmland during extreme weather events;
- the sustainability of blue carbon resilience credits under sea level rise projections and likely increased extreme weather events; and
- the co-benefits of increased habitat availability for various aquatic species.

PROJECT ACTIVITIES

- Survey waterways on site to measure bathymetry.
- Collect repeat high resolution aerial imagery to monitor inundation extent if there is an extreme event during the project timeline.
- Survey the baseline aquatic fauna of the site using conventional and/or eDNA methods prior to the commencement of restoration. Resurvey the aquatic fauna to assess changes.
- Survey vegetation and predict the impact on vegetation of extreme weather or climate change.
- Monitor water level, salinity and turbidity at both downstream and upstream ends of the site.
- Build a spatial and/or hydrodynamic model using the DEM and calibrated / validated using the hydrodynamic monitoring data. This model will replicate inundation for scenarios encompassing various hydrological management options for the site (including manipulation of topography / bathymetry and levies) and projected sea level rise; storm surge events; extreme rainfall events.
- Setup an automated camera system which will monitor the sites development from farmland to wetland. The camera will track changes in vegetation / habitat type, inundation and bird numbers.
- Provide ecological advice to the restoration project partners on the likely implications for blue carbon persistence of the modelled inundation for the range of scenarios.

WAIKATO REGIONAL COUNCIL

Waikato and Waipa River Nature Based Solutions Feasibility Investigations

PROJECT DATES

August 2023 to June 2025

(note that the MfE funding is to assist with the wider project that will extend past June 2025).

LOCATION

Waipa and Waikato River (downstream of Karapiro Dam) catchments

Figure 1. Lower Waikato model domain extent (orange outline).

LOCAL CONTEXT

To understand catchment scale impacts of Natural Based Solutions (land use change) on flood flows to mitigate current and future flood exposure. Also identify impediments to implementing Natural Based Solutions across a catchment. The Lower Waikato and Waipa Control Scheme has been established in the project area since the 1958 floods.

Reducing peak flows through catchment land use change could negate the need to further rely on artificially managing flood flows. Reducing future peak flows due to climate change could also reduce the need to increase the capital cost and residual risk to maintain current Level of Service. Land use change could also provide other significant benefits across catchments and river systems such as improvements to water quality, run off, biodiversity, low flows and carbon sequestration.

PROJECT OBJECTIVES

- Understanding the changes to peak flows through the Waipa/Waikato River systems of Nature Based Solutions at a sub catchment/system scale using existing hydrology/hydraulic models.
- Understand how Nature Based Solutions at a sub catchment scale can be incorporated into a larger catchment system utilising existing hydrology/hydraulic models.
- Understand how tools (derived from models) showing the effectiveness of Nature Based Solutions can be used with communities.
- How to align and engage with communities within both a large river system and tributary (sub catchment) to understand how to implement any significant Nature Based Solution.
- How to align and engage with multiple iwi across a large river system and tributary (sub catchment) to understand how to implement any significant Nature Based Solution.

PROJECT ACTIVITIES

1. 2D hydrology and Hydraulic model of entire Waipa River and Waikato River (downstream of Karapiro Dam) using TUFLO software.
2. Model versions of current land use and land use from 1840. Version of each land use with/without Flood protection (stopbanks).
3. Community Tool to show impact of land use change on peak flood flows.
4. Report to identify impediments to implementing Nature Based Solutions.