HORIZONS FLOOD MODELLING & MAPPING GUIDELINE (Task 2-2, FVA)

February 2026

horizons
REGIONAL COUNCIL

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February 2026
Report No. 2026/EXT/1992
ISBN. 978-1-991351-96-8

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HORIZONS FLOOD VULNERABILITY ASSESSMENT

HORIZONS FLOOD MODELLING & MAPPING GUIDELINE

23 JULY 2025

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HORIZONS FLOOD VULNERABILITY ASSESSMENT

HORIZONS FLOOD MODELLING & MAPPING GUIDELINE

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REV	DATE	DETAILS
01	20/12/2024	Draft for review
02	24/04/2025	Updated report for review
03	26/06/2025	Final for issue
04	30/06/2025	Revised final for issue
05	17/07/2025	Revised final for issue

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Approved by:	Richard Woods	17 July 2025	

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EXECUTIVE SUMMARY

Horizons Regional Council (HRC) has engaged WSP New Zealand Limited (WSP) and the National Institute of Water and Atmospheric Research (NIWA) to complete a comprehensive flood vulnerability study for the region. The purpose of the project is to document and consolidate the available flood modelling and complete a flood vulnerability assessment to inform and make recommendations for the multiple uses of this type of information.

This report aims to provide a thorough review of international and domestic best practice for flood modelling and mapping practices, and provide a regional flood modelling framework for Horizons that is based on focusing on the flood risk use cases identified by Horizons Regional Council (HRC) and relevant Territorial Authorities.

Flood modelling and mapping are an important part of the flood risk management process and is important to identify and understanding flood risk. This forms the foundation for identifying strategies to improve resilience and minimize the consequences of flooding. Strategies can include:

- Engineering or nature-based solutions to reduce the frequency and extent of flooding.
- Land use planning and zoning to avoid development in flood prone areas.
- Retreat from areas that may experience frequent flooding.
- Adaptation to lessen the impact of flooding, through planning guidelines like design guidelines for buildings and infrastructure, or early warnings systems.

The following key findings were identified from the desktop review:

- For flood modelling internationally and within New Zealand, the typical flood modelling and mapping process consists of developing a method statement, collecting relevant data, developing hydrologic and hydraulic models, modelling of design events, and production of flood maps or outputs. Additional practices that contribute to the best outcomes for flood modelling and mapping include:
    - Identifying the end user within the method statement and using this to understand the outputs required.
    - Developing modelling scenarios that incorporate climate change, changes within the catchment and future growth.
    - Developing modelling assessment levels that can be used to guide the type of modelling and the outputs and uses.
- Within New Zealand there is no standard approach or regulation for flood modelling, meaning that councils have developed their own tools to manage flood risk. This is prevalent throughout New Zealand's water industry, and has resulted in the development of national guidelines for stormwater modelling.
- Frameworks have been developed to assess liquefaction and landslide hazard in NZ that include different levels of assessment to ensure outputs are fit for purpose for a range of users.

Workshops were held with HRC and local authorities to understand how flood modelling and mapping is used within the region, and to present an initial framework for regional flood modelling. A follow up survey was sent to the local authorities to gain further insight into how flood modelling and mapping outputs are used. Following the workshops and survey, six user personas have been developed. Each persona includes the context of the role, how flood modelling and mapping outputs are used and output requirements.

A regional flood modelling framework has been developed collaboratively with HRC. This framework employs a staged approach based on the required detail of output and available data, allowing for assessments at different scales. The goal was to build on existing frameworks and develop a comparable structure to allow for multi-hazard assessment. This framework facilitates user specific flood modelling that is tailored to the information available, or the output required by the user. The framework developed features four levels of assessment, ranging from a regional level down to a site-specific detailed level. Output features and the key uses are linked to each assessment level.

The framework can be used by HRC to understand the applicability of existing flood modelling outputs for different uses within the region, and can also guide the level of modelling assessment for future modelling based on the intended outcome and use.

1 INTRODUCTION

1.1 PURPOSE OF REPORT

Flooding poses a significant risk to communities, infrastructure, and the environment, necessitating effective flood risk management strategies. With changes in flood frequency and intensity due to climate change and ongoing urbanisation in flood-prone areas, it is important that local government authorities adopt comprehensive and multi-faceted approaches to mitigate flood risks and increase resilience.

This report aims to provide a thorough review and set of recommendations for flood modelling and mapping practices, focusing on the flood risk use cases identified by Horizons Regional Council (HRC) and the region's Territorial Authorities. A desktop review using international best practices has been conducted to evaluate the application of flood modelling outputs and flood hazard mapping. This review has captured flood risk management best practices relevant to flood modelling use cases within the region. The review has also captured domestic best practice, and the relevant regulatory and policy context.

Based on the best practice review, and development of flood modeling and mapping user personas, a regional flood modelling framework has been developed. This has been developed collaboratively with HRC to ensure accurate interpretation and capture of institutional and regionally specific knowledge. Following this, the suitability of HRC's existing models, data, and maps for each of the identified use cases has been assessed.

This comprehensive assessment establishes a baseline for utilising existing models, data, and maps, identifying gaps, and providing recommendations for future flood modelling and mapping efforts. The goal is to deliver high-quality, fit-for-purpose data and models that effectively support flood risk management in the Horizons Region.

1.2 HOW TO USE THIS GUIDELINE

This report presents the regional framework for flood modelling, with inputs and parameters informed by current best practices and legislation. It is intended to be a living document, subject to regular review and updates. As flood risk management practices evolve, new legislation is enacted, or statutory regulations change, this report should be revised to incorporate the latest standards and regulatory requirements. This ongoing review process ensures that the framework remains relevant, effective, and aligned with the most up-to-date knowledge.

2 SETTING THE SCENE

2.1 FLOOD RISK MANAGEMENT

Effective flood risk management is important for minimising the impact of flooding on communities, infrastructure, and the environment. With the changing frequency and intensity of flood events due to climate change, along with ongoing urbanisation in flood-prone areas, it is essential to adopt a comprehensive, multi-faceted approach to reduce risk and increase resilience. This section presents two conceptual frameworks for flood risk management.

2.1.1 PARA FRAMEWORK

The PARA framework, originating from environmental risk management, is commonly used in broader risk management applications and is relevant for natural hazards (Ministry for the Environment, 2023). The aim of the framework is to provide structured strategies for managing risk. PARA components are described below (Ministry for the Environment, 2023; Te Uru Kahika, 2023):

- **Protect** – aims to safeguard people, property and infrastructure by reducing the frequency or extent of a hazard through protection measures. For flood risk this includes engineering solutions such as stopbanks, levees or dams, or natured-based solutions of wetland restoration or riparian planting.
- **Avoid** – prevents development in exposed locations to reduce risk. For example, land-use planning or zoning can ensure that new property or assets are not located within areas exposed to flood hazards.
- **Retreat** – relocation of people, property, assets to safer areas. This can include managed retreat, voluntary or forced relocation of impacted communities, or relocation of critical infrastructure. For flood risk, this may involve relocating people or communities away from flood prone areas that are exposed to repeated or extreme flood risks.
- **Accommodate** – adapting so that the impact of a hazard is minimised. This includes strategies and mitigation, such as elevating buildings and adopting flood plain management strategies, which still allows flooding to occur but resulting in reduced community impacts. Accommodate can also include warning systems.

An example of the components of the PARA framework for a flood risk management application is shown in Figure 2-1.

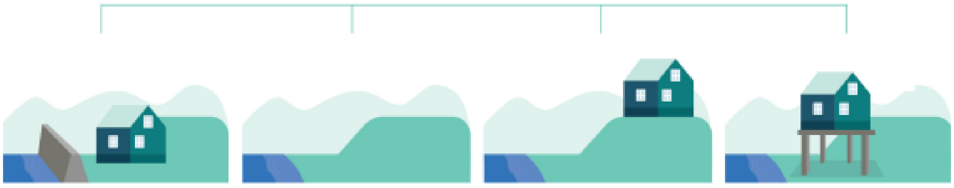

Figure 2-1: Example of the PARA framework for managing flood risk (Ministry for the Environment, 2023).

Flood modelling is fundamental to understand flood behaviour, by identifying high risk areas, and improving understanding of the frequency, extent, and characteristics of flooding. Flood modelling and mapping provides the evidence base to support decision making for each component of the PARA framework such as:

- **Protect** – flood maps and modelling provide an understanding of flood extents and behaviour to inform the design of defences that can lessen the consequences of flooding.
- **Avoid** – flood maps and modelling identify land that is highly or unacceptably at risk of flooding. This can be used to inform land used planning techniques to prevent development in exposed areas
- **Retreat** – flood modelling is used to understand how flood risk changes over time. This guides decisions on where critical infrastructure or communities may need to relocate from.
- **Accommodate** – flood modelling, including details on depth or extent, helps to inform design guidelines for buildings and infrastructure, or early warnings systems. Assets are built to/above the modelled depths and allow people to adapt to be within the floodplain.

Multiple Councils within New Zealand, including Greater Wellington, Waikato and Canterbury are applying the PARA Framework to manage flood risk and meet their requirements under the Local Government Act (Te Uru Kahika, 2023).

2.1.2 FLOOD RISK MANAGEMENT FRAMEWORK

The Flood Risk Management Framework is used commonly by Governments in Australia, including Queensland and New South Wales, and is recognised by the Australian Institute for Disaster Resilience. It promotes the development and implementation of sustainable strategies for managing the floodplain (AIDR, 2017). The framework (Figure 2-2) supports robust decision making, and utilises flood information to inform decision making and is consistent with ISO 31000:2009 Risk Management Process (AIDR, 2017). It encourages understanding flood behaviours to inform risk management strategies.

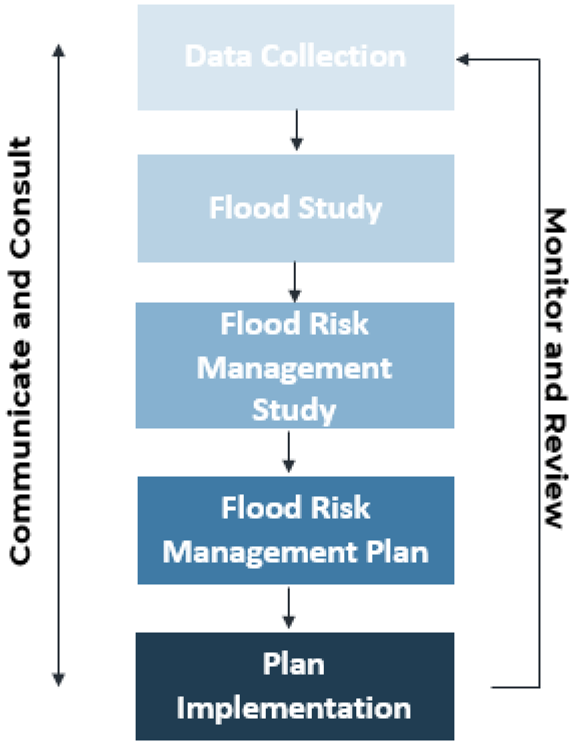

Figure 2-2: Process of flood risk management (adapted from QMFP, 2017).

The flood risk management process is often implemented to update or provide flood information, to support emergency management decision-making, or for land-use or spatial planning. The process involves five key stages, with communication and consultation occurring throughout the entire process with the final plan being regularly monitored and reviewed. The key parts of the process are:

- **Data collection**: gathering relevant data about past flood events, hydrological patterns, and the community (Queensland Government, 2017). The data required may vary depending on the scale, type of study and outputs required (NSW Government, 2023).
- **Flood study**: defining the nature and extent of the flood risk and through use of hydraulic and hydrologic modelling to understand flood behaviour (QFMP, 2014; AIDR, 2017). Outputs from modelling and mapping identify areas affected by floods and provide information about the flood depth and velocity (Fischer & Stanchev, 2022).[1]

[1] For the purpose of this study, the HRC regional flood risk framework will contribute to the flood study section of the flood risk management framework shown in Figure 2-2.

- **Flood risk management study:** understands the risks to the community and identifies mitigation options to manage flood risk (NSW Government, 2023). A flood risk management study can also review flood information and identify areas where improvements are required to better understand and improve flood risks (NSW Government, 2023).
- **Flood risk management plan:** builds on the flood risk management strategy and outlines how the Council will effectively manage flood risk in the area. The plan generally includes emergency management planning and land use planning. The flood risk management plan needs to be consistent with legislation, policy and guidance material. It is designed to be effective in addressing flood risk to existing communities and proposed or modified development areas (NSW Government, 2023).
- **Plan implementation:** the flood risk management plan is implemented by the Council. Examples include:
    - Making flood information available
    - Updating land use planning controls
    - Informing emergency management planning
    - Design and planning of flood infrastructure assets (NSW Government, 2023).

2.2 CURRENT LEGISLATIVE FRAMEWORK

Within New Zealand, several organisations are responsible for the management and identification of natural hazards (Saunders, Beban, & Kilvington, 2013). The Resource Management Act 1991 (RMA), Building Act 2004, Civil Defence and Emergency Management Act 2002 (CDEM Act) and the Local Government Act 2002 (LGA) and Local Government Official Information and Meetings Act 1987 (LGOIMA) are all key pieces of legislation that have a role in natural hazard risk management. This section discusses the pieces of legislation most relevant to flood risk management. They are also mapped to each use-case persona detailed in Appendix B.

2.2.1 THE RESOURCE MANAGEMENT ACT

The Resource Management Act 1991 (RMA) promotes the sustainable management of natural and physical resources. Sections 30 and 31 of the RMA outline the functions of Regional and Territorial Authorities, requiring both to be responsible for the avoidance or mitigation of hazards in relation to land use.

Section 106 allows consenting authorities (typically territorial authorities) to refuse consent of a subdivision if there is a significant risk of natural hazards. In the context of flooding, this could be if it is assessed that the land is subject to inundation, or if the subdivision or use of the land may worsen or accelerate inundation.

Part 5 of the RMA relates to standards, policy statements and plans, outlining a streamlined planning process to enable councils to create and manage policy statements and plans. This enables central government to support local authorities in their implementation of the RMA.

National Policy Statement (NPS) sets objectives and policies on matters of national significance including flood management. An NPS does not state rules, allowing a local authority to apply it to their region in a way that is most relevant to their region.

National Environment Standards (NES) are regulations that prescribe standards, methods and regulations for particular activities and issues. These typically apply to a specified region, district or part of NZ, and can set technical and non-technical standards.

The RMA requires local authorities to give effect to an NPS through documents such as a Regional Policy Statement (RPS) or any proposed plans. An RPS provides an overview of the significant resource management issues within a region and sets the policy direction for the region. Specific to flooding, this may include specifying what TA controls a river or catchment.

A Regional Plan (RP) assists a regional council in carrying out its functions under the RMA and must give effect to the NPS, NES and RPS.

A territorial authority must prepare a District Plan (DP) for their district to assist in carrying out functions under the RMA. A DP must give effect to an RPS. This can include the control of land use for the purpose of avoiding or mitigating natural hazards.

2.2.1.1 HORIZONS ONE PLAN

Horizons 'One Plan' (referred to as 'the Plan') has been developed in accordance with the RMA and combines the Regional Policy Statement, Regional Plan and Coastal Plan (Horizons Regional Council). The One Plan defines how natural and physical resources will be cared for and managed throughout the entire region. Within the Regional Policy Statement, RPS-HAZ-NH establishes the framework for management of natural hazards under the RMA and outlines the responsibilities for the both the Regional Council and Territorial Authorities (Horizons Regional Council). Within the Plan, the approach for managing natural hazards includes:

- Set a clear regional framework for natural hazard management;
- Improve clarity under the roles of RC and TA under the RMA;
- Discourage residential development and placement of critical infrastructure in areas prone to natural hazards (such as high risk of flooding);
- Provide natural hazard information to TA's and the public (Horizons Regional Council).

Specific to flood hazard management, the Plan states that new development must not be allowed in areas that would be inundated by a 0.5% annual exceedance probability (1 in 200 year) flood event unless flood protection or mitigation measures are in place. The flood protection measures must be soundly designed and constructed such that there is minimal risk of the measures failing. To achieve this, the Plan also states that Territorial Authorities must identify areas that would be inundated by a 0.5% annual exceedance probability (1 in 200-year) flood event on planning maps in district plans. (Horizons Regional Council).

2.2.1.2 NATIONAL ADAPTATION PLAN

New Zealand's National Adaptation Plan (NAP) aligns with the RMA to provide cohesive and effective climate adaptation strategies and provides a framework for integrating climate resilience into planning and decision making under the RMA. This includes when developing or amending regional plans to ensure climate risks are considered in things like land use planning (Ministry for the Environment, 2022). The NAP has an emphasis on risk-based decision making, aligning with the RMA's objective of sustainable management of natural and physical resources (Ministry for the Environment, 2022).

2.2.2 THE BUILDING ACT

The Building Act 2004 facilitates safe construction, alteration, demolition and maintenance of new and existing buildings, while aiming to control and encourage better building design and construction practices. It relates to a building within a plot of land which might be impacted by a natural hazard.

Section 71 states that a building consent authority can be refused if the land is subject to natural hazards, such as flooding, and provisions cannot be made to protect the land, building work or other property from the natural hazard. Section 72 of The Building Act 2004 states that despite Section 71, a building consent authority (TA) must grant a building consent if it considers that the building work will not accelerate, worsen or result in a natural hazard on the on which the work Is to be carried out on or any other property.

2.2.2.1 THE BUILDING CODE

The Building Regulations 1992 (Building Code) outlines the minimum performance standards that a building must meet. Section E1 provides the minimum requirements and performance measurements for buildings to protect people and other property from the adverse effects of surface water. The performance provision E1.3.2 states that "*Surface water, resulting from an event having a 2% (1 in 50 chance) probability of occurring annually, shall not enter buildings*" (MBIE, 2023). This provision applies to housing and communal buildings.

2.2.3 THE CIVIL DEFENCE AND EMERGENCY MANAGEMENT ACT

The objective of the Civil Defence and Emergency Management 2002 (the CDEM Act) is to improve and promote the sustainable management of hazards and is primarily focused on planning and preparing for emergencies (Saunders, Beban, & Kilvington, 2013). The CDEM Act encourages coordination across a range of agencies including police, fire and lifelines (NEMA, 2019).

At a regional level, Councils have responsibilities under the CDEM Act for planning and operational roles during emergencies. The CDEM Act requires local authorities become members of regional CDEM groups, and to coordinate emergency management through regional groups across the four R's (Rouse, 2011; NEMA, 2019):

- **Reduction** of the risk of the emergency occurring. This includes planning (through RMA, CDEM and LGA), and improving awareness of hazards. Reduction aims to prevent new, or reduce existing risk from occurring.

- **Readiness** for emergencies if/when they occur. During the readiness phase, operational systems and capabilities are developed. For flooding this can include evacuation planning, warning systems and public awareness.
- **Response** to emergences when they occur. This includes actions taken to save human and animal life and property. During the response phase the plans and systems developed during the reduction and readiness phases are put into operation.
- **Recovery** from emergencies, such as a flood once they have occurred. Recovery efforts can be immediate, medium and long-term and aim to regenerate or enhance a community following an emergency.

There is often overlap between the R's. For example, planning activities can reduce floods and proactively consider the recovery efforts (Rouse, 2011).

2.2.4 THE LOCAL GOVERNMENT ACT

The Local Government Act 2002 (LGA 2002) sets out the roles and responsibilities of territorial and local authorities. The LGA provides a framework and powers for local authorities to decide what activities the undertake and how they are undertaken. This act also encourages local authorities in promoting the four well-beings of economic, social, cultural and environmental through a sustainable approach (Rouse, 2011). Councils are required to develop a Long-Term Plan (LTP) to identify outcomes and actions to be achieved within a 10-year work programme. If flood risk management is key to achieving a community's well-being, then it should be included within the LTP.

2.2.5 LOCAL GOVERNMENT OFFICIAL INFORMATION AND MEETINGS ACT (LGOIMA)

The Local Government Official Information and Meetings Act 1987 (LGOIMA) gives the public the right to request official information held by local government agencies. Part 6A of the LGOIMA legally requires Territorial Authorities to provide Land Information Memoranda (LIMs) for a specific property for anyone who requests one. The LGOIMA outlines requirements and specifies the information that must and can be included in LIMs.

The law has changed and from 1 July 2025 the Local Government Official Information and Meetings Amendment Act 2023 comes into force on 1 July 2025. The new provisions require LIMs to contain understandable and "known" information about natural hazards and the impacts of climate change that exacerbate natural hazards. A significant change is that regional councils are required to provide territorial authorities with natural hazard and climate change information for LIMs. In April 2025 new regulations were passed prescribing how natural hazard and climate change information is to be presented in the LIMs which will come into force on 17 October 2025.

At the time of this report being finalised, the Guidance on the LGOIMA Changes and Regulations had not been released. Additionally, Horizons and the sector were seeking legal advice on what "known" information means as well as what "reasonable possibility that the hazard or impact may affect the land concerned (whether now or in the future)" and “potential” means. Consequently, this report cannot confirm flooding information provisions for the purposes of LIMs at this time.

2.2.6 SOIL CONSERVATION AND RIVERS CONTROL ACT

The Soil Conservation and Rivers Control Act 1941 is a foundational piece of New Zealand legislation aimed at managing and mitigating the effects of soil erosion and river-related hazards. The purpose of the Act was to promote soil conservation and prevent damage from floods and erosion. It empowers authorities to undertake works that protect land and infrastructure from the adverse effects of water and soil movement by granting powers to Regional Councils to carry out river control and soil conservation works. These include constructing stopbanks, planting vegetation, and managing river channels. It allows for the creation of schemes funded by both central and local government, often with contributions from landowners who benefit from the works. While many of its functions have since been absorbed into newer legislation like the Resource Management Act 1991, the 1941 Act laid the groundwork for integrated catchment management and remains relevant in the administration of older flood protection schemes.

2.2.7 SUMMARY

Within New Zealand, flood risk is identified and managed by multiple functions of government and referred to in various pieces of legislation. Additional pieces of legislation relevant to flood risk management include The Drainage Act 1908 and the Soil Conservation and Rivers Control Act 1941 (McSweeney, 2006).

The roles and responsibilities for managing flood risk are shared among central government, local government, and communities (MfE, 2008). Each group plays a vital part in implementing legislation and taking action to reduce and manage flood risks effectively.

The New Zealand legislative framework for flood risk management follows a hierarchical system (MfE, 2008). Nationally, the National Emergency Management Agency (NEMA) and the Ministry for the Environment (MfE) set national policy. At a regional level, regional authorities, such as Horizons Regional Council, have the responsibility for policy setting and planning, while also undertaking any operational roles for managing floods. Territorial authorities within the region have responsibilities under the Building Act, the CDEM Act, the LGA, and the RMA. These statues seek to achieve comprehensive flood risk management.

2.3 INTERNATIONAL BEST PRACTICE

This assessment reviewed flood risk management, modelling, and mapping international literature from Australia, including the Australian Runoff and Rainfall guidelines, the United Kingdom (UK), United States of America (USA), Canada, World Bank, Global Facility for Disaster Reduction and Recovery (GFDRR), and United Nations Office for Disaster Risk Reduction (UNDRR).

Flood modelling and mapping is an important part of the flood risk management process to understand flood risks and as the foundation for identifying strategies to improve resilience and minimise the consequences of flooding (Fischer & Stanchev, 2022). This process is presented in Figure 2-3.

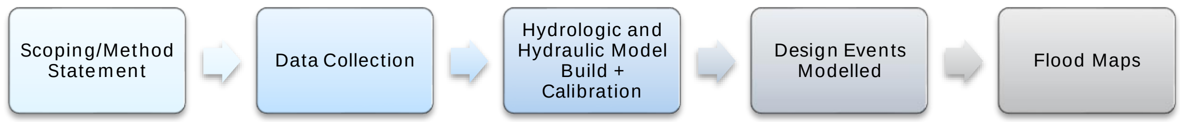

Figure 2-3: Process for flood modelling based on international review (Adapted from (Queensland Government, 2017; Government of Canada, 2018; SEPA, 2015; AIDR, 2017; UK EA, 2019; Ball, et al., 2019)

The **scoping/method statement** involves developing a statement that outlines the purpose of the flood model, outlines any information that already exists, and provides justification for the approach (Environmental Agency UK, 2023). Within this, the spatial extent, output types, probability range and modelling parameters can be determined (Ball, et al., 2019). The scoping stage can also allow for identification of the key process/es that must be modelled to accurately model the problem (Ball, et al., 2019).

The **data collection** stage involves sourcing all relevant data for the study. This can include terrain data (topography, bathymetry, land use zonings, land use, and structures), historic data (recorded rainfall or flood marks) and design rainfall data (rainfall inputs based on analysis of past records). During this stage the data is to be analysed to understand its accuracy, completeness, and spatial extent. Gaps in existing data may be identified and may lead to additional data being captured.

Following the data collection stage, the **hydrologic** and then **hydraulic models** are developed. The hydrological model estimates the discharges in the river and its tributaries during a flood event. The results of the model are dependent on the catchment characteristics, rainfall, and the antecedent conditions of the catchment. The flow hydrographs produced from this model are used for the hydraulic model, which simulates the passage of water through the catchment. Hydraulic models can be one-dimensional, two-dimensional, or combined approach.

Both the hydrologic and hydraulic models require **calibration/validation** and **sensitivity** checks to ensure that they are accurately representing actual site conditions. Inputs from historic events including recorded water or flow levels, flood extents, and aerial photography, are applied to the models, and parameters adjusted until the model replicates recorded flood events (Queensland Government, 2017; Environmental Agency UK, 2023; Ball, et al., 2019). In some locations data availability and constraints can mean that calibration is limited (Ball, et al., 2019). The UK's Environmental Agency recommends using at least three flood events for calibration if possible (2023).

Once the model has been calibrated, **design events** are modelled to provide an understanding of the flood behaviour during different rainfall events. Design floods are typically defined by their likelihood of occurring any given year. This is typically expressed as the 'annual exceedance probability' (AEP) or 'annual recurrence interval' (ARI).

To build an understanding of flood behaviours to inform risk assessments and further decision making, a range of flood events should be considered (Queensland Government, 2017). The Australian Institute of Disaster Resilience (AIDR) recommend that, as a minimum, flood hazard mapping be completed for a design flood event (DFE), a flood smaller than the DFE, and the probable maximum flood or representative event (AIDR, 2017). This provides users of flood modelling outputs with an overview of flood hazard events.

Flood maps are developed, and represent aspects of flood behaviour such as depth, velocity, flow rate and hazard. They are generally a representation of peak flood values, such as the maximum flood depth. The presentation and features of flood maps are generally modified depending on the end-user.

Additional practices that contribute to the best outcomes for flood modelling and mapping include identifying the end user in the scoping stage, incorporating future growth and climate change scenarios, and planning for a range of levels of assessments.

2.3.1 END USERS

As part of the response to the 2010-2013 food events, the Queensland Government has been supporting Councils and disaster management entities with comprehensive flood management projects (Queensland Government, 2017). This includes implementing fit-for-purpose flood studies and mapping. Nine themes that benefit from undertaking flood studies have been identified (QFMP, 2014; Queensland Government, 2017), and include internal and external uses. Examples of the uses are shown in Figure 2-4.

To support developing fit-for-purpose flood modelling and mapping, the scoping stage has an emphasis on identifying the theme; therefore, the end user and outcome of the study. The Flood Mapping Kit links each theme and use of flood modelling outputs to flood risk management (QFMP, 2014). Examples of the areas of interest for each theme are provided, for example:

- Land use planning – zoning and urban design, land use strategies, resumption programmes.
- Structural works – engineering design, levees, flood gates.
- Emergency management – flood warning, business continuity, evacuation and recovery plans.

Identifying and having a focus on end users from the beginning of the project assists with understanding the project budget, the level of study required, and timing of the project.

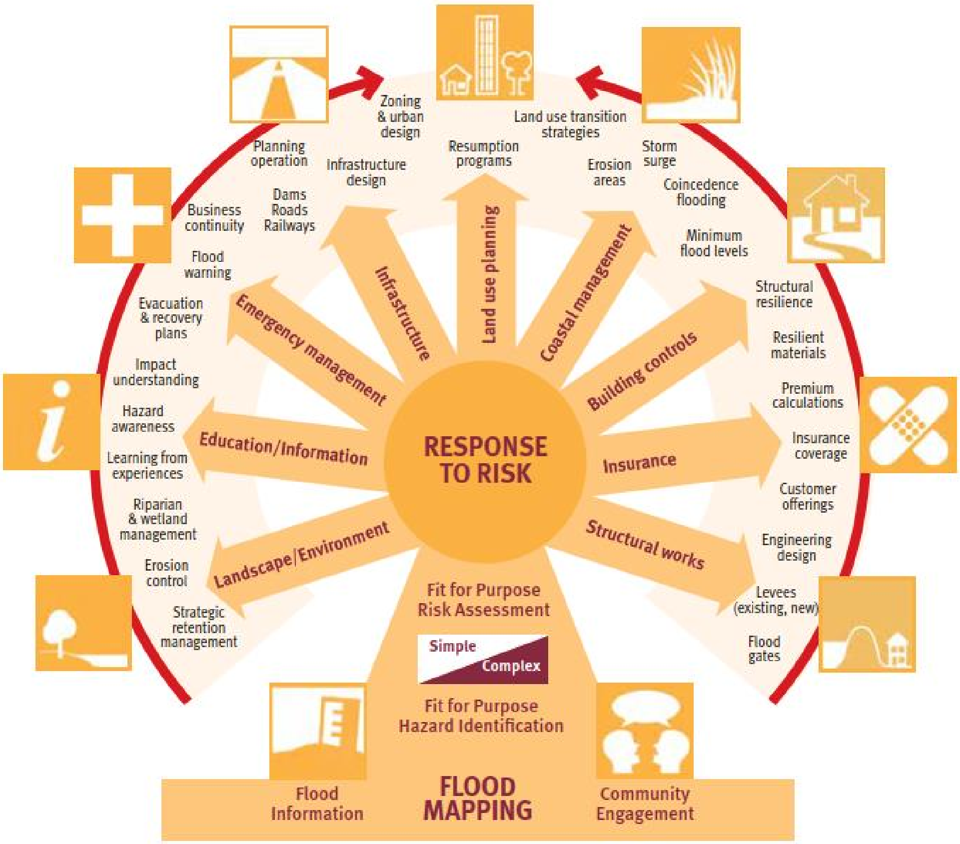

Figure 2-4: Economic and community resilience framework that demonstrate interconnections between flood risk management (QFMP, 2014). This includes the themes that benefit from flood studies, and how they may utilise the results.

A study by the United Kingdom (UK) Environment Agency also found that the content on flood maps needs to be tailored depending on the end-user (Priest & Joanna, 2012). Based on workshops and interviews held with different users of flood maps, recommendations were provided for three groups of users, including flood risk strategic planners, emergency planners and the 'at risk' public (Priest & Joanna, 2012).

The study found that, in the UK, flood risk strategic planners, who were more experienced with flood hazard data and could use several types of outputs, including detailed information on the flood hazard, consequences and assets/infrastructure. Contrasting this, emergency managers were found to require more simple information to use in decision making, including event information and details on people and assets exposed. Flood maps provided for the general public were largely used for public education to motivate people to prepare for flooding. This theme of producing maps that are based on user-specific requirements is also highlighted by the World Bank and GFDRR (Jha, Block, & Lamond, 2011).

Examples of providing flood modelling and mapping outputs for different uses are provided by the Queensland Government in their Guide for Flood Studies and Mapping in Queensland document (2017). Outputs are broken down into three key uses, including emergency management, land use planning and community engagement. Each area is linked to the purpose of the mapping and includes examples of flood mapping characteristics for that specific use. Flood map examples are also provided to demonstrate how outputs can differ for uses to ensure the correct level of detail and information is provided for that user group. For example, flood depth maps for community awareness are displayed qualitatively as 'high, medium and low' hazard (Figure 2-5), while for emergency management the flood depth is displayed as quantitatively as a range of depths in 0.5m increments (Figure 2-6).

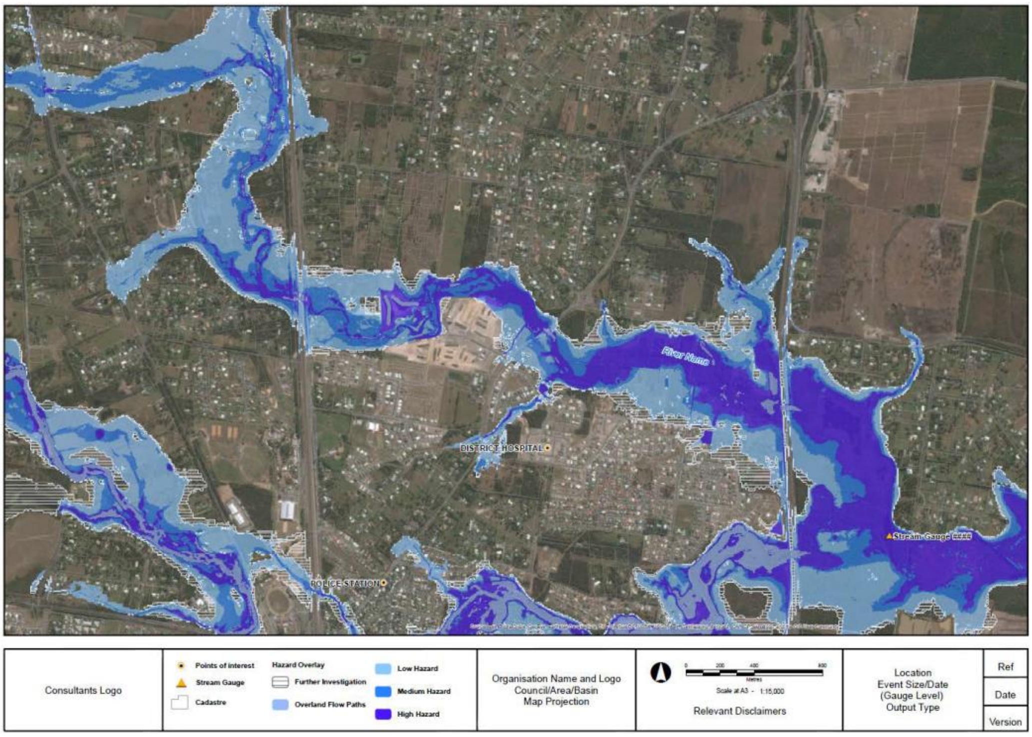

Figure 2-5: Example of flood mapping output for local community use (Queensland Government, 2017). Flood depth is displayed as low, medium and high hazard.

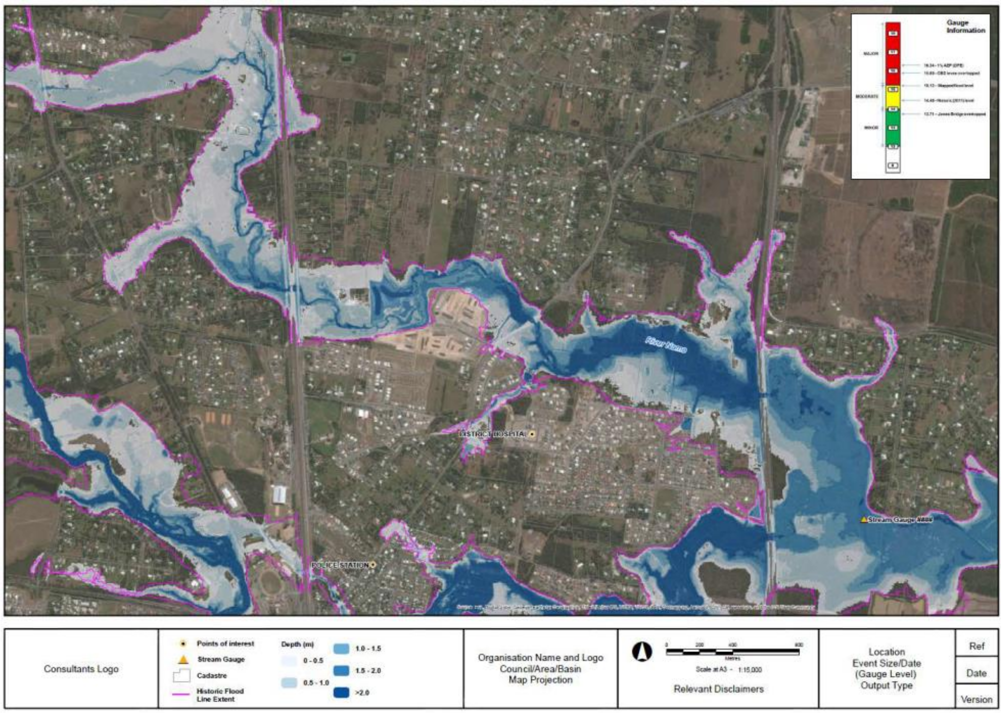

Figure 2-6: Example of flood mapping output for emergency management use (Queensland Government, 2017). Flood depth is displayed as 1.5 m intervals.

2.3.2 FUTURE GROWTH AND CLIMATE CHANGE

There are several variables that can change flood behaviour and the level of flood risk in a catchment. Most notably, changes in climate, affecting the flood's hydrology, or changes in land use, such as urban intensification, can have significant impacts. Climate change can influence a range of factors that impact flood behaviour. This includes but is not limited to:

- Frequency and severity of flood-producing rain events
- Antecedent conditions of the catchment and flood plain
- Impacts on sea level
- Hydrology changes due to storminess

Addressing or considering climate change in understanding future flood risk is only one part of a comprehensive approach to building resilience (Rockefeller Foundation, n.d). Flood behaviour is also significantly impacted by changes within the catchment and floodplain, such as land use changes and urban development (NSW Government, 2023; FMEA, 2001). These changes can alter the flow and storage of water, affecting the severity and frequency of flooding events. Consequently, the impacts on exposed communities and assets can vary greatly.

Understanding how flood behaviour evolves with future scenarios, including both climate change and catchment modifications, is important for informed decision-making. The NSW Government suggests different options of land use changes that can be considered when modelling future development scenarios (2023). This includes all areas that are likely to be rezoned for more intense uses, all future development proposals, or time related scenarios. Changes within the catchment, such as vegetation changes, can also increase flood behaviour, including the travel time for flows, and/or inundation levels within the floodplain (NSW Government, 2023). The NSW Government provides examples of combined scenarios that can be used for emergency management, land use, and infrastructure planning. They highlight that current and future outputs of flood models need to be identifiable and separated to provide a strong evidence base for informed flood risk management decisions and recommendations.

Integrating the combined impacts of climate change, future catchment characteristics, and land use change scenarios into flood modelling can inform comprehensive flood models that better support flood risk management strategies.

2.3.3 LEVEL OF ASSESSMENT

Flood modelling can be completed at different levels of assessment allowing for the identification of broad trends, while providing a comprehensive view of flood risk. The level of assessment needs to be appropriate for the purpose of the modelling and should be identified at the project planning stage (SEPA, 2015). The level of modelling and its appropriate use within a project, is also dependent on the quality and availability of input data (FEMA, 2021). In Queensland, the importance of developing fit-for-purpose maps for different communities is achieved through promoting different levels of flood modelling (QFMP, 2014).

International literature notes that flood modelling is typically categorised into three broad levels ((QFMP, 2014; SEPA, 2015). Figure 2-7 and Figure 2-8 provide examples of these levels which generally fit into the following three categories (QFMP, 2014; SEPA, 2015):

- **National/state wide** flood mapping utilises national datasets. This level of mapping is essential for understanding broad-scale flood behaviour and hazards and informs policy and strategic planning. Outputs at this scale can be used for identifying the flood extent (UK EA, 2019).
- **Town/catchment** level mapping offers a higher resolution of data and often focuses on improving understanding of a catchment. Town and catchment level flooding is suitable for identifying extents and approximate flood depth (UK EA, 2019). Uses can include emergency planning.
- **Comprehensive** flood modelling can also be conducted at a local level, requiring detailed information on a site or city. They can also be completed when a higher level of flood hazard needs to be investigated, such as development within a flood risk area (Environmental Agency UK, 2023). Outputs include depths, velocity and extents (UK EA, 2019). The outputs are typically used for design of critical infrastructure or housing developments (SEPA, 2015; Environmental Agency UK, 2023). When considering site-specific flood hazard the Ball et al (2019) hazard curves have been widely used (Figure 2-9).

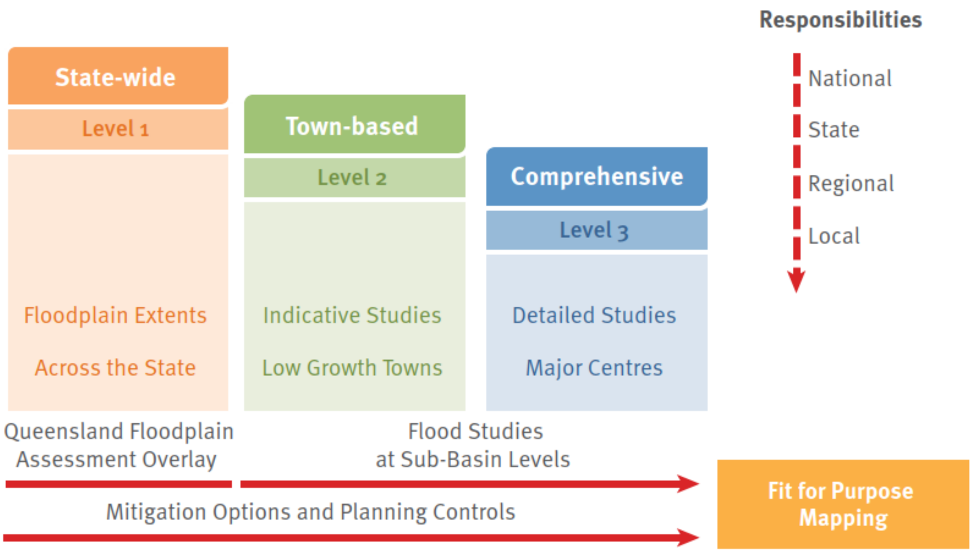

Figure 2-7: Example of levels of flood mapping assessment for Queensland (QFMP, 2014)

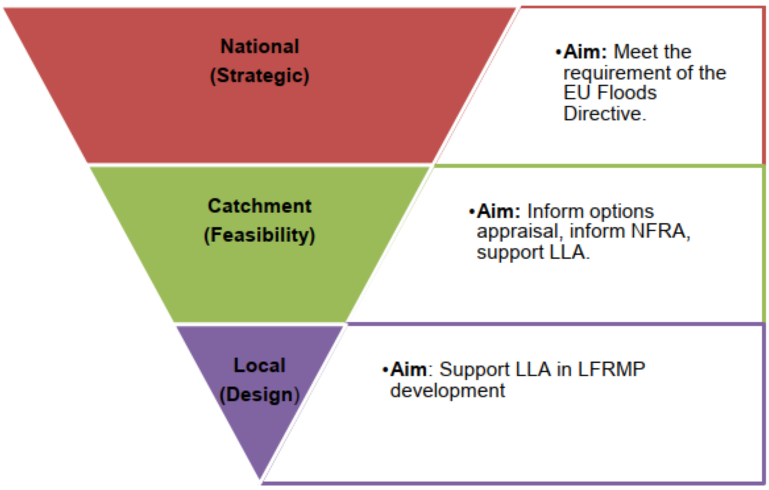

Figure 2-8: SEPA's flood modelling framework, consisting of three levels of assessment (SEPA, 2015).

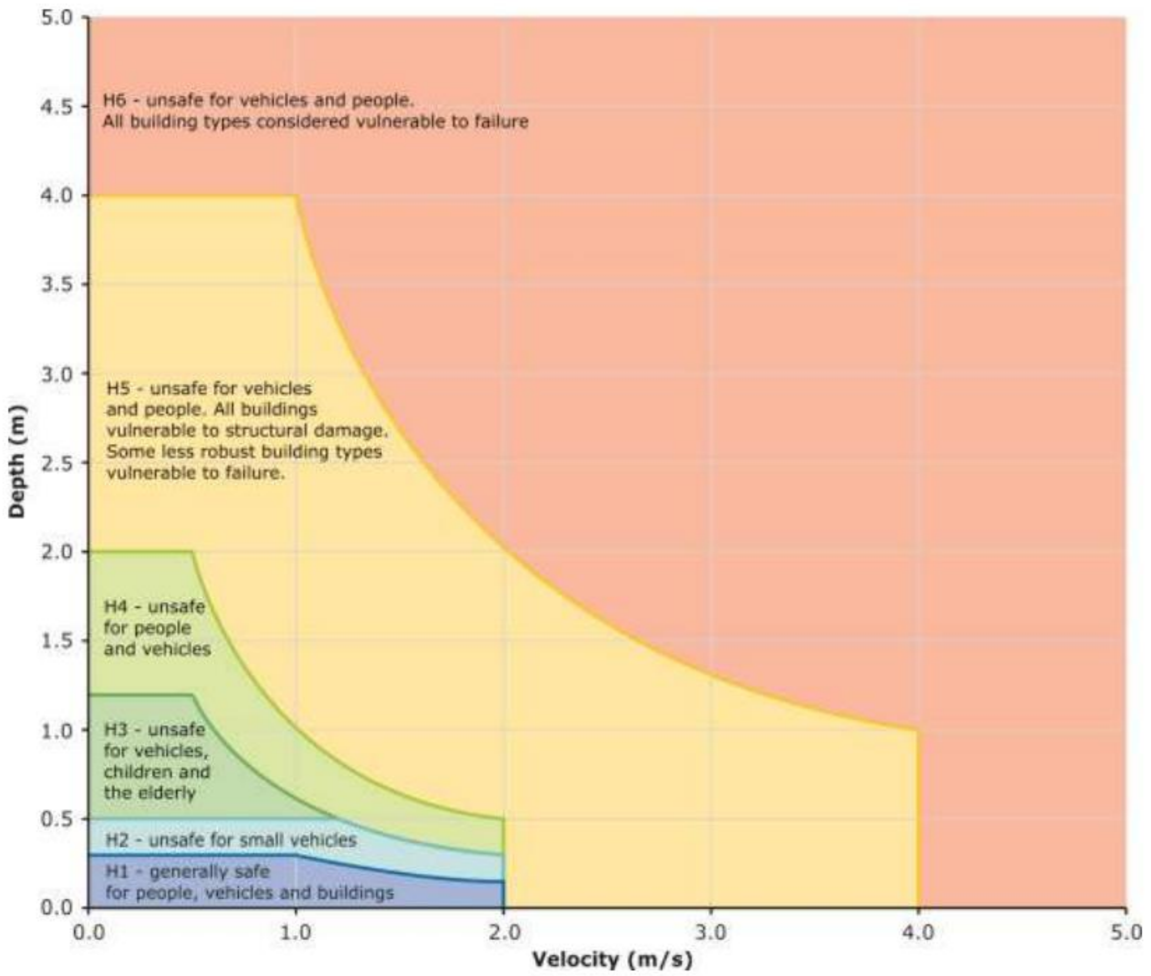

Figure 2-9: SEPA's flood modelling framework, consisting of three levels of assessment (Ball et al, 2019).

Input data availability can often limit the level of assessment that is appropriate or feasible. For example, if only low-resolution terrestrial data is available, then typically likely only a high- level study can be completed, or additional data will need to be collected. Data availability needs to be considered in the scoping stage when determining the level of assessment, outputs, and uses of the modelling and mapping. Identifying critical gaps in the data allows for the modelling process to be adjusted accordingly to ensure that model results and maps are fit for their intended purpose.

2.4 NEW ZEALAND BEST PRACTICE

In New Zealand there is no standard approach or regulation to comprehensively manage flood risk. As a result, local government Councils often use different tools to identify and manage their risk (MfE, 2008; Water NZ , 2024). Often this can be a result of local variability in funding, design standards and policies, and differing Council approaches (Water NZ, 2023). Where guidance does exist, it is typically specific to a regional or city/district level based on a specific hydraulic model that has been developed.

NZS 9401 '*Managing flood risk*' is a process standard developed in 2008 which provides a best practice approach to flood risk management in New Zealand (NZS, 2008). It aims "*to ensure that proper consideration is given to all aspects of flood risk when making decisions, so that over the longer term, the risk of flood damage decreases*" (NZS, 2008). The standard is a high-level decision-making framework based on accepted best practice and is not a technical document (MfE, 2010). It is voluntary and allows for regional variability in flood risk management which can make comparison across different regions difficult (Rouse, 2011; Water NZ, 2023).

2.4.1 NZ STORMWATER MODELLING GUIDELINES

The previously described inconsistencies and challenges are prevalent across the water and river management industry within New Zealand. To address some of these, Water NZ has developed a National Stormwater Modelling Guide and National Urban Stormwater Modelling Guidelines (Water NZ , 2024; Water NZ, 2023). The overall objective of these documents is to work towards developing a consistent and robust flood modelling process to enable more informed decision making for stormwater modelling.

The National Urban Stormwater Modelling Guidelines presents a literature review and gap analysis (Water NZ, 2023). The literature review includes both NZ and international (Australia, USA and UK) practices for stormwater. The gap analysis describes gaps and inconsistencies that need to be overcome to enable a consistent approach for stormwater modelling. The gaps relevant to this study include data collection, understanding why a model is needed and how it will be used, and lack of national direction and coordination for flood risk management (Water New Zealand, 2023).

The National Stormwater Modelling Guide presents approaches to address inconsistencies and gaps in stormwater modelling, providing a nationally consistent process for stormwater flood hazard modelling, along with guidance and definition of best practice approaches (Water NZ , 2024). The Guide is structured around four key processes of modelling (Figure 2-10). The project and the model need to be planned, allowing for a base model to be developed and used for the design runs (use). Once the simulations are complete, the model can be archived, with the base model maintained, and shared (Figure 2-10).

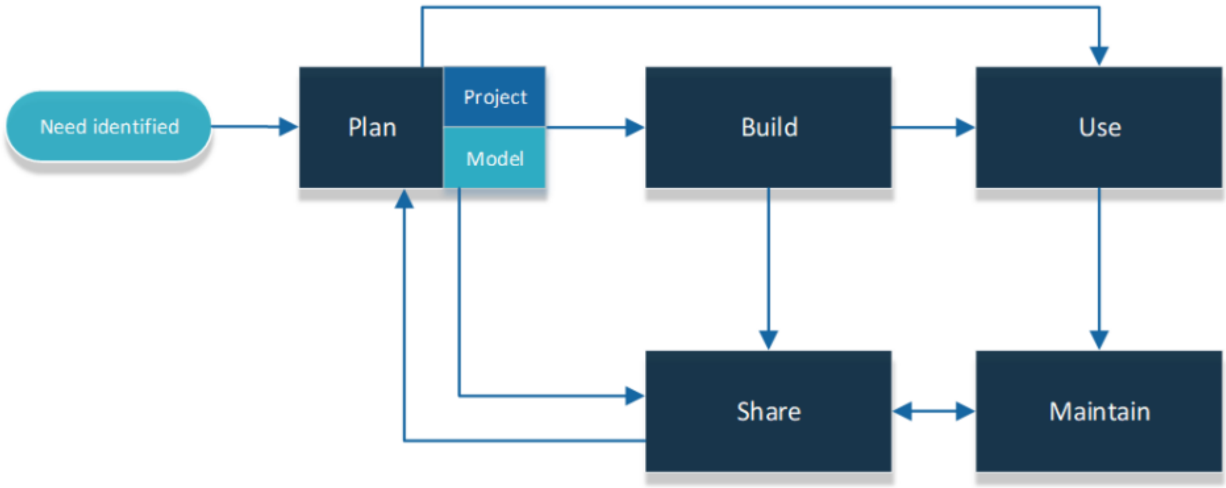

Figure 2-10: Key modelling processes for stormwater modelling (Water NZ , 2024).

Guidance and best practice are provided for each stage of the modelling process:

- **Plan** – guidance for planning is provided for planning both the project and the model:
  - **Project** – defining the model purpose, stakeholders, review of background information and quality assurance.
  - **Model** – confirm the approach and methodology, select the modelling software, define success, and collect data.
- **Build** – preparation of hydrological inputs, development of hydraulic models, setting boundary conditions, quality assurance and model confidence, and defining limitations.
- **Use** – run the model for current and future scenarios by varying the hydrologic and hydraulic parameters.
- **Maintain** – approaches to archive and update the model assets.
- **Share** – metadata and data formats and managing intellectual property rights.

The National Stormwater Modelling Guide also links the purpose and application of a modelling outcome to the model type (Water NZ , 2024). Examples of purposes include emergency management (evacuation and lifeline planning), building consents and structure planning (spatial plan and regional and district plan changes). Outcomes from modelling include flood hazard, extent identification, and infrastructure design.

Examples of outputs produced from stormwater modelling are included in the guide, and include levels and depth, flood extent and flood hazard (Water NZ, 2023). Example of additional outputs, such as flood contours, animations, and the time to inundation are also listed. Similar to what was common in international literature, it is highlighted that the outputs should be clearly linked to the original purpose of the modelling (Water NZ, 2023).

2.4.1.1 APPLICABILITY TO HRC FLOOD RISK MANAGEMENT FRAMEWORK

While not specific to fluvial modelling, which is the primary focus of this study, the findings from the review of New Zealand stormwater modelling guidelines (Water NZ , 2024; Water NZ, 2023) are applicable to this project, and provide the best example within New Zealand for an industry standard for water modelling. The need for a clear consistent framework for modelling at a range of scales is necessary across all aspects of modelling to ensure robust outputs for effective flood hazard management. Modelling outputs listed in the guidance is similar to what can be produced for riverine and fluvial flood modelling and is used to inform some of the uses of modelling for the flood risk management framework described in Section 4.

2.4.2 REVIEW OF REGIONAL/LOCAL COUNCIL FLOOD MODELLING PROCESSES

Established flood modelling guidance documents remain largely unpublished by New Zealand Councils, with very few available as online documents. As stated above, while NZS 9401 provides a best practice approach to flood risk management, it still allows for regional variability (Water NZ, 2023). Only a few councils have made their flood management guidelines publicly available.

Guidelines are essential for effective flood risk management, providing clear instructions and strategies to protect communities and infrastructure. The absence of publicly available flood modelling and mapping guidance within New Zealand suggests a gap in comprehensive and coordinated flood risk management. Here we summarise some of the key parts of regional flood guidelines that are publicly available in New Zealand:

- **Greater Wellington Regional Council (GWRC)** – a Flood Hazard Modelling Standard has been developed to outline protocols for anyone working on a GWRC flood modelling project (GWRC, 2021). These have been developed to ensure projects are completed in a robust and consistent way in line with accepted industry practice. Key aspects contributing to best practice from this standard include:
  - Flood hazard models may be revised within 5-10 years due to increased data, improved data quality, changes to catchments, the occurrence of floods to validate and calibrate models, and changes in technology and industry practice.
  - Community engagement and collaboration can help build accurate flood models. The FHMS includes three stages for community consultation including when gathering data about the flood, when finalizing the hydraulic model, and to show and explain the flood hazard modelling results.
  - Project plans should be created that outline the objectives of the study and state that the outputs should be at a sufficient level of detail and quality for informing district planning and emergency management.
  - Catchment information, including current and planned land use changes such as large-scale urban development, or land use changes that may occur under district plan zones.

- Detailed information on structures should include the age of as-built drawings, design standards, and condition of the structure.
- GWRC note that the use of outputs can include flood warning, floodplain management planning, asset management, and provided to other parties for emergency planning, district planning and consenting (GWRC, 2021)

- ***Tauranga City Council (TCC)*** *- to support the flood hazard maps released to the public, TCC have released a 'Flood Hazard Modelling and Mapping Practice Note'. This document provides an overview of the modelling process, inputs, outputs and uses.*
  - *TCC recognise that the input data is a snapshot as to when the model was built. Tauranga has been rapidly expanding, resulting in land use changes within the catchments. For this reason, TCC has a programme to update flood models regularly due to changes in catchments (including new land levels, changes to contours and flow of water, and new building or infrastructure information).*
- **Bay of Plenty Regional Council (BOPRC)** – guidelines have been developed for activities requiring Hydrological and Hydraulic and/or general engineering calculations or assessments (BOPRC, 2012). This includes construction such as culverts, stormwater systems, or services crossing a watercourse. An updated hydraulic modelling guideline has been developed by BOPRC and is referenced by Water NZ 2023 as part of their literature review but is not publicly available.
  - Due to the impacts of climate change on increasing the magnitude, level and frequency of flooding, the capacity of flood protection and stormwater assets must be reviewed when new flow information is available.
  - Design scenarios are provided for existing, 2040 and 2090 scenarios with associated climate change factors (BOPRC, 2012).

2.4.3 EXISTING NATIONAL NATURAL HAZARD ASSESSMENT FRAMEWORKS

Within New Zealand, hazard assessment frameworks have been developed for liquefaction and landslide hazards. Both frameworks recognise that the information about the hazard can be used for multiple purposes (EQC, MBIE, MfE, 2017; de Vilder, Kelly, Buxton, Allan, & Glassey, 2024). They have been developed with this as a primary consideration and have been designed to include different level of assessments to ensure the outputs are fit for purpose and relevant for different users. They provide end users with clear guidance on the necessary inputs and suitable scale of outputs, while acknowledging the intended purpose of the outputs as this governs the scope and the level of assessment required (EQC, MBIE, MfE, 2017).

The liquefaction guidance recognises that the level of detail required for a study is determined by the intended use and uncertainty (EQC, MBIE, MfE, 2017). The framework aims to provide clarity around the level of detail and the purpose of the study. It also seeks to avoid liquefaction assessments conducted with lower certainty being used for a purpose that requires a high level of detail.

Four levels of assessment are defined (Level A – D), where the level of detail of the assessment increases, the uncertainty decreases. This ensures that liquefaction vulnerability is more accurately defined. Level A studies are generally a regional assessment, completed with large-scale regional geology, geomorphology and groundwater maps, while Level D is site-specific and involves site-specific geological information and quantitative analysis of sub-surface data (EQC, MBIE, MfE, 2017). A high-level overview of the framework, including the level of assessment and associated use and detail is presented in Table 1.

Table 1: Liquefaction assessment framework including key features, use and detail for each level of assessment (Adapted from EQC, MBIE, MfE, 2017).

Level of Detail	Key Features	Use and Minimum Detail Required
Level A – Basic Desktop Assessment	Considers basic geology, groundwater and seismic hazard Desktop study Screening for identifying liquefaction related risk	Used for regional policy, regional plan, and district plan. Study extent can vary from 100 – 50,000 km^2 Scale can be greater than 1:25000 , or around 1:10000-1:5000 Can be used for plan changes, land use and subdivision consents, or building consents where development scenario is sparsely populated or a rural-residential setting
Level B – Calibrated Desktop Assessment	High level calibration of geological/geomorphic maps Assessment of a small number of subsurface investigations Screening for liquefaction related risk with reduced error from a Level A study.	Used for plan changes, building consents, subdivision consents, and land use consents. Study Area can range from 5 – 1 km^2 Typical scale of 1:250-1:500 (land use and subdivision consent), or 1:500 or less (building consent)
Level C – Detailed Area-Wide Assessment	Quantitative assessment of moderate density of subsurface investigations Groundwater and geomorphology assessed in finer detail	Used for building consents, subdivision consents, and land use consents. Study Area can range from 5 – 1 km^2 Typical scale of 1:250-1:500 (land use and subdivision consent), or 1:500 or less (building consent)
Level D – Site Specific Assessment	High density of subsurface investigations on or close to specific site Considers site-specific details of the development	Used for building consents, where extent of study is less than 1 km^2 Typical scale of 1:500 or less

Five levels for landslide susceptibility, hazard and risk analysis have been developed within the NZ Landslide Guidelines (de Vilder, Kelly, Buxton, Allan, & Glassey, 2024). Details are provided on the key features, required inputs and outputs, and the application of the different levels. The five levels (A – E) range from a susceptibility analysis (Level A) to a full probabilistic quantitative risk analysis (Level E). Similar to the liquefaction assessment, as the level of detail increases, the uncertainty decreases. The assessment also includes consideration of climate change scenarios to be used at a screening stage (Level A-B) and for more detailed assessments (Level C-E). A summary of the levels of assessment and the key features and uses can be found in Table 2.

Table 2: Landslide assessment framework, with the key feature and use for each level of analysis (adapted from de Vilder, Kelly, Buxton, Allan, & Glassey, 2024).

Level of Analysis	Key Features	Use
A – Susceptibility	Mapping existing landslides and land potentially susceptible to landsliding Considers climate change scenarios	Determines where further assessment is required when land-use, subdivision and building consents or a plan change are being sought Informs the minimum basis for land zoning
B – Hazard Analysis	Assigns a frequency to the potential landslides	Plan making and changes for rural zone, and future urban zones
C – Semi Quantitative Risk Analysis	Risk assessment of a limited range of landslides sizes (eg most likely or max. credible)	Plan making and plan changes for general residential zones, medium and high-density residential zoning and tertiary education zones. Recommended minimum for land-use, subdivision, and building consents for Building Importance Level 2 building or natural hazard sensitive activity in areas identified as high-moderate susceptible to landslides
D – Basic Quantitative Risk Analysis	Risk assessment from landslides of certain scenarios (e.g. 1-in-100 rainfall event)	Forms basis for district plans and site-specific analysis. Recommended minimum for plan making and plan changes for hospital zones. For building consents is recommended minimum for Building Importance Level 3, 4 and 5
E – Detailed Quantitative Risk Analysis	Risk assessment considering the full range of triggering event. Includes detailed regional or site-specific modelling.	Forms basis for district plans, plan changes, land-use, subdivision and building consents

3 HRC FLOOD MODELLING PERSONAS AND USE CASES

This section outlines the key findings from the workshops held with HRC and local authorities, which are used to guide the development of flood modelling personas and the regional flood modelling framework.

3.1 INTRODUCTION

To develop a framework for regional flood modelling that is fit for purpose, it is important to understand the users of flood modelling and mapping. In consultation with HRC, a range of user personas for flood modelling and mapping were identified to guide the development of the HRC flood modelling framework. Personas were initially informed based on the experience and assumptions of WSP. Two workshops and a series of interviews were conducted over 21-22 November 2024. The objectives of the workshops and meetings were:

- Identify uses of flood modelling and mapping within HRC including capturing specific user requirements such as ARI.
- Identify user specific requirements for outputs of flood modelling.
- Present an initial framework for regional flood modelling.

3.2 WORKSHOPS

3.2.1 REGIONAL COUNCIL

An in-person workshop was held with members of HRC at the council offices on 21 November 2024. Follow up interviews were conducted for each user persona to better understand the user specific requirements. Attendees of the workshop covered a range of roles within HRC including:

- Planning
- District advice
- Emergency management
- Science communication
- Hydrology/Flood Forecasting
- Asset management/infrastructure planning
- Climate change

3.2.1.1 WORKSHOP STRUCTURE

The workshop was structured as follows:

- Outline the background research on flood modelling in NZ, and how other hazards (liquefaction and landslides) are assessed using a tiered level
- Present flood modelling process and best/good practice from international review.
- Present the initial framework and receive feedback from council on this. Workshop attendees were provided an A3 printed draft framework, with the opportunity for them to provide feedback. Feedback included:
    - Adding in additional uses of flood modelling for different levels of assessment.
    - Providing commentary on the uses of flood modelling at the different levels.
    - Provide feedback on uses of flood modelling that were included within the framework but that are outside of HRC's role (such as site-specific planning).
- During the workshop, mock-ups of geospatial outputs were also provided to HRC to facilitate discussion on output requirements and uses of flood modelling.

3.2.2 TERRITORIAL AUTHORITIES

A hybrid workshop was held on 22 November 2024 and was attended by approximately 30 members of local TAs who may use the outputs of the flood modelling. The purpose of the workshop was to present the project to the TAs and to highlight the key information that had been presented at the HRC workshop the previous day. A follow up survey was distributed to attendees to capture user requirements from a TA point of view (refer Section 3.3).

3.3 ONLINE SURVEY

In addition to the workshops, an online survey was developed with 31 questions framed around the objectives of the workshops and understanding how people interact with flood modelling and mapping outputs, and requirements for their role.

The online survey was captured via a Microsoft Form and was sent to members of TAs within the Horizons Region who had attended the TA Workshop. The survey was broken into 9 sections, and included:

1. **User information** – role, region and current use of flood modelling and mapping tools.
2. **Effectiveness and challenges** – with using/accessing existing flood mapping and modelling.
3. **Training and workshops** – participation in training/workshops on how to use existing HRC flood modelling and mapping tools.
4. **Improvements and features** – for existing mapping and modelling tools and additional functionalities required.
5. **Usage and requirements** – use cases, scale, outputs, attributes (velocity, depth, etc.) and accessibility of flood modelling and mapping outputs.
6. **Interpretation and support** – requirement for decision support tools.
7. **Guidance and standardisation** – availability of guidance to use flood maps and need for regional/national standardisation).
8. **Vulnerability information** – flood vulnerability information required to manage flood risk).

9. **Additional feedback** – opportunity to provide additional feedback on flood modelling and mapping, and on WSP's proposed regional flood modelling framework.

Section 9 of the survey included the proposed regional flood modelling framework and prompted survey respondents to provide feedback on the framework based on their role and specific uses of flood modelling and mapping.

3.3.1 SURVEY RESULTS

The survey was open to members of TAs who attended the workshop on 28 November 2024 and closed on 13 December 2024. 18 survey responses were submitted, with an additional response received via email direct to WSP. Responses covered six District/City Councils throughout the region, representing a variety of roles and users of flood modelling and mapping.

Key survey results are presented below, with the full results presented in Appendix A.

Effectiveness and challenges

Most of the survey respondents find existing modelling and mapping tools provided by HRC to be effective in supporting their role. Challenges faced by users include coverage limitations (including the lack of coverage in rural areas, and a limited number of modelled events), usability of the geospatial viewer (unavailability of aerial basemap imagery, the scale of mapping and inability to search addresses), technical limitations (inability to enquire the levels) and awareness and understanding of the outputs.

Training and Workshops, and Improvement and Features

Almost all (94%) respondents use flood models and maps; however, most survey respondents had not participated in a training session on using HRC's flood modelling and mapping tools. Those who did found the workshops to be helpful.

Usage and requirements

Figure 3-1 presents the current use cases for utilising flood modelling and mapping. The scale of data required ranges from 1:50,000 to 1:500; however, many were unsure on the scale required for their role. Typically, lower resolution outputs (1:10,000 and above) were identified for emergency management purposes, with higher resolution outputs (1:1,250 and lower) for spatial planning. Asset management requires high resolution (1:500). The most common attributes required for flood mapping include flood depth, extent, flood hazard classification and the locations of critical infrastructure, assets and routes.

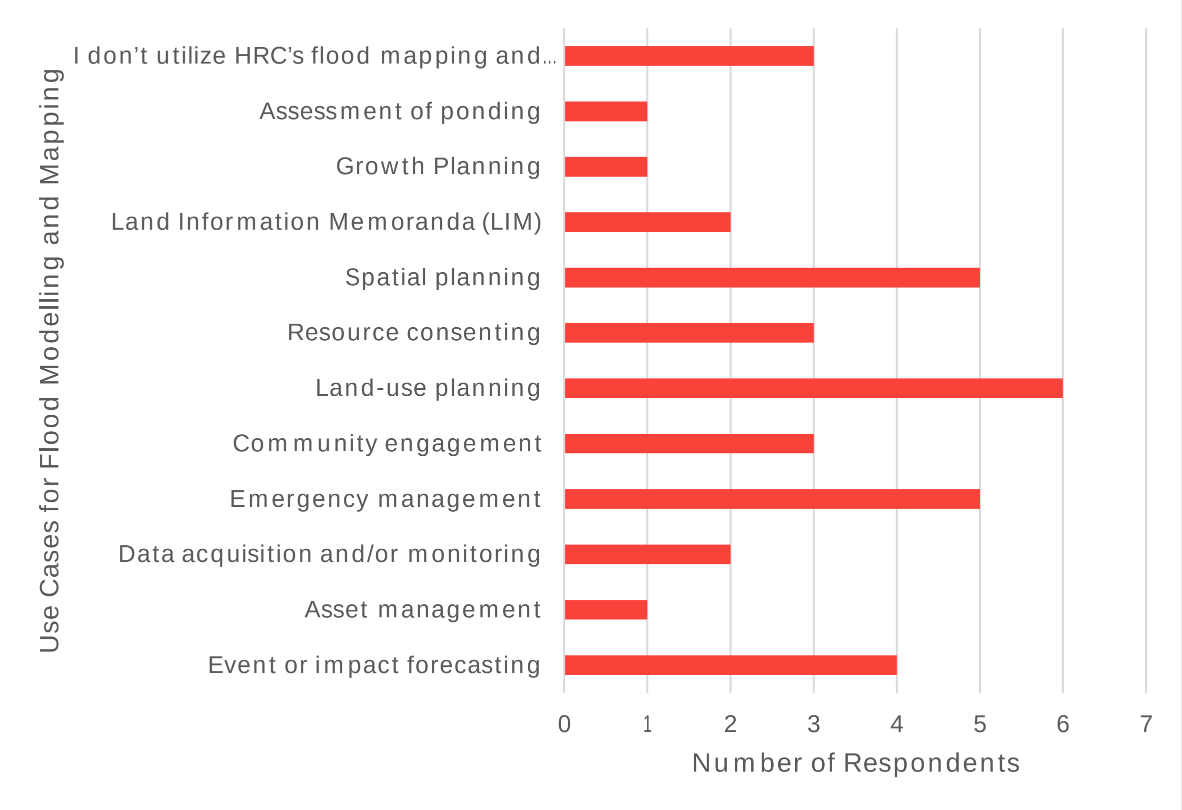

Figure 3-1: Survey results for "Which of the following use cases do you utilise HRC's flood mapping and modelling for?".

The results indicated a strong preference for using geospatial online platforms, with many participants also favouring geospatial data layers such as raster and shapefiles. Additionally, council advice services, which provide software for extracting flood information, were frequently mentioned. Hard copy maps and district advice services were less commonly preferred but still noted by some respondents.

Interpretation and Support/Guidance and Standardisation

More than half of the respondents can sufficiently interpret flood information to be used in their role; however, the majority of respondents feel that there is not adequate guidance to be able to use flood maps. Almost all respondents feel that regional or national standardisation of flood risk guidance would assist in using flood maps.

Additional Feedback on Modelling and Framework

During the online workshop and attached in the online survey (refer to Appendix A), participants were able to view and provide feedback on the initial proposed regional flood modelling framework (presented in Section 4). Respondents from the TA's felt that the approach and layout of the framework was easy to follow, and the guidance and intended uses for assessment were appreciated. Feedback was provided on the levels of assessment for planning purposes, which was incorporated into the framework (Section 4) and the personas presented in Appendix B. Concerns were raised surrounding the lack of LiDAR for particular districts or areas which limits the availability for flood modelling and decision making.

3.4 RESULTS

The results and feedback provided from the workshops and survey have been used to inform and further develop the regional flood modelling framework, presented in Section 4. Results of the in-person workshop with HRC, the individual interviews, and the online survey have been used to develop user personas for the following roles:

- Regional District Advice
- Planning
- Asset Management
- Emergency Management
- Investigations and Design
- District Advice - Territorial Authority

These personas are presented in Appendix B. It should be noted that personas are not applicable to just one organisation. For example, the Emergency Management persona may apply to Emergency Management staff at the Regional Council, and Territorial Authorities. Each persona has been linked to the framework presented in Section 4, with examples of the uses and outputs required for that persona.

HRC also has an established Hazard Mapping Steering Group (HMSG) with representatives from the Policy, District Advice, Emergency Management, Hydrology, Operations, and Design team. The HMSG provides a platform for coordinated decision-making and departmental collaboration for the development, maintenance, and curation of natural hazard mapping.

4 REGIONAL FLOOD MODELLING FRAMEWORK

Following the best practice literature review, a Horizons Region framework for regional flood modelling assessment has been developed. Similar to other hazard assessment frameworks in New Zealand, such as for liquefaction and landslides (Refer to Section 3.2.1), this framework employs a staged approach based on the required detail of output and available data, allowing for assessments at different scales. The goal was to build on existing frameworks and develop a comparable structure to allow for multi-hazard assessment.

The purpose of incorporating different levels of assessment is to facilitate user-specific flood modelling tailored to the required outputs or available information. The creation of this framework has been a collaborative effort, involving close consultation with the HRC staff. A draft framework was initially presented to HRC in the workshop held on 21 November 2024. The draft was also shared with local Territorial Authorities (TAs) during the November 22 workshop and included in the follow up survey. Feedback was sought from both HRC and TAs, and aimed to understand how users apply flood modelling results across different roles and scales, which would then be integrated into the framework, particularly in the outputs required, uses of modelling and input data.

Table 3 presents the Horizons Region framework for regional flood modelling. It will establish a baseline for utilising existing models, data, and maps, identifying gaps, and providing recommendations for future flood modelling and mapping efforts. It will also support the delivery of high-quality, fit-for-purpose data and models that effectively support flood risk management in the Horizons Region. The framework can also be used by HRC to understand the applicability of their existing modelling outputs for different uses within their region, while also guiding the level of modelling assessment required for future modelling based on the intended outcome and use.

We recognise that flood modelling outputs produced at coarser resolutions can be applied for different purposes than what is suggested in the 'Uses' column of Table 3. For example, using regional modelling produced at an A Level for a Level D purpose. However, this framework has been designed for the recommended level based on the intended use case.

Table 4 provides the recommended uses of each level for the various user personas that were identified from the workshops (Section 3). While Table 4 notes that Levels A and B can be included on LIMS, we recommend this applies to a notation or reference only. For example, the regional level flood mapping produced in this Flood Vulnerability Assessment is not suitable to be mapped at site-specific scale or presented at this level on LIMs.

Table 3: Regional Flood Modelling Framework for Horizons Regional Council.

Level of Detail	Key Features	Output Features	Uses
Level A – Basic Desktop Assessment	Regional model Validated against extents Structures/assets identified from LiDAR Calibration/sensitivity includes check of selected locations against historic records	Low resolution may include flood depth. Approximate map scale down to 1:5,000 or greater. Could be greater than 1:25,000 Unlikely to have velocity Suitable to understand the extent of flooding for further detailed investigation Exposure assessments and prioritising areas for further investigation	Emergency management readiness and recovery planning Regional policy and development plan High level community engagement High level asset management and long-term planning for flood infrastructure
Level B – Basic Validated Desktop Assessment	Regional model Validated against extents Structures/assets identified from lidar Calibration/sensitivity includes check of selected locations against historic records	Low resolution may include flood depth. Approximate map scale down to 1:5,000 or greater Unlikely to have velocity (aspire to have velocity) Suitable to understand the extent of flooding for further detailed investigation Exposure assessments and prioritising areas for further investigation	Asset management for flood infrastructure Local Government (Regional and District) policy setting Readiness, recovery and high-level response planning Contingency and evacuation planning District scale planning or policy adjustments Zoning as a function of spatial planning Long-term infrastructure planning
Level C – Localised Catchment Model	Detailed catchment model Includes some assets and streams Sensitivity testing. Validation of model parameters to extents and some levels. Starting to look at gauge calibration.	Refined model Approximate scale down to 1:1,250-1:500 May have velocity and depth Shows exposure (spatial extent) Flows at gauges Water levels, depths and velocities at critical infrastructure/areas Flood hazard classification	Strategic catchment and infrastructure planning Regional and district policy setting Urban growth and land use planning Decision support for Integrated Catchment management (ICM) Climate adaptation planning Resource Management Act Consents (including land-use, subdivision and resource) Zoning as a function of spatial planning Readiness and recovery planning Community response planning
Level D – Specific Detailed Assessment	Site specific model Includes all assets/structures Often a property/parcel level Sensitivity testing. Calibration at gauges for multiple events and comparison with historic records.	High resolution Approximate map scale down to 1:500 (or less) Includes depth, velocity along with spatial extent Flood hazard classification	LIMS – public use case for property-specific decision making Detailed design of flood protection assets Emergency management response and recovery during a flood Urban growth and land use planning decisions Detailed site planning and development controls Resource Management Act Consents (including land-use, subdivision and resource) Building Consents and site considerations

Table 4: General applicability of level of detail for use by the different identified user personas.

Level of Detail	Regional District Advice	Planning*	Emergency Management	Asset Management	Investigation and Design	Territorial Authority LIMs
Level A – Basic Desktop Assessment	Possible	Suitable	Suitable	Suitable	Possible	Possible
Level B – Basic Validated Desktop Assessment	Suitable	Suitable	Suitable	Suitable	Suitable	Possible
Level C – Localised Catchment Model	Suitable	Suitable	Suitable	Suitable	Suitable	Suitable
Level D –Specific Detailed Assessment	Suitable	Suitable	Suitable	Suitable	Suitable	Suitable

*Refer to Appendix B for a detailed overview of the applicability of the different levels of detail for the different uses for the Planning persona

5 CONCLUSION

Flood risk management in the Horizons Region is underpinned by four key pieces of legislation, and delivered by national government, local government and communities. To successfully understand and manage the risk of flooding, fit for purpose modelling and mapping is required. A review of international and local flood modelling and mapping literature, and existing local natural hazard assessment frameworks was conducted as part of this study. Beyond the flood modelling process, best practice involves understanding the end user of the modelling and mapping and developing levels of assessment to guide the modelling process to ensure resilient outcomes.

Based on this we have worked collaboratively with HRC to develop a regional flood modelling framework. Feedback was also sought from local TAs. This framework consists of four levels of assessment and is to the design of the assessments developed for liquefaction and landslide assessment in New Zealand, whereby different levels of assessment each require different data inputs and can be used for different purposes. In developing a flood modelling framework that spans across different levels of assessment we are also allowing for multi-hazard assessment for the Horizons Region in the future.

The flood modelling framework developed encompasses four levels of assessment, ranging from regional to site specific. Each has different features and outputs, such as scale and flood characteristics. The different levels of assessment have been mapped to the use case personas developed to demonstrate how the level of assessment will contribute to flood risk management for a user. In developing these we have worked with HRC to understand the uses and requirements of personas and how flood modelling is required to their role, and mapped these uses to the levels of assessment within the framework. This will enable roles/personas within HRC to understand the recommended level of modelling and mapping required for a particular use within their role.

This framework will establish a baseline for HRC to assess existing flood models, and identify gaps and provide recommendations for future flood modelling and mapping efforts that is fit for purpose and meets the needs of the end user.

The framework can also be used by HRC to understand the applicability of HRC's existing modelling outputs for different uses within their region, while also guiding the level of modelling assessment required for future modelling based on the intended outcome and use.

6 LIMITATIONS

This report ('Report') has been prepared by WSP New Zealand Limited ('WSP') exclusively for Horizons Regional Council ('Client') in accordance with the WSP Request for Proposal dated 16 July 2024 and the CCCS 4th Edition Dec 2017 signed 9 September 2024 ('Agreement').

Permitted Purpose

This Report has been prepared expressly for the purpose of supporting HRC in developing a comprehensive flood vulnerability study for the region that considers the multiple uses of flood modelling information ('Permitted Purpose'). WSP accepts no liability whatsoever for the use of the Report, in whole or in part, for any purpose other than the Permitted Purpose. Unless expressly stated otherwise, this Report has been prepared without regard to any special interest of any party other than the Client.

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The data reported and Conclusions drawn by WSP in this Report are based solely on information made available to WSP at the time of preparing the Report. The passage of time; unexpected variations in ground conditions; manifestations of latent conditions; or the impact of future events (including (without limitation) changes in policy, legislation, guidelines, scientific knowledge; and changes in interpretation of policy by statutory authorities); may require further investigation or subsequent re-evaluation of the Conclusions.

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APPENDIX A – ONLINE SURVEY

Survey Questions

An online survey was developed with 31 questions framed around the objectives of the TA workshop and understanding how people interact with flood modelling and mapping outputs, and requirements for their role. This section presents the survey questions that were sent within the survey.

Question 1: What is your role within your organization? (Select one)
Question 2: If you selected other, please specify.
Question 3: What district do you operate in?
Question 4: If you selected other, please specify.
Question 5: How familiar are you with HRC's flood mapping and modelling tools?
Question 6: How frequently do you use HRC's flood mapping and modelling tools in your work (includes district advice service, HRC public map viewer or info held by TA GIS)?
Question 7: How effective do you find HRC's flood mapping and modelling tools in supporting your work?
Question 8: What challenges do you face when using HRC's flood mapping and modelling tools?
Question 9: Have you participated in any workshops or training sessions on HRC's flood mapping and modelling tools? (this does not include Fridays use case workshop)
Question 10: If yes, how useful did you find these workshops or training sessions?
Question 11: Do you use flood models and/or maps?
Question 12: Which of the following use cases do you utilise HRC's flood mapping and modelling for?
Question 13: If you selected other, please specify.
Question 14: For your role, what scale of data do you require?
Question 15: If you selected other, please specify.
Question 16: What attributes do you require for your flood maps?
Question 17: If you selected other, please specify.
Question 18: For the work you do, what would be the best means to access flood maps and/or models?
Question 19: If you selected other, please specify.
Question 20: What flood modelling outputs would be helpful in your role?
Question 21: If you selected other, please specify.
Question 22: If the internet was not available, would you require access to flood map information or data to perform your role?
Question 23: What improvements would you suggest for HRC's flood mapping and modelling tools?
Question 24: Are there any additional features or functionalities you would like to see in these tools?
Question 25: Do you use the district advice service?
Question 26: If so, what improvements would you suggest for the district advice service?
Question 27: Are you able to sufficiently interpret flood information to be used in your role?
Question 28: If not, would you require decision support tools?

Question 29: Is there adequate flood risk guidance available for you to use flood maps in your role?
Question 30: Would regional or national standardisation of flood risk guidance assist you with using flood maps?
Question 31: What flood vulnerability information would be useful to manage flood risk in your role?
Question 32: Do you have any other comments or feedback regarding HRC's flood mapping and modelling tools?
Question 33: The attached image shows the proposed Regional Flood Modelling Framework. With your specific use case in mind, please provide feedback or recommendations on this framework.

Survey Results

This section presents the results to the online survey that was sent out to attendees of the TA workshop.

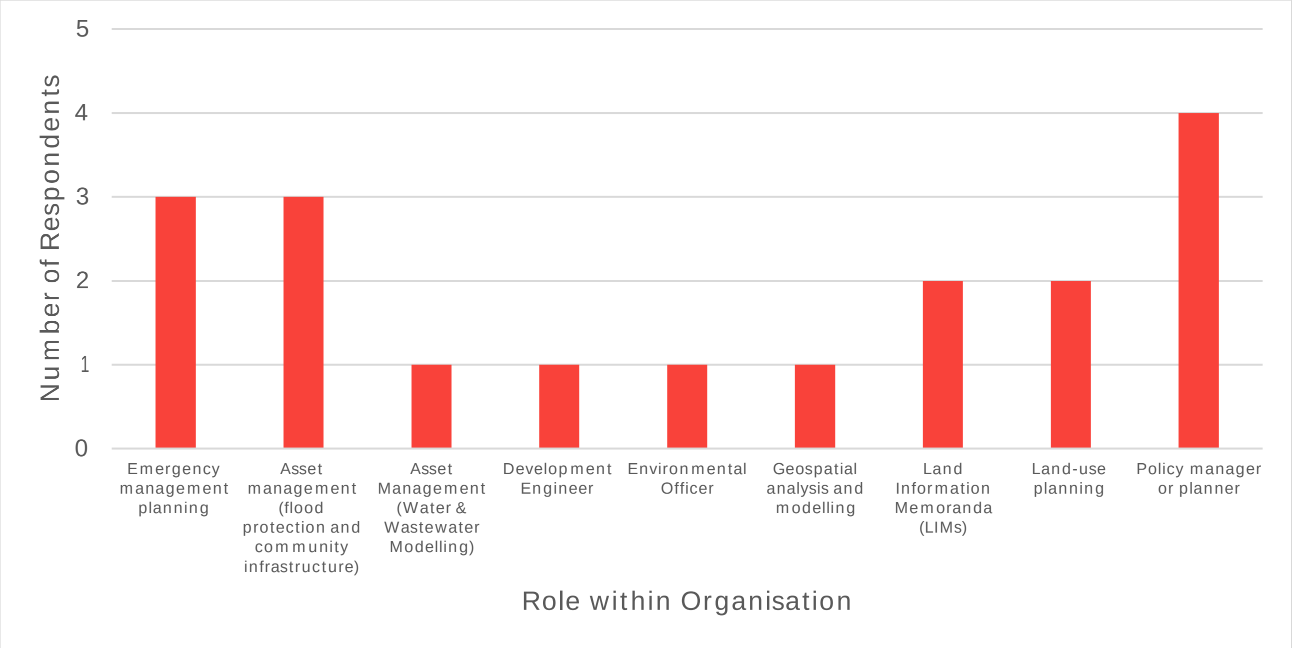

Figure A-0-1: Responses from Question 1: What is your role within your organization?

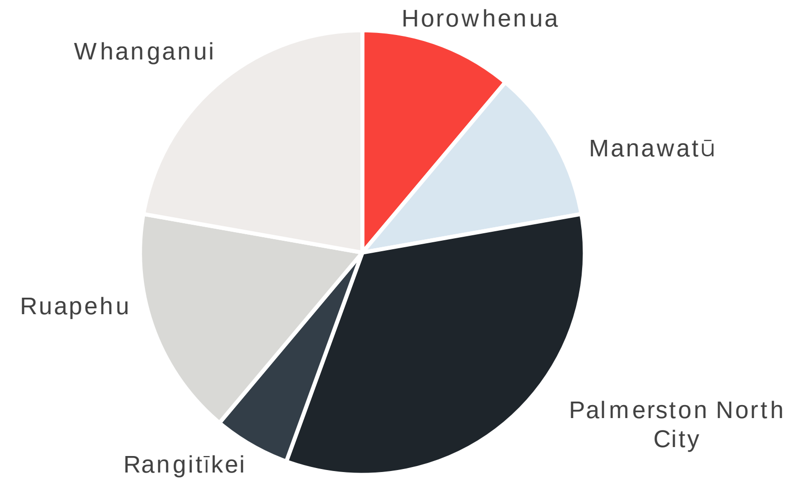

Figure A-0-2: Responses from Question 3: What district do you operate in? Note an extra response was emailed to WSP from the Tararua District.

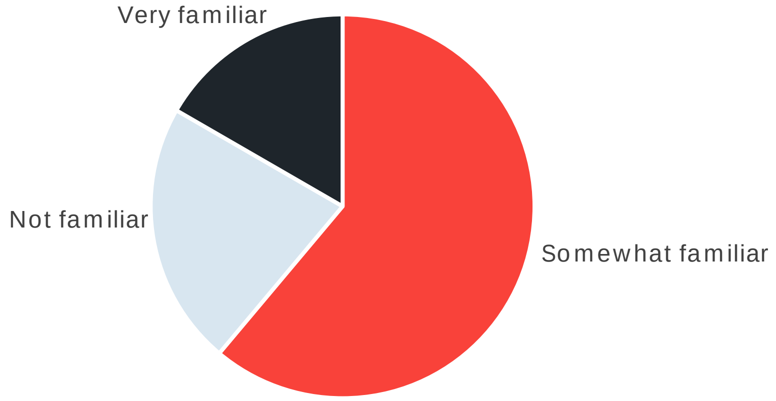

Figure A-0-3: Responses from Question 5 How familiar are you with HRC's flood mapping and modelling tools?

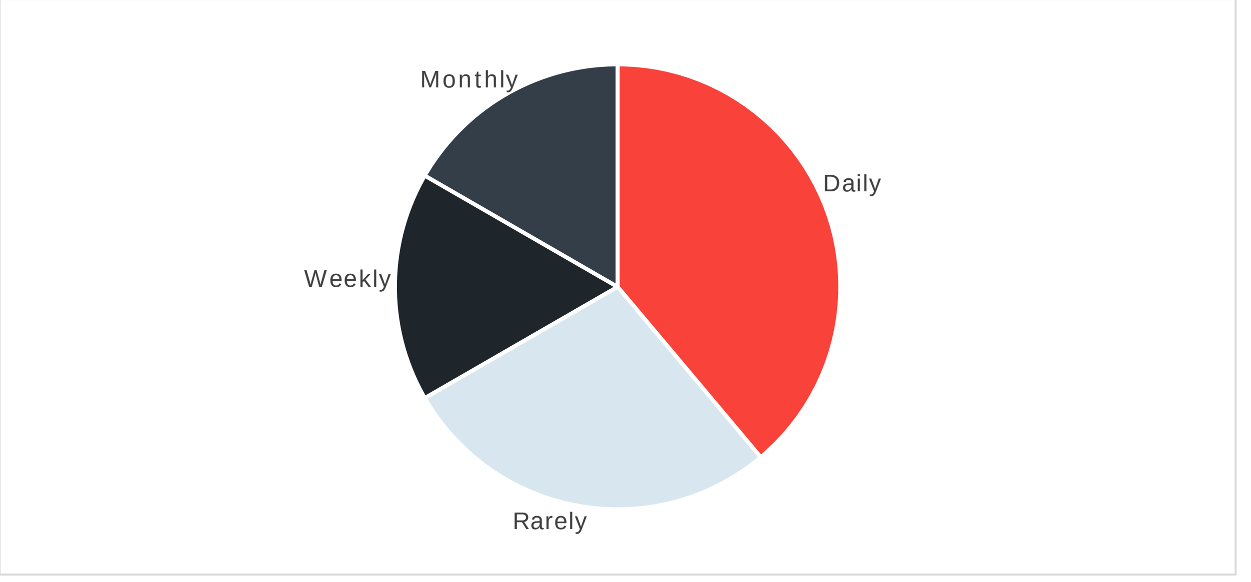

Figure A-0-4: Responses from Question 6: How frequently do you use HRC's flood mapping and modelling tools in your work (includes district advice service, HRC public map viewer or info held by TA GIS)?

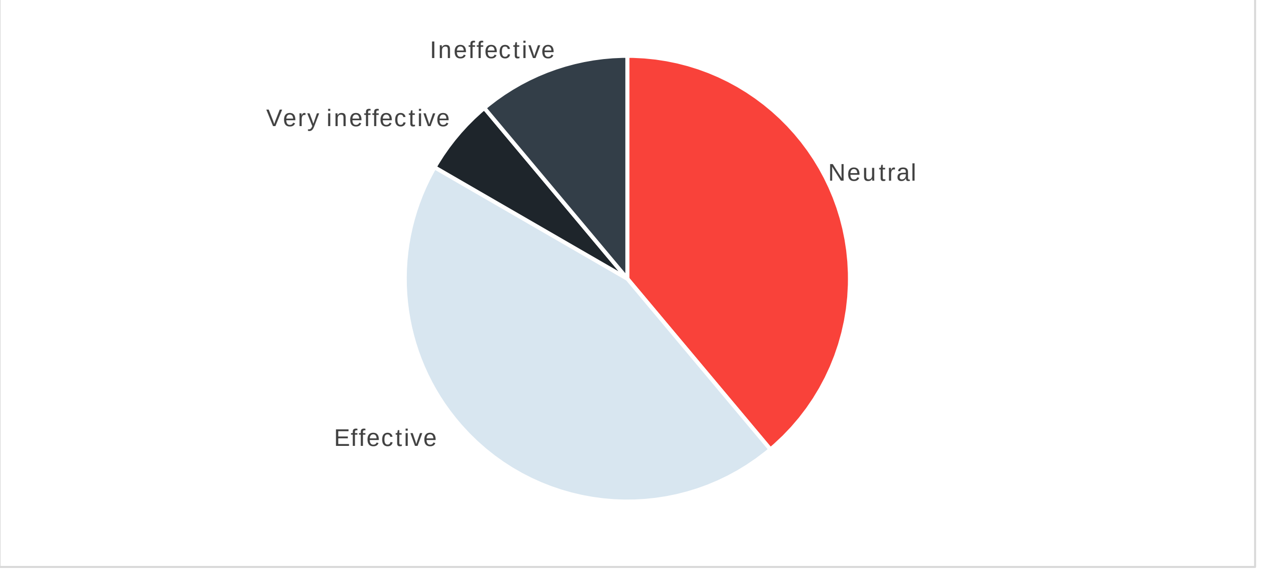

Figure A-0-5: Responses from Question 7: How effective do you find HRC's flood mapping and modelling tools in supporting your work?

Challenges users face when using existing mapping and modelling tools include:

1. **Coverage Limitations**:
   - o Limited to 1/100 and 1/200-year events and only on main rivers.
   - o Rural land not modelled, requiring site-specific assessments.
   - o Lack of coverage in some areas.
2. **Map Detail and Usability**:
   - o Basic maps without aerial imagery, making it hard to use landmarks or understand topography.
   - o Inability to search for specific addresses.
   - o Lack of functionality and accuracy due to the scale of mapping.
3. **Awareness and Understanding**:
   - o Lack of awareness about the available outputs from flood mapping tools.
   - o Uncertainty about whether the tools being used are the correct ones.
4. **Accuracy and Interpretation**:
   - o Predictions can be inaccurate.
   - o District Advice responses are more useful for interpreting information.
   - o Issues with accuracy when using flood modelling as an overlay in GIS systems.
5. **Technical Limitations**:
   - o Inability to enquire about levels and how tailwater levels interact with city-wide models.
   - o Problems with the accuracy of overlays due to topography.
6. **General Feedback**:
   - o Some users have no problems.
   - o Interest in learning more about the tools and using them as needed.

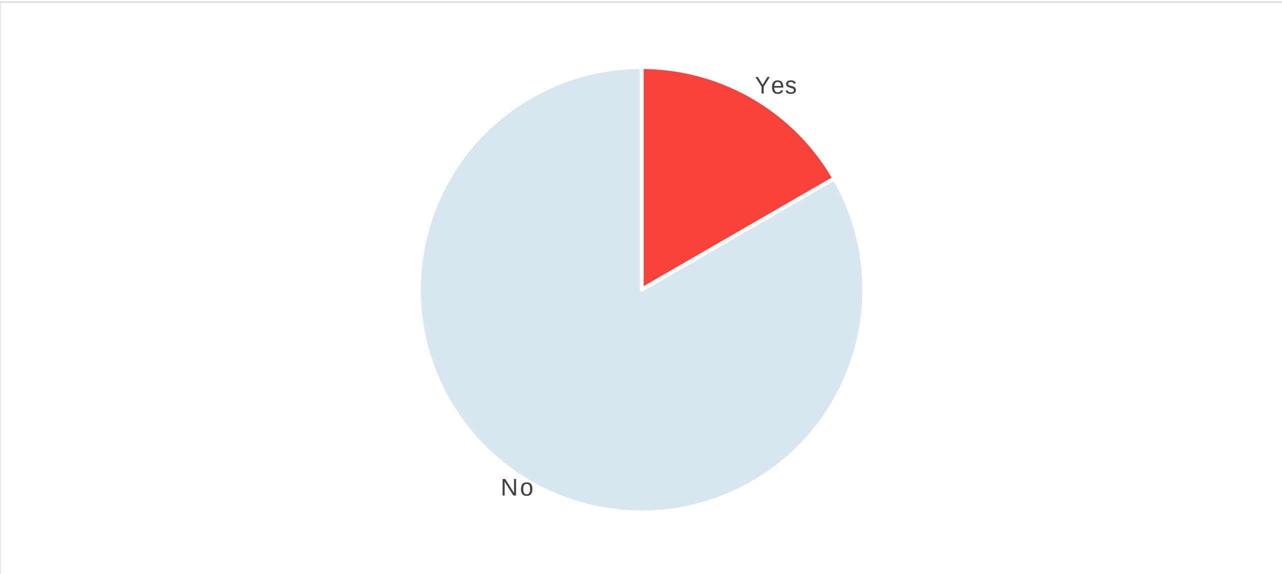

Figure A-0-6: Responses from Question 9: Have you participated in any workshops or training sessions on HRC's flood mapping and modelling tools? (this does not include Fridays use case workshop). All respondents who had attended any workshops or training sessions found them to be useful.

Figure A-0-7: Responses from Question 11: Do you use flood models and/or maps?

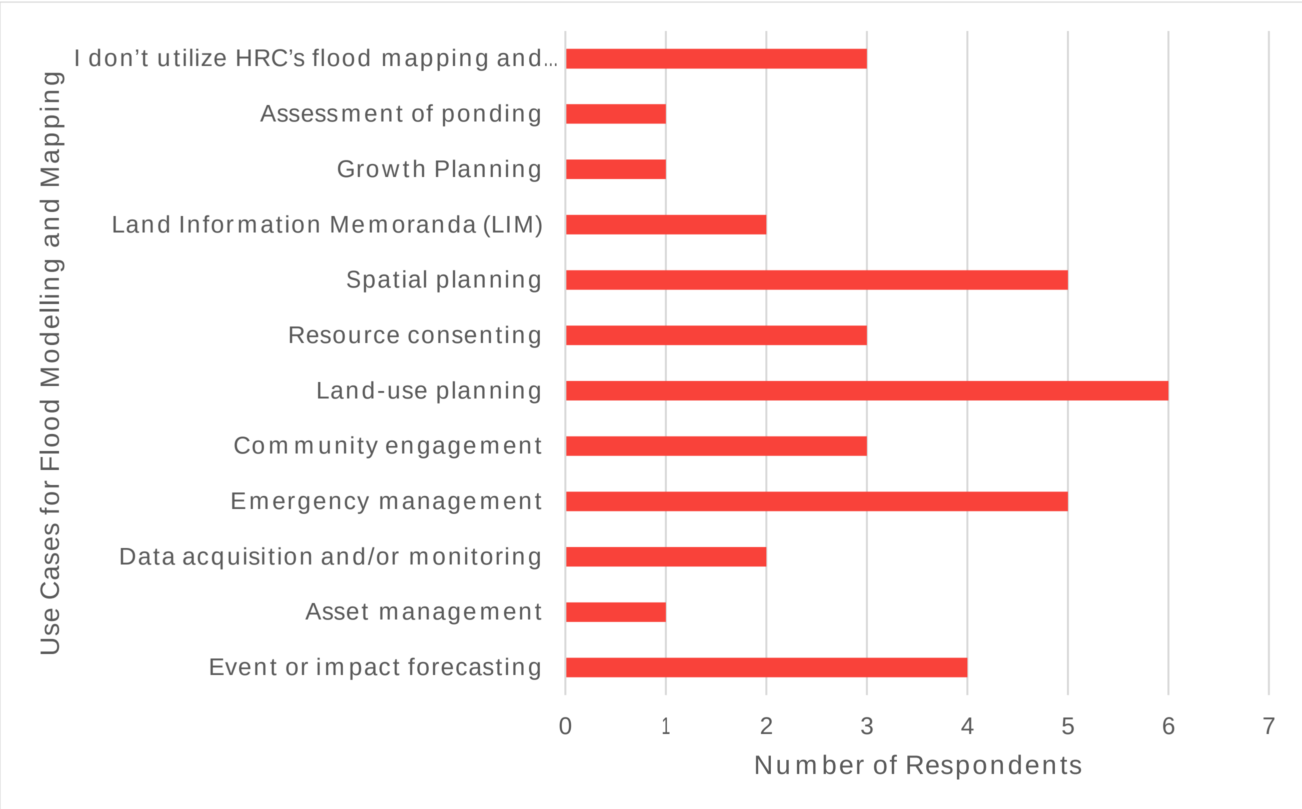

Figure A-0-8: Responses adapted from Question 12: Which of the following use cases do you utilise HRC's flood mapping and modelling for?

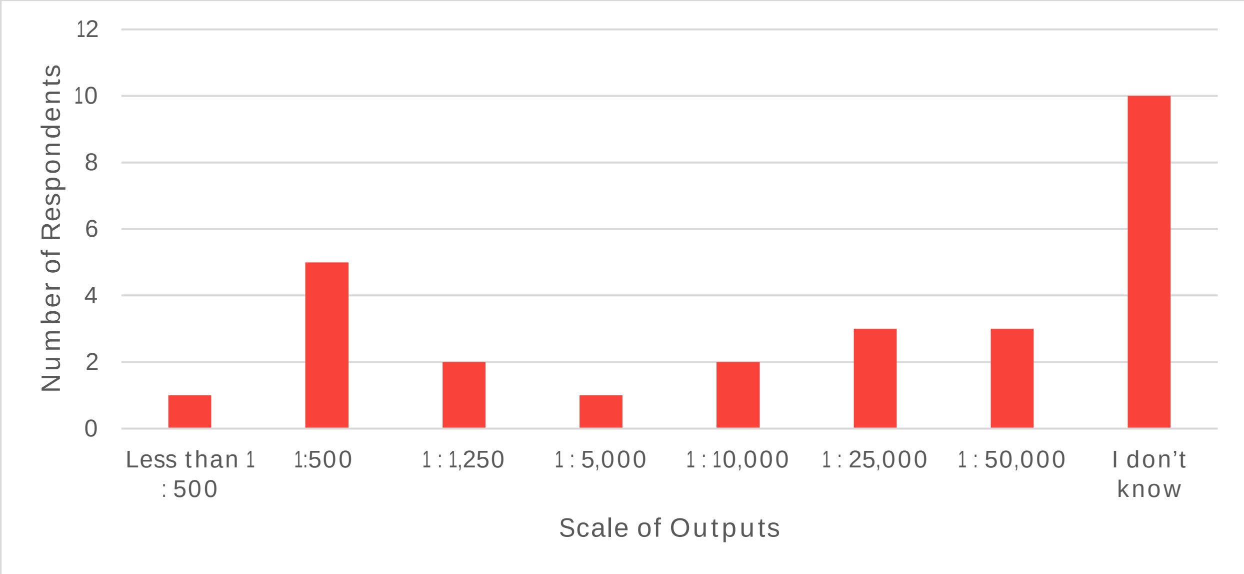

Figure A-0-9: Responses from Question 14: For your role, what scale of data do you require?

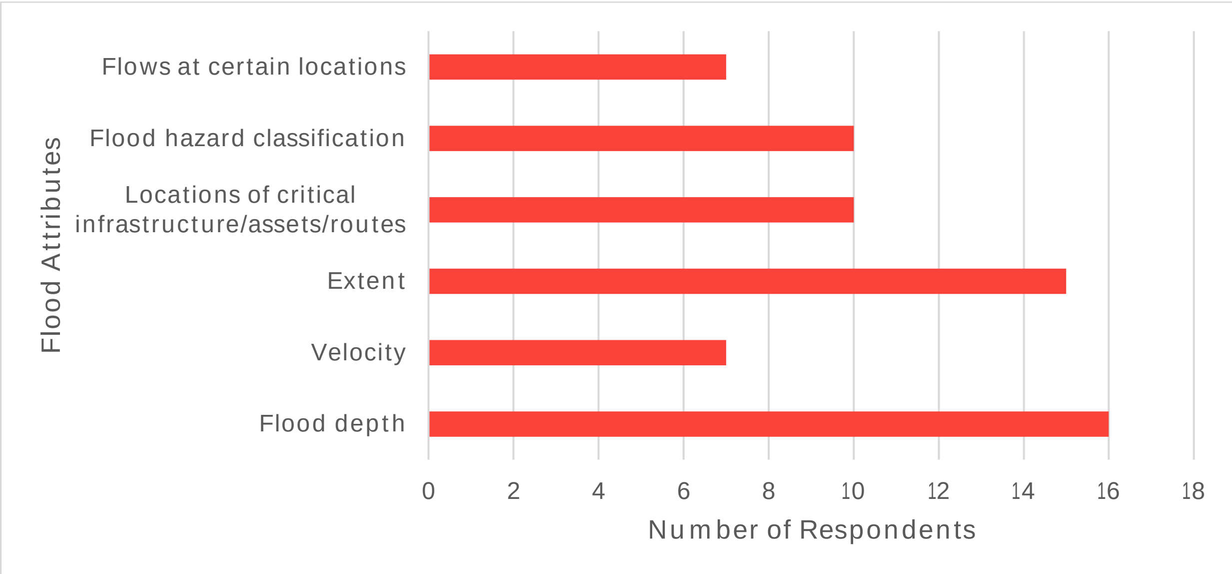

Figure A-0-10: responses from Question 16: What attributes do you require for your flood maps?

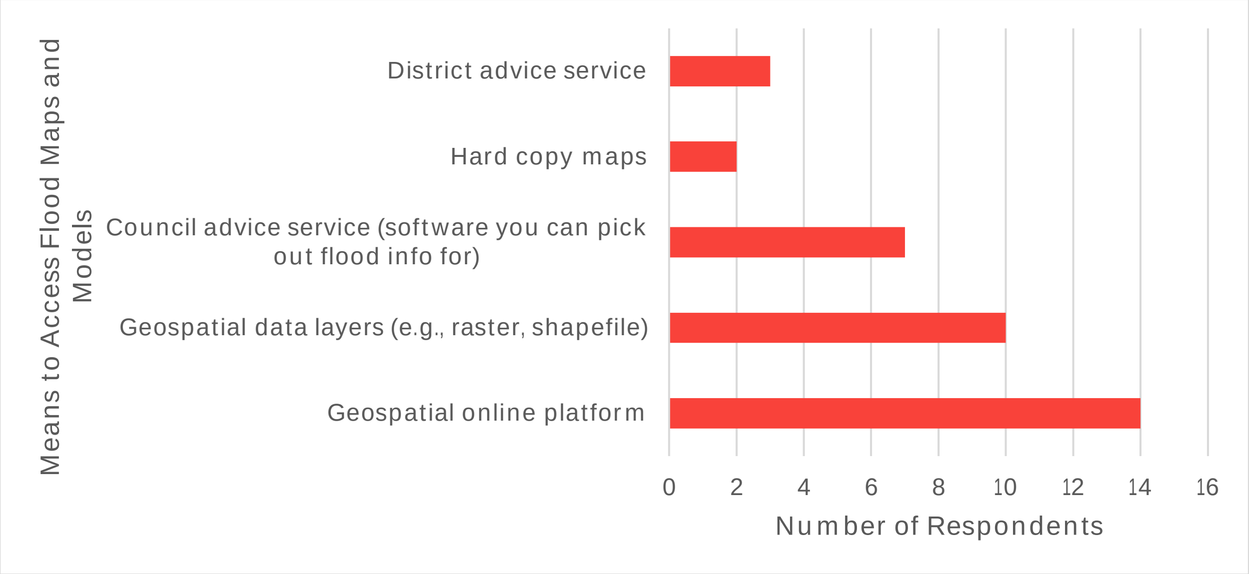

Figure A-0-11: Responses to Question 18: For the work you do, what would be the best means to access flood maps and/or models?

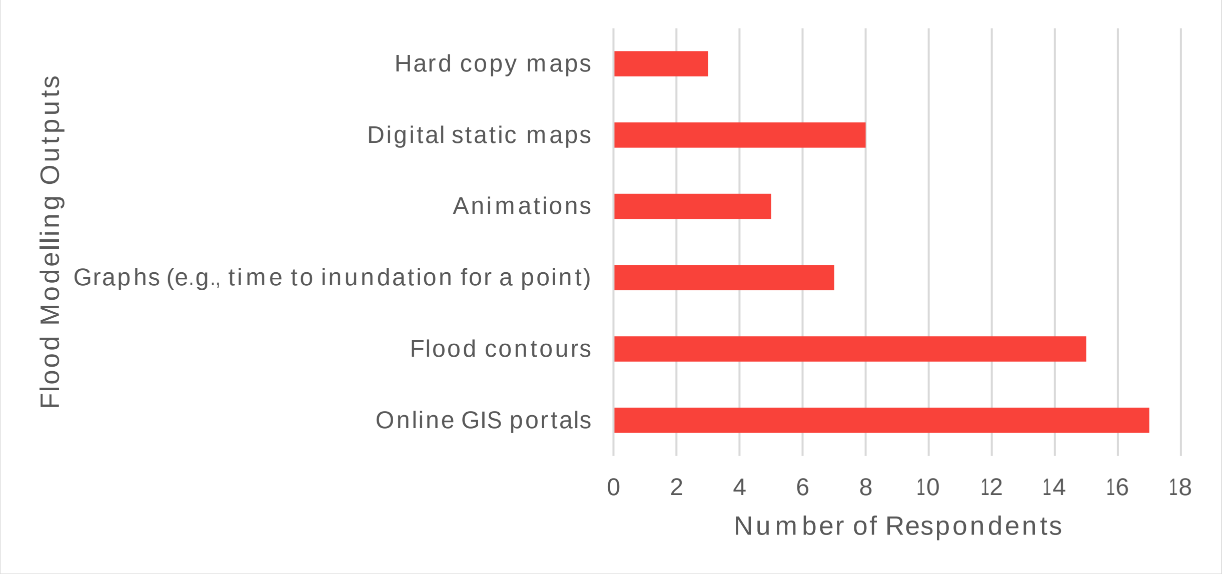

Figure A-0-12: Responses to Question 20: What flood modelling outputs would be helpful in your role?

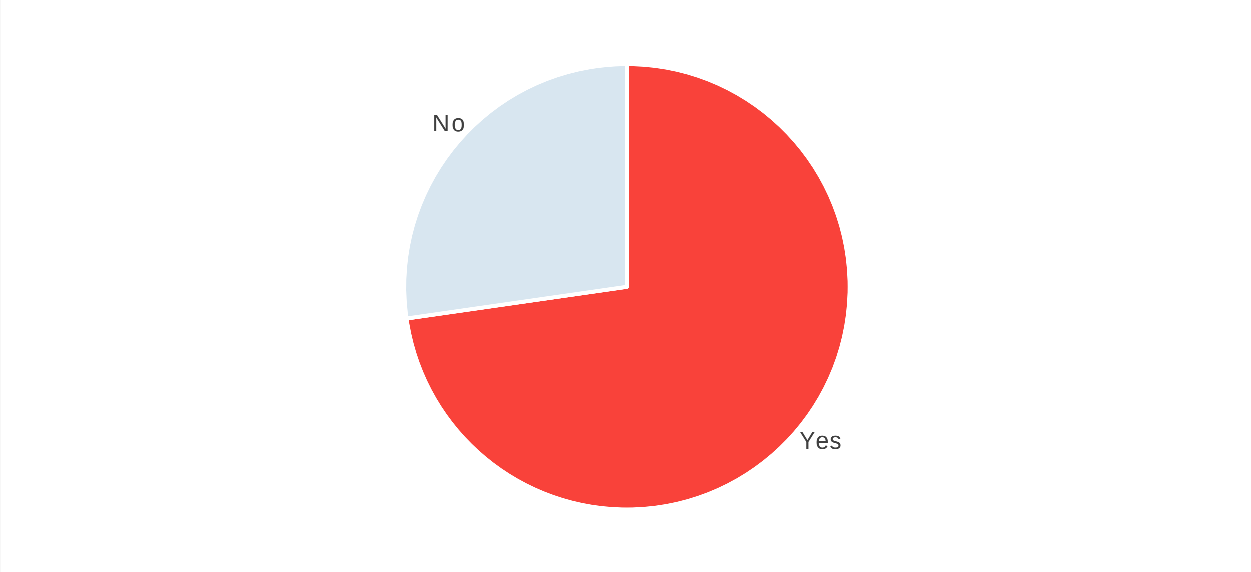

Figure A-0-13: Responses to Question 22: If the internet was not available, would you require access to flood map information or data to perform your role?

Respondents provided a range of suggestions aimed at improving usability, accuracy, and accessibility. Key improvements are summarised below:

1. **Enhanced Hazard Mapping**:
    - Include overspec hazard mapping for larger events (e.g., 1/500-year events) to aid in planning and response.
    - Overland flow maps for each District to support neighbouring districts and predict localized flooding.
2. **Improved Map Details and Functionality**:
    - Ability to change the base map for better property details.
    - Zoom in closer to properties and show property boundaries.
    - Ensure address search is limited to New Zealand addresses.
    - Show aerial imagery and land contours.
    - Allow users to query the data from the map or provide cross-sectional profiles.
3. **Increased Coverage**:
    - Map all areas, including those currently not covered.
    - Provide results or outputs for all scenarios.
    - Increased coverage to include more detailed local areas.
4. **Data Availability and Integration**:
    - Availability of data on online portals for streaming and download.
    - Integration with other Territorial Authority (TA) data.
    - Sharing of data before, during, and after events.
    - Ensure the system works with current systems for integrated and up-to-date information.
5. **Search Functionality**:
    - Ability to search for specific addresses.
6. **Training and Support**:
    - Training for users and support for questions.
    - Portal to leave questions.
    - Training for those unfamiliar with existing tools.
7. **Policy and Classification**:
    - Flood classification against policy objectives.

8. **Flood Modelling**:
    - Detailed modelling for specific areas like the lower Manawatu.
    - Flooding and ponding depths at a scale that individual lots (1:1250) can be assessed.
    - Development of flood models for currently unmodelled rivers and streams
9. **Modelling Approach**:
    - Knowledge of modelling approach including rainfall data inputs, modelling confidence and software used.
10. **Documentation and Interpretation**:
    - Limitations document to assist with interpreting information.
11. **General Feedback**:
    - Some respondents had no suggestions or did not use the tools enough to know.
    - Some were unsure or had no opinion.

Additional features respondents would like to see within the tools include:

1. **Training and Familiarity with Tools**:
    - Provide training for using the tools
2. **Data Accessibility and Usability**:
    - Allow users to query the data from the map or provide cross-sectional profiles.
    - Provide overland flow maps for each district to help predict localized flooding.
    - Provide data on the online portal, both streaming and download service.
3. **Documentation and Interpretation**:
    - Provide a document with limitations to assist with interpreting information.

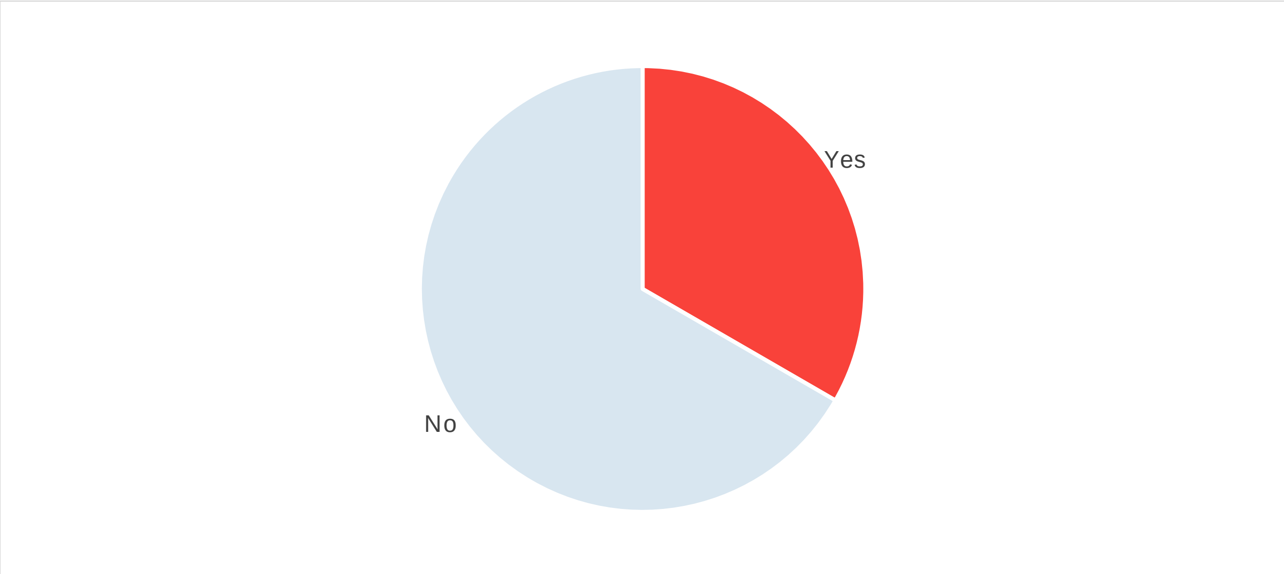

Figure A-0-14: Responses to Question 25: Do you use the district advice service?

Respondents were asked to provide improvements for the District Advice Service:

1. **Audience/User of Service**:
    - Answers are worded for property owners and could be tailored for TA's and focus on the information required.
2. **Information Provided**:
    - Provide less general information and more information that is specific to the property.

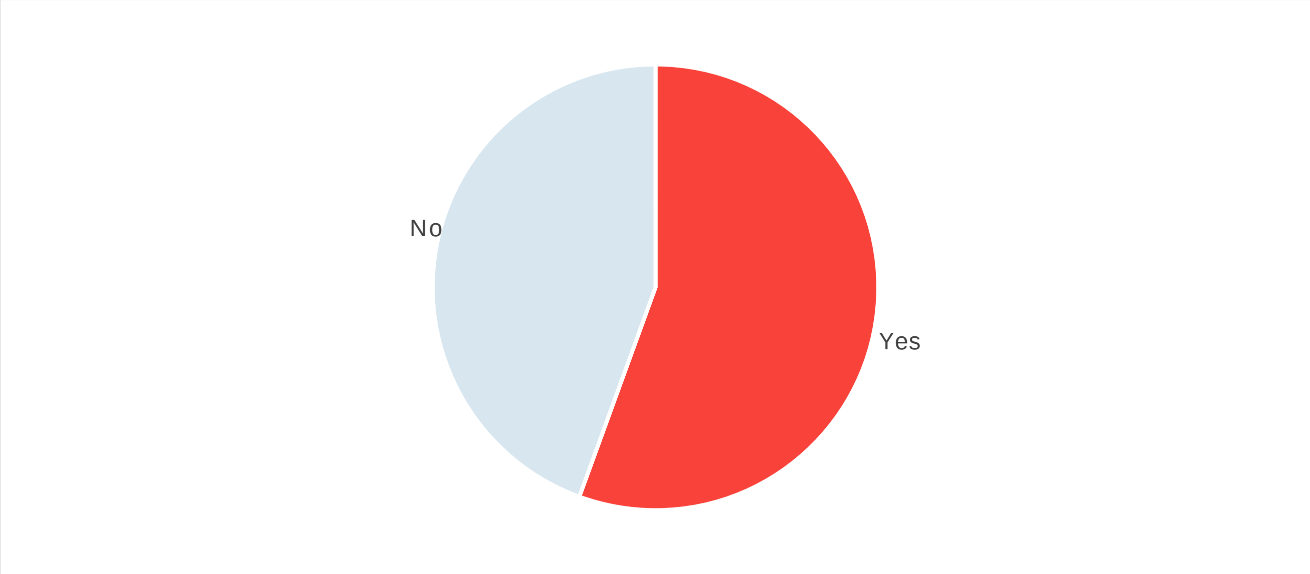

Figure A-0-15: Responses to Question 27: Are you able to sufficiently interpret flood information to be used in your role? Of all respondents, 22% would require decision support tools (note this includes respondents who selected 'Yes' and 'No' to Question 25).

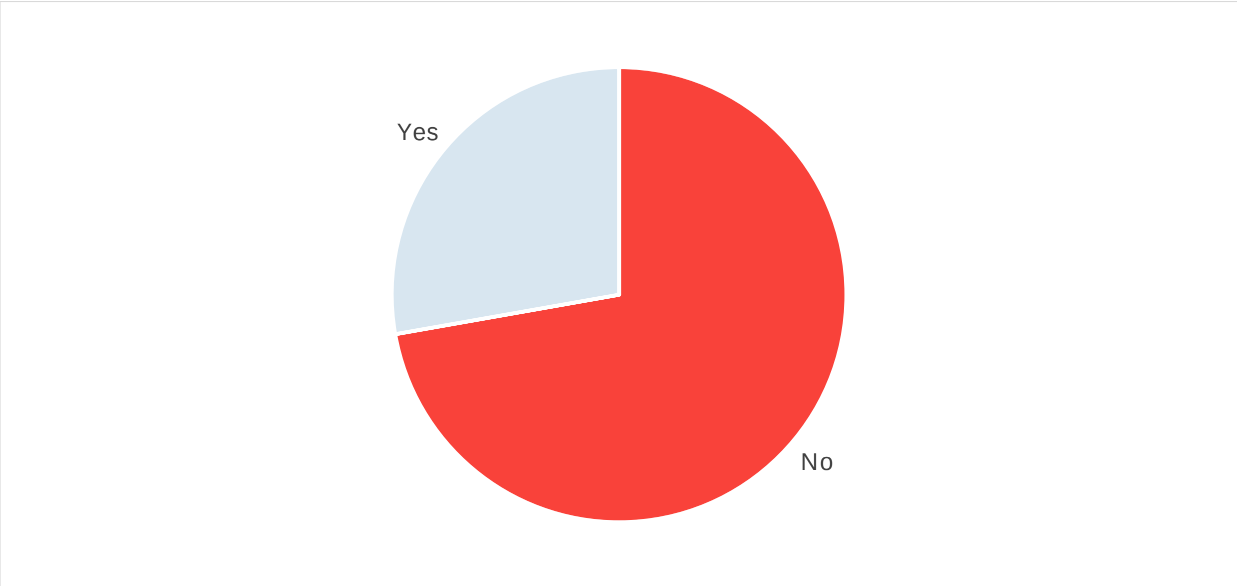

Figure A-0-16: Responses to Question 29: Is there adequate flood risk guidance available for you to use flood maps in your role?

Figure A-0-17: Responses to Question 30: Would regional or national standardisation of flood risk guidance assist you with using flood maps?

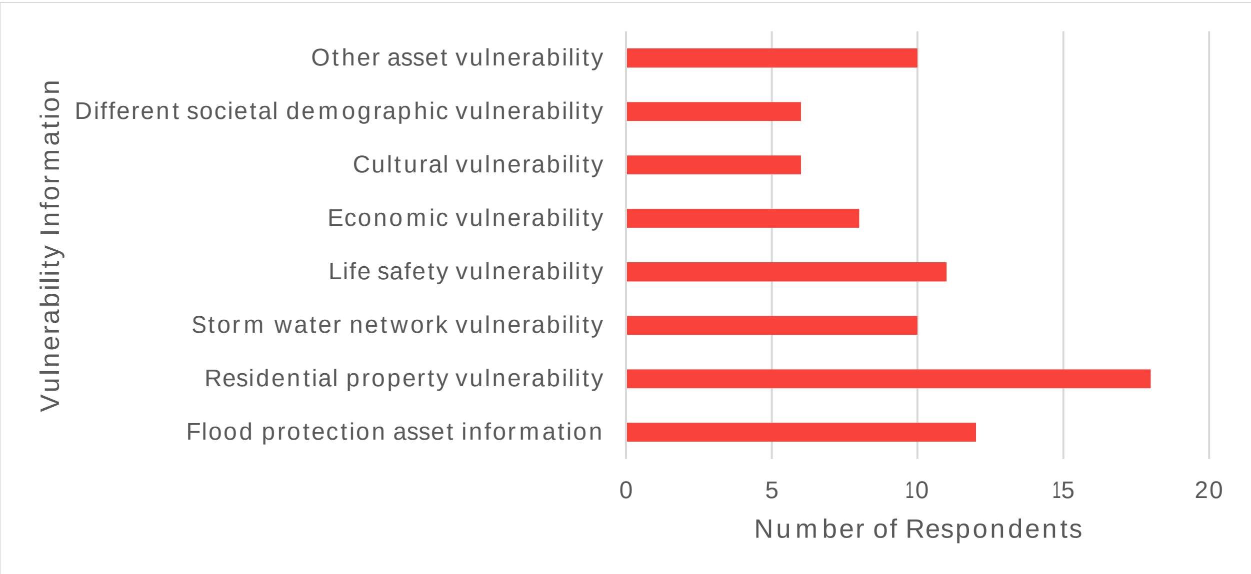

Figure A-0-18: Responses to Question 31: What flood vulnerability information would be useful to manage flood risk in your role?

Respondents were given the opportunity to provide comments or feedback regarding HRC's flood mapping and modelling tools. These are summarised below:

1. **Modelling Approach**:
   - Knowledge of modelling approach including rainfall data inputs, modelling confidence and software used.
   - Type of rainfall data utilised (synthetic, design or actual).
2. **Areas with flood modelling**:
   - Complete additional modelling for unmodelled rivers and streams such as the Rangitikei River and Pourewa Stream.
   - Improve extent of data.
3. **Flooding/Ponding**
   - Improve clarity and level of detail for flooding and ponding within modelling outputs.

Respondents were asked to provide feedback on the proposed Regional Flood Modeling Framework:

1. **General Usefulness**:
   - The tools are considered useful for emergency and recovery planning.
   - The framework is seen as a good starting point and easy to follow.
   - The approach and layout of the table with specific guidance and intended uses for assessment are appreciated.
2. **Preferred Levels for Planning**:
   - Level C is recommended for policy and land use planning, especially for key towns and higher-risk settlements.
   - Level D is also seen as very useful for Territorial Authorities and for building site considerations.
3. **Concerns and Limitations**:
   - There is concern about the lack of LiDAR data for certain districts, which limits flood modelling and decision-making.

APPENDIX B – USE CASE PERSONAS

Regional District Advice

Overview:

The District Advice team provide natural hazard and One Plan advice to members of the public for property developments as well as information for prospective property purchases, insurance matters and land valuation assessments. They provide formation and recommendations to territorial authorities to assist them in their decision-making with respect to subdivisions/land use and building consents. They also provide information to territorial authorities for district planning (such as growth planning and rezoning) and provide property related natural hazard information for Land Information Memorandums. District Advice also manage the Building Act requirements for the construction and alterations of large dams. This includes the implementation of the new dam safety regulations that ensure dams are well operated, maintained, and regularly monitored so the potential impact of dam incidents and failures are reduced.

Use of Flood Modelling and Mapping Linked to Regional Flood Risk Assessment:

Level of Detail	Key Features of Model	Uses for Persona
Level A – Basic Desktop Assessment	Regional model Validated against extents Structures/assets identified from LiDAR Calibration/sensitivity includes check of selected locations against historic records	Maps developed at this scale are suitable to provide an indicative regional summary of areas potentially exposed to flooding. They can be provided in the public viewer but should not be viewed at site specific scales. Maps to be provided for District Advice should be in line with HRC's One Plan (1 in 200-year flood event)
Level B – Basic Validated Desktop Assessment	Regional model Validated against extents Structures/assets identified from lidar Calibration/sensitivity includes check of selected locations against historic records	Maps developed at this scale have a higher resolution than Level A mapping. Level B maps may have been refined around flood extent boundaries using empirical observations such as photographs or historical mapping. They can be provided in the public viewer but should not be viewed at site specific scales. Maps to be provided for District Advice should be in line with HRC's One Plan (1 in 200-year flood event)
Level C – Localised Catchment Model	Detailed catchment model Includes some assets and streams Sensitivity testing. Validation of model parameters to extents and some levels. Starting to look at gauge calibration.	Maps produced at this level can be used by TAs for the provision of hazard and property information to support subdivision consenting. Catchment level mapping should be displayed at a suitable scale based on the resolution of the model in a public viewer.
Level D –Specific Detailed Assessment	Site specific model Includes all assets/structures Often a property/parcel level Sensitivity testing. Calibration at gauges for multiple events and comparison with historic records.	Modelling at this level can be used for the creation of site-specific map information to be used by TAs to support building consents. Detailed modelling produced at this level can be displayed at site-specific scales. Considered the most appropriate scale for mapping in LIMs.

Output Requirements:

Public Facing GIS Viewer – Flood extents for a 1 in 200-year flood event.

Internal GIS Viewer – Flood extents, hazard, velocity, and depths for a range of scenarios.

Paper Maps and Actions Plans – Tangible resources for decision making during events.

Key Considerations:

Vulnerability and Consequences – Link flood levels to potential consequences displayed as a range – this is crucial for informed planning.

Public Communication – Outputs should convey qualitative risk levels to be accessible by the general public.

Public Interface – The District Advice role acts as the primary interface between the Horizons Maps | Public Viewer and the Council's internal GIS viewer.

Emergency Management

Overview:

The Emergency Management persona utilises flood modelling and mapping to enhance all phases of emergency management: Reduction, Readiness, Response, and Recovery. Under the Civil Defence and Emergency Management Act, regional councils have responsibilities for planning and operational roles during emergencies. Up-to-date flood modelling is an important resource to inform effective planning and operational flood response activities.

Use of Flood Modelling and Mapping Linked to Regional Flood Risk Assessment:

Level of Detail	Key Features of Model	Uses for Persona
Level A – Basic Desktop Assessment	Regional model Validated against extents Structures/assets identified from LiDAR Calibration/sensitivity includes check of selected locations against historic records	Maps developed at this scale are suitable to provide an indicative regional summary of areas potentially exposed to flooding. They can be used for readiness and recovery planning, and response evaluation and assessment They may be helpful to assist with community engagement.
Level B – Basic Validated Desktop Assessment	Regional model Validated against extents Structures/assets identified from lidar Calibration/sensitivity includes check of selected locations against historic records	Maps developed at this scale have a higher resolution than Level A mapping. Level B maps may have been refined around flood extent boundaries using empirical observations such as photographs or historical mapping. Level B maps can be used for readiness and recovery planning, response evaluation and assessment. They can also help to inform contingency and evacuation planning.
Level C – Localised Catchment Model	Detailed catchment model Includes some assets and streams Sensitivity testing. Validation of model parameters to extents and some levels. Starting to look at gauge calibration.	Maps produced at this level can inform catchment scale assessments for readiness, contingency planning, and response evaluation and operational planning. Level C models are particularly useful to inform the development of community response plans.
Level D –Specific Detailed Assessment	Site specific model Includes all assets/structures Often a property/parcel level Sensitivity testing. Calibration at gauges for multiple events and comparison with historic records.	This level of assessment can be used for detailed response and recovery functions during flood event.

Output Requirements:

GIS Datasets – providing visual representations of flood extents for training exercises.

GIS Viewer – interactive tools with visuals of floods, attributes and potential consequences for real-time data analysis.

Hard-Copy Maps and Actions Plans – tangible resources for decision making during responses.

Event Animations – visual aids to illustrate flood scenarios and impacts.

Key Considerations:

Vulnerability and Consequences – link flood levels to potential consequences displayed as a range – this is crucial for informed planning.

Public Communication – outputs should convey qualitative risk levels to be accessible to the general public.

Critical Assets – focus on mapping key infrastructure such as communication, roads, power stations, marae, schools and hospitals.

Educational Tool – flood maps serve as vital education resources to help the public understand flood risk.

Asset Management

Overview:

The Asset Manager is responsible for utilising flood modelling and mapping to identify risks and plan for future upgrades and new capital works within the Council. This role focuses on understanding the level of service of assets during flood events and mitigating the worst physical and financial losses. The information is typically kept internal and is crucial for strategic planning, infrastructure upgrades, and developing business cases for government funding.

Use of Flood Modelling and Mapping Linked to Regional Flood Risk Assessment:

Level of Detail	Key Features of Model	Uses for Persona
Level A – Basic Desktop Assessment	Regional model Validated against extents Structures/assets identified from LiDAR Calibration/sensitivity includes check of selected locations against historic records	Maps developed at this scale are suitable to provide an indicative regional summary of areas potentially exposed to flooding. They are suitable for high level asset management on a regional scale and can inform long-term planning. They can be used for regional assessments of assets levels of service and to communicate renewal and upgrade planning.
Level B – Basic Validated Desktop Assessment	Regional model Validated against extents Structures/assets identified from lidar Calibration/sensitivity includes check of selected locations against historic records	Maps developed at this scale have a higher resolution than Level A mapping. Level B maps may have been refined around flood extent boundaries using empirical observations such as photographs or historical mapping. They can include specific information about the impacts on flood extents from operating specific asset types e.g floodgates. They are also useful to inform regional assessments for long-term planning.
Level C – Localised Catchment Model	Detailed catchment model Includes some assets and streams Sensitivity testing. Validation of model parameters to extents and some levels. Starting to look at gauge calibration.	Maps produced at this level can inform asset management at a catchment or flood scheme level to understand levels of services and planning of infrastructure upgrades and investment. They can also be used for strategic catchment and infrastructure planning.
Level D –Specific Detailed Assessment	Site specific model Includes all assets/structures Often a property/parcel level Sensitivity testing. Calibration at gauges for multiple events and comparison with historic records.	Modelling and mapping at this level can be used for detailed design of flood protection infrastructure including an understanding of asset levels of services. They can be used to inform operational decision-making for specific assets during flood events.

Output Requirements:

Internal GIS Viewer – Integration of flood assets with different flood events.

Geospatial Viewer for TA's – Includes flood depth, velocity and extent all integrated with critical infrastructure and assets.

Key Considerations:

Risk Identification and Planning – Use flood modelling and mapping to identify key areas for upgrades and new capital works.

Service Level Assessment – Understand and assess the level of service of assets during flood events, ensuring a range of scenarios and Annual Recurrence Intervals (ARIs) are considered.

Strategic Planning – Incorporate long-term changes in catchment areas (e.g., 30 years out) into planning processes.

Infrastructure Planning – Utilise modelling outputs for planning infrastructure upgrades, identifying new capital works, and preparing business cases for government funding.

Visual Mapping – Ensure mapping outputs are visual and clearly show asset locations, ponding areas, and designated spillways to prevent future development in flood-prone areas.

Planning

Overview:

The Planner specialising in land use and spatial planning is responsible for developing and implementing plans and policies that guide the use of land and the arrangement of physical spaces within a community. This role ensures that land use is sustainable, efficient, and meets the needs of the population while considering environmental, social, and economic factors. The Planner uses flood modelling and mapping to inform district planning, ensuring compliance with the Resource Management Act (RMA) and promoting safe and sustainable development by avoiding or mitigating flood hazards. At a Territorial Authority level this can also include resource consenting. Regional Council Planners use flood modelling and mapping to provide advice on development proposals and for submissions to district plans, considering the requirements of the regional policy statement and plan.

Use of Flood Modelling and Mapping Linked to Regional Flood Risk Assessment:

Level of Detail	Key Features of Model	Uses for Persona
Level A – Basic Desktop Assessment	Regional model Validated against extents Structures/assets identified from LiDAR Calibration/sensitivity includes check of selected locations against historic records	Maps developed at this scale are suitable to provide an indicative regional summary of areas potentially exposed to flooding. They can be useful to inform the development of regional policies and plans. Due to the indicative nature of low-resolution flood extent boundaries, Level A maps are not recommended for site specific planning decision making.
Level B – Basic Validated Desktop Assessment	Regional model Validated against extents Structures/assets identified from lidar Calibration/sensitivity includes check of selected locations against historic records	Level B maps may have been refined around flood extent boundaries using empirical observations such as photographs or historical mapping. As there is more confidence in flood extent boundaries, Level B mapping may be used for detailed district-scale planning or inform policy adjustments. In some instances, they can be used for community and suburb scale planning to identify locations that may require further investigation.
Level C – Localised Catchment Model	Detailed catchment model Includes some assets and streams Sensitivity testing. Validation of model parameters to extents and some levels. Starting to look at gauge calibration.	Maps produced at catchment level can be used for applied planning at regional or catchment scales. Use cases can include informing plan changes, for regional policy setting, urban growth planning and land use planning. Level C mapping can be useful for community adaptation planning by informing option assessments such as cost-benefit or Dynamic Adaptive Policy Pathways (DAPP) analyses.

Level D –Specific Detailed Assessment	Site specific model Includes all assets/structures Often a property/parcel level Sensitivity testing. Calibration at gauges for multiple events and comparison with historic records.	Site-specific flood modelling and mapping can be used for detailed site planning and development control, urban growth planning, and land use planning. This level of detail is suitable for resource consenting, flood mitigation options analysis, and detailed design of mitigation structures for catchment/community planning.

Output Requirements:

Internal GIS Viewer: Integration of flood risk data with decision support tools for planning.

Public Mapping Outputs: Clear visualization of flood extents, typically at 0.5% AEP. Future RMA direction may require this to shift to 1% AEP with climate change considerations.

Key Considerations:

Strategic Planning and Risk Identification: Incorporate long-term flood risk projections into district and regional plans, considering climate change impacts and inform land use decisions.

Policy and RMA Compliance: Ensure that planning meets the requirements of the RMA for safe and sustainable development.

Conflict Resolution: Address potential conflicts between regional flood risk assessments and local district advice.

Public Communication: Clearly communicate flood risk information to the public, ensuring transparency and awareness.

Investigations and Design

Overview:

The Investigations and Design team offers a range of technical modelling and engineering services to both internal and external clients. Their expertise includes conducting hydrological and hydraulic modelling, offering specialised advice on complex modelling aspects such as assumptions, input parameters, scenarios, calibration, validation, and interpretation of outputs. They also design and review flood protection scheme assets, develop engineering solutions for these assets, and manage the entire lifecycle of modelling contracts from commissioning to finalisation.

Use of Flood Modelling and Mapping Linked to Regional Flood Risk Assessment:

Level of Detail	Key Features of Model	Uses for Persona
Level A – Basic Desktop Assessment	Regional model Validated against extents Structures/assets identified from LiDAR Calibration/sensitivity includes check of selected locations against historic records	Interpretation and review of flood hazard maps to advise and support other personas such as spatial and land use planning.
Level B – Basic Validated Desktop Assessment	Regional model Validated against extents Structures/assets identified from lidar Calibration/sensitivity includes check of selected locations against historic records	Interpretation and review of flood hazard maps to advise and support other personas such as spatial and land use planning.
Level C – Localised Catchment Model	Detailed catchment model Includes some assets and streams Sensitivity testing. Validation of model parameters to extents and some levels. Starting to look at gauge calibration.	Applied asset management at a catchment and scheme level to understand levels of services and planning of infrastructure upgrades and investment within a flood protection scheme.
Level D –Specific Detailed Assessment	Site specific model Includes all assets/structures Often a property/parcel level Sensitivity testing. Calibration at gauges for multiple events and comparison with historic records.	Detailed design and review of flood protection infrastructure including understanding levels of services of assets. This level of modelling and mapping is used to provide engineering solutions for specific flood protection assets.

Output Requirements:

Modelling Reports and Outputs - providing technical advice regarding complex modelling reports and outputs to other functions within council.

Geospatial Data – Raster and shapefile layers of flood hazard to be included to support other functions of council (e.g., modelled scenarios of 200yr ARI flood to support decision making on proposed works).

Design and Maintenance: Ensure that flood infrastructure is designed and maintained to mitigate flood risks effectively.

Key Considerations:

Modelling services – This use case provides modelling services to internal and external clients, with some outputs used for public facing purposes.

Territorial Authority Land Information Memoranda (LIM)

Overview:

Under the Local Government Official Information and Meetings Act 1987 (LGOIMA) Territorial Authorities are required to provide a Land Information Memoranda (LIM) for individual properties to potential buyers or sellers of a property. The LIM provides a comprehensive report including historic and current data pertaining to consents, drainage, hazards, rates, and land features specific to the property. For flood mapping and modelling, the TA role provides district advice that is site specific to the application of flood hazard models.

Use of Flood Modelling and Mapping Linked to Regional Flood Risk Assessment:

Level of Detail	Key Features of Model	Uses for Persona
Level A – Basic Desktop Assessment	Regional model Validated against extents Structures/assets identified from LiDAR Calibration/sensitivity includes check of selected locations against historic records	Maps developed at this scale are suitable to provide an indicative regional summary of areas potentially exposed to flooding. While the existence of Level A mapping can be identified on a LIM, the uncertainty associated with flood extent boundaries can lead to individual properties being identified as erroneously exposed. Maps developed at this scale could possibly be applied to individual site locations provided sufficient detail and context is provided.
Level B – Basic Validated Desktop Assessment	Regional model Validated against extents Structures/assets identified from lidar Calibration/sensitivity includes check of selected locations against historic records	Level B maps may have been refined around flood extent boundaries using empirical observations such as photographs or historical mapping. Therefore, there may be more confidence in map extents that have had refinement in specific locations. To confidently apply Level B mapping to individual LIMs would require additional validation of model extents. More detailed resolution mapping is preferred for LIMs.
Level C – Localised Catchment Model	Detailed catchment model Includes some assets and streams Sensitivity testing. Validation of model parameters to extents and some levels. Starting to look at gauge calibration.	Level C catchment modelling can be identified on LIMs. These models are generally developed for other use cases e.g., flood protection design. Modelling at this scale is suitable provided calibration and mapping site validation is described in LIMs.
Level D –Specific Detailed Assessment	Site specific model Includes all assets/structures Often a property/parcel level Sensitivity testing. Calibration at gauges for multiple events and comparison with historic records.	Detailed site-specific flood mapping is recommended to be incorporated into Land Information Memoranda (LIM)

Output Requirements:

Geospatial Online Viewer – Flood extents and flood hazard classification.

District Advice Service – Flood information to provide information to public upon request.

Geospatial Data – Raster and shapefile layers of flood hazard.

Key Considerations:

Public Communication – Outputs should convey qualitative risk levels to be accessible to the general public. Outputs should also clearly communicate flood risk information to the public, ensuring transparency and awareness.

Public Interface – This use case acts as the interface between the flood modeling outputs and the public to assist in decision making.

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horizons

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