UNDERSTANDING THE PHYSICAL AND SYSTEMIC VULNERABILITIES IN INTEGRATED STOPBANK-DAM CATCHMENTS

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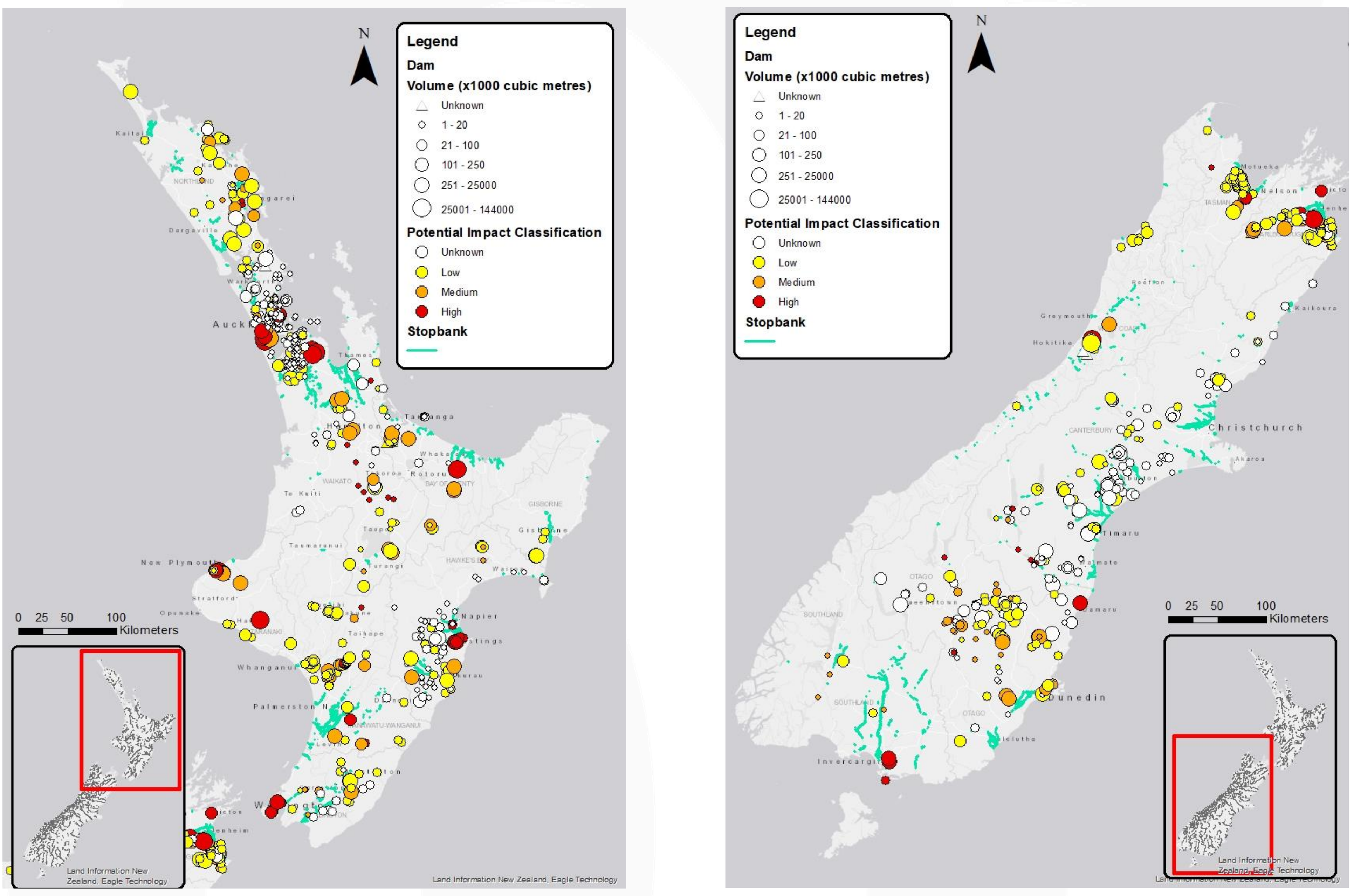
BACKGROUND

The use of flood protection strategies varies internationally based on different regions' hydrological, geomorphological, financial, social, and governance factors. The three main strategies employed within New Zealand are: (1) structural defences (2) planning measures to ensure people and infrastructure are out of harm's way, and (3) emergency management, including preparation (MfE, 2008). Despite the implementation of these strategies **there is, and always will remain, a flood risk** in some areas. It is therefore necessary to optimise funding to reduce flood risk in a cost-efficient manner that provides the greatest benefit.

Dams and stopbanks form a significant portion of our structural flood defences. Within the same catchments, dams and stopbanks are often constructed from similar local materials, however, the **geotechnical properties of these materials are often poorly characterised, poorly understood and/or poorly documented** (Blake et al., 2018; Crawford-Flett, Pascoal, & Wilson, 2018). These uncertainties which affect embankment performance are compounded due to now outdated practices during design and construction (Crawford-Flett & Haskell, 2016; Ericksen, 1986).

While the NZSOLD Dam Safety Guidelines provide performance criteria for dams, there is currently no equivalent for stopbanks. This can lead to **differences in levels of resilience provided by dams and stopbanks which may not be proportional to the relative importance of the structures.** In addition to this, single stopbank and dam elements may be managed by individual entities who may not understand the impact of a single structure in a system-wide context. This highlights that **a system-wide approach is necessary for effective flood management.**



Documented dams and stopbanks in New Zealand (Blake et al., 2018; Crawford-Flett, Pascoal, & Wilson, 2018)

This project aims to deepen the understanding of geomechanical and hydraulic vulnerabilities within integrated dam-stopbank flood protection systems. This will be achieved by conducting experimental overtopping tests on model dams and stopbanks. The project also aims to develop a framework to aid the identification of structures with potential weaknesses so that vulnerabilities within larger catchment systems may be addressed.

PROJECT SCOPE

This project aims **to reduce flood risk through improved system management by furthering the understanding of dam-stopbank interactions within the same catchment.** A comparative analysis of the various flood protection strategies (i.e. defences, town planning, minimum building elevations, warning systems, and disaster funds) will be undertaken to determine under what conditions they work effectively. Investment in **New Zealand's flood protection may have scope to be optimised** and lead to a more effective management strategy from this analysis.

Much of New Zealand's physical flood defence is reliant on embankment systems made up of individual stopbank and dam elements. **These systems are only as strong as their weakest elements** so it is critical to understand the factors that influence the failure modes of individual structures.

To this end, an **experimental programme will be undertaken to determine the relative influence of certain geotechnical and hydraulic parameters**, such as relative flow-embankment orientation, defect orientation, and soil collapsibility. This will lead to the **development of a scheme for prioritising parameters and defects based on the magnitude of their contribution to overtopping failure mechanisms.** Through this generic scheme, flood protection systems may be improved by better targeted investment and maintenance of individual embankment elements.

A broader framework for determining systemic vulnerabilities on a catchment scale will also be established. This will allow structures with potential geomechanical, hydraulic, or managerial vulnerabilities within larger systems to be identified and addressed. This will help to move the management of dams and stopbanks away from an individual element view to a broader system perspective.

Ultimately, this project aims to develop: (1) a deeper understanding of the importance of individual embankment elements, (2) a framework to identify "weak links" in stopbank-dam embankment networks, and (3) tools to prioritise maintenance and investment in embankment systems. **Ultimately, this project aims to move flood risk management towards a broader system-wide view** to improve resilience and safety in downstream communities.

Example of previous international overtopping lab experiment (Amaral, Caldeira, Viseu, & Ferreira, 2020)

OUTPUTS – WHAT DOES THIS MEAN FOR NEW ZEALAND

Technical community will benefit from New Zealand-focused experimental datasets concerning the relative risk of soil parameters and flow conditions to embankment resilience.

New Zealand hazard and embankment engineering communities will benefit from the creation of a generic vulnerability assessment framework to aid identification of potential "weak points" with systems.

Regional authorities & embankment owners will gain an improved nationwide understanding of favourable management decisions and recommendations to help inform optimal flood management investment.

Stakeholders will benefit from the improved management of embankment networks and therefore safer flood protection networks.

Rangataiki River flood wall breach in April 2017. (Chris McKeen, Fairfax New Zealand)

TIMELINE

Stage 1 – Flood Strategy Comparison – early 2021: Analysis of different international countries flood protection strategies and generalisations to determine under what condition strategies perform effectively

Stage 2 – Protection Optimisation – mid 2021: Investigation of New Zealand conditions to ascertain optimum flood protection strategies

Stage 3 – Laboratory Experiments - early 2022: Laboratory experiments to determine how various parameters and defects influence certain failure modes

Stage 4 – System Vulnerability Framework – late 2022: Framework to identify potential embankment vulnerabilities on a system scale based on geomechanical and hydraulic deficiencies

Stage 5 – Recommendations – early 2023: Recommendations for flood protection strategies in areas with identified potential vulnerabilities

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