

CASCADING FLOOD CONSEQUENCES OF DAM OPERATION AND STOPBANK BREACHES

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BACKGROUND & SCOPE

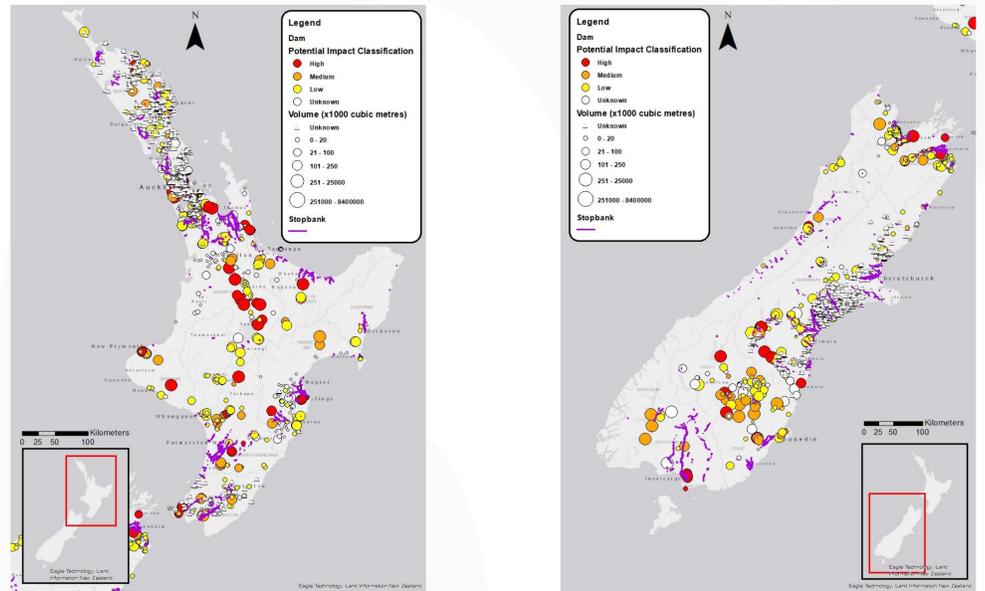
Dam operation upstream of stopbanks can present a cascading risk where dam outflow influences stopbank loading and the likelihood of breaching. Understanding how these structures interact enables a better understanding of the potential consequences and empowers work to address consequences, improving resilience.

As such, understanding dam-stopbank interactions on a systems level has been identified internationally as a **critical research gap** (ICOLD, 2022). There is also a growing demand that individual flood defence structures are **managed as a broader system**.

However, research on the cascading risk between dams and stopbanks is limited. Specifically, there is a **lack of quantitative research** on how dam operation can affect stopbank loading and the consequences of breaching.

This study answers this by **quantifying the cascading flood risk** posed by dam operation on under-design stopbank breaching and the consequences in terms of inundation area, land losses and building losses.

By developing a novel methodology and quantitative insights, we enable a deeper understanding of the cascading consequence and more informed decision-making when selecting adaptation strategies.



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

**How does dam operation during floods affect stopbank loading and what are the consequences?
Developing a framework for modelling dam operation, stopbank breaching, and the consequences.
Results enable more informed decision-making when selecting adaptation strategies.**

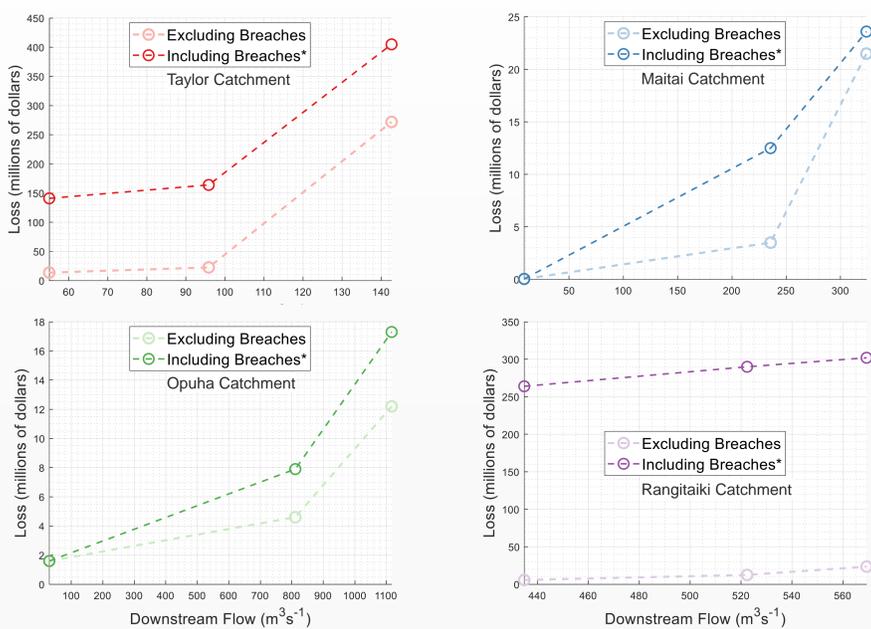
METHOD

This is the third segment of research from a wider thesis investigating dam-stopbank interactions.

The first research segment developed flood models of four New Zealand Catchments to determine the **range of possible dam outflows during a 100-year event** (1% ARI). This was achieved by varying operational parameters (duration of pre-releases, initial reservoir level, and maximum gate opening).

The second research segment developed a framework for probabilistically simulating stopbank breaching. Every metre of stopbank with water >50% of the stopbank height was considered a possible breach location. **Breach locations were randomly chosen** where the threshold was exceeded and simulated the equivalent of every 100 metres. Breach dimension and formation were based on empirical breaching equations in combination with fragility curves (Wallace et al., 2024).

This research builds on the previous segments, using the maximum, median, and minimum dam outflows as the basis for the stopbank breach scenarios. This allows the length of stopbank above the breaching threshold for different flows to be assessed. The breaching threshold for this study was water reaching 50% of the stopbank height. The catchments are: (1) Taylor River, Blenheim, (2) Maitai River, Nelson, (3) Opuha River, Canterbury, and (4) Rangitaiki River, Bay of Plenty.



Losses under min, median, and max dam operation flow, including and excluding stopbank breaching
Note: 'Including Breaches' uses areas with a 95% Probability of flooding, given that a breach occurs.

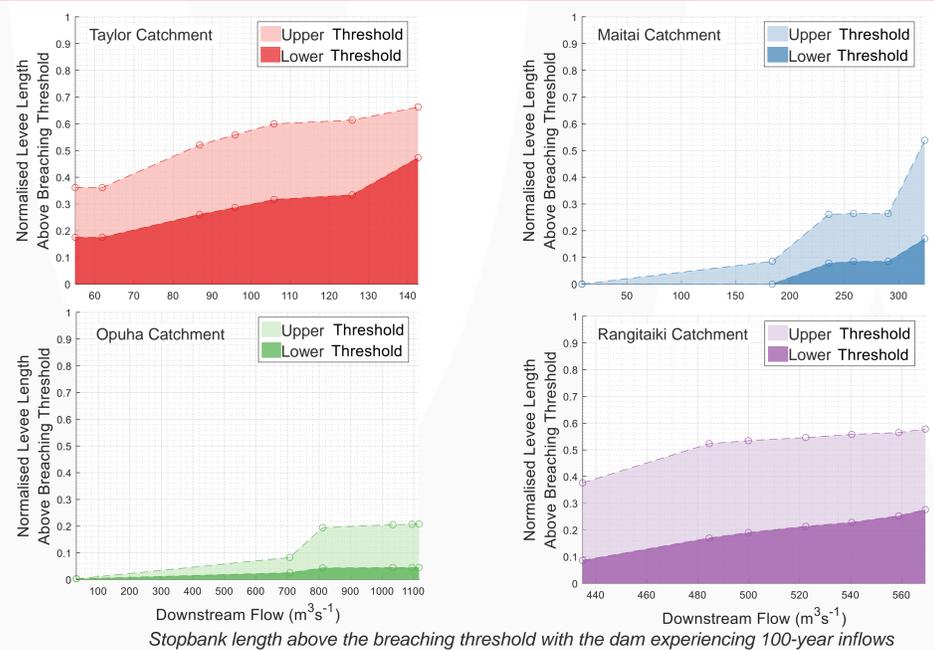
OUTPUTS – WHAT DOES THIS MEAN FOR NEW ZEALAND

Technical communities benefit from the development of an adaptable framework for assessing the dam-stopbank interactions and the monetary consequences

New Zealand hazard and embankment engineering communities will benefit from a better understanding of the infrastructure and communities exposed to flooding

Regional authorities & embankment owners gain an improved understanding of the value of stopbank-dam assets that facilitates more informed decision-making when selecting adaptation options.

Public & Wider Stakeholders benefit from improved management of catchment systems



RESULTS & DISCUSSION

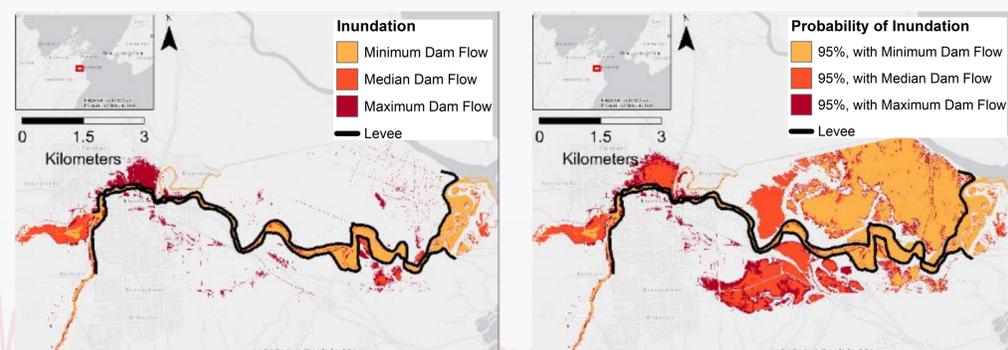
Dam operation quantitatively increased downstream depths and caused greater lengths of the stopbanks to exceed the modelled breaching threshold with at least 20% (up to 55%) of stopbank lengths exceeding the breach threshold

Breaching **tripled the potentially exposed area** in half the case study catchments. While most of the affected cover was productive land (cropland and paddock), recent land use trends show that this cover is increasingly being converted to higher-value orchards, vineyards, and built environments, representing an increase in potential losses.

The **losses increased by at least 950%** between minimum flow dam operation without breaching and maximum flow dam operation with breaching (i.e. best and worst case scenarios).

These cascading losses between dam operation and stopbank breaching are **currently not captured** in either guidance or research.

Stopbanks cannot offer absolute protection while breaching or overtopping can result in greater consequences than alternative strategies. Considering cascading consequences facilitates more informed decision-making when selecting adaptation options. Without such considerations, the **risk behind stopbanks may be underestimated**, leaving communities vulnerable to unexpected flooding.



Flood maps under different dam operation scenarios, including and excluding stopbank breaching

REFERENCES

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We wish to acknowledge the professional and financial support provided by, RNC, GRI, AUT, and UC.