NEW ZEALAND
Society on Large Dams

RESILIENCE TO NATURE'S CHALLENGES | Kia manawaroa – Ngā Ākina o Te Ao Tūroa | National SCIENCE Challenges

Dam-levee catchment systems

Current issues, international developments, and research outlook

Dr Kaley Crawford-Flett (presenter)

Content credit: Thomas Wallace, David Bouma

NZSOLD Online Symposium

Next week 22/23 March: Advances in Practice

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- This presentation:
  - Introduction: dams and levees (stopbanks)
  - Current international initiatives
  - (The beginnings of) A New Zealand national perspective
  - Current PhD research

- Mark Townsend
  - Dams and levees as part of integrated catchment management systems: BoPRC and New Zealand operational context
- Peter Mulvihill
  - Lessons learned from recent NZ and international flood events

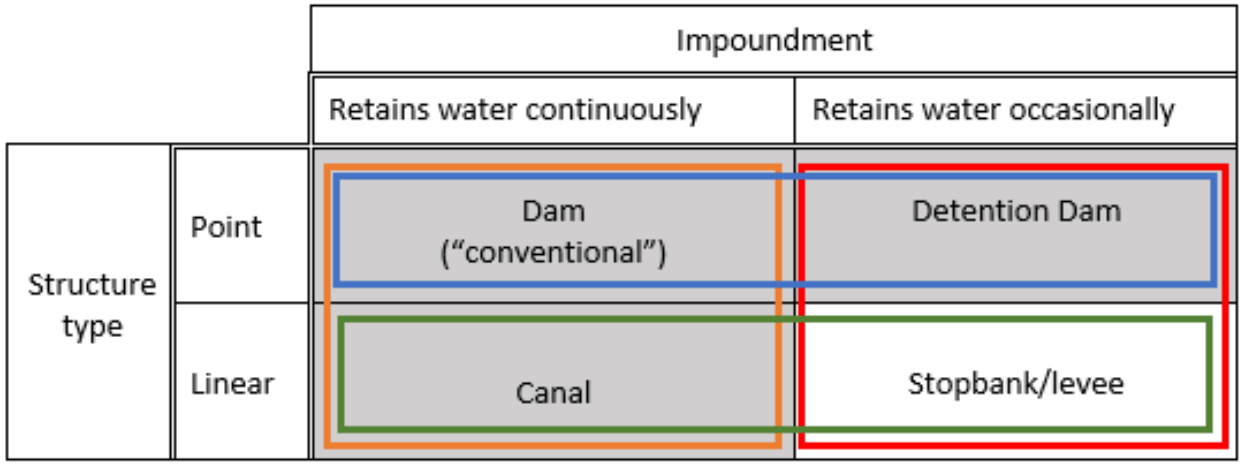
Motivation

Dams and levees (stopbanks) serve critical functions in distributed flood protection **systems,** but are often managed as **individual elements.**

Considering **element vulnerabilities** in a **system context**:

- Various (diverse) owners/stakeholders
- Different engineering design 'philosophies' (purpose/expectations)
  - Dams: 1 in 10,000 year recurrence events to 'Probable Maximum'/'Maximum Credible'
  - Stopbanks: 1 in 100 or 1 in 20 (?) year recurrence events
- Different design/construction standards
- System performance increasingly in the headlines

Dams, canals, stopbanks: same, same, but different…



Consider similarities and differences in terms of:

- Function: attenuation vs. routing
- Seepage loading: transient vs. steady state
- Spatial variation in:
  - Engineering properties (geotech/hydrotech/structural)
  - Monitoring and surveillance/performance indicators (State-of-Practice)
- Dam Safety Guidelines (Proposed Dam Safety Regulations)
- NZS 9401:2008 (Flood Risk Management Standard)…?

Current international initiatives

Current international initiatives: USACE, FEMA

2021, USA:

www.leveesafety.org

Objectives:

1. Levee owners and all levels of government understand their **roles and responsibilities** in managing flood risk and creating resilient communities.
2. Levee owners have **knowledge and tools to manage levee performance**.
3. **Communities** have access to **clear and actionable information** regarding the benefits and risks of living with levees.
4. Levee owners and all levels of governmental agencies **manage levees in a manner to reduce environmental impacts**.
5. Federal **agencies will align their programs** to support levee-related flood risk management and community resiliency activities.

Current international initiatives - ISSMGE

Failure paths for levees
Final

SIMSG ISSMGE

February 2022

PREPARED BY
Technical Committee on
Geotechnical Aspects of Dikes and Levees
(TC201)

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Citation: Van, M.A., Rosenbrand, E., Tourment, R., Smith, P. and Zwanenburg, C. Failure paths for levees. International Society of Soil mechanics and Geotechnical Engineering (ISSMGE) – Technical Committee TC201 'Geotechnical aspects of dikes and levees', February 2022. Download (TC201 Dykes and Levees | ISSMGE)

2022, International

International Society of Soil mechanics and Geotechnical Engineering (ISSMGE)

Technical Committee **TC201 "Geotechnical Aspects of Dikes and Levees"**

ICOLD Technical Committee on Levees

DRAFT REPORTS:

COMPARISON OF DAMS AND LEVEES
Similarities, differences and recommendations

LEVEES AND FLOOD DEFENCES ACROSS THE WORLD
Characteristics, Risks and Governance

2018-2024, International

New Zealand representation: **David Bouma** (NZSOLD, Tonkin and Taylor)

- Significant move for ICOLD into the levee space
- Reporting: NZ co-authorship and contributions
- Support from NZSOLD/River Managers' SIG

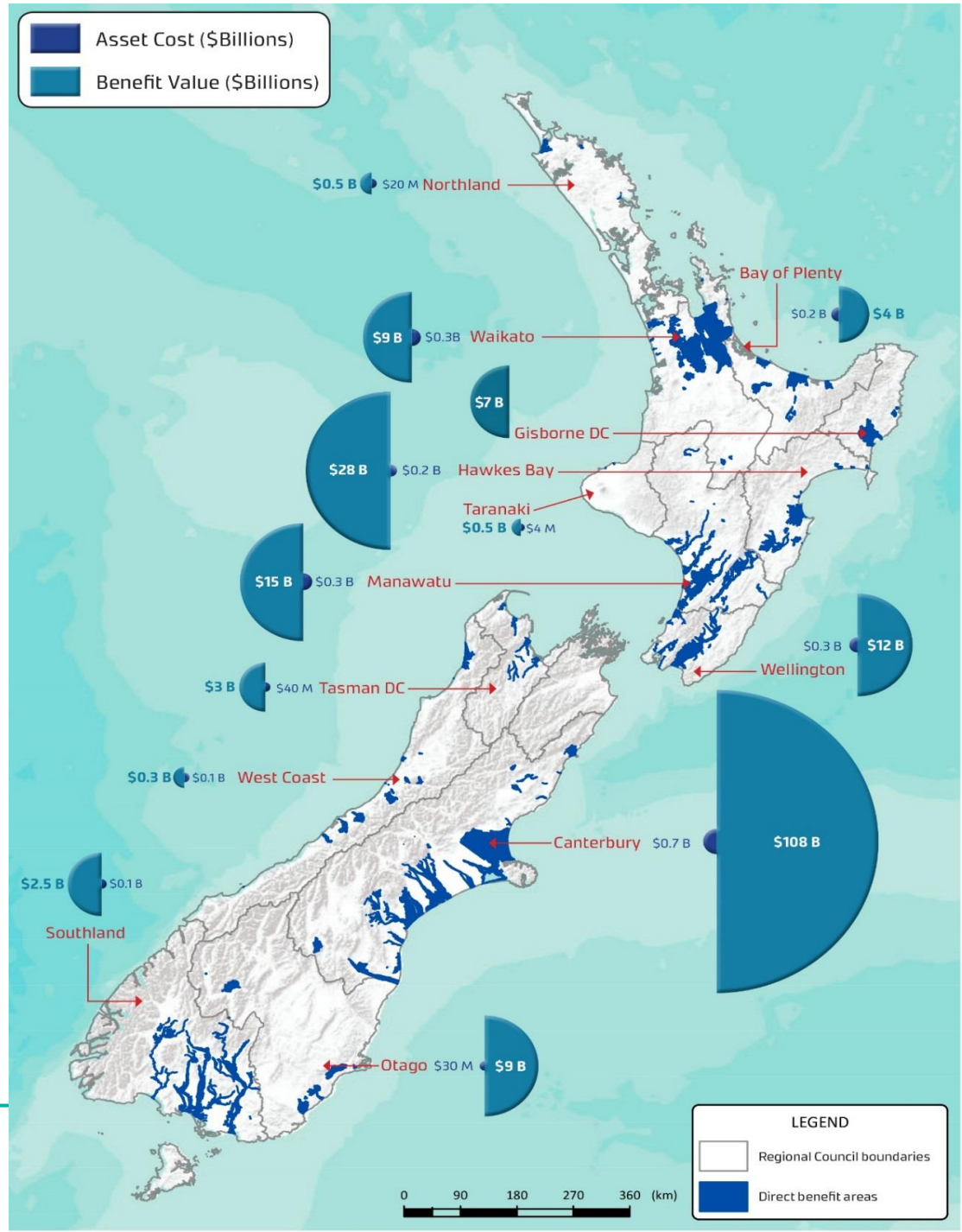
ICOLD TC-Levees

LEVEES AND FLOOD DEFENCES ACROSS THE WORLD
Characteristics, Risks and Governance

New Zealand representation: **David Bouma** (NZSOLD, Tonkin and Taylor)

- Forthcoming NZ chapter:

- **NZ-1** Facts and figures on levees and flood defences in New Zealand
- **NZ-2** Protected value, safety standards and flood risk
- **NZ-3** Recent major floods and (near-)failures of levees
- **NZ-4** Legislation and governance in New Zealand
- **NZ-5** Guidelines and good practices
- **NZ-6** Common practices during Levee Life Cycle
- **NZ-7** Critical knowledge and data gaps; critical research needs
- **NZ-8** Summary of Key Facts



A National Perspective for NZ

Standards, Guidance, Regulations, Acts: Systems Approaches?

Dams

- Building Act (2004)
- Resource Management Act 1991 (RMA)
- Proposed Building (Dam Safety) Regulations (2024?)

Stopbanks/levees

- Soil Conservation and Rivers Control Act 1941
- Resource Management Act 1991 (RMA)
- Local Government Act 2002
- Civil Defence and Emergency Management Act 2002

NZS9401:2008

Managing Flood Risk - A process standard

Table 1 — Flood risk management framework

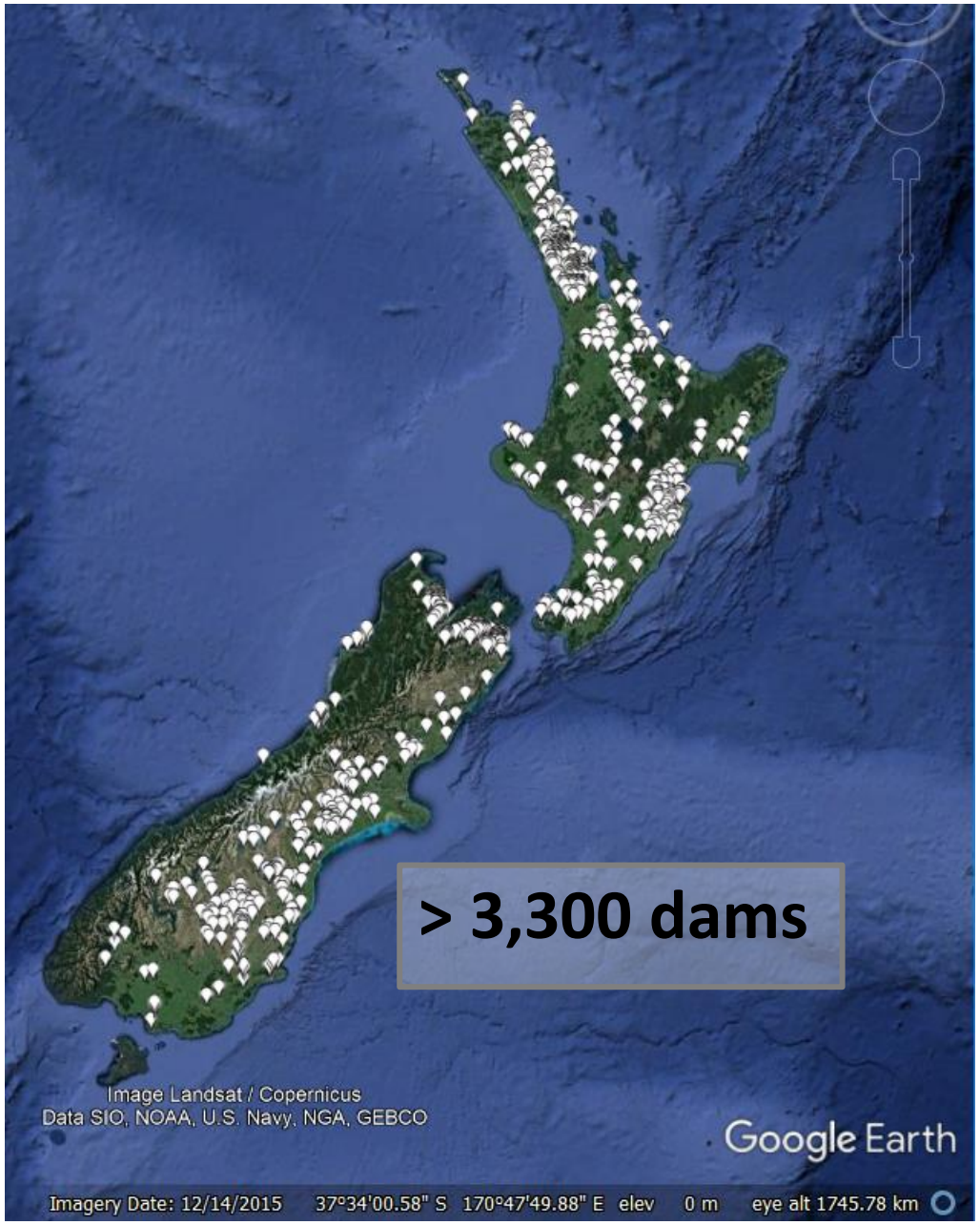
Elements	The five elements are:
	• *Catchment-based management* to provide a natural framework within which to manage flood risk;
	• *Sustainable management* to bring natural and social systems together over the longer term to provide a context for flood risk management decisions;
	• *Adaptive management* to ensure that changes in natural processes, hazards, exposed values, and their vulnerability are identified by monitoring and addressed in a timely manner;
	• *Risk management* to encourage a wider assessment of strategies and options, anticipation of change, and awareness of residual risks; and
	• *Comprehensive risk treatment strategies* including *reduction, readiness, response,* and *recovery.*
Principles and outcomes	
1	**Engaging communities and stakeholders**
	(a) Communities and stakeholders are involved in formulating flood risk management solutions; (b) Decisions are a shared responsibility of all relevant interests; (c) Individual responsibility for managing personal risk is enhanced; (d) Public and private interests are balanced; (e) The roles and responsibilities of all stakeholders are clear and agreed; (f) A comprehensive risk communications strategy is in place and actively managed.
2	**Understanding natural systems and catchment processes**
	(a) Natural river and catchment processes as these affect flood risk management are understood by all those affected; (b) Systematic assessments form the basis for catchment-based management of flood risk; (c) Allowing rivers to revert to their natural behaviour is an option for consideration.
3	**Understanding the interaction of natural and social systems, in a catchment-based management context**
	(a) Decisions on flood risk management are made within the wider context of natural and social systems; (b) Catchment-based management strategies integrate environmental, economic, social, and cultural dimensions; (c) Adaptive management is an integral component of flood risk management.
4	**Decision-making at the local level**
	Decisions are based on how communities and stakeholders seek to manage risk in terms of their interests and affordability.
5	**All possible forms and levels of management**
	(a) Data and information, appropriate methodologies, and best practice guidance are available and used; (b) A long-term risk assessment of flood management solutions is essential; (c) All options to reduce or mitigate flood risk are considered; (d) Impacts and cumulative effects are assessed; (e) Outcomes for aquatic, land, and coastal environments are considered; (f) The performance of the flood risk management system is monitored and actively managed.
6	**Residual risk**
	(a) Residual risks are identified and addressed; (b) The impacts of extreme events are considered as residual risks; (c) Routine risk analyses are necessary to ensure that residual risk management remains appropriate.

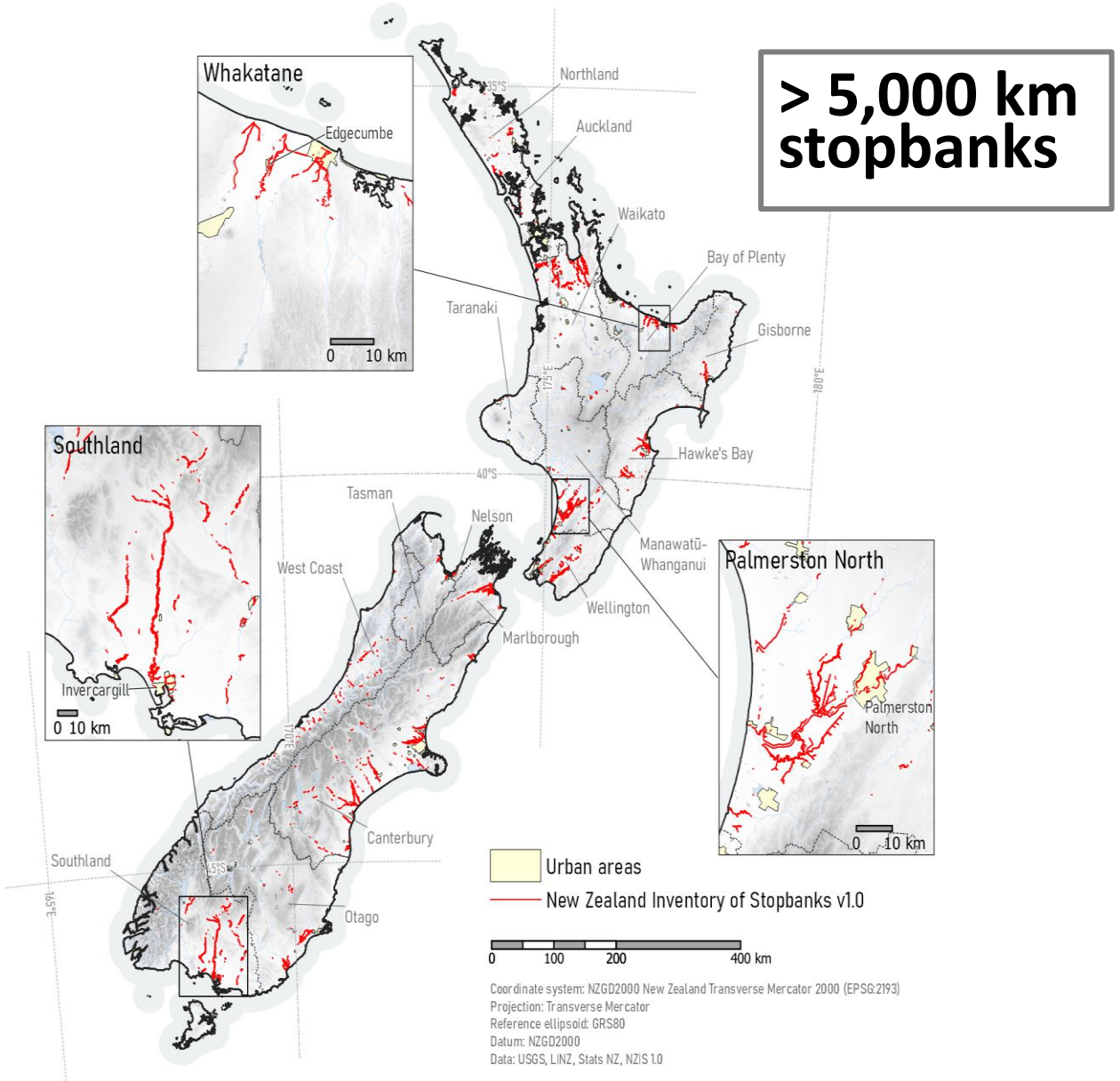
NZS9401:2008

Managing Flood Risk – A process standard

- Strictly process-oriented
  - i.e. no mention of dams or stopbanks as elements
- Used as part of a business-case to exclude stopbanks from Regulatory Dam Safety Scheme
- Elements highly relevant to dam-stopbank systems
  - Catchment based management
  - Sustainable management
  - Adaptive management
  - Risk management
  - Comprehensive risk treatment strategies (reduction, readiness, response, recovery)
- Continued central directive “Decision-making at local level”

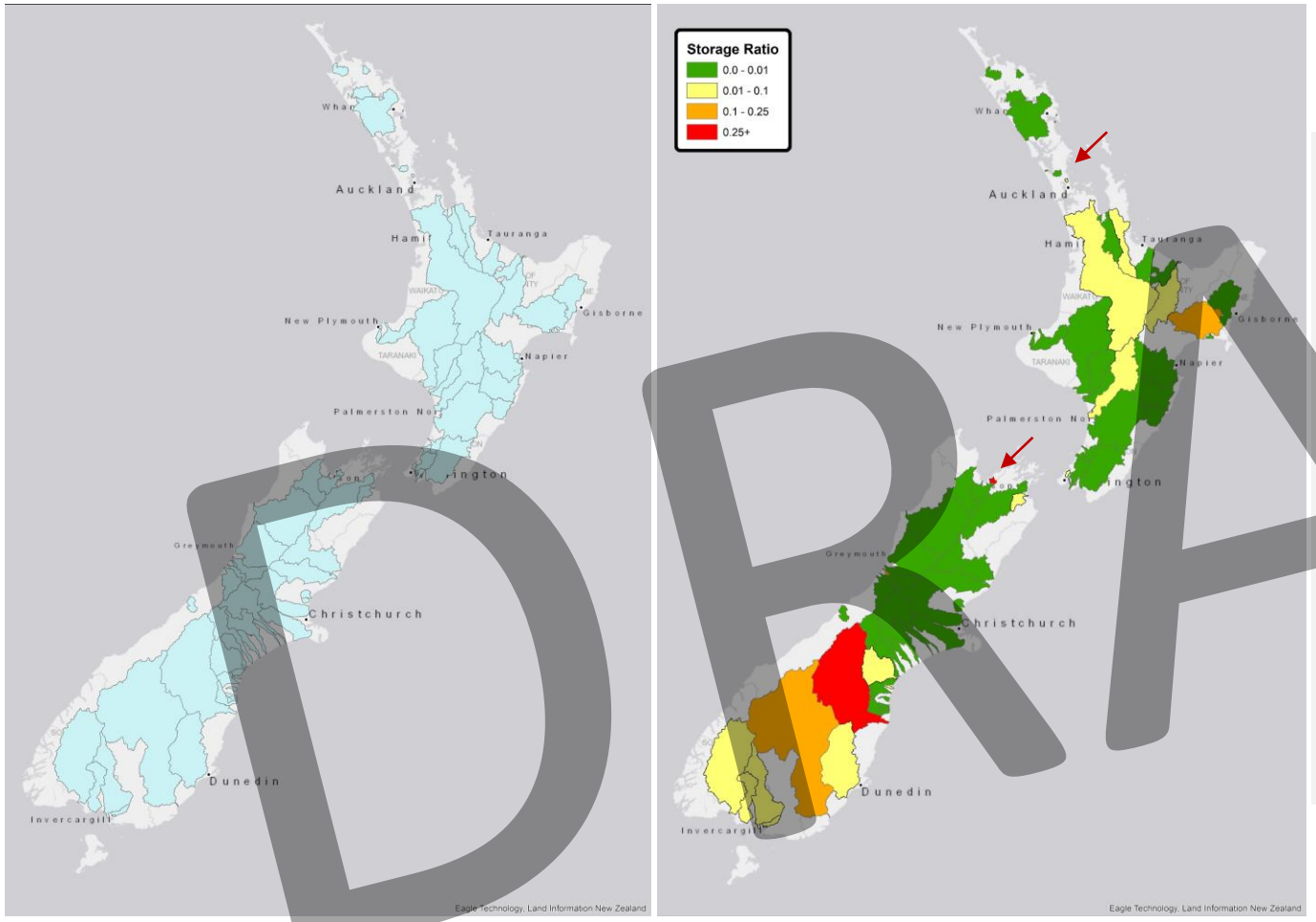
NZ Inventories of Dams (NZID) and Stopbanks (NZIS)





Crawford-Flett, Blake, Pascoal, Wilson, Wotherspoon (2021) *A standardised inventory for New Zealand's stopbank (levee) network and its application for natural hazard exposure assessments. Journal of Flood Risk Management.*

Relative influence of dams on a catchment



NZ catchments containing both dams and stopbanks
(from the best-available data: NZID and NZIS)

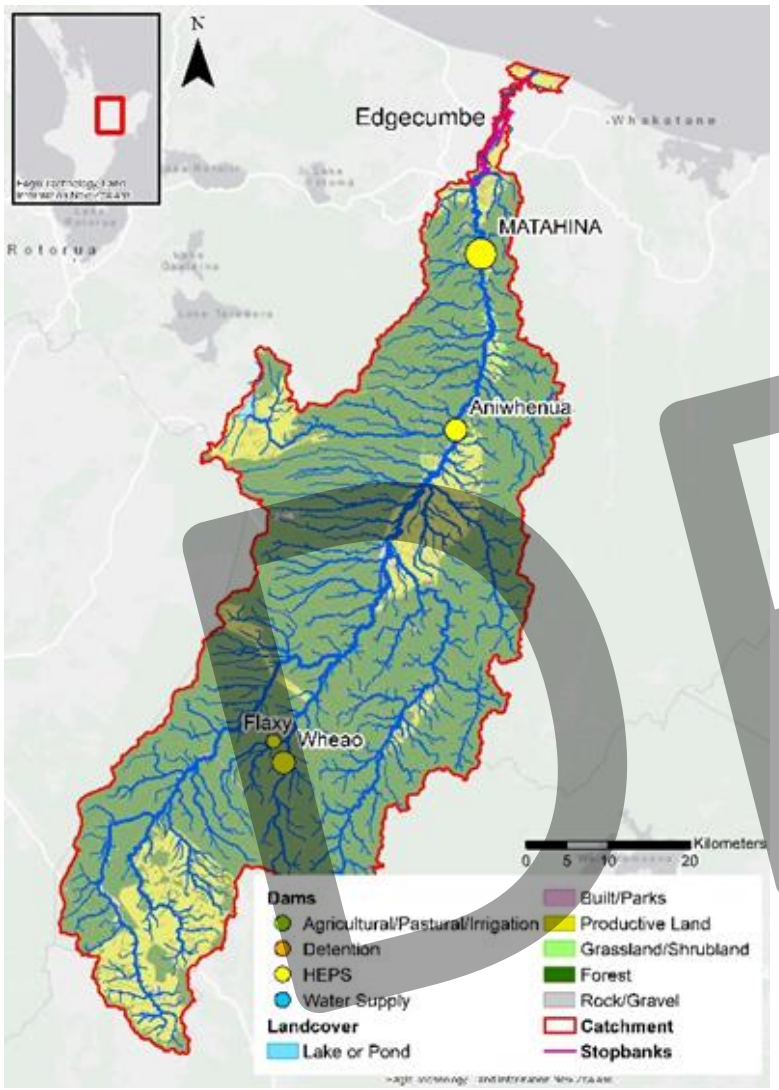
Potential influence (of dams on catchment)

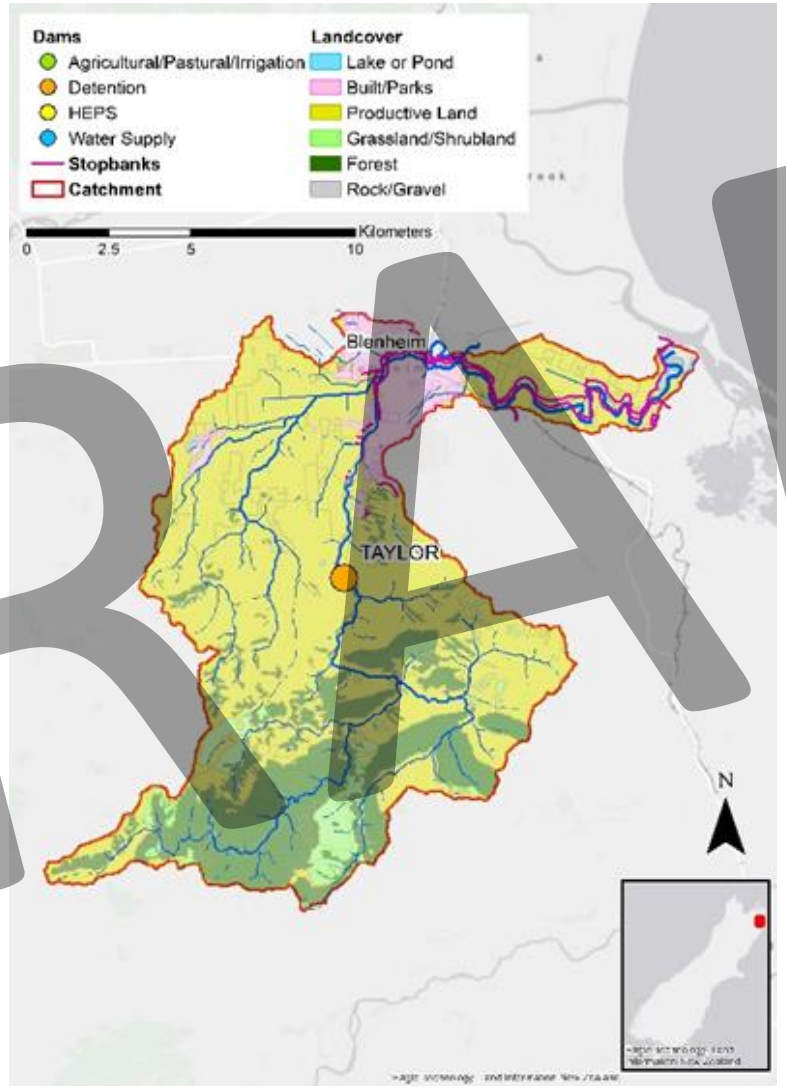
New measure to indicate relative theoretical capacity of catchment to store flood flows.

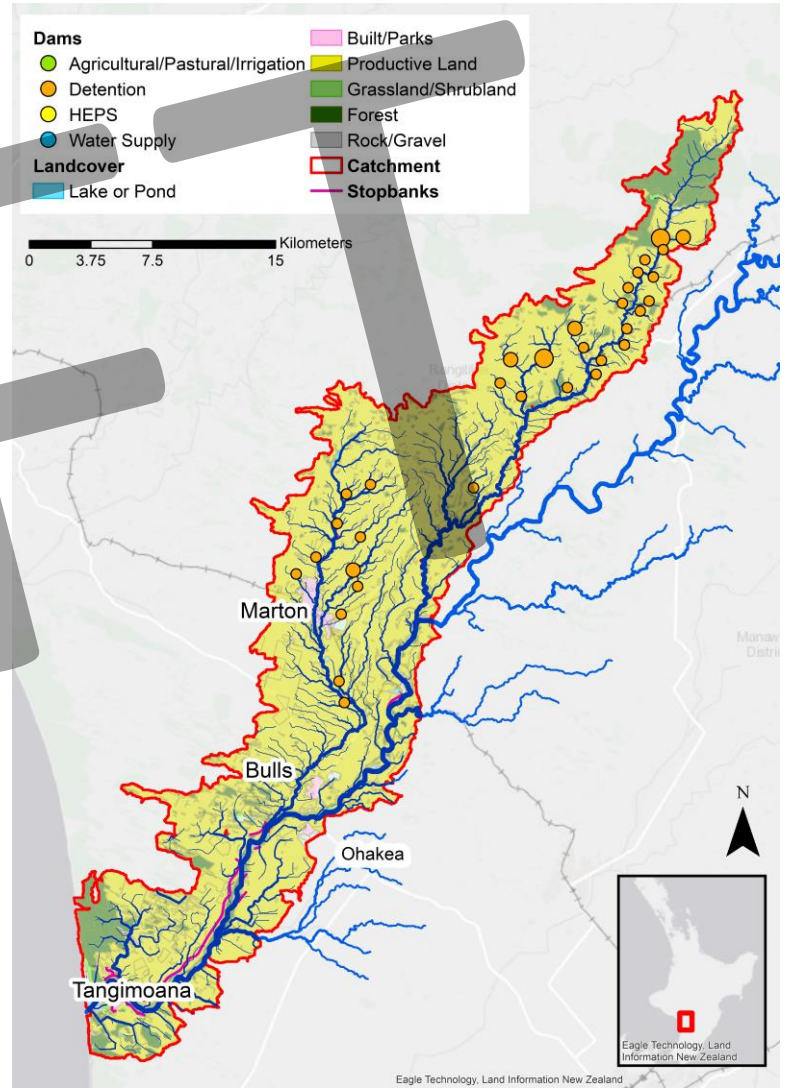
$$\text{Storage ratio} = \frac{\sum Dam\ retention\ volume}{\sum Annual\ runoff\ volume}$$

Images: Thomas Wallace, PhD Candidate (thomas.wallace@pg.canterbury.ac.nz)

Large variability in dam-stopbank catchments







Images: Thomas Wallace, PhD Candidate (thomas.wallace@pg.canterbury.ac.nz)

Understanding the Physical and Systemic Vulnerabilities in Integrated Stopbank-Dam Catchments

Thomas Wallace, PhD Candidate

- Characterise operational **'degrees of freedom'** for case-study NZ catchments
  - Opportunities for intervention/control
- Develop an understanding of **maturity in operational elements** in our flood defence systems so that risk-reducing activities may be more effectively prioritised
  - Roles and responsibilities
  - Communications
  - Continuous improvement
- Use operational vulnerabilities to undertake **probabilistic breach flood modelling** to determine the exposure of communities and infrastructure to flooding.
- Develop **alternative operational strategies** and high-level recommendations that are able to reduce the exposure of communities and infrastructure.

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Summary

- Dams and levees (stopbanks) serve critical functions in distributed flood protection **systems,** but are often managed as **individual elements.**
- Many similarities and many differences between dams and stopbanks
  - Design/operation/management
  - Loading, deterioration, monitoring
  - Regulatory
- Dam-levee systems are increasingly critical to societies, both nationally and internationally
- New NZ research attempts to provide a national perspective on integrated dam-stopbank catchments and opportunities for improvement

Thomas Wallace will be providing an open-forum update and discussion opportunity on his PhD research, March 28th at 2pm.
If you'd like to participate, please contact Kaley and/or Thomas (kaley.crawford-flett@canterbury.ac.nz, thomas.wallace@pg.canterbury.ac.nz)

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