UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Tsunami Impacts on Lifelines

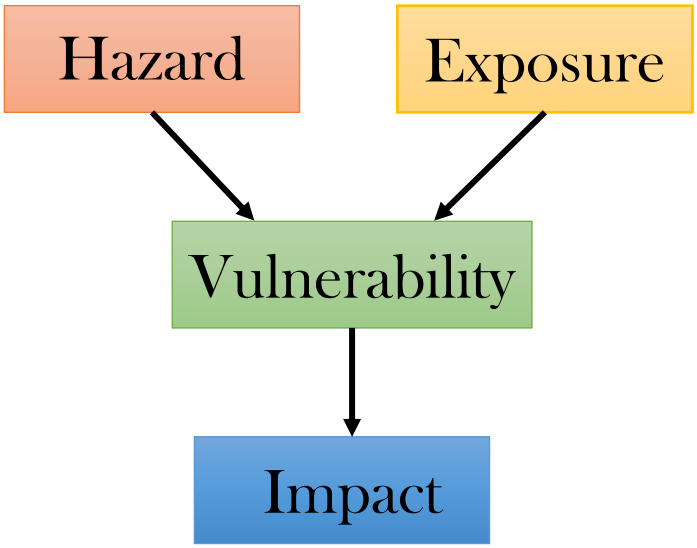
James Williams, Thomas Wilson, Nick Horspool, Matthew Hughes, Emily Lane

GNS SCIENCE TE PŪ AO
NIWA Taihoro Nukurangi
RiskScape
Environment Canterbury Regional Council Kaunihera Taiao ki Waitaha
EQC EARTHQUAKE COMMISSION Kōmihana Rūwhenua
Emergency Management Canterbury
National SCIENCE Challenges
RESILIENCE TO NATURE'S CHALLENGES

Presentation Outline

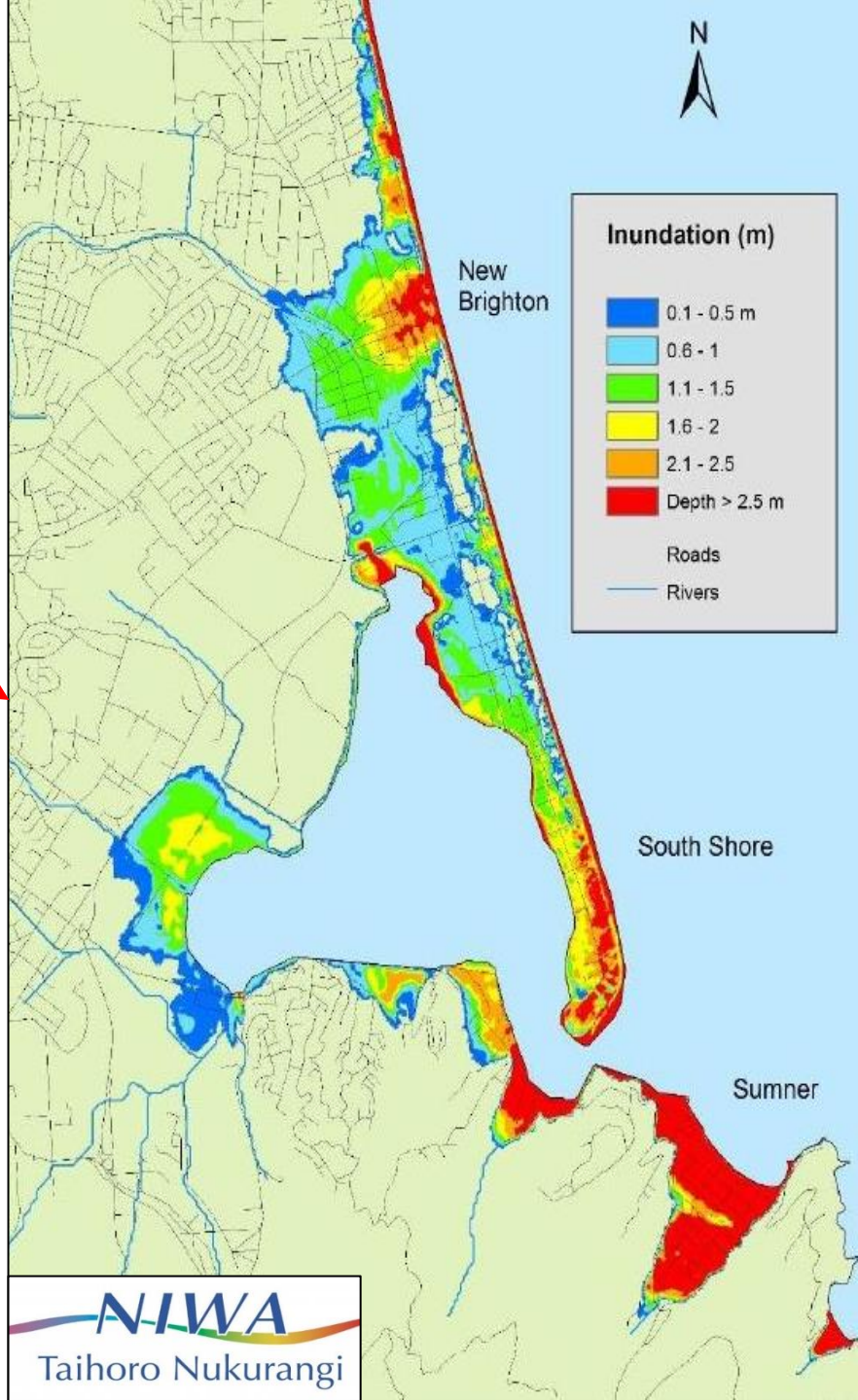
- Tsunami Damage Styles
- Impact Assessment Process
- Impacts on Christchurch Lifelines
- PhD Project

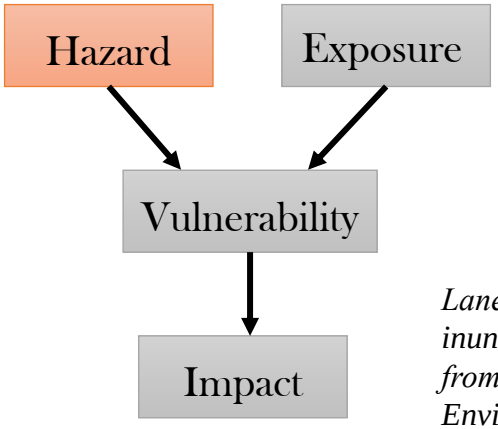
Case Study: Christchurch



Williams, J.H., 2016. Impact assessment of a far-field tsunami scenario on Christchurch City infrastructure.

Tsunami Hazard

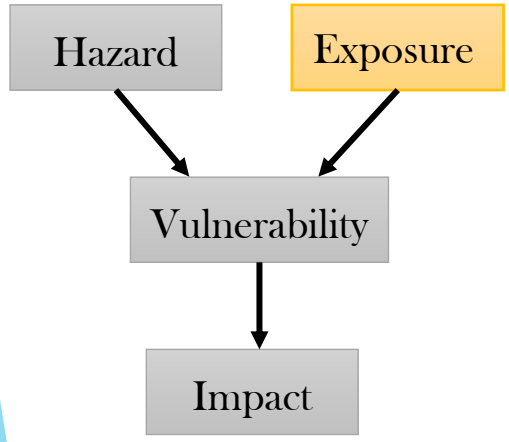


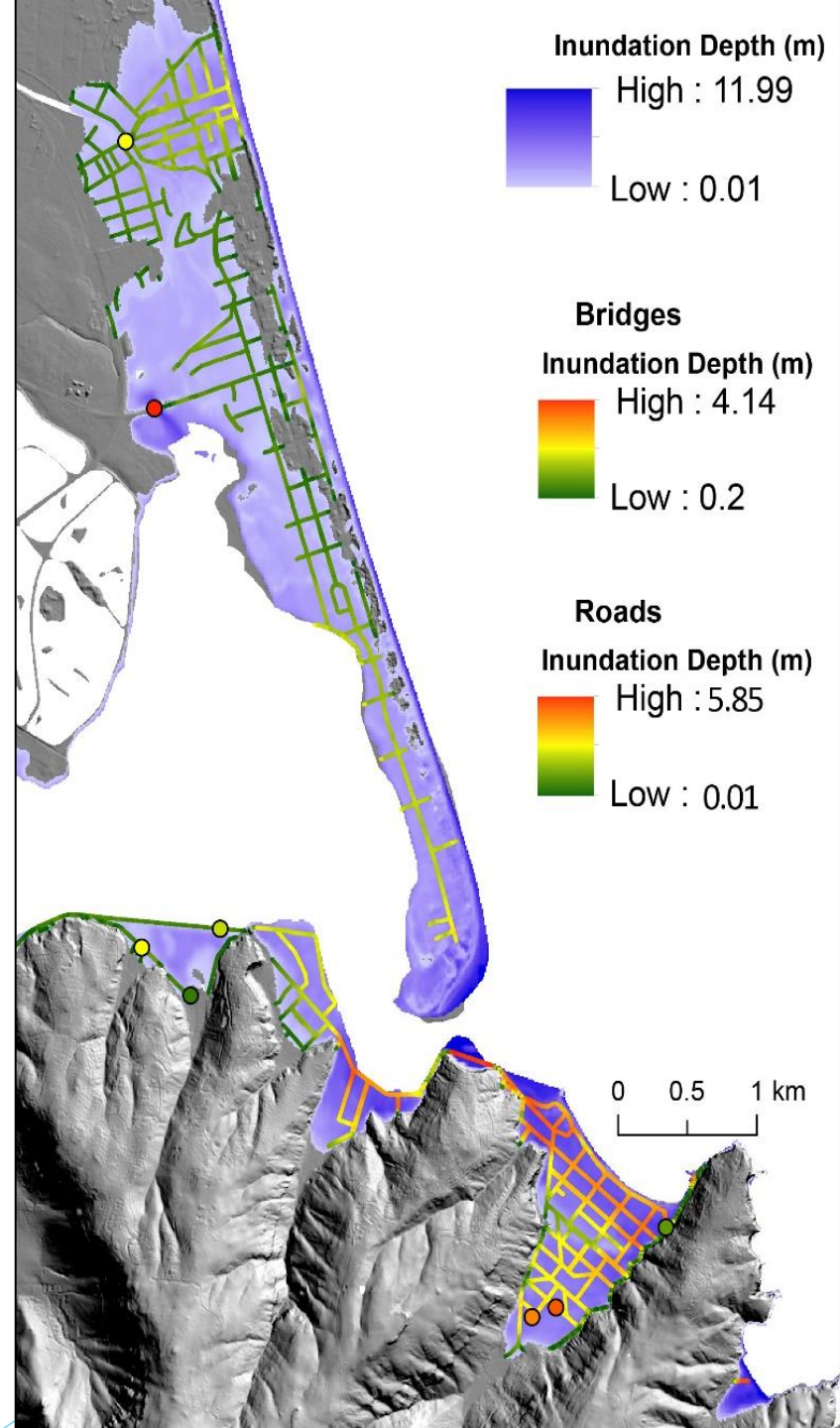


Lane, E. et al. (2014) 'Updated inundation modelling in Canterbury from a South American Tsunami', Environment Canterbury Report R14/78. Christchurch, New Zealand.

Asset Exposure

Depth (m)	Impact Lengths (km)					Impact Counts			
	Roads	Storm-water	Waste-water	Potable-water	Rail	Bridge	Cell Sites	Pump Stations	Fuel Tanks
	S1	S1	S1	S1	S1	S1	S1	S1	S1
<1	58.8	21.8	36.1	70.5	.5	7	6	4	15
1 - 1.9	36.7	12.7	23.8	43.4	1.1	1	7	3	16
2 - 2.9	20	9.1	14.6	24.7	.7	2	5	2	0
3 - 3.9	13.8	5.5	11.7	17.8	0	0	2	1	0
4 - 5	4.2	3.5	5.6	8.4	0	0	1	2	0
>5	.5	.1	.23	2.4	0	0	0	0	0
Total	**134**	**52.7**	**92**	**167.2**	**2.3**	**10**	**21**	**12**	**31**





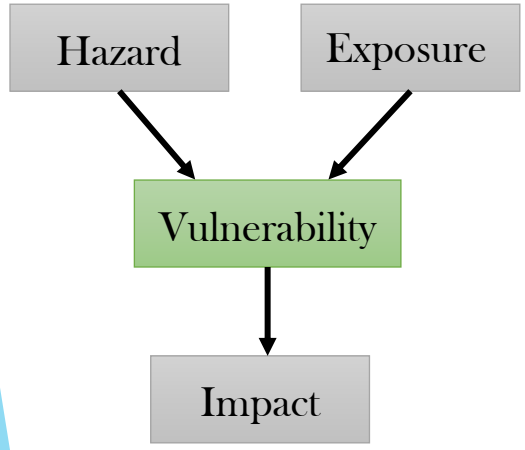
Tsunami Vulnerability

Three methods used:

1. Existing Vulnerability Functions

2. Develop Vulnerability Functions

3. Damage Probability Index



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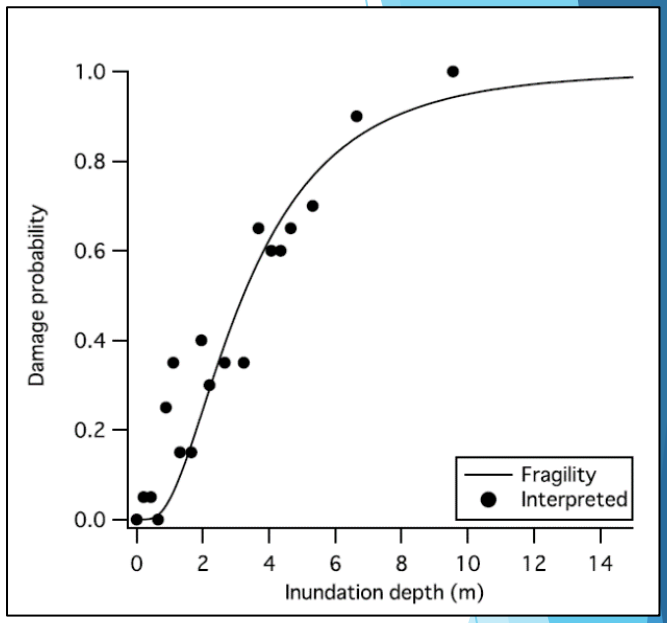

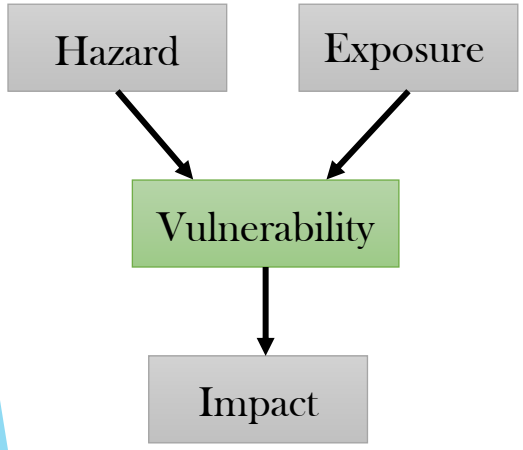

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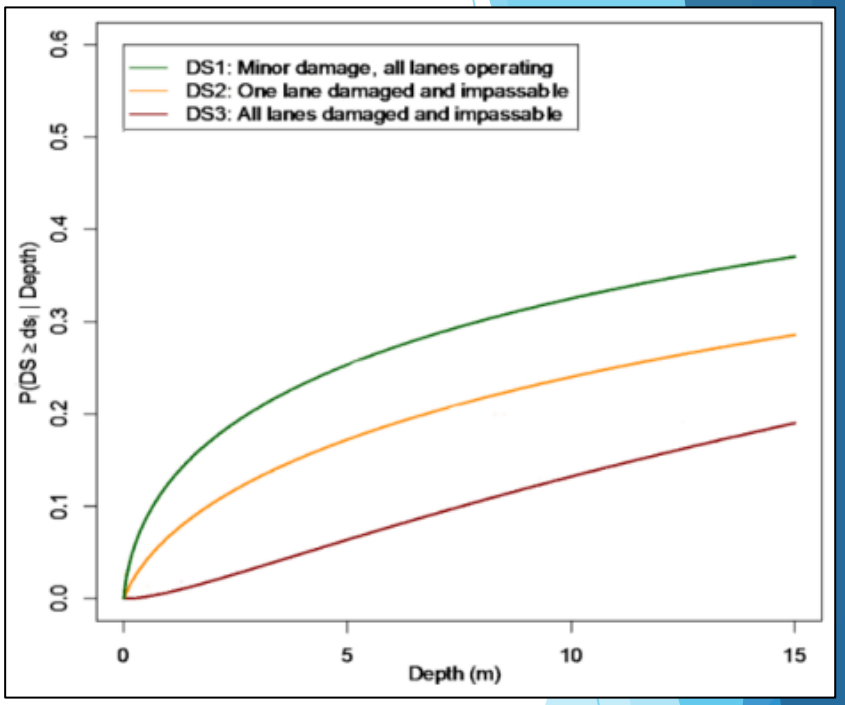

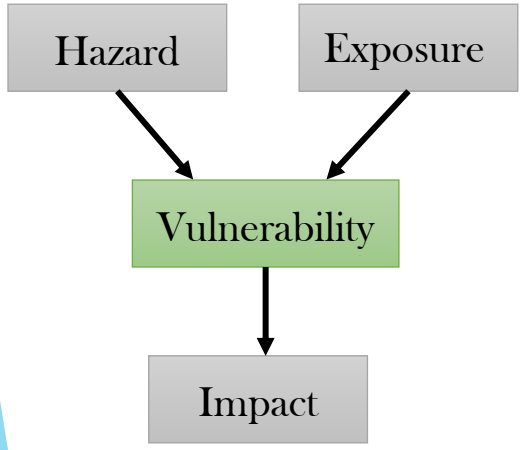

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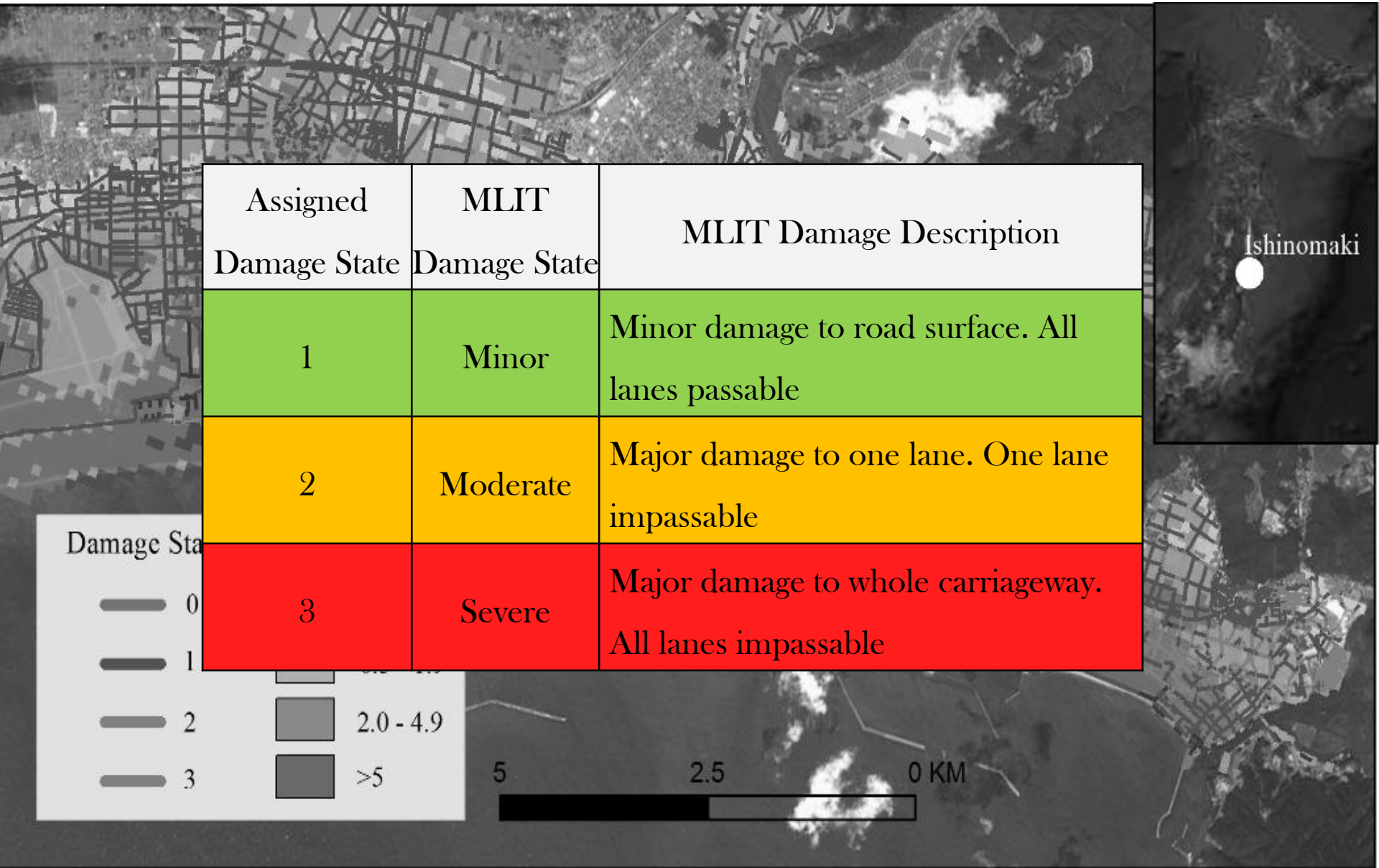
2011 Tohoku Earthquake Tsunami:

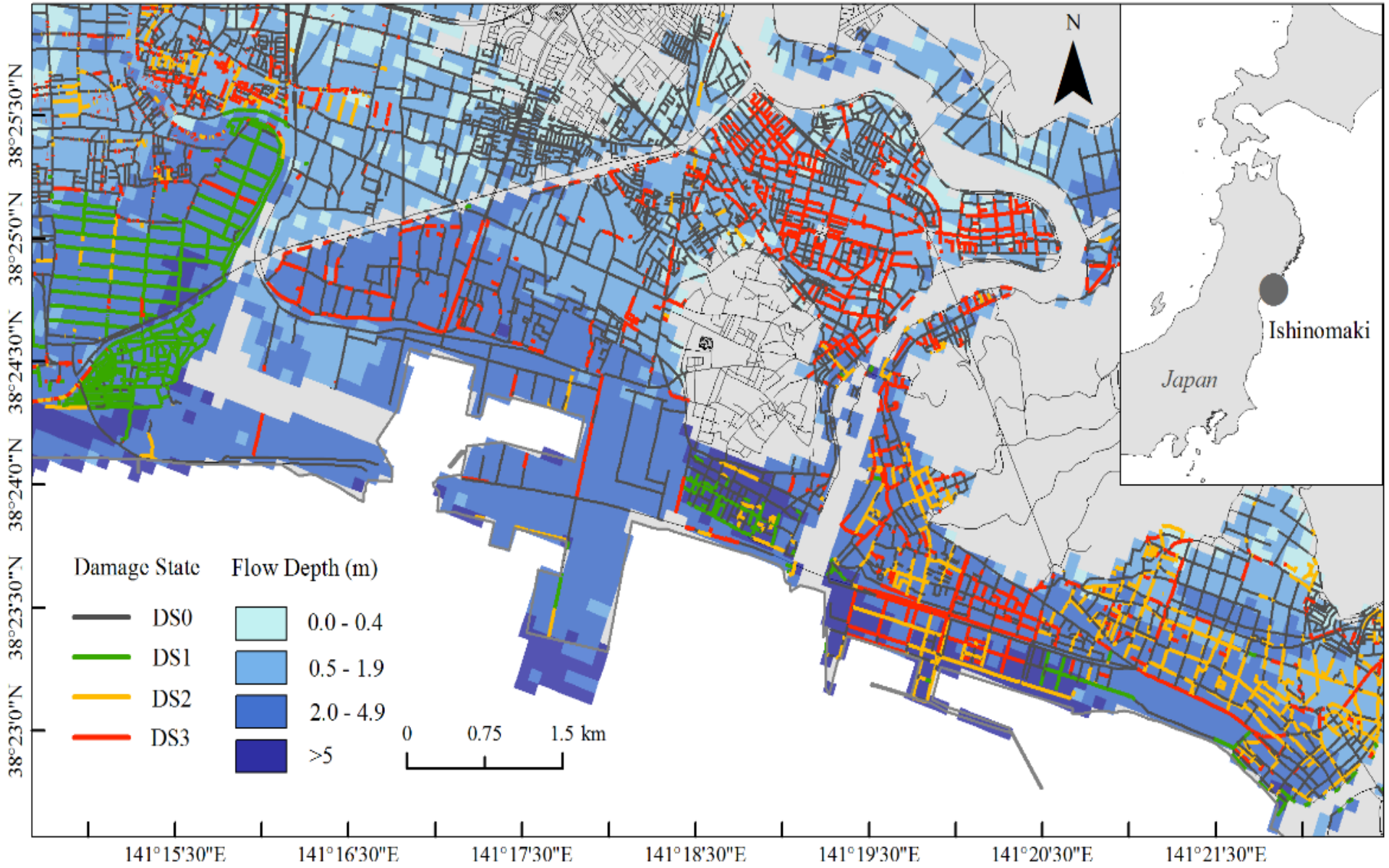
Japan Roads Analysis



Assigned Damage State	MLIT Damage State	MLIT Damage Description
1	Minor	Minor damage to road surface. All lanes passable
2	Moderate	Major damage to one lane. One lane impassable
3	Severe	Major damage to whole carriageway. All lanes impassable

2011 Tohoku Earthquake Tsunami:

Japan Roads Analysis



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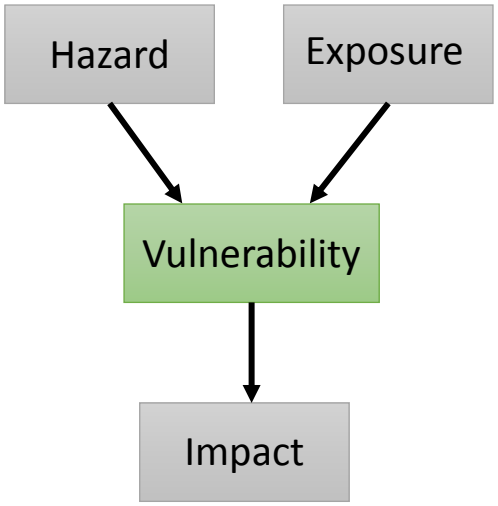
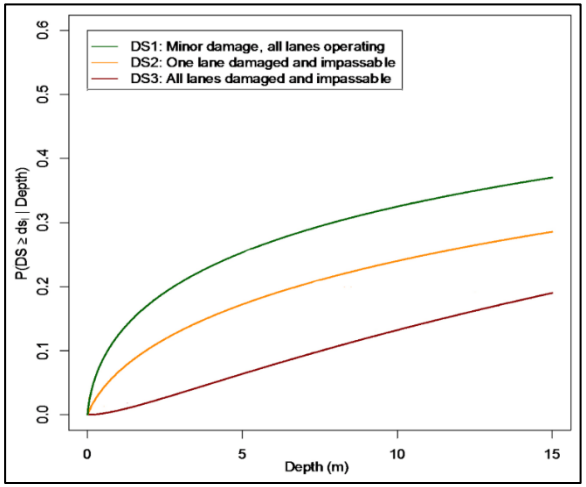
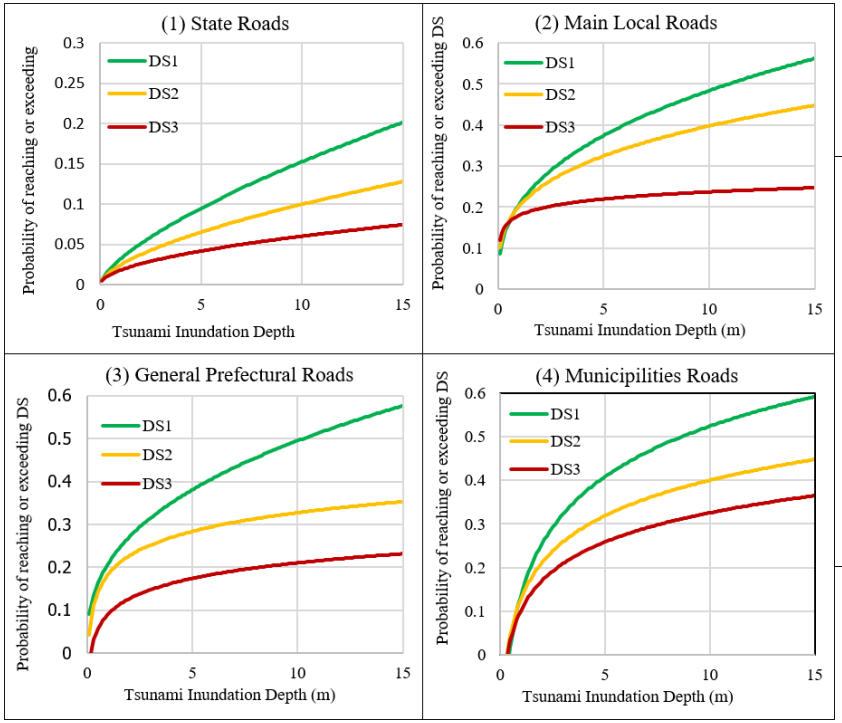


Generic Fragility



Use Type Fragility



Tsunami Vulnerability

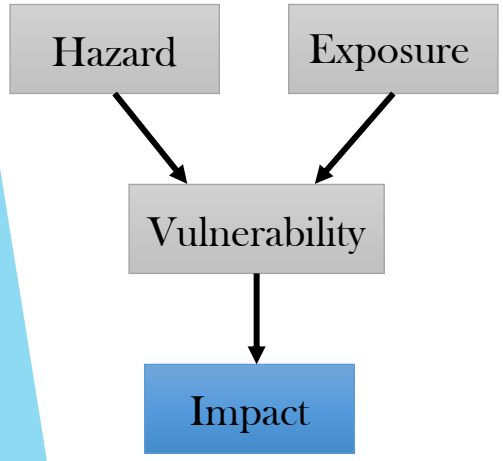
Three methods used:

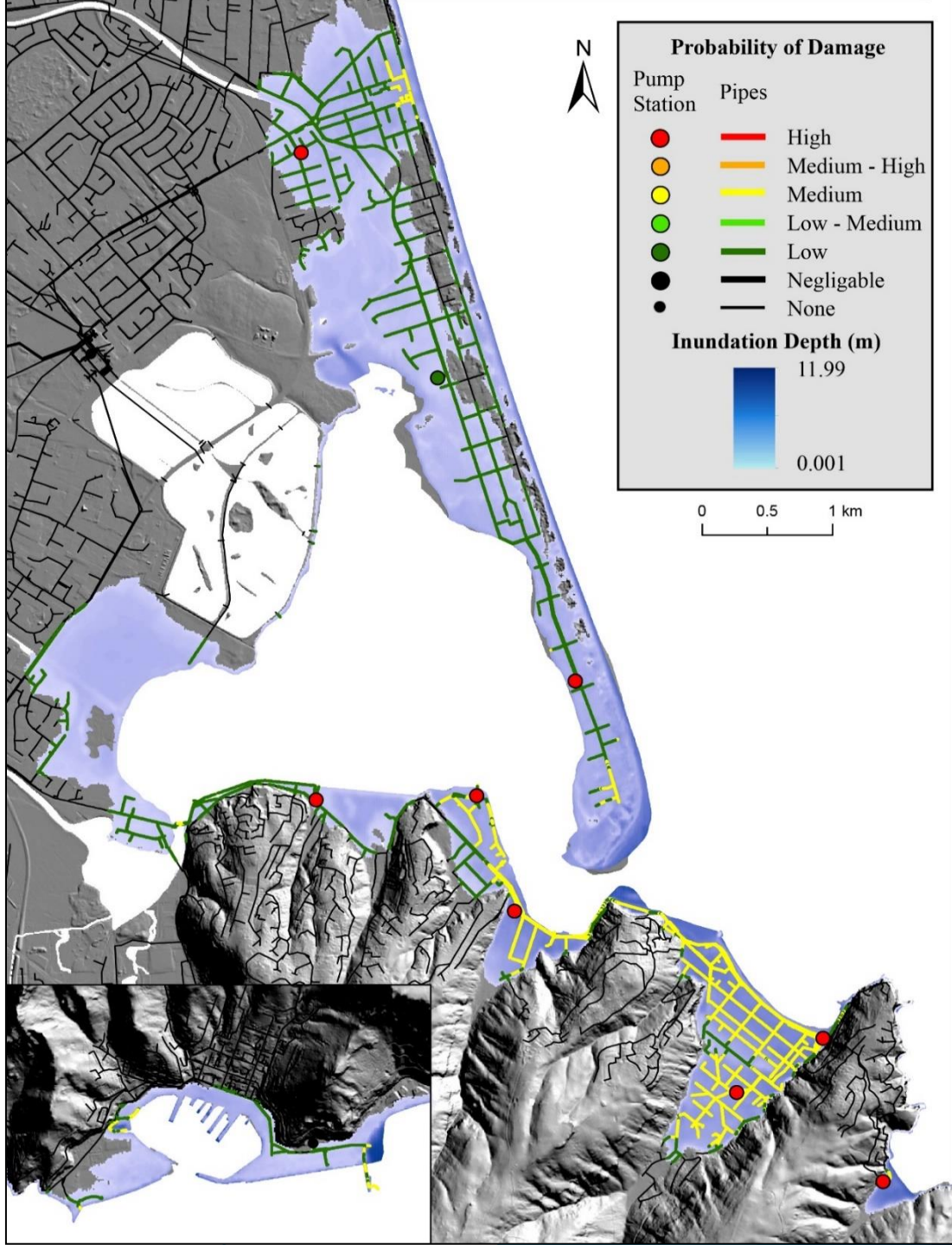
3. Damage Probability Index

Horspool, N.A.; Fraser, S. 2016. An Analysis of Tsunami Impacts to Lifelines, GNS Science Report 2016/22. 87 p.

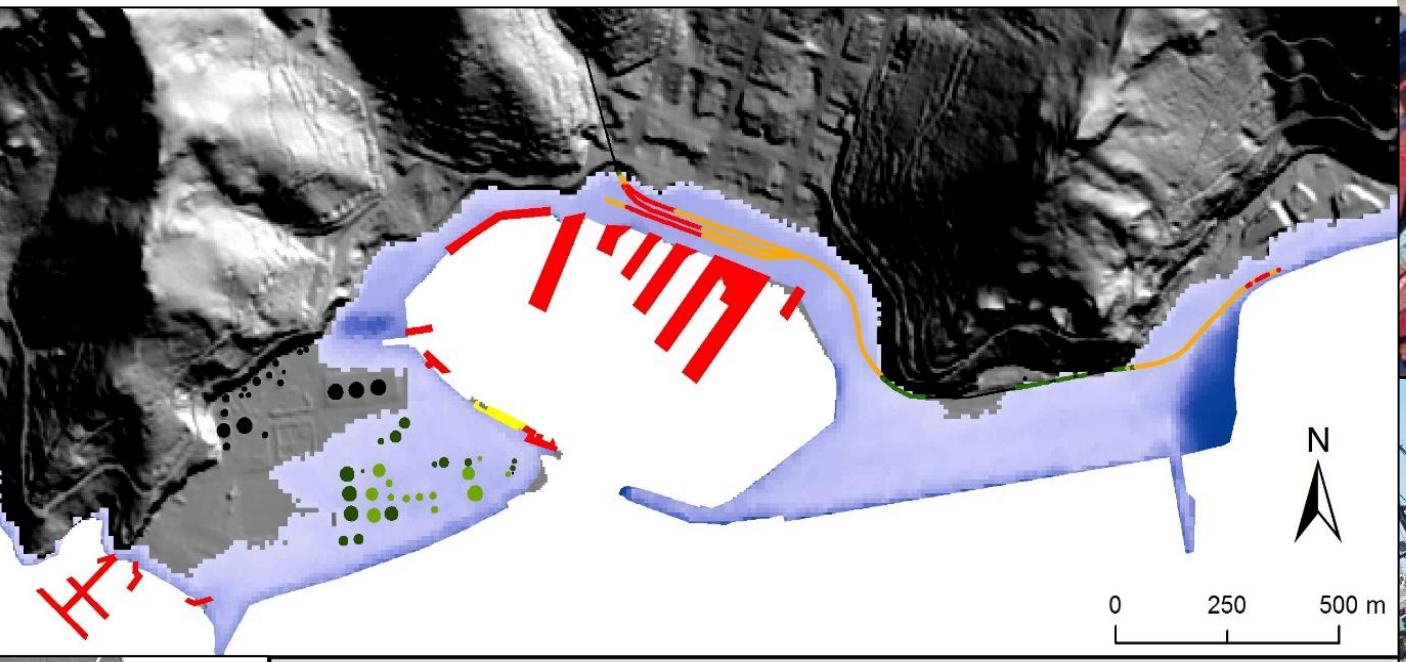
Lifeline Asset	Flow Depth < 0.5m		Flow Depth 0.5m – 2m		Flow Depth >2m		Data Quality
	Probability of Damage	Damage Type	Probability of Damage	Damage Type	Probability of Damage	Damage Type	
Transportation							
Roads							
Pavement	Low	Silt and light debris coverage, ponding	Medium	Debris & sediment coverage, scour of weak base materials, removal of signage and markings, ponding	Medium-High	Debris strikes , scour of base materials, lifting of carriage-way, removal of barriers and signage, cracking of pavement, liquefaction of base materials, ponding, debris and sediment coverage	High
Bridges	Negligible-Low	Superficial debris strikes	Medium	Some bank erosion, superficial debris strikes , sediment deposition, scour of footings, corrosion, washout of light timber structures	High	Debris and sediment deposition, erosion of adjoining banks, loss of signage and markings, side barriers bent or sheared, debris strikes, scour of footings, aggradation of waterway, widening of waterway separation of deck from footings, lateral distortion of super structure, separation of girders, washout of superstructure, corrosion, loss of utilities across bridge	High

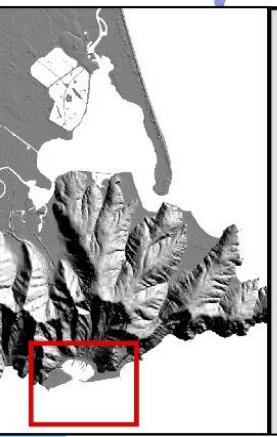
Waste Water


Hazard
Exposure
Vulnerability
Impact


N
Probability of Damage
Pump Station
Pipes
High
Medium - High
Medium
Low - Medium
Low
Negligable
None
Inundation Depth (m)
11.99
0.001
0
0.5
1 km

Port Facilities





Probability of Damage

Fuel Storage Tanks
- 0
- .001 - 0.05
- .05 - 0.1
- .1 - 0.15

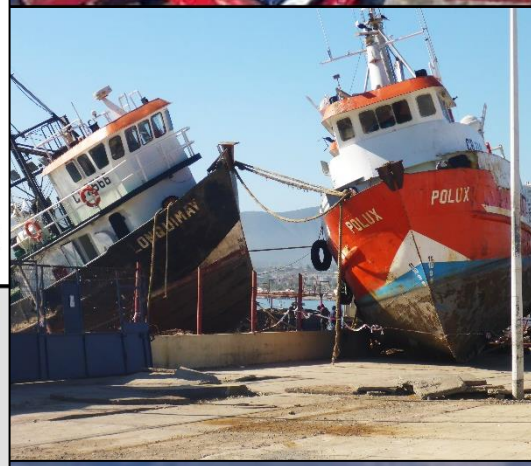
Wharves

Rail
- High
- Medium - High
- Medium
- Low - Medium
- Low
- Negligible
- None

Inundation Depth (m)

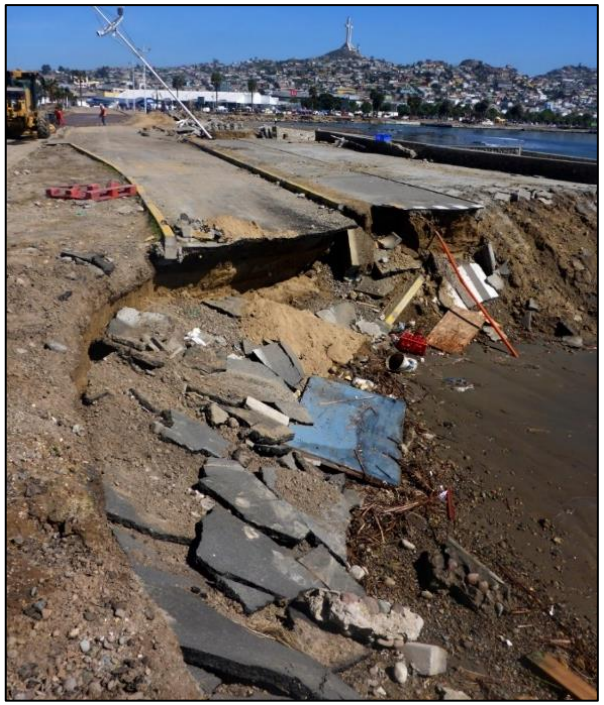
11.99

0.001



(Source: voanews.com)

Roads

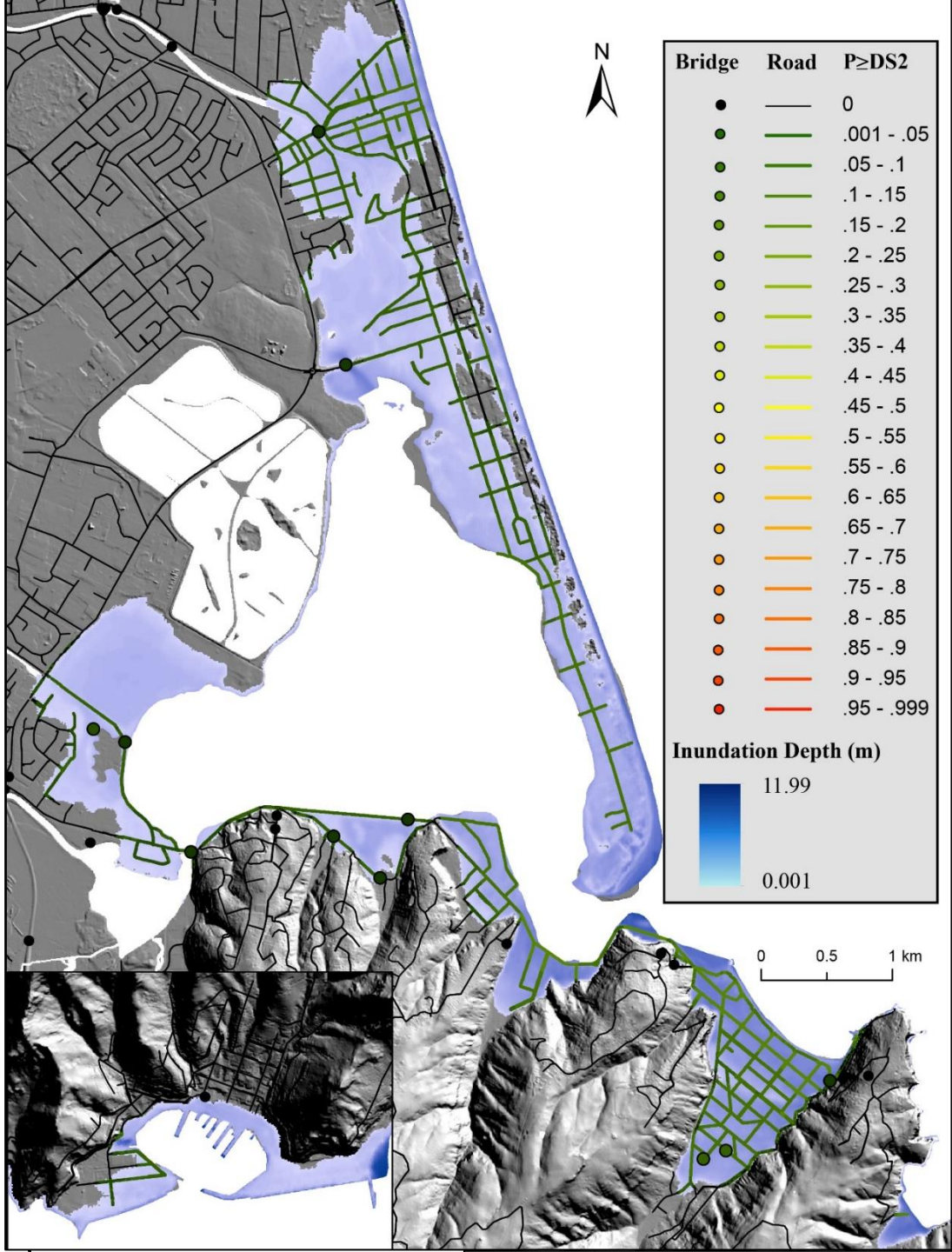


Hazard

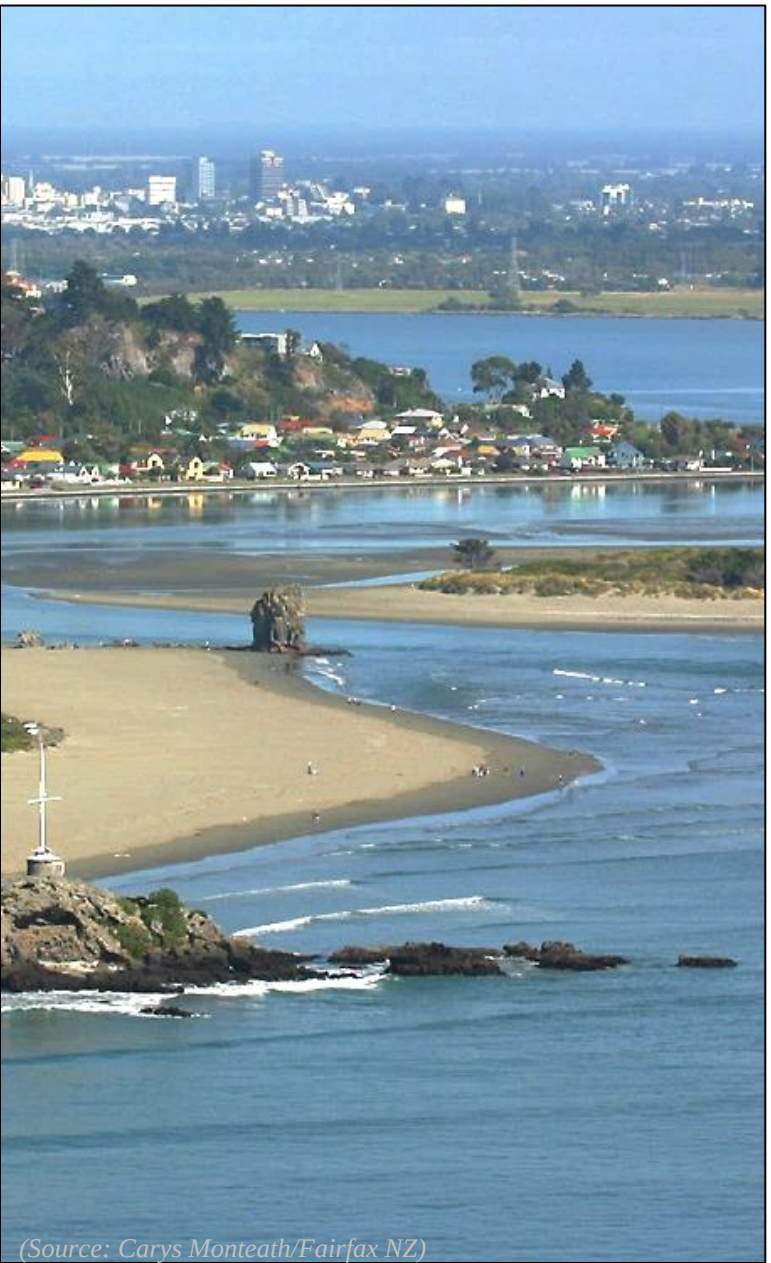
Exposure

Vulnerability

Impact



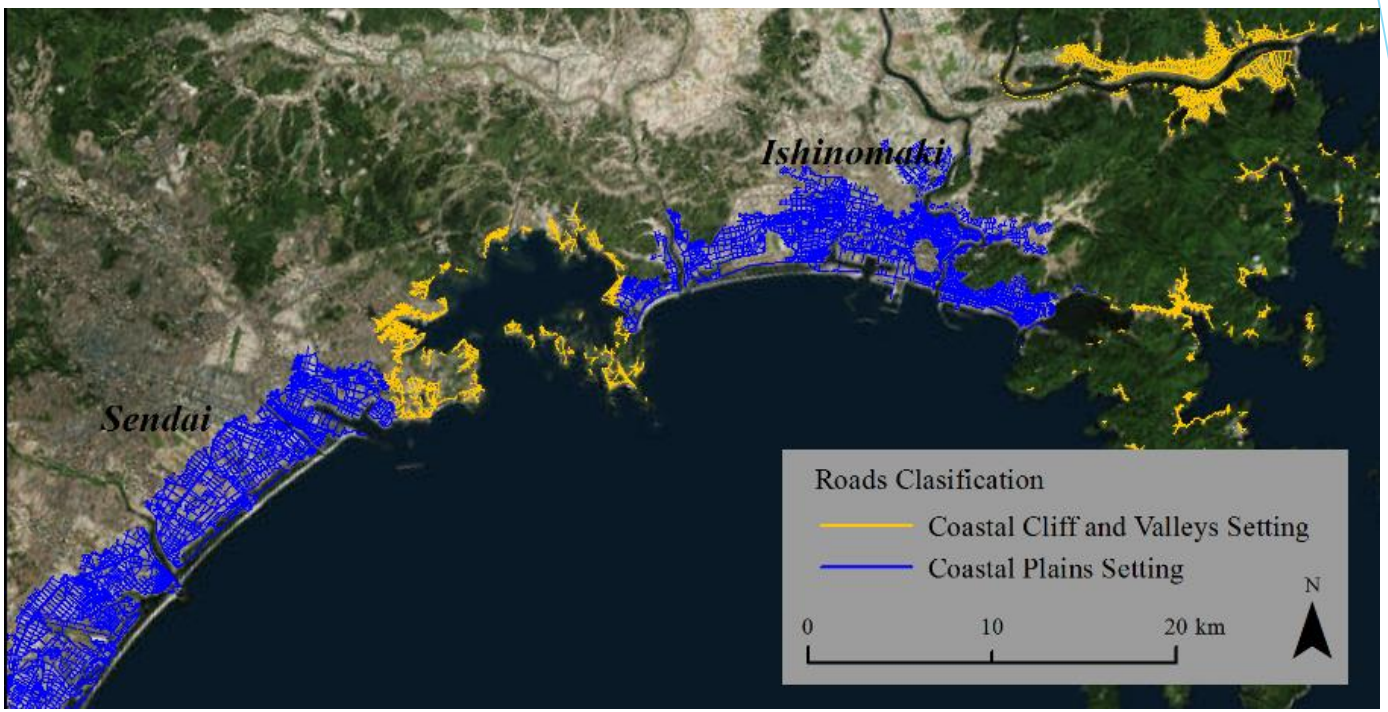
Model Limitations

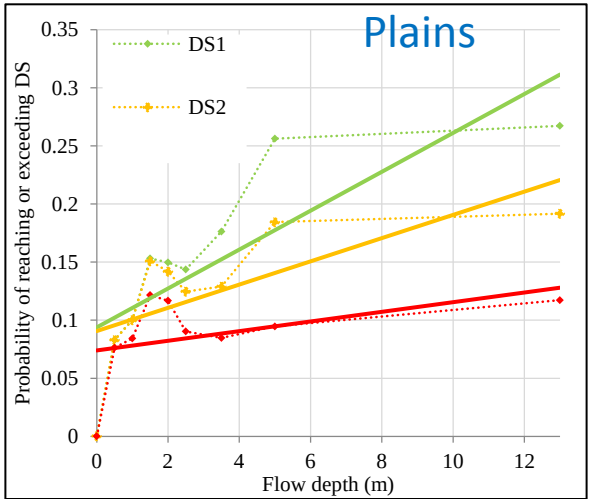


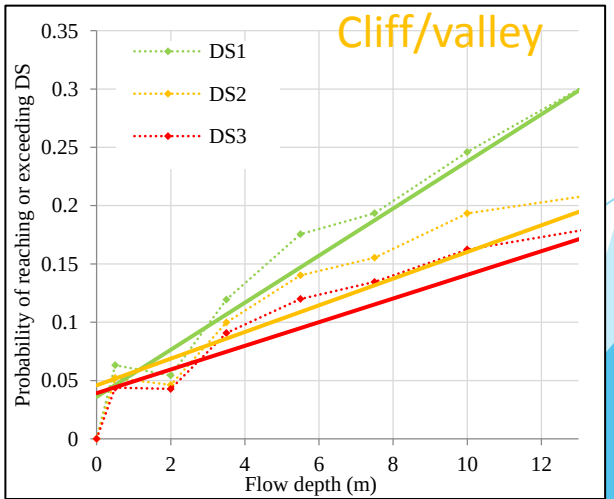
(Source: Carys Monteath/Fairfax NZ)

- Exclusively inundation
- Lack of damage states
- Qualitative data
- Incomplete asset database
- Isolated networks/assets

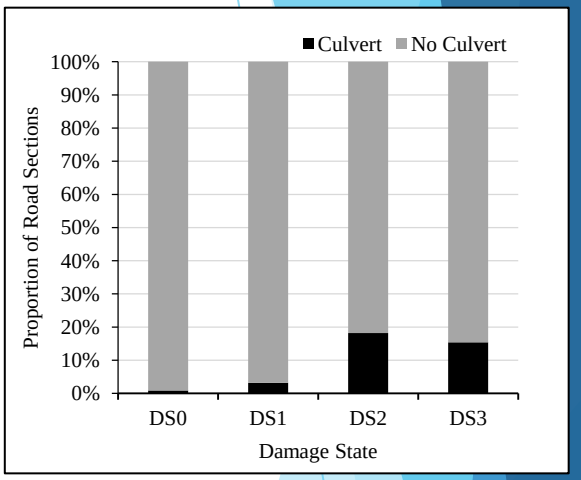
Road Damage: Topography

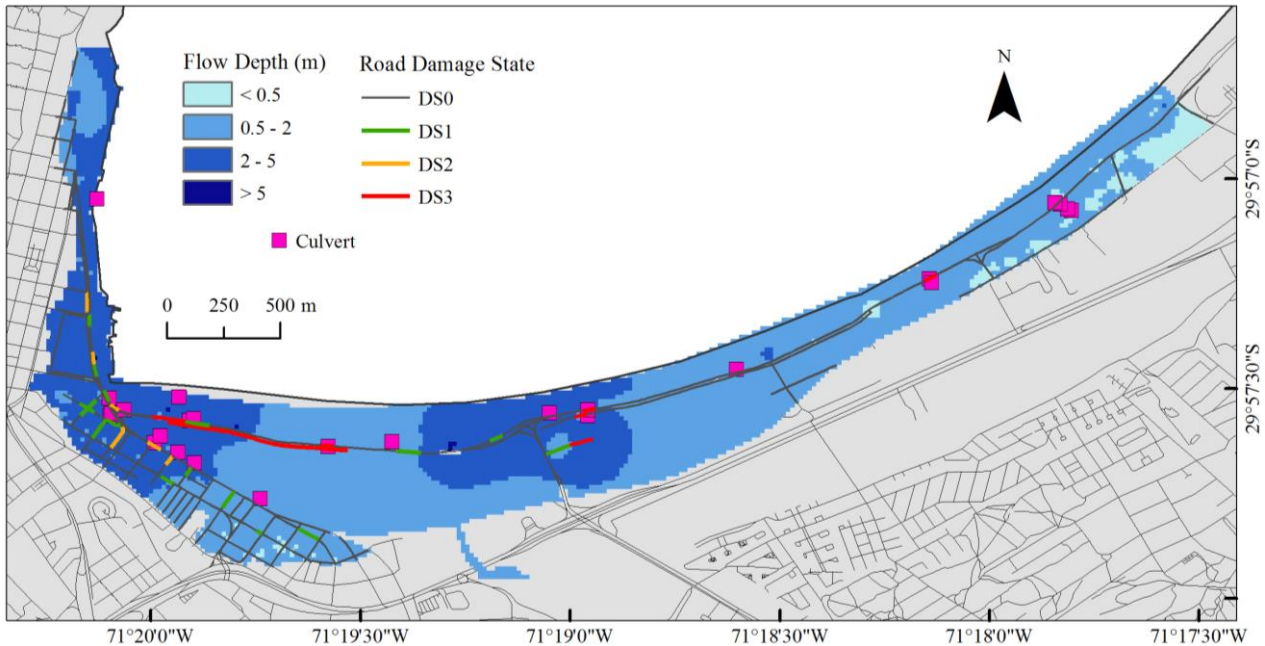




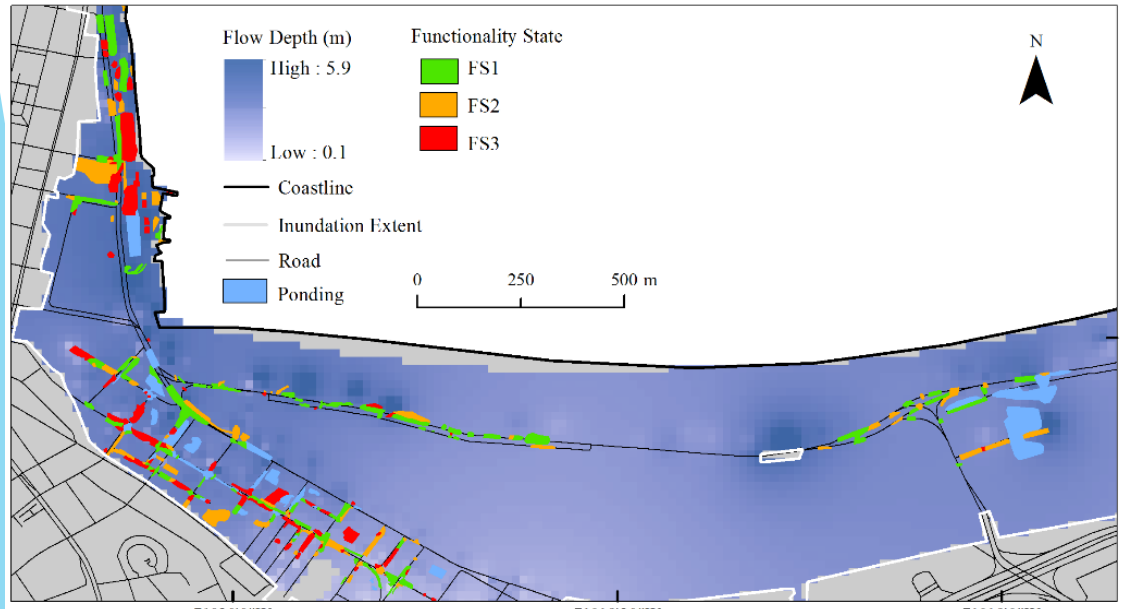


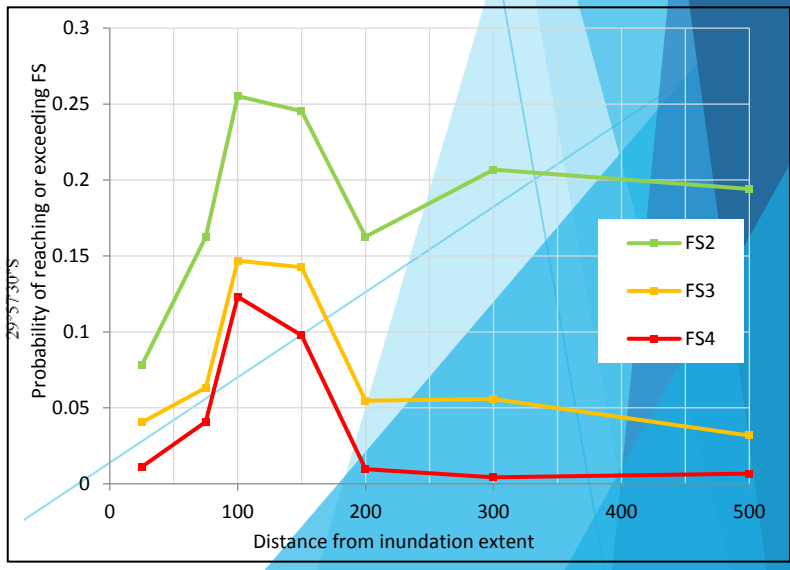
Road Damage: Culverts





Road Functionality: Debris





PhD Project

- Develop Vulnerability functions
  - Range of data sources (surveyed, empirical, expert)
  - Range of HIMs (depth, velocity, hydrodynamic forces)
  - Range of impact metrics (damage, functionality, restoration time, $)
- Application of functions for a New Zealand based Case study
- Longitudinal case study of impacts and recovery

QUESTIONS?

Supervision Team:

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[1] *Department of Geological Sciences, University of Canterbury*

[2] *GNS Science*

[3] *National Institute of Water and Atmospheric Research*

Supporting Organisations:

RiskScape NIWA Taihoro Nukurangi GNS Science Te Pū Ao Environment Canterbury Regional Council Kaunihera Taiao ki Waitaha National Science Challenges Resilience to Nature's Challenges EQC Earthquake Commission Kōmihana Rūwhenua Civil Defence Emergency Management Canterbury

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