Infrastructure Monthly Meeting
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Auckland Volcanic Field Population Exposure and Evacuation Clearance Time Modelling

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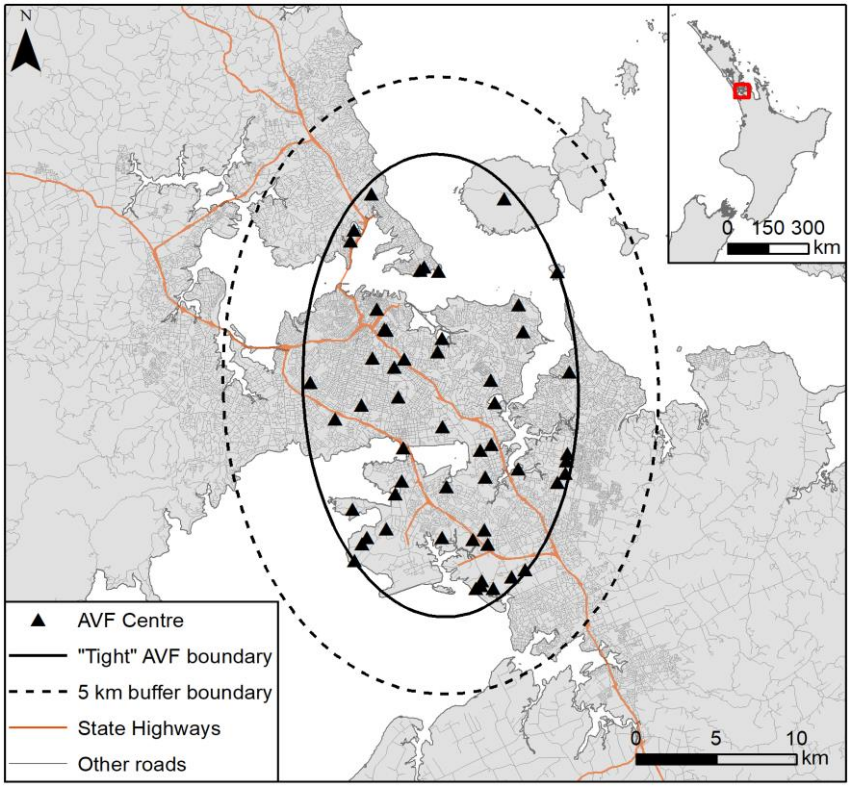
Auckland Volcanic Field

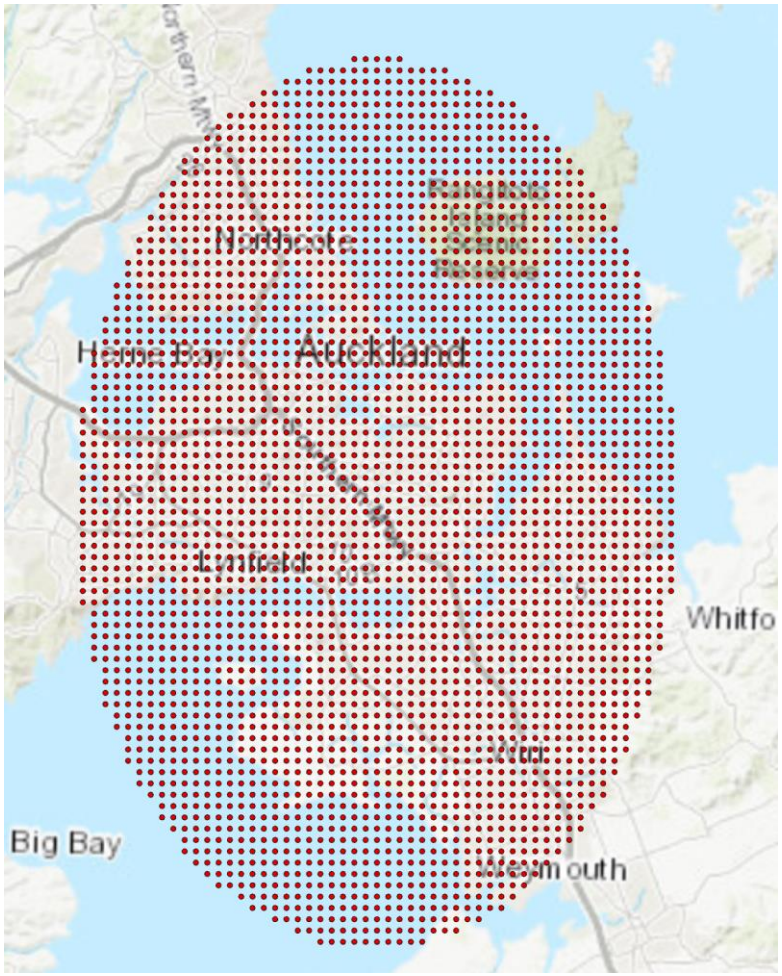
- AVF at least 53 eruptive centres in 190 ka distributed across 360 km^2
- Monogenetic volcanic field
- ~1.6 million people in Auckland
- Significant infrastructure and economic exposure



Boundaries from Runge et al. (2015)

AVF Grid

- Grid based on the +5 km AVF extent
- 500 x 500 m spaced grid points
- Total 3,312 points
- Runge et al. (2015) recommends the 5 km buffer to account for ongoing field development e.g. volume of Rangitoto

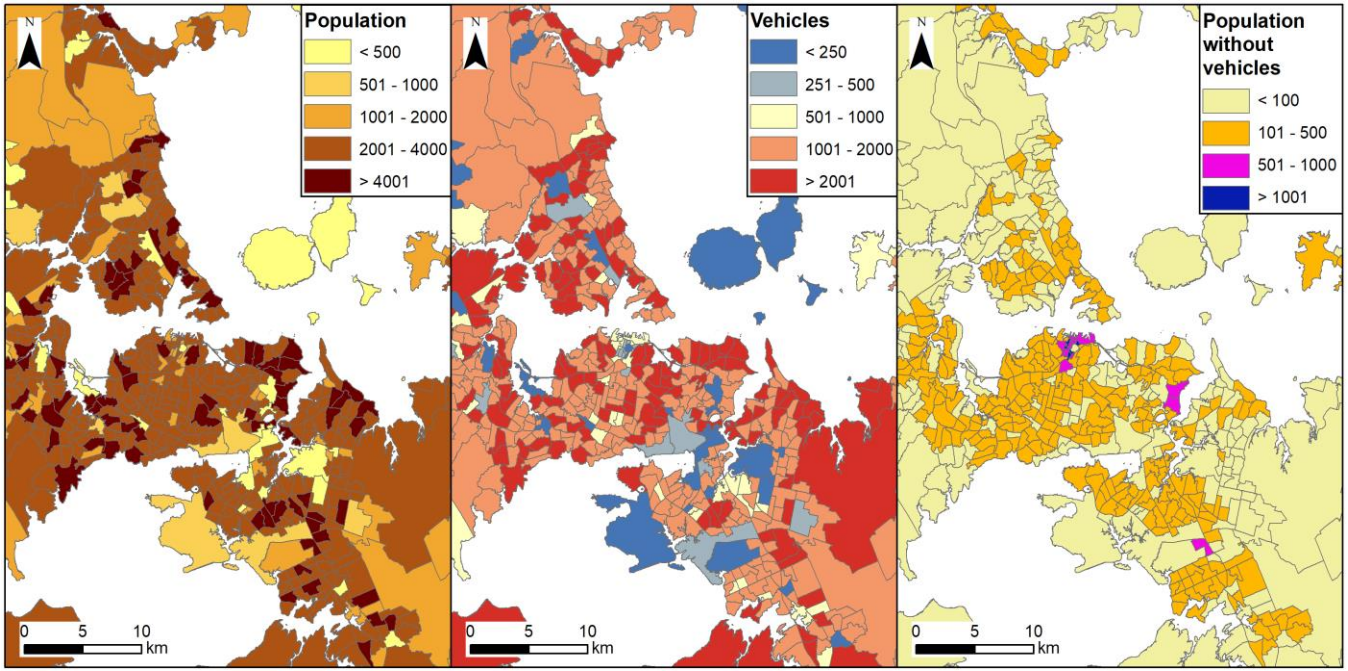


AVF Evacuation Zones

- Two zones to be declared under the AVF Contingency Plan (Auckland Council, 2015):
  - Primary Evacuation Zone (PEZ) - corresponds to a high hazard area
  - Secondary Evacuation Zone (SEZ) - corresponds to a moderate hazard area
- PEZ area encompassing both the inferred vent area and a 3 km zone extending radially from the vent area
- SEZ is an area extending 2 km radially from the PEZ boundary

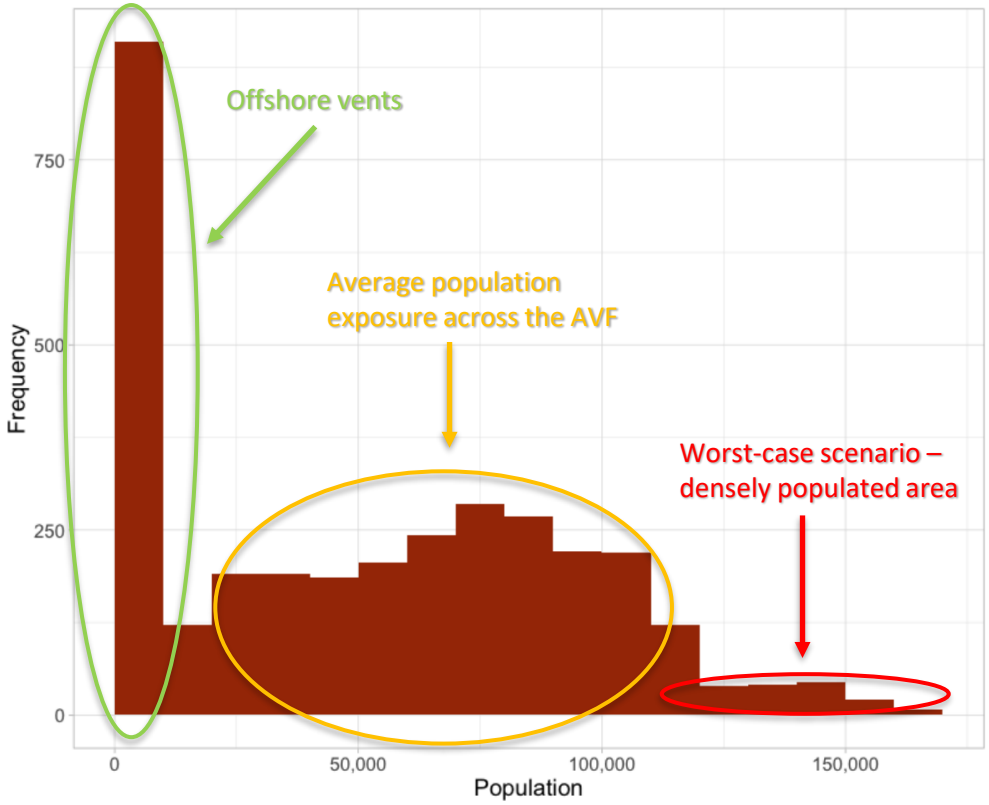
Exposure Analysis

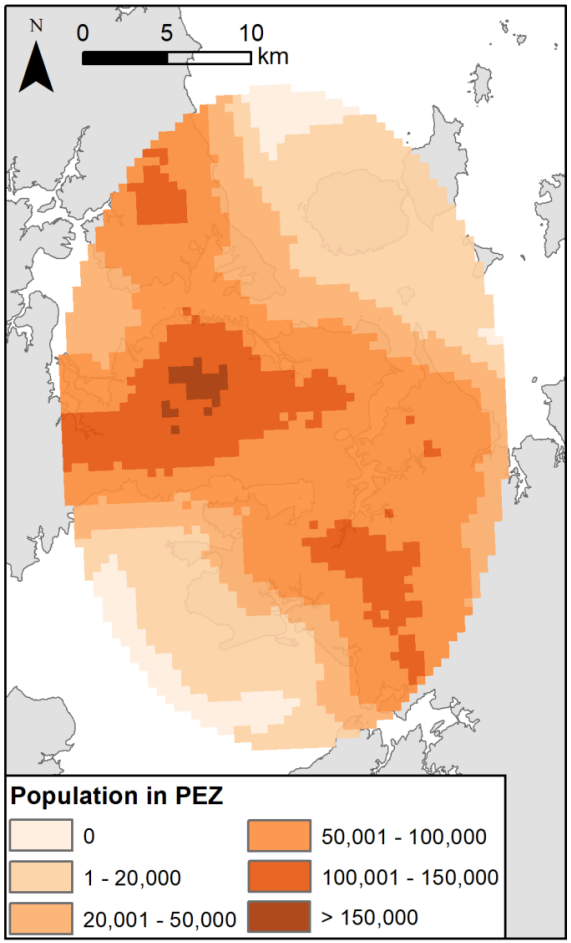
- Number of people – Displaced population
- Number of privately owned vehicles – Number of vehicles likely evacuating
- Number of people who do not own vehicles – Those needing evacuation support



Exposure Analysis

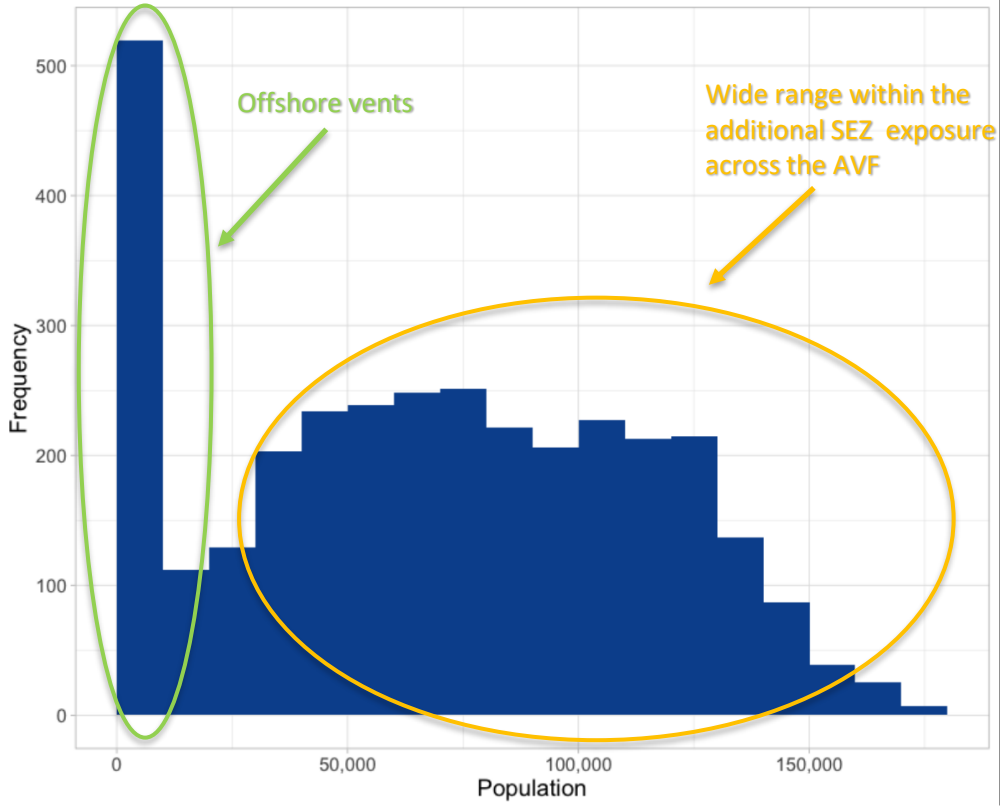
A. Primary Evacuation Zone

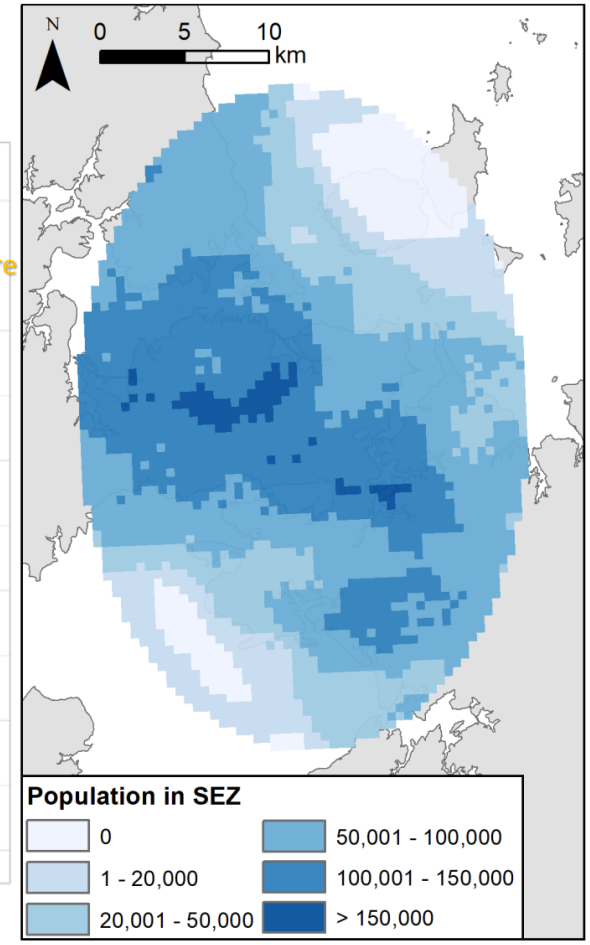




Exposure Analysis

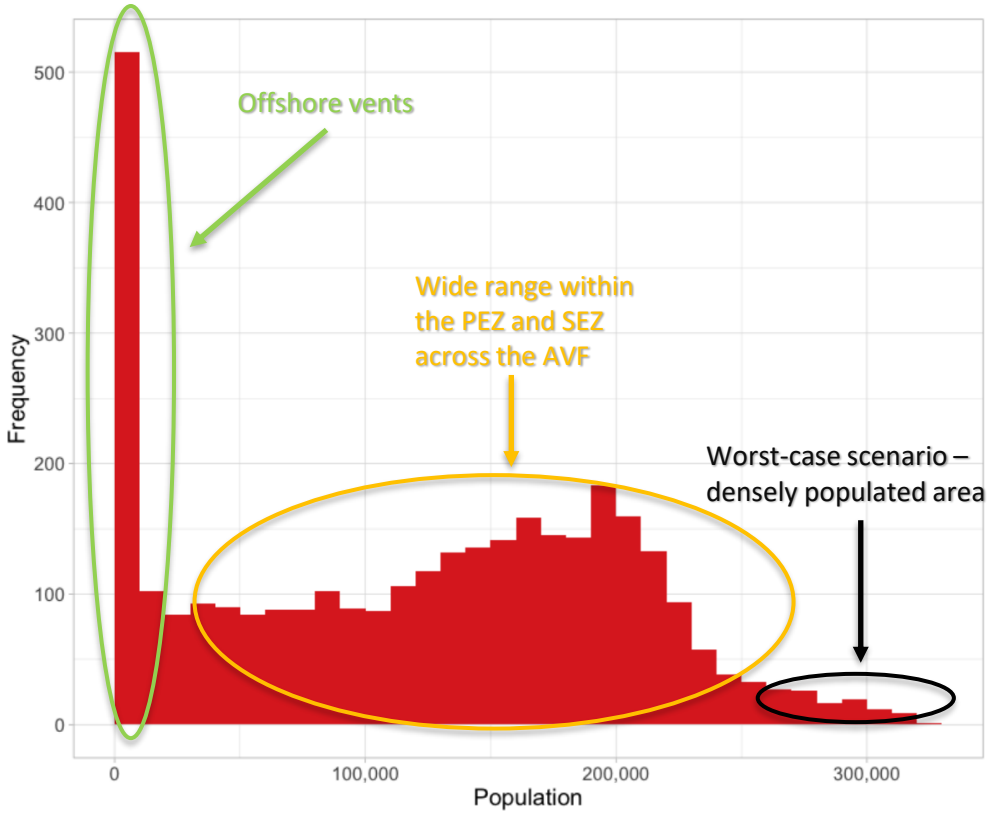
B. Secondary Evacuation Zone

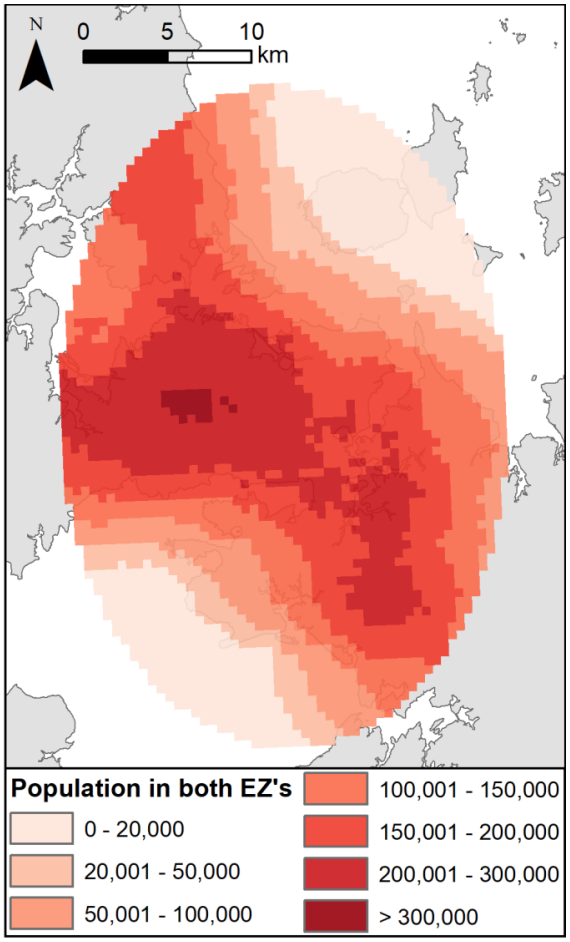




Exposure Analysis

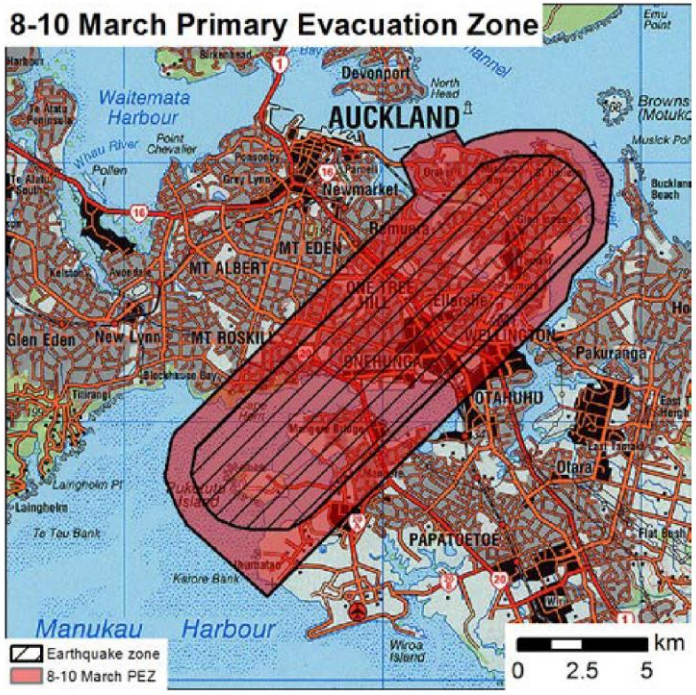
C. Both Evacuation Zones





Pre-eruption vent uncertainty

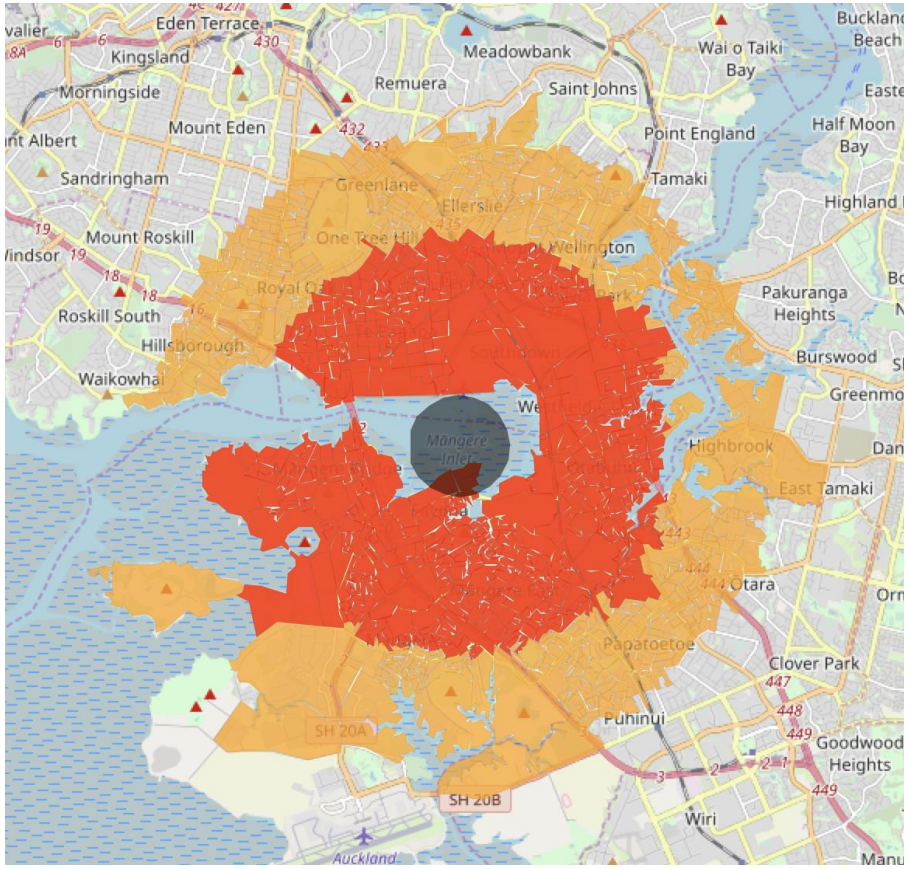
- Understanding the likely vent location is one of the biggest challenges – Especially for evacuation decision-making
- E.g. Extended Exercise Ruaumoko scenario (Deligne et al. 2015)
- Modelled vent uncertainties areas of 0-10 km at 0.5 km intervals

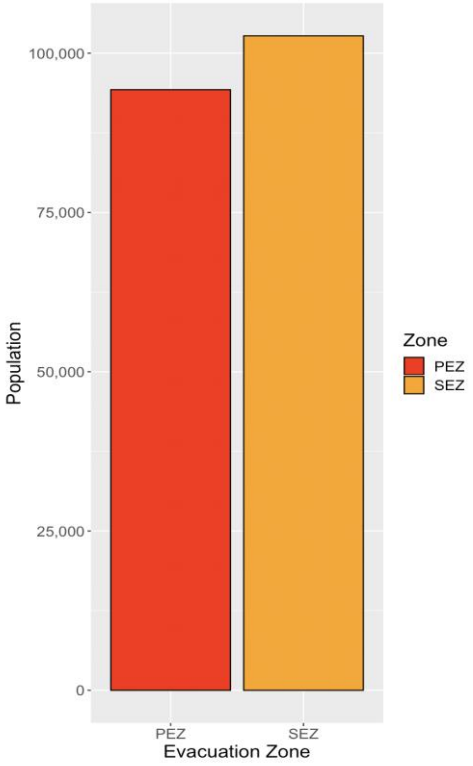


Deligne et al. (2015)

Exposure Analysis

- Model for all vent locations in the DEVORA grid
- Shown with 1 km vent buffer





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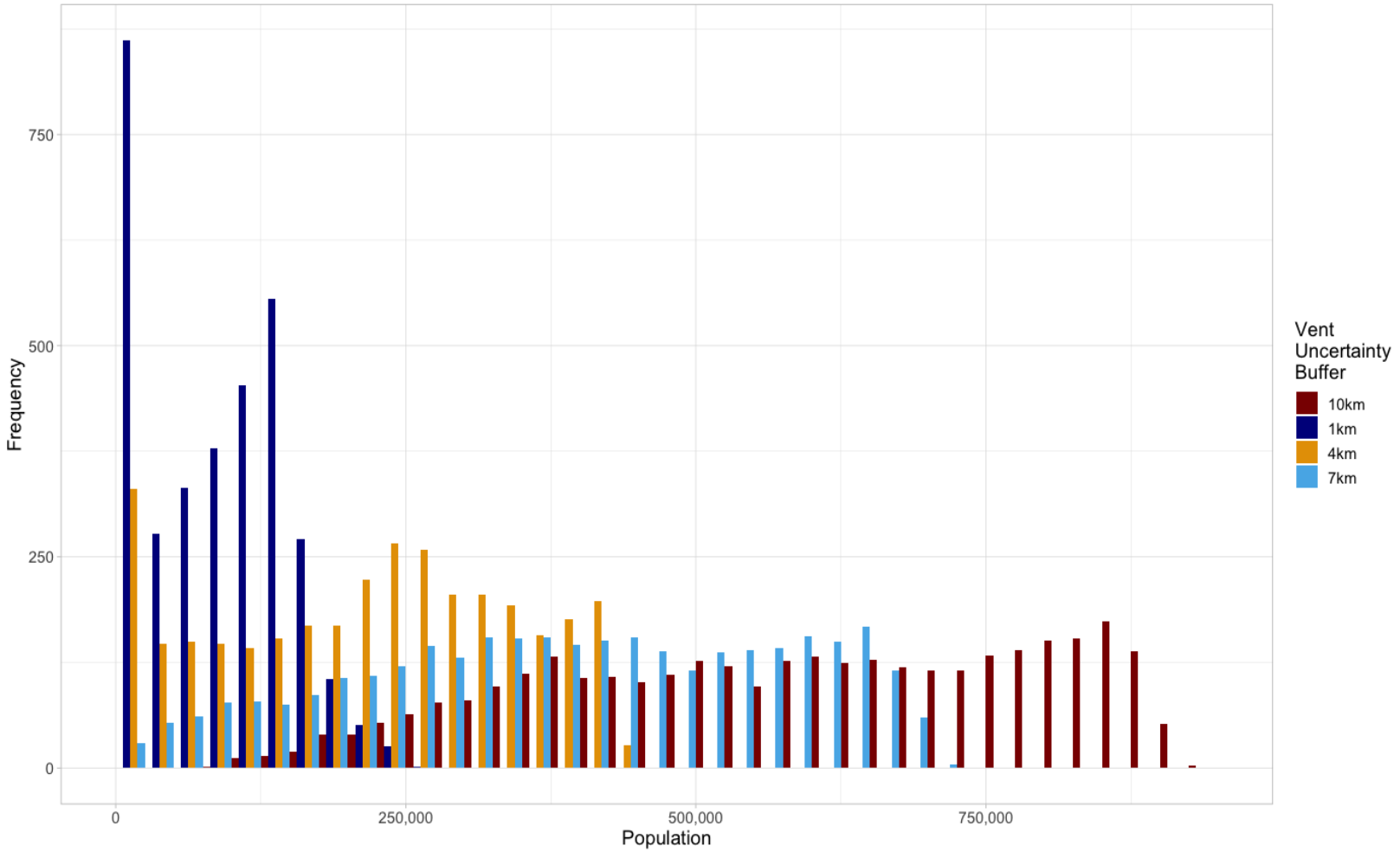

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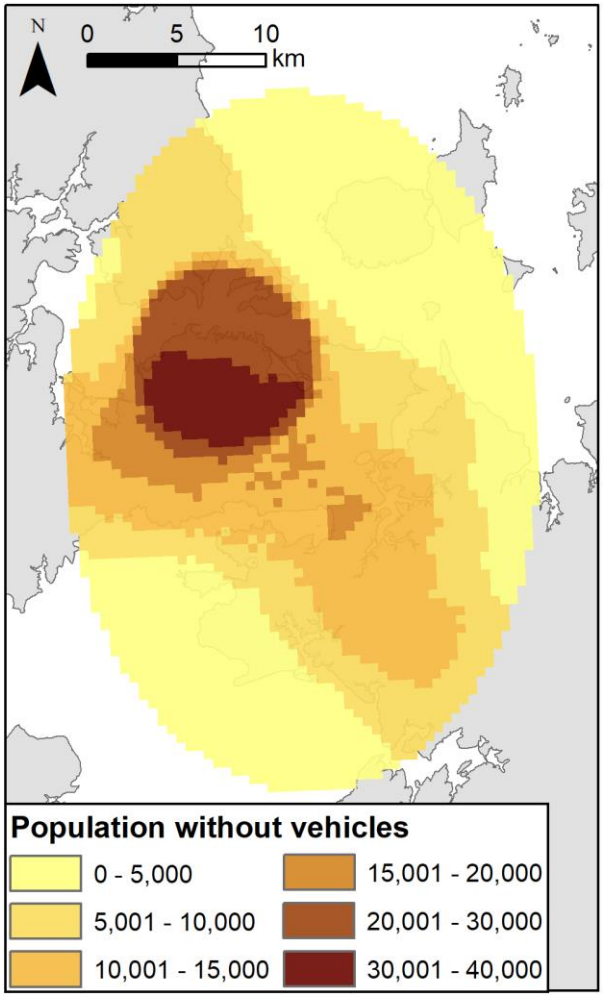
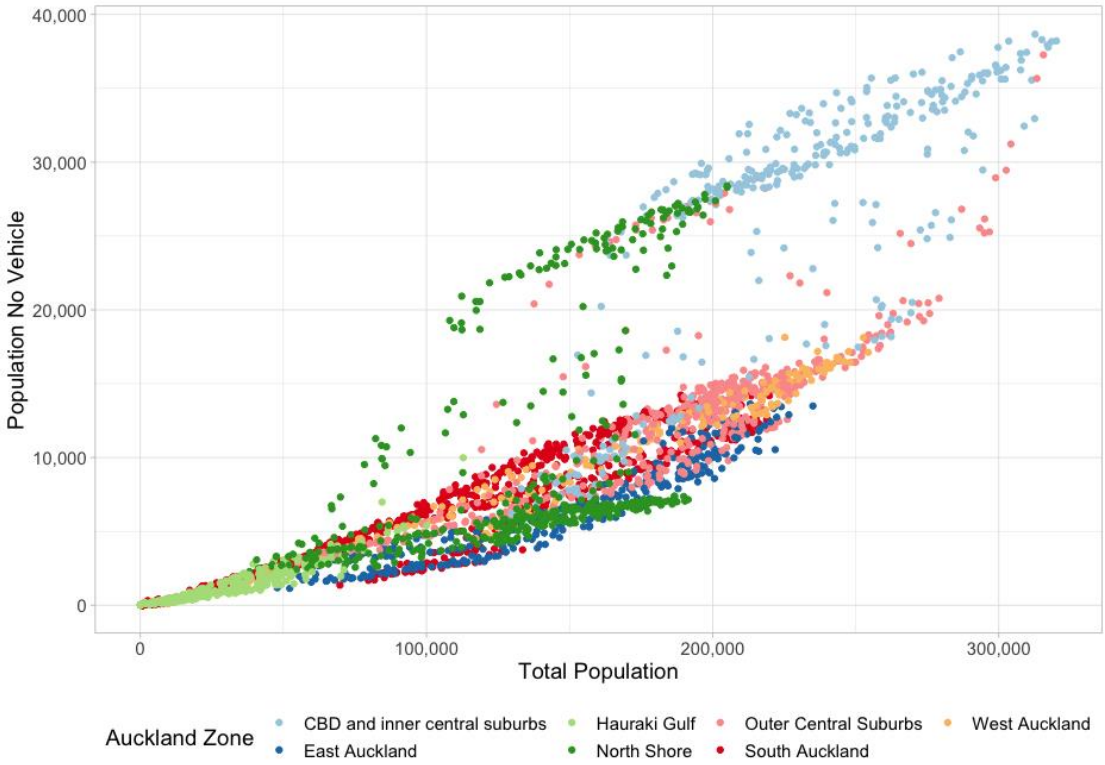




Evacuation clearance times

- Evacuation clearance time – How long to evacuate the identified area
- Urbanik et al (1980) defines this into four distinct categories:
    - Decision Time - The time elapsed from detection of an incident until official to make decision to order an evacuation.
    - Notification Time - The time required to get the evacuation notification to all individuals in the specified area.
    - Preparation time - The time required for individuals to prepare to evacuate the specified area.
    - Response time - The time required for individuals to physically move out of a specified area.

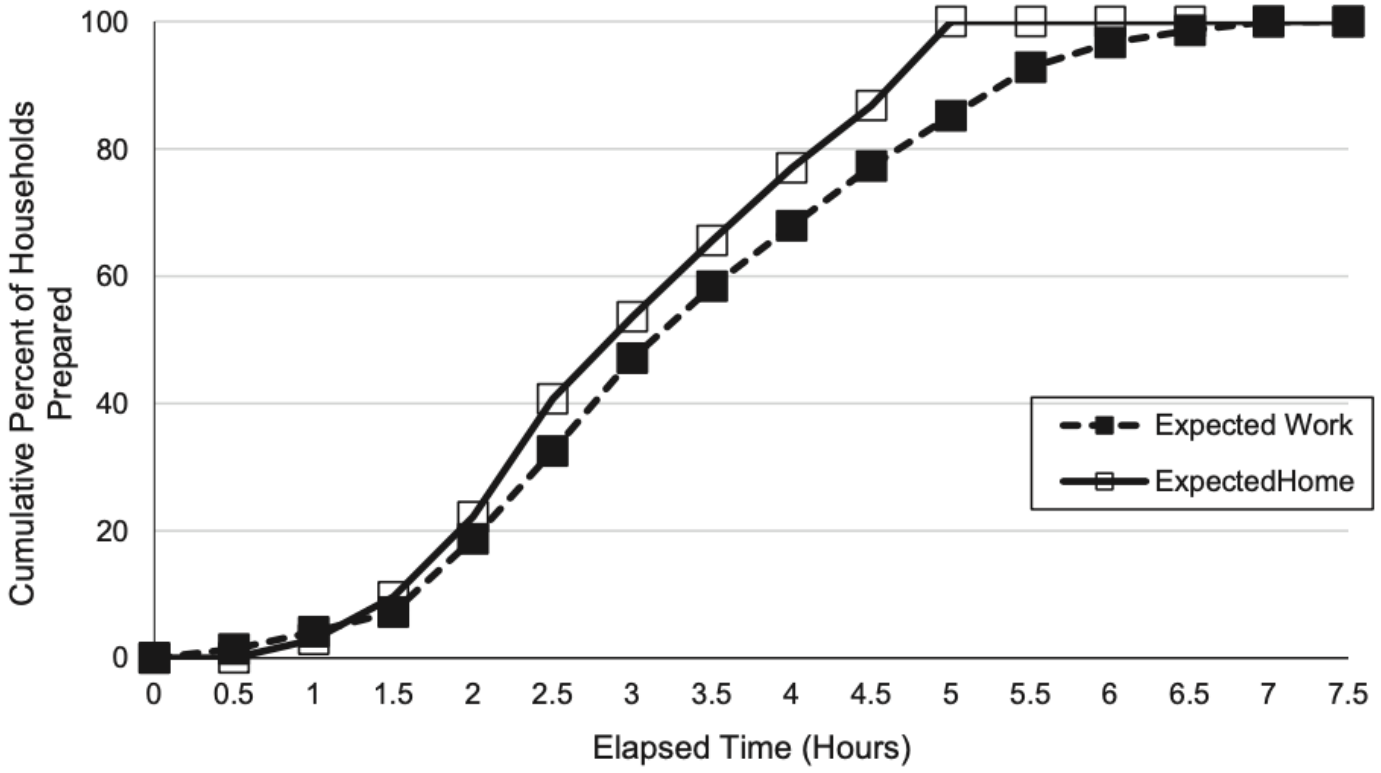
Decision Time

- Minimal data around decision time.
- During Exercise Ruaumoko - Several participants expressed the view that the evacuation call was probably a day late; this could have been attributed to a slow passage of information. However, this seems to be due to a limitation of the exercise (Cronin 2008).
- In Galveston County, Texas it took few hours to make the evacuation order from the National Hurricane Centre making the “hurricane warning” notification (treat as analogous for eruption threshold exceeded), but this was 4 weeks after Katrina, so social memory and recent visual of the consequence could of caused bias.

Notification Time

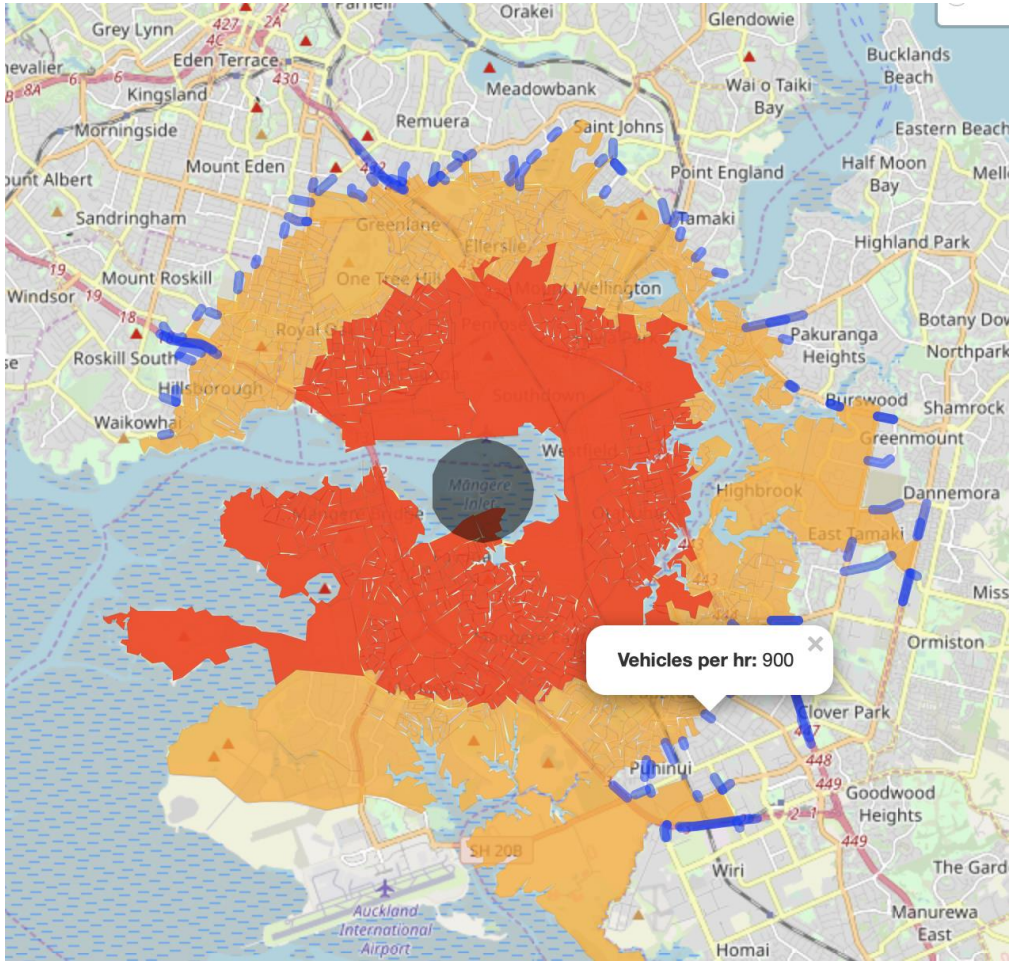
- In progress
- Research from the US how people typically receive the notification
    - TV
    - Radio
    - Websites
- Currently being reviewed the proportion of how people receive in NZ who receive the new NEMA messaging alert

Preparation Time



From Lindell et al. 2020

Response Time



- Sum the number of roads carrying capacity using standard vehicles per lane per hour exiting the SEZ i.e. exit bottlenecks

$$ExitTime = \frac{\sum_{vehicles}}{\sum_{v/hr}}$$

Response Time

- This is as the roads feeding into the major arterial exit roads have a greater capacity than the exit roads
- Egress routes reduced by the NZTA ONRC as primary collector, arterial, regional and a national roads
- Road Vehicle Capacities are taken from the Highway Capacity Manual (HCM, 2016) and AusRoads design standards
    - Highway – 1,900-2,200 vehicles/hour/lane
    - Arterial roads – 900-1,000 car/hour/lane

Response Time

- Stochastically sample for the identified egress routes from each AVF vent grid point:
    - Road vehicle capacity – Uniform distribution
    - Reduction in road capacity due to crisis – The capacity of traffic flows in evacuation drops by 10–20% (Yin et al 2020).
- This is conducted 100 times per AVF point and vent uncertainty to produce a distribution of vehicle capacity for the vent and evacuation zone.

Response Time

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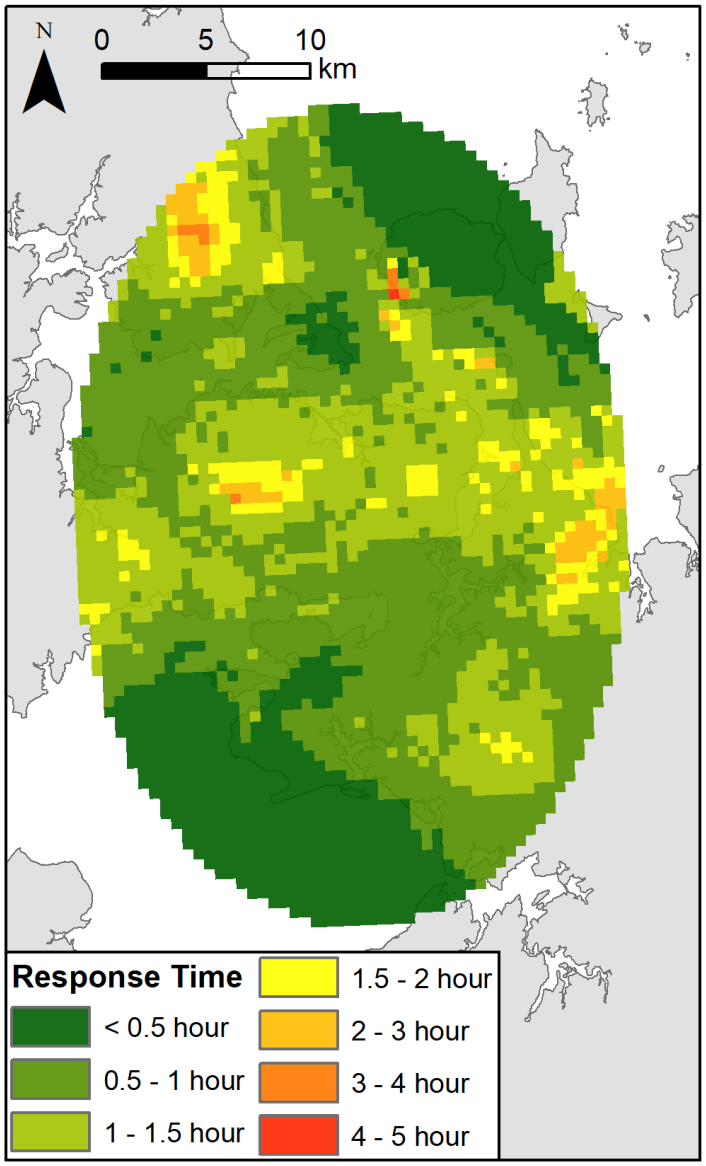

Evacuation clearance times

- Bring the distributions for each of the four components into forming a single distribution for each vent grid point and vent uncertainty distance representing evacuation clearance time.
- Raster subtraction will provide areas where vent uncertainty to is a significant factor for changes in exposure and clearance time
- Output is a high-level spatial model of the AVF estimating clearance times
- These time estimates can then be tested with AEM and NZ Police and compared against other international examples e.g. estimates of 84 hours for Miami and 72 hours for New Orleans (Chinander Dye et al 2014).

Next Steps

Subsequent follow on work as part of my PhD project

- Develop a short-term eruption forecasting model for the AVF
- Combine the eruption forecasting model with dynamic cost-benefit analysis (Bebbington and Zitikis, 2016) in an evacuation decision-support tool for the AVF

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Thank you

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