

## Determining Volcanic Risk in Auckland

Ross Roberts

*Auckland Council*



*TVNZ artist's rendition of the start of an Auckland eruption, 2012*

*Kilauea, last year*

Jan Lindsay, Graham Leonard, Natalia Deligne, Tom Wilson,  
Richard Smith, Elaine Smid + others!

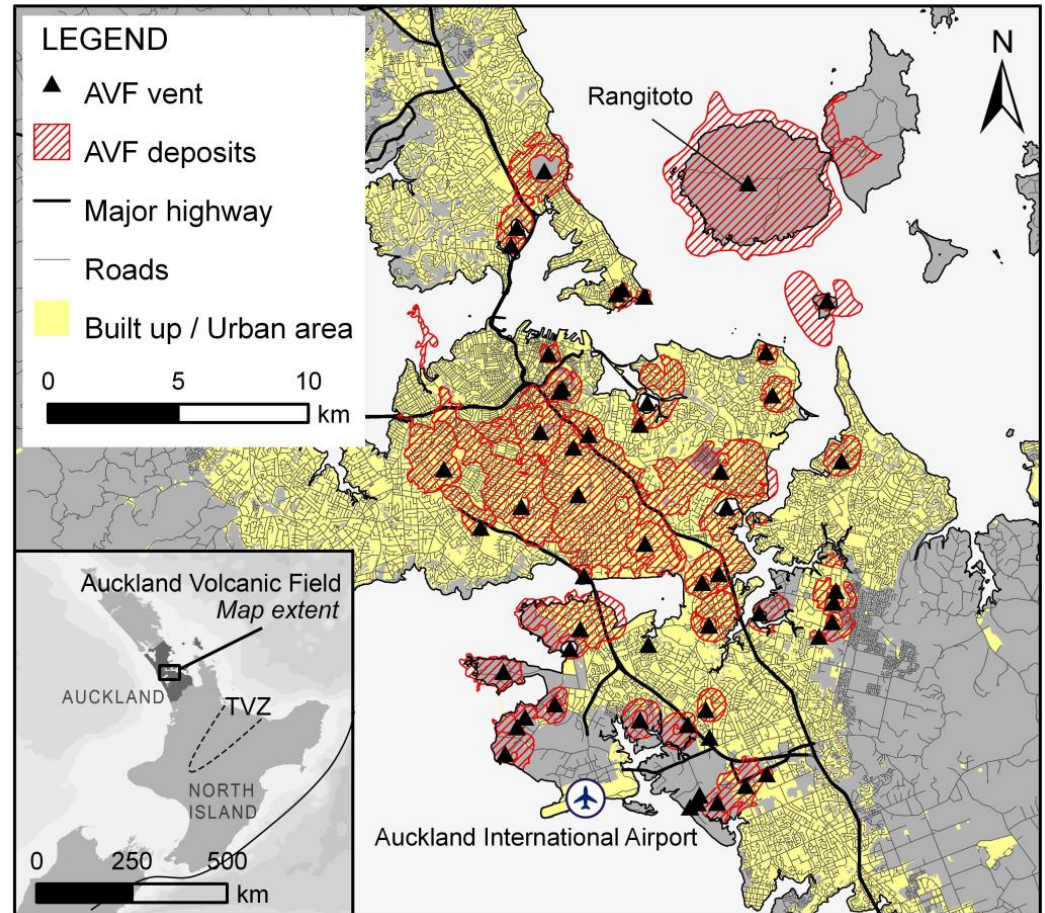
# The problem

## Before DEVORA

- Research ad-hoc and scattered. No integrated volcanic hazard and risk projects.
- 1993 Allan and Smith hazard summary remained the most up to date information. Volcanic risk was only touched upon in passing.

# Auckland Volcanic Field

- ~53 small “monogenetic” basaltic centres
- Intraplate (not related to subduction)
- Active from ca. 200,000 to 550 yBP
- Lies beneath Auckland, pop. ~1.5 million

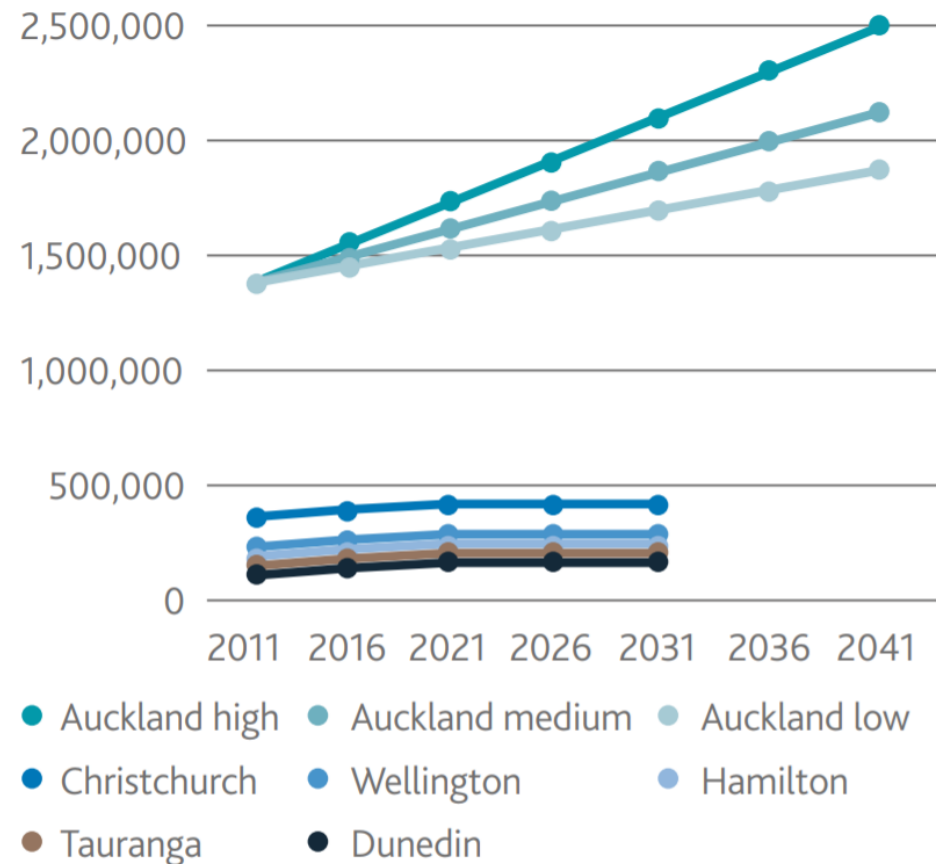


*from Lindsay et al. 2016*



# Population

- Hyper-diverse
  - More than 200 different ethnicities
  - 40 per cent of Aucklanders not born in New Zealand
- Growing fast



Source: Statistics NZ and Auckland Council

# AEM Group Plan

## Very high priority

- Coastal inundation (storm surge)
- Flooding (river and catchment)
- Infectious human disease pandemics
- Severe winds
- Super storm

## High priority

- Coastal erosion (beach and coastal cliff)
- Earthquake (includes liquefaction)
- Lifeline utility failure: communications
- Lifeline utility failure: electricity
- Hazardous substances spill
- Land instability
- Major transport accident (aircraft, rail, road, marine)
- Lifeline utility failure: airport, port, rail, roading
- Tsunami (distant, regional or local source)
- Urban fire
- Volcanic eruption (Auckland Volcanic Field or ashfall from distant source)
- Wildfire (rural)

## Moderate priority

- Animal pandemic
- Civil unrest
- Dam failure (stormwater and other)
- Drought (agricultural)
- Lifeline utility failure: fuel supply
- Lifeline utility failure: water supply
- Marine oil spill
- Plant and animal pests
- Terrorism
- Tornado

## Low priority

- Dam failure (water supply)
- Drought (water supply)
- Information technology infrastructure risk
- Lifeline utility failure: gas
- Lifeline utility failure: wastewater
- Radiation incident
- Space hazards<sup>13</sup> (including solar flares)



# AUCKLAND: IT'S OUR VOLCANO



**Inaugural meeting, October 2006**



# Official launch, 6 Nov 2008



## TEPHRA TROUBLE

### VOLCANIC HAZARDS ROAD SHOW

#### WHERE?

Te Korowai Room  
Auckland Museum, Auckland

#### WHEN?

7.30-8.30pm  
6 November 2008

#### WHO?

**Dr. David Johnston:** Joint Centre for Disaster Research, Massey University/GNS Science

**Dr. Jan Lindsay,** Institute of Earth Science and Engineering, The University of Auckland

**Tom Wilson,** Natural Hazards Research Centre, University of Canterbury



#### WHAT?

This travelling road show summarises 15 years of research on the potential impacts of volcanic eruptions on New Zealand.

The lectures will describe key lessons from a series of post-impact reconnaissance trips to eruptions in Argentina, Chile, Ecuador, USA, Italy, Iceland, Philippines, Japan and Indonesia. These trips have increased our knowledge and understanding of the likely impacts to:

- People and communities
- Engineering lifelines
- Infrastructure
- Key primary industries



Further lectures will take place in other venues from September to December 2008

For more information contact Tom Wilson  
([thomas.wilson@pg.canterbury.ac.nz](mailto:thomas.wilson@pg.canterbury.ac.nz))

Roadshow is supported by the  
Earthquake Commission





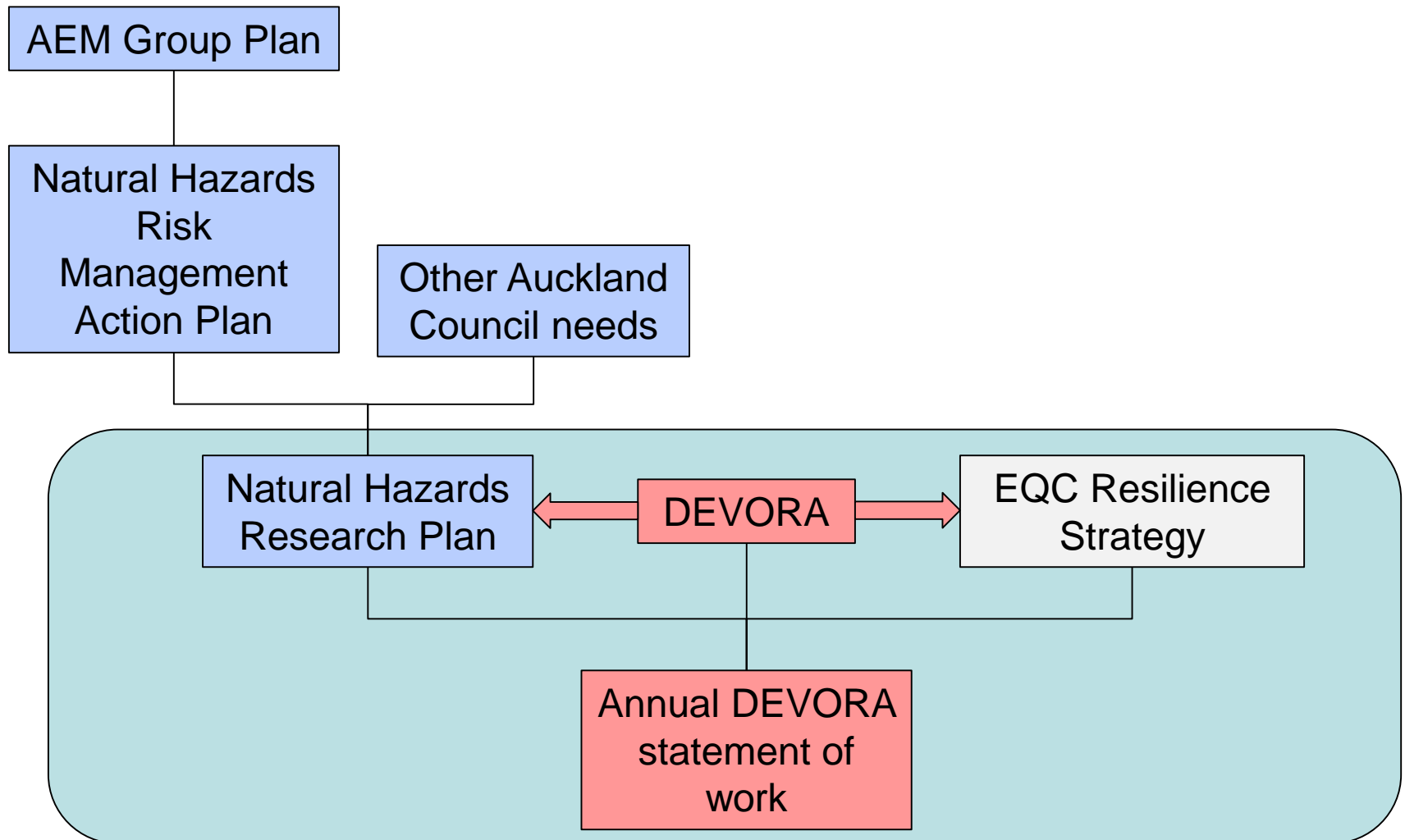
## Determining Volcanic Risk in Auckland

- Multi-agency, transdisciplinary collaborative research programme
- Original aim: make Auckland better prepared for and safer from volcanic activity
- Primary focus is Auckland Volcanic Field, some consideration of disruption from distant volcanoes





# Decision making



# Annual DEVORA planning cycle



## Statement of Work



DETERMINING VOLCANIC RISK IN AUCKLAND

Statement of Work for 2017-2018



## Steering Committee (Autumn)



Research,  
Forums,  
workshops



## The Master "ideas" spreadsheet

| Task name | Deliverables/Milestones | Completion  |
|-----------|-------------------------|-------------|
| DEV1      | Task 1                  | Completed   |
| DEV2      | Task 2                  | In Progress |
| DEV3      | Task 3                  | Not Started |

325 entries

## The annual budget



## Steering Committee (Spring)

## Phase 1: 2008 - 2015

### Theme I: Geological Model

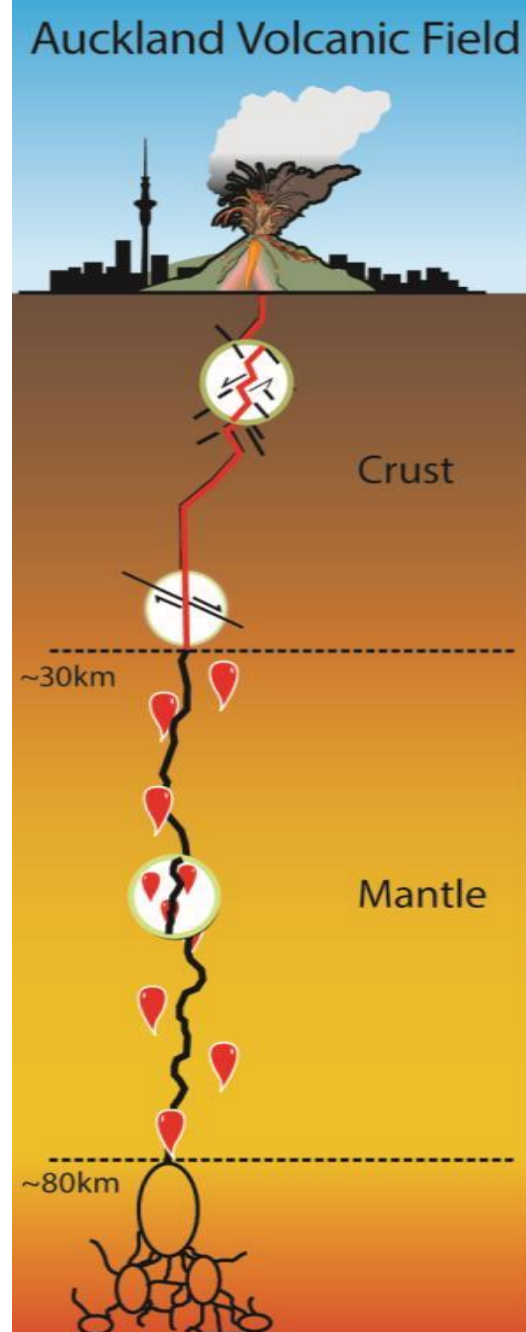
- Where is magma coming from?
- How fast will magma travel to surface?

### Theme II: Hazard Model

- What are likely styles and hazards of future eruptions?
- How does eruption style depend on substrate and environmental factors?

### Theme III: Risk and Social Model for Auckland

- How will each hazard affect people and infrastructure?
- What are the risks to people and infrastructure?
- How can these risks be reduced?



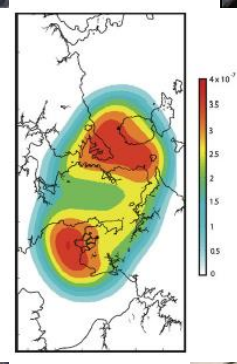
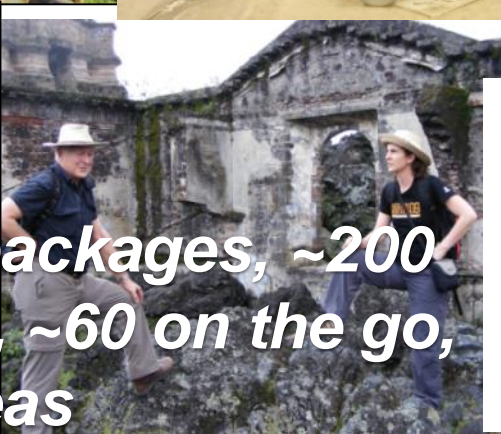
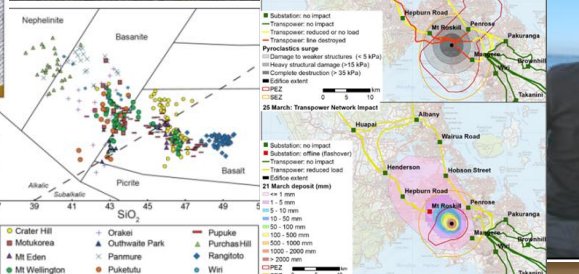
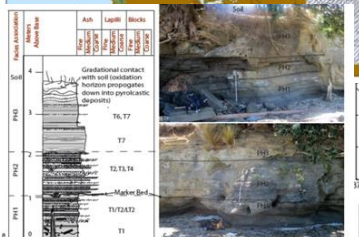
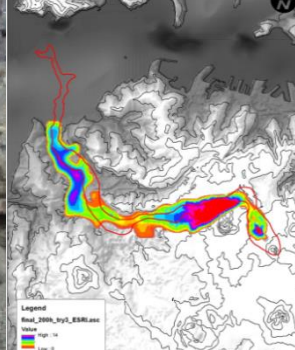
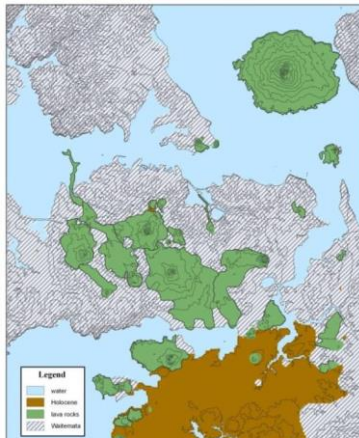




## Phase 2: 2015 - “DEVORA 2020”

1. We are confident in knowing the Auckland Volcanic Field (AVF)
2. Our diverse society knows, understands and trusts our science
3. People will behave appropriately in a volcanic crisis
4. People understand and appropriately mitigate risk and consequence in language/formats that suit their needs
5. Auckland Council, businesses and individuals have anticipated, prepared for and are able to respond and recover - planning appropriately
6. DEVORA supports 'Resilient Auckland'
7. Auckland continues to thrive following any NZ eruption
8. Our science has wider benefits
9. Auckland is linked in to other major hazard programmes, aligned to DEVORA
10. We are confident in knowing other volcanic threats to Auckland





***325 work packages, ~200 completed, ~60 on the go, ~60 are ideas***

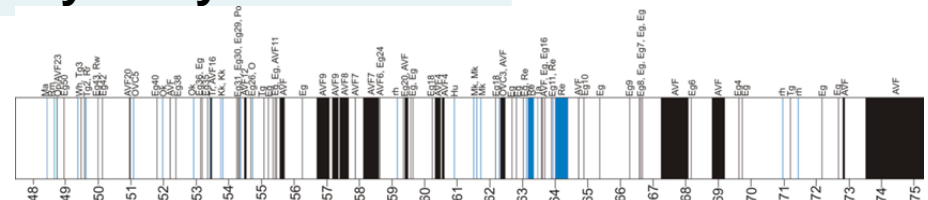


# Frequency of tephra fall

Estimated minimum frequency of tephra fall from local and distal volcanoes in Auckland over the last 11,000 years



| Volcanic Source                     | Minimum frequency           |
|-------------------------------------|-----------------------------|
| Okataina Volcanic Centre            | Once every 3,000 years      |
| Taupo Volcanic Centre               | Once every 1,300 years      |
| Mayor Island                        | Once every 9,000 years      |
| Taranaki Volcanic Centre            | Once every 3,000 years      |
| Tongariro Volcanic Centre           | Once every 2,200 years      |
| Auckland Volcanic Field             | Once every 3,000 years      |
| <b>Total – all sources combined</b> | <b>Once every 400 years</b> |





# DEVORA research highlights: ages



Contents lists available at ScienceDirect

Journal of Volcanology and Geothermal Research

journal homepage: [www.elsevier.com/locate/jvolgeores](http://www.elsevier.com/locate/jvolgeores)



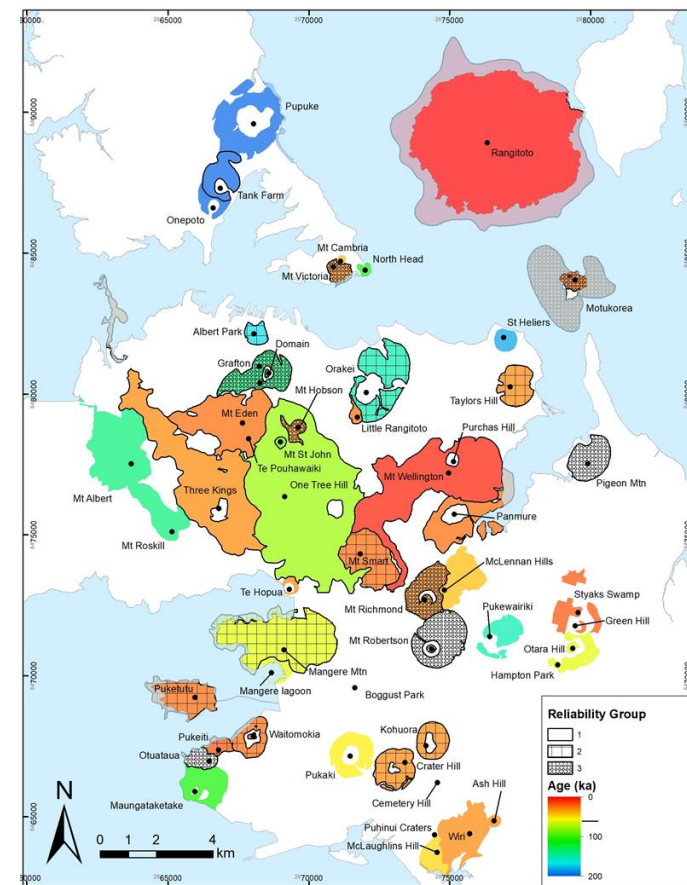
High-precision  $^{40}\text{Ar}/^{39}\text{Ar}$  dating of Quaternary basalts from Auckland Volcanic Field, New Zealand, with implications for eruption rates and paleomagnetic correlations

Graham S. Leonard <sup>a,\*</sup>, Andrew T. Calvert <sup>b</sup>, Jenni L. Hopkins <sup>c</sup>, Colin J.N. Wilson <sup>c</sup>, Elaine R. Smid <sup>d</sup>, Jan M. Lindsay <sup>d</sup>, Duane E. Champion <sup>b</sup>

- No obvious spatial progression of eruptions
  - some alignment to known faults
- A number of temporal patterns

Gone from 15 to 40 of 53 volcanoes dated, now **one of the best dated volcanic fields in the world**

- Oldest dated centre 193 ka (Pupuke)
- An increase in the rate of volcanism since 60 ka
- 48% of eruptions have repose periods < 1000 yrs
- 6 eruption "flare-up" between 30-34 ka
- Apparent "coupling" of eruptions close in space and time
- Generally a complex eruption history



# Likelihood of a future eruption in AVF?

## Approach A:

55 eruptions over 200,000 years.

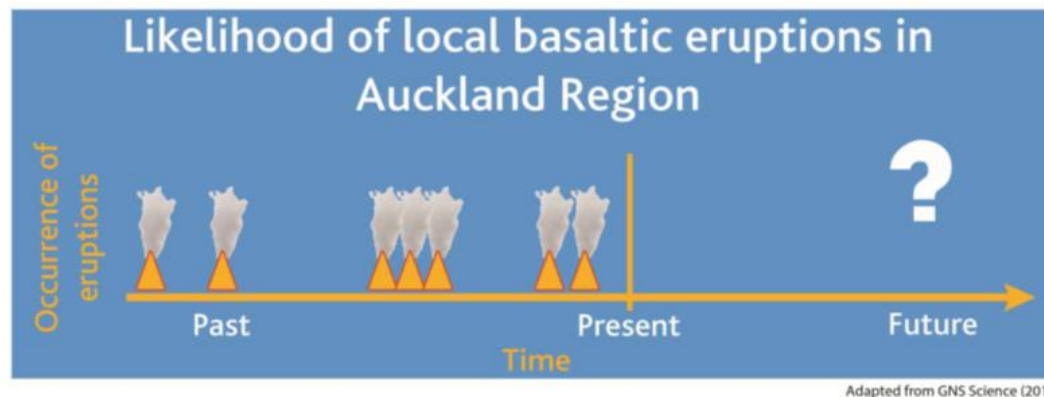
Recurrence rate = 1 eruption every 3,600 years.

## Approach B:

Increased eruption rate since 60,000 years. Using this time period:

Recurrence rate = 1 eruption every 1,500 to 2,600 years.

(But within that time, repose periods have ranged from 50 to 10,000 years.....)



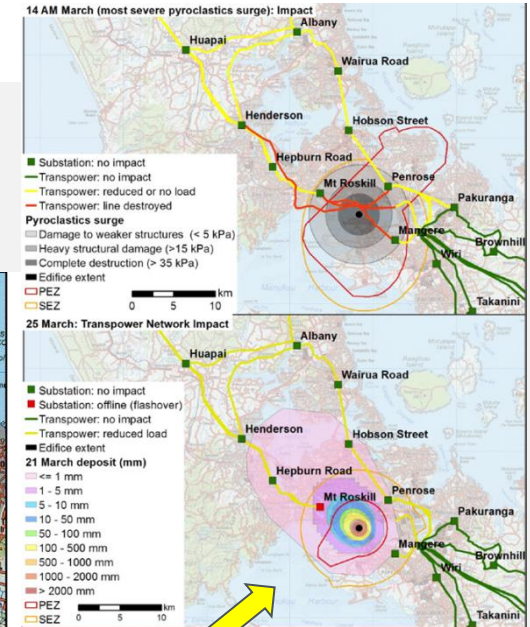
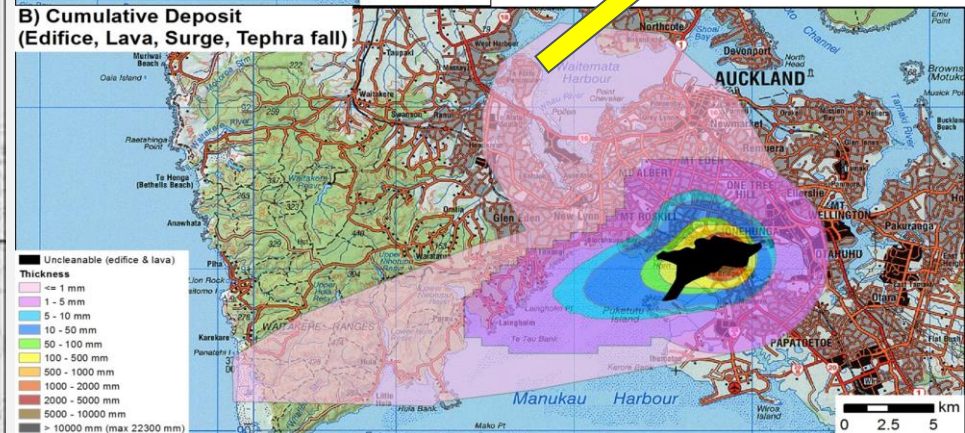
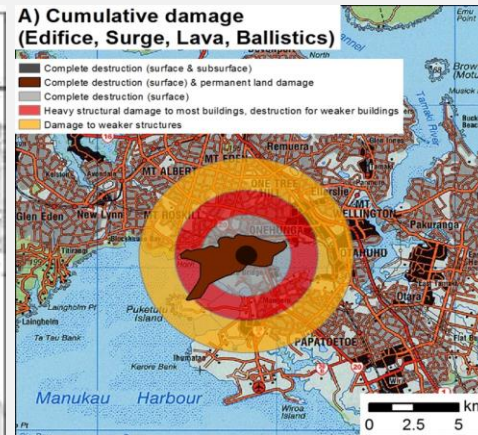
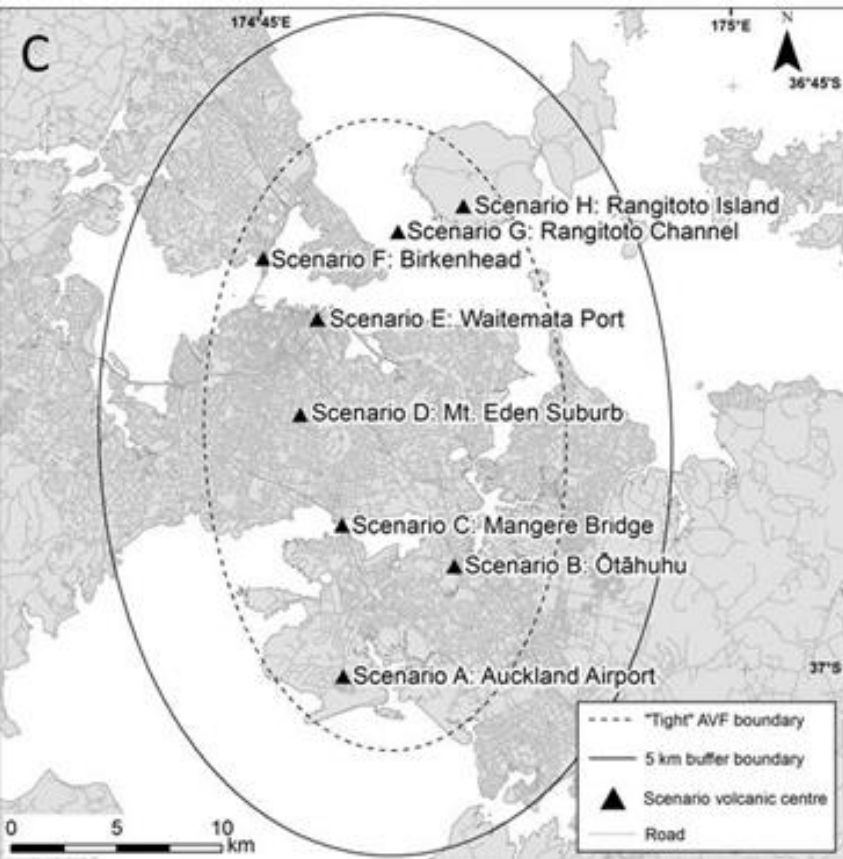
**So..... No one number is adequate to fully explain hazard, but an eruption is unlikely in our lifetime**



# Our research informs 8 DEVORA scenarios

Which are being used to assess impacts using Riskscape (*Deligne et al. 2017*)

e.g. Scenario C:  
Mangere Bridge

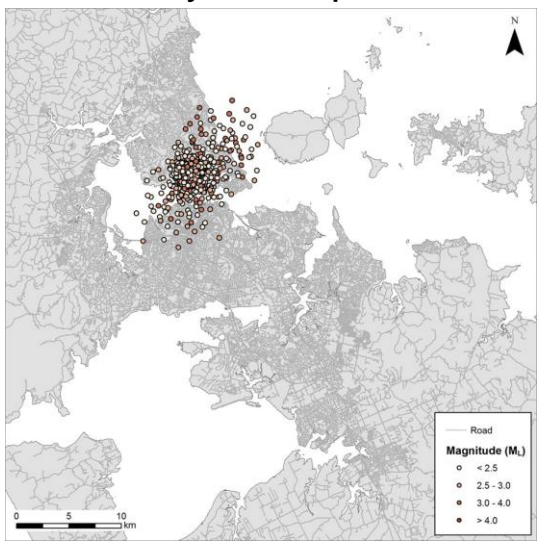




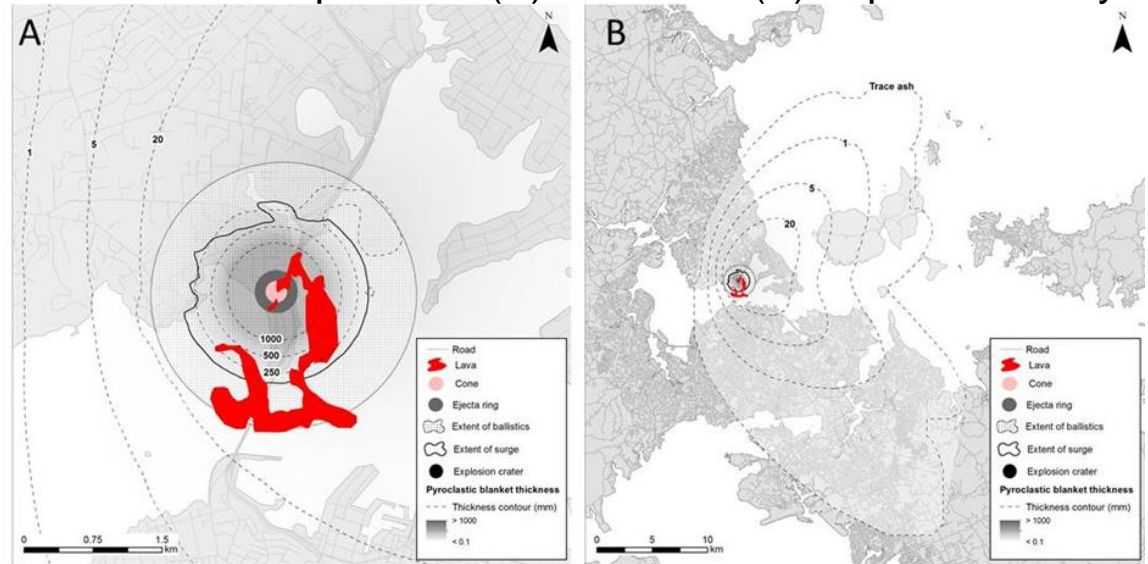
# Scenario F: Birkenhead

Josh Hayes et al

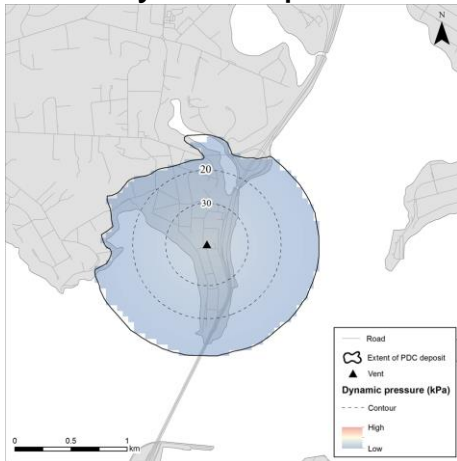
## Precursory earthquakes



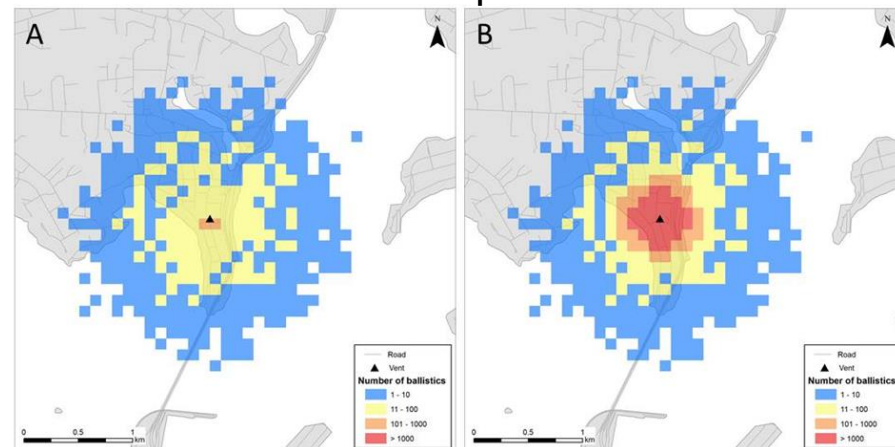
## Cumulative proximal (A) and distal (B) deposits on day 160



## PDC dynamic pressure



## Number of ballistic projectiles with impact energy exceeding 2750 J at 2 different eruption time intervals



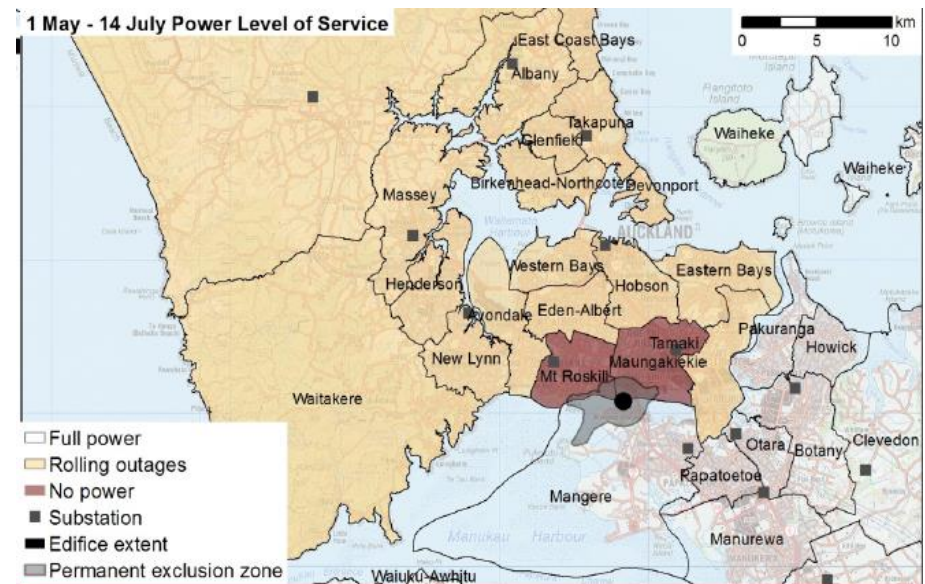
Sectors investigated:

**Electricity \* Fuel \* Roads \* Rail \* Port \* Airport \* Water supply \* Wastewater \*  
Stormwater \* Telecommunications \* Building damage**

## Results show:

- Power out to Northland for months
- Severe water shortages for a year
- Airport closed for 2-3 months
- 100,000 people will be displaced
- 11,000 will be left homeless
- Raw sewage will be discharged into both harbours for 2-3 years.

Auckland electricity network outage map:  
2-3 months after eruption

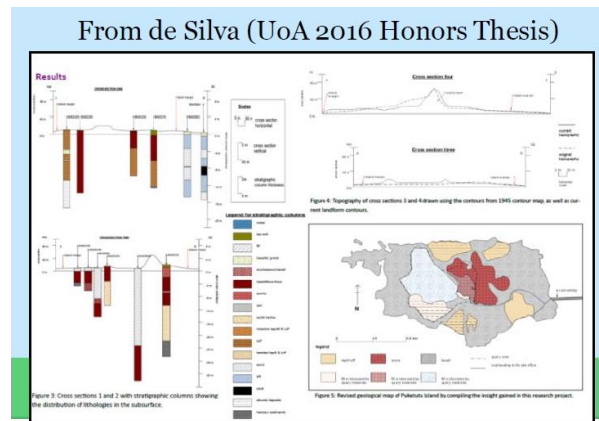
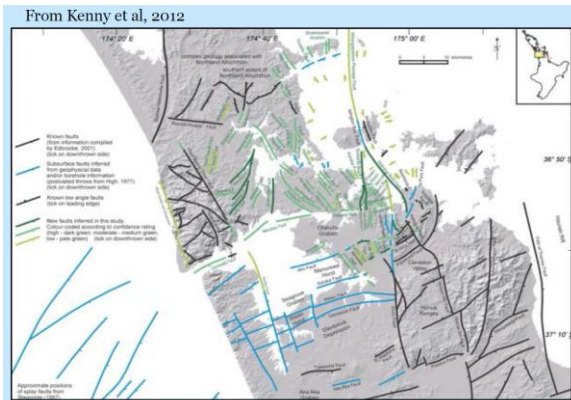


# Borehole database



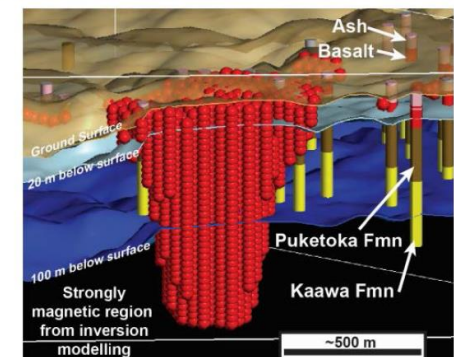
Tracy Howe

- In 2008, DEVORA began compiling the **DEVORA borehole database** in order to map the substrate.
- Used to determine the location of unknown faults, locate holes for deep borehole seismometers, and help us better understand the extents of previous eruptions



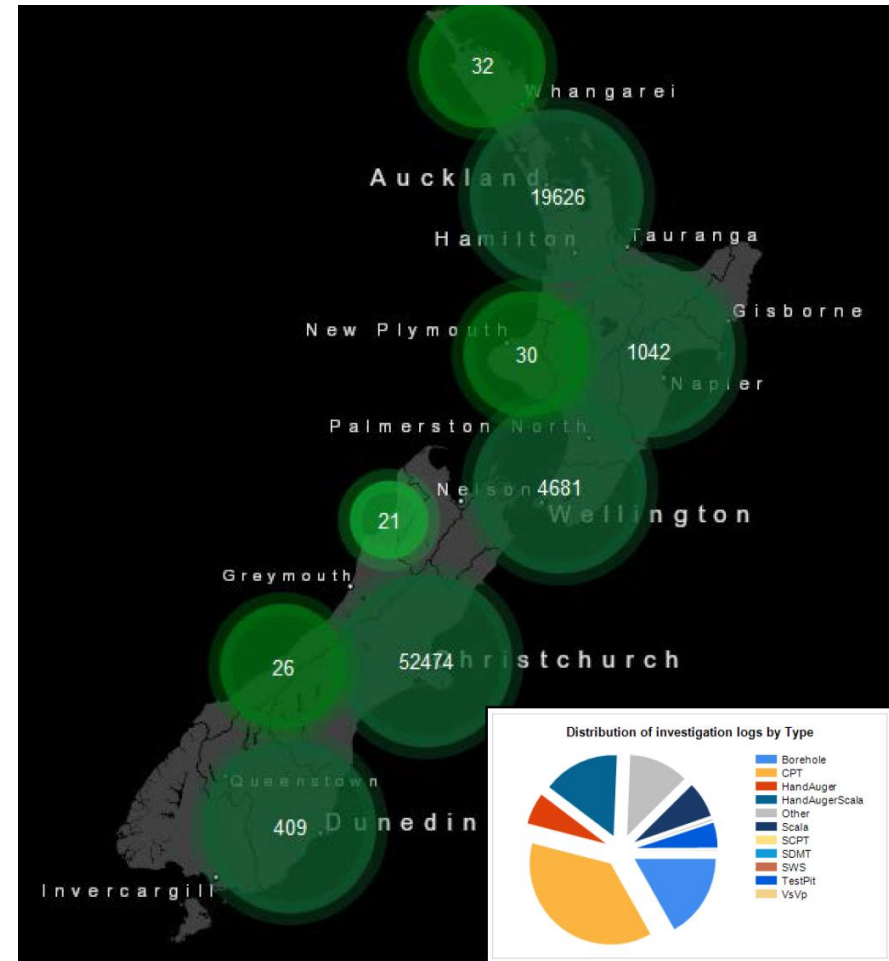
GNS Urban Mapping Team

## Basalt resource calculation





- Transitioned into the New Zealand Geotechnical Database
- Value of data - \$300 million?
- Used by consultants, councils, insurers, GNS etc



# Communication

**Web page:**

<http://www.devora.org.nz/>



[Home](#) [Project Details](#) [Press](#) [Events](#) [Resources](#) [Researcher's Hub](#) [Contact us](#)

## Welcome

### Determining Volcanic Risk in Auckland

Auckland is a vital link in New Zealand's economy, and the city and surrounding region are internationally desirable places to live and work. However, Auckland sits on a volcanic field.

The DEVORA research programme is aimed at a much-improved assessment of volcanic hazard and risk in the Auckland metropolitan area, and will provide a strategy and rationale for appropriate risk mitigation.

[Details](#)



## DEVORA Communications Plan and Media Guide



**By Elaine Smid and Jan Lindsay**

School of Environment, University of Auckland

*Image: DEVORA researcher Darren Gravley is interviewed on TVNZ about his research, April 2013. Photo by Cheng Yil Sim.*

DEVORA Report 2015-01 | June 2015 | ISBN [print]: 978-0-9876566-6-7; ISBN [PDF]: 978-0-9876566-7-4

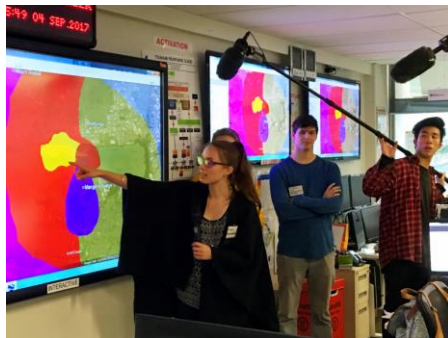


# Communication

## Social Media



## Outreach and training



## Fact sheets

### CITY OF VOLCANOES

THE AUCKLAND VOLCANIC FIELD NGĀ TAPUWAE Ō MATAAHO

An Introduction to Auckland's volcanoes

The Auckland Volcanic Field (AVF), or Ngā Tapuwae Ō Mataaho, is the name given to the volcanic area located in Auckland / Tāmaki Makaurau, New Zealand. The AVF is different to the volcanic systems that construct big volcanic cones in the central North Island of New Zealand, such as Mt Ruapehu or Taranaki. The AVF tends to erupt in a new location each time, instead of experiencing repeated eruptions in one location. The AVF eruptions also tend to be much smaller in scale. This type of activity has resulted in many small hills and pits across the Auckland landscape, rather than one big cone. This fact sheet shares some interesting facts about Auckland's many volcanoes.

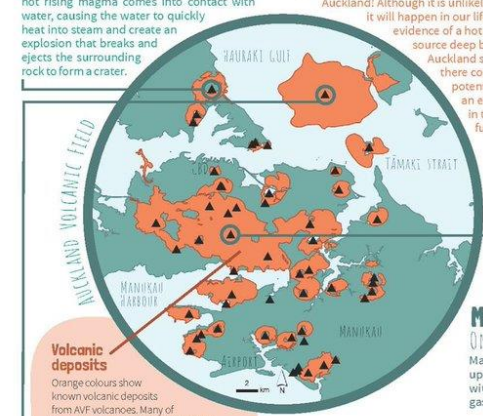
#### Pupuke

AUCKLAND'S OLDEST VOLCANO

Lake Pupuke is up to 200,000 years old. The lake was formed in a volcanic explosion crater that filled with water over time. Such explosion craters, called *maars*, form when hot rising magma comes into contact with water, causing the water to quickly heat into steam and create an explosion that breaks and ejects the surrounding rock to form a crater.

**53** VOLCANOES

There are approximately 53 volcanoes in Auckland! Although it is unlikely that it will happen in our lifetime, evidence of a hot magma source deep beneath Auckland suggests there could potentially be an eruption in the future.



#### Volcanic deposits

Orange colours show known volcanic deposits from AVF volcanoes. Many of these deposits are buried by the city or the sea, so geologists interpret outcrops (rock exposures) and drill cores (rocks extracted from the ground) to estimate their extent.

#### Maungakiekie

ONE TREE HILL

Maungakiekie is an example of a *scoria cone*. The cone is made up of basaltic *scoria* - a dark, iron-rich, fragmented volcanic rock with vesicles (holes). The vesicles were once filled with volcanic gases, and indicate that the eruption was moderately explosive.



#### DID YOU KNOW?

Many of the volcanoes (*maunga*) were Māori pā sites, making up the largest network of defensible settlements in Polynesia. In 2014, 14 of the maunga were returned to iwi in a Treaty settlement and are now cared for by the Tūpuna Maunga Authority.

#### Rangitoto

AUCKLAND'S YOUNGEST VOLCANO

Rangitoto's full name is Ngā Rangī-i-totonga a Tamatekapua, after a Māori captain who was wounded there. It experienced at least two eruptions about 600 years ago. Lava flows make up the volcano's broad slopes, and a *scoria cone* made of loose rock forms the cone shape at the top. *Lava tubes* can be found throughout Rangitoto. These tunnels were formed when the outer surface of the lava cooled and hardened before the inside, which continued to flow.

**LARGEST.** Rangitoto is 10 times larger in volume than any other AVF volcano, and is taller than the viewing deck in the Auckland Skytower!

**260** METRES ABOVE SEA LEVEL

Auckland's youngest volcano is also its

**220** METRES ABOVE SEA LEVEL



# Benefits to AC

- Access to expertise in case of an eruption
- Better quality planning based on more robust science
- A better prepared population



# Challenges

- Demonstrating success
- Ongoing funding
- Making research implementable

## Managing Volcanic Risk in Auckland

Auckland Civil Defence & Emergency Management  
Joint DeVoRA Forum

**Date:** Friday 27th of September  
**Venue:** Lower NZI Room, Aotea Centre  
**Time:** 8.30am – 3.30pm

### Overview:

The Auckland Volcanic Field (AVF) is the most densely populated field of its type in the world. To date, 56 volcanoes have been identified in the field, each having their own unique characteristics formed by a range of volcanic processes. With the last eruption occurring only 550 years ago, at Rangitoto Island, a future eruption could occur at any time.

Being located on an isthmus, entirely contained within the AVF, Auckland has many unique challenges to be able to effectively respond to the next eruption. This forum will highlight how collaborative relationships between Auckland Council, national and regional stakeholders and the wider Civil Defence and Emergency Management sector are building resilience and preparing for the next AVF eruption.

### Schedule:

|         |   |
|---------|---|
| 8.30am  | Registration  |
| 9am     | Welcome by Cr Michael Goudie  |
| 9.10am  | Opening Address by Honorable Nicky Kaye                               |
| 9.30am  | Session One: Auckland's volcanic risk and planning frameworks         |
| 10.15am | Morning tea   |
| 10.45am | Session Two: DEVORA: Better understanding the Auckland volcanic field |
| 12.30pm | Lunch   |
| 1.30pm  | Session Three: Managing Auckland volcanic risk: CDEM partners         |
| 2.30pm  | Close by Cr Michael Goudie  |
| 2.45pm  | Afternoon tea.  |

► **RSVP:**  
Brodie.rafferty@aucklandcouncil.govt.nz



# 10 year celebration...

## Design includes:

- the names of all 53 Auckland volcanoes (size correlates to mentions in our DEVORA Quarterly Reports!)
- a complex magma plumbing system
- a maar-diatreme
- a tuff cone
- \*steep-sided scoria cone
- an ash cloud

