

# Pre-event risk communication and behavioural change: Whakaari / White Island, Aotearoa New Zealand



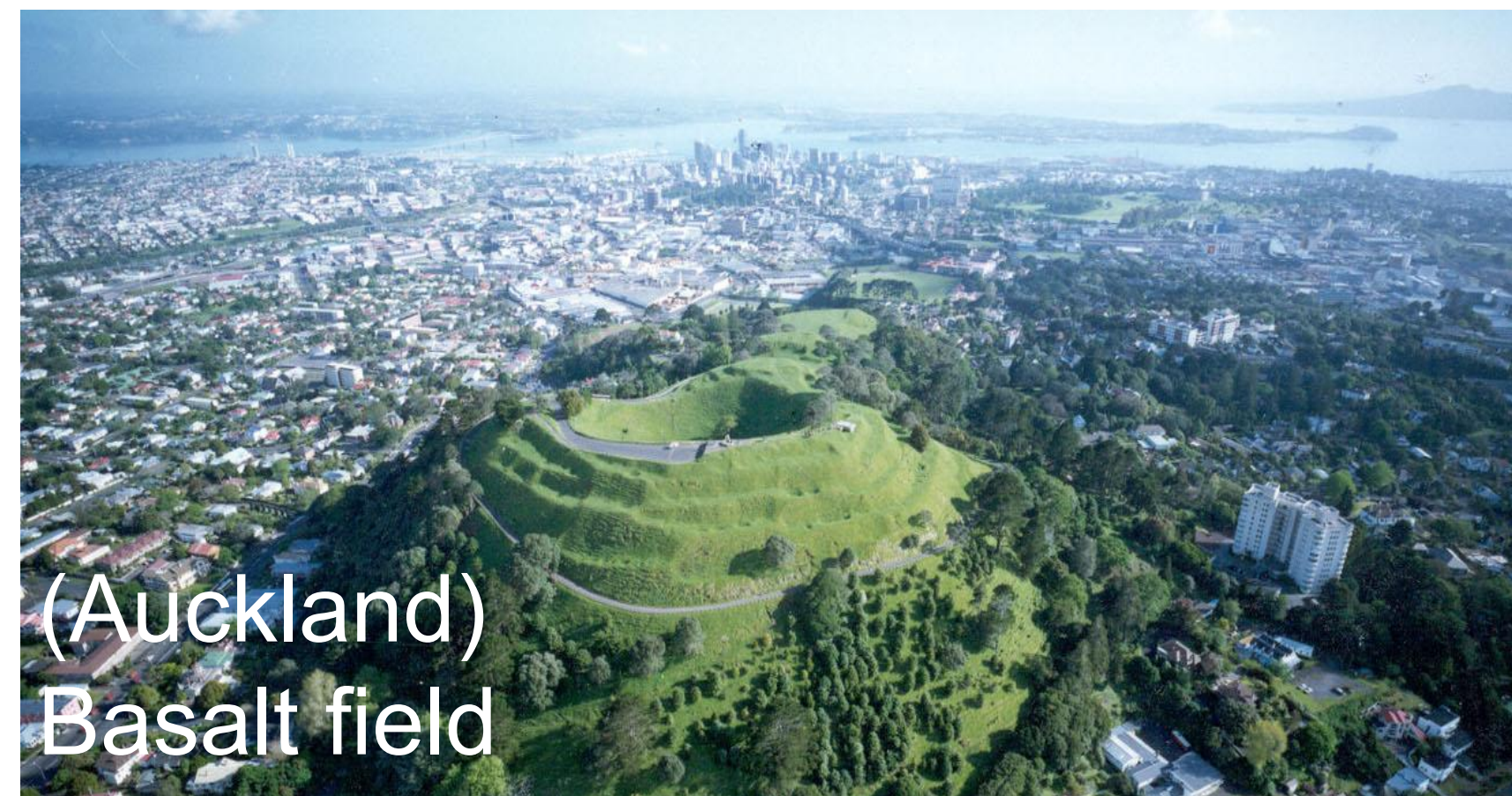
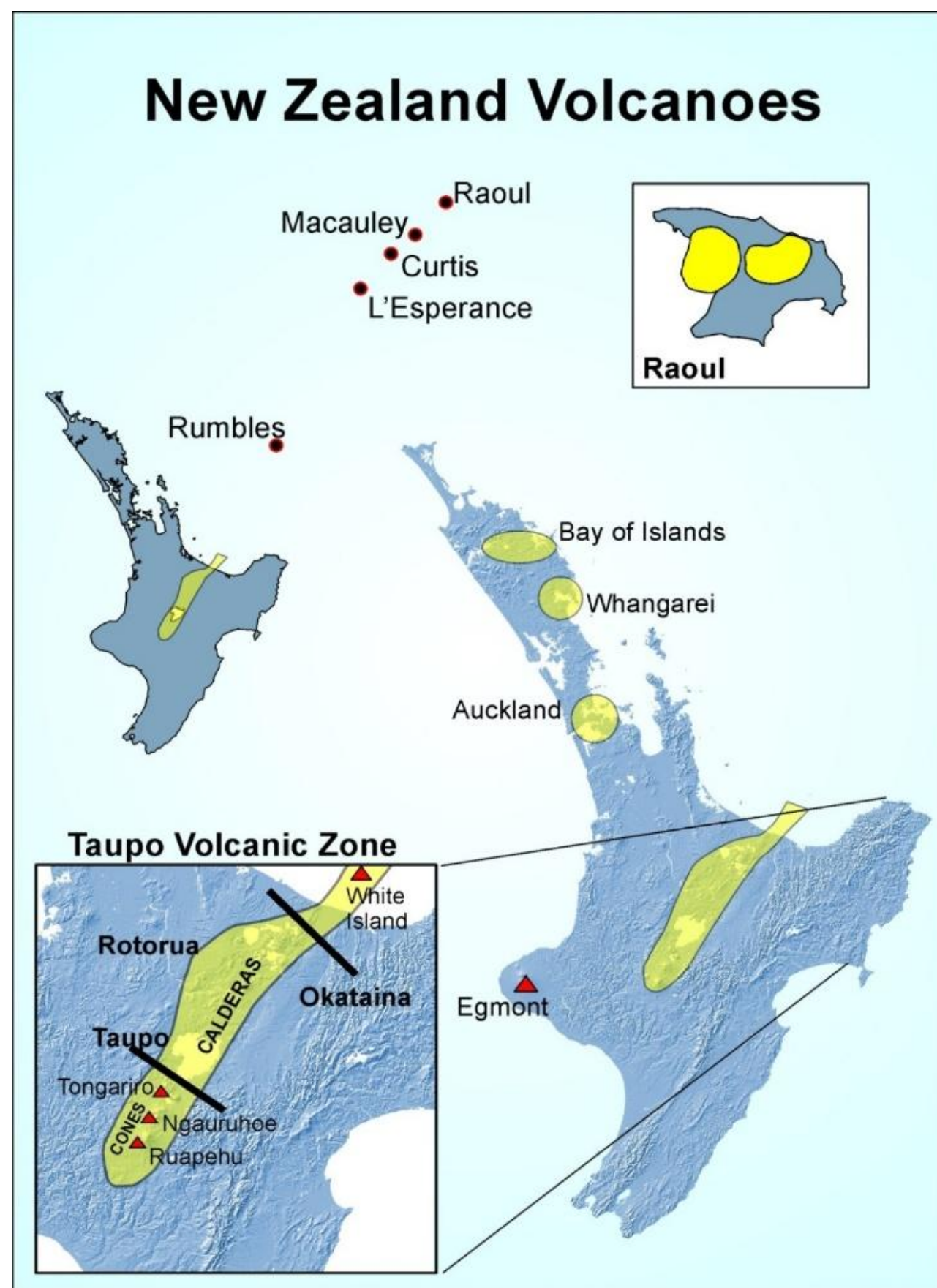
**Nico Fournier and Volcano Monitoring Group**

**Earth Sciences New Zealand** (*formerly Te Pū Ao - GNS Science*), Aotearoa New Zealand



formerly







# 6 Volcanic Alert Levels in NZ a.k.a. our patients “status”

We set the VAL by voting in the  
GeoNet Volcano Monitoring Group

New Zealand Volcanic Alert Level System			
		Volcanic Alert Level	Most Likely Hazards
Eruption	5	Major volcanic eruption	Eruption hazards on and beyond volcano*
	4	Moderate volcanic eruption	Eruption hazards on and near volcano*
	3	Minor volcanic eruption	Eruption hazards near vent*
Unrest	2	Moderate to heightened volcanic unrest	Volcanic unrest hazards, potential for eruption hazards
	1	Minor volcanic unrest	Volcanic unrest hazards
	0	No volcanic unrest	Volcanic environment hazards
<p><b>An eruption may occur at any level, and levels may not move in sequence as activity can change rapidly.</b></p> <p><b>Eruption hazards</b> depend on the volcano and eruption style, and may include explosions, ballistics (flying rocks), pyroclastic density currents (fast moving hot ash clouds), lava flows, lava domes, landslides, ash, volcanic gases, lightning, lahars (mudflows), tsunamis, and/or earthquakes.</p> <p><b>Volcanic unrest hazards</b> occur on and near the volcano, and may include steam eruptions, volcanic gases, earthquakes, landslides, uplift, subsidence, changes to hot springs, and/or lahars (mudflows).</p> <p><b>Volcanic environment hazards</b> may include hydrothermal activity, earthquakes, landslides, volcanic gases, and/or lahars (mudflows).</p> <p><b>*Ash, lava flow, and lahar (mudflow) hazards may impact areas distant from the volcano.</b></p>			
<p>This system applies to all of New Zealand’s volcanoes. The Volcanic Alert Level is set by GNS Science, based on the level of volcanic activity. For more information, see <a href="http://geonet.org.nz/volcano">geonet.org.nz/volcano</a> for alert levels and current volcanic activity, <a href="http://gns.cri.nz/volcano">gns.cri.nz/volcano</a> for volcanic hazards, and <a href="http://getthru.govt.nz">getthru.govt.nz</a> for what to do before, during and after volcanic activity. Version 3.0, 2014.</p>			



# Volcanic Activity Bulletins

a.k.a. what is happening at our volcanoes and the “so what?”

New Zealand Volcanic Alert Level System			
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**An eruption may occur at any level, and levels may not move in sequence as activity can change rapidly.**

**Eruption hazards** depend on the volcano and eruption style, and may include explosions, ballistics (flying rocks), pyroclastic density currents (and near floating ash clouds), lava flows, lava domes, landslides, ash, volcanic gases, lightning, lahars (mudflows), tsunami, and/or earthquakes.

**Eruption hazards occur** during and after the new volcano, and may include steam eruptions, volcanic gases, earthquakes, landslides, uplift, subsidence, changes to hot springs, and/or lahars (mudflows).

**Volcanic environment hazards** may include hydrothermal activity, earthquakes, landslides, volcanic gases, and/or lahars (mudflows).

**\*Ash, lava flow, and lahar (mudflow) hazards may impact areas distant from the volcano.**

This system applies to all of New Zealand's volcanoes. The Volcanic Alert Level is set by GNS Science, based on the level of volcanic activity. For more information, see [geonet.org.nz/volcano](https://geonet.org.nz/volcano) for alert levels and current volcanic activity, [www.nzvolcano.co.nz](https://www.nzvolcano.co.nz) for volcanic hazards, and [www.gns.govt.nz](https://www.gns.govt.nz) for what to do before, during and after volcanic activity. Version 3.01 2014.

CLOSED - Geo...pace - Miro

Taupō Weather - MetService

Tongariro National Park

MetVUW

NIWA Weather

NZ Topo map

SARTopo

Tracks and Trails Map

Workday

geonet.org.nz

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GeoNet

NHC Toka Tū Ake

Earth Sciences NZ

News

Earthquake

Landslide

Tsunami

Volcano

Data Discovery

Data Types

Data Access

WHAKAARI/WHITE ISLAND

Whakaari/White Island activity limited to steam and gas emissions. Volcanic Alert Level remains at level 2 and Aviation Colour Code remains Yellow.

Published: Mon Jul 7 2025 2:30 PM

Volcanic Activity Bulletin

VOLCANIC ACTIVITY BULLETIN **WI-2025/10**

Mon Jul 7 2025 2:30 PM; Whakaari/White Island Volcano

Volcanic Alert Level remains at 2

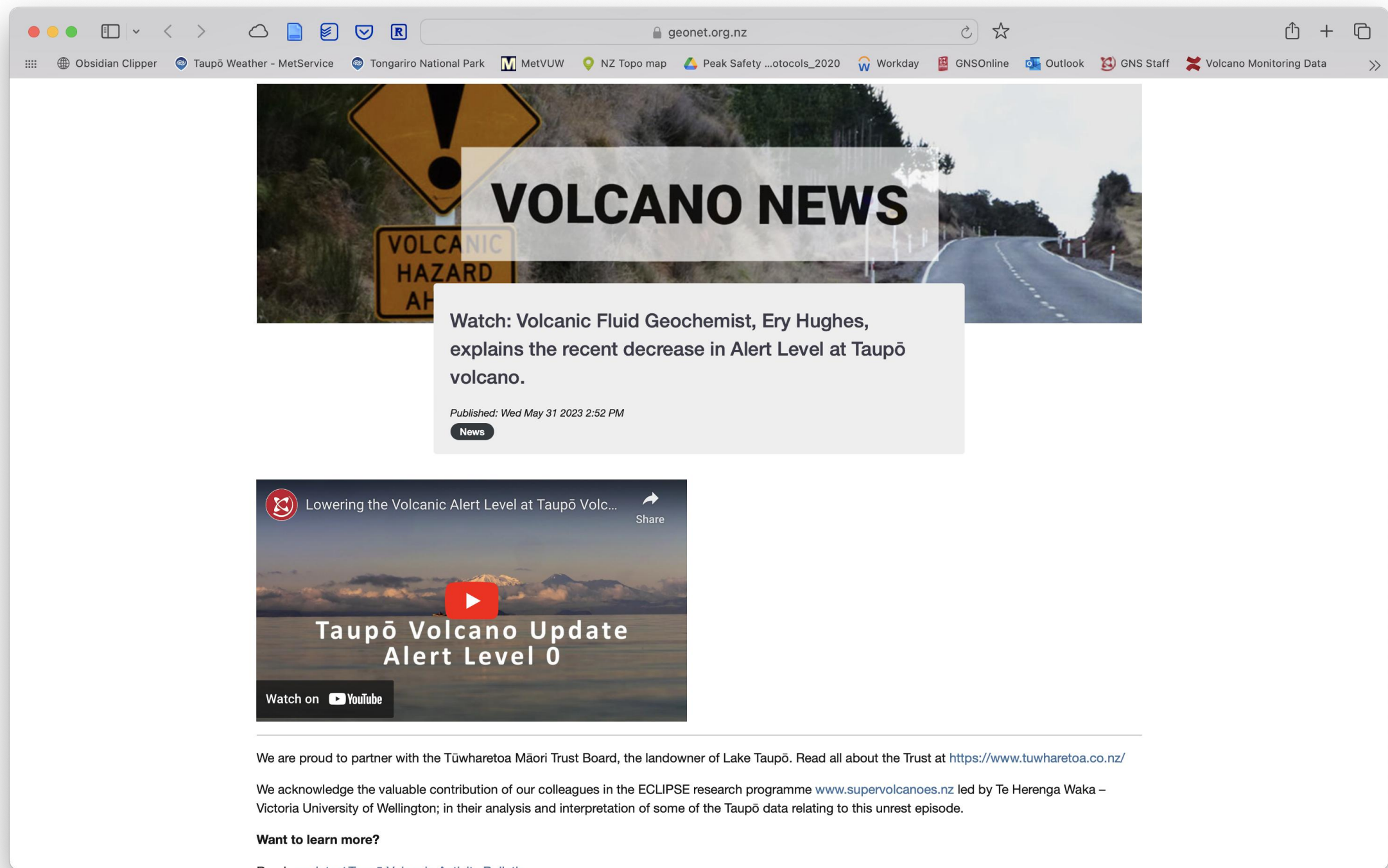
Aviation Colour Code remains at Yellow


Based on observations from a recent observation flight, webcam and satellite imagery, we can confirm no further ash emissions



# Communication products

Bulletins, videos, news items, social media (X/Twitter, Facebook), fact sheets





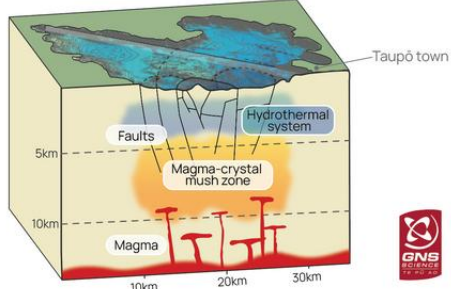
# Taupō Volcano

Taupō is the most frequently active and productive rhyolite caldera in the world

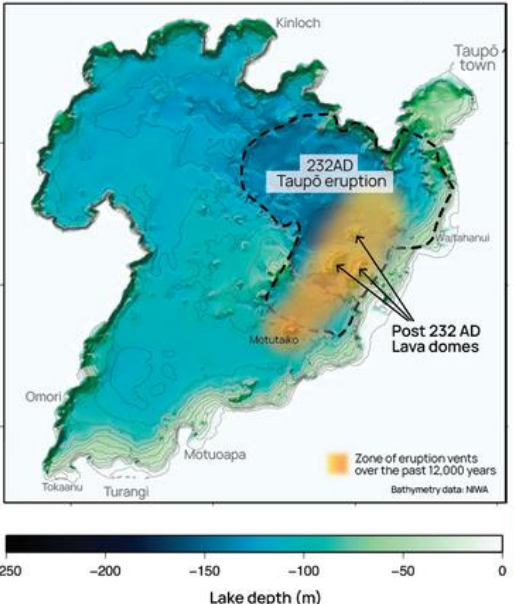
### Formation

- Caldera volcanoes are created by collapse of the ground surface due to emptying of their sponge-like magma chambers in huge eruptions - **which are very rare.**
- Taupō Volcano has had 2 caldera forming eruptions in the last 25,500 years and they formed much of the current lake basin.
- Magma accumulates in the crust between 5 and 10 km below the lake floor before rising to the surface to erupt.

### What is below Lake Taupō?



### What is below Lake Taupō?



### Volcanic Eruption History

- Volcanoes in the Taupō area began erupting >300,000 years ago.
- The Ōruanui eruption 25,500 years ago created a large basin that formed much of the present lake
- Between the Ōruanui eruption and the Taupō eruption (about 1790 years ago) at least 27 much smaller eruptions spread pumice and ash beyond the lake and formed lava domes. 25 of those eruptions occurred in the last 12,000 years including the Taupo eruption.
- Many of these smaller eruptions were bigger than the 1995/96 Ruapehu eruptions but smaller than the 1886 Tarawera eruption and about 1/10th the size of Mt St. Helens 1980 eruption

### Volcanic Unrest

- Taupō is an active volcano
- Volcanic unrest is the term given to natural phenomena caused by underground processes associated with active volcanoes.
- Volcanic unrest has occurred often in the last 150 years at Taupō (17 times between 1870 and 2022)
- Volcanic unrest can include earthquake swarms including surface fault ruptures as well as slow ground movement.

### Volcanic Unrest phenomena

- These occur on and near the volcano
- Hazards in heightened unrest may include changes in hydrothermal systems, gas discharge, new springs or steam eruptions
- Earthquakes, tsunami and landslides
- Ground deformation (uplift or subsidence)

### Volcanic Eruption phenomena

- Eruptions can produce ashfall, hot ash clouds (pyroclastic flows), flying rocks, large waves in the lake. Ash can remobilise with rain as lahars.

### The Taupō Eruption (232 ± 10 AD, 1790 years ago)

- Is considered the most powerful eruption known of the last 5000 years globally - it was unusually large compared to most Taupō eruptions.
- The plume reached a height of 35 - 40 km.
- Covered parts of the North Island in at least 1 cm of ash.
- Lakeside areas were covered in tens of metres of pumice and ash pyroclastic deposits.
- The flow spread up to 90 km from the vent, spreading over all barriers except the upper slopes of Ruapehu.

### GNS Science monitors Taupō Volcano with...

22 lake levelling sites	9 seismometers	9 GNSS stations
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Fact Sheet

[www.gns.cri.nz](http://www.gns.cri.nz)

Fact Sheet - September 2022

**Our science advisory feeds into risk management**



# VAAC / Aviation-facing

## VOLCANO OBSERVATORY NOTICE FOR AVIATION (VONA)

Item No	Element	Content
1	Message title	VOLCANO OBSERVATORY NOTICE FOR AVIATION
2	Issued:	20161009/2130Z
3	Volcano:	White Island 241040
4	Current Aviation Color Code:	Green
5	Previous Aviation Color Code:	Yellow
6	Source:	GNS Science, New Zealand
7	Notice Number:	NZ VONA 16/08
8	Volcano Location:	3731 S17710E
9	Area:	White Island, North Island, New Zealand
10	Summit Elevation:	1053FT
11	Volcanic Activity Summary:	No eruptive activity has been seen since 13 September 2016.
12	Volcanic Cloud Height:	No information
13	Other Volcanic Cloud information:	Nil
14	Remarks:	ACC changed from Yellow to Green
15	Contacts:	Duty Volcanologist, +6473748211ph,+6473748199fax
16	Next Notice:	Will be issued when conditions at the volcano warrant changing the aviation color code or when a significant volcanic event occurs within the current color code.

Two-way relationship with VAAC:

VO > VAAC (VONA, eruption info for models)

VO < VAAC (Eruption detection / confirmation)

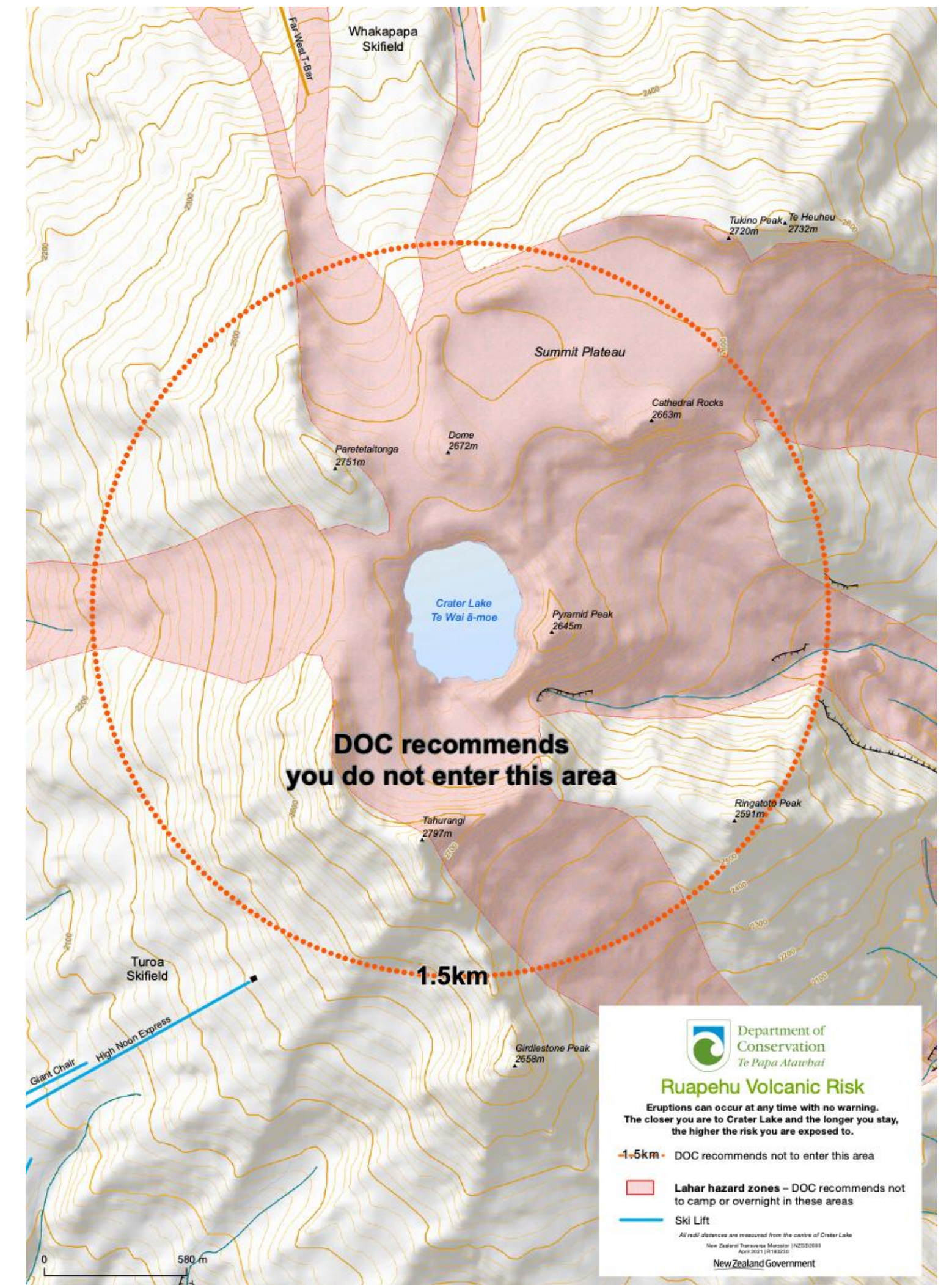
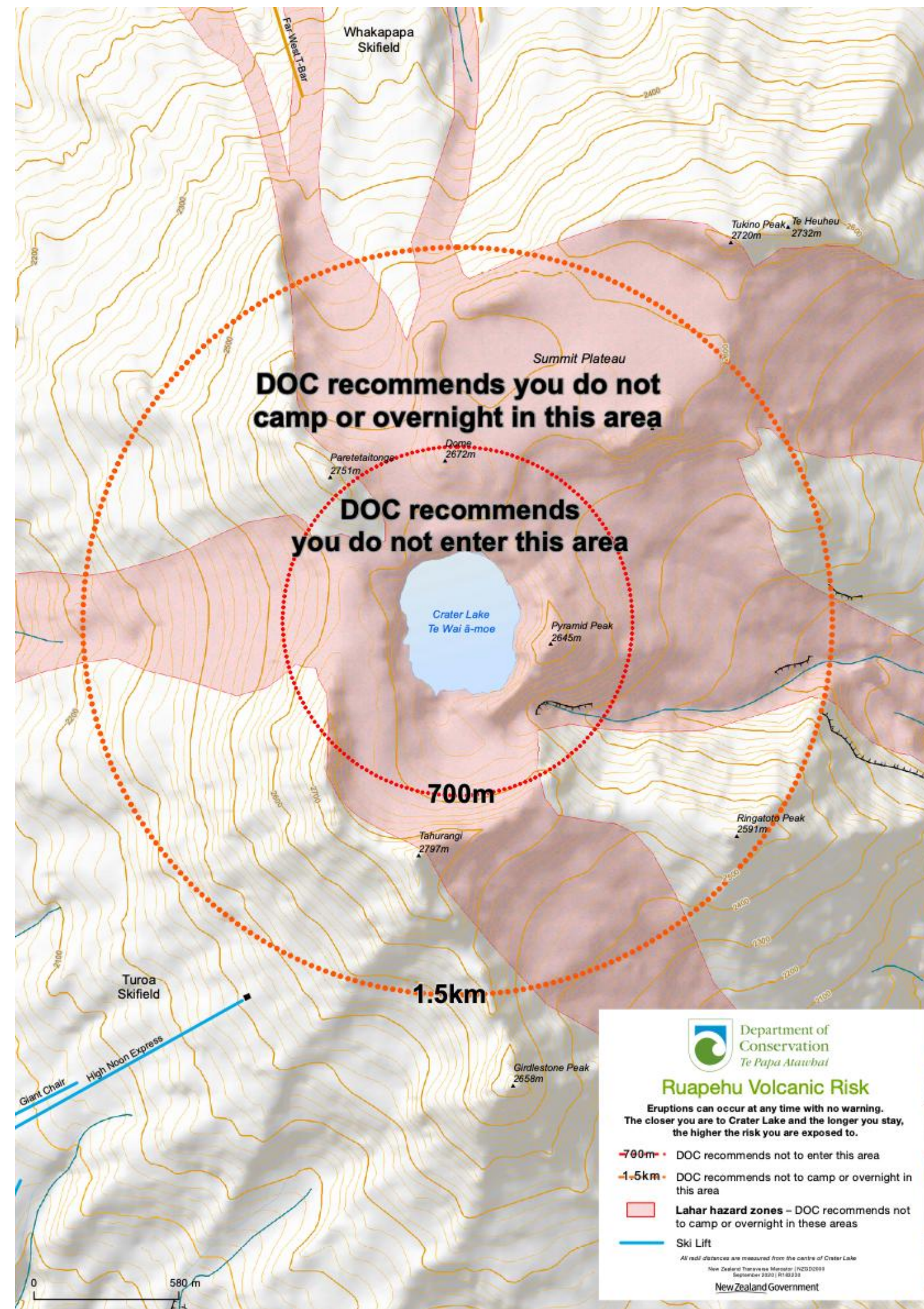


# For local and national authorities: scenarios with respective likelihood

<div><div>Taupō Volcano Scenarios</div><div>Version: 1.03 20 January 2023</div></div> <div>Relative likelihood of scenarios occurring for Taupō volcano from its current state of minor unrest (VAL1) within the next three-month period (20 January – 20 April 2023). Credible maximum earthquakes and shaking scenarios are given in Slides 17 and 50 onwards.</div>			
Scenario	Examples	Potential hazards	Likelihood of scenarios occurring <u>within the next 3 months (at 2 s.d.)</u>
<b>A</b> <i>Minor UNREST decreases to no unrest (VAL1 → 0)</i>	<b>2019 at Taupō:</b> An elevated number of earthquakes continued for around 8 months in total, including a M5 damaging earthquake. Uplift occurred at a rate of about 10mm/year.	<ul style="list-style-type: none"><li>Minor unrest hazards (<b>earthquakes and deformation</b>) decrease and return to normal background levels.</li></ul>	<b>35-53%</b> About as likely as not
<b>B</b> <i>Minor UNREST continues (VAL1)</i>	<b>2008-2010 at Taupō:</b> Up to 150 earthquakes recorded per day over nearly 2 years, four >M4.0. Inflation near Horomatangi Reef with uplift recorded of 40-50mm/year.	<ul style="list-style-type: none"><li><b>Earthquakes:</b> Rate of earthquakes (number per week) remains similar to May - Sept 2022. Felt earthquake shaking, potential for damage from stronger events (up to about M7).</li><li><b>Ground Deformation:</b> Instrumentally detected.</li><li><b>Other:</b> Earthquakes may trigger landslides and tsunami.</li></ul>	<b>17-57%</b> About as likely as not
<b>C</b> <i>Minor UNREST increases to moderate or heightened unrest (VAL1 → 2)</i>	<b>1983-84 at Taupō:</b> Earthquakes occurred for 13 months, causing minor structural and contents damage. Uplift of 53mm in northern caldera area, rupture of Kaiapo Fault near Kinloch and subsidence of western side of the Fault. This example is at the lower end of Scenario C.	<ul style="list-style-type: none"><li><b>Earthquakes:</b> Notable increase in size and/or number of located earthquakes (up to about M7), may trigger <b>landslides</b></li><li><b>Ground deformation:</b> may become visible and disrupt shallow underground infrastructure, particularly in the case of fault rupture</li><li><b>Other:</b> Hydrothermal system responses or explosions mostly underwater in Lake Taupō, such as a burst of hot water and steam above the vent(s), with potential tsunami – at the upper end of this scenario.</li></ul>	<b>3-6%</b> Very unlikely



# Volcanic risk management for visitors at Ruapehu





# Volcanic risk management for visitors at Tongariro post 2012 eruption



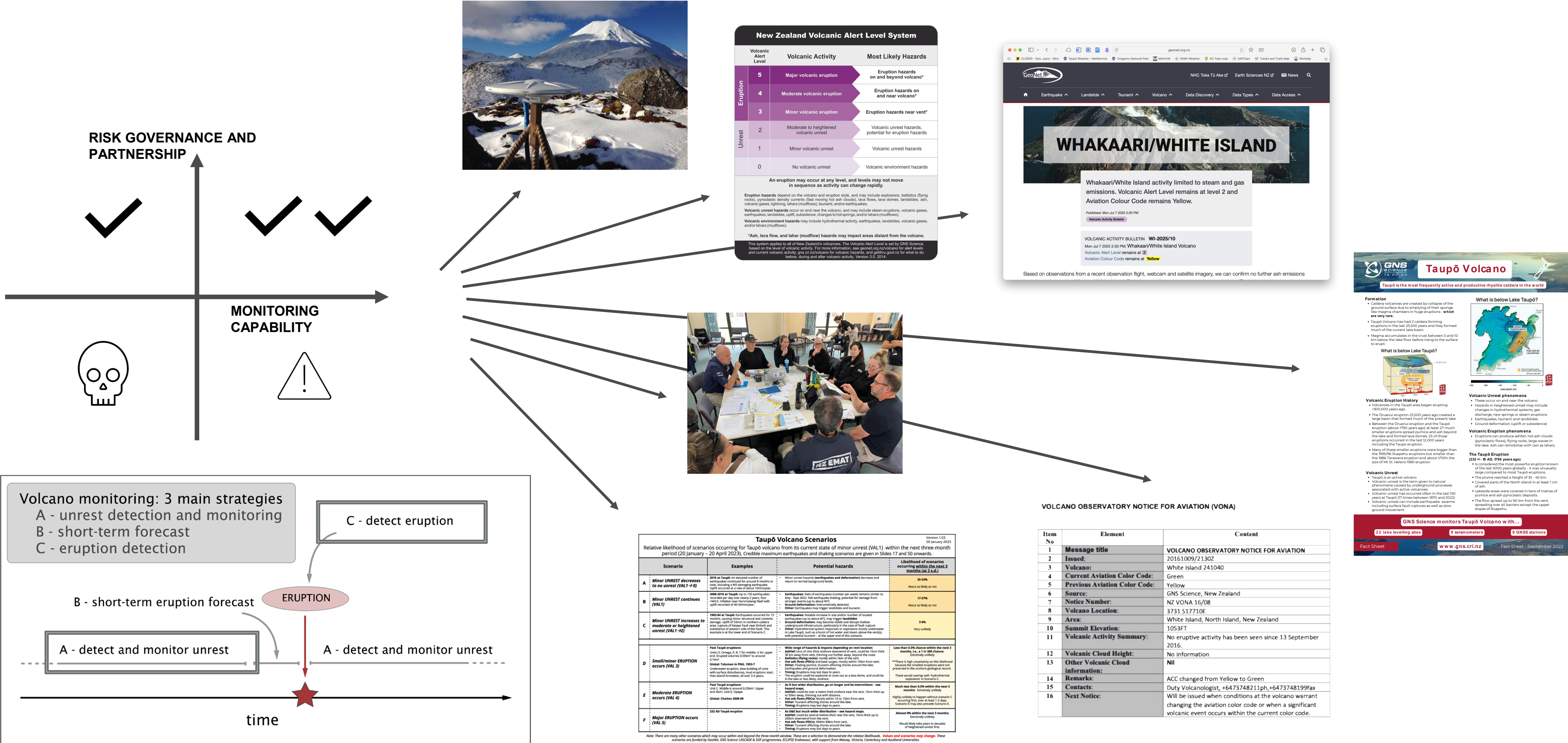
Jolly and Tait, 2012

	Fatalities per year estimated	Fatality risk per visit
Falls	0.2	$2.8 \times 10^{-6}$
Hypothermia	0.33	$4.6 \times 10^{-6}$
Heart attack	1	$1.4 \times 10^{-5}$
Avalanche (extrapolated from Ruapehu)	0.05	$7.0 \times 10^{-7}$
Car accident in vicinity	1	$1.4 \times 10^{-5}$
Volcanic eruption (Jolly and Taig 2012)	0.08	$1.1 \times 10^{-6}$
<b>Volcanic eruption estimate range (this report)</b>	<b>0.9-5.3</b>	<b><math>1.3-7.5 \times 10^{-5}</math></b>

Activity	Hazard	Location	Individual fatality risk	Risk per...	Basis	Source
Tramping on TAC	Volcanic eruption	Near Ketetahi	$1.1 \times 10^{-6}$	Walk	As described above	Jolly and Taig (2012)
<b>Tramping on TAC</b>	<b>Volcanic eruption</b>	<b>Near Ketetahi</b>	<b><math>1.3 \text{ to } 7.5 \times 10^{-5}</math></b>	<b>Walk</b>	<b>As described above</b>	<b>This report</b>
Downhill skiing and boarding	All	US, Australian and Italian ski resorts	$6.7 \times 10^{-7}$ to $2.9 \times 10^{-6}$	Day of skiing or boarding	Range quoted from lowest to highest from ski areas	Windsor et al. 2009 Postgrad Med Journal 85 pp 316-321
Walking and scrambling	All accidents	Mt Snowdon	$2.6 \times 10^{-6}$ to $4.1 \times 10^{-5}$	Single walk along track	Averaged from 2006 to 2010	Private communication to Tony Taig from Snowdon National Park Authority
Climbing	All accidents	Mt Cook	$1.3 \times 10^{-4}$ to $6.5 \times 10^{-3}$	Day of climbing	Range quoted from lowest to highest based on nights spent in huts	Malcolm 2001. NZ Med Journal 114 pp78-80



# Volcanic risk management in New Zealand is rather comprehensive

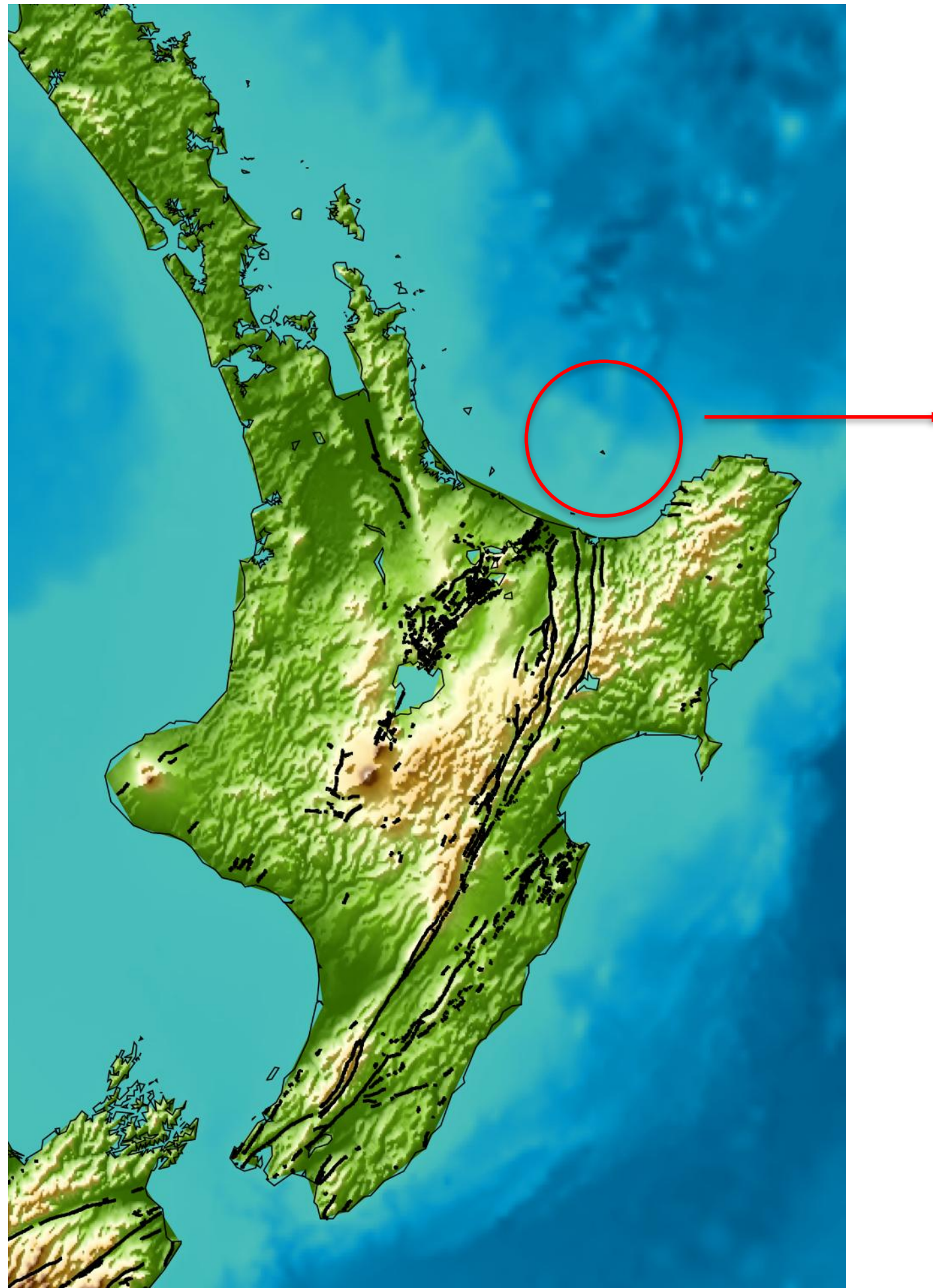




**or is it...?**



# Whakaari / White Island





# Hundreds of visitors daily



Photographs: Chuck Marshall (lifeinmichigan.com)

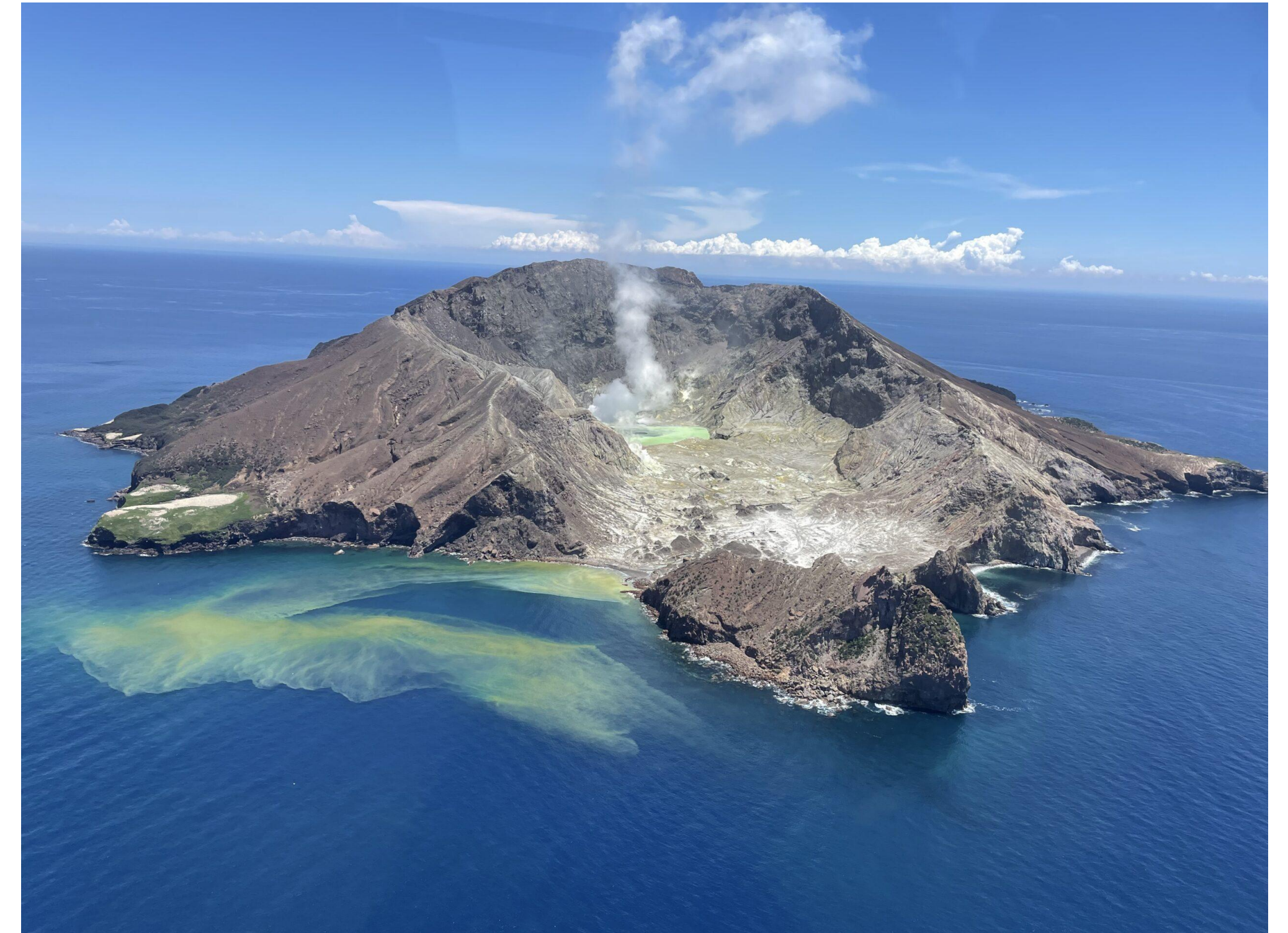




# Hundreds of visitors daily



Chuck Marshall (lifeinmichigan.com)



Volcanic Air Safari



# Eruption on 9 December 2019 at 14:11



*Michael Schade, twitter*



# Rapid onset eruption without immediate warning, but in period of heightened unrest

A relatively small eruption

Major impacts because  
tourists were right at the vent.

47 people on the island



*White Island Flights / NZ Herald*



# Most of the crater floor affected by surge and pyroclastic flows



*Auckland Rescue Helicopter Trust*



*Instagram/The Helicopter Page*



# Some tour operators still offshore near the island



*RNZ / Michael Schade*



*AFP photo / Michael Schade*



# Rescue operations

Initial rescues in the first few hours. 47 people on island at time of eruption. ~ 20 fatalities. Survivors evacuated by boats and helicopters. Main injuries were burns.

By 5pm, no signs of survivors.

Rescue and recovery operations halted due to potential risk of another eruption

**Focus on recovering the 8 missing persons**



*RNZ / Dom Thomas*



# Whakaari recovery operations – Friday 13 December 2019





# The aftermath





# Two Government inquiries

## Worksafe NZ inquiry

Lens = safety at work

Scope = period preceding the eruption, up to the eruption itself

Two initial charges against GNS / the VO:

1. **Failure to ensure the safety of visitors** on the day of the eruption (our “workplace”) (dropped)
2. **Failure to communicate the risk** to our heli providers (pleaded guilty to lesser charge)

## Coronial inquiry (ongoing)

Lens = wider volcanic risk management system

Scope = before, during and after the eruption. **Systemic issues impacting the outcome of such eruption**



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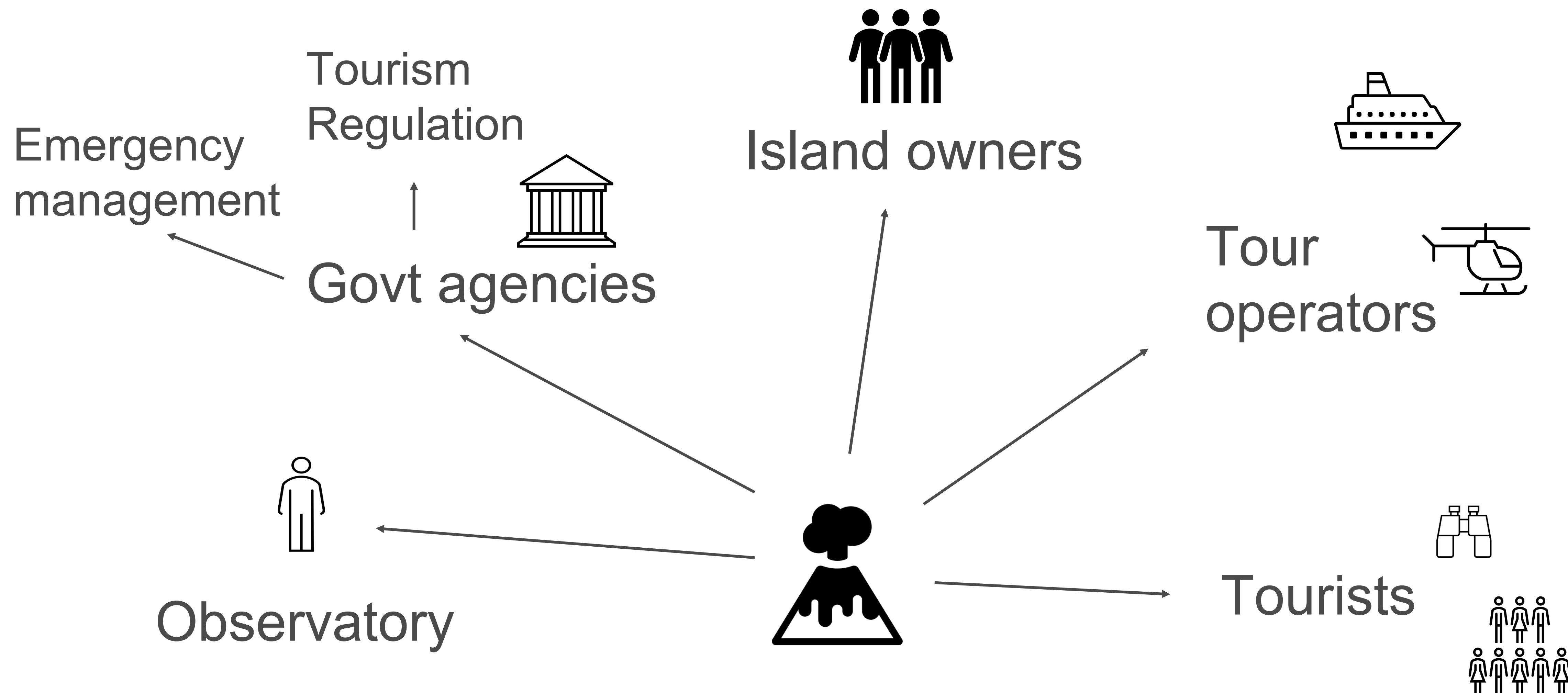
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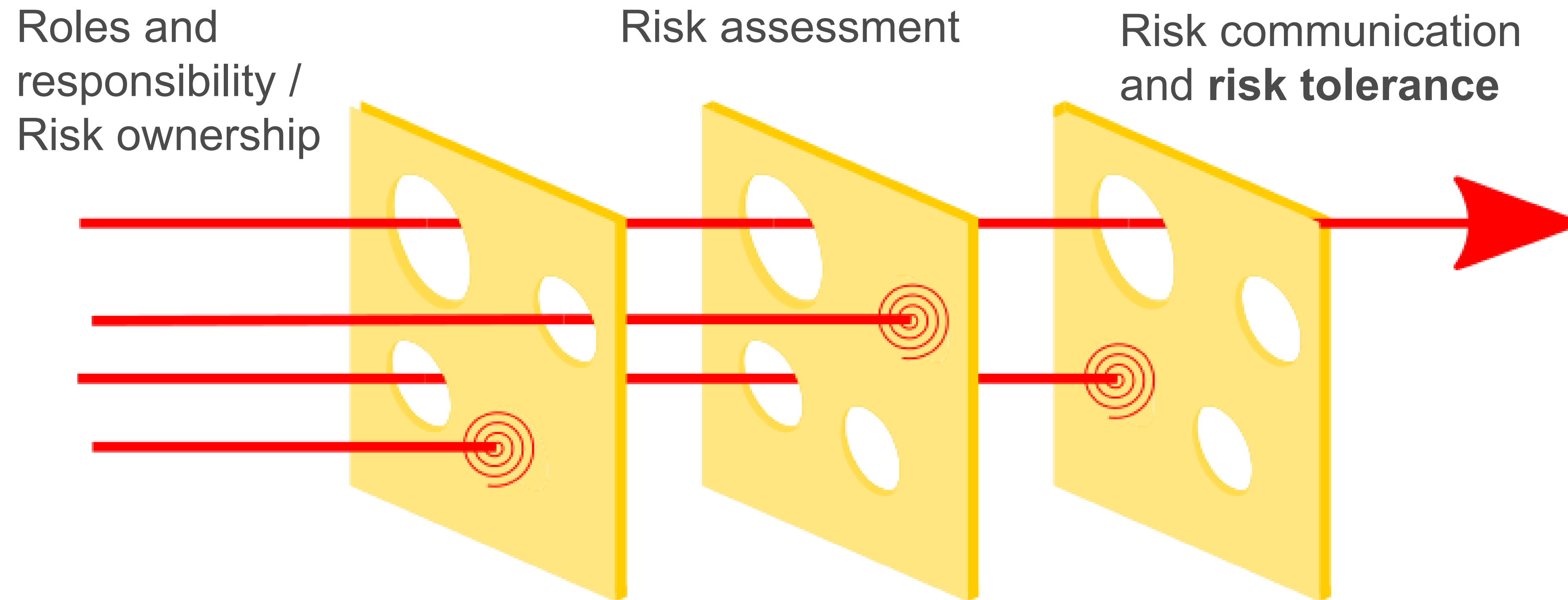


# Who owns the risk? Who is the decision maker?





# There are always vulnerabilities





# Some takeaway points from an EW4All perspective

Difference between monitoring capability and efficiency.  
Some volcanoes just don't cooperate

**EW4All needs to fit the local legislative framework, incl. roles and responsibilities**

**Risk assessment** is only the first step

**Risk communication** is crucial

**Risk tolerance discussions** are often missing







How do we introduce essential conversations about risk tolerance in EW4All?