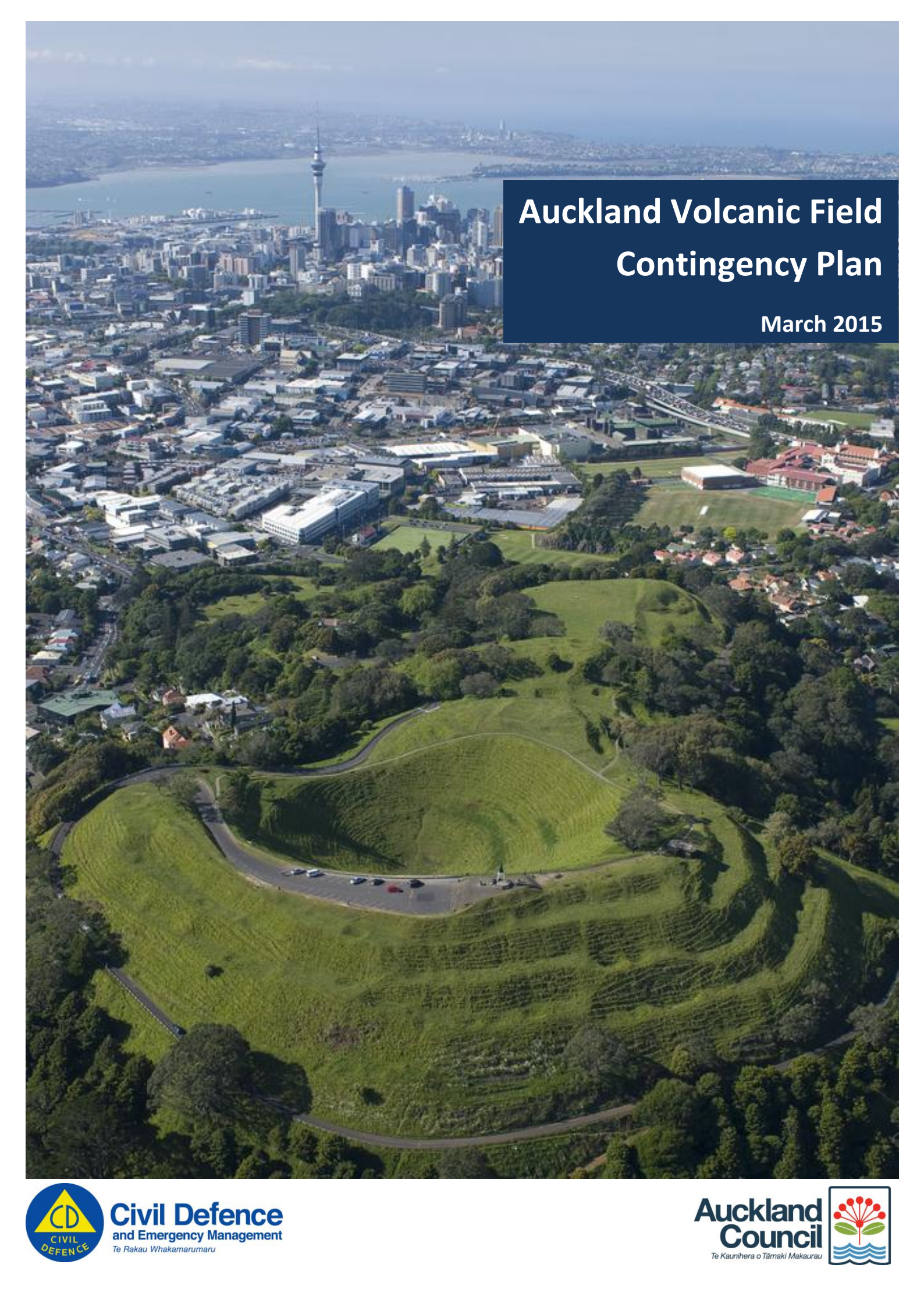


An aerial photograph of Auckland, New Zealand, showing the city skyline with the Sky Tower, the harbor, and the surrounding volcanic fields. The foreground features a large, green, grassy volcanic cone with a winding road and a parking area. The city is densely packed with buildings, and the harbor is visible in the background.

Auckland Volcanic Field Contingency Plan

March 2015



Civil Defence
and Emergency Management
Te Rakau Whakamarumaru

**Auckland
Council**
Te Kaunihera o Tāmaki Makaurau



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Section 1: Introduction

Volcanic eruption within the Auckland Volcanic Field (AVF) is a very real hazard for the Auckland region. While an AVF volcanic eruption may directly affect a relatively small proportion of the region's population, the longer term impacts are likely to affect a much wider geographic area with significant implications for a broad range of industries and services, nation-wide.

This Contingency Plan: Auckland Volcanic Field (the Contingency Plan) sets out the planning arrangements for management of an eruption within the AVF.

Purpose of the Contingency Plan

The purpose of the Auckland Volcanic Contingency Plan is to identify, strengthen and co-ordinate the regions resources and capabilities to ensure a level of preparedness for timely and effective responses to increased volcanic activity. This Contingency Plan **does not** address contingency planning for a volcanic eruption outside the AVF.

Objectives of the Contingency Plan

The principal goal of this plan is to establish comprehensive and co-ordinated management of response and recovery operations. To achieve this goal, the following objectives are identified:

- Establish a hazard assessment framework.
- Guide provision of appropriate and timely public information and warnings
- Guide decision making around evacuations
- Establish processes for the provision of scientific advice on hazards, risk and consequences.

Supporting Plans

The Contingency Plan complements existing civil defence and emergency management operational planning documents, and only contains information specific to the management and co-ordination of response to a volcanic eruption.

The Contingency Plan also identifies roles, responsibilities of key response agencies but does not replace the need for these organisations to prepare their own contingency plans (for the continuance of their core business functions).

Plan Maintenance

This plan will be reviewed annually for the first 5 years in order to incorporate the latest volcanic research and reflect changes in the Civil Defence Emergency Management sector.

Section 2: Operational Environment

This section provides a summary of the volcanic hazards and risks specific to Auckland’s volcanic field. An understanding of the special character of the Auckland Volcanic Field (AVF) allows an appropriate planning and response framework to be established.

Geographic Context

Central Auckland is located on a narrow isthmus between the Waitemata and Manukau Harbours. This is a major geographical feature that constrains the location of lifeline utilities including power, transport, gas and communication networks. This also limits land-based evacuation routes. The AVF covers the entire width of the Auckland isthmus (see figure 1), consequently there is a high risk of a volcanic eruption causing multiple and catastrophic utility failure. Many utilities running through the Auckland isthmus service large areas (e.g. power to Northland) and consequences may be widespread.

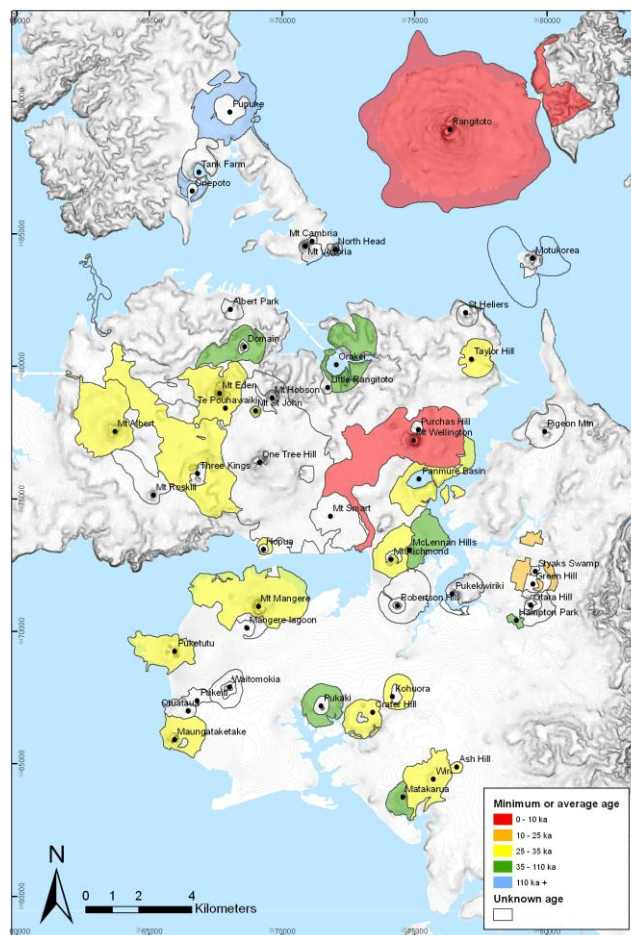


Figure 1: The Auckland Volcanic Field best age estimates¹

¹ Modified from Lindsay, J. M, Leonard, G. L. 2009. Age of the Auckland Volcanic Field. IESE Report 1-2009.02.

The Auckland Volcanic Field extends beneath both the Waitemata and Manukau Harbours. Interactions of magma with shallow harbour water, or terrestrial ground or surface water can result in explosive and highly destructive volcanic activity.

Auckland's topography is largely comprised of short steep catchments. The distance and direction that volcanic products such as base surges and lava flows will travel is largely controlled by topography. Consequently these hazards will probably affect targeted areas however, it is difficult to predict which areas will be affected until the location of the vent is determined.

Auckland Volcanic Field Characteristics

An eruption within the AVF could occur anytime: The return period between past events has ranged from tens to thousands of years. The most recent eruption occurred some 550 years ago. A future eruption may therefore occur at any time in the future.

The site of future eruption cannot be predicted: The geologic record indicates that the AVF is a monogenetic volcanic field (typically only one eruption episode occurs from each vent, although some eruption episodes have involved more than one vent). The monogenetic nature of Auckland's volcanoes means that a future eruption will most probably involve a new volcano being formed, rather than renewed activity from an existing volcano.

There may be a relatively short pre-eruption period (possibly only a couple of days): The AVF volcanoes are characterised by low viscosity basaltic magma, which rises quickly to the crust (at speeds of between 0.1 and 2.2 km/hr). This means that the warning period for any pending eruption (from the early stages of detection to the commencement of volcanic activity) is likely to be short, in the order of 1 day to a few weeks².

The initial phase of activity is likely to be the most catastrophic: Most of the past eruptions have started with an explosive phreatomagmatic eruption producing base surges and resulting in the formation of a tuff ring. The abundance of sea water and groundwater in and around Auckland means a future eruption is also likely to start this way.

There may be more than one eruption vent: It is possible that there will be more than one eruption vent, or that magma may erupt along an elongated fissure (though it is expected that any vents in a multi-vent episode will be in relatively close proximity)

The volcanic event may continue for a long time: Unlike many other natural hazards in New Zealand, a volcanic event will occur over a long time frame, over a period of months up to a year or more;

Many hazards may result from a volcanic eruption: Volcanic activity will give rise to a number of hazards, which will have minor to severe impacts both in terms of damage and geographic extent.

² Blake, S, Smith, I.E.M, Wilson, C. J.N, Leonard, G.L. 2006: Lead times and precursors of eruptions in the Auckland Volcanic Field, New Zealand: Indications from historical analogues and theoretical modelling. GNS Science Consultancy Report 2006/34.

Volcanic Hazards

Detailed summary information on the volcanic hazards to affect Auckland, their consequences and mitigation options is given in Appendix 3. The risk associated with these hazards has been assessed and is summarised in Table 1.

When planning for response, particular attention should be given to those hazards that pose a potentially high or severe risk, for which some mitigation options are available (see table 1). For example, crater formation poses a severe risk, but there are no known options for mitigation (other than evacuation with sufficient prior warning). Whereas lava flow and air-fall tephra pose high risks, however there are some mitigation options available that will reduce the impact. See Appendix 3 for information on mitigation options.

Table 1: Volcanic Risk Matrix

Hazard	Area Affected	Infrastructure Impact	Human Impact	Mitigation Options
Base Surge	Up to 5km	Extreme	Extreme	No
Volcano Formation	Up to 3km	Extreme	Extreme	No
Air-fall Tephra	Widespread	High	Low	Yes
Lava	>10km	High	Low	No
Gas	Widespread	Moderate	High	Yes
Ballistics	Up to 5km	Moderate	Moderate	Yes
Shock Waves	>3km	Moderate	Low	Yes
Earthquake	Widespread	Low	Low	Yes
Lightning	Widespread	Low	Low	Yes
Tsunami	Widespread	Low	Low	Yes

Weather

Weather conditions can complicate and exacerbate volcanic hazards and should be considered during volcanic response and planning.

Wind

- The direction and strength of wind will influence the distribution of volcanic ash and lapilli from the eruption column. Auckland's predominant wind direction is westerly but this is highly variable. Regular wind forecasts will be required in order to determine the hazard zone. The hazard zone should be reviewed and updated regularly based on these forecasts.
- Ash that has settled can also be remobilized by wind.
- Wind direction can vary at different altitudes causing unexpected aviation risk.
- Strong winds can spread fires that result either directly or indirectly from volcanic activity.

Rain

- Wet ash is up to two times as dense as dry ash, increasing the risk of roof collapse.
- Rain will wash volcanic ash off roofs and roadways into stormwater systems blocking drains and causing flooding.
- Ash can cause corrosion and may be electrically conductive. Rain may cause flashovers on electricity insulators resulting in power outages.

Potential Consequences

The risks and impacts of a volcanic eruption in the AVF are diverse and complex, with different physical processes likely to give rise to many different physical, social and economic impacts. Importantly, the location and duration of the volcanic eruption will largely dictate the extent of these impacts. These are likely to be both ‘moderate term’ (for the months or years of volcanic activity) but also significantly longer term (e.g. for the volcanic vent area where reoccupation of the area may not be possible for many years, if ever).

Local Consequences

Refer to Appendix 3 for more detailed information.

While not exhaustive, the following is intended to provide general guidance on the possible local impacts resulting from a volcanic eruption. The Auckland Volcanic Scientific Advisory Group (AVSAG) will provide a more detailed assessment of consequences that is specific to the event and location.

Built

- **Buildings and Infrastructure:** Total destruction and burial of buildings and infrastructure directly over the vent and in the path of base surges and lava flows. Damage to infrastructure from ash (e.g. roof collapse, electricity failure, infiltration into buildings and equipment damage to water and wastewater pump stations, storm water system blockages). Secondary effects, particularly resulting from electricity failure. Windows blown out from shockwaves.
- **Transport:** Disruption to the Region’s transport and lifeline networks, including direct physical impacts on infrastructure, severance of transport corridors or service lines, closures to ports, airports and maintenance/operational impacts (e.g. ash fall disruptions) depending on the location of any volcanic vent. Large volumes of ash on roads requiring removal and disposal;
- **Hazardous Substances Storage:** Potential impact on hazardous chemical and fuel storage areas;

Economic

- **GDP:** Economic modeling suggests that an AVF eruption will result in a reduction in Auckland’s GDP in the first year;
- **Business Operations:** Disruption to regional and local business and to economic operations (e.g. loss of staff, loss of access to supplies, loss of business centers);
- **Trade:** Potential disruption to the port, airport or main land based transport corridors, major gateways for goods and access to the region;

- **Commercial:** Disruption to commercial activity (particularly retailing due to loss in market confidence and loss of markets);
- **Tourism:** Loss of tourism initially, probably followed by an influx of tourist to see the volcano;
- **Insurance:** Issues with post-event insurance availability and premium loadings;
- **Resources:** Long term (or possibly permanent) loss of land use and economic return from volcanic vent area.

Social

- **Displacement:** Displacement of residents and businesses from evacuation zone.
- **Community Services:** Disruption to operation of community services (e.g. schools);
- **Psychological:** Psychological impacts on community, high levels of stress;
- **Networks:** Displacement of community and social networks (moderate to long term);
- **Employment:** Loss of employment and economic security;
- **Health:** direct (casualties, respiratory effects, eye irritations), and indirect (car crashes, giardia outbreaks, contamination, clean-up risks, roof collapse etc).
- **Safety:** Health and safety impacts on the region's resident population (e.g. resulting from ash fall, volcanic gasses, fire fountaining or indirect casualties);

National Consequences

- **GDP:** Economic modeling has suggested that an AVF eruption would result in a reduction in GDP in the first year;
- **Air Travel:** Disruption to Auckland International Airport as a major portal to the country (trade and tourism);
- **Business:** Disruption to nationally important business and commercial activity (particularly if the CBD affected);
- **NZD:** Pressure on the New Zealand dollar;
- **Port:** Disruption to the Port as a major national gateway for goods to the country;
- **Transport and Infrastructure:** Disruption of transport and infrastructure services to and from the north (e.g. the Harbour Bridge, Marsden Point Pipeline and the Main Power Trunk);
- **Resources:** The need for national support and resources to be deployed.
- **Financial Markets:** Possible implications for New Zealand's international reputation and financial markets if Auckland, or New Zealand generally, is or is perceived as suffering significant and prolonged disruption affecting the ability to function;
- **Welfare:** Significant accommodation and other welfare needs for a prolonged evacuation of a large impacted population.
- **Wider Impacts:** All other regions would suffer from a lack of accessibility to Auckland infrastructure, supply chains, business closure and possible relocation of large numbers of internally displaced people
- **International Aid:** It is possible that New Zealand would need to accept and coordinate overseas aid.

Coordinated civil defence emergency management support at the national level or, should a national state of emergency be declared, the direction and control of national resources, may be required to assist local response, as set out in the National CDEM Plan (and supporting Guide).

Section 3: Monitoring and Warnings

Monitoring

Under the Civil Defence and Emergency Management National Plan GNS Science is required to undertake routine volcano surveillance and assess the significance of information gathered regarding the state of the AVF.

The Auckland Volcanic Seismic Monitoring Network

The Auckland Volcano-Seismic Monitoring Network (AVSN) comprises eleven sites distributed around the AVF, (Waiatarua, Moumoukai, Motutapu, Herne Bay, East Tamaki, Awhitu Peninsula, Eden Park, Army Bay, Riverhead, Waiheke Island and Karaka Rd). The AVSN is part of GNS Science's GeoNet network.

The AVSN is designed to monitor seismic activity associated with the onset of volcanic activity, but also detects non-volcanic earthquakes. By recognising a change in the prevailing seismic pattern that may signify magma movement within the volcanic field, warning of impending volcanic eruption can be given.

Seismic activity is monitored continuously. Data is digitally recorded and then transmitted via satellite to GNS Science at Wairakei and Wellington for computer analysis.

GNS Science will deploy additional portable monitoring equipment when signs of possible volcano unrest are detected.

Warnings

The National Civil Defence Emergency Management Plan Order 2005 (S62) sets out the responsibilities and procedures for civil defence emergency warnings.

- **GNS Science** is responsible for issuing **Volcanic Alert Bulletins** indicating the appropriate **Volcanic Alert Level**.
- **MCDEM** is responsible for issuing **national CDEM** warnings.
- The **ACDEMG** will be responsible for issuing appropriate **public alerts** (refer to Appendix 2) within the region.
- **MetService** is responsible for issuing **aviation SIGMET** and **volcanic ash advisories**, reporting and forecasting the distribution and spread of the ash cloud from an erupting volcano for the purpose of aviation safety.

Volcanic Alert Levels

The status of the volcanic field at any time is defined by an assigned *Volcanic Alert Level* (VAL) as described in figure 2. **GNS Science** is responsible for assessing the level of activity of Auckland's volcanoes and issuing Volcanic Alert Bulletins. Volcanic activity in the AVF is likely to develop over a relatively short period of time.

	Volcanic Alert Level	Volcanic Activity	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

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 (fast moving hot ash clouds), lava flows, lava domes, landslides, ash, volcanic gases, lightning, lahars (mudflows), tsunami, and/or earthquakes.

Volcanic unrest hazards 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).

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.**

Figure 2: Volcanic Alert Level System

Physical Warnings

The next AVF eruption will occur when magma presently forming 80-100km beneath Auckland rises to the surface. As the magma rises through the crust, it will most likely generate small tremors which can be detected using seismometers and later, earthquakes which can be felt. A volcanic eruption is expected to occur after a period of earthquakes lasting a few days to a few weeks, although some modelling suggests that, in extreme cases, the warning time may be as little as several hours. Results of seismic monitoring to date indicate a very low level of background seismicity in Auckland, which improves the likelihood of detection of an impending eruption and eventual location of its vent.

Physical signs of an impending eruption may include:

- Tremors up to MM6 (Slightly damaging – people and animals alarmed, unsecured object may fall)
- Localised ground uplift and surface cracking at the eruption site (eruption imminent)
- Steam eruptions close to the eruption site (eruption imminent)
- Increased gas output at the ground surface

Section 4: Risk Assessment

One of the key requirements for civil defence emergency management is to understand the area's most likely to be at risk. As the future sites of volcanic eruption cannot be predicted, predicting the hazards and risks associated with volcanic eruption in the AVF is more complex. For example, hazards from a volcanic eruption will be dependent on whether the eruption occurs on land or below water and the risks will depend on the location of the eruption in the AVF.

Hazard Zone Assessment Tool

For the purposes of contingency planning, a uniform distribution of hazard zones is proposed as a *preliminary* guide for impact assessment. The *Hazard Zone Assessment Tool* is to be used for *initial* assessment of the likely area at risk from volcanic eruption following detection of a change in seismicity by the AVSN. As the magma rises to the surface it is expected that the probable vent location will get more accurate (figure 3). The initial spread of uncertainty will significantly influence evacuation decision-making.

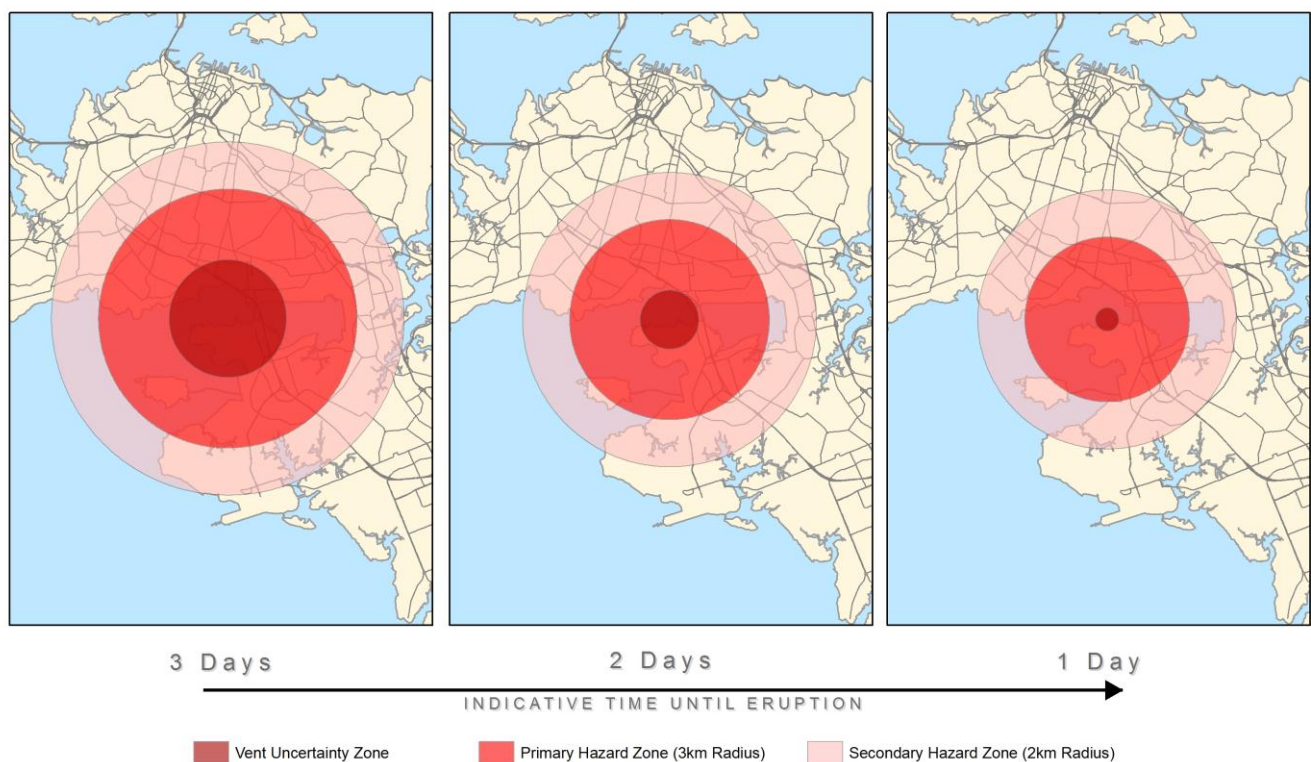


Figure 3: Time sequence progression of the vent uncertainty area as the magma rises to the surface.

There are two main hazard zones:

- **Primary Hazard Zone** – The primary hazard zone is a 3km radial zone around the vent uncertainty zone (figure 3) that represents an area of high hazard. All hazards may occur within this zone including base surges, volcano formation, ash-fall, lava, gas, ballistics, shockwaves, earthquakes, lightning and tsunamis. People and animals within this zone maybe severely injured or killed. Infrastructure is likely to be severely damaged or destroyed. Underground infrastructure maybe damaged from heat exposure, ground deformation or high-velocity ballistic impacts.
- **Secondary Hazard Zone** – The secondary hazard zone is a 2km radial zone around the primary hazard zone (figure 3) and represents an area of moderate hazard. Hazards may include base surges, ash-fall, lava, gas, ballistics, shockwaves, earthquakes and lightning. Broadly speaking people and animals located in this zone may be injured or suffer significant health effects. Infrastructure on the surface may be severely damaged.

Because early estimates of the eruption site are likely to be loosely constrained, the application of these uniform hazard zones (indicated above) should be applied around the vent zone using GIS or other mapping software.

Table 2: Hazard Zones

Hazard Zone	Radial distance from previous hazard zone
Vent Uncertainty area	unconstrained
Primary Hazard Zone	0-3km
Secondary Hazard Zone	3-5km
Ash zone 1 (>10mm ash thickness)	5-15km
Ash zone 2 (5-10mm ash thickness)	15-18km
Ash zone 3 (1-5mm ash thickness)	18-30km

As the HZAT is an *initial* assessment tool it should be reviewed in conjunction with ongoing scientific updates, provided by the AVSAG, to refine understanding of the likely areas and impacts. Ash distribution will be highly directional and dependent on wind conditions, and lava flow distribution will be highly dependent on topography.

Section 5: Evacuation Planning

Evacuations will be undertaken in accordance with the process outlined in the Auckland Evacuation Plan. This section outlines the process for determining volcanic evacuation zones, and volcano-specific considerations to be used in evacuation planning. Evacuation planning requires the involvement of a diverse range of organisations and will not be undertaken in isolation.

Assessing the Need for an Evacuation

An evacuation will be needed if:

- Hazard assessment indicates urban or strategic area may lie within 5km of the inferred eruption center;
- Potential risk to life

Evacuation Zones

Identify Primary Evacuation Zone (PEZ)

- Primary Evacuation Zone includes both the vent uncertainty area and primary hazard zone as defined by the HZAT or as modified in consultation with AVSAG to recognise factors such as predominant wind direction, topography etc.).
- Identify highest priority areas within this zone if population density is high.
- Review when AVSAG provides updated advice:
 - Extreme Risk Hazard Zone boundaries may be modified according to topography;
 - Priority areas may be identified on the basis of prevailing winds and weather conditions;
 - Boundaries may be altered to include tsunami or other hazards if the eruption is off-shore;
 - Boundaries may be altered to consider secondary hazards.

Identify Secondary Evacuation Zone (SEZ)

- Secondary evacuation zone aligns with the secondary hazard zone as defined by the HZAT or as modified in consultation with AVSAG to recognise factors such as predominant wind direction, topography etc).
- This zone may include the following areas:
 - Areas at risk of catastrophic impact from volcanic hazards if eruption is large
 - Areas which have become isolated due to the eruption hazard;
 - Areas where lifeline services have been or are likely to be severed;
 - Areas where winds or topography have the potential result in greater hazard impacts; or
 - Areas deemed to have a level of risk based on updated advice from AVSAG.

Operational Considerations

Evacuation Controls

Consideration should be given to:

- Limited or partial evacuation of the SEZ.
- Lifeline utilities and contractor access to evacuation zones as it is safe to do so.
- Number and profile of evacuees
- Vulnerable communities, aged-care facilities, hospitals, educational facilities etc.
- Road capacity, distances travelled and timing of evacuation (e.g. time of day)

Cordons

When planning an evacuation cordon the following will be considered. Due consideration will also be given to the draft cordon management guidelines developed by the Ministry of Civil Defence Emergency Management.

- Volcanic hazards and potential secondary hazards;
- Potential for the area to become isolated due to eruption or loss of lifelines;
- Ability to provide personnel support (including shift changes, communications, shelter and staff welfare);
- Ability to evacuate from post, if required.

Influencing Uncertainties

Consideration should be given to the following matters when deciding when to commence an evacuation.

Risk

- Time required for an evacuation vs scientific advice on the probability, timing and location of an eruption (and uncertainties);
- The 'cost' of an evacuation relative to the 'benefits'
- The safety of personnel assisting in evacuation (from primary and secondary hazards);
- Potential for evacuation routes to be affected by volcanic activity.

Logistics

- Resource availability (people and materials) to assist in evacuation;

Complicating Factors

- The potential issues arising from people outside the PEZ self- evacuating on the same routes or through areas and routes needed for evacuation of the PEZ);
- Likely duration of evacuation;
- Area to be evacuated to – within-region, outside-region;
- Impact on local infrastructure, disruption to businesses, schools, etc.;

- Evacuating vulnerable communities – prisons, care facilities, hospitals, those receiving 24hr home care, zoo;
- Availability of supplies for those not evacuated;
- Staged evacuation;
- Pets.
- Registration of evacuees.
- Possibility of severe weather conditions restricting one or more evacuation routes or methods (e.g. ferry).

Section 6: Roles and Responsibilities

In the event of a volcanic eruption it is important to recognise that a diverse range of specialist advice will be required.

Lead Agency

The **ACDEMG** will be the Lead Agency unless a national declaration is implemented.

Roles and Responsibilities - Key Response Agencies

The roles and responsibilities of different agencies in the event of an AVF eruption are summarised in Table 3. This Table is intended to outline specific roles and responsibilities in the event of volcanic eruption and does not devolve any organisation of the responsibilities identified under the National Plan, CDEM Plan or other legislative requirements.

Organisation	Key Roles <i>(in addition to normal CDEM response roles)</i>
ACDEMG	Lead Agency <i>(Refer to Appendix 2 for ECC team checklists)</i> ■ Assess Risk - identify hazard zones ■ Plan Evacuation ■ Manage volunteers and resources ■ Public Information and Media Management ■ Liaise and coordinate with emergency services, welfare providers, AELG, and other stakeholders/groups. ■ Source and prioritise allocation of health and safety equipment ■ Assess and coordinate mitigation options ■ Provide for welfare and recovery – including registration
MCDEM	■ Assess national consequences – economic and infrastructure ■ Source and prioritise allocation of nationally scarce resources: – Health and safety equipment – face masks – Filters for generators etc – Fuel ■ Coordinate international and national resources, aid and scientific advisors
GNS Science	■ Provide Volcanic Alert Levels and Volcanic Alert Bulletins to the ACDEMG, MCDEM, media and public. ■ Through AVSAG, provide advice on the ongoing and potential effects of a volcanic eruption to the Lead Agency. ■ Set Aviation Alert Codes and provide Volcano Observatory Notices to Aviation (VONAs). ■ Monitoring volcanic activity. ■ Provide Health Advice – liaison and monitoring with MOH regarding health issues.

NZ Police	■ Plan and implement the evacuation plan. ■ Security.
NZ Fire Service	■ Member of the Technical Advisory Group – mitigation. ■ Assess secondary hazards – fires from lava, gas explosions etc. ■ Provide specialist equipment for working in a hazardous environment.
Met Service	■ Provide warnings on volcanic ash emissions including: – Issuing appropriate NOTAMS (Notice to aviation) on volcanic hazard areas through Airways; – Issuing SIGMETS (significant meteorological advice for pilots) on ash cloud and dispersion to aviation; – Issuing volcanic ash advisory messages (VAA) about ash-cloud and dispersion to aviation. ■ Responsible for Volcanic Ash Advisory Centre.
Airways Corporation	■ Advise the Lead Agency of civil aviation conditions. ■ Advise aviation operators of volcanic SIGMET and appropriate VAA information. ■ Collect, from aircraft, Volcanic Activity reports (VAR), pass this information to GNS and MetService and report to Lead Agency.
Civil Aviation Authority of New Zealand	■ Maintain a regulatory oversight that a means exists whereby civil aviation aircraft operations can be safely carried out in proximity volcanic ash. ■ Liaise with airline operators, Airways and MetService.
AWAG	■ Provide welfare assistance and support to all affected communities. ■ Assess needs of affected communities. ■ Provide advice and guidance to NWCG and seek support as appropriate.
Lifeline Utilities	■ As requested by the lead agency, manage supply or disconnection to the areas at risk. ■ Assess network risks and secondary hazards.
NZDF	■ Member of the Technical Advisory Group - providing advice and operational resources for mitigation and response.
Harbourmaster	■ Assess risk to strategic marine assets especially those required for evacuation, response and recovery efforts. ■ On-water navigational safety, especially in response to risk from submarine eruption.
DHBs	■ Assess risk to health services and need for hospital evacuations. ■ Coordinate evacuations and ensure rest homes and care facilities have the necessary support.

Table 3: Roles of Key Response Agencies

Time-Sequence Response Roles

The table below indicates key response activities as they relate to Volcanic Alert Levels.

Volcanic Alert Level	Volcano Status	Period	Response Activities - ECC	Response Activities – Other Agencies
0	No volcanic unrest	Not applicable	■ Auckland Volcanic Scientific Advisory Group (AVSAG) established /and meet on a regular basis to confirm and discuss AVF activity, changes or refinements in contingency plans or other planning and response documents, explore the use of probabilistic eruption forecasting and decision-making thresholds. ■ Make recommendations for update of the Contingency Plan as appropriate. ■ Public education programme and awareness campaigns.	
1	Minor volcanic unrest – volcanic unrest hazards	1 day and up to a few weeks	■ Establish Operational Response Group (SOP201). ■ AVSAG notified and convened (see Appendix 4). ■ Nomination of Lead Agency – CDEM Group. ■ Issue regular public information statements. ■ Alert of threat provided from the ACDEMG direct to: – KRAs – Civil Aviation Authority; – New Zealand Airways Corporation. ■ Perform risk assessment using the Hazard Zone Assessment Tool (refer to Section 4). ■ Convene AWAG.	GeoNet (GNS Science) ■ GNS Science continues to monitor volcanic activity, set VAL and issue Volcanic Alert Bulletins as appropriate. <i>If the HZAT suggests a high-density population area or key strategic resource may be affected, escalate response activities.</i>
2	Moderate to heightened volcanic unrest – volcanic unrest hazards and potential for eruption hazards	Up to 1 to 3 days	■ Consider commencement of Evacuation within PEZ and SEZ and management of this area as an ‘Incident Control’ area (as per CIMS). ■ Issue warnings to public using media and other available local warning systems (e.g. Loud speaker attached to a helicopter) ■ Convene all recovery task groups. ■ AVSAG mobilised to advise the lead agency on the volcanic activity and likely hazards.	GeoNet (GNS Science) ■ GNS Science continues to monitor volcanic activity, set VAL and issue Volcanic Alert Bulletins as appropriate.
3	Minor volcanic eruption – eruption hazards near vent	A few hours to 1 day	■ Evacuate immediately, if not already undertaken. ■ AVSAG continues to advise the lead agency on the volcanic activity and likely hazards.	GeoNet (GNS Science) ■ GNS Science continues to monitor volcanic activity, set VAL and issue Volcanic Alert Bulletins as appropriate. Met Service ■ Issue volcanic ash advisory Airways Corporation ■ Assess risk to aviation from volcanic ash
4	Moderate volcanic eruption – eruption hazards on or near volcano	Up to a few hours	■ AVSAG continues to provide regional scientific advice and respond to hazards as these develop. In particular, base surges, lava flow, wind direction and ash fall, air quality, gas emissions. ■ Plan for disposal of volcanic ash ■ Assess consequences and secondary impacts	GeoNet (GNS Science) ■ GeoNet continues to monitor volcanic activity, set VAL and issue Volcanic Alert Bulletins as appropriate.
5	Major volcanic eruption – eruption hazards on and beyond volcano	Not applicable		

Table 4: Time-sequenced response roles

Appendix 1: List of Acronyms

AELG	Auckland Engineering Lifelines Group
AVF	Auckland Volcanic Field
AVSAG	Auckland Volcanic Scientific Advisory Group
AVSN	Auckland Volcano-Seismic Monitoring Network
AWAG	Auckland Welfare Advisory Group
CAA	Civil Aviation Authority
CDEM	Civil Defence Emergency Management
ACDEMG	Auckland Civil Defence Emergency Management Group
CIMS	Co-ordinated Incident Management System
DHB	District Health Board
ECC	Emergency Coordination Centre
GNS Science	Institute of Geological and Nuclear Sciences
HZAT	Hazard Zone Assessment Tool
MCDEM	Ministry of Civil Defence Emergency Management
MoH	Ministry of Health
MoT	Ministry of Transport
MCDEM	Ministry for Civil Defence Emergency Management
NWCG	National Welfare Coordination Group
NZDF	New Zealand Defence Force
PIM	Public Information Manager
PEZ	Primary Evacuation Zone
SEZ	Secondary Evacuation Zone
TAG	Technical Advisory Group
VAB	Volcanic Alert Bulletin
VAL	Volcanic Alert Level

Appendix 2: ECC Team Checklists

Planning and Intelligence

- ☐ Establish AVSAG and TAG when atypical seismicity is detected (See Appendix 4).
- ☐ Provide advice on Safety Equipment (PPE) (See Appendix 5) with advisory assistance from the AVSAG and TAG. Prioritise distribution of equipment.
- ☐ **Transport Routes:** advise transport network providers on the following matters:
 - Ash fall and ash disposal locations (for clearance of ash and debris from routes and networks);
 - Overall impact areas and hazard zones (for establishment of detour corridors should sections of highway be within 3-5km of the eruption site).
- ☐ **Risk Assessment:** using Hazard Zone Assessment Tool (see Section 4) provide an initial assessment (rapid, though course) of the likely impacts of volcanic eruption. That is:
 - The population within each hazard zone;
 - The number of households within each hazard zone; and
 - Strategic lifelines within each hazard zone (with Lifelines Liaison input).
- ☐ **Evacuation:** Identify the following:
 - Areas where damage is likely if eruption hazards escalate (SEZ);
 - Areas likely to be isolated in the event of eruption (particularly in terms of water supply, wastewater disposal, power and road access);
 - Areas where there is potential for significant damage due to secondary hazards (e.g. fire, hazardous substance leakage).
 - Areas that may be impacted by tsunami.
- ☐ **Ash Disposal:** (See Appendix 6)
 - Identify and get approval for ash disposal sites.
 - Direct logistics/operations to implement collection.
- ☐ **Consequences Assessment:** information on the effects of eruption on the social, economic and built environments.

☐ **Evacuation Planning:** assess and input the following information for evacuation planning (See Section 5)

- Population in PEZ and SEZ;
- Special needs of people within the above areas;
- The time required for effective evacuation of the resident population from the PEZ;
- The safety of personnel assisting in evacuation;
- The potential issues arising from people outside the PEZ self- evacuating on the same routes or through areas and routes needed for evacuation of the PEZ);
- Best estimate of probability, location and timing of an eruption (use AVSAG);
- Assessment of the ‘cost’ of an evacuation relative to the ‘benefits’.
- Registration of evacuees.
- Evacuation within region or out of region options

☐ **Mitigation Options:** assess mitigation options with TAG (see Appendix 3).

Logistics

- ☐ Plan for **disposal of ash** – collection and transport.
- ☐ Consider resources required for **mitigation**.
- ☐ **Signage** requirements for evacuation zones (erect early to minimise health and safety risk).
- ☐ Source and distribute **health and safety** equipment as advised by Planning and Intelligence (likely to be in high demand).
- ☐ **Evacuation Planning**: assess resource availability for evacuation.

Liaison

- ☐ **Lifelines Liaison:** assess volcanic impacts on strategic lifeline utilities and identify knock-on effects from utility failures. Identify potential for widespread impacts (e.g. power outages)
- ☐ **Lifelines Liaison:** provide an overview of utility mitigation plans.
- ☐ **Lifelines Liaison:** determine utilities logistics requirements, particularly regarding health and safety equipment and other resources that will be in high-demand.
- ☐ **Lifelines Liaison:** refer utilities to AELG volcanic impacts posters and reports available on the AELG website.
- ☐ **Health Liaison:** get information on health impacts from Planning and Intelligence (sourced from the AVSAG) and provide this to appropriate health agencies.

Welfare

- ☐ **Minimise ash impacts** on welfare centers (e.g. instructions for clearing ash off roofs etc.).
- ☐ Ensure Welfare Centres have access to appropriate **health and safety equipment** (See Appendix 5)
- ☐ **Minimise transportation** in areas affected by ash
- ☐ **Monitor** the **health** of people evacuees and internally displaced people, particularly in response to volcanic ash exposure (see Appendix 5).
- ☐ Ensure **affected communities** have access to appropriate **support**.

Operations

- ☐ **ECC Location:** Ensure that any GECC site is located away from areas of impact from the HZAT and from any valleys which may become lava flow corridors.
- ☐ **ECC Location:** Consider potential impact on utilities supplying the site and ability for alternatives:
 - Communications
 - Water supplies (ash contamination and disruption to network)
 - Land-based transportation
 - Power (ash impacts and damage to network)
- ☐ **ECC Maintenance:** Consider arrangements for:
 - Ash removal and disposal from building;
 - Building services (maintenance of air conditioning, air re-circulation services may need to be considered);
 - Specialist cleaning services (e.g. for acid rain, ash deposits)
- ☐ **Identification:** Provide official identification for the following groups:
 - AVSAG and TAG representatives;
 - GNS Science
- ☐ **Rescuing Belongings:** Consider and coordinate activities to rescue valued belongings from evacuation zone. This should only be undertaken if safe for workers. Valued belongings may include:
 - Photographs
 - Pets
 - Important Documents

Public Information and Media Management

Uncontrolled reporting and assessment of hazard and impact from unofficial sources is a strong possibility. Establish a strong media presence early with trustworthy spokesperson in order to mitigate risk.

- ☐ Use volcano messages from MCDEM's 'Working from the same page: Consistent messages for CDEM'. Planning and Intelligence will assist in composing all public information messages to confirm appropriateness for Auckland before they are released.
- ☐ Ensure **public information is aligned** with GNS Science Volcanic Alert Bulletins – both in terms of timing and content. Use tables below for guidance on the messages required at each VAL.
- ☐ Use Group Controller-approved Scientific and Technical Advisors as **spokesperson**.
- ☐ **Public Information Content:** Add value to scientific information being disseminated by GNS Science such as hazards, consequences, evacuation zones, population affected etc.
- ☐ **Signage:** Identify signage requirements: evacuation zones, restricted access, health and safety information, evacuation routes, notice of potential hazard zones.
- ☐ **Signage:** Prepare text for signage

*The following information is from the “**Community Behaviour-Based Communication Framework**” developed by MCDEM, GNS Science and Massey University for Exercise Ruaumoko.*

- ☐ **Uncertainty:** Unfortunately one or more of the important attributes required of warning messages (specificity, consistency, certainty, accuracy, clarity) is usually deficient or missing during a volcanic crisis. Responding authorities must recognise this.
- ☐ **Construction:** Five topics are important when constructing a warning message:

Topic	Function
hazard or risk	the warning message must contain information about the impending hazard with sufficient simple detail that the public can understand the characteristics of the hazard that they need to protect themselves from
guidance	the message should include guidance about what they should do to maximize their safety
location	the warning message must describe the exact location that is at risk
time	the message should address the timeframes required for response
source	who is issuing the warning, by what authority

- ☐ **Credible Sources:** Warnings are more likely to be believed if they come from 'credible' sources. The public's perception of credibility of information sources is a subjective judgment and has been shown to be related to notions of expertise and trustworthiness. Credibility can be judged on:
 - the "credentials" of the person or agency issuing the warning;
 - the relationship of the organisations to other "credible" organisations; and
 - the past history of job performance.

- ☐ **Rumour Control:** Rumour control is a critical function for agencies responsible for giving out public information and these agencies should be proactive in identifying and correcting incorrect or misleading information. However, some caution is needed because immediate and harsh official denouncement of popular views may be counterproductive and treated with suspicion as the public often prefer to hear a range of opinions before drawing their own conclusions on a subject.

- ☐ **Correcting Incorrect Information:** During a crisis systems often break down, data are misinterpreted and conditions rapidly change rendering previously released information 'out-of-date'. Incorrect or misleading information should be corrected by follow-up information, accompanied by explanations as to the origins of apparently 'unreliable' information.

- ☐ **Care with Forecasting and Predictions:** When the current information is full of uncertainty (a common situation prior to and during an eruption) it is important to avoid making or disseminating unrealistic forecasts. This will lessen concerns about the "cry wolf syndrome" which is common among many public officials.

TABLE

1

Phase
Volcanic Alert
Level
Human Status

Pre-Event 'Quiet Time'

0

Learning, preparing

CONTEXT	1	What the scientists will be saying	• Usual dormant or quiescent state. • Typical background surface activity; seismicity, deformation and heat flow at low levels. Some science information on GeoNet site (e.g. small non-volcanic earthquakes)
			• Low salience of it as a threat. Don't believe it will happen. • Knowledge and understanding can be improved over time, but it is really difficult to shift preconceptions. • People not too scared to prepare or believe risk, but are sceptical of reality of risk.
OBJECTIVES	3	Aims of this period	• Build trust in authorities (if you don't get trust here, it will be a lot harder to get later / in an emergency). • Get people to prepare – understand risk, warning systems, response actions including evacuation, have home and work emergency plans and kits.
			• Ensure consistent messaging • Must be pragmatic. • Positive messages that it can be done (trying to engender trust). • Capitalise on any opportunities, e.g. paper publications, eruptions elsewhere, tectonic earthquakes affecting Auckland.
MESSAGING	5	KEY MESSAGE THEMES	• Key public education messages, e.g. Auckland is a volcano, the risks associated with it, that consequences can be reduced by being prepared, having knowledge and plans.
			• None, but know what warnings to expect and actions to take when unrest starts.
	7	'Information' messages	• Auckland is a volcano. It could erupt. This is how it could erupt. These are the precursors we might see. This is the monitoring we routinely do. Here is the uncertainty around precursors, and what it might lead to. • What are Scientific Alert Levels, what is a seismograph. • Preparedness actions of authorities. • Living and working in an ash environment. • 'What we want to do' items from '3' above.
			• Eruptions are possible in your lifetime. Currently no signs on which to say there will be an eruption any time soon. • Eruptions do not appear to be regularly spaced over time. They are possible at any time. • The lead time to an eruption is most likely to be weeks to months, but could be much shorter.
			• Preparedness actions of individuals (the types of preplanning they could do, e.g. what to do with their children, how to help others), and how those actions could escalate (evacuation options) • Understand risk, warning systems, response actions including evacuation, have home and work emergency plans and kits. • Standard CDEM messaging re. preparedness.
HOW	10	Mechanisms	• CDEM Group public education programme. • Museum. Public lectures. Media stories. • Community networks empowered to educate. • Exercise evacuation procedures.

TABLE

2

Phase
Scientific Alert
Level
Human Status

Unfelt Activity		
0 – 1 →		
First community 'shock'		
CONTEXT	1	What the scientists will be saying - Initial signs of possible volcano unrest. No eruption threat. - Seismic, geodetic, thermal or other unrest indicators below the AVF. Science Alert Bulletins on GeoNet website and sent out.
	2	Expected community behaviour - Anxiety. Some positive, which can be channelled into action. But in a few cases there may be 'negative anxiety' (extreme fear leading to total inaction). - Massive public information searching. People will search tv, radio, internet, everywhere. - Social networks operating – calling friends/family. Social amplification of risk (risk perception goes up as you go away from the situation). - Self-evacuation may begin
OBJECTIVES	3	Aims of this period Calm and reassure the public. Describe the phenomena, risk and possible trends, official responses (monitoring, emergency management), and what the correct public response is.
	4	Advice to communicators - Ensure consistent messaging - Try to explain the uncertainty and the real risk in an uncertain period. - Demand for information will be intense. Guidance on how/where they can get information. - Pre-planned information becomes useful. - Be proactive in correcting misleading and incorrect information – this is essential. - Messaging must be beyond affected region (to minimise social amplification of risk phenomena) - But focus is still on Auckland residents. Bulk of time and energy should go into those at risk. Regular communication is needed.
MESSAGING	5	KEY MESSAGE THEMES What is happening, and what the authorities are doing about it.
	6	'Warning' messages There is a possibility of a future eruption. There is no current threat.
	7	'Information' messages Repeat information of SALO, but more frequently and higher profile
	8	Dealing with probability and uncertainty - There is unrest, although unfelt - It may or may not be related to volcanic activity - There is no immediate threat. - Unrest can lead to eruptions in periods of months to days. - Authorities are monitoring the unrest, any changes will be notified immediately to the public.
	9	'What to do' messages - Understand risk, warning systems, response actions including evacuation - Urgently prepare home and work emergency plans and kits.
HOW	10	Mechanisms Media

TABLE

3

Phase

Scientific Alert Level

Human Status

Felt Activity BEFORE Decision to Evacuate

1 – 2 →

Physical confirmation of threat

CONTEXT	1	What the scientists will be saying	- Initial signs of unrest. - Confirmation of volcano unrest. Eruption threat. - Earthquakes become shallower and/or larger. May be other indicators such as gas, hot springs, steam, ground deformation.
	2	Expected community behaviour	- Physical confirmation will convert most doubters (visual/felt cues). - Many people will have delayed any action until this time. - Perception may be different if their first warning is a physical warning (no unfelt activity prior to this phase). - Massive information searching for confirmation of status, validity (reassurance).
OBJECTIVES	3	Aims of this period	Calm and reassure the public. Describe the phenomena, risk and possible trends, official responses (monitoring, emergency management), and what the correct public response is.
	4	Advice to communicators	- Ensure consistent messaging - Try to explain the uncertainty and the real risk in an uncertain period. - Demand for information will be intense. Guidance on how/where they can get information. - Pre-planned information becomes useful. - Be proactive in correcting misleading and incorrect information – this is essential. - Messaging must be beyond affected region (to minimise social amplification of risk phenomena) - But focus is still on Auckland residents. Bulk of time and energy should go into those at risk. Regular communication is needed.
MESSAGING	5	KEY MESSAGE THEMES	- What is happening, and what the authorities are doing about it. - Calm and reassure.
	6	'Warning' messages	Those at risk prepare for possible evacuation.
	7	'Information' messages	- Repeat information of SAL0, but more frequently and higher profile. - Discussion about when and how to evacuate. Who will announce decision to evacuate.
	8	Dealing with probability and uncertainty	- Increasing likelihood. Slightly decreasing uncertainty (eruption more likely). - Dilemma: risk to life vs. uncertainty of making the wrong call. - Public don't want to hear probabilities, they only want to hear certainties.
	9	'What to do' messages	- Prepare for the possibility of evacuation. Gather family, prepare Get Away Kit if not already ready. Plan where to go. Go to family and friends if at all possible. - Refer to Notifications Annex of Evacuation Plan for detailed actions text. - Prepare for possible ash fall outside of potential evacuation zone.
HOW	10	Mechanisms	TV, Radio, internet news, CDEM web, GeoNet web, newspaper, public meetings.

TABLE

4

Phase

Scientific Alert Level

Human Status

Felt Activity AFTER Decision to Evacuate

1 – 2 →

Searching, deciding, evacuating

CONTEXT	1	What the scientists will be saying	- Confirmation of volcano unrest. Eruption threat. - Earthquakes become shallower and/or larger
	2	Expected community behaviour	- Massive information searching for confirmation of evacuation order, validity (reassurance). - Will look for official and informal support and direction on what to do. Will check to see if others are acting or intending to act. Decision to act will be based on a mixture of all of these pieces of information and social connections – e.g. children at school, family at other locations, friends. - Many people who are not officially told to evacuate will want to evacuate. Some officially directed to evacuate will refuse to move.
OBJECTIVES	3	Aims of this period	Prompt orderly and timely evacuation of only those people who need to evacuate
	4	Advice to communicators	- Ensure consistent messaging - As for felt activity (Table 3), and also: - Give clear evacuation advice on the key message themes - Expect a lot of enquiries – make it clear who needs to evacuate, why, and who needs to stay
MESSAGING	5	KEY MESSAGE THEMES	Focus on evacuation processes
	6	‘Warning’ messages	Evacuate from stated areas in stated timeframe.
	7	‘Information’ messages	- Auckland evacuation plan; evacuation processes - Hazards and risks of a volcanic eruption - Living and working in an ash environment.
	8	Dealing with probability and uncertainty	An eruption is likely to occur but is not certain. However, evacuation will take time and must therefore commence now.
	9	‘What to do’ messages	- Who has to go and who is to stay, why; timeframe; where to go; what route to take; what to do when you get there; what assistance people will get at all stages. - Refer to Notifications Annex of Evacuation Plan for detailed actions text.
HOW	10	Mechanisms	- Radio, TV, internet news, CDEM web, GeoNet web - Message boards for people en-route. Door-to-door route alert. - Feed information to official and informal organisational networks.

TABLE

5

Phase

Scientific Alert Level

Human Status

During Eruption

2 (briefly) → 3 & 4

Coping, evacuating

CONTEXT	1	What the scientists will be saying	- Minor eruptions commenced; possibility of hazardous eruptions. - Escalation up to 'large hazardous eruption'. - Description of eruption phenomena – as per Science Alert Bulletin.
	2	Expected community behaviour	- Most people who had refused to evacuate will decide to evacuate now. - There will be strong pressure from people outside of the evacuation zone to also evacuate. - Ash fall will impact the personal and business activities of those who have not evacuated. - Intense information searching. - Evacuated people will at some stage start wanting to return.
OBJECTIVES	3	Aims of this period	- Evacuate remaining people from zone. - Keep people from entering the evacuated zone. - Help others to continue life as normally as possible. - Provide welfare to those evacuated.
	4	Advice to communicators	- Ensure consistent messaging. - Evacuees will need information on activities within the evacuation zone (to calm anxiety, and to provide options for action). - Evacuees will need welfare information.
MESSAGING	5	KEY MESSAGE THEMES	- Strong direction to evacuate and stay out of zone. - Focus on welfare information.
	6	'Warning' messages	- Evacuate designated zones and stay out. - Weather and ash fall forecast information.
	7	'Information' messages	- Status of the volcano, associated hazards and their locations. - Response activities of authorities. - Ash fall forecasts, and how to live and work in an ash environment. - Welfare information; how to cope as an evacuee.
	8	Dealing with probability and uncertainty	An eruption is occurring, so no remaining uncertainty in that respect. However, a number of uncertainties remain: duration of eruption, ash fall areas and thickness; escalation and changes in eruption types; when people will be able to return.
	9	'What to do' messages	- Evacuate from zone and stay out. - Work safely in an ash environment (see resources for various aspects). - Evacuees register and contact welfare agencies early if they need support.
HOW	10	Mechanisms	TV, Radio, internet news, CDEM web, GeoNet web, newspaper, public meetings.

TABLE **6**
Phase
Scientific Alert Level
Human Status

			<i>Later Phases of Event / Post-Event</i>
			<i>Decreasing (4 → 3 → 2 → 1 → 0)</i>
			<i>Returning, recovering</i>
CONTEXT	1	What the scientists will be saying	- The eruption has stabilised, de-escalated or ceased. - Description of the processes still active. - GeoNet website, Science Alert Bulletins and Science Alert Level changes
	2	Expected community behaviour	- Community trauma due to losses (physical, financial, livelihood), uncertainty, - Desire to return immediately - Questions: Who will pay for my losses? When can I return? Why can't I return yet? Is it safe to return? What welfare is available? Are all lifelines available? What employment is available? How to clean-up ashfalls?
OBJECTIVES	3	Aims of this period	- Provide clear and accurate information. - Reassure people to remain evacuated until the return order is given. - Facilitate orderly return once this begins, with effective recovery. - Provide appropriate welfare assistance at all stages. - Allow community input and participation in recovery processes including plans.
	4	Advice to communicators	- Ensure consistent messaging. - Many public questions, strong pressure to return home. - Provide clear accurate information and be honest, especially about uncertainty. - Expect and allow for community feedback and participation. - This will be a long communications process.
MESSAGING	5	KEY MESSAGE THEMES	- What is happening (volcanic and emergency management). - Remaining evacuation orders. - Detailed welfare and recovery information.
	6	'Warning' messages	- Do not return until told to. Explain why. - On return explain ongoing risks and uncertainty.
	7	'Information' messages	- Effective recovery directions. See Recovery Plan. - Welfare processes and resources available. - Auckland remains a volcano. It could erupt again. This is how it could erupt. These are the precursors we might see. This is the monitoring we routinely do. Here is the uncertainty around precursors, and what it might lead to. - Actions of authorities.
	8	Dealing with probability and uncertainty	There is a likelihood of ongoing activity or renewed activity, but this is uncertain – authorities are continuing to monitor activity and will advise the public of any changes immediately.
	9	'What to do' messages	- People to remain evacuated until the 'all clear' or return order is given. - Where to find welfare, recovery information. - What to do about ash/other clean up.
HOW	10	Mechanisms	- TV, Radio, internet news, CDEM web, GeoNet web, newspaper, public meetings. - Detailed return and recovery information packs.

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Appendix 3: Hazard Matrix for the Auckland Volcanic Field

Hazard	Description	Area Affected	Infrastructure Impacts	Human Impacts	Warnings	Mitigation
Air-fall Tephra (Volcanic Ash)	Air-fall tephra or Volcanic ash consists of fragments of pulverized rock, minerals and volcanic glass, less than 2mm in diameter. In phreatomagmatic eruptions, steam condensation in the eruption plume can produce wet ash. Remobilisation of volcanic ash caused by water and wind may cause additional hazards (e.g. mudflows or lahars) Airfall tephra can be divided into two types hazards; suspended ash found in the eruption column and plumb and the ash fall hazard as experienced on the ground. Note: Lapilli consists of tephra between 2 and 64 mm in diameter and can display characteristics similar to both airfall tephra and ballistics.	The area affected by volcanic ash will be dependent on the size and nature of the eruption, wind direction and strength and particle weight. Ash plumes from an eruption within the Auckland Volcanic Field may rise up to 10km into the atmosphere and distribute material up to 50km away from the vent. This may result in millions to hundreds of millions of cubic meters of material being spread across Auckland. Ash thicknesses are likely to range from a few mm to 1 m thick. The predominant wind direction over Auckland is westerly therefore ash is likely to be thickest to the north-east and east of the vent.	Volcanic ash is hard, highly abrasive, mildly corrosive and conductive when wet. Building & Structures - Contamination and infiltration of ash through windows, doors and HVAC systems. - Ash ingress through air intake and condenser units leading to reduced performance, stalling and overheating (e.g. HVAC systems, back-up generators) - Damage from abrasion and ash loading may lead to collapse particularly if ash is wet (e.g. roofs, bridges etc.). - Guttering and other drainage systems may clog or get blocked potentially leading to water ingress and flooding. Communications - Equipment (e.g. towers, exchanges, satellites) may be damaged from contamination, abrasion, corrosion, ash loading and flashover. - Networks may suffer from congestion and overloading. - Airborne ash particles may cause signal attenuation and interference in low frequency services, satellite and radar communications. Energy & Gas - Substations particularly control and cooling systems are at risk from contamination and failure. - Overhead power lines may fail from ash loading. - Electricity outages may cause cascading failure issues. - Ash contamination of insulators may cause flashovers and reduce tolerable step and touch voltages. - Minor damage to gas pipeline valve controls and SCADA	Volcanic ash may cause respiratory effects, eye symptoms, skin irritation and psychological issues. Injuries may also be caused from secondary hazards such as structural collapse, vehicular accidents, slips and falls from roofs etc. Infrastructure disruption may lead to sanitation and health issues. Thick ash may isolate communities from essential supplies. Agricultural land will be damaged from burial and increased toxicity. Ash is potentially toxic to grazing animals if ingested. Untreated drinking water for humans may become unpalatable due to discoloration or a metallic taste before it becomes a health hazard.	Volcanic ash may be produced following the commencement and for the duration of an eruption. Volcanic ash may occur without warning but an eruption may be forecast through seismic monitoring or other methods (see Section 3). GeoNet will provide notification through a Volcanic Alert Bulletin and/or National Warning System. Ongoing Volcanic Alert Bulletins from GeoNet will provide updates to the volcanic alert level, hazard information and ash fall forecast maps and links to further mitigation.	Prepare operational plans for managing volcanic ash including communication plans for dealing with customers/public. Consider dependency on critical services and take steps to increase resilience (e.g. back-up power generator, review stocks of essential equipment). People & Animals - People should avoid unnecessary exposure to ash and wear effective face masks. People that suffer from asthma need to take additional precautions. - Ensure livestock have clean food and water. Buildings & Structures - Seal building (e.g. damp towels and duct tape) and restrict access to limit spreading ash. - Use dry methods such as a shovel, broom or vacuum cleaner to remove volcanic ash wherever possible. - Cover sensitive equipment with plastic sheeting. Shutdown non-essential equipment (including HVAC systems) where possible. Minimise use if operation is necessary and monitor sites regularly. If possible add additional filters to external air intakes. - Disconnect or cover outlets, downpipes and gutters to reduce ash ingress into water supply and drainage networks. Energy & Gas - Ash contaminated sites and components, especially insulators need to be regularly cleaned. - Consider shut down of gas prior to an eruption. Transport - Avoid all non-essential travel and implement road safety measures such as reduced speed limits, one-way rules, headlights on and safe following distances. - Cover or wash vehicles and aircraft regularly. Check, clean and replace air and oil filters. - Identify ash disposal sites and prioritise roads for clean-up. Water Supply - Water intakes should be closed before turbidity becomes excessive.

Hazard	Description	Area Affected	Infrastructure Impacts	Human Impacts	Warnings	Mitigation
			systems. - Ash loading may sink floating roofs on petrol tanks causing spills. Transport - Ash may damage vehicles and clog oil and air filters. - Visibility and traction will be severely reduced in both dry and wet conditions. - Road closure thresholds depend on tephra characteristics, depth, road gradient and local weather conditions. Ash falls > 50mm may make roads impassable. - Port and rail activities may be disrupted or forced to stop from damage to equipment (e.g. cranes and rail signals) - Ash may lead to the closure of airports and airspace due to risk of engine failure, severe abrasion and landing issues. Water Supply - Ash clean-up will increase water demand. - Ash can increase turbidity in raw water sources. - Excessive turbidity can lead to ash penetrating further into the network. - Ash that penetrates the network may block filters, cause accelerated wear and tear on pumps and overload motors. - Ash is toxic and strongly acidic which may cause a slight depression of pH. Wastewater - Ash may enter the wastewater network causing reduced capacity, blockages and overflows. - Ash may cause accelerated wear and tear on pump components and screening equipment. - Ash may increase suspended solid load of effluent, which may interfere with treatment			- Turbidity can be removed by normal coagulation/flocculation treatment. - Ensure regular monitoring of turbidity and pH and adjust treatment as required. Wastewater - Limit ingress of ash into storm water drains and sewer lines. - Shut down all non-essential equipment and monitor other equipment closely. - Consider bypassing pumping stations and treatments plants as a protective measure to avoid severe and costly damage to pumping and treatment equipment.

Hazard	Description	Area Affected	Infrastructure Impacts	Human Impacts	Warnings	Mitigation
			processes Ash may increase volume of sludge for disposal.			
Ballistics	Ballistic material consists of tephra larger than 64mm and can be categorized as a block or bomb. Volcanic blocks and bombs can be extremely large measuring meters in diameter and weighing tons but decrease in size as you get further from the vent.	Volcanic blocks and bombs typically follow ballistic trajectories and dispersal is influenced by projectile velocity, weight and vent geometry. Most volcanic blocks and bombs are deposited within the first few (1-2km) kilometers from the vent.	All above ground infrastructure is at risk from impact damage. Shallow buried infrastructure may also be damaged from the impact of volcanic blocks and bombs. Volcanic bombs may ignite fires on contact with combustible material.	Volcanic blocks and bombs may cause severe injuries and death to people within the affected area.	Ballistics may be produced following the commencement and for the duration of an eruption. Ballistics may occur without warning but an eruption may be forecast through seismic monitoring or other methods (see Section 3). GeoNet will provide notification through a Volcanic Alert Bulletin and/or National Warning System. Ongoing Volcanic Alert Bulletins from GeoNet will provide updates to the volcanic alert levels, hazard information and maps and links to further mitigation.	Reinforced concrete structures may minimize the impact and protect people and infrastructure from smaller blocks and bombs. Evacuation and site exclusion is the best form of mitigation.
Base surge	Base surges can be wet or dry and cool or hot and can develop without an associated eruption column. Base surges normally hug the ground and flow out laterally from the base of an eruption column. The sideways pressure from lateral blasts can be dangerous. Base surges are commonly associated with phreatomagmatic eruptions and the interaction of magma and water. Base Surges are associated with the majority (80%) of Auckland Volcanic Field volcanoes.	In the past Auckland Volcanic Field Base surges have travel up to 6km from the vent in a period of seconds to a few minutes depending on local topography and eruption energy. Base surges may rise over ridges and hills rather than always travel down a slope. Individual surges may deposit more than 0.2m of material near the vent. Multiple base surges may build a deposit of more than 7m of material near the vent. Surge thickness, density and speed decrease towards the outer extent of the flow.	Infrastructure within the first few kilometres of the vent will be completely destroyed. Infrastructure located further away may be severely damaged and/or partially buried making accessibility difficult.	Base surges will be very hazardous to all living things in their path. Survivability increases with distance from the main axis of the surge. People and animals caught by the blast will be buried alive and asphyxiate if they don't suffocate from the heat first.	Base surges occur with little or no warning but commonly occur at the commencement of an eruption but can also occur throughout the duration of the eruption. An eruption may be forecast through seismic monitoring or other methods (see Section 3). GeoNet will provide notification through a Volcanic Alert Bulletin and/or National Warning System. Ongoing Volcanic Alert Bulletins from GeoNet will provide updates to the volcanic alert levels, hazard information and maps and links to further mitigation.	Evacuation is the only effective form of mitigation from a base surge. Removing critical assets and other infrastructure may minimise loss. Sealing buildings and boarding windows may help reduce damage. Critical assets may be protected from lower intensity surges in reinforced concrete buildings or underground.

Hazard	Description	Area Affected	Infrastructure Impacts	Human Impacts	Warnings	Mitigation
Volcano Formation	Maars (craters) and scoria cones are typical eruptive products from an eruption produced from the build-up of tephra and lava and/or the explosive release of pre-eruption country material.	Craters of up to 1.5 km in diameter can be formed within the Auckland Volcanic Field. Individual cones can extend up to 1 km across. A row or series of cones can form next to one another usually along a fissure that may be kilometres long.	Infrastructure above and below a crater will be completely destroyed. Infrastructure above ground within the foot print of the cone will likely be destroyed Buried Infrastructure within the footprint of the cone or ring (not including the crater) may be damaged (e.g. pipelines and cables may be broken and dislocated etc.).	Immediate loss of all life within the vent crater, cone or ring.	Formation of Maars, tuff rings and tuff cone will form over the course of the eruption. An eruption may be forecast through seismic monitoring or other methods (see Section 3). GeoNet will provide notification through a Volcanic Alert Bulletin and/or National Warning System.	No effective mitigation options exist for near vent infrastructure. Mitigation will be in the form of redundancies identified prior to an event. Evacuation, asset stripping and site exclusion within the impact areas may minimise loss. Shut down and/or isolate infrastructure services within the affected area prior to the eruption.
Earthquakes	A volcanic earthquake is an earthquake (or ground shaking) caused by movement of magma through the crust. Volcanic earthquakes can occur before and during eruptions. There are two different types of shaking associated with volcanic earthquakes; discrete shaking and tremors. They have different frequencies, durations and impacts. Earthquakes may trigger landslides or cause liquefaction in low lying areas and/or reclaimed land (e.g. South Auckland)	Volcanic earthquakes are expected to be felt in close proximity to a vent.	Volcanic earthquakes may damage weak structures particularly those founded on steep slopes but the risk is considered low. Volcanic earthquakes may damage contents and insecure equipment. Infrastructure built upon reclaimed or low lying land (e.g. Airport and Ports) may be susceptible to liquefaction. The effects of single discrete shaking may be different to the effects of a prolonged tremor.	People may be injured from falling contents and debris. However the risk to life is considered low. People may suffer psychological impacts from prolonged shaking and/or fear of further and potential volcanic activity.	Volcanic Earthquakes will generally occur without warning. Volcanic Earthquakes are a common precursor to volcanic activity and are expected to be felt for a period of days prior to commencement of an eruption.	Seismic restraining and strengthening of contents and buildings. Conventional strengthening may not be suitable for prolonged tremors. Ensuring redundancies have been taken into consideration for dependant infrastructure. Regular monitoring and checks of infrastructure for damage (e.g. for pipe leakage etc.) Consider shutdown and isolation of services (e.g. gas reticulation) depending on the severity of the shaking. Prepare contingency plans on the implication of volcanic activity in the vicinity of the shaking (e.g. prepare traffic management plans and cordons)
Gas	Volcanic gases predominantly consist of steam, followed by carbon dioxide and lesser amounts of sulphur and chlorine compounds. Volcanic gases may escape through vents and flowing lava. Volcanic gases can also escape through the soil even without an eruption. Lava on contact with seawater creates dense white clouds of hydrogen chloride which can be carried downwind at low elevation. Volcanic gases can create acid rain, be concentrated and pond in low-lying areas and topographic depressions.	Hazardous concentrations of gases are present only very close to the vent (within 1 – 2 km). Concentrations decrease sharply with distance from the source. Away from the vent gases pose no more than an irritant or nuisance. Acid rain may be experienced up to 10km downwind of the vent.	Volcanic gases and acid rain can cause corrosion problems to buildings and infrastructure downwind. HVAC systems and any equipment that requires aspiration (anything that 'breaths') are particularly vulnerable to corrosion. Volcanic gases can pond in low-lying areas such as basement garages, cellars and underground car parks etc. Volcanic gases heavy in sulphur dioxide may cause flashover risks of electrical equipment.	Volcanic gasses can lead to breathing difficulties, asphyxiation, nausea, skin irritation and in high enough concentrations can lead to death. Acid rain has been shown to have an adverse impact on vegetation, soil and water, killing insects and aquatic life, in high enough concentrations. Acid rain typically does not directly affect human health as the acid in the rainwater is too dilute.	Volcanic gas is a precursor of volcanic activity and so you can have the gas permeate through soil without an eruption. Volcanic earthquakes associated with the rise of magma may be an indication of increased volcanic gas emissions but otherwise there is little warning.	People need to avoid exposure to volcanic gases and acid rain. Those people in close proximity of the vent should evacuate. Regularly wash exterior fittings and surfaces. Check and maintain equipment as necessary. Regularly monitor gas levels particularly in low-lying basement areas. Dispersal of gases from active vents and cooling lava following cessation of activity.

Hazard	Description	Area Affected	Infrastructure Impacts	Human Impacts	Warnings	Mitigation
Lava	Lava flows are streams of hot (1000°C or more) molten rock which flow under gravity into and along topographic lows. Lava flows are generated by dry eruptions and are associated with over half (60%) of Auckland Volcanic Field volcanoes. Auckland Volcanic Field lava flows are characteristically Aā or Pāhoehoe flows. Pahoehoe lava is more fluid than Aā, causing thinner, faster moving flows. Lava flows may be driven by a spectacular eruption of gas-fuelled magma that is ejected hundreds of meters above the vent, known as a fire fountain. Lava flows can be produced from primary or secondary vents and can also be associated with partial cone collapse or breaching.	The distance lava flows travel depends on the viscosity of the lava, output rates, volume erupted, steepness of the slope, topography and obstructions in the flow path. Fire-fountaining of lava can reach 200 – 300m in height. Lava flows can travel along the ground for distances of more than 10km and is strongly influenced by topography. Aā flows have a flow front velocity of 10 to 40 m/hr and Pahoehoe flows have a flow front velocity of 1 to 10 m/hr	Lava flows will cause total destruction of all buildings and infrastructure in their path. Reinforced concrete structures or buildings may divert the flow. Power poles will burn even if insulated. Infrastructure may be buried by a lava flow and even after the lava has cooled access may be difficult. Shallow buried infrastructure may be damaged from thermal exposure. Lava that infiltrates tunnels and pipelines may travel a lot further as the tunnel or pipeline will serve as an insulator. Lava flows may cause fires and large explosions if comes into contact with combustible material and/or petroleum.	Lava flows seldom threaten life because of their slow rate of movement. People and animals can generally get out of the way in time. Lava flows will kill and destroy anything caught in their path. Lava flows can explode when they come into contact with water or vegetation/swampland due to concentrations of organic gases.	Fire fountaining may occur within hours of the eruption and therefore there will be little warning. Lava flows generally occur later in the eruption sequence, following fire-fountaining. Because lava flows are strongly controlled by topography, the flow and potential area affected can be easily modelled. An eruption may be forecast through seismic monitoring or other methods (see Section 3). GeoNet will provide notification through a Volcanic Alert Bulletin. Ongoing Volcanic Alert Bulletins from GeoNet will provide information and forecasts on lava movement.	Staged evacuation of the surrounding area and along topographic lows is the best form of mitigation for a lava flow. Earth-constructed barriers may be able to divert the flow if an alternative path is available. Cooling lava with water has been known to increase the viscosity and slow progress. Barrier, cordons, signs and other access restrictions may be necessary to keep people away from the lava. Shut down and isolate portable fuel and gas lines.
Lightning	Ash clouds due to their density and constant motion can generate powerful electrical fields producing intense and frequent lightning discharges.	Lightning may occur up to 50km downwind from the vent.	Lightning can interfere with radio communications and short circuit electrical equipment. Buildings or tall structures hit by lightning may be damaged as the lightning seeks unintended paths to ground. Lightning can also start fires in buildings and installations.	People or animals struck by lightning may suffer severe injury due to internal organ and nervous system failure but the risk of being struck by lightning is low. Lightning may ignite vegetation fires.	Frequent lightning pulses will occur within the eruption column and plumb within hours of the eruption onset.	Buildings, towers and other tall structures that can act as conductors should be properly insulated and grounded. This is typically common practice.
Shock Waves	A shockwave is a change in pressure caused by an explosion or a body moving faster than the speed of sound. Shockwaves are commonly associated with energetic eruptions and/or base surges.	Shockwaves propagate in all directions away from the vent and usually travels ahead of a base surge. Shockwaves can be funnelled by topography, buildings and other structures.	Shockwaves may shatter windows and damage weak structures.	People may be injured from flying glass or damage to structures. The direct risk to people and animals from a shock wave (unless in the path of a base surge) is considered low.	Shockwave may occur during the initial stages of the eruption when the volcano explodes but generally there is no warning. The eruption may be forecast through seismic monitoring or other methods (see Section 3). GeoNet will provide notification through a Volcanic Alert Bulletin.	Windows can be boarded or taped and weak structures can be strengthened.

Hazard	Description	Area Affected	Infrastructure Impacts	Human Impacts	Warnings	Mitigation
Tsunami	A Tsunami is a series of waves caused by the displacement of a large volume of water. Tsunamis associated with volcanic eruptions can be generated by the up-doming of the sea floor or coastal area, fallout of the eruption column, base surges and accompanying shockwaves and submarine explosions.	Tsunami run-up heights will be dependent on the volume of water displaced, direction of movement, topography of the area and duration of the displacement. Tsunamis generated by volcanic processes are only likely to generate tsunami with relatively small run-up. Modelling suggests wave heights will be no larger than 2.5m most of them being less than 1m Low-lying coastal areas within 1km of the disturbance may be affected.	Tsunami may damage buildings and infrastructure located in low-lying coastal areas. Tsunami may increase erosion leading to loss of support of structures and may cause minor inundation and flooding. Auckland Airport and the Ports of Auckland are two examples of large infrastructure potentially at risk from tsunami generated by a volcanic eruption.	People and animals in low-lying areas may be injured if struck directly by a tsunami though the risk to life is considered low. Inundation by saline waters may affect plant life.	A tsunami may occur without warning.	In the event of an eruption near water or along a coastline people should evacuate low lying areas. Infrastructure utilities with assets near the coast line should consider preventative measures (e.g. water proofing or relocation) to minimise damage.

Appendix 4: Auckland Volcanic Scientific Advisory Group – Terms of Reference

The Auckland Volcanic Scientific Advisory Group (AVSAG) consists of representatives from the Auckland CDEM Group, the Ministry of Civil Defence & Emergency Management (MCDEM), Crown Research Institutes, State-Owned Enterprises and Universities. This body will provide advice to the Group Controller of the Auckland CDEM Group and National Controller, of MCDEM (the 'Controller(s)') on scientific matters in the lead-up to and during an emergency involving a volcanic eruption located within the Auckland Volcanic Field (AVF), enabling the Controller(s) to meet their goals and objectives.

The AVSAG provides advice covering 3 general fields of expertise:

- Volcanic Monitoring and warnings/alerts
- Social Consequences
- Volcanology (event characterisation and progression, physical consequences)

1.0 Mandate

The AVSAG's advice will be provided to the Controller(s), and will contribute to the work of the Group Emergency Coordination Centre and National Crisis Management Centre in the lead-up and response to an eruption in the AVF.

2.0 Responsibilities

2.1 Crisis Response Role

The AVSAG will play a critical role in ensuring that the Controller(s) is provided with a high standard of reliable scientific advice to support the CDEM response to a volcanic eruption in the AVF and is kept informed of any new developments in relevant science and research. Members of the AVSAG will:

- bring relevant experience to the AVSAG;
- contribute to the provision of authoritative scientific advice;
- be expected to make a full and considered contribution to the work of the AVSAG and to contribute fully to the debate and to the decision making processes of the AVSAG;
- provide expert guidance within the AVSAG when an issue, which falls within their particular area of expertise, is under discussion;
- contribute to the debate in the capacity of a well-informed professional where the issue does not fall within their expertise;
- be prepared to provide, on occasion, expert advice on relevant issues outside Group meetings, as requested by the Auckland CDEM Group or MCDEM.
- be prepared to attend as required and contribute to the deliberations of the AVSAG;
- be prepared to attend and represent the AVSAG at meetings involving the public and media.

The AVSAG will properly assist in the development of flexible responses that cover (in an appropriate and feasible way) the whole range of anticipated risks related to a volcanic eruption in the AVF. The AVSAG may play a role in coordinating the research response to a volcanic eruption in the AVF.

2.2 Role during Non-Emergency Periods

- AVSAG members will be required to participate in meetings and to contribute to the development of procedures outlining how the AVSAG will operate during an AVF eruption.
- AVSAG members will be expected to participate in AVF-scenario exercises.
- AVSAG members will be responsible for keeping all sub-group members informed of activities, procedures and events.
- All sub-group members will be expected to ensure that their correct contact details are maintained on the Auckland CDEM Group Contact Database.
- AVSAG members may be required to contribute to planning for the coordinated research response to an AVF eruption.
- AVSAG members will adopt a coordinated response to research being produced that is relevant to activities, procedures and events involving the AVSAG.

3.0 Frequency of Meetings

Face-to-face meetings will be held at least on an annual basis, in conjunction with other Auckland centred events to minimise travel costs and inconvenience.

3.1 Attendance

All Members will need to attend the AVSAG meetings. A Member who is unable to attend may nominate a replacement, from their relevant sub groups, to participate in the meeting.

4.0 Decisions

All decisions presented to the Controller(s) during an emergency involving a volcanic eruption event located within the AVF must typically be an opinion or position agreed upon and accepted by the AVSAG as a whole. This must also be the case when disseminating information to the public via the media.

Ideally, debate and conflicting views will need to be resolved within the AVSAG in order to provide a consistent message to the public to ensure confidence in the process. The Chair shall ensure that the differing opinions held by the various members of the AVSAG are fully investigated and discussed. If these views cannot be resolved then this should be accurately portrayed in communications with the Controller(s).

The AVSAG should be open about the assessment of risk or where the scientific evidence is subject to uncertainty, and reports should make clear the inadequacy of available data especially where judgement calls are required. This is especially important when other groups in the wider community, with the benefit of hindsight, draw different conclusions based on the same data.

The CDEM Group Controller and National Controller are ultimately responsible for all decisions made during an emergency event. The AVSAG will provide the best advice possible to support these decisions.

5.0 Reimbursement of Expenses

5.1 Planning

It is expected that agencies involved in the AVSAG will carry reasonable costs for day-to-day involvement themselves. However, where activities require a significant time commitment (expenses or travel) over and above that which can be reasonably expected from annual meetings as set out in these terms of reference, and/or where expenses are incurred for which costs are not met by an individual's employment condition arrangements, reimbursement can be negotiated on a case by case basis.

5.2 Response

During an emergency event where agencies are committing significant time and resources, and where expenses are incurred for which costs are not met by an individual's employment condition, applications can be made to the Auckland CDEM Group (Group Controller) for reimbursement of costs. It is necessary for advice to be available without restrictions due to cost and these claims will be met.

6.0 Amendment to Terms of Reference

The Members may discuss the AVSAG's role, activities and resources, and review these for consistency with the formal Terms of Reference. Any necessary amendments should then be considered with the Auckland CDEM Group and MCDEM. This will ensure any new developments, not foreseen when the Terms of Reference were set out, have a chance to be included.

7.0 Term of Tenure

The membership of the AVSAG and the corresponding Sub-Groups will be reviewed every 12 months from the 1 October 2007. This will allow for current members to step down as well as accommodating the addition of new members.

8.0 Membership

The AVSAG operating response procedure is depicted in Figure 4. Monitoring capability is maintained by GNS Science through the GeoNet project. Therefore, GNS Science has the ability to co-ordinate unanimous advice to ACDEMG and MCDEM through the AVSAG. Information sharing and co-ordination with the wider expert community is important and membership from these agencies forms the wider expert community contingent. Members of AVSAG include, but are not limited to, relevant individuals from:

- GNS Science
- Auckland Council
- MCDEM
- Universities (Auckland, Canterbury, Massey, Victoria, Waikato)

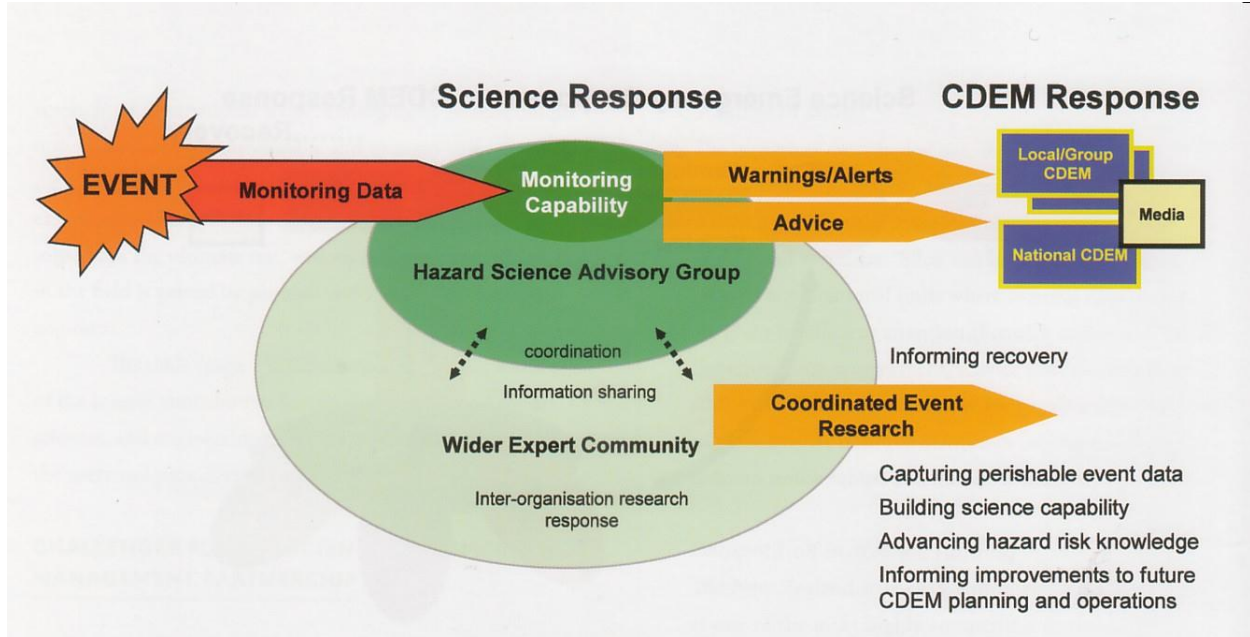


Figure 4: AVSAG operating response procedure.

Appendix 5: Health and Safety Information

For detailed information regarding health hazards of volcanic ash, refer to:

http://www.ivhnn.org/images/pamphlets/Health_Guidelines_English_WEB.pdf

Lindsay, J. M, Peace, C. 2005: AELF/7: Health and Safety in a Volcanic Ash Environment. Auckland Regional Council Technical Publication No 290

Health Effects

1. Respiratory effects *NB: People with chronic lung problems are at special risk.*

Fine ash particles and high exposure can cause:

- Nasal irritation;
- Throat irritation;
- Severe bronchitic symptoms (for people with pre-existing chest complaints);
- Airway irritation (for people with asthma or bronchitis); and
- Breathing discomfort.

2. Eye symptoms *NB: Contact lens wearers are at special risk*

Grit can scratch the eye causing:

- Eyes feel like they have foreign particles in them;
- Eyes become painful;
- Sticky and watery eyes;
- Corneal scratching; and
- Acute conjunctivitis.

3. Skin irritation

Acidic ash can cause:

- Irritation and reddening of skin;
- Secondary infections

Indirect Health Effects

1. Road

Traffic accidents resulting from:

- Reduced visibility;
- Ash covering road markings; and
- Ash making roads slippery.
- Thick ash may make roads impassable, cutting off access to basic supplies.

2. Power

Ash can cause power cuts and cause health problems due to:

- Lack of heating; and
- Disruption to infrastructure that requires power.
- Wet ash is conductive – safety required when operating electrical equipment.

3. Water Supply

Ash can cause:

- Contamination of water (especially open domestic water tanks);
- Lowered pH and inhibited chlorination; and
- Clogging of water supply equipment.
- Water shortages due to high demand for cleaning.

4. Sanitation

Ash can disable municipal sanitation systems leading to increased disease.

5. Roofs

Ash on roofs can cause:

- Roof collapse causing injury or death; and
- Death or injury falling from roof while clearing ash.

6. Animal health

Ash can be toxic to grazing animals.

Protection Measures

- Limit Driving
- Reduce ash in your house: **keep doors and windows closed.**
- Protection: **wear dust masks or cover face with damp cloth.**
- **Eye Protection:** wear goggles.
- **Drinking Water:** disconnect downpipes to water supply before ashfall, drink safe water.
- **Home-grown food:** wash with clean water.
- **Clean-Up:** lightly wet ash and remove with shovel.

Appendix 6: Possible Ash Disposal Sites

(Source: *Potential Volcanic Ash Disposal Sites*, GNS Science, Laurence Dolan, Carla Wilson, David Johnston, Client Report 2003/75, June 2003)

The following sites are potentially suitable for volcanic ash. These sites have been assessed as environmentally and physically safe, and culturally and economically acceptable to Auckland communities.

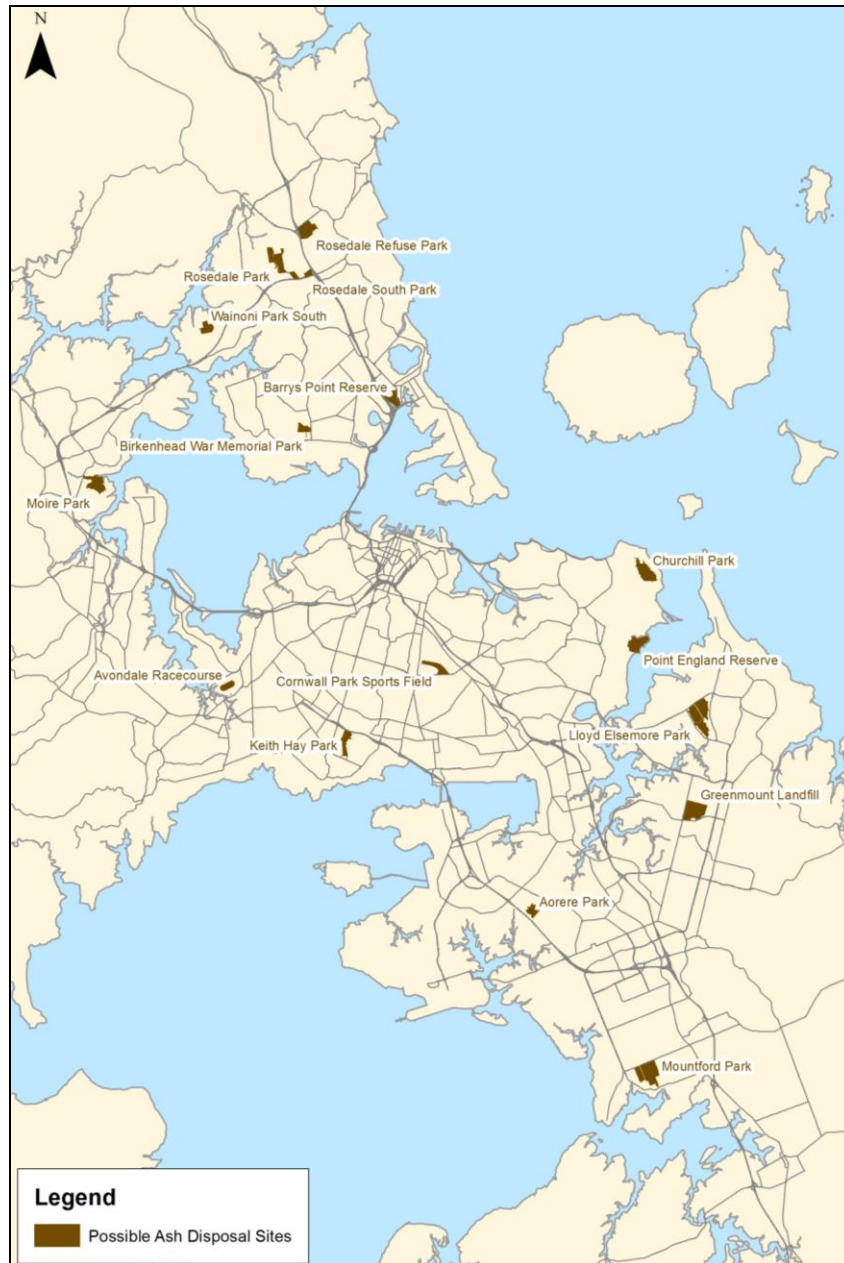


Figure 5: Map of possible ash disposal sites

Further assessment of sites should be undertaken using the following site assessment.

Site Preparation Requirements

Site preparations may include:

- Formation of metalled access roads on site, suitable for heavy vehicles and machinery;
- Stripping back and stockpiling of topsoil for use as cover;
- Diversion of surface water upstream of the disposal site, particularly for gully sites. Tomos or pipes may develop in the ash if there is a stream above the ash and no drainage provided;
- Under-drainage, in some situations, to reduce the potential for saturation;
- Formation of a toe berm out of another, more stable and stronger, material with more predictable behaviour;
- Sediment control measures, in accordance with ARC Guidelines for Land Disturbing Activities in the Auckland Region, Erosion and Sediment Control, 1999

Site Operations

The following issues need to be considered:

- Access routes to minimise danger for trucks entering/exiting the site and other road users;
- Site layout and sequencing of disposal operations to minimise double handling of ash and cover materials;
- Vehicle movements to minimise the potential for trucks to get bogged and possible wheel wash facilities to reduce mud buildup on access routes
- Compaction of the material. Lifts of approximately 450mm (300mm when compacted) is recommended, to control settlement and make long term behaviour of the ash more predictable
- Use of water cart(s) to wet down ash to reduce dust nuisance;
- A maximum slope of 1V:3H is likely to ensure stability. Cover on slopes will be necessary to minimise erosion
- Ash should be covered with topsoil and grassed to reduce rainfall infiltration and erosion;
- Sediment control measures, in accordance with ARC Guidelines for Land Disturbing Activities in the Auckland Region, Erosion and Sediment Control, 1999.

Site Identification Criteria

If none of these sites are suitable then additional sites should be assessed against the criteria below. Refer to Potential Volcanic Ash Disposal Sites report for a full list of sites assessed in 2003.

Desirable features of disposal locations include:

- Close proximity to source
- Existing access to the main road for heavy vehicles
- Situated away from waterways (which could be affected by disposal activities)

- Availability of soil for cover (although other forms of ground cover, including planting of rye grass, ivy, or use of pre-grown lawn/turf for immediate coverage, may be options)
- End use of disposal site; and
- Resource consent requirements

The following criteria can be used for exclusion mapping:

- Public land
- 1:100 year flood plains;
- water supply catchments;
- sites of natural and cultural significance.

The following technical issues would also need to be considered, on a site specific basis, in planning for a disposal location and ash disposal operations:

- Formation of access roads
- Equipment requirements
- Stability of the ash material during and following deposition, including compaction requirements and maximum slope angles
- Potential dust nuisance (which could be mitigated by water sprays and prompt covering and grassing following completion); and
- Daily maintenance of equipment to reduce wear.