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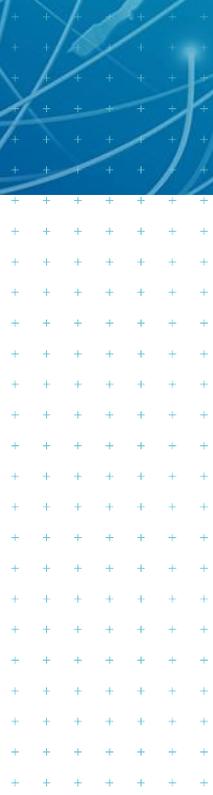
Ash Fall Hazard and Impact Review

Prepared for
Tauranga City Council

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1 Introduction

The focus of this report is to provide Tauranga City Council (TCC) with high-level guidance on the volcanic ashfall hazard in Tauranga and its likely impacts on TCC infrastructure. For the purposes of this assessment, the TCC assets considered are the three-waters infrastructure and roads. This study consists of the following four steps:

- 1 Assess and characterise the ashfall hazard using published material to determine the estimated ash thicknesses for selected recurrence intervals.
- 2 Conduct an impact assessment for TCC infrastructure.
- 3 Conduct a high-level review of existing ashfall hazard preparedness, response and recovery plans for TCC.
- 4 Provide recommendations where future work should focus for volcanic ashfall risk management.

The report is intended for use by TCC to identify where future work for ashfall impacts should focus.

2 Ashfall hazard assessment

Volcanic eruptions can produce a range of hazards, including ashfall, pyroclastic flows, lahars and ballistics, which all have the potential to be both destructive and deadly. Given Tauranga's location, it is unlikely to be affected by ballistics and lahars, which are restricted to areas near the volcanic vent. Pyroclastic flows affecting Tauranga are considered to have such a low return period, they are not considered further.

The most widespread of all eruption hazards is volcanic ashfall, with the potential of reaching hundreds of kilometres from the source (Wilson et al., 2012). While ashfall rarely results in fatalities, the widespread dispersal of ashfall can result in large-scale social and economic impacts across various infrastructure sectors (Jenkins et al., 2014; Wilson et al., 2014). Volcanic ashfall is therefore regarded as a *disruptive* rather than a *destructive* hazard (Wilson et al., 2014).

There are several volcanoes across the North Island that have the potential to produce an eruption that would result in ashfall impacting Tauranga. GNS have developed the New Zealand ashfall probabilistic volcanic hazard model (PVHM; Hurst and Smith, 2010) for New Zealand's North Island. This uses frequency/magnitude relationships to estimate ashfall thicknesses for given recurrence intervals. From this, Hurst and Smith (2010) have developed maps for 500-year and 10,000-year return periods (Figure 2.1 and Figure 2.2). These form the basis of the two scenarios applied for this assessment (Table 2.1). The 500-year scenario is conservatively taken as 1 mm thickness for the following reasons:

- The PVHM model does not include trace ashfall levels which can be widespread in an event; and,
- Most methods for assessing impact use a minimum of 1 mm ashfall depth as the hazard intensity.

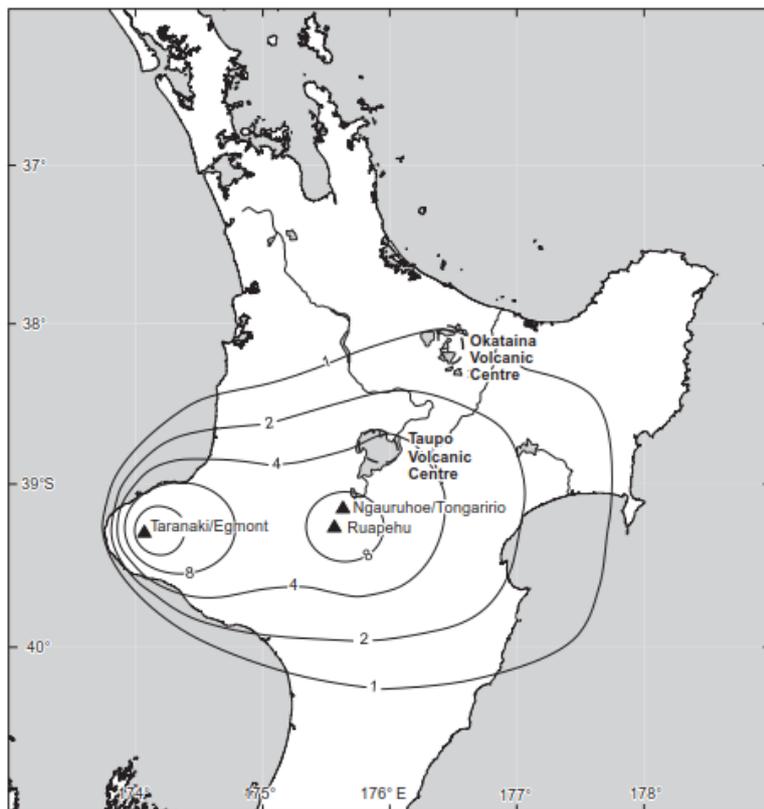


Figure 2.1: Volcanic ashfall hazard map for the 500-year return period (from Hurst and Smith, 2010)

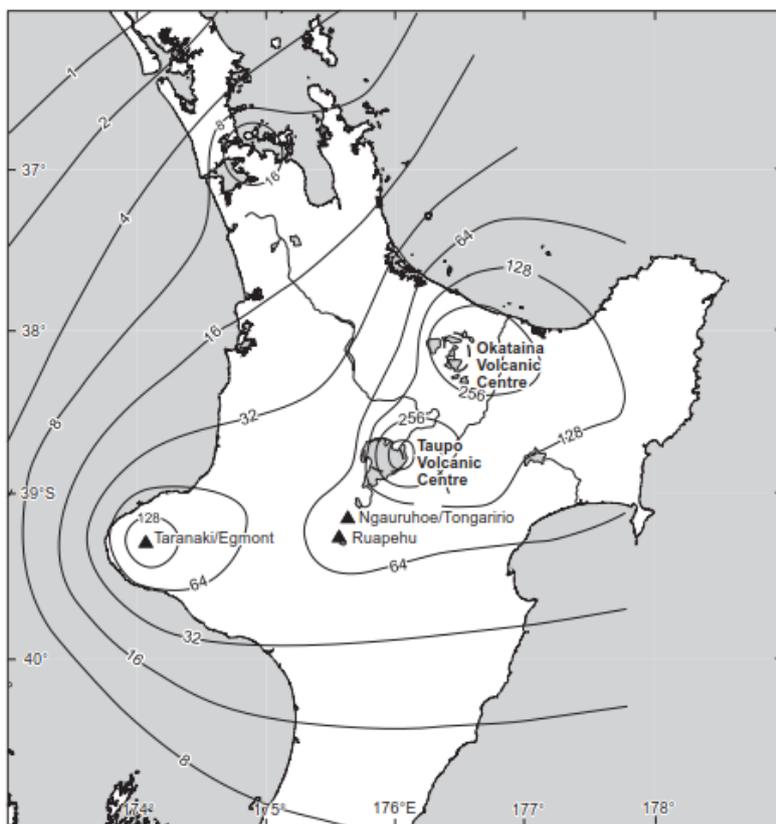


Figure 2.2 Volcanic ashfall hazard map for the 10,000-year return period (from Hurst and Smith, 2010)

Table 2.1: Probabilistic hazard scenarios applied for this assessment

Return period (ARI)	Ashfall depth (mm)
500-year	1 mm
10,000-year	64 mm

It is worth noting, Tauranga has been impacted from past eruptions, which resulted in greater ashfall depths than that presented in Table 2.1. An example of is the 1314 AD Kaharoa eruption of Tarawera (in the Okataina Volcanic Centre), which deposited between 90 and 100 mm of ash over the TCC area (Figure 2.3; Sahetapy-Engel et al., 2014). Another, extreme case is the eruption from Oruanui eruption from Taupo ~26,000 years ago which is one of the largest eruptions in New Zealand history and the most recent global super eruption. This produced ~400 mm thick deposits of ash in Tauranga. (Figure 2.4; Alloway et al., 2007). Both of these examples demonstrate that TCC is susceptible to more severe ashfall events.

It is noted that Tauranga experienced minimal ashfall (< 5 mm) as a result of the 1886 AD eruption of Mt Tarawera (Walker et al., 1984). This was due to the wind direction, transporting the ash east, towards East Cape and Gisborne. The Hatepe eruption from Taupo, which occurred in ~232 AD (Holdaway et al., 2018), is also thought to have resulted in minimal ashfall in Tauranga due to the wind direction at the time.

Given the geographic proximity of Tauranga to the Okataina and Taupo volcanic centres, and the relatively recent volcanic activity impacting the Bay of Plenty region, the Kaharoa eruption (100 mm ashfall depth) has been used as an additional scenario to demonstrate the impact from a Caldera style eruption to TCC assets.

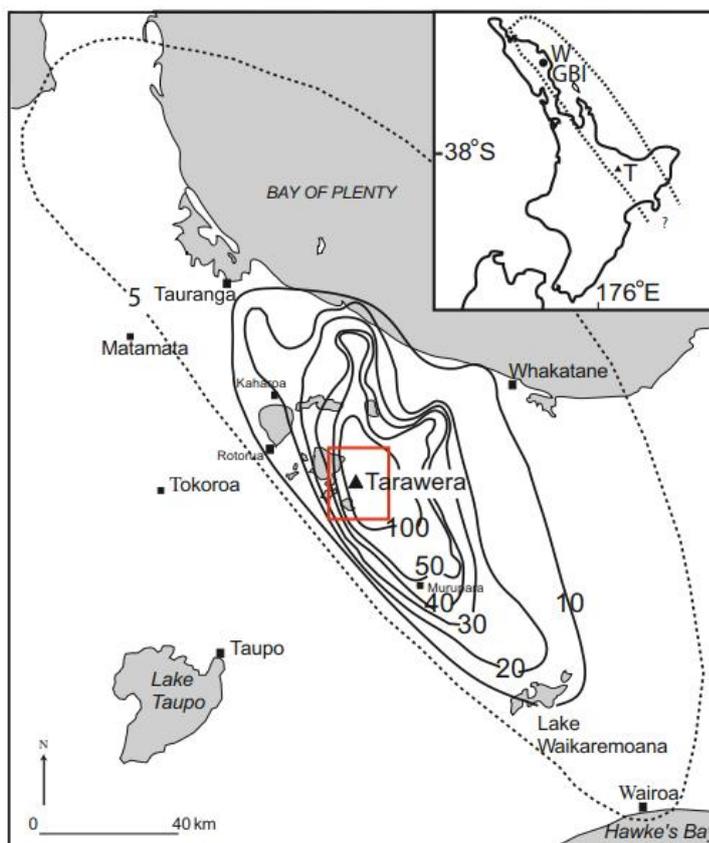


Figure 2.3 Ashfall isopachs (in cm) from the 1314 AD Kaharoa eruption (from Sahetapy-Engel et al., 2014)

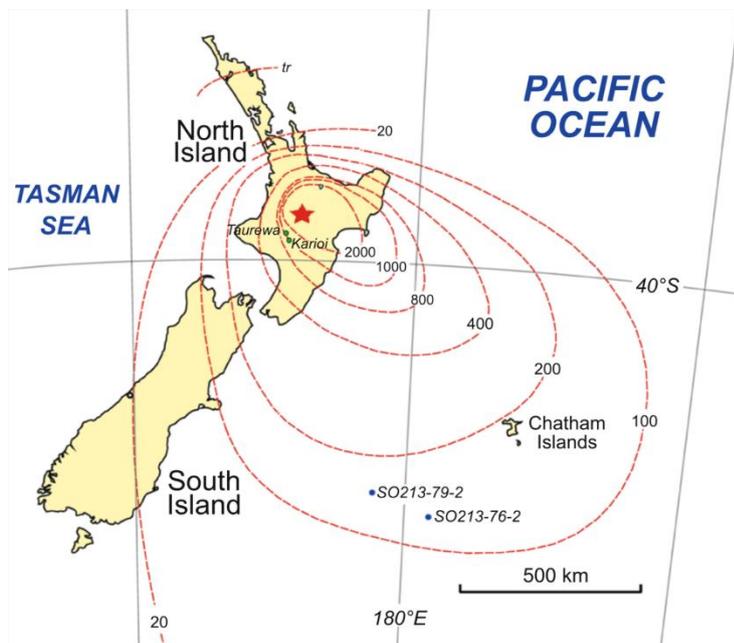


Figure 2.4: Ashfall isopachs (in mm) from the Oruanui eruption of Taupo ~26,000 years ago (from Dunbar et al., 2017)

Mayor Island and White Island are two volcanoes off the coast of the Bay of Plenty that have the potential to produce ashfall events that could impact Tauranga during their next eruption. Mayor Island is 45 km north of Tauranga, and is thought to erupt on average once every 3,000 years - although some past smaller eruptions might not have been recorded in the geological deposits (Houghton et al., 1995). Mayor Island has a variety of eruptive styles, one of which is a caldera-forming eruption, which occurred approximately 6,340 years ago. A repeat of this style of eruption along with an easterly wind direction would likely result in significant ashfall deposits in Tauranga. An estimate of the ashfall distribution from this eruption with an easterly wind would result in ashfall depths of around 5-10 cm and cause significant disruption to aviation and shipping in and around the port of Tauranga for an extended period (Houghton et al., 1995).

White Island is located 90 km west of Tauranga and 48 km offshore within the Bay of Plenty. It is a highly active volcano in an almost constant state of minor volcanic unrest (Geonet, n.d.). The recent eruptive history of White Island includes several small scale eruptions: with lava dome formation and collapse along with explosions and ash emission between 1975-2000; explosive eruptions between 2012-2013; and a small eruption that covered the crater floor in ejected material in 2016. Nairn et al., (1991) produced 1 in 100-year and 1 in 1,000-year eruption event ash dispersal maps based on a predominantly westerly wind direction, which dispersed ash across East Cape. However, if an eruption of White Island occurred with an easterly wind direction, this could result in ashfall depths within Tauranga of 5-10 mm from the 1 in 100-year event and 50 mm from the 1 in 1,000-year event (Nairn et al., 1991).

The PVHM developed for the ashfall hazard (Hurst and Smith, 2010), was based on a range of historic volcanic events (including the above) along with the likelihood of the wind direction (Figures 2.1 and 2.2). In addition to the 500- and 10,000-year scenarios from the PVHM (Hurst and Smith, 2010), we have also considered the 1314 AD Karahoa eruption as an 'extreme' scenario. All three scenarios have been used when considering impacts within the sections below.

3 Impact assessment for TCC assets

The three hazard scenarios (500 and 10,000 year return periods and Karahoa eruption scenario) provide an understanding of exposure across the TCC area. Specific published vulnerability functions can then be used/applied to estimate the level of impact and potential damage to TCC assets and networks within the exposed area.

A summary of the TCC assets¹ considered in this assessment are presented in Table 3.1. This assessment does not include water supply and wastewater pipes as these are typically closed networks, and therefore are not susceptible to damage by ashfall infiltrating the system.

Table 3.1: Number of each asset type in this assessment

Asset type	Number
Water supply treatment site	2
Water supply reservoir	15 (All closed roof)
Water supply pump station	5
Wastewater treatment site	2
Wastewater pump station	162
Stormwater pump station	9
Stormwater pipes	942 km
Stormwater open channels	124 km
Road	756 km (includes State Highways)

Each asset type (e.g. pump stations, treatment plants etc.) and its characteristics will result in different impacts for a given ashfall depth. By applying published ashfall vulnerability functions, developed from international observations and laboratory experiments, the degree of damage for each asset type can be estimated.

3.1 Direct vulnerability and impact to TCC assets - methodology

For the range of assets being considered for this assessment, appropriate vulnerability function approaches have been selected based on relevant literature (Table 3.2).

Table 3.2: Source for the applied vulnerability functions for each asset type

Asset type	Vulnerability function source
Water supply treatment site	Wilson et al., (2017)
Water supply reservoir *	Wilson et al., (2014)
Water supply pump station	Wilson et al., (2014)
Wastewater treatment site	Wilson et al., (2017)
Wastewater pump station	Wilson et al., (2014)
Stormwater pump station	Wilson et al., (2014)
Road	Blake et al., (2017)

* If open roofed

¹ Three-waters infrastructure information was provided by TCC and is as of the 31 March 2019. Road data is from LINZ (2019), which was last updated on 15 April 2019.

Wilson et al., (2014) present a tabular description of the expected impacts for a variety of assets for different ashfall ranges. Blake et al., (2017) and Wilson et al., (2017) present vulnerability functions which indicate the probability of an impact (or a specified degree of damage) being reached or exceeded for a given ashfall depths. When using these functions, the difference between two probabilities of damage state exceedance is the resultant probability of that damage state being observed for the given hazard intensity.

The different impact states and corresponding descriptors are presented in Table 3.3.

Table 3.3: Impact state and corresponding description (from Wilson et al., 2014 and Blake et al., 2017)

Impact State (IS)	Three-waters impact descriptor	Road impact descriptor
0	No damage	No disruption
1	Cleaning required	Skid resistance reduction
2	Repair required	Impassable for some vehicles
3	Replacement or financially expensive repair	Impassable for all vehicles if ash is unconsolidated

3.2 Infrastructure impact assessment

By applying the ashfall hazard scenarios for the three considered scenarios, the likely damage state can be inferred through the vulnerability functions (Table 3.2). The results are presented in Table 3.4.

Table 3.4: Expected damage state for each assessed asset type for the 500-year and 10,000-year ARI scenarios and the Kaharoa 1314 AD eruption scenario

Asset type	500-year ARI median damage state (1 mm)	10,000-year ARI median damage state (64 mm)	Kaharoa eruption median damage state (100 mm)
Water supply treatment site	0	2	2 – 3
Water supply reservoir	0	1	1 – 3
Water supply pump station	0	2	2 – 3
Wastewater treatment site	0 – 1	2	2 – 3
Wastewater pump station	0	2	2 – 3
Stormwater pump station	0	2	2 – 3
Road	0 – 1	1 – 3	1 – 3

As shown in Table 3.4, for the majority of assets during the 500-year ARI scenario, there is likely to be no disruption (IS0). Roads will likely experience no disruption (IS0), however they could also experience a reduction in traction (IS1). In terms of three-waters infrastructure assets, the impact is likely to be no disruption (IS0), however wastewater treatment sites would likely require some clean up (IS1).

For the 10,000-year ARI scenario, roads are likely to experience reduced traction for vehicles resulting in speed reduction (IS1), but could be more severe if ash is unconsolidated making roads impassable (IS3). For the three-waters infrastructure, there will likely be repairs required (IS2), but it is possible the impact could vary from clean up required (IS1) through to extensive repairs and replacement (IS3).

For the Kaharoa 1314AD deterministic scenario, roads are likely to experience reduced traction for vehicles resulting in speed reduction (IS1), but could be more severe if ash is unconsolidated making roads impassable (IS3). The three-waters infrastructure is likely to require repair (IS2) or replacement (IS3). Water supply reservoirs are roofed and therefore would require cleaning (IS1), however the roof could collapse under ash loading (IS3).

More detail on infrastructure impacts is provided within sections 3.2.1 to 3.2.4.

3.2.1 Water supply

In general, water treatment sites are susceptible to a range of impacts from increasing volcanic ashfall thickness. At small thicknesses, impacts are likely to include clogging and abrasion, with larger thicknesses leading to a potential collapse of structures (Wilson et al., 2014). Differences in the impacts can also arise due to the chemical composition of the ash (causing corrosion) as well as weather-related effects, as rain can cause sedimentation to occur on components.

TCC rely on open intakes on both the Tautau and Waiarohi streams, which can transport ash-contaminated water into the treatment facilities and networks. This can have a range of more specific impacts, such as:

- An increase in the turbidity and acidity of the water (Johnston and Houghton, 1995; Johnston, 1997). Suspended particles can act to 'shelter' pathogenic (disease-causing) micro-organisms, which reduces the efficiency and effectiveness of disinfection treatments at water treatment facilities.
- Toxicity due to presence of soluble salts that can be released on contact with water. The most abundant soluble elements in ash are typically calcium (Ca), sodium (Na), potassium (K), magnesium (Mg), aluminium (Al), chlorine (Cl), sulphur (S) and fluorine (F). In addition, iron (Fe), aluminium (Al) and manganese (Mn) are all likely to be well above background levels.
- Smaller water storages, such as roof water tanks and drinking troughs, may also be contaminated by ash leachates, rendering them undrinkable (Johnston, 1997).
- At water treatment plants, ash may cause wear and tear on equipment, and may also short circuit electrical equipment (FEMA, 1984).
- An increased demand for water resources may occur as water is used to clean up after the volcanic eruption (FEMA, 1984, Johnston, 1997).

Pump stations are susceptible to a range of impacts from increasing volcanic ashfall thickness. At small thicknesses, impacts are likely to be clogging and abrasion ranging up to collapse of structures at higher thicknesses (Wilson et al., 2014). Differences in the impacts can arise due to the chemical composition of the ash and weather-related impacts as discussed above.

It is considered there will be little direct impact to water supply pipes from ashfall as they are closed networks.

3.2.2 Wastewater

Wastewater networks and treatment plants are susceptible to a range of impacts from ashfall. Separated wastewater systems (as per those within TCC) can incur ash ingress through gully traps, cross connections, around manhole covers, or through holes and cracks in sewer pipes.

Ash-laden sewage entering a treatment plant is likely to cause failure of mechanical pre-screening equipment such as step screens or rotating screens. Ash that penetrates further into the system will settle and reduce the capacity of biological reactors as well as increasing the volume of sludge and changing its composition. Table 3.5 lists more detailed information on ashfall impacts for wastewater treatment plants.

Table 3.5: Impacts of ashfall on wastewater treatment plant system component (USGS, n.d.)

System component	Impacts of volcanic ashfall
Pre-treatment equipment	<ul style="list-style-type: none"> • Ash will damage comminutors and grit classifiers. • Coarse (>1 mm) ash will block mechanical screening equipment, overloading motors and gear boxes.
Primary settling tanks	<ul style="list-style-type: none"> • Ash will increase the solid load arriving at the plant. • Coarse ash will increase the volume of sludge for disposal. • Ash will change the proportion of inorganic matter.
Secondary treatment	<ul style="list-style-type: none"> • Ash will enter open reactors (biological reactors) and tanks from direct fallout, but the main ingress is likely to be through the sewer lines. • The main effect is likely to be a reduction in capacity (due to ash accumulation on tank floors) rather than interference with biological processes, although there is the potential for effluent toxicity to be affected (e.g. more acidic) which may in turn, impact beneficial bacterial growth and effectiveness of treatment. • Deposited ash would require cleaning filters and reactors while the system remains operational.
Tertiary treatment	<ul style="list-style-type: none"> • Any residual very fine ash may increase the suspended solid load of the effluent, necessitating adjustments to disinfection treatment.
Sludge treatment	<ul style="list-style-type: none"> • Ash will increase the mineral content of sludge.
General effects on plant	<ul style="list-style-type: none"> • Ash will cause accelerated wear and tear on pumps and motors.

Network pump stations are susceptible to a range of impacts from increasing volcanic ashfall thickness. At small thicknesses, impacts are likely to be clogging and abrasion ranging up to potential collapse of structures (Wilson et al., 2014). Differences in the impacts can arise due to the chemical composition causing corrosion as well as weather, as rain causes sedimentation on components.

It is noted that ash impacts on TCC's wastewater treatment wetlands at Te Maunga are difficult to predict, however they are likely to be significant, as the ash will impact ecosystem health, biological processes, turbidity of the water etc.

3.2.3 Stormwater

Ash, especially of a fine grain size, is easily washed into storm water systems by rainfall or via the clean-up process. Because ash has a high density, it is not held in suspension but instead accumulates easily causing potential pipe blockages and local flooding. If ashfall coincides with heavy rainfall, flooding can become more prevalent, due to partial or complete blockages of pipes and channels. As a result, it is important that extra care is taken during the clean-up process not to exacerbate blockages by further washing material into drains. Refer Section 4.2.3 for further discussion.

Pump stations are susceptible to a range of impacts from increasing volcanic ashfall thickness. At small thicknesses, impacts are likely to be clogging and abrasion ranging up to collapse of structures (Wilson et al., 2014). Differences in the impacts can arise due to the chemical composition causing corrosion as well as weather, as rain causes sedimentation on components.

3.2.4 Roads

Roads are susceptible to a range of impacts from increasing volcanic ashfall thickness (Figure 3.1 and Figure 3.2). At small thicknesses, impacts are likely to be abrasion of road surface and markings ranging up to collapse of structures (Wilson et al., 2014). Differences in the impacts can increase as

well as weather, as rain causes sedimentation and increasing loading. A summary of the damage and disruption from increasing ashfall thicknesses (refer below from GNS (n.d.)):

- Visibility can be severely reduced during an ashfall.
- Visibility can be severely reduced after an ashfall if there is remobilisation of ash by wind or traffic.
- Ashfalls > 1 mm depth may cover road markings.
- Ash reduces traction, in both dry and wet conditions. Ashfalls > 50 mm may make roads impassable when wet. Increased abrasion to markings and paved stones.
- Very thick ashfalls may create extra loading on bridges, especially when wet. Ash remobilised in rivers may also create a risk of mud-flows (lahars).



Figure 3.1: Ash cloud falling onto a highway following the Mt. Tongariro eruption, 6 August 2012 (GNS)



Figure 3.2: Driving in approximately 10 mm ashfall, near Futaleufu, Chile (GNS)

3.3 Outage assessment

Based on the impacts described above, the estimates for expected outage durations can be inferred using the T+T (2018) report for Bay of Plenty Regional Council (BOPRC). The estimated outage durations for TCC assets are presented in Table 3.6. These are indicative ranges based on the ashfall thickness (mm) for unique asset types, and were informed by interviews with relevant asset managers and an extensive literature review.

Table 3.6: Outage duration estimates for TCC asset types for the 500-year and 10,000-year ARI scenarios

Asset type	500-year scenario estimated outage	10,000-year scenario estimated outage
Water supply treatment site	No outage	Weeks-months
Water supply reservoir	No outage	No outage
Water supply pump station	No outage	Hours-days
Wastewater treatment Site	No outage	Months or greater
Wastewater pump station	No outage	Weeks
Stormwater pump station	No outage	Weeks
Road	No outage	Weeks to months

As shown in Table 3.6 there is likely to be significant outage impacts to wastewater and water supply treatment plants for the 10,000-year scenario. Impacts to roads will also be significant and have the potential to restrict/prevent access to critical sites, such as pump stations, treatment plants etc. Following an event, restoring road access to the sites will be of primary importance.

Impacts on wastewater and stormwater pump stations are likely to take weeks to restore. This is due to the availability of replacement components given the number of pump stations impacted across the region, and number of parts on stock as well as resource availability to carry out the required repairs. Water supply pump stations require cleaning so assuming access is permitted, this can occur promptly.

Impacts to water supply and wastewater treatment sites are likely to take weeks-months or longer to restore. Similar to pump stations, this is due to the availability of replacement components, of which most are not kept on stock in the region, with the majority needing to be imported from overseas.

No outage is expected for water supply reservoirs as they are all understood to have closed roofs. It is only likely that damage would occur at significant ash thickness (> 100 mm) in the form of roof collapse and infilling of reservoirs leading to irreparable damage to moving parts, structural damage to equipment.

3.4 Clean-up requirements

Substantial clean-up is required following an ashfall event. This is required to prevent ongoing issues such as ashfall remobilisation and societal health issues. It is noted that at smaller ashfall thickness (~1 mm), in urban areas it is likely only possible to clean up ~1% of the ash (Hayes et al., 2015). This is due to the difficulty of physically collecting such a thin, dispersed layer. However, for urban areas that experience more significant ashfall depths (> 50 mm), it is thought possible to remove up to 80% of the ash.

For the 500-year scenario, there will likely be a requirement for street sweepers to clean roads and airports (Hayes et al., 2015; 2017). Where three-waters assets/networks have only experienced minimal impact, clean-up may also be minimal as it will likely be washed or blown away. Property owners should be able to self-manage clean-up for their homes and property.

For the 10,000-year scenario, there will be a high demand for heavy machinery and considerable effort will be required to clean up roads, airports, other impervious surfaces and recreational areas (e.g. parks). Residents are also likely to dump debris on the roadside and there will be a requirement for a large workforce to support the clean-up effort.

Additional comments regarding issues for the cleaning of specific asset types are presented in Table 3.7.

Table 3.7: Summary of clean up issues for different asset types

Asset type	Comment
Stormwater pipes	Ash will enter pipes through inlets and can solidify in pipes resulting in blockages and potential flooding should heavy rain occur. As networks are buried, clean-up will be difficult. Clean up will likely be via a combination of suction trucks and water blasting machinery. It is very difficult to estimate the volume of ash which will be required to be cleaned from stormwater pipes as this will depend on a range of factors.
Stormwater channels	Open channels are exposed to infilling from ashfall, but also ash can be transported by general catchment run off. Blockages can occur within channels and pipes, which will be difficult to clean and can result in subsequent flooding should heavy rain occur. Clean up will likely be via a combination of suction trucks, water blasting equipment and heavy machinery such as diggers. It is very difficult to estimate the volume of ash which will be required to be cleaned from stormwater channels as this will depend on a range of factors.
Roads	Heavy machinery and street sweepers will likely be required (Figure 3.3). Clean-up machinery can be impacted due to filter clogging and increased maintenance during operation (Hayes et al., 2015). Estimated volumes of ashfall on the roads for the 500-year scenario is ~7,500 m ³ and for the 10,000 year scenario is ~480,000 m ³ .

The clean-up and subsequent disposal effort following ashfall is a problematic exercise. The volume of debris is likely considerable and disposal sites should be pre-planned. As an example, Auckland Council has conducted this exercise, identifying 14 disposal sites for volcanic ashfall debris disposal (ACDEM, 2015).

Based on the area of TCC (from LINZ boundary data), for each of the hazard scenarios, the volume of ashfall and volume that is able to be cleaned up (based on the percentages described above from Hayes et al., (2015)) can be calculated (Table 3.8). These values do not consider additional debris being transported into the region via windblown or fluvial transport methods.



Figure 3.3: Heavy machine clearing the main roads in the town of Futaleufu, Chile (GNS)

Table 3.8: Summary of estimated ashfall volume and clean-up disposal volume for each of the ashfall scenarios based on the TCC area

Ashfall hazard ARI scenario	Ashfall volume (m ³)	Clean-up disposal volume (m ³)
500-year	135,000	1,350
10,000-year	8,640,000	6,912,000

For comparison, an Olympic sized swimming pool is 2,500 m³ meaning the clean-up volume from the 10,000 year ARI scenario is ~2,800 swimming pools worth of debris.

The BOPRC CDEM Group Distant Source Volcanic Ash Response Plan (BOPRC, 2012) outlines that infrastructure and services need to consider both clean-up and disposal of ashfall for their assets. The plan states the following activities should be considered when identifying an ash disposal site:

- Consider identifying potential sites in advance that are 'less valuable' sites e.g. old quarries have been used in the past.
- Ash is considered toxic to the environment. Guidance provided by district/city councils on handling the removal should be followed. The environmental effects would need to be taken into account (refer to BOPRC Water and Land Plan, permitted activity for earthworks etc.).
- Consider sensitivity of Iwi, landowners and affected parties and consult widely with all.
- Wind effect at disposal sites can be problematic i.e. wind can spread the collected ash (ash must be stabilised on site).

3.5 Indirect ashfall impacts

Additional to the impacts described above, TCC networks and services can be compromised due to dependent services (e.g. power supply and telecommunications). An example of this can be treatment facilities and pump stations requiring power supply to operate. Overhead transmission, substations and power generation sites are all susceptible to damage or outages (Wilson et al., 2014), resulting in disruption of service. Specific impacts are beyond the scope of this report, however can be found within BOPRC (2012).

If TCC experienced an ashfall event, the roads to the south and/or west are likely to also be more severely impacted (with greater ashfall depths) due to their proximity to the likely volcanic sources.

This will impact access to the region and will have flow on effects for other sectors e.g. access for food, fuel, staff etc.

Adverse impacts will likely be experienced to the wider BOP region/local communities/economy (BOPRC, 2012). In particular, the following sectors will be impacted:

- Tourism
- Retail
- Agriculture
- Forestry
- Horticulture

In addition to these sectors there will be potential for significant impacts to regional infrastructure providers such as Kiwirail, NZTA, Port of Tauranga, Tauranga Airport. It is important that TCC be aware of these potential impacts and how response efforts may be co-ordinated and planned in the most efficient manner. Refer to Figure 3.4 for photo of airport impacts.



Figure 3.4: Volcanic ash disrupts flights in Argentina, 9-June 2011 (Reuters)

4 Mitigation and response considerations

This section covers a brief review of existing response plans within the Tauranga region, and provides some high level considerations for response planning and mitigation.

4.1 Brief review of existing response plans

As part of this assessment, a high-level review of existing plans for TCC, Western Bay of Plenty District Council (WBOPDC) and BOPRC was undertaken. This was carried out to identify gaps within the plans and provide some context for further work. The documents reviewed as part of this are outlined in Table 4.1.

Table 4.1: Existing emergency management and response plans

Plan reviewed	Volcanic risk included	Comments
BOPRC CDEM Group Distant Source Volcanic Ash Response Plan 2012.	Yes	Outlines volcanic risk to TCC area, however does not include in-depth risk management strategies – see section 4.1.1 for further detail.
WBOPDC Stormwater Asset Management Plan 2013.	Yes	Identifies potential risks and impacts to storm water assets and outlines some response actions. However provides little information on risk management strategies.
RLC Infrastructure Strategy 2015	Yes	Identifies potential risks and impacts to infrastructure and outlines the need to clean up and dispose. However provides little information on risk management strategies.
RLC Civil Defence Emergency Management Plan 2015	Yes	Identifies the volcanic ashfall hazard from near proximal sources as a high priority hazard and ashfall from distal sources as a priority hazard for the CDEM Group.
TCC Infrastructure Strategy 2015.	No	Mentions geographical context and volcanic hazard exposure, however no impact/risk assessment included.
BOPRC CDEM Group Plan 2018.	No	Mentions geographical context and volcanic hazard exposure, however no impact/risk assessment included.
BOPRC Long Term Plan 2018.	No	Mentions geographical context and volcanic hazard exposure in section 2, however no impact/risk assessment included.
TCC Waste Management and Minimisation Plan 2016.	No	Volcanic hazard/exposure or risk is not mentioned.
BOPRC CDEM Group Welfare Plan 2019.	No	Volcanic hazard/exposure or risk is not mentioned.
BOPRC CDEM Group Community Resilience Plan 2016.	No	Volcanic hazard/exposure or risk is not mentioned.
WBOPDC Wastewater and Water Supply Asset Management Plans 2013.	No	Volcanic hazard/exposure or risk is not mentioned.
WBOPDC Waste Management And Minimisation Plan 2017.	No	Volcanic hazard/exposure or risk is not mentioned.

4.1.1 BOPRC CDEM Group Distant Source Volcanic Ash Response Plan (2012)

BOPRC outlines various actions required for a response to a distant volcanic eruption, which is stated as non-life-threatening, however extremely disruptive (BOPRC, 2012). BOPRC have adopted probabilistic volcanic ash scenarios calculated by GNS Science (Hurst et al., 2010) in order to identify areas within the region most at risk. The plan summarises potential regional impacts, alert warnings to expect and sets out roles and responsibilities for responding to an ashfall event.

4.2 Mitigation and response planning

Labadie (1983) sets out five general areas for response planning, as summarised in Figure 4.1 below. These can be useful to frame more specific response and mitigation plans.

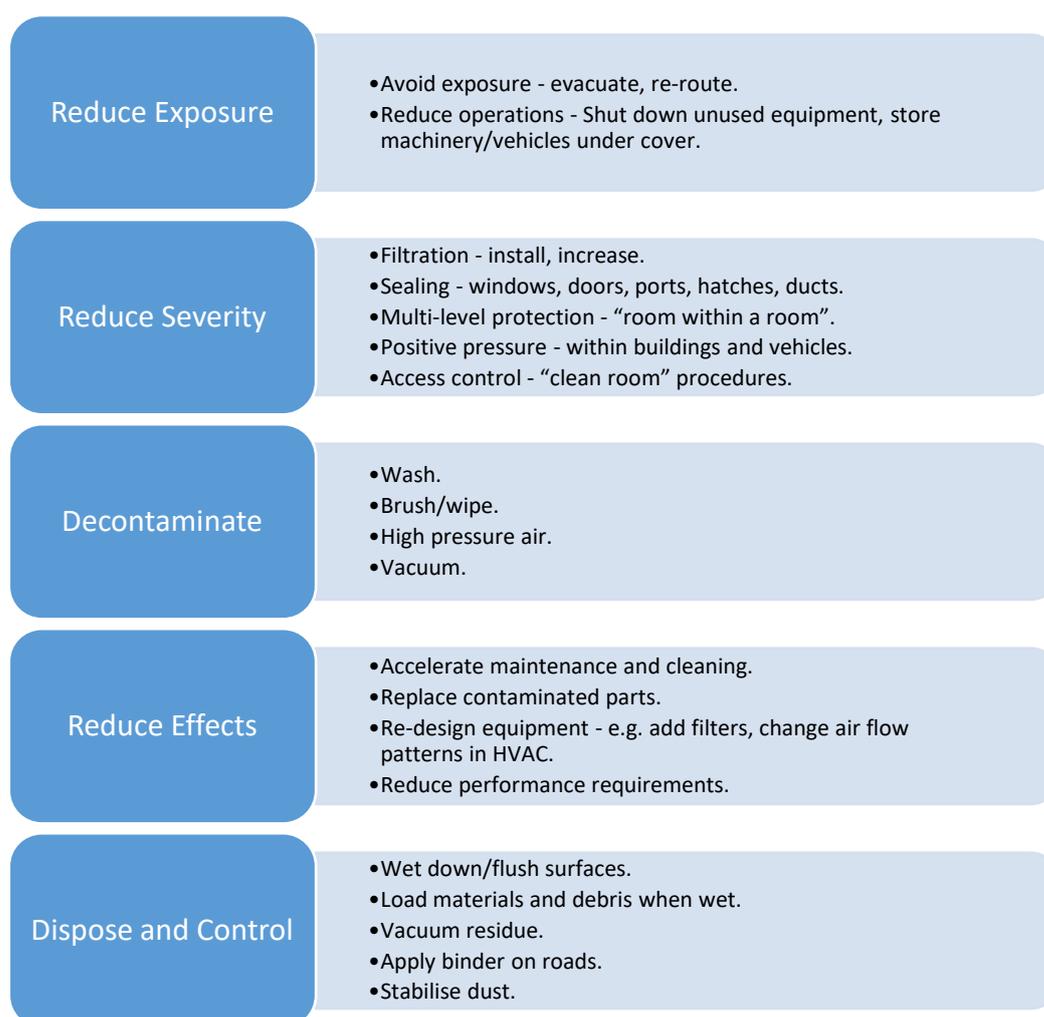


Figure 4.1: Framework for ashfall response and mitigation planning (adapted from Labadie, 1983)

4.2.1 Water supply

The following water supply mitigation suggestions have been summarised from Waikato Regional Council (WRC, 1999) relating to general water supply mitigation:

- Water supply intakes should be closed before turbidity and acidity levels become excessive.
- Vulnerable plant equipment and pumps should be covered when ash fall is impending.

- High turbidity levels may be able to be managed if water treatment filters are cleaned regularly. It is necessary, however to be aware that they may become blocked.
- People should be advised to boil water when turbidity levels are high, as suspended ash may decrease the effectiveness of any disinfection or flocculation process.
- As fine ash can remain in suspension for long periods (days to weeks) a coagulation-flocculating agent may need to be added.
- There will likely be the need for a water management plan to handle excessive demands for water after an eruption. Reservoirs may require filling and public information messages regarding water conservation may need to be broadcast.

Additional suggestions have been summarised from WRC (1999) relating to roof water supply mitigation:

- Disconnect the downpipes leading to the tank.
- Cover open tanks.
- Where downpipes have not been disconnected, do not use the water until tests have been done to ensure that it is not toxic.
- Where the roof supply is found to be non-toxic, but the turbidity is high, boil water before drinking.
- If no tests can be done, the water tank should be drained, flushed and refilled with uncontaminated water.

4.2.2 Wastewater

The following approaches are recommended by Federal Emergency Management Agency (FEMA, 1984) in relation to wastewater treatment plants:

- Temporarily cover all mechanical equipment that might be exposed to ash fall.
- Where possible, place sandbags or other devices at the entrance channel to the plant to trap ash. (This procedure requires frequent attention due to normal settleable solids present in sanitary waste).
- Consider removing or bypassing the comminutor during the initial heavy flows of ash into the plant.
- Frequently check the primary clarifier to prevent (a) damage to the sludge collection mechanism and/or the digester sludge pumps and (b) the transference of ash to the digester. Depending on the type of mixing employed in the digester, further damage may occur in the sludge transfer pumps.
- To clear ash from individual sections of the treatment facility, bypass individual units, or in extreme instances, make a complete plant bypass to a holding pond or lagoon. This will obviously result in adverse environmental impacts that will need careful consideration.
- Toxicity may occur in the plant effluent to the extent that the bacterial growth is damaged or lost. At the first signs of distress on a biofilter, check and adjust the pH level of the influent to the biofilter (FEMA, 1984).
- Ash will increase the mineral content of sludge.

4.2.3 Stormwater

Significant impacts can occur as ash enters drainage systems, causing blockages and increasing the risk of flooding. The following should be considered:

- When washing ash off streets avoid washing it down the drains and manholes of stormwater systems and sanitary sewers.
- Use protective measures such as sandbags around manholes and drains, or weirs in the manholes to trap the ash (Markesino, 1981; FEMA, 1984).
- When cleaning areas served by free discharging stormwater systems, use dry methods of removing ash (for example, hand sweep ash out from the gutters) prior to flush cleaning.
- To avoid ash entering stormwater and wastewater networks, it is important to educate residents on the acceptable methods of disposing of ash (FEMA, 1984).
- Ash deposits should be removed from any catchpits as soon as possible or ash will form a crust making it difficult to remove later on (FEMA, 1984).
- Buildings should disconnect downpipes to prevent ash entering the stormwater system (USGS, n.d).

4.2.4 Roothing

The following items should be considered when planning for ashfall responses for roading networks:

- Speed restrictions or road closure may be necessary to combat visibility problems and slippery road conditions caused by ash falls (FEMA, 1984).
- After the 1980 Mount St Helens eruption a number of dust retardants were used successfully to control the ash before it was removed. "Coherex" (an emulsion of petroleum resins), lignin sulphate and rock salt were among those used to stabilise the dust (FEMA, 1984; Labadie, 1983; Johnston, 1997). However, these dust control methods did not control heavy ash deposits for a long period of time, and they were also expensive (FEMA, 1984).
- The best method of removing ash from roads is to sprinkle the ash with water and blade it to the side or middle of the road. The ash can then be picked up by belt or front-end loaders. A power broom can be used or water flushed over the road to remove the remainder of the ash (Labadie, 1983; Johnston, 1997).
- Conventional snow removal methods should not be used to remove ash off roads. Snow removal methods only stir the ash up and cause it to resettle on the roadway (FEMA, 1984).
- Where roads are made of gravel, try to avoid removing too much of the gravel off the surface during the clean-up process. Additional gravel may be required to replace any that is lost, and may also assist in stabilising any dust that cannot be collected.

5 Recommendations and summary

Pre-planning for an ashfall event consists of knowing what to do in the event of an eruption and how to ensure an aligned response from all relevant organisations to help reduce impacts across the wider region. This is particularly relevant for all Lifeline organisations.

This study documents the potential volcanic ashfall hazard for TCC, the likely impacts on TCC infrastructure, and some initial considerations for response planning.

There are a number of areas that TCC could consider in order to be better prepared for an ashfall event. These recommendations are as follows:

- Identification and pre-planning for ash disposal sites, based on estimates of potential ashfall volumes (e.g. ACDEM, 2015).
- Review existing asset management plans and operational plans to ensure they appropriately address and link volcanic risks.
- Conduct a workshop(s) with relevant agencies e.g. BOP Emergency Management, MCDem, NZTA, KiwiRail, Port of Tauranga, Lifeline utilities etc. to:
 - Align planning and emergency management responses
 - Develop consistent messaging in the event of an ashfall event
- Develop a database of TCC-owned buildings/infrastructure to capture attributes such: as roof pitch and material; location/type of filters and power generator inputs; access routes etc.
- Develop a series of more detailed pre-eruption infrastructure mitigation measures for all sectors, and identify key actions with operational staff. Examples of this include:
 - Plans to cover air vents on pump stations
 - Plans to close the water supply intakes into reservoirs
- Consider water supply contingency measures, given the reliance on exposed surface water intakes and the likelihood of increased water usage for clean-up following an ashfall event.
- Review availability of on-site/portable power generators for emergency power supply to critical facilities. Also consider how these may function in an ashfall situation, and any mitigation required.
- Consider testing of ash impacts on infrastructure and the ability to clean roads and machinery.
- Pilot test water supply treatment operation with mobile treatment plants.

Finally, it is noted that transport is likely to be the most important sector initially, as access will be key for continuity of critical facilities. Reduced access will also likely have impacts for fast moving consumer goods and planning should consider routes which will be less impacted (i.e. those from the north, rather than the south).

6 Applicability

This report has been prepared for the exclusive use of our client Tauranga City Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

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