EXERCISE RUAUMOKO

LIFELINES SECTOR NOTES

A REPORT PREPARED FOR

AUCKLAND ENGINEERING LIFELINES GROUP

AND

NATIONAL ENGINEERING LIFELINES COMMITTEE

OCTOBER 2008

CONTENTS

INTRODUCTION

Exercise Ruaumoko illustrated the criticality of Auckland to the New Zealand economy and the vulnerability of its infrastructure. The Exercise, which tested New Zealandôs arrangements for mitigating and responding to a volcanic eruption in Auckland, commenced with planning in November 2007 and culminated in a two-day operational phase in March 2008.

The main Exercise reports, prepared by the Ministry of Civil Defence & Emergency Management and the Auckland Civil Defence Emergency Management Group, contain recommendations designed to strengthen infrastructureôs ability to withstand pressures of the type that a volcanic eruption can pose. The following detailed notes complement those two reports by drawing together Exercise issues arising in the Auckland Lifeline sectors with a view to informing and enhancing approaches to future risk reduction in relation the Auckland Volcanic Field and other natural hazards.

Following some general comments in the next section, the notes turn to issues arising in the following sectors

- Electricity
- Petroleum
- Gas
- Telecommunications
- Water / Wastewater
- Transport (Air, Road, Sea and Rail)

Information sources

The material in the notes has been drawn from various sources, including

- Auckland Lifeline Utility Status Reports and Auckland CDEM Group Situation Reports prepared during the Exercise
- Situation Reports prepared during the Exercise in the National Crisis Management Centre
- Evaluation responses as consolidated by the AELG Project Manager

The notes also draw extensively from material and ideas presented at five Workshops convened in Auckland by the National Engineering Lifelines Committee and Auckland Engineering Lifelines Group on 12 and 13 August 2008. These Workshops were aimed to consolidate Ruaumoko learnings in the Lifeline sectors, consider post-eruption issues and suggest options for further work.[1] Consolidated material on impacts and possible mitigation steps is in Attachment 1.

[1] The workshops, which were each 2 hours long, brought together representatives from the water, transport, telecommunications, electricity and petroleum sectors respectively.

The Workshops were informed *inter alia* by the *Ruaumoko Post-Outbreak Scenario* prepared by Dr Jan Lindsay (University of Auckland). Accordingly, these notes contain more extensive material on post-outbreak conditions (relating for example to ash management matters) than would have been possible from a review of documents relating to the Exercise alone. The full text of the post-outbreak scenario is included in this document ï see Attachment 2.

The Post-Outbreak Scenario envisages a vent that bridges the Mangere Inlet west of Mangere Bridge within 5 days, tremors, wave activity resembling storm surges and continued emission of volcanic gasses for 5 days, lava flows for 2 weeks, and 35 days of ash eruption. Ash falls in all areas around the vent, but wind conveys a concentration to the north-west over Waitakere and North Shore Cities. Ash deposits up to 10 cm remain a problem for up to 6 months. Areas in Mangere Bridge and Onehunga remain closed for several months.

Readers should be aware that, while the sector notes are believed to be ñquiteòcomprehensive, they should not be regarded as a complete description of impacts or responses.

Mitigation

It is clear from information provided following the Exercise that many Lifeline companies have already taken the opportunity that the Exercise presented to consider improvements to their readiness to handle a volcanic event in Auckland. Many have reported consideration of, and progress on, a range of improvements aimed at mitigation.

Some of the mitigation ideas mentioned in the following notes are likely to be quite expensive. Inclusion of these ideas does not imply commitment to address the issues. Others appear to have the characteristics of a ñquick winò and therefore might be more amenable to early consideration.

Next steps

We hope that these notes might be useful for next phases of work by individual lifeline companies, AELG Sector Committees and Ministries. It might also help inform forthcoming work of the Auckland CDEM Group, which has been requested to ask impacted Lifeline utilities to report on the degree to which current and planned mitigation measures would have reduced the impact from this or other volcanic scenarios.

AELG is also undertaking work on impacts of ash on electricity and telecommunications networks. This project will add to knowledge in the area, and will support mitigation and recovery planning.

Auckland Engineering Lifelines Group
National Engineering Lifelines Committee

October 2008

SOME COMMON ISSUES AND THEMES

This section summarises a range of issues that are common to Lifeline companies, identified during the Exercise and in the AELG / NELC Workshops held in August 2008. Matters that are more specific to individual sectors are set out in the notes that follow.

There is common interest in

- finding ways to meet both immediate staff safety needs and post-eruption family needs, to promote staff availability for recovery work. This could include consideration of
    - ways to meet housing needs of displaced employees (and temporary employees arriving from other areas) to support recovery operations
    - the case for a regional stockpile of Personal Protection Equipment for those involved in ash clean-up and the like
- setting up protocols or similar to promote access to sites in eruption / evacuation zones as soon as safe, for inspection, replenishment of diesel for generators, attention to filters and other and restorative work
- managing sub-contracts, especially in cases where more than one company relies on single contractors for services likely to be required as part of an emergency response
- establishing arrangements for locating ash cleared from roads and other exposed areas
- finding quick / easy ways to meet consenting requirements for new investments and the like.

Each of these areas deserves attention and might be the subject of further joint / collaborative work.

Other issues identified at the Workshops also suggest questions and issues that, while common, are probably better considered by individual Lifeline companies or sector groups. These include

- the impact of ash on a wide range of assets and equipment, and the consequent need for consideration of
    - protection, filter availability and stocks of other spare parts
    - clearing ash from specific assets and sites[2]
- supply chain issues, e.g. the ability of entities that supply Lifeline companies to maintain the flow of needed goods and services,

[2] In some cases, plant shutdowns may be required for ash clearance.

including air filters and other spare parts. This includes taking steps to help ensure that delivery arrangements are in place (e.g. via road, port, airport)

- the corresponding need to understand priority requirements of lifeline company customers
- access to emergency generators and fuel given the likelihood of electricity outages[3] - commercial availability and delivery issues both arise
- availability of communications including media used for remote monitoring and control
- the case for
    - regional dispersion of staff with key skills
    - duplication / decentralisation / regional diversification of key infrastructure assets and sites including consideration of investment in back-up generation (these might best be considered during annual planning, and when business cases are being prepared for new investments and the like)
- possible arrangements to encourage reduced demand for / promote conservation of infrastructure services
- whether there is scope to develop or improve mutual aid arrangements
- commercial / solvency implications for some companies, especially those reliant on billing Auckland consumers, together with the associated issue of meeting staff payroll requirements and other liquidity needs.

Other more general matters raised at the Workshops included

- the need for good public health messages (those with respiratory issues are a particular area of focus) and quite possibly to evacuate the ash-fall zone (this zone is likely to be considerably larger that than the immediate eruption evacuation area)
- risks arising from ash damage to road vehicles in general, needed to meet transport needs for return to ñbusiness as usualò

[3] Helpful information and advice is contained in ñ*Auckland Region* Generator *Resources Review*ò, Auckland Engineering Lifelines Group (AELG) / Civil Defence Emergency Management Group (CDEMG), April 2008. The Ministry of Economic Developmentôs advice is at http://www.med.govt.nz/templates/MultipageDocumentTOC____34073.aspx (in summary, this advice is to the effect that companies should make own arrangements to meet emergency needs wherever possible).

- the need to divert resources from new construction and investment in favour of recovery effort
- the possible case for new temporary governance arrangements to coordinate recovery, recognising that much equipment, materials and personnel / skill resources will be in short supply
- the possible use of land and facilities at Auckland Airport as part of the response and recovery effort.

Looking further ahead, Workshop participants also noted the possible case, in the interests of volcanic mitigation, for accelerating existing plans for new investment in Auckland infrastructure. There is also a case for considering routes and locations for future Auckland infrastructure investment that by-pass volcanic field, and for consideration to location of new national infrastructure outside Auckland.

ELECTRICITY

NATURE OF ASSETS IN THE AREA

- Generation
    - Southdown (Mighty River Power, 125 MW, gas-fired)
    - Otahuhu A[4] and B (Contact Energy, B = 380 MW, both A and B are gas-fired)
- Transmission lines supplying northern part of Auckland, Northland[5]
    - 220 kV line between Otahuhu and Henderson - continues on to Whangarei with a connection to Marsden Point (this line would be a priority for restoration)
    - 110 kV line from Otahuhu to Penrose, Mt Roskill and Henderson ï continues on to Marsden Point (this line would be a secondary priority for restoration)
- Transpower substations at Otahuhu, Penrose, Pakuranga, Mt Roskill, and Mangere and Auckland field office
- Approximately 12 Vector substations, including Auckland International Airport
- Vectorôs local sub-transmission and distribution lines
    - sub-transmission lines include lines in Vectorôs tunnel from Transpowerôs substation at Penrose to Vectorôs substations at Liverpool Street and Hobson Street[6]
    - note that all other parts of Vectorôs sub-transmission system are underground and that all Vectorôs sub-stations are enclosed (thus offering some ash protection)
- Vectorôs main office in Khyber Pass (includes call centre)[7]

WHAT HAPPENED?

Notifications received early in the exercise

- Non-essential staff at Transpower at Mt Roskill, Penrose and Mangere substations, and Auckland field office, evacuated. Emergency Coordination desk relocated from Great South Road to Otahuhu

---

[4] Otahuhu A is used for reactive power only.

[5] Transpowerôs lines supply 11 grid exit points north of Auckland. Ngawha (Top Energy, being expanded to 25 MW[5], geothermal) is the sole generation plant north of Auckland.

[6] This tunnel (3 meter diameter) is 9.2 kms in length. Auckland CBD can also be supplied from Penrose / Mt Roskill substations.

[7] Vector has an alternative office site in Henderson (does not include an alternative call centre).

- Vector Emergency Coordination desk (the ñIncident Teamò) relocated to Henderson
- Cessation of fault repair (other than ñmaking safeò and attention to traffic lights)

Notifications received during exercise

- Possible localised or city-wide outages due to seismic activity
- Reports received of possible transmission failure ï potential outage to northern part of Auckland, Northland
    - advice received that alternative temporary generation may be required in these areas
- Vector advised that able to supply 150 MW to Transpowerôs Mt Roskill substation providing supply available at Penrose
- Ash falls of less than 5 mm expected to cause insulator flashovers
- Possible upper-North Island transmission instability if transmission lines suddenly compromised
- Both 33 kV cables supplying Vectorôs Mangere West substation tripped due to seismic activity, disconnecting 360 industrial consumers in the evacuation zone. Supply also lost to Watercareôs Mangere Treatment Plant. Vector advised that it could switch to backup supply if required
- Transpower requested assistance with transport and location decisions for replacement pylons[8], and assistance with transporting additional structure materials from Australia for new line[9]

Demand changes (up and down)

- Demand would fall in Auckland as evacuation takes place and commercial and industrial activity eases

Supply changes (up and down)

- Southdown generation evacuated and closed
    - a matter for Transpower to handle in its grid system operator role - no direct impact on Auckland
- Outages in Mangere (impacting 4,000 residents) and other localised disruptions due to cable breakages (earthquake damage)
    - subsequently reported as ñoutages in evacuation zone to thousands of properties including 360 industrial customersò
- ñComplete power shortage in WCC, NSCC and Northlandò[10]

---

[8] The request was for access to all-terrain vehicles to assist with access, and for geo-technical advice to assist with location decisions.

[9] Transpower has sufficient spares for new temporary line (single circuit deviation). This request related to priority work to restore secure permanent arrangements.

[10] Excon inject 14-1405-1 refers.

WHAT WERE THE IMPLICATIONS?

Direct

- Damage to transmission lines could take several weeks to repair using temporary new structures and conductors
    - Transpower estimated that in worst case ñapproximately 3.8 km of the 220 kV link from Henderson to Otahuhu in conjunction with a similar length of the 110 kV links from Penrose and Mangereòwould be lost. ñIn such an event, Transpower will build a 9 km single circuit 220 kV deviation around the affected areas. Restoration may take 10 to 14 days but would be sufficient to restore supplies to all of Northland and north Auckland excluding Mt Roskill.ò Understood that this line would be built on public road reserve and other public land
    - ñRestoration of 110 kV line would be dependant on the sourcing of additional towers from within New Zealand or overseasò
- Ash fall likely to disrupt
    - transmission from Roskill to Henderson
    - distribution lines and transformers (flashovers, overheating). Shutdowns needed to enable cleaning

Cascade

- Risk to national petroleum supplies if electricity supply to Marsden Point disrupted
    - all shipping from Marsden Point (i.e. jetty and road tanker loading facilities) ceased following power outage
    - Refinery cannot operate without power from grid (33 MW required)
        - Emergency generators (not available on site) could power loading facilities but would require 2 to 3 weeks for installation
    - once electricity restored, loading of stored refined products can recommence immediately. The refinery itself would require two to three further days to recommence production
    - electricity outages would also include Wiri pipeline[11]
    - electricity outage would further restrict diesel loading onto road tankers at Wynyard Wharf
- Telecommunication companies reported that electricity outages would impact on their ability to continue services including international services

[11] Note that Wiri Oil Terminal has back-up power (recently installed).

- Telecom advised that priority sites in Auckland to the north have generators and standby fuel capacity to keep services running

- Watercare noted that electricity outage would disrupt water supplies and wastewater treatment
  - urgent need for fuel for generators (needed within 3 days)
    - supply lost to Watercareôs Mangere Treatment Plant
    - wastewater spills likely if pumping or Treatment Plant fails
  - ñBoil Water Noticesòissued, but absence of electricity makes compliance with these notices very difficult for many / most households ï a significant public health issue

- Traffic light failures, adding to road congestion
  - Transit sought priority in power restoration north of Auckland (streetlights and traffic signals) for safety and security reasons

WHAT DO OTHER SECTOR NOTES SAY ABOUT MEETING ELECTRICITY NEEDS?

The following cascade effects appear in the notes for …. Petroleum

- Numerous requests for priority fuel supplies, e.g. for generators. These included requests for supply to other Lifeline companies including (specifically)
  - telecommunication companies, who reported requirement for petroleum to keep generators running
  - Watercare, who noted urgent need for fuel for generators (required within 3 days)

…. and Gas

- Outage of pipeline from Onehunga to Mangere Bridge means that Otahuhu electricity generation plant out of action

…. and Telecommunications

- No cascade implications reported. However, any actual disruption may interrupt much remote control and communication capability (including of infrastructure facilities) and EFTPOS

WHAT COULD HAVE REDUCED THE IMPACTS?

Operational issues

- Improved access to diesel for generators (i.e. enlarged stock holdings by owners of critical facilities, improved petroleum contingency planning as a further back-up)
- Need for improved understanding of the regulatory, legal and practical conditions for erection of new / temporary transmission lines in new

locations (both public and private land) as part of an emergency response

- Transpowerôs request for assistance with transport and location decisions for replacement pylons, and for assistance with transporting additional structure materials from Australia, suggest possible areas for consideration
- Improved understanding of the practicalities and commercial issues relating to possible connection of ship generators (frigate? Inter-island ferry?) to transmission / distribution lines. (Progress in this area may involve capital expenditure)

Issues involving capital expenditure

- Questions raised re electricity security north of Auckland may suggest a review of case for additional investment in generation and / or transmission to serve the area
- Increased deployment of back-up generation at critical facilities (including for ship and road tanker loading at Marsden Point, Wynyard Wharf and Wiri Pipeline)

WHAT MITIGATION MEASURES ARE ALREADY UNDERWAY OR UNDER ACTIVE INVESTIGATION?

- Transmission investment in the Auckland area
  - North Auckland and Northland Project ï 37 kms of 220 kV underground cable from Pakuranga to Penrose and then on to Albany
  - North Island Upgrade Project ï major grid upgrade between Whakamaru and Pakuranga
- Other proposals to strengthen Vectorôs network (these proposals arise from and are associated with Transpowerôs plans)[12]

[12] See http://www.electricitycommission.govt.nz/pdfs/opdev/transmis/gup/naan/May2008/Attachment-C-Vectors-network.pdf

PETROLEUM

NATURE OF ASSETS IN THE AREA

- Pipeline from Marsden Point refinery to Wiri (conveys around 95 percent of Aucklandôs petroleum supplies)
- Wiri Oil Terminal (handles the majority of Aucklandôs petroleum supplies)
- Wynyard Wharf load-out terminal (a small facility, diesel and marine oil)
- Jet fuel facility at Auckland International Airport
- Road tanker fleet
- Local service stations and truck stops (including along evacuation route)
- Private commercial supplies (e.g. at bus depots and the like)

WHAT HAPPENED?

- Stocks were reduced at Wiri Terminal as eruption imminent, to reduce risks. Terminal later evacuated / closed. 45 million litres on site, equal to 5 days supply (longer if protected for priority consumers)
- Pipeline from Marsden Point refinery closed (pipeline stop valves closed at Hillsborough) due to risk of direct eruption damage and consequent spill into waterways (risk of 1.5 million litres released should fracture or rupture of pipeline occur)
- Road tanker supply to Auckland instigated / stepped up from Marsden Point, Mt Maunganui and Wynyard Wharf[13]
    - road tankers based in Auckland relocated to Mt Maunganui early in the exercise, and operations north of Auckland were relocated to Whangarei
    - Marsden Point has only two road tanker loading bays, and Wynyard Wharf only one, thus limiting supply from those sources
- Refinery increased sea shipments to Mt Maunganui and Wynyard Wharf
- Refinery later closed due to electricity outage north of eruption area
    - Note: Refinery has back-up generation sufficient only to handle safe shut-down and fire-fighting (not sufficient for loading already refined product onto ships or road tankers)

[13] Wynyard Wharf has 5 to 6 days diesel stock available. This facility remained operational throughout the exercise.

- Pipeline from Marsden Point crossing Manukau Harbour inlet into Ambury Park reported to be under stress. Later reported that pipeline believed damaged by eruption
- Late in the exercise, CDEM Group Controller issued requisition notice covering fuel supplies at Wiri Terminal.

Demand changes (up and down)

- Evacuation phase: Additional demand along evacuation routes, resulting in supply outages at service stations and truck stops
- Post-evacuation: Likely fall in demand in Auckland (uneven impact within the Auckland area). Possible increase in demand in locations where evacuees temporarily reside

Supply changes (up and down)

- Service stations closed in threatened area
- Evacuation phase: Petroleum companies acted to keep major stations on evacuation routes supplied
    - Note: Capacity to supply Auckland from road tankers is very significantly less than via Marsden Point pipeline (pipeline usage is equivalent to 260 truck / trailer movements per day)
    - fuel companies reported deliveries impeded by road congestion (e.g. return trips to Marsden Point and Mt Maunganui) leading to service stations running out of stock
    - significant security issues on service station forecourts expected

WHAT WERE THE IMPLICATIONS?

Direct

- Pipeline repair could take 6 months or more - resource and material prioritisation required
    - Note: Refinery is equipped to handle small pipeline breakages within 3 days (100 meters of spare pipe on hand) but repair following a Ruaumoko-type event would take months (an undersea pipe landing near the airport might be considered ï cost c $20 m)
- Trucking of jet fuel not possible due to absence of a truck loading facility at refinery and shortage of trucks of the high standard required (only three available)
- Aircraft operators would need to make arrangements for refuelling other than at Auckland International Airport
    - arriving international flights may need to carry sufficient fuel for return journeys

Cascade

- Numerous requests for priority fuel supplies, e.g. for generators. These included requests for supply to other Lifeline companies including (specifically)
    - telecommunication companies, who reported requirement for petroleum to keep generators running
    - Watercare, who noted urgent need for fuel for generators (required within 3 days)
- Additional fuel required at North Shore, Ardmore airports

WHAT DO OTHER SECTOR NOTES SAY ABOUT MEETING PETROLEUM NEEDS?

The following cascade effects appear in the notes for …. Electricity

- Risk to national petroleum supplies if electricity supply to Marsden Point disrupted
    - all shipping from Marsden Point (i.e. jetty and road tanker loading facilities) ceased following power outage
    - Refinery cannot operate without power from grid (33 MW required)
        - emergency generators (not available on site) could power loading facilities but would require 2 to 3 weeks for installation
    - once electricity restored, supply of stored refined products can recommence immediately. The refinery itself would require two to three days to recommence production
    - electricity outages would also include Wiri pipeline[14]
    - electricity outage would further restrict diesel loading onto road tankers at Wynyard Wharf

…. and Gas

- Any gas outage to Northland might require petrol refinery to operate outside air emission consent if outage duration is extensive

…. and Telecommunications

- No cascade implications reported. However, any actual disruption may interrupt much remote control and communication capability (including of infrastructure facilities) and EFTPOS

…. and Road Transport

- Ability to deliver essential supplies (including petroleum and super-market supplies) adversely impacted. Police assistance possibly required.

[14] Note that Wiri Oil Terminal has back-up power (recently installed).

WHAT COULD HAVE REDUCED THE IMPACTS?

Operational issues[15]

- Improved access by petroleum companies to
    - generators in emergency conditions (including preparation of service stations so they are ñgenerator capableò)
    - diesel to run generators (i.e. enlarged stock holdings by generator owners, improved petroleum contingency planning as a further back-up)
    - Note: improved clarity re responsibly of Lifeline companies for planning in this area also required (aimed to answer the question ñto what extent can we rely on CDEM mechanisms to meet these emergency needs?ò)
- Consideration of possibilities for dispensation from dangerous good licensing requirements to permit general freight trucks and their drivers to haul tank wagons in emergencies
- Consideration of possible access to diesel stock at Napier Port (19 million litres[16]) held for use at Whirinaki Power Station when ñnormalò electricity supply arrangements are fully stretched (may involve some capital expenditure if additional equipment required for loading ship tankers)

Issues involving capital expenditure

- An evaluation of how Aucklandôs needs (and needs of other regions) could be met in absence of pipeline from refinery, and / or if Wiri terminal damaged, is suggested. This could, for example, include consideration of possibilities for
    - facility to offload petroleum products from ship tankers at an Auckland port (unloading to tanks, pipeline or direct to trucks)
    - barging of petroleum products from Marsden Point
    - replacement for Wynyard Wharf (Wynyard Wharf unlikely to be available beyond 2013)
    - increased road tanker loading capacity at Mt Maunganui

---

[15] Note that, while it did not emerge as an issue in Ruaumoko, national supplies are vulnerable if jet aircraft movements cease through Auckland Airport (reason: a consistent off-take of jet fuel is needed to avoid airport tanks reaching capacity ï no alternative jet fuel storage facilities are available - refinery is configured to produce products including jet fuel in pre-specified proportions and 95 per cent of the refineryôs jet production is conveyed to Auckland Airport ï unavailability of jet storage therefore compromises entire refinery production). A solution involving adjustment to petroleum specification regulations is available ï MED has under action.

[16] Approximately equal to 300 road tankers.

- Evaluation of possible greater use of rail for petroleum transport (could be combined with evaluation suggested above). This could include consideration of possibilities for
    - completion of rail link to Marsden Point refinery
- Investigation of possible adaptation of road tankers so they can pump direct to vehicle tanks
- Increased deployment of back-up electricity generation at critical facilities (including for ship and road tanker loading at Marsden Point, pipeline from refinery and selected petrol stations[17])

WHAT MITIGATION MEASURES ARE ALREADY UNDERWAY OR UNDER ACTIVE INVESTIGATION?

- Steps to increase pumping capacity on pipeline (includes investment in back-ups)
- Petroleum contingency planning under development in Auckland and more widely
    - petrol rationing arrangements need consideration (work on national rationing options is at an early stage ï may be scalable to meet regional needs)

[17] Back-up generation has recently been installed at Wiri Terminal. Back-up generation has also been considered at the refinery (co-generation using gas discharged in refinery operation) but was found to be uneconomic (33 MW required for full operation).

GAS

NATURE OF ASSETS IN THE AREA

- High pressure pipelines located near threatened area. These include
    - high pressure pipeline extending north of Auckland as far as Whangarei (this pipeline crosses Manukau Harbour)
    - four gate stations serving Auckland
    - pipeline from Onehunga to Mangere Bridge (north shore of Mangere Inlet) ï this pipeline serves Otahuhu electricity generation plant
- Local distribution pipelines within area of seismic activity

WHAT HAPPENED?

During the exercise, it was reported that

- High pressure pipeline is ñvery robust and expected to keep operating; however pressure has been reduced é . and would be shut off automatically by low pressure trip sensors if rupturedò
    - continued earthquakes caused concern over major pipelines in the area outside evacuation zone
- However, an eruption in the location assumed in the exercise would likely have breached the pipeline (see further below).

Demand changes (up and down)

- Nothing reported

Supply changes (up and down)

- Pipelines supplying affected areas sealed[18] (this step minimises overall supply impact)
    - a few pipeline ruptures reported in the Mangere area
- Some customers may have noticed reduced supply due to reduced pressure in high pressure pipeline

[18] Service pipes to consumers would not be attended to individually as the volumes would be too high. Vectorôs existing Emergency Response Plan covers these matters. A regulatory regime for handling gas transmission outage contingencies, recently developed by the Gas Industry Company in consultation with the gas industry, could also be brought into operation if needed to help manage the event. Like its voluntary predecessor (the industry National Gas Outage Contingency Plan (NGOCP)) the new regulations are based on allocating line pack amongst priority customers. Both the new and old regimes cover (inter alia) the interface between transmission and distribution. Vectorôs Emergency Response Plan will not be affected by the new arrangements.

WHAT WERE THE IMPLICATIONS?

Direct

- If high pressure pipeline is shut or damaged, ñgas supplied north of that point would be disrupted for monthsó[19]

Cascade

- Outage of pipeline from Onehunga to Mangere Bridge means that Otahuhu electricity generation plant out of action
- Any gas outage to Northland might require petrol refinery to operate outside air emission consent if gas outage duration is extensive (this arises because refinery would need to switch to other fuels with greater carbon and sulphur content)

WHAT DO OTHER SECTOR NOTES SAY ABOUT MEETING GAS NEEDS?

The following cascade effects appear in the notes for Telecommunications

- No cascade implications reported. However, any actual disruption may interrupt much remote control and communication capability (including of infrastructure facilities) and EFTPOS

WHAT COULD HAVE REDUCED THE IMPACTS?

Operational issues

- Improved safety messages, e.g. turning off vehicles if gas smelt
- Explore issues relating to air emission consent at petrol refinery ï how would breaches of the consent be handled?

Issues involving capital expenditure

- Increased use of sectorisation? (c.f. Wellington in context of earthquake risk)

[19] The new regulatory regime, in common with its predecessor (the NGOCP), would also assist with managing an event of this large magnitude (previous footnote refers).

TELECOMMUNICATIONS

NATURE OF ASSETS IN THE AREA[20]

- Main ñnationally significantò fibre and copper lines paralleling SH1, across Mt Eden, One Tree Hill and Onehunga
- Main exchanges / data centres (Telecomôs largest data centre is in Mayoral Drive, Vodafone has two of its four ñstrong nodesò in Auckland / Manukau). TelstraClear has major facilities in Penrose and Symonds Street. Kordia has two data centres nationally, both in Auckland
- Numerous cell sites (but note that some re-routing is possible)
- Local copper lines and exchanges
- Kordiaôs main office in downtown Auckland and main transmission tower (telecommunications and broadcasting) at Waiatarua (West Auckland)

WHAT HAPPENED?

- Pre-eruption safeguards included consideration of re-location of essential activities and other ñwork aroundsò where possible, checking level and location of stocks of fuel, filters, and other spare parts
- Later, reports received of possible cable damage impacting national and international communications
- Kordia reported no disruption. Secured facilities in Auckland and relocated network management to Wellington
    - Kordia also reported possibility of transmission disruptions outside the region (radio, TV)
- TVNZ also able to conduct essential transmission activities from Wellington if Auckland not operable

Demand changes (up and down)[21]

- Cellular and landline coverage intermittent across the city, and very significant slowdown in broadband speed, due mainly to overloading
    - Telecom reported
        - no infrastructure damage, but reduced reliability due to extensive overloading, including in South Auckland and Waikato
            - Examples: 40 per cent increase in mobile / SMS usage with particular increases along evacuation routes and in Northland, Waikato and Bay of Plenty. Fixed line

[20] International cable connections are located in Auckland but are not close to the eruption area.

[21] Some of this material originated from injects.

services have likewise experienced a 40 percent increase, affecting operation in Auckland, Coromandel and Waikato

        - overloading may cause ñline busyòresponse
    - Vodafone reported:
        - cellular congestion along highways in Auckland, Waikato and Northland, and intermittent text delays
        - high loading nationwide including landline congestion in Waikato
- Severe cellular congestion along evacuation routes
    - delays occurred in delivering text messages between Telecom and Vodafone networks
- Extreme international congestion reported
- Increase in 111 calls

Supply changes (up and down)

- Telecom and Vodafone
    - increased landline and cellular capacity along evacuation routes and evacuee locations (Bay of Plenty to Northland)[22]
    - advised customers to minimise use of the network until the crisis is passed
    - sought information on location of evacuee centres in order to better target deployment of additional equipment
- Telecom reported that it is increasing capacity in Waikato, Northland and Bay of Plenty
- Vodafone turned off cellular data services (e.g. internet services) to allow additional capacity for voice
- Possibility of outages at key telecommunication facilities near the eruption area and CBD due to ash fall. While the larger of these facilities typically have back-up generation with diesel supplies and internal water supply for air-conditioning, replenishment of both water and diesel, and attention to air filters at these and at smaller sites, may be required before ash fall ceases. These tasks may be problematic if access to the area is restricted.[23]
    - For example, TelstraClear reported that outage at both Symonds Street and Penrose would result in failures of all calls north of Taupo and all TCL supplied international connections

[22] It is understood that services need to shut down for two hours or so when these increments in cellular capacity are made.

[23] The Post-Outbreak Scenario envisages 35 days of ash disruption. Ash falls over a wide area but the Scenario envisages concentration over the north-west areas of the urban area, including Waitakere and North Shore Cities.

- Possible loss of international communications due to extended power outages north of Auckland (the majority of international communication infrastructure is located there). Backup generation is available for limited times at each facility

WHAT WERE THE IMPLICATIONS?

Direct

- TCL reported that serious damage to key infrastructure would result in service disruption for ñ2 to 12 weeks, or as long as 2 yearsò
- Ash likely to impact on many facilities including cell-sites
- Impact of ash on TV signals unclear, but possibility arises that, due to ash cloud, Kordiaôs main link carrying TVNZ programmes to the prime broadcast site (Waiatarua, West Auckland) would be either lost or impaired (in this event, Kordia would either convey signal to Waiatarua by fibre, or broadcast from Wellington)

Cascade

- No cascade implications reported. However, any actual disruption may interrupt much remote control and communication capability (including of infrastructure facilities), EFTPOS[24] and inter-bank transactions

WHAT DO OTHER SECTOR NOTES SAY ABOUT MEETING TELECOMMUNICATION NEEDS?

The following cascade effects appear in the notes for .... Electricity

- Telecommunication companies reported that electricity outages would impact on their ability to continue services including international services
    - Telecom advised that priority sites in Auckland to the north have generators and standby fuel capacity to keep services running

…. and Petroleum

- Numerous requests for priority fuel supplies, e.g. for generators. These included requests for supply to other Lifeline companies including (specifically)
    - Telecommunication companies, who reported requirement for petroleum to keep generators running

…. and Water / Waste

- Water outages would put at risk many workplaces (including infrastructure workplaces) and air conditioning plants (including for infrastructure data centres and the like)

[24] Excon inject 14-1004-1 notified wide disruption in EFTPOS.

WHAT COULD HAVE REDUCED THE IMPACTS?

Operational issues

- Identification and communication to telecommunication companies of information on location of evacuee centres in order to target increased mobile coverage
- Improved understanding, particularly by consumers in the commercial sector, of
    - vulnerability to phone systems (diversification etc)
    - how phone systems are managed at times of stress

  to improve information on what to expect (extending to improved understanding of potential for priority access to phone systems)
- Consideration of vulnerability to common sub-contractor (Downer Connect)
- Steps to meet air circulation and air conditioning needs, including availability of filters etc and possibility of temporary or permanent covers for roof-top equipment and the like
- Review of mobile cell-sites. How many mobile sites exist? Who owns and where are they located when not in use?

Issues involving capital expenditure

- Biggest risk to telecommunication is an electricity outage ï may suggest need for increased investment in batteries, and in generators and fuel

WHAT MITIGATION MEASURES ARE ALREADY UNDERWAY OR UNDER ACTIVE CONSIDERATION?

A sample

- Vodafone investigating case for increased geographical separation of key facilities including main data centres (ñstrong nodesò). Vodafone also reviewing electricity back-up needs at cell-sites, call centre capacity and geographical dispersion of staff with needed technical skills.
- Telecom has
    - developed volcano contingency plan
    - increased battery lives at cell-sites and other locations
- TelstraClear has reconsidered battery and generator/fuel issues (some significant improvements made), and is building skills in alternate locations

- Issues relating to priority access are under review by Auckland Engineering Lifelines Group[25]
- Improved sector coordination is under development by the telecommunication companies and government ministries (Telecommunications Emergency Planning Forum)
    - possible national contingency plan including agreement on inter-carrier co-operation mooted

[25] The ability for continued access to 111 by all users needs to be taken into account in this review.

WATER / WASTEWATER

NATURE OF ASSETS IN THE AREA

- Water sources are the Hunuas (this is largest source) and Waikato River, Waitakeres and Onehunga (Onehunga is an underground source)
    - major pipeline bringing water from the south crosses the volcanic field (conveys 60 per cent of Auckland's water)
    - another significant pipeline in or near the field supplies Mangere and the airport
- Six water treatment plants including Onehunga (Onehunga is in the evacuation zone)
- Mangere Wastewater Treatment Plant (handles sewerage from four cities in the Auckland area - Mangere is in the evacuation zone)
    - Western Interceptor (large wastewater pipe from West Auckland to Mangere Treatment Plant - conveys 25-33 percent of Auckland sewerage - crosses Manukau Harbour within the eruption zone)
- Water pipes on Harbour Bridge (convey two-thirds of North Shore City's water)
- Numerous Watercare and city pumping stations for water and sewerage

WHAT HAPPENED?

- Water supply to evacuation area shut off 3:00 pm 13 March to avoid uncontrolled system loss
- Action taken to isolate major Hunua no. 3 pipeline conveying water from the south, to avoid risk of drain-down of the system should this major line be damaged
    - isolation resulted in loss of Auckland water supply from southern sources. Taking into account potential for Huia water treatment plant to shut down as result of ash fall, a need arose for conservation measures
- Shutdown of Onehunga underground supply. Onehunga Water Treatment Plant evacuated / closed due to location (within evacuation zone), storage of chlorine gas and risks to staff
- Widespread localised watermain failures and supply outages due to seismic damage
    - much of this due to wide use of cast iron and asbestos-concrete pipes that are vulnerable to seismic activity

- Chemical contamination of water sources (e.g. western dams)[26]
- Boil water notices issued for Auckland, Waitakere, Manukau due to health risks arising from local watermains becoming contaminated by sewer breaks and overflows
- Manukau siphon on the Western Interceptor (main trunk sewer) failed
- Mangere Wastewater Treatment Plant evacuated (ran on ñfixed / manual modeò for a period before failing)

Demand changes (up and down)

- Reduced demand due to evacuation and general slowdown in commercial activity
- Likely increased demand for treated water for fire-fighting and wash-down / clean-up

Supply changes (up and down)

- Water supply compromised by

---

[26] Volcanic chemical contaminants that are typically problematic in volcanic eruptions include: Aluminium (Al), Iron (Fe), Manganese (Mn), Bromium (Br), Flouride (F), Sulphate and Chlorate.

Solids (Al, Fe, Mn, etc) will add turbidity which could impact immediately on clarification and filtration. Current process control will shut the plants down, which will require source substitution. The effects will be dependent upon the volume and duration of the ash fall. It may be possible to change plant coagulant dosing and remove the additional solids loading but this will be dependant on the volume/ depth of ash.

Turbidity has two effects

- ï aesthetic, for which the DWSNZ has guidelines which are very likely to be exceeded
- ï more importantly, the solids loading will have the effect of ñmaskingò any biological contaminants and will therefore reduce the efficiency of disinfection (chlorination) posing a high risk of microbiological contamination.

The additional solids will pose problems for the capacity of solids handling processes at treatment plants and may result in sludge discharge to the environment.

Soluble chemicals (F, Br, Sulphate, Chlorate) are those that leach out of ash and ash sedimentation in storage lakes or in the surrounding catchments. Their presence could be long duration, again dependant upon volume of ash fall. All can have a significant health effect.

Soluble chemicals can also add acidity, i.e. lower pH of impounded water and that of inflows to storage lakes from water catchments. Effects can be short or long term , again dependant on scale of ash fall. Acidic water will become unpalatable and corrosive and will create significant issues in the treatment process.

For those consumers dependant on roof water (rural within Waitakere, Manukau, Rodney), ashfall impact will be immediate and possibly severe due to ash concentration in the relatively small volume of storage available (these consumers should immediately disconnect tanks from the roof).

(Reference GNS Report SR2004/25, Aug 2004, ñ*Impacts of Volcanic Ash on Water Supplies in Auckland"*)

- localised pipe failures due to seismic activity, especially in vicinity of eruption[27]
- isolation of Hunua No. 3 watermain passing through the zone 50 percent reduction in demand called for (very difficult to achieve)
- loss of Onehunga underground source and treatment plant (due to seismic and volcanic activity)
- electricity outages affected
    - Huia Water Treatment Plant, which was operated on stand-by generator (although at reduced loading)
    - Waitakere Water Treatment Plant, out of service
    - many pump stations ï exception: those few generator-equipped stations
- supply curtailed to some areas adjacent to evacuation zone (network configuration means that cuts cannot be targeted exactly to any given area)
    - some water supplies in these areas may require supply using standpipes and tankers
- ash fall compromised water availability for houses reliant on roof water - many of these in West Auckland / Rodney, and Manukau (depending on wind direction)

- Sewerage failures due to
    - plant evacuation (Mangere Wastewater Treatment Plant) but plant expected to fail due to ash fall, ultimately destroying exposed plant and overloading the solids stream processes (consequence will be discharge into Manukau Harbour of up to 300 million litres per day through designed overflows)
    - Manukau siphon failure resulting in substantial discharge to Manukau Harbour
    - breakages and other damage (due to seismic / volcanic activity)
    - electricity outages, except where generators available

WHAT WERE THE IMPLICATIONS?

Direct

- Extensive asset and other damage likely, for example:
    - contamination of water sources (e.g. western dams)
    - major pipeline from the south could take months / years to repair, depending on the length of pipeline damage[28]

[27] Pipes in the Onehunga area, which are cast iron, are amongst the oldest in the area. Mangere Bridge area has cast iron and asbestos cement pipes that are considered to be vulnerable to seismic activity.

- Onehunga water-source loss may take years to remedy - loss may be permanent
- ash contamination, e.g. in catchment areas, water storage lakes and treatment plants
- Mangere Wastewater Treatment Plant damaged by ash fall ï restoration could take months or years (availability of specialised plant parts would be an issue)

- Upgrade / treatment processes may be required to remove chemical contaminants ï could be needed for months or years
- Widespread localised flooding from broken water mains and wastewater overflows (some of these potentially long-lasting) due for example to
  - seismic activity and other direct damage
  - ash blockages of stormwater system
  - wastewater from the Western Interceptor was allowed to spill into Manukau Harbour
    - Reason: better to have one spillage point into an area reasonably able to handle the effects (significant tidal range), than to allow many smaller spills to local creeks (e.g. Whau Creek)
    - reinstatement of Interceptor may take months / years
  - further spillage from combined sewer / stormwater system
    - arising from ash build-up and blockages
    - resulting from action to avoid risk of pump damage due to ash entering the combined sewer / stormwater system from rain and cleanup operations (e.g. Orakei)
  - lack of electricity for pumping (e.g. North Shore City Council has only one generator for wastewater pumping)
  - ash damage to Mangere Treatment Plant
- Significant potential for health issues arising from contamination of water reticulation system
  - boil water notice issued but electricity outages restrict household compliance (health and safety advice)
  - compliance with Drinking Water Standards compromised by contamination and quality assurance monitoring impacted by resource unavailability of staff and laboratory resources

[28] The main concern is availability of pipe supplies.

Cascade

- Water outages would put at risk many workplaces (including infrastructure workplaces) and ash damage to air conditioning plants (including for infrastructure data centres and the like)
- Water outages could also put at risk some key community facilities (e.g. hospitals)

WHAT DO OTHER SECTOR NOTES SAY ABOUT MEETING WATER / WASTEWATER NEEDS?

The following cascade effects appear in the notes for …. Electricity

- Watercare noted that electricity outage would disrupt water supplies and wastewater treatment
    - urgent need for fuel for generators (needed within 3 days)
        - supply lost to Watercareôs Mangere Treatment Plant
        - Wastewater spills likely if pumping fails
    - ñBoil water noticesòissued, but absence of electricity makes compliance with these notices very difficult for many / most households ï a significant public health issue

…. and Telecommunications

- No cascade implications reported. However, any actual disruption may interrupt much remote control and communication capability (including of infrastructure facilities) and EFTPOS

WHAT COULD HAVE REDUCED THE IMPACTS?

Operational issues

- Improved PIM re boil water notices, e.g. advice on alternative means of water disinfection (e.g. Janola, BBQ)
- Development of acceptable short-term exposure levels to chemical contaminants[29]
- Targetted water quality testing in emergency situations
- Improved generator hire arrangements (or acquisition, a capital expenditure item)
- Removal of obstructions from storm water drains to reduce blockages
- Increased stocks of spare parts including filters for air conditioning

[29] Drinking water standards are expressed in values for long-term exposure. If these could be exceeded for short term periods, it may be possible to accelerate re-commissioning of some water treatment plants.

- Coverage of sewerage cess-pits in combined stormwater / sewer areas (central Auckland City) to avoid ash washing into Orakei Main Sewer.

Issues involving capital expenditure

- Increased number of valves to reduce the size of the areas that need to be evacuated due to water supply shutdowns
- Increased use of valves able to be controlled remotely
- Increased use of resilient pipe materials
- Improved arrangements for protecting sensitive equipment against ash
- Improved planning of alternative means to source and deliver water to suburban locations (including review of potential use of ship-based desalinisation facilities)
- Facility to use non-potable water (sea water, wastewater) for fire-fighting
- Increased access to alternative sources of water for air conditioning and the like (e.g. North Shore DHB is investigating water storage)
- Expanded sources of water (say bottled) for human consumption (major logistical production issues may arise)
- Stockpiling domestic water treatment kits for emergency use (or households could be encouraged to obtain own kits)

AIR TRANSPORT

NATURE OF ASSETS IN THE AREA

- Airports: Auckland International Airport, Whenuapai, North Shore and Ardmore (the latter two for helicopters and light aircraft only)
    - Auckland International Airport is major international and domestic transport hub

WHAT HAPPENED?

- Scheduled traffic through Auckland Airport ceased early in the exercise, but effort put into keeping the airport open as long as possible
    - runways operational and available in daylight under visual flight rules for a period (inspections required following seismic tremors)
    - skeleton crew on hand, including rostered fire crew
    - Airport reported as able to handle military aircraft and helicopters
- Later, Auckland Airport was evacuated and closed
- International flights would be diverted to Ohakea or Wellington[30]
- Whenuapai initially operational but closed to normal traffic
- Request for additional fuel at North Shore, Ardmore
- Passenger and aircraft parking congestion at other airports
- Major difficulties with airport access via road given proximity to eruption zone

Demand changes (up and down)

- Increased activity at North Shore, Ardmore
- Increased demand for domestic and international departures from Auckland International Airport seems probable, but absence of arriving aircraft would reduce number of available departures

Supply changes (up and down)

- Auckland International Airport, Whenuapai closed
    - impacts on passenger travel and air freight
    - noted that 100 mm of ash might take up to 7 days to clear from runways

[30] NB: Ohakea is the only other North Island airfield able to handle 747s.

- Note: Question raised whether CAA rules are unduly restrictive in relation to early scientific alert levels

WHAT WERE THE IMPLICATIONS?

- Very significant disruption to air transport across New Zealand. Impacts on
  - day to day travel
  - tourism
  - freight

WHAT DO OTHER SECTOR NOTES SAY ABOUT MEETING AIR TRANSPORT NEEDS?

The following cascade effects appear in the Petroleum notes

- Additional fuel required at North Shore, Ardmore airports

WHAT COULD HAVE REDUCED THE IMPACTS?

Operational issues

- Review alignment of scientific alert levels (especially levels 2 and 3) with CAA procedures
- Explore possible use of land and other facilities at Auckland Airport to support overall response and recovery
- Explore case for additional fuel at North Shore, Ardmore

WHAT MITIGATION MEASURES ARE ALREADY UNDERWAY OR UNDER ACTIVE INVESTIGATION?

- Additional generators being installed at AIAL (domestic and international terminals), together with sewerage pump trucks

ROAD TRANSPORT

NATURE OF ASSETS IN THE AREA

- State Highways 1, 20, 20 A and 20 B
    - Auckland Harbour Bridge (SH1)
    - Mangere Harbour Bridge (SH20)
- NZTA control centre
- Other major roads owned and controlled by TLAs
- Bus depots and fleets

WHAT HAPPENED?

- Group EOC took control of key regional transport resources at the commencement of the exercise week to ensure that they would be appropriately used
    - Group EOC advised media that the Southern Motorway will be restricted to evacuation and related traffic
- Ministry of Transport liaised with Transit and Ontrack to secure alternative routes along SH 16 and 1 in case of damage to Great South Road, Southern Motorway and the Mangere Bridge
- Cracks appeared in Harbour Bridge abutments due to seismic activity[31]
- Mangere Bridge threatened by seismic activity. Alternative route (eastern north/south bypass) expected to quickly reach capacity
- Cracking on Kiwi Esplanade (near Mangere Bridge) as eruption imminent
- Bridges needed inspection following seismic tremors - some closures needed for inspection (depending on seismic activity)
- SH 20 closed from Puhinui Road to Mt Roskill. SHs 20 A and 20 B also closed
- NZTAôs Auckland Office operations would be transferred to Hamilton and ARTAôs operations would be transferred to an alternative Auckland site (one of their depots)

Demand changes (up and down)

- Evacuation phase
    - substantial increase in road traffic especially along arterial routes, potentially leading to substantial congestion
        - Note: During the Exercise, road authorities reported that they did not anticipate major congestion to arise from

[31] Inject 13-1413-1 refers.

evacuation. However, there were also reports of ñ5 hour delay SH1 South ï 4 lanes for southbound traffic only. CDEM has restricted use to the evacuation and related traffic from the evacuation zoneòand ñevacuation traffic numbers exceed the Southern Motorway capacityò (NCMC SitRep 13/3 18:00).

- increase in demand for ad hoc suburban road transport to evacuation collection points and railway stations (including vehicles, e.g. busses, wheelchair-friendly vehicles, drivers)
- increase in demand for road transport out of Auckland (including vehicles, e.g. busses, wheelchair-friendly vehicles, drivers)
- congestion interfered with delivery of needed goods and services (e.g. petroleum deliveries, commenced from Tauranga and other locations given loss of petroleum pipeline from Marsden Point to Wiri))

- Post-evacuation phase:
  - new transport patterns (household, commuting and freight) arise - these need to be understood in order to consider possible adjustments to public transport schedules and routes, freight management and the like

Supply changes (up and down)

- Extensive traffic management during evacuation, e.g.
  - many on-ramps closed (police assistance required). On-ramps to Southern Motorway from Northern and Northwest Motorways closed
  - off-ramps closed from Green Lane to Mt Wellington. All other major arterial roads within 5 km of eruption zone closed
  - eruption likely to disrupt Great South Road, Southern Motorway and Manukau Harbour Bridge
    - Noted that alternative ñpredominant / priority routeòvia eastern north / south bypass will quickly become congested
  - public advised not to travel into CBD
- ARTA advised that some form of bus service could be maintained if busses were moved (in advance) to western and southern depots (OHPs from AELG pre-exercise workshop)
  - bus operators took action to distribute fleets to minimise risks
- Steps taken to inspect bridges
- Ash clearance became a priority
  - NZTA notes that 180 mm ash depth would close Harbour Bridge. This is a weight issue, allowing for added weight of ash

clearing equipment (but no other traffic) and possibility of rain[32] NZTA also notes that

- 5 mm would lead to traffic traction problems

- Difficulties experienced due to traffic accidents and the like[33]
- Post-eruption: Extensive damage to many State Highways and other arterial roads from direct impacts, seismic, lava, ash and wave activity

WHAT WERE THE IMPLICATIONS?

Direct

- Very extensive ash clearance required
  - initial focus on main routes (including Harbour Bridge) and needs of emergency vehicles and other vehicles involved in response activities and/or delivery of priority goods and services (including petroleum and supermarket supplies)
  - in absence of information on best / acceptable locations for its placement, cleared ash would likely be placed on parks and similar areas
- Mangere Bridge (if not destroyed) would need detailed inspection, requiring 2 weeks from date access allowed to the site. Rebuilding of Mangere Bridge and Onehunga Bay Causeway (if required) could take a year
- Likely incremental ash-damage to engines of all road using vehicles

Cascade

- Ability to deliver essential supplies (including petroleum and super-market supplies) adversely impacted. Police assistance possibly required

WHAT DO OTHER SECTOR NOTES SAY ABOUT MEETING ROAD TRANSPORT NEEDS?

The following cascade effects appear in the Electricity notes

- Traffic light failures, adding to road congestion
  - Transit sought priority in power restoration north of Auckland (streetlights and traffic signals) for safety and security reasons

[32] Transit also notes that õon a conventional bridge with shorter spans a deeper layer of 500 mm would be OK.ò

[33] Much of this originated from injects.

WHAT COULD HAVE REDUCED THE IMPACTS?

- Strategic location of
  - ash-moving equipment
  - busses
- Increased understanding of
  - regional freight flows and priorities (some early adjustments to location of freight handling facilities will be required ï possibilities include Wiri)[34]
  - possibilities for improved traffic management
  - evacuation volume assumptions including modelling transport / traffic evacuation movements
- Co-ordination of public transport needs for emergency response / evacuation between ARTA and city authorities[35]
  - includes better arrangements for moving evacuees to staging posts, handling inter-modal evacuee transitions and clarification of lines of authority between ARTA and local authorities in evacuation
  - ARTA best placed to manage bus allocation if needs clearly specified (availability of drivers a particular issue)
- Availability of engineers for bridge inspections
- Clarity around acceptable locations for placement of ash cleared from roads
- Improved arrangements for meeting required information needs (requests from Wellington considered to be particularly demanding)

[34] This comment also applies to rail and sea transport.

[35] Public transport includes busses and rail.

SEA TRANSPORT

NATURE OF ASSETS IN THE AREA

- Ports at Auckland, Onehunga
    - Auckland Port is major transport hub (but Tauranga and others can handle some of the traffic)
- Inland ports at East Tamaki, Wiri ï these could be used as holding spaces for containers

WHAT HAPPENED?

- Auckland Port staffing reduced to 15 percent. Arriving vessels redirected
- Onehunga Port damaged and closed. Manukau Harbour cleared of vessels
- Port of Tauranga advised that shipping arrivals need to be prioritised to ensure that essential consumable goods are given priority

WHAT WERE THE IMPLICATIONS?

Direct

- Ash clearance of wharves and terminals would be a major issue
- Container traffic would be diverted to Tauranga / Whangarei

WHAT DO OTHER SECTOR NOTES SAY ABOUT MEETING SEA TRANSPORT NEEDS?

The following cascade effects appear in the Rail Transport notes

- Routes used by freight services to the Port and points north would be disrupted

WHAT COULD HAVE REDUCED THE IMPACTS?

Operational issues

- Liaison with logistics companies to redirect export freights to other ports
- Secondment of port staff to Tauranga and other ports

Issues involving capital expenditure

- Consideration of new facilities at Auckland ports, e.g.
    - roll-on roll-off facility
    - petroleum handling and storage

    - rail access
- Consideration of additional inland port facilities, including north of Auckland
    - facilities at Auckland Port could be used as an inland port in these circumstances

RAIL TRANSPORT

NATURE OF ASSETS IN THE AREA

- Main trunk line
- Onehunga industrial line
- Local stations and track

WHAT HAPPENED?

- In general, rail services would be halted while the situation was assessed and site inspections carried out
- Ontrack advised that bridge on the Newmarket ï Otahuhu line damaged
    - initially the line remained open and available for evacuation (subject to a speed restriction of 10 km per hour)
    - subsequently the was closed
- Trains stopped at Pakuranga, with busses taking evacuees south from that point

Demand changes (up and down)

- Evacuation phase: Additional demand

Supply changes (up and down)

- Capacity reduced by line closures and other precautions
- Electricity failure would have cut services
- Routes used by metro passenger and freight services to the Port and points north would be disrupted

WHAT COULD HAVE REDUCED THE IMPACTS?

Operational issues

- Coordination of public transport through ARTA

Issues involving capital expenditure

- Investigate case for additional diesel-powered rail engines

Attachment 1

IMPACTS AND RESPONSE MATRIX

The following material, which draws from Workshops convened by the National Engineering Lifelines Committee and Auckland Engineering Lifelines Group on 12 and 13 August 2008, sets out consolidated material on impacts and possible mitigation steps.

The three pages cover

- Impacts
- Advance Mitigation Possibilities
- Response Mitigation Possibilities

Impacts matrix

The dimensions of the Impacts matrix are ñdegree of impactòand ñduration of impactò, both rated on scales of 1 to 6 (with 6 being ñhighò).

As a guide:

- Column 1 covers immediate impacts
- Column 3 relates to ñwithin a weekò
- Column 4 is ñwithin a monthò
- Column 5 is ñup to 6 monthsò
- Column 6 is ñbeyond 6 monthsò

Accordingly, cells towards to the *top-right corner* of the Impacts matrix show impacts that are considered likely to be both substantial and long-lasting.

Mitigation matrices

The dimensions of the Mitigation matrices are ñdegree of mitigationòand ñcost of mitigationò, both rated on scales of 1 to 6 (with 6 being ñhighò). Thus, mitigation possibilities towards the top-left of the matrix show possibilities that are considered likely to be most cost-effective.

IMPACTS – Consolidated

		Duration of Impact				
		1	2	3	4	5
Degree of impact	4	**Telecommunications:** Ash blockages to filters takes CBD and other sites down **Telecommunications:** Changed / increased demand, including increase in 111 calling	**Petroleum:** Disruption to fuel supplies to emergency services and other priority users **Petroleum:** Main pipeline from refinery shut to minimise spill risk **Petroleum:** Refining and ship tanker loading ceases at refinery (due to electricity outage). Rationing and increased importing of finished product required **Water:** Area of potential serious breakage isolated to avoid draining water mains (consequent need for demand reduction)	**Water:** NSCC supply reduced by 2/3 if harbour bridge affected **Water / general**: Increased demand for water (and for other resources and equipment) for ash clearance **Transport / general**: Ash fall disrupts road delivery of supplies for household and infrastructure use (including supermarket supplies) **Electricity / genera**l: Power outage will restrict infrastructure and other services (including rail transport) over a potentially wide area - plant and office / operating centres affected - large demand for generators and fuel **General:** Increased volume of enquiries re health **General:** Major slowdown in much commercial activity, e.g. tourism **General:** Ash damage to plant / equipment impacts wide range of infrastructure and other services	**Water:** Loss of Onehunga underground source **Water:** Ash contamination of catchments and reservoirs - immediate and long-term effects **General:** Increased population in NSCC (evacuees) with associated infrastructure needs **General:** Consenting issues arise associated with repair effort **General:** Major issues re ash clearance (especially in transport sector). Significant questions re appropriate location of cleared ash	**Water:** Environmental impacts from sewerage spills including from Western Interceptor **Transport:** Closure of port, airport and rail services. SH 20 closed for a year. Causes: direct impacts, seismic, lava, ash, wave activity **Petroleum:** RAP breakage. Repair takes 6 months **Gas / general**: Loss of gas supply over wide area impacts household, commercial and industrial users **General:** Revenue base for many infrastructure and other companies affected. Possible additional need to pay fines / compensation
	3	**Electricity:** Ash disruption / damage to transformers **Petroleum:** Forecourt security issues arise / expand **Transport / genera**l: Road congestion during evacuation disrupts delivery of supplies for infrastructure and other services including fuel for generators	**Water:** Ash blocks storm water system, leading to flooding and sewage overflows **Telecommunications:** Common contractor over-committed? **General:** Ash disrupts access to affected areas for emergency needs and repair work **General:** Supply chains for spare parts etc needed for infrastructure and other services unreliable	**Water:** Household supply difficulties. Water quality reduced (cf Drinking Water Standards) due to sewerage discharges, and ash / chemical contamination [check]. Power outage restricts ability to boil water **Petroleum:** Limited supplies at service stations, especially independently owned and operated stations (staffing, stock deliveries, and electricity issues) **Telecommunications / genera**l: Telecommunication overload and outages (landlines and cellular) may restrict infrastructure and other services including internet and international links over a potentially wide area (impact lessened where other media available) **Water / general**: Reduced water supply restricts some infrastructure and other services (e.g. hospitals, air-conditioning for telecommunications equipment)	**General:** Increased impact on staff availability if evacuation area extended due to ash fall **General:** Ash disruption / damage to infrastructure and other plant (e.g. Orakei combined pump station). Shutdowns required for cleaning **General:** Staff / contractor unavailability restricts ability to maintain services (inspections, repair work, checking water quality standards etc)	**Water:** Large number of old asbestos/concrete pipes likely to be damaged **General:** Focus on emergency response restricts / eliminates ability to do other day to day work
	2	**General:** Immediate staff loss due to uncertainty of scale of eruption	**General:** Ash will affect health (including eyes), especially those with respiratory conditions **General:** Ash cloud possibly interfering with remote monitoring of infrastructure and other equipment	**Telecommunications:** Link failure TVC - WTA [check] leads to significant loss of services **General:** Increased demand for contractors / equipment - longer repair times **General:** Significant HSE issues arise	**Water:** Homes with roof-supply likely to be seriously impacted	**Water:** Savings required, boil water notice issued **General:** Progressive ash damage to engines of all road vehicles
	1	**General:** Increased need for information for CDEM and other response needs	**Telecommunications:** Impact of dust clouds on TV and other signals **Transport:** Possible need to close Harbour Bridge while ash cleared	**General:** Areas outside but near evacuation area may need to be evacuated due to services disruption	**Transport:** Demand for public transport difficult to predict	

ADVANCE MITIGATION – Consolidated

Degree of mitigation		Cost of mitigation				
		1	2	3	4	5
	4	**Transport:** Locate ash clearance equipment near places of greatest likely need		**Petroleum:** Investigate use of road tankers as emergency mobile service stations **Telecommunications:** Investigate diversification and independence of critical systems	**Petroleum:** Investigate possible use of Government's diesel stock at Napier for general emergency use (presently held for use when electricity generation under stress) **Petroleum:** Investigate completion of rail link to Marsden Point **Transport:** Investigate case for additional diesel-powered rail engines	**Petroleum:** Investigate possible arrangements for sea transport from refinery to Auckland (e.g barging, dry riser to facilitate ship tanker unloading at Auckland and / or near Wiri) **General:** Consider routes and locations for future Auckland infrastructure investment that by-pass volcanic field (including consideration to location of new national infrastructure outside Auckland) **General:** Consider diversification / relocation of essential facilities (e.g. data and call centres), e.g. during annual planning and business case phases
	3	**Electricity:** Investigate supply using generators from naval or other ships **Telecommunications:** Develop national contingency plan (including inter-carrier collaboration etc) **General:** Review air-conditioning & other filter systems **General:** Review BCPs incl arrangements to promote early staff return to work (also review possibilities for dispersion of key staff to alternate centres (or building skills in alternate centres), use of outsourcing etc)	**General:** Consider supply / contract arrangements and stock levels for fuel, filters and other essential consumables (including location and ability to rapidly deploy) **General:** Build temporary roofing to protect against ash	**Water:** Consider use of more resilient pipe materials to mitigate seismic effects.	**Water:** Consider increasing reservoir storage in the region **Water:** Install multiple network isolation valves to reduce the size of the areas that need to be evacuated due to water supply shutdown. Consider valve automation **General:** Consider case for back-up generation	**Telecommunication:** Consider case for essential links (e.g. international satellite dishes and cable links) south of Auckland
	2	**Telecommunications:** Consider corporate contingency planning to meet communication needs **Water:** Review potential use of ship desalinisation equipment **Water:** Stockpile (national or regional) domestic water treatment kits for distribution in emergency **General:** Set up mutual aid arrangements where not already in existence (including PHUs)	**Water:** Plan for use of non-potable water for wash down / clean-up / fire **General:** Increase the volume of fuel storage that lifeline utilities and the region maintains **General:** Take steps to ensure essential contractors not overloaded	**General:** Consider decentralisation of corporate activity to minimise business disruption **General:** Consider levels and location of spare part stocks, e.g. filters **General:** Consider (a) how to meet housing needs for temporary employees (b) case for regional stockpile of PPEs for those involved in clean-up		**General:** Consider process for deployment of all-terrain vehicles to aid access and repairs
	1	**Water:** Pre-plan how to distribute water to urban areas - tankers or IBC's on street corners etc. **Water:** Establish plan for issuing boiled water notice **Water:** Remove obstructions from storm water drains to reduce blockages **General:** Consider common HR policies to meet recovery needs **Transport:** Increase understanding of how freight moves around NZ	**General:** Investigate case for increased battery life	**Transport:** Investigate case for RoRo facility for critical freight **General:** Build skills in alternative locations	**Transport:** Consider case for inland port north of Auckland	**Transport:** Investigate rail access to airport

RESPONSE MITIGATION – Consolidated

		Cost of Mitigation				
		1	2	3	4	5
Degree of mitigation	5	**Water:** Issue boil water notice and other public health messages via media **Transport:** Pro-active freight management / seek assistance of experts in SH traffic management	**Water:** Close main water supply from South, to protect against drain-down that would result from damage. Resultant need for call for 50 % savings in non-evacuated areas **Petroleum:** Public communication / central coordination of supply including for emergency services	**Transport:** Adopt active traffic management, including use of contractors **Transport:** Use PoA as an inland port	**General:** Restore main infrastructure assets based on priority ranking **General:** Ash protection and clearance	**Petroleum:** Install sub-sea temporary pipe to skirt AVF
	4	**General:** Prioritise recovery effort (e.g. in relation to major roads) including deployment of contractors **General:** Allocate available generators	**Petroleum:** Commence trucking from Marsden Point, deploy hand-pumps at service stations **General:** Undertake emergency-only work until emergency needs met	**Telecommunications:** Need to prioritise services **Water:** Determine acceptable short-term exposure levels to chemical contaminants	**Water:** Implement treatment processes to remove chemical contaminants **Transport:** Amend air schedules to meet demand and aircraft availability / relocate air hub to alternative airport **Transport:** Relocate port hub to Tauranga, with staff seconded there	
	3	**General:** Instigate BCPs, including teams for restoration of equipment, staff relocation (including working from home), rosters and payment	**Transport:** Consider options for freight, e.g. establish Wiri freight logistics centre (use Metroport), greater use of Tauranga Port **General:** Seek assistance from CDEM / Police to meet security needs			**General:** Use airport land and facilities to assist general recovery effort
	2	**Transport:** Use points-men at key intersections where lights inoperative **General:** Co-ordinate arrangements for staff travel to work	**Water:** Water quality testing **General:** Instigate conservation / restrictions for water and other services likely to be in short supply **General:** Obtain generators from outside the region			
	1		**General:** Provide helicopter transport for repair crews			

Attachment 2

The following Post-outbreak Scenario, prepared by Jan Lindsay (University of Auckland) appears in the overall report on Exercise Ruaumoko.

Ruaumoko post-outbreak scenario

Jan Lindsay

Background: Ruaumoko eruption onset

The Ruaumoko eruption began on the 14th March at 13:00 hrs after a two week period of precursory activity involving escalating seismicity, anomalous CO_2 emissions and ground deformation. The eruption commenced with steam emissions through the shallow waters of Mangere Inlet, less than 500 m offshore from Kiwi Esplanade. Small explosions throwing mostly lithic (non-magmatic) rock fragments ~ 100 m into the air in vertically directed dark plumes began less than an hour later.

Immediate impacts, first 5 hours

- Explosions rapidly increase in violence as magma reaching the surface is blasted apart due to interaction with the water in the harbour
- Some of the larger explosions send jets of ash and steam to > 1km above the surface and generate air shock waves that blow out windows in buildings within 2 km of the vent
- Outward directed components of the explosions send spear-headed plumes out to 600 m laterally from the vent, where they collapse to generate minor surges that reach land at Kiwi Esplanade and Onehunga Wharf
- A voluminous white and grey, vigorously convecting eruption column quickly rises to several km elevation above the vent, expanding to a steam and ash cloud drifting downwind and depositing fine ash; frequent lightening pulses within the eruption column and cloud cause some interference with communications
- Violent and rapid base surges of ash and steam spread outwards from the base of the eruption column, reaching 1 km from the vent in most directions; more violent surges from periodic collapse of the eruption column travel out to ~ 2 km radially from the vent
- Persistent showering of coarse ash and small scoria fragments over a roughly circular area approximately 2 km in radius from the vent; meter-sized ballistic clasts fall out to 1.5 km from the vent in all directions
- Rapid excavation of an explosion crater in the vent area and development around the vent of a rampart of ash and coarse scoria approximately 0.5 km in diameter
- Ash deposits are up to 50 cm and 0.5 cm thick, 1 and 10 km from the vent, respectively; fall out of wet ash and accretionary lapilli (small hardened balls of ash that fall like hailstones) downwind of the vent in places

- Continued seismic tremor interspersed with periodic felt VT earthquakes (largest M4.5); ground shaking causes damage to buildings in Mangere Bridge area
- Continued emission of CO_2 and other volcanic gases from the vent area; a SE wind blows the steam/gas plume to the NW at low elevations and strong gas smells are detected
- Waves resembling storm surge hit surrounding coastlines

Impacts, first 5 days

- During the first day discrete eruptions become increasingly frequent and associated eruption columns reach 8 km above the vent, spreading into an expanding eruption cloud at 10-12 km elevation
- Heavy tephra fall (> 64 mm thickness) occurring within 3 km of vent in all directions and downwind to 8 km (see Figure 1).

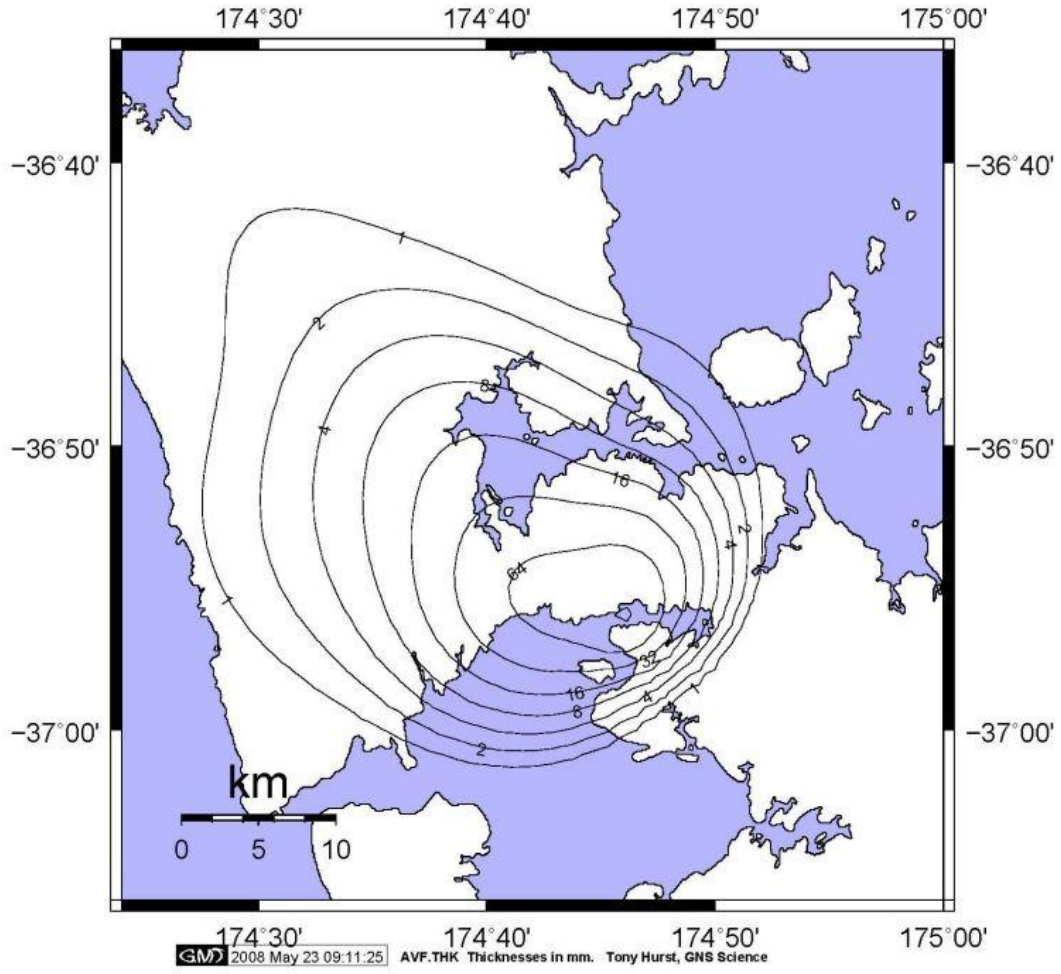

Figure 1 *Predicted ash fall thickness (in mm) after 5 days of the Ruaumoko eruption (model based on 0.001 km^3 of material erupted in the first 5 days, and an eruption column 3-8 km high). Courtesy Tony Hurst, GNS Science.*

- Development of a 0.5 ï 0.7 km wide explosion crater and surrounding 50 m high tuff ring rampart of coarse ash and scoria isolates the magma from the surrounding shallow seawater
- Base surges affect areas within 2 km from the vent in all directions; and further in some cases
- Fire fountaining begins, sending blobs of magma 300 m into the air above the vent and producing localised spatter and scoria rampart (within a few hundred meters of vent)
- Continuous sub-plinian ash column produces cinder cone by fall-out, which reaches 70 m in height and several hundred meters in width by day 5
- The growing volcano encroaches on land, joining the promontory north of Kiwi Esplanade and Ngaio Ave (to the south) and Onehunga Wharf (to the north), effectively cutting off the Mangere inlet west of SH20 and Mangere bridge
- High water levels at each high tide erode tephra deposits and portions of the tuff rampart and the sediment load begins to cause drainage and erosion problems in all impacted areas
- Continued seismic tremor interspersed with periodic felt VT earthquakes (largest M4.5), that may be large enough to cause damage; seismicity drops off after 5 days.
- Continued emission of CO_2 and other volcanic gases from the vent area
- Occasional waves resembling storm surge hitting surrounding coastlines

Impacts, first month

- At the end of the first week, lava flows begin issuing from the base of the scoria cone into the harbour, travelling intermittently at about 100 m per hour in two main directions; SE towards Ambury Park and NE towards Onehunga Wharf and SH20
- On day 10, lava flows fill much of the harbour in the Onehunga Wharf area, and reach the Wharf, generating explosions and fires
- By day 11, lava has also filled a good portion of the harbour north of Ambury Park and is encroaching on land near Seaforth Avenue
- Lava flows stop on day 13, after destroying much of Onehunga Wharf and filling much of the surrounding harbour and the southern portion of Gloucester Park, as well as much of the harbour to the west of the vent and coastal areas of Mangere Bridge township (see Figure 2)
- Semi-continuous ash and lapilli eruption column continues to build scoria cone, which completely fills the initial explosion crater and reaches 120 m in height by day 25
- The blocked Mangere Inlet causes water from catchment drainage to begin ponding east of Mangare Bridge causing local flooding of upstream shorelines

Impacts, first 6 months

- Fire fountaining (and ash column) stops on day 35, and the eruption finishes. The scoria cone is now 150 m high

- Ash continues to be a problem in large areas of the city for up to 6 months; undisturbed deposits within 10 km are up to 1-10 cm (thicker in downwind direction). Local telescoping results in even thicker patches
- The interior of the thickest part of the lava flows remains hot for months to even years after the eruption finishes
- The areas in Mangare Bridge and Onehunga directly impacted by the scoria cone, lava flows, surges and tuff ring remain in an exclusion zone for several months after the eruption ceases. Damage to SH 20 is eventually repaired and it is reopened one year after cessation of activity
- The blocked Mangere 1Lakeôcontinues to fill up, causing continued flooding, until a new channel is cut through to Otahuhu Creek to the east.

Figure 2 *Ruaumoko volcano on day 35 (ash deposits not shown).*