MINISTRY OF HEALTH
MANATŪ HAUORA

newzealand.govt.nz

Response to Major Fires

Guidelines for Public Health Units

Revised edition 2014

Citation: Ministry of Health. 2014. *Response to Major Fires: Guidelines for Public Health Units – revised edition 2014*. Wellington: Ministry of Health.

Published in January 2014
by the
Ministry of Health
PO Box 5013, Wellington 6145, New Zealand

ISBN 978-0-478-41591-9 (online)
HP 5363

This document is available at www.health.govt.nz

Contents

List of tables

Introduction

The purpose of these guidelines is to assist the public health response to major fires to minimise their public health risk. The focus is on industrial fires, but some of the content is also relevant to large scrub or forest fires, such as the 2010 forest fire at Mt Allan, near Dunedin.

The most significant industrial fires in New Zealand have been the 1984 ICI warehouse fire in Mount Wellington, Auckland, which led to the risk management framework for hazardous substances that exists today, and the 2008 Icepak cool stores fire in Tamahere, near Hamilton. Other recent examples of major fires include VJ Distributors in Hastings (2006); the former Patea freezing works (2008); the former Southdown freezing works in Penrose, Auckland (2008); Miller Moyes Seacraft, in Ellerslie, Auckland (2010); the former Waipukurau Hospital (2010); and the Silver Fern freezing works in Te Aroha, near Hamilton (2010).

Fires can expose people to a range of hazardous substances. In fact every major fire is a chemical incident (WHO 2009). The size and scale of fire events vary greatly and the consequences of these releases are also variable. The longer a fire burns, the more products of combustion are formed.

Fires can pose a substantial threat because:

- they release chemicals into the air that may disperse at concentrations well above background levels
- new chemicals can be formed as a result of combustion
- the dispersion of fire-fighting water can cause material from the fire to enter waterways.

There may also be intense local deposition of material from the fire, including parts of the structure of the building.

In cases of major fires, public health units (PHUs) are involved if the public health may be put at risk. These units may be asked for advice on environmental sampling during and after fires, as well as advice on other health-related matters such as evacuation and sheltering. This advice will need to be incident specific because the combustion products produced will vary depending on the chemicals and materials present and the temperature of the fire.

These guidelines provide an overview of the types of contaminants that can be released during fires and the information that needs to be collected to inform decisions on sampling and analysis. They also include advice on evacuation versus sheltering in relation to fire incidents, health monitoring and communication. They do not replace hazardous substance incident protocols that have been developed by a PHU for use in its own region.

Major changes to this 2013 revised edition include who to contact for chemical advice support, a new subheading “when attending fire incidents”, and public health values that could be used in cases of emergency.

1 Being prepared

1.1 Knowing the hazardous sites

An overview of the location and nature of highly hazardous sites, including tyre dumps and waste sites within your region, is important for understanding the potential risk to public health. Being prepared in this way is useful not only for fires but also for chemical spills and other releases of potential public health significance.

The main focus should be on identifying specific sites, or industrial areas that are likely to include such sites and are close to residential development. Identification may be as a result of resource consent applications, WorkSafe New Zealand or territorial authority information, and/or location test certificate data.[1]

1.2 When to notify the PHU

Criteria for the New Zealand Fire Service to notify the PHU should be worked out locally. Typically such criteria include the scale of the event, multi-agency involvement, involvement of a Fire Service hazmat/command vehicle,[2] contamination of water, evacuation or sheltering of the public, and involvement of sensitive locations.

Note: the health and safety of PHU staff who will attend an incident is an important consideration, which should not be overlooked in planning for such events.

1 Location test certificate data are accessible online to HSNO enforcement officers.

2 There are 17 Fire Service hazmat/command vehicles in New Zealand located to allow rapid deployment to most parts of the country.

2 Roles and responsibilities

2.1 When a fire occurs

Once notified of the fire, and the information indicates actual or potential casualties, it is useful to check that the District Health Board emergency manager has been notified (thus forewarning the hospital emergency department). Depending on the scale of the fire, the PHU may activate an incident management team.

The main roles and responsibilities of the PHU in relation to a fire are:

- public health risk assessment
- provision of public health advice – to the incident controller and the public (both via the media and directly to evacuees)
- provision of information to GPs and the hospital emergency department (if required)
- environmental sampling, if appropriate.

Depending on local circumstances, the medical officer of health may be asked to decide whether to evacuate residents and when evacuated residents are able to return home. Often the former decision has already been made by emergency services prior to the arrival of PHU staff at the incident. In some circumstances it may also be necessary to consider recommending closure of nearby schools and early childhood centres to prevent public exposure.

2.1.1 When attending fire incidents

Unlike the Fire Service, the PHUs are not trained to actively involve themselves in fire incidents. It is reiterated that you do **not**:

- enter hot zone
- enter areas where personal protective equipment (PPE) is required.

2.2 After the fire

After or during the incident (depending on its duration), the PHU should notify the Ministry of Health and/or the Environmental Protection Authority via a Hazardous Substance Incident Report. After the incident, internal and external debriefings should occur with the aim of identifying the lessons learnt and, if required, which procedures should be updated.

3 Toxic products from fires

Fires in structures such as factories can vary markedly in size, intensity and the type of materials involved. Chemical conversions will occur both during the fire, as a result of combustion and mixing with water (or foam), and after, when the chemicals enter the wider environment. The combustion temperature will affect dispersion of the smoke.

3.1 Types of toxic products

Toxic products from fires can be divided into three categories: asphyxiants, irritants and other products.

Asphyxiants

There are two main types of asphyxiants:

- simple asphyxiant gases (eg, methane and nitrogen), which displace oxygen, causing hypoxia
- chemical asphyxiants, which interfere with oxygen delivery (eg, hydrogen cyanide and carbon monoxide, which may be rapidly fatal).

Asphyxiants are a major hazard inside burning buildings.

Irritants: inorganic acid gases and organic irritants

Smoke irritants are important as potential causes of adverse health effects, not only inside buildings but also in smoke dispersed into wide open areas. Irritants include:

- inorganic acid gases (eg, hydrogen chloride, hydrogen bromide, hydrogen fluoride, nitrogen oxides, sulphur dioxide and phosphorous pentoxide)
- organic irritants (eg, formaldehyde, acrolein and crotonaldehyde).

Other products

This category covers any chemical present in bulk, or that is toxic at low concentrations, that could be released in the fire plume[3] and may have important short- and long-term health implications; for example, particulate matter (PM_{10}),[4] polycyclic aromatic hydrocarbons (PAHs) and dioxins[5] (Health Protection Agency 2002).

Dioxins are formed at very low levels in most combustion processes, but especially from burning chlorinated organic compounds. Their toxicity is due to their environmental persistence and consequent dietary exposure.

---

3 The fire plume is defined as the motion generated by a source of buoyancy, which exists by virtue of combustion and may incorporate an external source of momentum. The buoyancy source may be due to glowing or flaming combustion of a solid or liquid with no external source of momentum, or to gaseous, liquid, spray, or aerosol discharge from an opening at various mixes of mass flow and momentum.

4 A PM_{10} is particulate matter with an aerodynamic diameter of up to 10 microns.

5 Polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) are collectively referred to as dioxins.

3.2 Potentially hazardous facilities and combustion products

Potentially hazardous facilities may include:

- chemical storage facilities
- industrial facilities that use, manufacture or store chemicals
- bulk fuel storage
- tyre manufacture and storage
- plastic manufacture and storage
- clandestine drug laboratories.

Building materials that are likely to be hazardous or to produce hazardous combustion products include:

- treated timber
- asbestos-containing materials
- panels containing expanded polystyrene (sandwich panels)
- paints, resins and varnishes.

3.3 Types of fires and their products

Non-flaming fires

Slow thermal decomposition results in oxidation in non-flaming conditions. The products are rich in organic compounds and are usually highly irritating to the respiratory tract. Other products include inorganic acids and carbon monoxide. These fires are rarely a public health risk beyond the building, although they may have a strong smell and represent an environmental nuisance to surrounding areas.

Well-ventilated fires

These occur when there is plenty of air. Initially the levels of smoke and toxic products are low, but as the fire develops carbon monoxide and carbon dioxide production can be significant, and inorganic compounds may be released as gases.

Controlled flaming fires

These occur when the air supply is restricted. This type of fire threatens the wider environment beyond the building of origin, including the occupants within large buildings. High concentrations of carbon monoxide, carbon dioxide, hydrogen cyanide, organic products, smoke and inorganic acid gases occur (Health Protection Agency 2002).

3.4 Combustion products

Fires in a range of industrial facilities can release combustion products which are potentially hazardous to health. Combustion products are determined by the material burning and the type of fire (see above). Possible combustion products for fires involving specific materials are listed in Table 1.

Acute hazards associated with fires include the release of unburnt toxic parent materials and/or the production of toxic combustion products. People's exposure will depend on their proximity to the fire as well as the meteorological conditions. The hazards in relation to proximity to a fire can be grouped into two categories.

Close proximity to the fire (ie, within building or room) or immediate vicinity of the fire source (zone 1)

The major risks are from heat and rapid generation of toxic compounds such as asphyxiant gases, carbon monoxide and hydrogen cyanide, and the low availability of oxygen, which may be rapidly lethal in just a few minutes. This area is most likely to be of major concern to the emergency services.

Outside the immediate fire zone (zone 2)

The size of the zone 2 area depends on the size of the fire and the chemical nature of the hazards. Toxic gases such as carbon monoxide are likely to be present in the plume at much lower concentrations than in zone 1, and are therefore less likely to be a hazard to health, unless individuals are directly in contact with the plume. Table 2 shows the combustion products generated from certain burning materials in this zone.

Fire-fighting activity itself can release a range of materials depending on the composition of the fire-fighting water or foam. Contamination of soil and waterways through run-off of fire-fighting water and deposition of airborne contaminants can create long-term hazards.

3.5 Fires involving specific substances

Polychlorinated biphenyls (PCBs)

Fires involving PCBs are unlikely but may occur where PCB-containing material is stored awaiting disposal, or old electrical equipment (eg, capacitors) is still in use. Both require an exemption under the Hazardous Substances and New Organisms (Stockholm Convention) Amendment Act 2003, so these sites should be known to the PHU. Removal of PCBs is required by 2016. PCB fires are smoky and yield large amounts of black, oily soot. The soot is contaminated with PCBs, PCDFs and, if chlorobenzenes are present (eg, in transformers), PCDDs. PCB fires pose serious risks to building occupants and fire fighters.

Clandestine methamphetamine labs

Clandestine methamphetamine lab fires have the potential to be highly volatile. Numerous hazardous substances are present. For further information, see the *Guidelines for the Remediation of Clandestine Methamphetamine Laboratory Sites* (Ministry of Health 2010).

Asbestos

For guidelines on managing asbestos in relation to fires, see Appendix 1 in this document and *The Management of Asbestos in the Non-occupational Environment: Guidelines for public health units* (Ministry of Health 2013).

Tyres

Although tyres can be difficult to ignite, once they start, tyre fires can be very difficult to control and extinguish and may burn for a long time. They produce more smoke and more toxic contaminants when they smoulder than when they burn freely (Health Protection Agency 2010).

Forests or scrub

Particulate matter is the most consistently elevated contaminant due to forest fire or bushfire smoke (Dennekamp and Abramson 2011). The smoke also contains polycyclic aromatic hydrocarbons (PAHs), carbon monoxide, aldehydes, organic acids, volatile organic compounds (VOCs) and ozone (following reactions in sunlight).

A review of studies looking at bushfires and respiratory morbidity and mortality found a small effect on respiratory morbidity, consistent with an association found with urban PM_{10} pollution (Dennekamp and Abramson 2011). Problems encountered by such epidemiological studies include the fact that the smoke episodes are generally short and the exposed population is typically rural and small. Only a few studies (which tend to have been running at the time of the event) have examined outcomes other than emergency department attendance, hospital admission or mortality.

Table 1: Indicative combustion products for certain burning materials

<table>
<tr><th></th><th>CO</th><th>PAHs</th><th>Particulates</th><th>Chlorinated organic compounds (eg, dioxins)</th><th>VOCs</th><th>SVOCs</th><th>Irritant organic compounds (eg, acrolein and formaldehyde)</th><th>O_3</th><th>HCN</th><th>HCl</th><th>P_2O_5</th><th>Isocyanate</th><th>HF and HBr</th><th>NO_x</th><th>SO_2</th><th>NH_3</th><th>Metals</th></tr>
<tr><td>Clandestine drug labs</td><td rowspan="13">✓</td><td rowspan="13">✓</td><td rowspan="13">✓</td><td rowspan="13">✓</td><td rowspan="13">✓</td><td rowspan="13">✓</td><td rowspan="6">✓</td><td rowspan="6">✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>Landfills</td><td></td><td>✓</td><td></td><td>✓</td><td>✓</td><td>✓</td><td></td><td>✓</td><td>✓</td></tr>
<tr><td>Paints and solvents</td><td></td><td>✓</td><td>✓</td><td>✓</td><td></td><td></td><td></td><td></td><td>✓</td></tr>
<tr><td>Pesticides</td><td></td><td>✓</td><td></td><td>✓</td><td></td><td></td><td></td><td></td><td>✓</td></tr>
<tr><td>Petrol storage</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Plastics factory/warehouse</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td></td></tr>
<tr><td>Polystyrene</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Oil storage</td><td rowspan="6">✓</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>✓</td><td></td><td></td></tr>
<tr><td>Resins and adhesives</td><td rowspan="5">✓</td><td>✓</td><td>✓</td><td></td><td>✓</td><td>✓</td><td>✓</td><td></td><td>✓</td><td></td></tr>
<tr><td>Rubber, tyres, belting</td><td>✓</td><td>✓</td><td></td><td></td><td></td><td>✓</td><td>✓</td><td></td><td></td></tr>
<tr><td>Timber storage</td><td></td><td></td><td></td><td></td><td></td><td>✓</td><td>✓</td><td></td><td>✓</td></tr>
<tr><td>Upholstery – polyurethane</td><td>✓</td><td>✓</td><td></td><td>✓</td><td>✓</td><td>✓</td><td></td><td>✓</td><td></td></tr>
<tr><td>Vegetation – forests</td><td></td><td></td><td></td><td></td><td></td><td>✓</td><td></td><td></td><td></td></tr>
</table>

Sources: adapted from Health Protection Agency 2002, with additional information from Bhargava et al 2002; Ergut et al 2007; North Carolina Department of Health and Human Services (nd); Office of the State Fire Marshal 2004; Shibamoto et al 2007; Wang et al 2001; Ministry of Health 2010.

CO = carbon monoxide; PAHs = polycyclic aromatic hydrocarbons; VOCs = volatile organic compounds; SVOCs = semi-volatile organic compounds; O_3 = ozone; HCN = hydrogen cyanide; HCl = hydrogen chloride; HF and HBr = hydrogen fluoride and hydrogen bromide; NO_x = oxides of nitrogen; SO_2 = sulphur dioxide; NH_3 = ammonia.

Table 2: Combustion products generated from certain materials outside the immediate fire zone

Material involved	CO	HCN	HCl/HBr/ HF	NO_x	SO_2	P_2O_5	Organic irritants	Inorganic irritants (eg, NH_3)	PAHs	Other (eg, dioxins)	PM_{10}
Polymeric material[6]	+/-	+/-	+	+	+/-	-	++	+	+/-	++	++
Wood	-	-	-	+/-	-	-	+	-	+/-	+	+/-
Rubber/tyres	+/-	+/-	+	+/-	+++	+/-	++	+/-	+/-	++	++
Oil/petrol	-	-	-	-	+/-	-	++	-	+/-	+	++

Source: Health Protection Agency 2010.

CO = carbon monoxide; HCN = hydrogen cyanide; HCl/HBr/HF = hydrogen chloride / hydrogen bromide / hydrogen fluoride; SO_2 = sulphur dioxide; P_2O_5 = phosphorous pentoxide; NH_3 = ammonia; PAHs = polycyclic aromatic hydrocarbons; PM_{10} = particulate matter of 10 micrometres or less in diameter.

Key:

+++ likely to be present in very high quantities
++ likely to be present in high quantities
+ likely to be present
+/- may be present at low level
- unlikely to be present

6 For example, plastics.

4 Public health risk assessment

Exposure is most likely in the immediate fire zone (zone 1). This should be borne in mind by the PHU staff who attend a fire, who should take necessary precautions (eg, remain upwind and, if necessary, wear a dust mask).

4.1 Initial assessment

Establish the nature and magnitude of the fire by determining:

- the building contents – the quantity and type of hazardous substances
- the age of the building – are asbestos or PCBs likely?
- the geographic area involved – residential, industrial, sensitive locations (hospitals, schools, early childhood centres, aged care facilities)
- an estimate of the neighbouring population – this information may be qualitative (eg, densely or sparsely populated).

Carry out a rapid risk assessment, covering:

- proximity of the fire to the closest houses
- exposure risk:
  - downwind population
  - population exposed to contaminated run-off or deposited material
- who is most likely to be affected because they live or work near the site of the fire
- who is likely to be most vulnerable to health effects
- besides air quality, what will potentially be affected (eg, drinking-water source, recreational water, food, soil).

Site inventories are useful but they don't necessarily indicate which substances are burning and/or released, and they are not always immediately available or up to date. Initial risk assessment is based on smoke and combustion products unless the material on fire has been identified. The main emissions of concern arising from any fire will be combustion products, which are determined by the burning material and the type of fire. Combustion products include particulate matter, and irritant and asphyxiant substances.

Initial decisions will be made on the basis of this rapid assessment and invariably incomplete information. As further information comes to hand the risk assessment should be refined. However, all chemical risks cannot be identified and assessed with certainty because the combustion products discharged and in what quantities will remain unknown.

4.2 Further assessment

Hazard identification

- What health effects are caused by the contaminant(s)?
- What is the frequency and severity of these health effects?

Exposure assessment

It is unlikely you will be able to measure contaminant levels during the critical time for acute exposure. However, factors that influence exposure (and dose) are:

- age (eg, infants, children, older people)
- health status (eg, pregnancy, asthma, chronic obstructive respiratory disease, cardiovascular disease)
- behaviour and activities (eg, exercising outdoors – increased physical activity causes deeper respiration and more fine particles are inhaled).

It is also important to determine:

- the extent of population exposure during a certain time period
- how many people are exposed.

Dose–response relationship

What are the health effects at different exposure levels?

Risk characterisation

What is the risk of health effects in the exposed population? The wind and weather dilution factors for the plume will reduce its potential toxicity. The major immediate risk to public health in zone 2 is likely to be exposure to irritants and particulates. Irritant gases, even at low concentrations, may cause significant irritation of the eyes and respiratory tract, which may be resolved following removal from the exposure, with no long-term consequences.

The generation of more complex products such as PAHs, dioxins and particulate matter are of concern, but are likely to present a significantly greater risk from long-term or repeated exposure than following a single exposure.

Exposure modelling is complex, and visual observation and environmental monitoring often provide more useful estimates of exposure. In the response stage of the event it is usually impossible to make a quantitative risk assessment.

There is the potential for continued public exposure to chemical hazards once the fire is over, depending on the extent of contamination. However, living in a contaminated area after a fire does not necessarily mean there is a public health risk. This depends on how hazardous the level of a contaminant is and the existence of exposure pathways. Evacuation may be necessary if contamination is severe.

5 Evacuation or sheltering?

Assuming evacuation and sheltering are both feasible, the choice of one over the other depends on the balance of risks. This decision will depend on the exposure level and duration. Evacuation of people from the area of likely contamination to a safe area by emergency services is often a precautionary measure. Some people may opt to self-evacuate. However, unless there is a potential risk from explosion (eg, LPG cylinders) or spread of the fire, sheltering is likely to be more effective at protecting public health.

The evidence supporting this is largely from modelling, although Kinra et al (2005) found more symptoms were reported among those evacuated than among those sheltered in response to a large plastics factory fire, where partial evacuation of residents similarly exposed to the smoke plume occurred. This difference did not persist beyond two weeks. In this study, direct exposure to smoke was a more important determinant of illness (four or more symptoms) than 48-hour cumulative exposure.

Expert guidance in the United Kingdom favours sheltering over evacuation for chemical air pollution incidents, including fires. However, Baxter (2005) notes that the effects of low cumulative exposure to irritants on those with pre-existing respiratory disease needs to be studied following sheltering.

5.1 Aspects to consider when deciding whether to evacuate or shelter

Important aspects to consider when making a decision whether to shelter or evacuate people potentially exposed to a fire include:

- fire management:
  - likely duration of the event
  - controlled burning or fire fighting
- hazardous substances:
  - extent of health hazard (highly toxic, toxic, irritant; short-term versus long-term effects)
  - chemical and physical properties
  - quantity
- weather:
  - wind direction
  - rain
  - forecast
  - effect on plume movement and height
- topography:
  - effect on plume movement and height
- exposure:
  - distance from fire source of nearest houses
  - timing (already exposed, imminently, not for several hours)
  - likely duration (hours, days)

- population:
  - location
  - size
  - characteristics (eg, people with impaired mobility, elderly, those at special risk, such as on home dialysis or oxygen use)
  - residential facilities (eg, boarding school, rest home, hospital)
- time available to evacuate
- time of day
- transport availability.

Controlled burning minimises soil and water contamination because there is no run-off. Under favourable conditions it may also reduce air pollution due to more efficient combustion and dispersion. However, if the plume comes to ground there is a risk of short-term air pollution and soil and water contamination.

In contrast, fire-fighting with water or foam poses a risk of soil and water contamination from run-off, depending on containment measures. It may also reduce the combustion temperature, leading to more toxic air contaminants and reduced plume buoyancy, which can increase the ground-level impact (Health Protection Agency 2010).

Health effects may occur among evacuees from direct exposure to smoke and the psychological impact of evacuation.

5.2 Evacuation

Evacuation is preferable when the area is not yet exposed but will become exposed due to forecast wind direction, and the likely exposure duration means protection by sheltering may be insufficient. Evacuation may also be a better option if there is a:

- known or suspected highly toxic substance
- risk of explosion
- relatively small number of evacuees.

For evacuation to occur there must be sufficient time for people to:

- be informed (door-to-door, loud hailers, radio/TV)
- get essentials (eg, medication, baby supplies, pets, cash/cards)
- close all doors and windows
- secure their homes and leave.

It is more difficult to carry out evacuation effectively late at night or in the early hours of the morning. Note that evacuation must be to a sufficient distance away so that people will not have to be moved again if the wind changes.

The decision to authorise return depends on adequate information to support the conclusion that the area is safe. After a major fire this may require some environmental monitoring data. Decision-making also involves consideration of the negative health effects of evacuation (eg, the psychological impacts).

Criteria that need to be met before authorising the return of evacuees include:

- the incident is under control and is not expected to escalate
- residential premises are considered safe
- if necessary, environmental sampling and analyses have been completed
- advice has been provided about actions that should be taken on returning home, such as opening windows and doors to ventilate the house for an appropriate time
- advice has been provided about whom to contact if health effects develop (eg, Healthline, general practitioner).

It is not possible to include a list of chemicals with levels at which return is regarded as safe, due to the number of chemicals that could be involved. Ultimately the decision to allow return will be a matter of judgement, informed, if necessary, by discussion with the Institute of Environmental Science and Research Ltd (ESR). It will depend on the toxicity of the substances (where known), the existence of exposure pathways and the feasibility of any intervention to prevent exposure from a given pathway. In instances where samples have been taken and return has occurred before the results are available, the results will inform advice about the need for any protective actions to continue.

5.3 Sheltering

Sheltering is used when evacuation would cause a greater risk than staying put, or evacuation cannot be carried out. During sheltering, people are advised to stay indoors (with their pets), close all doors and windows, stay away from windows, and shut off ventilation, air conditioning and certain heating systems to prevent outside air entering indoors.

Depending on building airtightness, this usually results in a significant reduction in contaminant concentrations inside compared to outside for some hours, with the extent of protection depending on the ambient concentration (WHO 2009). Infiltration may be reduced 10 fold even in poorly airtight buildings, and this increases markedly by sealing windows and doors with tape, damp towels or newspaper. It will also be less in an interior room. People can be advised to breathe through a wet cloth over the face if the atmosphere inside becomes uncomfortable (Health Protection Agency 2009).

Residents need to have access to a radio and should be advised to remain tuned in to the local radio station for advice and information about changing conditions and when it is safe to leave the house and/or open windows. A help-line number should be provided.

6 Environmental sampling

6.1 When to consider collecting environmental samples

Environmental samples may be collected during a fire to identify and monitor air- and waterborne contaminants, or afterwards to determine if contamination of the surrounding area has occurred. Situations where environmental sampling may be appropriate include:

- a residential community is likely to be exposed to airborne contaminants
- the fire involved a large quantity of hazardous substances
- solid/visible contamination is present in a residential property, educational facility or parkland (eg, dust, ash or other debris from the fire, including burnt building materials)
- drinking-water supplies are likely to be affected by either airborne contaminants or run-off from the fire (ground, surface, roof, storage reservoirs)
- contamination of food (including home fruit and vegetable gardens, crops, grazing pastures and shellfish/waterways) is suspected
- asbestos-containing materials are present
- notification of an environmental poisoning has been received and/or people self-report with symptoms following a fire.

6.2 Where to collect samples

It is important to take samples at sites that are considered important because of potential human exposure to chemicals released, in addition to sites where the environment might have been affected. These include sensitive locations such as schools and early childhood centres, homes representative of the highest exposure, parks, playing fields, and home gardens where fruit and vegetables are ready for harvesting.

6.3 Preparing a sampling plan

Information needed to prepare a sampling plan

The sampling strategy will be incident specific, and in some cases samples will need to be collected under urgency on an *ad hoc* basis (eg, fire-fighting water run-off samples). However, if sampling after an incident, a sampling plan should be prepared before commencing sampling whenever possible.

A well thought-out sampling plan will ensure that samples are collected from appropriate locations using valid sampling and handling procedures. Table 3 lists the information needed to prepare a robust sampling plan. If you are sampling after the event has finished, some information may have already been collected as part of a Hazardous Substance Incident Report to the Environmental Protection Authority. In some cases the plume direction and likely deposition zones will need to be modelled prior to sampling, using modelling software.

Table 3: Information needed to prepare a sampling plan

Information required	Information sources
Facility information, including: • chemicals involved – type and amount • construction and age of building	• Site owner, operator or workers • Fire Service • Regional and city/district council (resource consent information)
• Type of fire • How was the fire extinguished (what agents were used?)	• Emergency services
Temperature of fire	• Fire Service • Building Research Association of New Zealand
Properties and toxicity of the chemicals involved	• National Poisons Centre TOXINZ database • TOXNET • EPA – HSNO Chemical Classification and Information database • ESR • Safety data sheets
Combustion products	• National Poisons Centre • Safety data sheets • ESR • See Table 1
Populations likely to be affected	• City/district council • Regional council • PHU • ESR can arrange plume modelling if necessary
Location of drinking-water sources • Storage reservoirs • Surface water • Ground water • Roof water	• Drinking Water Assessment Unit • City/district council • Regional council
Weather conditions	• Regional council • National Institute of Water & Atmospheric Research (NIWA) • MetService

Source: adapted from Watterson et al 1999

6.4 What samples should be collected?

Sample locations can be identified *ad hoc* following visual observation, focusing on sites within possible plume-grounding areas. Fires generate a plume, which may contain gaseous pollutants, smoke and relatively large particles. The dispersion of a plume from a warehouse or factory, although it can be calculated, is a relatively complex process.

Studies conducted to assess the dispersion from warehouse plumes have shown that only when the building has suffered partial structural collapse are large amounts of heat released and high plume buoyancies created. For structurally intact buildings, most fire plumes will be ground based with little plume rise.

The major factors that affect longer-range plume behaviour (over 1 km) are the heat release and the way the plume is distributed over the building. It should be noted that plumes from open-air fires will be buoyant (many hazardous substances at factories are stored in the open).

If safe to collect, environmental samples may include the following:

- at the time of fire (in order to identify products of combustion) – air sampling within the plume, under the plume and/or at plume grounding; fire-fighting water run-off samples if safe and feasible to collect
- after the fire is contained and controlled (in order to identify other contaminants, such as asbestos), collect from:
  - the fire site, including air, debris, and soil samples
  - the area of plume deposition, including window sill wipes and gutter run-off samples, particulate and debris, and soil samples.

Consider having samples that may be contaminated analysed urgently. Other samples may be held and only analysed if required. The type of substance tested for will depend on the characteristics of the building and the chemicals it contains. Occasionally, sampling may be done to address public concern (eg, in relation to asbestos).

6.5 Sample collection

Because sample collection may be urgent, and the results can be compromised by unsatisfactory sampling containers, a small collection of glass solvent-washed bottles (like those used for SVOCs) and zip-lock bags should be kept for emergencies. The number and types of samples to be collected will depend on the size and location of the fire and the hazardous substances involved.

ESR should be contacted for assistance with developing the sampling plan, sourcing sampling containers and determining the number of samples to be collected (telephone 03 351 6019; fax 03 351 0010). The UK publication *Chemical Accidents – Procedures: Environmental Sampling after a Chemical Incident*[7] contains general guidance on the number and types of samples to collect following an industrial fire. Sources of information on how to collect samples from specific types of fires are listed in Table 4.

For chemical advice support, contact 0800 CHEMFIND or 0800 243 622.

Remember: Do not put your or other people's safety at risk when collecting samples.

Whenever possible, collect background samples from areas known to be unaffected for comparison. Samples from background or control sites (ie, the samples likely to have the lowest levels of contamination) should be collected first to avoid cross-contaminating samples. Make sure you change gloves and either change or clean any sampling equipment between samples to avoid cross-contamination. Record a Global Positioning System location and take a photograph of each sampling site for future reference.

7 http://collections.europarchive.org/tna/20081108171408/

Air samples

Air quality falls within the responsibilities of the regional council, but depending on the expertise or resources of the area there is a high probability that guidance will be sought from the PHU. PHUs have some responsibilities for the overall assessment of risk in such situations, and for providing advice, to councils in particular, on management from a public health perspective.

The type of substance tested for will depend on the characteristics of the building and the chemicals it contains. Samples could be tested for a host of airborne contaminants, including VOCs,[8] PAHs, nitrogen oxides, sulphur, particulates, asbestos, and other contaminants of concern.

Water samples

Drinking-water samples

These should be collected using the protocols given in Chapter 10 ('Chemical compliance') of the *Guidelines for Drinking-water Quality Management for New Zealand* (Ministry of Health 2013). Sampling and analysis of registered community supplies are the responsibility of the water supplier. Groundwater-sourced supplies should be sampled more than once to ensure that any plume of contamination is identified. Water suppliers may need guidance from the drinking-water assessor or health protection officer. The regional council may hold information about the likely flow direction and flow rate for the area, which can be used to determine when to repeat the sampling.

Take care when designing a sampling plan for individual household supplies. If the house has a storage tank it is possible that the water in the tank may not yet have been affected by the fire. If there has been no rainfall since the incident, the downpipes should be disconnected immediately to avoid possible contamination of the whole supply. Run-off from the first rainfall should be run to waste and samples taken from this water to determine contaminant levels. (If possible, the roof should be washed down before rainfall and samples collected.) Once these have been determined to be satisfactory, the downpipe can be re-engaged. Any dust, ash or debris present on the roof or in the guttering should be sampled (see 'Dust (including soot) sampling' below).

In the case of surface water supplies, it may be more appropriate to sample the source rather than the storage tank. If there is any possibility of the source being contaminated, the water supplier needs to be notified and the intake shut down until monitoring shows that contaminant levels are within acceptable limits.

Fire-fighting water run-off

Samples of fire-fighting water run-off may be able to be collected to provide information on the types of contaminants that could contaminate ground and surface water. Fire-fighting run-off water is likely to contain a mixture of combustion products and residues of any chemicals present at the facility, as well as any additives used in fire fighting, such as foam. During the fire, much of the flame suppressant foams used could produce hydrogen fluoride due to thermal degradation.

---

8 The Fire Service hazmat/command vehicle may have a photo-ionisation detector (PID). This enables measurement of VOCs.

Soil samples

Soil samples should be collected following the protocols in *Contaminated Land Management Guideline No 5: Site investigation and analysis of soils* (Ministry for the Environment 2004). The sampling depth should be chosen with care to ensure that elevated concentrations present on the surface are not diluted by cleaner underlying soil. There is only limited information available on soil contaminant levels in urban areas in New Zealand, so background samples will also need to be collected for comparison.

Contaminated land is the responsibility of territorial authorities, but they may seek advice from the PHU.

Table 4: Sample collection guidelines

Sample type	Guideline	Source
Air		
Drinking-water	*Guidelines for Drinking-water Quality Management for New Zealand 2013*	Ministry of Health 2013 www.health.govt.nz/publication/guidelines-drinking-water-quality-management-new-zealand
Water	*Environmental Sampling after a Chemical Accident*	Department of Environment, Transport and the Regions (UK) 1999 www.defra.gov.uk/environment/chemicals/accident/sampling/pdf/chap13.pdf
Soil	*Contaminated Land Management Guideline No 5: Site investigation and analysis of soils* *Environmental Sampling after a Chemical Accident*	Ministry for the Environment 2004 www.mfe.govt.nz/publications/hazardous/contaminated-land-mgmt-guidelines-no5/index.html Department of Environment, Transport and the Regions (UK) 1999 www.defra.gov.uk/environment/chemicals/accident/sampling/pdf/chap13.pdf
Dust wipes	*The Environmental Case Management of Lead-exposed Persons: Guidelines for public health units* (revised edition)	Ministry of Health 2007 www.moh.govt.nz/moh.nsf/indexmh/environmental-case-management-lead-exposed-persons?Open
Deposition or sweep samples	*New Jersey Department of Environmental Protection Field Sampling Procedures Manual* *Environmental Sampling after a Chemical Accident*	New Jersey Department of Environmental Protection 2005 www.state.nj.us/dep/srp/guidance/fspm/pdf/chapter06d.pdf Department of Environment, Transport and the Regions (UK) 1999 www.defra.gov.uk/environment/chemicals/accident/sampling/pdf/chap13.pdf

Dust (including soot) sampling

Dust wipes

Dust wipes can be collected following the protocols given in *The Environmental Case Management of Lead-exposed Persons: Guidelines for public health units* (Ministry of Health 2007). Commercially available 'wet wipes' should only be used to collect metal samples. The choice of wipe material for organic contaminants will need to be discussed with the laboratory beforehand. For organic contaminants, or where the contaminants are unknown, use either a non-medicated sterile wrapped gauze pad or a tissue moistened with water. Unused wipe material from the same batch should also be sent to the laboratory for blank analyses. Measure the approximate size of the sampled area.

Sweep sampling

Sweep sampling can be used to collect dust and ash from surfaces, and possibly guttering. Sweep the residue onto a clean piece of photocopy paper or aluminium foil and transfer into the container. Further details on collecting sweep samples are provided in the *New Jersey Department of Environmental Protection Field Sampling Procedures Manual* (New Jersey Department of Environmental Protection 2005). Measure the area sampled. If the material is wet, a clean dedicated metal spoon can be used to collect samples into a sample container.

Asbestos-containing materials (ACM)

Older buildings are commonly clad with ACM. Materials that contain asbestos deteriorate during fire, releasing asbestos fibres into the air. Asbestos must be identified urgently. Do not let untrained and unprotected staff remove debris. In cases where there is a potential for public health risk, the PHU should collect and send samples to Capital Environmental Services Ltd (CES) (telephone 04 566 3311, fax 04 566 3312). CES should be contacted for advice on how to sample and the number of samples to collect.

In an emergency CES will provide advice and, if necessary, the Ministry will authorise their scientists to make site visits, as occurred at the former Patea freezing works asbestos fire. The Ministry operates a formal on-call service, so for emergency responses telephone 0800 GET MOH.

Appendix 1 of this document should be read in conjunction with these guidelines for dealing with fires involving asbestos-containing materials.

6.6 Analysis suites (water, soil, dust wipes, air)

The choice of analyses will vary depending on the type and quantities of hazardous substances involved in the fire. Common analytical tests are listed in Table 5. Contact ESR prior to collecting samples (telephone (03) 351 6019; fax (03) 351 0010). ESR will provide advice on the appropriate sampling suite, arrange for the appropriate sample containers if sampling is non-urgent, and confirm whether the analyses will be covered under the Ministry of Health funded 'supporting local needs' service.

6.7 Sample transport and storage

Advice should be sought from the analytical laboratory on appropriate sample transport and storage. Generally, all samples should be kept cool and out of direct sunlight. Each sample container should be placed in a separate zip-lock bag to avoid cross contamination, either through direct contact with another sample or through leaks from a sample container. Keep samples likely to be highly contaminated separate from other samples. Check that all the labels are correct before submitting the samples for analysis.

6.8 Ambient air monitoring

In New Zealand there is only a limited amount of equipment available to monitor air quality during a fire. Regional councils may have portable equipment that could be used. Some industries may also undertake routine monitoring. It is possible that, in some cases, depending on the location of the fire, data could be obtained from regional council air quality monitoring stations[9] and any other sites in close proximity undertaking air quality monitoring for resource consent compliance.

Filters from the intakes of ventilation systems in adjacent buildings may be able to be analysed to provide an indication of what particulate materials people may have been exposed to during a fire. If filters are collected for analysis, information on the type and make of filter, the installation date and the flow rate of air through the filter will be needed.

If portable monitoring equipment is used to monitor ambient air quality, collect the sample(s) only from the edge of the evacuation zone. **Do not attempt to move closer to the fire without the correct protective clothing. If samples are needed from nearer a fire or from within a smoke plume, discuss with the incident controller how this can be achieved (eg, a fire fighter in full personal protective equipment may be able to obtain the sample).**

9 Ambient air monitors generally only measure PM_{10}, so larger particles will not be collected. Also, volatiles will be lost from the filter. Ambient dust monitors are not suitable for this type of sampling.

Table 5: Possible analytical tests according to sample type

Analysis suite	Water	Soil	Dust wipes	Air	Notes
Metals	✓	✓	✓	✓	Analysis suite will depend on the chemicals involved in the fire.
VOCs	✓			✓	VOCs are unlikely to persist in soil and dust samples.
SVOCs	✓	✓	✓		
Major ions	✓				Major ions are only of health significance in drinking-water.
pH	✓				
Pesticides	✓	✓	✓	✓	Only necessary if pesticides are involved in the fire.
Chlorinated organics (eg, dioxins)		?	?	✓	Will depend on the size of the fire and the chemicals involved.
PAHs	✓	✓		✓	Will depend on the size of the fire and the chemicals involved.
Particulates, SO_2, NOx, total fluoride*				✓	Will depend on the size of the fire and the chemicals involved.

* Total fluoride is used as a proxy measure of gaseous and particulate hydrogen fluoride that may have been released during the fire.

Notes:

1 Dioxins and PAHs can be present unless the combustion involves only 'clean' material (eg, wood).

2 VOCs = volatile organic compounds; SVOCs = semi-volatile organic compounds; PAHs = polycyclic aromatic hydrocarbons; SO_2 = sulphur dioxide; NO_x = oxides of nitrogen.

6.9 Interpreting the sampling results

Guidelines and standards that can be used to assist with the interpretation of sampling results are listed in Table 6. Air quality data can be compared against ambient air quality guidelines, national environmental standards and the US *Acute Exposure Level Guidelines*.[10] The *Acute Exposure Level Guidelines* (AEGL) are designed to protect the public (including susceptible populations) from acute exposure in an emergency for five exposure periods, ranging from 10 minutes to eight hours. There are three concentration levels (AELG-1, AELG-2 and AELG-3), based on the severity of effects (reversible irritation or discomfort, or asymptomatic non-sensory effects; serious or irreversible effects, or impaired ability to escape; life-threatening effects or death) for each exposure period. Other Guidelines can also be used, such as the Emergency Response Planning Guidelines (ERPGs),[11] which are levels designed to protect nearly all individuals below which certain health effects are not expected when exposed for up to one hour (ERPG-1, ERPG-2 and ERPG-3). Temporary Emergency Exposure Limits (TEELs)[12] are levels set to protect the general population, including susceptible populations above which certain health effects are not expected when exposed for longer than one hour (TEEL-1, TEEL-2, TEEL-3). TEELs are intended for use until AEGLs or ERPGS are adopted for chemicals.

[10] www.epa.gov/opptintr/aegl/pubs/chemlist.htm

[11] https://www.aiha.org/get-involved/AIHAGuidelineFoundation/EmergencyResponsePlanningGuidelines/Documents/2013ERPGValues.pdf

[12] http://response.restoration.noaa.gov/teels

Table 6: Guidelines and standards for interpreting sampling results

Sample type	Guideline	Source
Water	*Drinking-water Standards for New Zealand 2005 (Revised 2008)*	Ministry of Health 2008 http://www.health.govt.nz/publication/drinking-water-standards-new-zealand-2005-revised-2008
Soil*	*Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011* (the NES) *Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health*	New Zealand Legislation http://legislation.govt.nz Ministry for the Environment www.mfe.govt.nz/publications/hazardous/deriving-standards-for-contaminants-in-soil/methodology-for-deriving-standards-for-contaminants-in-soil.pdf
Dust wipes	*World Trade Center Indoor Environmental Assessment: Selecting contaminants of potential concern and setting health-based benchmarks* (May 2003)	United States Environmental Protection Agency www.epa.gov/wtc/copc_benchmark.pdf
Air	*Acute Exposure Guideline Levels* (AEGLs) Emergency Response Planning Guidelines (ERPGs) Temporary Emergency Exposure Limits (TEELs)	United States Environmental Protection Agency www.epa.gov/opptintr/aegl/pubs/chemlist.htm https://www.aiha.org/get-involved/AIHAGuidelineFoundation/EmergencyResponsePlanningGuidelines/Documents/2013ERPGValues.pdf http://response.restoration.noaa.gov/teels

* The NES came into effect on 1 January 2012.

Additional site history information may need to be collected to assist with interpretation, because in some cases previous activities in an area may have also been contributing sources. For example, elevated concentrations of lead and PAHs are likely to be found in old urban areas, and their presence in dust wipes may not be due to a fire. Regional and city/district council staff may be able to provide additional information that could help to interpret the results.

7 Communication

7.1 During the fire

Crisis and emergency risk communication requires decisions to be made within a short timeframe. These decisions may be irreversible and have an uncertain outcome, and information may be incomplete (Reynolds 2002). The STARC Principle (WHO 2009), which covers the elements of successful communication, is useful to consider when developing risk communication messages:

- **S**imple — people want to hear words they understand
- **T**imely — people want information as soon as possible
- **A**ccurate — people want to-the-point information
- **R**elevant — responses to questions should be factual
- **C**redible — openness is essential to credibility.

Appendix 2 contains two resources developed by the Centers for Disease Control and Prevention for crisis and emergency risk communication: *Message Development for Emergency Communication* and *You're the Spokesperson – What You Need to Know* (Reynolds 2002).

The initial public health communication should include:

- the nature of the fire
- who is (and is not) currently under threat
- evacuation orders and routes, or 'go in, stay in, tune in'
- the measures being taken to contain and/or extinguish the fire
- hazards, exposure pathways, protective actions
- how to get further information
- when an information update will be given.

Examples of health messages are contained in Appendix 3.

7.2 After the fire

It is important to assess public concerns about possible environmental contamination and their personal exposure, because these may indicate a need for further investigation and will guide the presentation of results to show that people's concerns have been addressed.

Immediately after the fire a health information sheet may be useful for residents. This may give advice on topics including (where relevant):

- house cleaning, including surface soot/dust removal (wet wiping rather than sweeping, vacuum cleaner with HEPA filter)
- drinking-water, if sourced from roof water or a bore (if ground water is potentially contaminated)
- home-grown fruit and vegetables
- gathering of puha or watercress
- recreational water use
- how to get further information
- what to do if symptoms or health concerns arise.

Consider how to most effectively get this information to residents. For example, attaching the leaflet to the front door may be more effective for evacuees returning home than placing it in the mailbox. It may also be necessary to hold a public meeting in association with other key agencies (eg, local government in the recovery stage).

8 Health monitoring

Whether any form of health monitoring occurs or not is a matter of judgement, and will depend on the scale of the fire and the potential (including public perception) for significant population exposure. Health monitoring can be initiated in the response or recovery stage of the incident.

8.1 Immediate health effects

Immediate symptoms may indicate either high exposure or high toxicity. The most common signs and symptoms of acute chemical exposure are non-specific, such as nausea, vomiting, headache, skin irritation, eye irritation, fatigue, respiratory symptoms, and central nervous system symptoms.

There are two main types of effects:

- syndromic conditions (eg, symptoms of respiratory irritation such as cough, sore throat/ nose)
- exacerbation of pre-existing diseases (eg, asthma, angina).

Data sources for the type of condition and outcome include:

- ambulance attendances
- general practice or accident and medical clinic attendances
- emergency department attendances
- Healthline calls.

Existing systems can be used to assess the fire's immediate impact as well as an alert for emerging acute health issues. Analysis of effects other than those directly related to the fire (eg, burns and smoke inhalation) require comparative information, which can be from the same population if pre-fire data are available. Alternatively, differences in exposure (eg, based on distance) within the same population could be looked at.

Health monitoring in the recovery stage, such as a survey, can be carried out in response to community concerns about exposure and ill health. Issues that need to be considered before monitoring is undertaken in this situation are:

- community expectations about monitoring resolving causation or detecting subtle effects (which are influenced by population size, biases, control or reference group availability, and the availability of outcome data for a control period)
- confidentiality of information
- how and when information will be made available to the participants
- interpretation of information (at individual and group levels) if any testing (eg, lung function) is carried out
- how information will be used (Department of Health and Ageing and enHealth Council 2002).

Suggested content for inclusion in a questionnaire is given in Appendix 4.

8.2 Long-term health effects

The assessment of possible chronic effects among the exposed population is likely to require an epidemiological study and is outside the scope of these guidelines. Such effects would be determined by the mix of chemicals, timing and duration of exposure, and proximity to the fire. Issues such as statistical power would need to be taken into consideration. Those on site (likely to be workers) and first responders will be at greatest risk of exposure. Any occupational health investigation would be the responsibility of the WorkSafe New Zealand.

Long-term health effects may also include mental health effects relating to the experience of a major fire.

9 Resources and sources of information

Resources and sources of information that may be useful for managing the public health risks from major fires include:

- maps – including Google satellite view (http://maps.google.co.nz)
- geographic information systems (GIS) – these provide a clearer picture to aid in risk assessment (eg, to plot the fire location, direction of plume, sensitive locations, evacuation zone; to estimate the population living within certain distances of the fire and potentially within the plume; or to map demographic factors such as age)
- the Fire Service hazmat/command vehicle – this will have online access to databases
- the CHEMFIND – all PHUs have free online access
- the TOXINZ National Poisons Centre – some PHUs have free online access
- the Environmental Protection Authority – the HSNO Chemical Classification and Information database is available online
- TOXNET http://toxnet.nlm.nih.gov – eg, the Hazardous Substances Data Bank (HSDB), which gives toxicological information on about 5000 chemicals
- air dispersion modelling – this takes account of wind speed and direction to predict plume movement, and can then be used to define the population potentially exposed to airborne contaminants and to provide estimates of the number of people exposed to certain levels of contaminants (if necessary, this can be arranged through ESR).

Appendix 1: Public health aspects arising from a fire involving asbestos containing materials: fact sheet for Public Health Units

Following a number of fires that involved asbestos-containing materials, public health staff requested a fact sheet on the public health issues that may arise from such fires. Dr Naty Foronda has prepared the following information, in consultation with Dr Richard Hoskins, David de Jager and Linda Dwyer, a scientist at Capital Environmental Services Ltd (the asbestos lab).

The development of this fact sheet was prompted by the Taranaki Patea freezing works fire. Although the local public health unit managed the situation very well, it became evident that very limited information is available on the potential public health consequences when dealing with fires involving asbestos-containing materials (ACM). The following information will assist public health units when dealing with such large-scale fires.

Thermal stability of asbestos

Asbestos was widely used because of its fire-resistant properties. However, it is not thermally stable when exposed to high temperatures. Chrysotile (white asbestos) decomposes at 800–850°C and the amphiboles ((crocidolite (blue) and amosite (brown) asbestos)) at 800–1000°C. Asbestos fibres will readily be converted to dust at prolonged exposure to such temperatures. In sheet form asbestos does not offer any fire resistance and it cracks in building fires. In a fire asbestos cement sheeting will disintegrate and can explode, releasing fibres over a wide area, mostly in the direction of the prevailing wind.

Effect of fire on asbestos fibre contamination

The effect of fire on asbestos fibre contamination was investigated and the following conclusions were drawn:

> Fire can change the mineral structure and mechanical strength of asbestos, fixing the fibres and transforming it to a less hazardous state. The process will generally affect only the outer layers leaving most fibres intact within the material. Internal fibres in a fibre bundle will be unaffected due to the insulating quality of the mineral.

A study was commissioned by the Victorian Department of Human Services to examine the concentrations of respirable fibres away from the incident site, ie, fire location using a computational fluid dynamics programme designed to simulate fires of varying sizes. Fires within buildings comprising substantial quantities of ACM do not result in hazardous conditions with respect to respirable asbestos fibres either close to the building or away from the building. This is true of fires involving asbestos cement sheet only.

Friable asbestos with in a fire does give off respirable sized fibres, such as the Broadcasting House fire.[13]

Sampling of the ash residue after the CESARE building test fire, respirable asbestos fibres were not found in the ash, however asbestos fibre bundles were present. These fibre bundles, while in their bundled form, are not respirable, however they could become respirable fibres through the clean-up process if the fibre bundles are exposed to further mechanical degradation. Therefore subsequent to a fire, the asbestos fibre bundles in the ash debris should be treated in the same manner as ACM during the clean-up process. Respirable fibre concentrations emitted by the fire were very low. The levels appear to be lower than average background levels. Plume modelling was used in determining the dispersion of respirable asbestos fibres away from a fire location which demonstrated that in this particular test, respirable fibre concentrations close to the fire were extremely small. Concentrations reduce further away from the fire being, theoretically, orders of magnitude lower.

Exposure of the general population

People resident in the area, may be exposed following a fire involving materials containing asbestos. Sources of exposure include:

- direct inhalation of asbestos in the original plume
- inhalation of asbestos fibres resuspended into the air (eg, wind driven or a result of mechanical processes) following deposition on the ground or other surfaces
- ingestion of local produce.

The degree of exposure of the general public will depend upon the concentration of asbestos in the air (directly from the plume during the fire or as a result of re-suspension following fire) and subsequent actions of the public and authorities. For example, rapid removal of significant fallout will reduce the potential for significant re-suspension exposures of the general public although it may result in exposures to staff involved in clean-up.

[13] Broadcasting House, a multi-purpose broadcasting centre on Bowen Street, Wellington, New Zealand, was caught by fire in 1997.

Mitigating factors against significant exposures of the general public following a fire involving ACM

- Not all the ACM present may be involved in the fire.
- Fibres may be entrapped in large pieces of material, etc.
- During a fire, most asbestos cement sheeting will be deposited as large pieces.
- Respirable fibres will be a fraction of the total released.
- Small proportion of fibres may be 'denatured' at prolonged exposure to high temperatures in large scale fires.
- Atmospheric dispersion and deposition (particularly as a result of rain) will reduce concentrations.[14]
- Duration of exposure will be short dependent on the type of ACM present.

Acute adverse health effects

Thermal injury or smoke inhalation is generally the most likely potential acute effect from large scale fires. Asbestos may produce irritation of the skin, eyes and respiratory tract due to mechanical action of the fibres. However this only occurs at very high air concentration levels well beyond those that members of the public would likely to encounter from a fire.

Respiratory symptoms were reported by people who have been exposed in asbestos fire. However there is no hard evidence to suggest a severe acute health impact consequent on a fire incident associated with asbestos-containing fallout. Despite the lack of hard evidence of an acute health impact, it is important that health professionals are aware of the potential for patients to associate symptoms with such incidents.

Long-term adverse health effects

There is no direct evidence of long-term health risks from fires involving ACM, although the literature in this area is limited. Considering the available evidence on asbestos exposures from fires involving ACM in the context of the results of epidemiological studies of occupational and environmental asbestos exposures, it is concluded that the risk of long-term health effects (mesothelioma and lung cancer) are minimal if appropriate clean-up procedures occur.

Evacuation

The usual first course of action is to 'shelter in place' unless directly threatened by fire in which case fire officers will direct evacuation. If evacuation has taken place for health reasons, the Medical Officer of Health and/or Health Protection Officer will determine when to advise residents that it is safe to return home.

---

14 A survey was conducted in Wellington a few years ago on cement sheet roofing and fibre run-off with rainwater. This was conducted over a 12-month period using encapsulated asbestos roofs, a blank and an un-encapsulated roof. Using Scanning Electron Microscope, the fibre run-off with rain water was found to be in the region of 13 million fibres per litre of water with little observed difference to the results between roof type. One blank of 12 indicated more fibre when compared with the samples after a particular month of exposure. The increase was found to be due to an asbestos cement roof further down the road being removed and replaced that particular month.

Laboratory analysis

The presence of asbestos in materials cannot be determined definitively by visual inspection. Actual determination can only be made by instrumental analysis, eg, polarised light microscopy, transmission electron microscopy or scanning electron microscopy. It is best to assume that the material contains asbestos until laboratory analysis proves otherwise.

Collect and send samples to Capital Environmental Services Ltd (2–4 Bell Road South, Gracefield, Lower Hutt, phone 04-566 3311, fax 04-566 3312) for asbestos analyses to confirm the presence and type of asbestos. Laboratory staff would be able to provide advice on how many samples should be collected for testing and how should these be collected. If necessary, a scientist from the laboratory would be sent to the affected area to provide assistance.

In general air sampling carried out following asbestos fires will not reveal significant levels of asbestos fibres. Therefore in many cases it will not be necessary to carry out such monitoring. Monitoring may however be appropriate after large incidents for public reassurance purposes. This is a decision that should be made on a case-by-case basis.

At the earliest opportunity after results are known, they should be made public so that members of the public are fully aware of the situation and can make an informed decision.

Effect of watering

Dependent on water pressure, it is important to note that the addition of water will not result in the further degradation of any asbestos fibre bundle. In particular it has been shown that the application of water is very effective in reducing the likelihood of asbestos fibres from becoming respirable in soils and sands. Land contamination issues are possible as a result of water washing asbestos fibre bundles or pooling water in an area (as a result of a fire in the area). In case of asbestos cement products, it is unlikely that the asbestos bundles would be sufficient in terms of fibre size and form to generate respirable dust cloud particles, when the water has evaporated. It could be an issue for lagging and friable material as there can be incidences of rainwater puddles from asbestos cement roof leaks that contain significant amounts of friable asbestos.

Clean-up operations within the building should be performed in accordance with the WorkSafe NZ requirements. The application of water will further reduce any exposure risk to nearby personnel working in the area, since wetting down the debris after a fire reduces the risk of respirable asbestos becoming airborne. However, it should be borne in mind that amosite repels water quite well. So if large amounts of friable amosite are present watering will have little effect.

Handling asbestos materials is a specialist task requiring appropriate training and equipment, including personal protective equipment (PPE). There is the potential for the workers involved to be exposed during the process.

Conclusions

The mere presence of asbestos in buildings or in ash/rubble does not necessarily pose a health risk to building occupants or the public. Asbestos fibres of respirable size must become airborne in sufficient concentration to pose a risk from inhalation.

Exposure of members of the public during and in the aftermath of a fire involving ACM is expected to be minimal if appropriate clean-up operations are undertaken. Thus the potential for long-term environmental exposure and the associated risk will be minimal. That said, this is dependent on what the ACM in the fire is. If it is lagging the whole scenario would be different.[15]

Some members of the public perceive a greater risk from large scale fires involving asbestos than is actually the case, and this should be taken into consideration when devising and issuing public warnings.

Prepared by the Environmental and Border Health Protection Group, Population Health Directorate, Ministry of Health, 29 July 2008.

Bibliography

Bridgman SA. 1999. Lessons learnt from a fire associated with asbestos-containing fallout. *Journal of Public Health Medicine* 21(2): 158–65.

Bridgman SA. 2000. Acute health effects of a fire associated with asbestos-containing fallout. *Journal of Public Health Medicine* 22(3): 400–5.

Bridgman SA. 2001. Community health risk assessment after a fire with asbestos containing fallout. *Journal of Epidemiology and Community Health* 55: 921–7.

Smith KR, Saunders PJ. 2007. *The Public Health Significance of Asbestos Exposures from Large Scale Fires*. London: Health Protection Agency.

Victorian State Government, Department of Human Services. 2006. *Report on the Investigation of the Effect of Fire on Asbestos Fibre Contamination*. Melbourne, VIC: Noel Arnold & Associates Pty Ltd. URL: www.health.vic.gov.au/environment/community/asbestos.htm

[15] Air tests taken, in windy conditions, for a few weeks after the Broadcasting House fire in 1997 showed large amounts of airborne asbestos fibre. The fibre had been distributed over a very large area by the smoke plume. This included inside buildings with open windows and on far sides of high rise in the vicinity of the fire. Some of this fibre had been heat altered, but this was only a very small portion of what was collected by dust wipes.

Appendix 2: Centers for Disease Control and Prevention's resources for crisis and emergency risk communication

This appendix reproduces copies of *Message Development for Emergency Communication and You're the Spokesperson – What you Need to Know* (Reynolds 2002).

Message development for emergency communication

First, consider the following:

Audience	Purpose of message	Method of delivery
• Relationship to event • Demographics (age, language, education, culture) • Level of outrage (based on risk principles)	• Give facts/update • Rally to action • Clarify event status • Address rumours • Satisfy media requests	• Print media release • Web release • Through spokesperson (TV or in-person appearance) • Radio • Other (eg, recorded phone message

Six basic emergency message components

1. **Expression of empathy**:

____

____

2. **Clarifying facts/call of action**:

Who____

What ____

Where ____

When____

Why____

How____

____

3. **What we don't know**: ____

4. **Process to get answers**:____

5. **Statement of commitment**: ____

6. **Referrals**: ____

For more information: ____

Next scheduled update:____

Finally, check your message for the following:

Positive action steps Honest/open tone Applied risk communication principles Test for clarity Use simple words, short sentences	Avoid jargon Avoid judgmental phrases Avoid humour Avoid extreme speculation

You're the spokesperson – what you need to know

CRISISEMERGENCY **RISKCOMMUNICATION** **Build trust and credibility by expressing:** • Empathy and caring • Competence and expertise • Honesty and openness • Commitment and dedication **Top tips:** • Don't over reassure • Acknowledge uncertainty • Express wishes ("I wish I had answers") • Explain the process in place to find answers • Acknowledge people's fears • Give people things to do • Ask more of people (share risk). **As a spokesman:** • Know your organisation's policies • Stay within the scope of responsibilities • Tell the truth, be transparent • Embody your agencies identity **CONSISTENT MESSAGES ARE VITAL**	**Prepare to answer these questions** • Are my family and I safe? • What can I do to protect myself and my family? • Who is in charge here? • What can we expect? • Why did this happen? • Were you forewarned? • Why wasn't this prevented? • What else can go wrong? • When did you begin working on this? • What does this information mean? **Stay on message** • What's important is to remember ..." • "I can't answer that question, but I can tell you ..." • "Before I forget, I want to tell your viewers ..." • "Let me put that in perspective ..." **BE FIRST, BE RIGHT, BE CREDIBLE**

Appendix 3: Examples of health information for the public

Smoke contains particles, gases and water vapour.

Soot is basically carbon dust, although it may contain some irritant chemicals.

Smoke may irritate the eyes, nose, throat and airways. Symptoms can include runny or sore eyes, dry or sore throat, sore nose, cough, tightness of the chest or difficulty breathing.

The small particles in smoke are more harmful than the larger particles because they can be inhaled deep into the lungs.

In healthy people, most symptoms disappear soon after exposure to smoke ends and do not cause long-term health problems. If your symptoms persist, phone Healthline (0800 611 116) for free 24-hour health advice or see your doctor.

Smokers, the elderly, children and those with heart disease, asthma or other lung disease are at greatest risk of harm from smoke inhalation. Avoid exposure if possible.

Outdoors exercise such as jogging causes you to breathe more deeply and inhale more small particles. Small particles are more harmful.

If you have asthma, lung or heart disease, seek medical help if your symptoms worsen and do not respond to your usual measures, or if you experience breathlessness or chest pain.

If you did not experience any symptoms at the time you were exposed to the smoke, you are very unlikely to have any long-term health effects.

Appendix 4: Checklist for health questionnaire content

Demographic information

Name
Address
Phone number
Date of birth
Age
Sex

Exposure information

Date of exposure
Address where exposed (indoors, outdoors)
Duration of exposure (indoors, outdoors)

Consider whether exposure pathways other than inhalation are relevant and need to be included.

Health effects

Symptom date of onset
Immediate or delayed (how long) symptom onset after exposure
Symptom duration
Symptom list:

- nausea
- headache
- dizziness/lightheadedness
- drowsiness
- skin rash
- eye irritation
- nose irritation
- sore throat
- shortness of breath
- cough
- wheeze
- chest pain/tightness
- other (please state)

Potential risk factors

Asthma
Chronic obstructive respiratory disease
Bronchitis
Angina
Heart disease other than angina
Cigarette smoker
Hay fever
Eczema

Action taken and outcome

No treatment
Self-treatment (what)
Phoned Healthline, outcome of call
Saw GP, outcome of GP visit
Went to emergency department, outcome

Hospital admission

Date of admission
Diagnosis
Duration of stay

References

Baxter PJ. 2005. Commentary: Evacuation decisions in chemical incidents benefit from expert health advice. *British Medical Journal* 330: 1474–5. URL: www.ncbi.nlm.nih.gov/pmc/articles/PMC558453

Bhargava A, Dlugogorski BZ, Kennedy EM. 2002. Emission of polyaromatic hydrocarbons, polychlorinated biphenyls and polychlorinated dibenzo-*p*-dioxins and furans from fires of wood chips. *Fire Safety Journal* 37: 659–72.

Dennekamp M, Abramson MJ. 2011. The effects of bushfire smoke on respiratory health. *Respirology* 16: 198–209. URL: http://onlinelibrary.wiley.com/doi/10.1111/j.1440-1843.2010.01868.x/pdf

Department of Environment, Transport and the Regions (UK). 1999. *Environmental Sampling after a Chemical Accident 1999*. URL: http://collections.europarchive.org/tna/20081108171408/

Department of Health and Ageing and enHealth Council. 2002. *Environmental Health Risk Assessment: Guidelines for assessing human health risks from environmental hazards*. Canberra, ACT: Department of Health and Ageing and enHealth Council. URL: www.health.gov.au/pubhlth/strateg/envhlth/risk/

Ergut A, Levendis YA, Carson J. 2007. Emissions from the combustion of polystyrene, styrene and ethylbenzene under diverse conditions. *Fuel* 86: 1789–99.

Health Protection Agency. 2002. *Products of Combustion: Draft summary information*. London: Health Protection Agency, Chemical Hazards and Poisons Division. URL: www.who.int/ipcs/emergencies/products_of_combustion.pdf

Health Protection Agency. 2009. *Sheltering or Evacuation Checklist*. London: Health Protection Agency, Centre for Radiation Chemical and Environmental Hazards. URL: www.hpa.org.uk/web/HPAwebFile/HPAweb_C/1194947308210

Health Protection Agency. 2010. *Chemical Hazards and Poisons Report* 18. London: Health Protection Agency, Centre for Radiation, Chemical and Environmental Hazards. URL: www.hpa.org.uk/web/HPAwebFile/HPAweb_C/1287142798000

Kinra S, Lewendon G, Nelder R, et al. 2005. Evacuation decisions in a chemical air pollution incident: cross sectional survey. *British Medical Journal* 330: 1471–4. URL: www.ncbi.nlm.nih.gov/pmc/articles/PMC558452/?tool=pubmed

Ministry for the Environment. 2004. *Contaminated Land Management Guideline No 5: Site investigation and analysis of soils*. Wellington: Ministry for the Environment.

Ministry for the Environment. 2011. *Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health*. Wellington: Ministry for the Environment. URL: www.mfe.govt.nz/publications/hazardous/deriving-standards-for-contaminants-in-soil/methodology-for-deriving-standards-for-contaminants-in-soil.pdf

Ministry of Health. 2008. *Drinking-water Standards for New Zealand 2005. revised 2008.* Wellington: Ministry of Health.

Ministry of Health. 2013. *Guidelines for Drinking-water Quality Management for New Zealand 2013*. Wellington: Ministry of Health.

Ministry of Health. 2007. *The Environmental Case Management of Lead-exposed Persons: Guidelines for public health units*. Wellington: Ministry of Health.

Ministry of Health. 2010. *Guidelines for the Remediation of Clandestine Methamphetamine Laboratory Sites*. Wellington: Ministry of Health.

Ministry of Health. 2013. *The Management of Asbestos in the Non-occupational Environment: Guidelines for public health units*. Wellington: Ministry of Health.

New Jersey Department of Environmental Protection. 2005. *New Jersey Department of Environmental Protection Field Sampling Procedures Manual*. Trenton, NJ: New Jersey Department of Environmental Protection. URL: www.state.nj.us/dep/srp/guidance/fspm/

North Carolina Department of Health and Human Services. (nd.). *Clandestine Methamphetamine Laboratories Information and Safety Sheet: Injury prevention for first responders, firefighters, law enforcement*. Raleigh, NC: North Carolina Department of Health and Human Services, Occupational and Environmental Epidemiology Branch. URL: www.epi.state.nc.us/epi/oii/pdf/methlab.pdf

Office of the State Fire Marshal. 2004. *Rings of Fire Revisited: Tire fire prevention and suppression*. Office of the State Fire Marshal, State of California. URL: http://osfm.fire.ca.gov/pdf/regulations/StudentManual.pdf

Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011. URL: http://legislation.govt.nz

Reynolds B. 2002. *Crisis and Emergency Risk Communication*. Atlanta, GA: Centers for Disease Control and Prevention. URL: http://emergency.cdc.gov/cerc/pdf/CERC-SEPT02.pdf

Shibamoto T, Yasuhara A, Katami T. 2007. Dioxin formation from waste incineration. *Reviews in Environmental Contamination and Toxicology* 190: 1–41.

Wang J, Levendis YA, Richter H, et al. 2001. Polycyclic aromatic hydrocarbon and particulate emissions from two-stage combustion of polystyrene: The effect of the primary furnace temperature. *Environmental Science and Technology* 35: 3541–52.

Watterson J, Halliwell C, Meharg A, et al. 1999. *Environmental Sampling after a Chemical Accident*. London: Department of Environment, Transport and the Regions (UK). URL: http://collections.europarchive.org/tna/20081108171408/

WHO. 2009. *Manual for the Public Health Management of Chemical Incidents*. Geneva: World Health Organization. URL: http://whqlibdoc.who.int/publications/2009/9789241598149_eng.pdf