The Investigation and Surveillance of Agrichemical Exposures

Guidelines for Public Health Officers

October 2024

Te Kāwanatanga o Aotearoa
New Zealand Government

Health New Zealand
Te Whatu Ora

Citation: Health New Zealand | Te Whatu Ora. 2024. *The Investigation and Surveillance of Agrichemical Drift Exposures: Guidelines for Public Health Officers*. Wellington: Health New Zealand | Te Whatu Ora.

Published in October 2024 by Health New Zealand | Te Whatu Ora
PO Box 793, Wellington 6140, New Zealand

ISBN 978-1-991139-12-2 (online)

Health New Zealand
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This document is available at **tewhatuora.govt.nz**

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Purpose and scope

These guidelines are to assist public health officers to investigate complaints of illness associated with exposure to off-target applications of agrichemicals.

The guidelines support public health officers to assess and understand the potential public health risks of agrichemicals widely used in Aotearoa New Zealand.

In addition to the overview covered in the body of the guidelines, further reference material has been included to provide more specific information about particular agrichemical substances or hazards. In these guidelines, agrichemicals are considered to include chemicals used in a primary industry context or on Department of Conservation land.

Key terms

The Environmental Protection Authority's (EPA) Hazardous Substances (Hazardous Property Controls) Notice 2017 defines an **agrichemical** as a substance used or intended for use in the direct management of plants and animals, or to be applied to the land, place, or water on or in which the plants and animals are managed, for the purposes of:

(a) managing or eradicating pests, including vertebrate pests; or

(b) maintaining, promoting, or regulating plant or animal health, productivity, performance or reproduction; or

(c) enhancing the effectiveness of an agrichemical used for the treatment of plants or animals; or

(d) mitigating environmental, sustainability, or climate change impacts;

and for the avoidance of doubt:

(a) includes any veterinary medicine, pesticide adjuvant, fertiliser, plant growth regulator, fumigant or domestic pesticide; and

(b) excludes any timber treatment chemical, antisapstain chemical and antifouling paint.

Agrichemicals are widely used across New Zealand. Agrichemical formulations can disperse beyond the intended application area as volatiles, droplets, or dust particles. The public may be unintentionally exposed by overspray or agrichemical formulations drifting from the intended application area. Due to their mode of application, incidents of drift are most often associated with plant protection products.

These guidelines focus on ways to assess potential acute risks posed to the public by agrichemical drift, with a particular focus on plant protection products, and to outline the responsibilities of public health officers in dealing with complaints or related issues.

Drift or **spray drift** is the aerial movement of an agrichemical beyond the site of its application, particularly through atmospheric movement of aerosol or liquid particles or through volatilisation. Dust particles from certain applications can also disperse widely but are not commonly encompassed under the term spray drift. However, they are included in these guidelines where relevant.

These guidelines refer largely to **agrichemical exposures** but even this is too wide of a classification to be able to provide detail on each agent. It is beyond the scope of these guidelines to cover all potential outcomes and risks to a member of the public who may be exposed to agrichemical drift.

Data and investigation processes

To characterise the population level health impacts and priority areas for information, a survey of agrichemical exposures was undertaken. The survey was informed by data from the Hazardous Substances Disease and Injury Reporting Tool (HSDIRT) and from the databases held by the National Poisons Centre. Such data were used to provide surveillance statistics to support hazard and risk data for the major hazardous agrichemicals in New Zealand. Toxicological data and reference values are limited to possible acute effects for the investigation of short-term or one-off exposures.

The processes of hazard identification and risk assessment are included in more detail, as they pertain to agrichemicals. An overview of key toxicological information is presented on commonly used agrichemicals or agrichemical classes such as glyphosate and organophosphates and the process of undertaking a risk assessment during the investigation of a chemical drift incident is covered in some depth. Again, this is focused on the assessment of risk for an acute or one-off exposure in a member of the public.

Key updates in this version

These guidelines are a revision of the *Guidelines for the Assessment, Surveillance, and Management of Injuries from Spray Drift* (Ministry of Health, 2007). The 2007 guidelines were created to enable public health officers to consistently identify incidents, and collect environmental, exposure and health data to assess the health effects of any unintended short-term agrichemical exposures.

Major changes in this edition are to:

- extend the scope of the guidelines from agrichemical sprays to other hazardous substances – including pesticides
- update information about surveillance of suspected cases
- update other information and the references provided.

Out of scope

Chronic exposures: these guidelines address the acute effects of exposures to agrichemicals and do not include chronic agrichemical exposure in bystander populations. Reference doses for chronic exposures are provided for completeness and as additional context against which to assess the more relevant acute scenarios.

Drinking water: Taumata Arowai is the water services regulator and implements the Water Services Act 2021. If an exposure is associated with ingestion of potentially contaminated drinking water, the drinking water supplier and Taumata Arowai should be notified. To notify Taumata Arowai, email notifications@taumataarowai.govt.nz. If there is an immediate risk to public health from drinking water, call 04 889 8350.

Environmental effects: are the responsibility of the regional council (or unitary authority). WorkSafe New Zealand may also have an enforcement role if the environmental damage was due to a worker not following all the necessary controls on an agrichemical set under the Hazardous Substances and New Organisms Act 1996.

Food: the Ministry for Primary Industries is the food safety regulator (including responsibility for the safety of non-commercial, home grown and wild foods). If contamination of food products are suspected , or any illnesses are suspected to

be from food, notify the Ministry for Primary Industries by email **info@mpi.govt.nz** or phone 0800 00 83 33.

Occupational exposures and other workplace risks: while medical practitioners must notify all suspected or confirmed hazardous substances injuries to the medical officer of health, any investigation of workplace exposures is undertaken by WorkSafe New Zealand under the Health and Safety at Work Act 2015.

Introduction

Main points

- In these guidelines, an agrichemical is any chemical used in a primary industry context or on conservation land. It includes herbicides, insecticides, fungicides, veterinary medicines, horticultural and forestry chemicals, pesticides, fertilisers, spray additives, and the agricultural use of detergents and sanitisers.
- Application of an agrichemical using a spray technique will inevitably involve some off-target drift, but the extent of such drift is determined by meteorological factors, topographical factors, and those factors that are operator controlled.
- The risk associated with drift involves a combination of the extent, concentration and nature of the drift, the toxicity or other hazardous properties, and the personal characteristics of the people exposed.

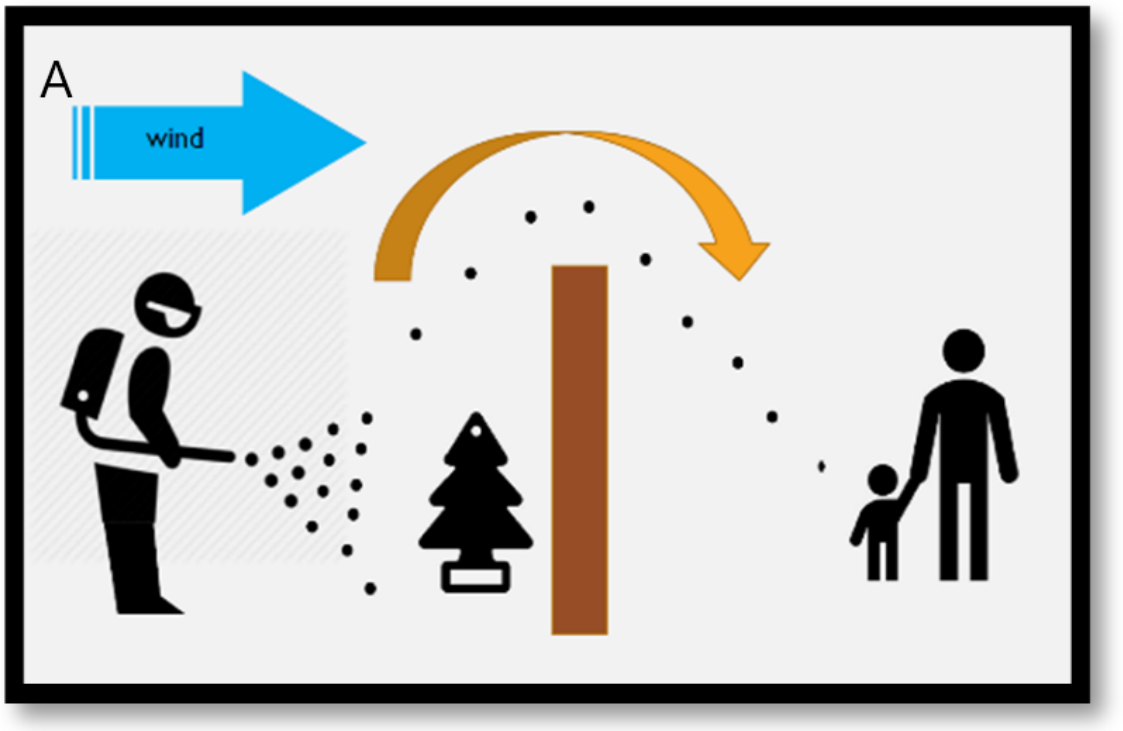
Agrichemical drift

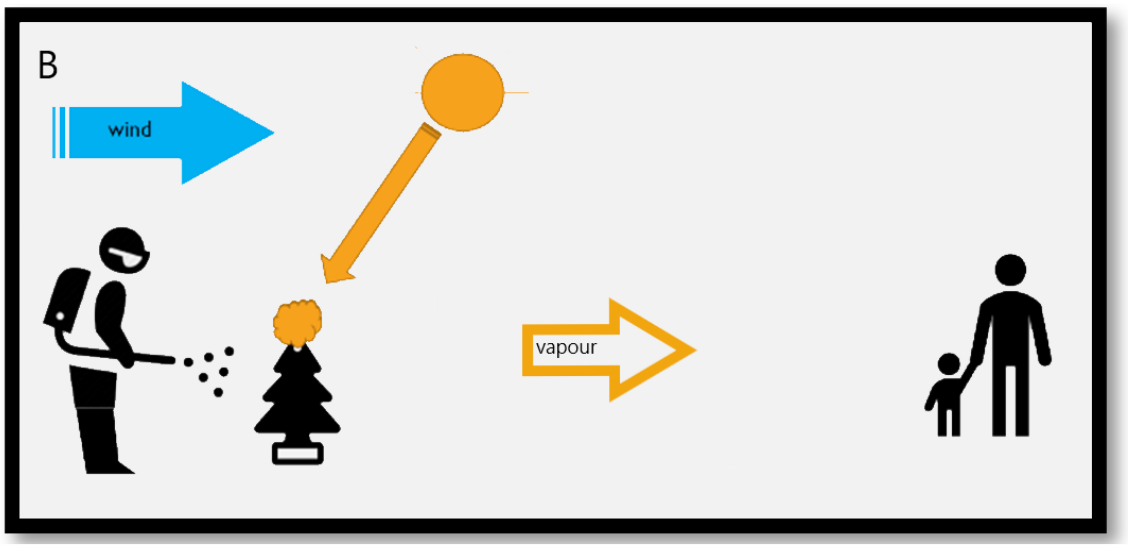
Agrichemical drift occurs when droplets, aerosols, or dust particles of agrichemical formulations move in the atmosphere to be inhaled or deposit on property or individual bystanders following an application. These applications, in an agricultural context, can come from a wide range of methods – including hand-held sprayers, vehicle-based tank and boom sprayers, and aircraft and unmanned drones.

In addition to agrichemical drift at the time of application, the public may also be exposed to agrichemicals after application. This can involve volatilisation of the applied agrichemical from plants or soil upon which it has been applied, and movement down wind of the application (see **Error! Reference source not found.** below). For the purposes of considering public exposure to agrichemicals, both scenarios are considered ‘spray drift’ in these guidelines.

Figure 1: Spray drift droplet spread and volatilisation

In Figure 1, Image A shows droplet spread. Image B shows volatilisation – where vapour is released from a treated surface and can potentially affect bystanders. These Images are adapted from original images by Paul Baynham, Mote Ltd.





These guidelines are a revision of the *Guidelines for the Assessment, Surveillance, and Management of Injuries from Spray Drift* that were published in 2007 (Ministry of Health, 2007). The 2007 guidelines were created to enable public health officers to consistently identify incidents, and collect environmental, exposure and health data to assess the health effects of any unintended short-term agrichemical exposures.

From a public health perspective, injuries from agrichemical drift fall under the broader category of injury from exposure to poisons and hazardous substances, for which Health NZ has issued separate guidelines (Te Whatu Ora, 2024).

These spraydrift guidelines provide information to support the investigation of all agrichemical drift incidents by public health professionals and provide information on the effects on human health.

While the guidelines refer heavily to agrichemicals and spray application this is only because this is considered the primary concern for most public health officers. Therefore, some unique considerations of the toxicity and exposure variables pertaining to agrichemical exposures are discussed.

The guidelines are an information resource to facilitate estimates of individual exposures to any chemical drift incident to be assessed against toxicological criteria. The guidelines also provide a general framework under which agrichemical drift is assessed and gives suggested data collection and case management advice.

Agrichemical uses in New Zealand

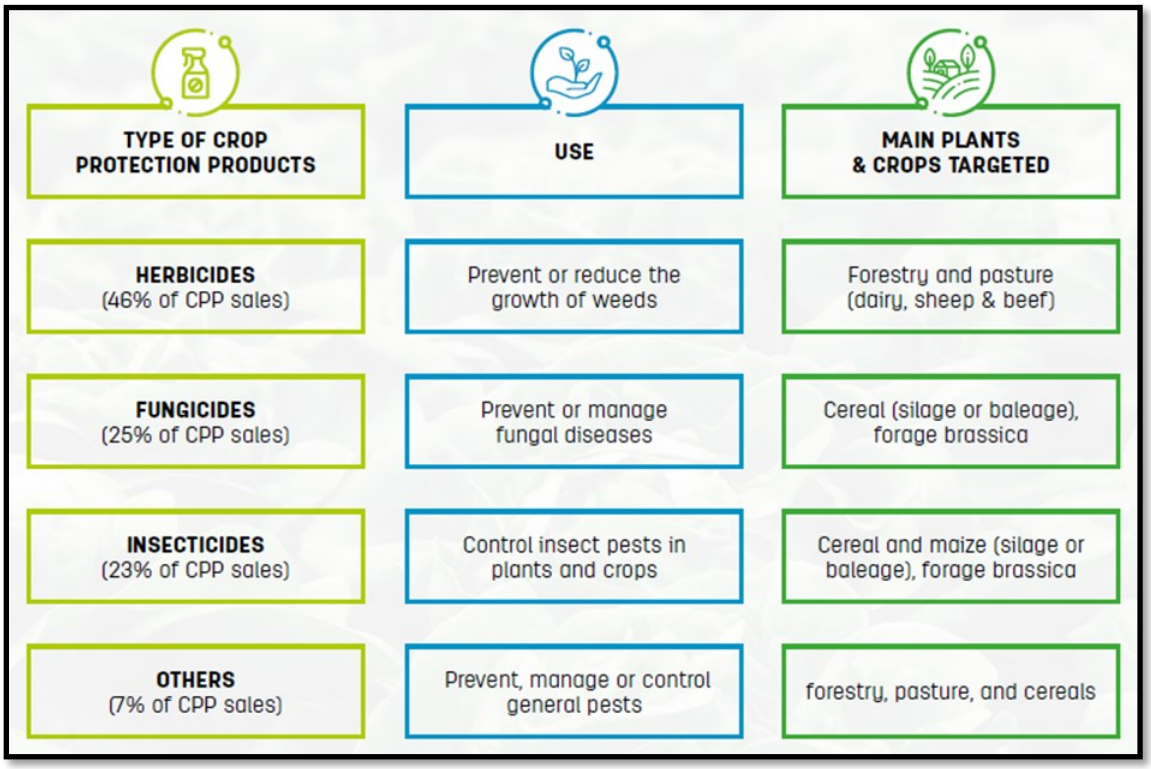
Agrichemical drift continues to be of public interest and references to some widely used agrichemicals have been prevalent in the media. While efforts are being made to reduce and replace some (usually environmentally persistent) agrichemicals, the wider public often remains concerned at their use and any possible exposure they may experience. The assessed and perceived risks can vary considerably.

Evidence suggests that the public are increasingly conscious of the long-term impacts of exposure to agrichemicals and potential risks to children (Barraza et al 2020; Calliera et al 2019; Remoundou et al 2014). Perceptions of the risks vary by culture, age, gender, occupation, and level of education, and there is a great amount of variation among studies as to the relative importance of these individual factors.

Agrichemical use data

While New Zealand uses numerous agrichemicals as a part of its agricultural economy, generally the specific quantities, and temporal or spatial use patterns, are not monitored. Therefore, it is difficult to say with certainty what national or regional trends there may be in the use of, or potential exposures to, specific or broad classes of agrichemicals (**Error! Reference source not found.**).

Figure 2: Summary of Agrichemical uses by industry (Nixon and de Morel 2019)



In addition to farming operations, local and regional councils rely on herbicides to control pest plant species. Increasing uptake of integrated pest management combined with new technologies (precision farming, micro-jet spraying systems, robotic weed control) may collectively reduce agrichemical use over the coming years (Thompson and Chauhan 2022).

A summary of some of the more common agrichemicals referred to in New Zealand literature and marketing material is included in **Error! Reference source not found.**. Information in the table is restricted to plant protection products or pesticides, as they are commonly called.

Table 1: Commonly used pesticides, classified by type of pesticide and chemical class

This table is adapted from Alvanja et al., 2004.

Pesticide functional group	Chemical class	Examples				
Herbicides	Phenoxy acetic acid	2,4-D		2,4,5-TP (Silvex)		
	Phenoxy benzoic acid	Dicamba				
	Thiocarbamates[a]	EPTC	Butylate	Sulfallate		
	Triazines	Simazine	Atrazine	Cyanazine		
	Anilides	Alachlor	Metolachlor			
	Dipyridyl compounds	Paraquat	Diquat			
	Phosphonates	Glyphosate				
	Organophosphates (OPs)	Glufosinate-ammonium				
Insecticides	Organophosphates[b]	Malathion	Chlorpyrifos	Parathion	Diazinon	Isofenphos
	Carbamates	Carbaryl	Methomyl	Carbofuran		
	Synthetic pyrethroids[b]	Permethrin	Cypermethrin	Bioresmethrin		
	Rotenoids	Rotenone				
	Neonicotinoids[b]	Clothianidin	Imidacloprid	Thiamethoxam	Thiacloprid	Acetamiprid
Fungicides	Thiophthalimides	Captan				
	Dithiocarbamates[a]	Maneb	Ziram	Thiram	Zineb	Manocozeb
Fumigants		Methyl bromide	1,3-dichloropropene			
		Sulfuryl fluoride				
		Chloropicrin				

[a] Thiocarbamates can be herbicides and fungicides

[b] The New Zealand Environmental Protection Authority has withdrawn approvals for some organophosphates and is currently reviewing synthetic pyrethroids and neonicotinoids (EPA, 2021a). The EU has banned clothianidin, imidacloprid and thiamethoxam

Vertebrate Toxic Agents

Vertebrate toxic agents such as sodium monofluoroacetate (commonly known as 1080) are used to control introduced mammalian pests and to control the spread of bovine tuberculosis due to carriage of *Mycobacterium bovis* by some mammalian pests.

In contrast to most other pest control agents, aerial application of 1080 is tracked and reported annually by the New Zealand Environmental Protection Authority (EPA) (EPA, 2020a). The dusts that are formed from these baits may drift during aerial applications and be detectable at distances beyond the treatment area (ESR 2021; Beasley et al., 2009).

The data from 1080 incidents and complaints that are available so far do not indicate a significant public health risk, although some occasional incidents have involved members of the public (EPA, 2020; EPA 2021b).

In its review of the toxicity of 1080, the EPA reported that only a single case of human intoxication through inhalation had been reported, from a 1948 workplace incident of a worker preparing baits and inhaling a “puff of the powder” with ensuing serious neurological effects (EPA 2022a).

WorkSafe also monitors and tracks 1080 incidents in the workplace (WorkSafe, 2022a). While quantitative data on public exposures are not available for 1080, the primary potential exposures of concern would be expected to be among workers. Typical urine levels of less than 0.0005 μg/mL (0.5 μg/L) have been reported for exposed workers, which is 30-fold lower than derived biological exposure indices (15 μg/L) (Beasley et al., 2009; WorkSafe 2022b).

Pesticide levels in New Zealand populations

A single biomonitoring survey of the pesticide burden of New Zealanders reported that urinary metabolites of some pesticides commonly used in New Zealand (organophosphates (OP), synthetic pyrethroids, and 2,4-D), were ubiquitous in the urine of children 5 to 14 years of age (Li et al., 2022).

While the urinary concentrations of dialkylphosphates (DAPs), indicative of exposure to many OP pesticides, were generally below those of most other countries, the concentration of TCPy, a metabolite specific to the OP chlorpyrifos, was substantially higher in school age children compared with the United States of America, Spain, and Thailand. This finding is potentially concerning due to the impact that chlorpyrifos may have on the developing nervous systems (Li et al., 2022).

Risk factors for elevated urinary pesticide concentrations did not generally include time spent on a farm. However, this was a risk factor for urinary chlorpyrifos, with a 40% increase in metabolite concentrations observed in children who spent time on farms during the high spray season (Li et al., 2022).

This study's findings did not suggest that agrichemical drift is a major source of pesticide burden in children, with some possible exceptions. Biomonitoring studies such as this are useful in informing the assessment of community or population level exposures to agrichemicals.

There have been other studies in the past that have looked at the levels of certain pesticides in the blood / breast milk of New Zealanders (primarily persistent organochlorine pesticides that is now prohibited in NZ)[1].

Agrichemical drift incidents in New Zealand

Data from the National Public Health Service entered into the HSDIRT surveillance data system, indicate that the number of people seeking medical treatment from agrichemical drift exposures in New Zealand is small, with nine cases of probable agrichemical drift exposure from 2014 to 2021 in the HSDIRT hazardous substance notifications system (**Error! Reference source not found.**).

The HSDIRT data are limited to those cases that were severe enough to result in a doctor's visit, and therefore will be an underestimate of the total number of exposures and cases. Each case in the system is reviewed by a medical officer of health.

The probable cases most often involved anti-cholinesterase insecticides. Two cases reported exposure due to helicopter-based application. A further 15 cases were considered to be "possibly" related to agrichemical drift (**Error! Reference source not found.**). In these cases, glyphosate was the most commonly reported active ingredient, and the illnesses were most often localised irritation of the respiratory tract, eyes, and skin.

Table 2: *Probable* agrichemical drift cases (2014 – 2021)

No. of people affected	Chemical name	Product Name	Spray method	Symptoms/health effects	Season
1	Alpha-cypermethrin	Sheriff 100	Helicopter spray	Skin irritation	Summer
1	MCPA	Agritone 750	Helicopter spray	Eye, skin and respiratory effects	Spring
1	Dichlorvos	Nuvos	Unrecorded	Numerous (CNS, GI, psychological, skin, eyes etc)	Summer
5	Chlorpyrifos	Lorsban 50EC	Unrecorded	Skin, respiratory and CNS effects	Summer
1	Chlorpyrifos	Rentokil	Unrecorded	CNS, respiratory and GI effects	Spring

Courtesy Liam Kelly (HSDIRT, EHINZ, 2022). MCPA: 2-methyl-4-chlorophenoxyacetic acid

1 https://www.tewhatuora.govt.nz/our-health-system/environmental-health/hazardous-substances/persistent-organic-pollutants-pops/dioxins/

Table 3: *Possible* agrichemical drift cases (2014 – 2021)

No. of people affected	Chemical name	Product Name	Spray method	Symptoms/health effects
1	-	Roundup	-	Eye irritation
1	Hydrogen Cyanamide	Hi - Cane	-	Eye irritation
4	Glyphosate	Roundup	Large quantities added to 4 hectares	Eye, respiratory, GI and psychological effects
1	Diazinon	-	-	Musculoskeletal
1	Hydrogen Cyanamide	Hi - Cane	-	Eye and respiratory effects
1	-	-	Roadside vehicle spraying	Psychological
3	Triadimenol	-	-	CNS and GI effects
1	-	Fumagri OPP	-	Respiratory
1	Glyphosate	Number 8	-	-
1	Chlorpyrifos	-	Handheld spraying	Skin irritation

There is no centralised database of regional council incidents involving agrichemical drift, and each council maintains its own collection of complaints that vary widely in scope, some of which pertain to exposures of the public.

Discussions with staff at some of the regional councils in New Zealand have confirmed many of the complaints received from the public about potential agrichemical drift exposures involve mild health effects (eg, headache, eye or throat irritation) that do not result in a doctor's visit. Complaints that could be confirmed as resulting directly from agrichemical drift formed a minority of overall complaints.

Health advice provided by councils usually consisted of a recommendation to visit a health professional such as a general practitioner, but anecdotal reports were that people seemed reluctance to do this due to cost and the lack of severity of symptoms.

The National Poisons Centre prepared a preliminary history of calls relating to agrichemical exposure (**Error! Reference source not found.**). This data has been screened to remove calls relating to occupational exposure but cannot be stratified by exposure route or amount. Therefore, the data will include any cases of ingestion, spills and informational enquiries relating to agrichemicals.

The data shows that glyphosate is the primary agent of interest followed by 2,4-D and MCPA. The prevalence of glyphosate in the call volume could be due to increased public awareness of this compound or due to high use. There is no stratification of these data on severity of symptoms.

Table 4: Summary of calls to the National Poisons Centre relating to non-occupational exposure to agrichemicals

Substance(s) noted in exposure	Counts in post August 2016 data (11 August 1016 to 31 December 2021)	Counts in pre August 2016 data (1 January 2010 to 10 August 2016)
2,4-D	61	94
2,4-D & glyphosate	6	0
2,4-D & MCPA	2	0
Diazinon	13	30
Glyphosate	838	1038
Glyphosate & MCPA	6	1
Glyphosate & terbuthylazine	28	17
Hydrogen cyanamide	41	37
Mancozeb	10	16
MCPA	85	97
Terbuthylazine	9	12
Total	1099	1342

2,4-D: 2,4-dichloropheoxyacetic acid, MCPA: 2-methyl-4-chlorophenoxyacetic acid

Risk Assessment

Main points

- Risk assessment includes hazard identification, dose-response assessment, exposure assessment, and risk characterisation.
- The EPA provides authoritative advice on the risk assessment of hazardous substances.
- The risk associated with drift involves a combination of the extent, concentration and nature of the drift, the toxicity or other hazardous properties, and the personal characteristics of the people exposed.

Introduction to risk assessment

Risk is the probability that specified adverse effects will occur. The United States Environmental Protection Agency (USEPA) defines human health risk assessment as:

> evaluating the toxic properties of a chemical and the conditions of human exposure to it in order both to ascertain the likelihood that exposed humans will be adversely affected, and to characterise the nature of the effects they may experience.

A widely used risk assessment model comprises four interrelated phases.

- **Hazard identification:** Assess available evidence on the presence and hazards of substances likely to cause adverse effects.
- **Dose-response assessment:** Determine the degree of the effects at different doses.
- **Exposure assessment:** Estimate the magnitude, duration and frequency of human exposure to substances of concern and the number of people exposed via different pathways.
- **Risk characterisation:** Combine the information gained from the hazard identification, dose-response assessment and exposure assessment phases to estimate the risk associated with each exposure scenario.

There are three inter-dependent steps in the process of decision-making regarding risk:

- risk assessment
- risk communication
- risk management.

These guidelines focus on risk assessment as this is a critical first step in risk analysis. Risk assessment asks: ‘What are the hazards?’ ‘What are the risks?’ and ‘Who will be affected, how, and to what extent?’ It includes hazard identification, dose-response assessments, exposure assessment, and risk characterisation. The background information will largely focus on agrichemicals, but the risk assessment framework is relevant to any chemical drift incident.

Hazard identification

Under the Hazardous Substances and New Organisms Act 1996 (HSNO Act 1996), a hazardous substance is any substance that meets or exceeds the threshold level specified in Hazardous Substances (Minimum Degrees of Hazards) Notice 2020 for any of the following hazardous properties.[2]

- explosiveness
- flammability
- ability to oxidise
- corrosiveness
- toxicity (including chronic toxicity)
- ecotoxicity, with or without bioaccumulation.

A ‘chemical’ is commonly defined as ‘any substance used in or resulting from a reaction involving changes to atoms or molecules’.

The HSNO Act 1996 does not define the term ‘chemical’ but it does define the term ‘substance’ as:

a. any element, defined mixture of elements, compounds, or defined mixture of compounds, either naturally occurring or produced synthetically, or any mixtures thereof
b. any isotope, allotrope, isomer, congener, radical, or ion of an element or compound which has been declared by the Authority, by notice in the *Gazette*, to be a different substance from that element or compound
c. any mixtures or combinations of any of the above
d. any manufactured article containing, incorporating, or including any hazardous substance with explosive properties.

It is important to note that not all chemicals are of equal concern. Toxicity, potential health hazards and patterns of use vary between chemicals, depending on the route of exposure or whether exposure relates to vulnerable population groups. Given the very large number of chemicals used in the home and the wider environment, a comprehensive description of their properties and hazards is not possible within the scope of these guidelines. Sources

[2] Further information is available at: **https://www.epa.govt.nz/industry-areas/hazardous-substances/rules-for-hazardous-substances/epa-notices-for-hazardous-substances/**

of information that will provide this detail on specific chemicals or classes of chemicals are given below.

In New Zealand, the Environmental Protection Authority (EPA) assesses the hazardous properties of hazardous substances and has set appropriate controls to manage the risks from such substances, including public health risks. For information on the EPA's assessments, see the EPA website. Resources are below.

- The Chemical Classification and Information Database (CCID) for information on the hazards of active ingredients: https://www.epa.govt.nz/database-search/chemical-classification-and-information-database-ccid/
- The approved hazardous substances with controls database: https://www.epa.govt.nz/database-search/approved-hazardous-substances-with-controls/
- Advice on the risk assessment of hazardous substances: https://www.epa.govt.nz/assets/Uploads/Documents/Hazardous-Substances/Risk-Assessment-methodology/Risk-Assessment-Methodology-for-Hazardous-Substances-How-to-assess-the-risk-cost-and-benefit-of-new-hazardous-substances-for-use-in-New-Zealand-Updated-December-2022.pdf

Identifying the chemicals of concern

Establishing the agrichemical(s) involved in a drift incident is crucial to understanding the potential risks. This is complicated by the existence of many trade names that may contain the same active ingredient, and the occurrence of formulated products with multiple active ingredients. While the non-active ingredients in a formulation may be of significance in some cases, it is primarily the active ingredient(s) in the sprayed product that must be established, if possible.

Useful sources of information are noted below.

Container labels: The label of the agrichemical will provide the trade name and active ingredient(s). Labels can be accessed directly from the container or from the New Zealand Food Safety Agricultural Compounds and Veterinary Medicines (ACVM) register.[3] Product labels will include information on the hazardous properties of the substance (eg, acutely toxic, skin/eye irritant, etc) as well as information on how to minimise or prevent adverse effects from occurring and what to do if exposure occurs. This information can be used to provide an initial assessment of the likely association between agrichemical exposure and reported adverse effects.

If a trade name and active ingredient list for approved substances is required, contact EPA (**www.epa.govt.nz** or 0800 429 7827 or email: **hazardous.substances@epa.govt.nz**). The manufacturer, supplier or importer should also be able to provide additional information.

3 https://eatsafe.nzfsa.govt.nz/web/public/acvm-register

Safety data sheets: A safety data sheet, or SDS, is a standardised document that contains occupational safety and health data. It includes information such as the properties of each chemical; the physical, health, and environmental health hazards; protective measures; and safety precautions for handling, storing, and transporting the chemical. It also provides guidance for each specific chemical on things such as:

- Personal Protective Equipment (PPE)
- first aid procedures
- spill clean-up procedures.

More information is available on the WorkSafe and EPA websites (WorkSafe, 2022b; NZ EPA 2022b).

Importers and manufacturers have a duty to prepare safety data sheets (SDSs) (formerly known as material safety data sheets or MSDS) for their products. The supplier has a duty to provide the safety data sheets to the workplace (refer to clauses 5 and 6 of the Hazardous Substances (Safety Data Sheet Notice) 2017).[4]

The name and contact details of the manufacturer or chemical distributor can be found on both the product label and SDS. Often there will be a freephone number or another contact number listed. These are also searchable online using common search engines and are also available on company (manufacturer, importer, or supplier) websites.

SDS vary considerably in the quantity and quality of information provided. People may also use agrichemicals that are outdated and do not have current registration. In addition, there may be off-label use of approved substances which are registered for other crops, for example there is anecdotal information that the organophosphate terbufos has been used off-label for kumara.

It is important to avoid misidentification when lists of currently registered pesticides are used. Mistakes arise when a name is assumed to have been spelt wrongly but the product is, in fact, not currently registered.

CHEMFIND: is a database owned by Responsible Care NZ (formerly the NZ Chemical Industry Council) that gives users 24-hour access to up-to-date chemical information on hazards identification, product composition, first aid measures, chemical spills, and more. It is available to public health officers responding to chemical incidents and emergencies.

Each local office of the National Public Health Service has a CHEMFIND licence, which is accessible via a nominated HPO. Responsible Care NZ will also provide technical assistance on a 24 hour, days a week by phoning 0800 CHEMCALL (243 622) if required.

Information services

4 Available at: https://www.epa.govt.nz/assets/Uploads/Documents/Hazardous-Substances/EPA-Notices/Hazardous-Substances-Safety-Data-Sheets-Notice-2017-EPA-Consolidation-30-September-2022.pdf

Some public health officers have access to electronic databases such as TOXINZ or library collections that hold or have access to agrichemical and general toxicology references.

Electronic databases provide links to research articles and more comprehensive chemical or toxicological information. Examples include INCHEM, eChemPortal, ToxLine, Google Scholar and PubMed TOXINZ, ATSDR toxicological profiles, Medline, TOXNET, TOXLINE, CANCERLINE, Hazardous Substances Data Bank, Commonwealth Agricultural Bureaux Abstracts (CAB Abstracts), CHEMICAL ABSTRACTS SEARCH (CAS-ONLINE), AGRICOLA, BIOSIS (Biological Abstracts), Science Citation Index (Sci Search), and CHEMFIND.

Useful pesticide toxicology and general toxicology references include the following.

- Environmental Health Criteria series published by the World Health Organization, Geneva.
- Krieger, R. (2010). Hayes' handbook of pesticide toxicology (Third edition). Academic press.
- Tomlin, C. (2010). The pesticide manual: incorporating the agrochemicals handbook: a world compendium/editor Clive Tomlin.
- US EPA (2022). Ingredients Used in Pesticide Products. https://www.epa.gov/ingredients-used-pesticide-products
- FAO and WHO (2021). Managing pesticides in agriculture and public health – A compendium of FAO and WHO guidelines and other resources. Second edition. Rome. https://www.fao.org/documents/card/en/c/cb3179en
- WHO International Programme on Chemical Safety (2022). Internationally Peer Reviewed Chemical Safety Information. https://inchem.org/#/
- TOXINZ database. http://toxinz.com
- The Standard "Management of Agrichemicals" (NZS 8409:2021) includes considerations of safe use, and community notification, relating to agrichemical spraying (Standards New Zealand, 2021).

National Poisons Centre: runs a 24-hour service providing information on chemicals, drugs, poisonous plants, poisonous insects and marine animals. The 24-hour urgent telephone number is 0800 POISON (0800 764 766); during working hours the non-urgent number is 03 479 7248. The permanent information specialist staff have expertise in toxicology, medical toxicology, chemistry, and pharmacology.

The Poisons Centre maintains an extensive database (TOXINZ), which incorporates comprehensive technical and toxicological information on agrichemical products, including all New Zealand–registered pesticides. In addition to the database resource, the Poisons Centre maintains a comprehensive toxicology library and has access to a range of other databases and information sources, both nationally and internationally.

Responsible Care NZ (formerly the Chemical Industry Council): provides public health officers with online advice via CHEMFIND® chemical data system and phone information when they are responding to chemical spills and other hazmat events.

Factors contributing to agrichemical drift

In any situation where application of an agrichemical incorporates a broadscale application technique, some off-target drift is often inevitable. The extent of drift is determined by meteorological factors, topographical features and factors that are operator controlled.

The risk associated with agrichemical drift involves a combination of three main factors: the extent, concentration, and nature (eg, droplet size, particle size) of the drift, the toxicity or other hazardous properties of the product, and the personal characteristics of the person(s) exposed.

Although all three factors can be controlled to an extent, most agrichemical products are by nature hazardous (although the degree varies greatly, depending on the chemical), and humans, animals and non-target plants cannot be entirely removed from the surrounding environment. Therefore, the main focus of agrichemical drift hazard minimisation is on reducing the extent of the drift.

Environmental factors

Factors that may contribute to agrichemical off-target drift are wind velocity, wind direction, turbulence, atmospheric stability, relative humidity, precipitation, air pressure, presence of inversion conditions, and air temperature.

In general, light winds (3–10 km/h) are most desirable for agrichemical application operations, for low drift hazard. These conditions improve the coverage of the target crop or pest. They also enable the operator to predict the direction and distance of potential drift and to make allowances for this.

In still conditions (less than 3 km/h), the movement of spray mist and vapour is less predictable due to turbulence. As wind speed increases above about 10 km/h, there is a corresponding increase in the potential for off-target agrichemical drift. Therefore, spraying should not be carried out when wind speeds are less than 3 km/h or more than 20 km/h, as measured at the application site. The experience and expertise of the operator may contribute to reducing drift.

The requirement for a risk assessment prior to spraying is a new requirement in the updated Operator Standards (NZS-84092021, Standards New Zealand, 2021). A variety of in-depth information on risk assessment factors is provided, including indicative guideline minimum separation distances (buffer zones) to prevent drift affecting the public.

Table 5: Guidance for buffer zones (NZS 8409:2021)

Application method	Guideline minimum distance (metres)	
	With shelter	Without shelter
Boom sprayer	2	10
Air-blast sprayer	10	30
Aerial application	100	300

Air temperature and humidity can affect the evaporation rate of liquid sprays. As the air temperature rises and/or relative humidity drops, the evaporation rate of droplets increases. This higher evaporation rate can increase droplet and aerosol drift during agrichemical application operations due to a decrease in droplet size, as turbulence and wind carry fine droplets and aerosols further than larger droplets.

Vapour drift is more likely on hot days when there is low humidity as evaporation from droplets, as well as evaporation of volatile chemicals from deposits on the ground and vegetation, is increased. Generally, temperatures below 25°C and relative humidity greater than 50 percent provide desirable spraying conditions.

Pesticides should not be applied immediately before, during or after a rainstorm. Rain can wash the agrichemical off the target on to adjacent land and into waterways. In addition, rain dilutes the spray, reducing the concentration at the target, thus also reducing its effectiveness.

Physicochemical characteristics of the agrichemical

Whenever possible, the least volatile agrichemical option should be used. Evaporation of the active ingredient during or after deposition can result in off-target vapour drift. This can be a problem, particularly when temperatures are high and humidity is low. The addition of spray drift reduction agents, such as Sprayfast, in the sprayed agrichemical will reduce drift.

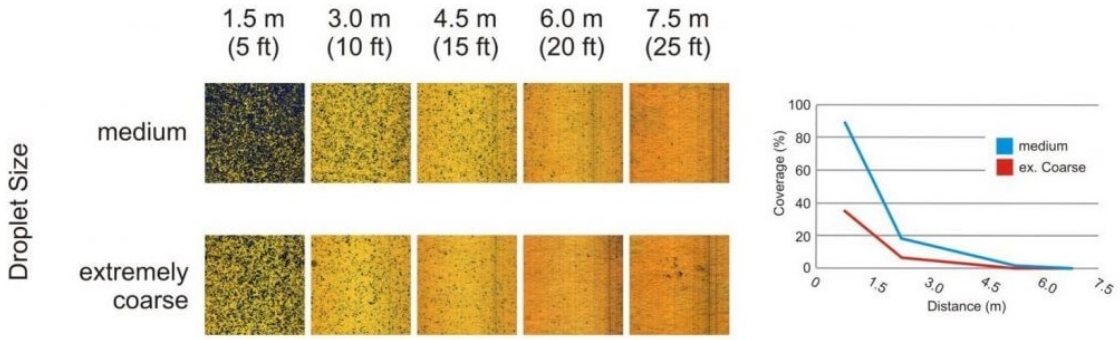
Equipment characteristics

Equipment type, nozzle type, droplet size, spray pressure, and distance from applicator to target are all important factors to mitigating agrichemical drift. Among the most important variables are the number and size of droplets formed during atomisation.

It is desirable to use the largest possible droplet size that enables good coverage. Small droplets or mists are more likely to drift as they are more easily carried by wind or air turbulence. High pressure spraying will also contribute to drift. The larger the distance between the point of spray release and the target, the greater the potential for off-target drift to occur.

Figure 3: Droplet size and travel

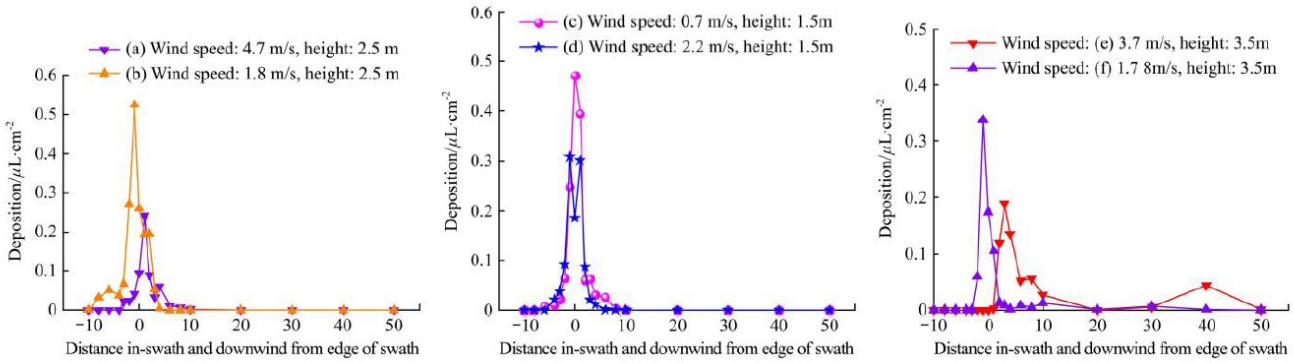
Water sensitive papers were used to detect droplets of spray applied by boom spray – blue dots show where spray is present. Image from Sprayers101.



Aerial application of agrichemicals from unmanned aerial vehicles (UAV; drones) or planes can also result in agrichemical drift beyond the target application areas (Emission Impossible 2021; Wang et al. 2020). Many of the contributing factors are similar to the more traditional application methods, with wind and droplet particle size being identified as key drivers of drift. However, height of application should also be considered with greater heights leading to more off-target drift. For UAV, rotor speed may affect droplet size with higher rotor speeds resulting in smaller, finer droplets (Wang et al. 2020; Ahmad et al. 2020).

Figure 4: Chemical drift from UAV sprayer

The first graph below shows the effect of wind at a spray height of 2.5m; the second at 1.5m, and the third at 3.5m. Application of the chemical at higher wind speeds and greater elevation can lead to detections up to 40m from the target site. Figure 4 is from Wang, et al. 2018.



Hazard identification – local effects

The public are likely to be exposed to agrichemicals from spray drift by inhalation or by deposition of spray on the skin or from contact with surfaces where spray has deposited (dermal exposure). Exposure through oral routes can also occur if people eat, smoke or drink around pesticides or forget to wash their hands after use. While agrichemical

ingredients may be absorbed and cause systemic effects, they may also cause local effects at the point of contact with the human body.

Numerous agrichemical formulations and active ingredients in New Zealand can irritate mucous membranes. Information on this, in addition to sensitisation properties, is a standard component of every agrichemical pesticide and pesticide formulation regulatory assessment.

Irritation of eyes, skin, and the respiratory tract are likely to be the most encountered acute health related effects for the public in agrichemical drift incidents. Some notable agrichemical active ingredients that are membrane irritants include chloropicrin, 2,4-D, MCPA, dicamba, glyphosate, and glufosinate-ammonium (Table 6). It is important to note that products containing other agents may also cause irritation, depending on their exact formulation. Information on safety classifications of specific formulations should always be checked as part of an investigation.

Table 6 also provides an example of how differences in irritancy can vary with subtle changes in active ingredient. MCPA, for example, is classified as highly irritating to the eye, Eye 1 (serious eye damage). The dimethylamine salt of MCPA is also highly irritating to the eye, but carries the additional classification of Skin irritation Cat 2, or mild skin irritant. It is therefore important to try to ascertain with as much specificity as possible the chemical identity of the agrichemical product being sprayed when investigating.

Table 6: EPA irritation hazard classifications for some commonly used agrichemicals

Chemical[a]	Hazard Classification
Chloropicrin (Tri-Form 60)	Skin corrosion Category 1 Serious eye damage Category 1
Dicamba (Performa, Kamba 750, Bandit)	Skin irritation Category 2 Serious eye damage Category 1
1,3-Dichloropropene (Tri-Form 60, Telone)	Skin irritation Category 2 Eye irritation Category 2
Glufosinate-ammonium (Patriot 1, Brutus, Bammer, Glamor SL)	Skin irritation Category 2 Eye irritation Category 2
Glyphosate (Roundup)	Skin irritation Category 2 Eye irritation Category 2
MCPA (Duke, Scout, Sabre)	Serious eye damage Category 1
MCPA (dimethylamine salt) (Agcare MCPA 750, Pasgold, Grassmaster)	Skin irritation Category 2 Serious eye damage Category 1

Chemical[a]	Hazard Classification
Thiram (Defender)	Skin irritation Category 2 Eye irritation Category 2

Source: NZ EPA, 2021a
MCPA: 2-methyl-4-chlorophenoxyacetic acid
[a] Trade names of common products containing these active ingredients are included in parentheses

Exposure assessments

This section is to assist in the assessment of where significant human exposure to pesticides from an agrichemical drift incident may have occurred, and where such exposure is unlikely. It is intended to help guide decisions on whether to undertake further investigations of complaints and incidents but should not be the sole determinant of such decisions by public health officers.

Routes and duration of exposure

Most agrichemicals contain chemicals that can be harmful to people, animals, or the environment. Skin exposure is the most common type of exposure since the skin is easily exposed when handling pesticides. Inhalation is less common, but it is still a potential source of exposure, particularly if users do not follow label instructions about respiratory protection.

Ingestion occurs when users eat, smoke or drink around pesticides or forget to wash their hands after use. Ingestion after contact with treated surfaces is particularly relevant to preschoolers because of their hand-to-mouth behaviour.

Even though hands and forearms are most subject to exposure, other parts of the body (eyes, abdomen, groin) absorb agrichemicals more quickly. The eyes and skin may also be affected by the corrosive effect of many chemicals.

Exposure to agrichemicals from drift to the public can occur through:

- direct inhalation of the aerosol, dust or fumigant
- skin absorption from direct or indirect deposition
- dermal and oral exposure to soil or house dust
- eating produce or drinking water contaminated with deposited chemical.

Exposures can be for a short period of time (acute) or ongoing (chronic). In an acute spray drift exposure scenario, the greatest exposures will be from the direct inhalation and dermal absorption routes.

Ongoing lower dose exposures would be expected from house dust and home gardening depositions, although these are more difficult to model and assign contributions from a single spray event. It is known, for example, that agrichemical residues in house dust can occur from tracking residues and soil into the home.

Measuring the risks associated with chronic exposure to agrichemicals is more complex, as it requires consideration of all potential routes of exposure over an extended timeframe. The health significance of the exposures can be assessed by comparison with health-based guidance values (HBGVs), such as acceptable daily intake (ADI)[5], tolerable daily intake (TDI),[6] reference dose (RfD)[7] or reference concentration (RfC)[8] for humans.

The ADI, TDI, RfD and RfC are **estimated doses** that, when taken into the body every day for a lifetime, are not expected to cause adverse health effects. Such comparisons may be useful in that they may show that exposures are unlikely to be of any health concern.

The approach set out here may be used at varying stages of responding to an incident or complaint, such as:

- when information becomes available about the chemicals used (eg toxicity and exposure pathways), and a decision is required on whether further investigation, possibly including sampling, is appropriate
- to identify the most likely major routes of exposure, and develop advice on how to minimise these
- to interpret results of analyses.

Exposure models

Models are often used to determine potential exposure in order to provide a dose estimate for comparison to the HBGV. As results from an air monitoring system are rarely available, modelling is used to predict how much agrichemical may be present in air after a given distance given local weather conditions and buffers. This assessment is complex and, if required, would be undertaken for public health officers by ESR's scientific experts.

When considering seeking advice to model exposures, public health officers need to remember that the input parameters selected are key to providing meaningful output. Some key exposure factors that may be required are given in Step 3 of the graded response protocol in this guidance.

5 ADI is an estimate of the amount of a substance in food or drinking-water, expressed on a body-weight basis that can be ingested daily over a lifetime without appreciable health risk.
6 TDI is analogous to ADI. The term 'tolerable' is used for agents that are not deliberately added, such as contaminants in drinking-water.
7 RfD is defined as an estimate of the dose of daily exposure to a substance (with uncertainty spanning perhaps an order of magnitude) for a human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.
8 RfC is defined as an estimate of the concentration of daily exposure to a substance (with uncertainty spanning perhaps an order of magnitude) for a human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.

Vulnerable populations

The risk from off-target spray drift is dependent, to a large extent, on the nature of the adjacent land use and who is present. There may be considerable spray drift, but no drift risk, if there is no-one at risk downwind from the spraying operation.

Some people may be more vulnerable to exposures, for example children and infants, people with pre-existing conditions, or the elderly. Agrichemical operators should be aware of any sensitive areas within the vicinity of their spraying operation and make allowances for these areas in terms of taking preventive measures.

Sensitive areas include:

- schools and childhood education environments and other residential care facilities
- hospitals
- residential buildings
- reserves and amenity areas
- drinking water catchments
- water bodies
- sensitive crops, animals or farming systems (e.g., organic farms, beekeeping)
- wetlands
- whenua tapu.

Appropriate timing of spraying may reduce the potential impact on sensitive areas from any drift that does occur. For example, spraying out of the season for sensitive crops that are grown nearby (that is, when the land is dormant) and spraying when nearby schools or institutions are unoccupied are ways of reducing exposures for sensitive environments and individuals.

Early childhood centres and preschools (and primary schools to a lesser extent) potentially provide situations that are comparable to residential sites in terms of soil access by young children. However, from a population perspective far more children can be exposed to contamination in an early childhood centre or preschool than would occur in a residential setting.

Post-application agrichemical drift

Volatile soil fumigant applications have the capability to enter the atmosphere after they have been applied (injected into the soil) if they move downwind into residential areas, creating a possibility for short-term bystander exposure events.

Fumigant agrichemicals can also include structural fumigant chemicals (e.g. sulphuryl fluoride) as well as soil fumigants for crops such as strawberries. Fumigants are volatile

and reactive compounds that are often irritating to mucous membranes and some are possible carcinogens (eg, 1,3-dichloropropene).

Illustrating this potential, the 2001 chloropicrin soil fumigant exposure incident in Hawkes Bay resulted in 60 people being evacuated, with 25 residents and firefighters seeking medical attention (NZ Herald, 2001). This incident was a result of soil fumigation into a tarpaulin-covered strawberry field, that leaked during the night, exposing the nearby residents of Clive. The extreme irritancy of chloropicrin was quickly noticed by the exposed residents and resulted in the seeking of medical attention.

Fumigants without irritant properties can also lead to exposure of nearby communities. In a study of the soil fumigant, Telone (1,3-dichloropropene), California EPA scientists found highly variable air levels reaching the town of Parlier, resulting in significant exposures above target concentrations (CDPR, 2018).

The study included weekly 1,3-dichloropropene measurements from a fixed air monitoring station for a 12-month period and found a cancer risk that exceeded 1 additional case of cancer in 100,000 exposed individuals. While this case would represent a more chronic, repeated exposure scenario, the same principles would apply for assessing acute, single dose exposures, although the risks would be assessed against acute toxicity endpoints.

Longer term or repeated exposures

The vast majority of applied (sprayed) agrichemicals are deposited on foliage and soils, with varying degrees of surface water run-off and in some cases, potential groundwater contamination.

Assessment of the impacts of post-application migration and deposition of residues of these agrichemicals down wind into house dust and residential soils or into drinking-water sources involves estimating chronic, lower dose exposures. These types of exposures cannot be easily traced to single spray events and could also originate from soil brought into the house on shoes and clothing. These exposures, while important from a chronic exposure perspective, are out of scope in these guidelines.

The exposure frequency of the public living or working near an agricultural area who become exposed multiple times through the year is an important consideration when estimating doses and risks from spray drift or post application drift exposures.

While the toxicological comparison values used in risk assessment are limited largely to acute and chronic HBGVs, the reality is that many residents living near these areas are more likely to experience multiple acute exposure incidents rather than a single exposure or daily exposures for a lifetime. Therefore, the acute reference dose and acceptable/tolerable daily intake values of the agrichemicals provide boundaries of acceptable exposure levels when estimating risks, with a more likely scenario falling between these extremes.

Risk characterisation

Risk calculations

On an individual chemical basis, a calculated dose from an exposure model, can be compared with an appropriate HBGV (eg, AOEL or ARfD) if available. If only a chronic HBGV (ADI or TDI) is available, it can be substituted as a conservative point of comparison.

Public health officers can access expert advice from ESR's scientists to calculate the risk. ESR's scientists can calculate the inhaled, oral or dermal dose that a suspected case may have been exposed to. For hand to mouth transfer (eg a toddler playing on grass that has agrichemical residue) a modified form of the oral dose calculation can be applied.

Once the doses from all the predicted exposure routes have been calculated, a **Hazard Quotient (HQ)** can then be determined by summing the total estimated dose and dividing by the HBGV eg, the ARfD or other reference dose as applicable. A hazard quotient less than or equal to one indicates that adverse effects are not likely to occur.

A hazard quotient greater than one provides an estimate of how much the concentration exceeds the HBGV. It does not provide an estimate of the probability of adverse effects.

Multiple exposures: Adding exposures from multiple chemicals may be appropriate if they either share a common mode of action (MOA) or target organ system (eg, nervous system, or liver).

A Hazard Index (HI) can be used to assess multiple exposures, it is calculated by summing the hazard quotients for the multiple chemicals. Similar to the hazard quotient, a HI value less than one indicates that the exposure is unlikely to result in adverse effects.

Risk communication and management

Main points

- Priorities should be based on the risk assessment but should also consider public perception of risk.
- The range of risk reduction alternatives must be evaluated, including the social, economic, and cultural implications of options.
- Exposures to drift may vary greatly and the response protocol for the investigation and management of such exposures is graded according to the likely harm.

Risk communication

Community perception of risk is not based on technical risk assessment alone. Public recognition of risk, in contrast to risk assessment based on probabilities prepared by experts, includes intuitive risk perception. The characteristics of such perception are related to concepts of fairness, familiarity, future and present 'catastrophe potential', and people's outrage at involuntary exposures to hazards not of their making.

Hazards arising from chemical exposure in the home environment, where people expect to be safe, will be judged by the public from more than a scientific risk-assessment perception. Comparisons with common risks, such as road-traffic crashes, will generally not convince a person who feels that they (or their child) are at risk. Involuntary exposures that may cause an illness at some unknown time in the future, in a way that is still not understood, and for which there may be little hope of a cure, are particularly alarming.

Effective risk communication is more likely to be achieved if:

- a careful and sensitive explanation is given to improve the level of understanding of the risk
- the feelings of dread towards chemical exposure are recognised and efforts made to help those concerned come to terms with those feelings before making decisions
- there is an appropriate urgency and level of response to hazards that may affect a large number of people (especially children).

In general:

- younger adults and individuals with higher levels of education tend to have better technical, scientific, and medical knowledge about hazards
- people tend to simplify complex and uncertain information into 'rules of thumb'
- people attempt to impose patterns on random events
- people overestimate the frequency of rare events and underestimate the frequency of common events

- individuals taking voluntary risks tend to be over-confident and believe they are not subject to the same risk as other individuals
- individuals forced to take involuntary risks overestimate the risk, and are often unwilling to believe ‘acceptable risk’ criteria set by national and international agencies
- people tend to use past life experiences to relate to new situations, which affects their perception of the new situation.

Risk communication needs to be a two-way process. It needs to be done in a way that people are informed and guided in the actions they take, while knowing that the experts are taking account of, and acting on, their concerns.

Risk management

Priorities for managing risk should be based on risk assessment but should also consider public perception of risk. The possible risk-reduction options must be evaluated, including the social, economic, and cultural implications of each.

This could be achieved along two lines:

- the control of actions and events that can translate a chemical-exposure hazard into a chemical-exposure risk
- the removal or containment of the chemical-exposure hazard.

Chemical exposures in non-occupational settings may vary greatly. A protocol for the investigation and management of such exposures should aim to provide a response that is graded according to the likely harm. It is intended to help guide decisions on whether to undertake further investigations of particular complaints and incidents, but should certainly not be the sole determinant of such decisions. Exposures are likely to be several orders of magnitude less than the current permissible workplace exposures.

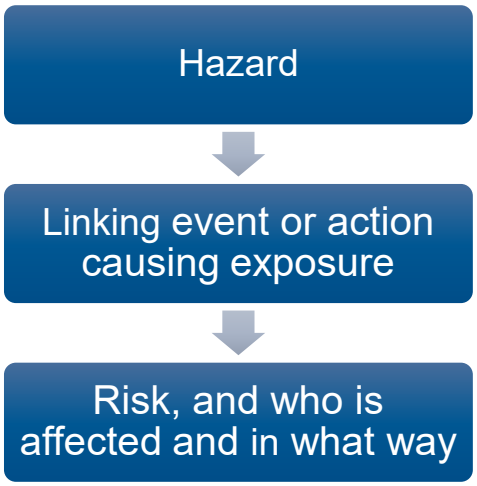
Case investigation

The investigation should follow the graded response protocol detailed in *The Investigation and Surveillance of Poisoning and Hazardous-substance Injuries – Guidelines for Public Health Officers* (Figure 6) (Te Whatu Ora 2024). In addition to comprehensive case notes, enter case details into HSDIRT, the Hazardous Substances Disease and Injury Reporting Tool, to track and record chemical drift investigations. All data collection and reporting should adhere to the key principles set out by Te Mana Raraunga, Māori Data Sovereignty Network (Te Mana Raraunga 2022). See the audit/guidance checklist here **Māori+Data+Audit+Tool.pdf (squarespace.com)**

The graded response protocol

Chemical exposure incidents do not always create a health hazard. The risk of developing health effects depends on the nature and scale of the chemical exposure. A graded response is based on the following three elements.

Figure 5: Three elements of a graded response



More fully, these are:

- the nature and scale of the chemical exposure and the corresponding potential to be a risk to human health
- mechanisms that may open pathways of exposure to create risk
- the nature of the risk in terms of probability, likely consequences, persons affected, and the degree of risk each may face. The existing state of health of each individual will influence likely consequences for them.

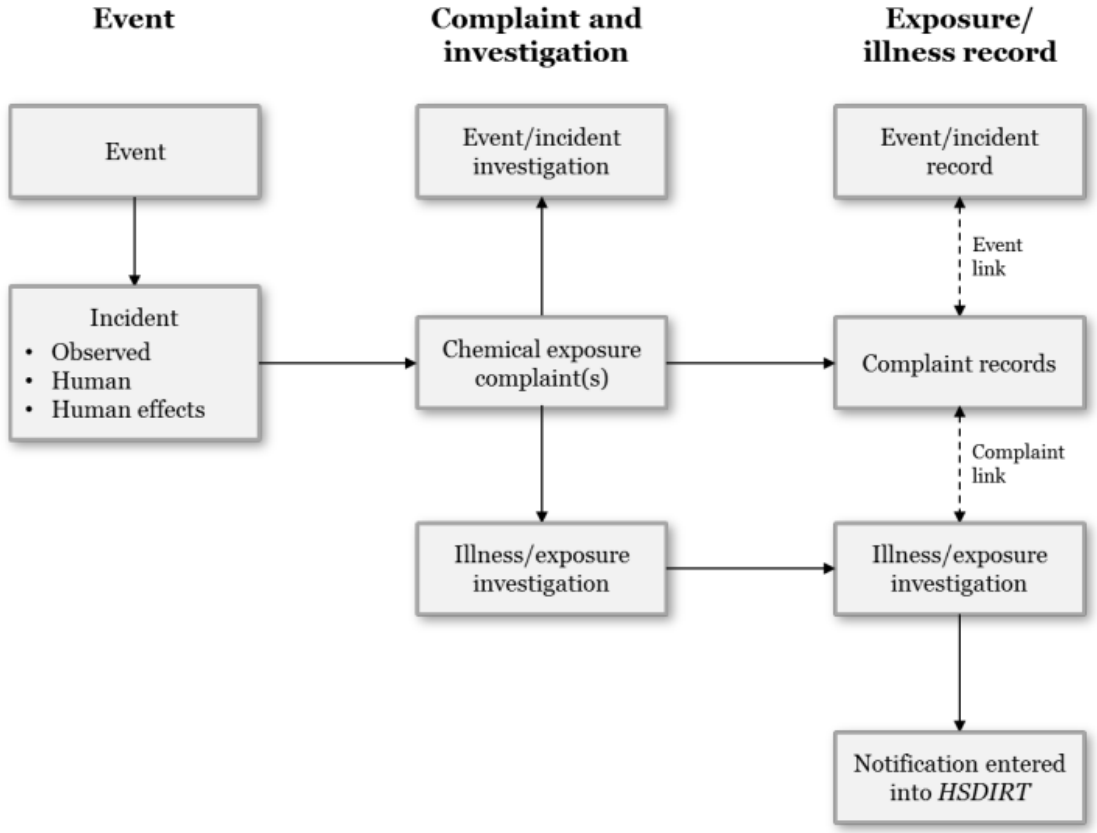
Using the graded response protocol and investigation forms

There are four key steps:

1. Receiving and processing the complaint(s)
2. Decision to investigate further
3. The investigation
4. Decision on action required.

Each step is described further in Figure 6, which also provides an overview.

Figure 6: Graded response protocol data flow, records and notification structure



Step 1: Receive and process the complaint

Grade the response to the level of hazard.

In practice, while Step 1 will always be completed, Steps 2, 3 and 4 will be completed only if appropriate.

Collecting complaint or notification data

When a hazardous-substance injury informant makes telephone (or direct) contact with a public health officer, the following procedure would generally be appropriate (an example of a complaint form following this procedure is attached in **Appendix A**).

1. Thank the caller for calling and advise that:
   a) the information collected will be used in assessing whether there is any public health risk so that appropriate action can be taken if necessary
   b) only designated staff have access to the information provided
   c) their name will be kept confidential unless they give permission for it to be released.

2. Explain there is a special procedure for recording data on chemical-exposure incidents, so you would like to ask a series of questions. Advise that they will be able to add any extra information they think is relevant.

3. Ask the appropriate questions in sequential order and record the information received.

4. Record information on the complaint section of the investigation form. For every individual who the informant advises was directly exposed (and is possibly ill as a result), record data on the exposure/illness record section of the form.

5. At the end of the specified questions give the caller an opportunity to supply any additional information they think relevant, thank them for calling and advise that a public health officer will get back to them shortly.

6. Supply copies of the forms to the appropriate people within the public health service.

7. The appropriate officer(s) will investigate the incident and record any updated information in the complaint and investigation form.

8. If there is a field investigation involving a visit to the site of the alleged chemical exposure, then more information may need to be added to the record. This may be done either by the designated contact point or by the officer carrying out the investigation, but responsibility for entering this data should be clearly designated.

Details are recorded under four main subheadings on the form: location, details, management, and investigation. For Health Act and HSNO Act notifications some of these details should be entered into the HSDIRT, if the notifying doctor did not already do this.

- **Location**: Record fundamental information, including contact details for the informant and the geographic location of the site affected.
- **Details**: Record information about the extent and circumstances of the incident, as perceived by the informant.
- **Management**: Record the names of any individuals exposed (and possibly made ill), and the decision on whether to take any further action. Further action may include a field investigation and/or referral to another agency.
- **Investigation**: Record information about the investigation of the site where the **hazardous substance** exposure occurred (not the investigation of the actual event that led to the injury occurring – that is the subject of the event/incident record). This page will only be needed if a field investigation is carried out (as recorded on the Management page). The results of any field investigation should be included in any referral to another agency.

Public health officers should also check whether the regional council or unitary authority has a regional plan that makes the application of chemical(s) a permitted activity subject to conditions, and if so, what they are, and whether the alleged operator has resource consent to undertake the activity, subject to conditions. Conditions of consents and rules in regional plans may include those relating to effects on human health.

Collecting exposure/illness information

Details (including any biological results) should be recorded in a separate exposure/illness record for each individual alleged to have been exposed, whether or not they experienced symptoms or illness as a result.

No exposure/illness record can stand on its own. It must come from and be linked to a complaint or notification record, so information on the precipitating incident is available. Aggregation of exposures/illnesses under a complaint or notification record also captures the inter-relatedness of cases of exposure and illness. This is important. For example, five separate illnesses that are linked to five separate complaints or notifications associated with the same incident could have quite a different interpretation from that of five illnesses that are related to a single complaint or notification.

Linkage of individual exposure and illness records to a complaint or notification record also enables identification of individuals similarly exposed who did not experience the illness. This could be important in deciding whether there is a cause-and-effect relationship.

Within the exposure/illness record, details are recorded under four main subheadings (pages): personal, symptoms, risk factors, and diagnosis.

Initial details for the exposure/illness record will be obtained from the original informant. However, it may be necessary to interview the exposed/ill person (or a caregiver) to complete the form, particularly if illness is alleged to be associated with the exposure. In some cases, it will be necessary to approach the person’s medical practitioner to obtain medical details.

Although most exposure/illness records will be based on the informant interview, subsequent investigation may reveal others who claim to have been exposed or made ill. Separate exposure/illness records will need to be created for these people. This can be done by entering the names of these people onto the management page of the complaint or notification record.

The details needed on each page of the exposure/illness record are described below.

Personal: This page records personal data for the individual affected and links this record to the complaint or notification record (and any associated event/incident record).

Symptoms: This page records any symptoms of illness that the person associated with the exposure. Data will only be entered onto this page if it is specifically indicated on the personal page that symptoms or illness were associated with the exposure. Symptoms are recorded using a series of check boxes, a box should only be checked if symptoms were experienced.

Risk and protective factors: As with the symptoms page, this page should only be completed if symptoms/illness were experienced. This page extends the questions about symptoms, but also covers risk factors and protective factors that may have either been responsible for the symptoms/illness experienced or affected susceptibility to the chemical exposure.

Diagnosis: This page also only opens if symptoms or illness are noted. The page mainly records information that will be available if a doctor has been consulted. It also includes the final conclusions of the investigating officer in relation to the possibility of a cause-and-effect relationship between exposure and illness.

Step 2: Decision to investigate further

Decide whether to proceed with a field investigation.

Once one or more chemical-exposure complaints or notifications have been received and details recorded, it is necessary to decide whether to proceed with a field investigation of the incident. This is necessarily a local decision and must consider local circumstances.

Once details related to one or more complaints (and associated exposures/illnesses) have been recorded in the investigation form, the designated contact person who recorded the information should give a printout of the form to the appropriate health protection officer (or medical officer of health).

The officer responsible for dealing with a complaint or notification should follow established procedures for ensuring the appropriate response, and, as appropriate, should consult or convene the response team. The first task is to decide on the appropriate action.

The three main possible actions are:

- take no further action
- refer to another agency (possibly in conjunction with the public health officer's investigation). If a referral is appropriate this should be done early in the process.
- begin an investigation (with or without referral to another agency).

Factors that should be considered in deciding what action to take include:

- whether people were reported as actually exposed, or whether environmental contamination was simply observed
- the number of people exposed
- whether exposed people reported symptoms or illness associated with the chemical exposure
- whether there was possible contamination of food, water supply or air

- the nature of the non-target area affected (eg, a school or early childhood centre would be of particular concern)
- the number of separate complaints or notifications about the same incident
- the level of local concern, or potential for such concern to occur
- the availability of investigative resources
- the time interval between the incident and the complaint or notification.

No further action

Considerations that might influence such a decision are:

- a lack of human exposure
- only one complaint or notification received (depending on the nature and seriousness of the complaint or notification)
- if the complaint is likely to be frivolous
- no water, soil, or air contamination potential
- a low level of public concern
- a lack of available investigative resources
- symptoms not associated with those expected from the alleged contaminant.

When a decision is made that no further investigation is necessary, the reason should be documented, and the decision should be endorsed by the medical officer of health or the principal/senior health protection officer.

Referral to another agency

Information on the roles of other agencies in chemical-exposure incidents is provided in the **Roles and Responsibilities** section of this guidance. An up-to-date list of appropriate contact people in those agencies should be maintained by the public health service. Similarly, those agencies should be aware of who to contact in the public health service if they become aware of a chemical-exposure incident.

Further investigation

Considerations influencing a decision to carry out further investigation include:

- illness associated with exposure reported
- more than one person exposed
- exposure having occurred in a sensitive area (eg, a school, kōhanga reo)
- more than one separate complaint or notification received
- soil, water, or air contaminated
- appreciable public concern

- investigative resources available.

Step 3: The investigation

Undertake further investigation to help determine the overall risk.

A public health officer's investigation of a chemical exposure incident may include:

- a field visit with staff from other agencies (a joint inspection with regional or district council staff is desirable if possible) to:
    - inspect the property where the chemical was applied and where contamination occurred, as identified by the informant(s)
    - interview people identified as exposed (either with or without associated illness)
    - interview the chemical operator (for ongoing application) and review any records of the environmental contamination.
- collection of biological and environmental samples for laboratory analysis of residues (if appropriate)
- information requests to medical practitioners (with patient consent) about people who consulted their doctors.

If an incident is claimed to have caused illness in several people, interviewing the cases would usually be sufficient to establish if there is any basis to the alleged causation. Guidelines are available for investigating potential clusters (Te Whatu Ora 2023).

When carrying out investigations, it is important to remain impartial and to show consideration to all parties. Speed of resolution of issues and fair and appropriate feedback to all parties is important.

Appointment of an investigation team leader

It is important that a leader be appointed for each incident investigation. This may always be the same person if one person is given responsibility for investigating all such incidents.

Visiting the site where the chemical was applied

Ideally, investigations should be conducted jointly by representatives of all agencies involved, including a public health officer. However, this will often not be practicable, and is not a reason to delay the investigation.

The owner or manager of the property where the application of the chemical took place should be contacted by phone to arrange a visit, including a face-to-face interview (although there may be circumstances in which an unannounced visit is appropriate). A request should also be made to interview (if possible, during the same visit) the operator who applied the chemical, if that person is not the owner/manager.

The purpose of the site visit and the interview should be made clear in advance: to obtain information on the chemical being used, the site and method of application, and other information that might be relevant to assessing the complaint(s) or notifications. It must be reiterated that the source of the contaminant is not necessarily the most obvious possibility.

The names of the officer(s) who will be making the site visit(s) and the agencies they represent should be advised in advance.

The name of the complainant or affected person should not at any time be divulged, unless the complainant or affected person has given their permission to do so.

If during the investigation, information indicates that an ongoing operation is likely to be dangerous, a warranted HSNO enforcement officer may serve a compliance order (under section 104 of the HNSO Act 1996) requiring a person to cease an operation that has, or is likely to have, an adverse effect on the health and safety of people or the environment.

However, the Director-General of Health has not given public health HSNO enforcement officers powers under section 104 of the HSNO Act 1996 to do this. This is because the powers are not considered likely to be required on a routine basis If officers need to use these powers they should contact the National Public Health Service national office urgently, to discuss the matter and so appropriate advice and support can be provided. The investigating officer may also wish to inform other regulatory agencies that have related powers under the HSNO Act 1996 or other legislation.

Public health HSNO enforcement officers should contact their manager if they consider there is a need for the exercise of any statutory powers that they have not been authorised to use under the HSNO Act 1996. The manager will discuss with the Ministry of Health who may then provide specialised assistance and/or refer the matter to an appropriate agency/individual with powers to take action.

Visiting the site affected by the chemical

The investigation ideally takes place in the presence of the complainant or affected person. This will provide an opportunity to collect additional details to complete any gaps in the complaint record.

If appropriate, environmental samples may be collected under section 103A of the HSNO Act 1996 to confirm whether contamination has occurred. This is at the discretion of the public health officer. Collection of samples is specialised. If prosecution is possible, then the full details of the technique by which the sample was collected must be recorded.

During the visit it is a good idea to draw an A4 approximate scale map or map of the location where the contamination took place, using Geographic Information System (GIS).

Taking photographs, as permitted under section 103A of the HSNO Act 1996, will often be appropriate as well.

Interviewing exposed/ill cases

During the initial complaint report, information on each person believed to have been exposed is recorded on an exposure/illness record. Often, particularly when symptoms or illness have occurred, the complainant will not know all the information that is sought. In such cases it would be appropriate to interview the exposed/ill people themselves as part of the investigation.

Interviews with people exposed/ill should be arranged by phone, if possible, and conducted as soon as reasonably possible. If it is intended to take biological samples, more information is provided on metabolites and biomarkers of common pesticides in Appendix B.

Public health staff should not automatically intend to take biological samples. Whether to take samples or not depends on test availability and what is known about the substances being tested for, such as half-life and background reference range. In most cases, biomonitoring data do not provide information on the timing, sources or routes of exposure. For chemicals that remain in the body for shorter periods, biomonitoring data may be much more difficult to interpret. Timing and duration of exposure become critical to the interpretation. For many chemicals, expert advice should be sought before biological sampling (such as from ESR).

When conducting the interview, the investigating officer should refer to the exposure/illness record and confirm all details supplied by the complainant, as well as filling in the gaps. Interviewees should be assured that all information collected will be kept confidential to those conducting the investigation and involved in any subsequent prosecution.

Interviews with anyone under the age of 16 should take place only in the presence of a parent, guardian or caregiver.

If a person with symptoms or illness associated with their exposure has consulted with a doctor, written permission to contact the doctor to discuss the diagnosis should be requested from the patient (or a parent/guardian/caregiver, if appropriate).

Non-invasive urine collection is preferable to blood sample collection. However, if a blood test is justified or necessary, advise the exposed person that they should arrange this as soon as possible with their medical practitioner.

Collecting event/incident information

Data on the incident collected during the field investigation will be recorded in an event/incident record on the investigation form. Once an event/incident record has been created, it can be linked to each of the corresponding complaint or notification records.

During the interviews and property inspections, information should be recorded on the event/incident section of the investigation form. Any notes made at the time should be retained on file in case a prosecution is taken.

Within the event/incident record in the investigation form, details are recorded under three main subheadings (pages): location, chemicals, and management.

Location

This records the name(s) of the investigating officer(s) as well as basic information to do with the application, such as:

- the incident number
- the name of the local public health service
- name(s) of investigating officer(s)
- the date of the investigation
- the address of the property where the chemical application took place
- the territorial authority that contains this property
- the name, address, email address, and telephone numbers of the owner (or manager) of the property
- the operator's name, address and email
- whether the operator is an approved handler
- whether or not the operator is a controlled licensee.

Chemical

This records information on the chemicals involved in the incident, including:

- the trade name of each separate product included in the chemicals
- the type of formulation for each trade name product
- the HSNO hazard classification of each product
- the list of active ingredients and their percentages in the formulation for each trade name product. If the chemical names are too complex, a CAS or EINECS registry number is an effective substitute and these should be provided on the product label or MSDS.

Exposure characteristics

When considering seeking advice to model exposures, public health officers need to remember that the input parameters selected are key to providing meaningful output. Among the key exposure factors that may be required are:

- meteorological conditions (wind speed, wind direction, temperature, humidity)
- physical properties of the spray (aerosol droplet size, pressure applied, vapour pressure)
- geographical conditions (ground slope, canopy height, barriers to wind flow)

- by-stander characteristics (body weight, exposed skin surface area, hand to mouth behaviour, breathing rate)
- chemical characteristics (absorption rate).

Management

This records:

- the conclusions from the investigation
- any follow-up actions initiated
- recommendations
- related complaints or notifications. The associated complaint records are linked from a field on this page by selecting from complaint records that are currently unlinked to any event/incident record.

Evaluation of information collected

During an incident investigation, including when interviewing the complainant(s) or affected person(s) and the operator (if applicable), information will be collected to answer key questions. These questions do not need to be asked directly of the people interviewed.

- Did environmental chemical contamination actually occur?
- Did the owner/manager of the property take all reasonable precautions to minimise environmental chemical contamination?
- Did the operator take all reasonable precautions to minimise environmental chemical contamination?
- What else could have been done?
- Is there evidence that the law has been broken?

These questions can only be answered after fully considering the information relating to the particular incident. As circumstances will vary widely, only general guidance can be given here. It is suggested that, at the least, particular consideration be given to:

- the consistency of the information received from the informant with the details obtained from the investigation, including details from the interview of the property owner or manager and the operator (eg, to confirm whether chemical application took place during the alleged period of exposure)
- whether the chemical was being used according to label instructions (eg, application rate)
- whether there was physical evidence of environmental contamination
- the qualifications and experience of the operator
- whether the application log was up to date

- the consistency of any symptoms/illness with what is known about the chemical, and whether the exposure could have been sufficient to cause such symptoms; whether symptoms/illness could have other causes, such as medications or infection
- other factors as appropriate.

Step 4: Decision on action required

Initiate the appropriate response to the level of risk.

Once information has been collected and evaluated, and questions answered, then the appropriate follow-up action needs to be considered. Such consideration should consider any related history of complaints and/or incidents. Possible follow-up actions include one or more of the following.

Take no further action

This may be the case if no corroborative evidence could be found to substantiate a complaint from a single individual. On rare occasions, complaints have been found to be frivolous or malicious.

Caution the operator

This would be appropriate if there is no prior history of such problems, and the incident could have been avoided with a little more care.

Require the operator to take appropriate measures to prevent similar occurrences

This might be appropriate if, for example, poorly maintained equipment contributed to the incident, there had been improper disposal of chemicals, or prior notice to neighbours would have helped to avoid problems.

Refer to another agency for possible action

This is likely to be appropriate if bylaws, or legislation administered by other agencies, had apparently been violated.

Roles and Responsibilities

Agencies with roles and responsibilities

Agencies involved in the management of chemical-exposure incidents, and setting and enforcing controls on hazardous substances include:

- Ministry of Health | Manatū Hauora
- Health New Zealand | Te Whatu Ora – National Public Health Service
- regional councils
- territorial authorities (district and city councils)
- Environmental Protection Authority
- Ministry for the Environment
- Civil Aviation Authority
- WorkSafe New Zealand
- Accident Compensation Corporation
- Ministry of Business, Innovation and Employment (Trading Standards)
- Fire and Emergency New Zealand
- industry federations and associations.

Roles and responsibilities must be considered in three contexts:

- the regulatory agency with statutory authority to bring about remedial action
- the person or organisation taking remedial action
- agencies with statutory functions to ensure that the facts are established and the best advice is made available.

Chemical-exposure incidents need to be investigated collaboratively to avoid duplicated effort and wasted resources and to ensure the most effective statutory response.

An understanding of the roles and responsibilities of other national and local government agencies is important in facilitating efficient and effective local management of chemical-exposure complaints and incidents.

Good communication links between key agencies are important. These should be established or reinforced, and regularly maintained to allow for efficient and effective sharing of information and resolution of issues.

Ministry of Health | Manatū Hauora

Manatū Hauora administers the Health Act 1956 and the Code of Health and Disability Services Consumers' Rights. Rights 5, 6, and 7 of the Code – the right to effective communication, to be fully informed and make an informed choice, and to give informed consent – ensure that the rights of an individual are protected. Public health officers, when exercising their powers, must ensure that any action meets the requirements of the Code.

Under section 97 of the HSNO Act 1996, Manatū Hauora is an enforcement agency for ensuring that the provisions of the HSNO Act 1996 are complied with when it is necessary to protect public health. This responsibility overlaps with many other enforcement agencies under the HSNO Act 1996.

Health New Zealand | Te Whatu Ora - National Public Health Service

The national office of the National Public Health Service in Health NZ:

- provides technical expert advice to public health officers
- develops policy/guidelines to assist public health officers in performing their public health activities
- conducts relevant training courses to assist public health staff.

Public Health Officers

Public health roles include hazardous substances operational and regulatory activities including:

- providing public health advice on risks associated with hazardous substances, products, and services
- taking appropriate enforcement action if necessary to protect public health under the HSNO Act 1996
- surveillance of Health Act and HSNO Act notifications received via emergency departments, laboratories, and medical practitioners
- communicating risk, including preparation of statements or advice about the health risks to individuals or groups, and effective use of the media.

When receiving notifications of hazardous substances injuries or diseases, the public health officer will undertake the following actions:

Initial response and preliminary assessment

- Receive record and interpret queries and concerns.

- Identify the cause of concern or complaint, the location and associated parties.
- Provide initial response and support to concerned persons.

Inspection, hazard evaluation and risk assessment

- Identify individuals or groups at risk.
- Identify compounding risks (eg, occupational exposure to chemicals).
- Identify sources and types of chemicals implicated and pathways of exposure.
- Collect samples if appropriate.
- Interpret laboratory results if appropriate.
- Assess the likely health risk from the information collected.

Information and risk communication

- Explain how the risk should be managed, in consultation with other relevant agencies.
- Consult with property owners and occupiers.
- Refer information to the regulatory agency that has statutory authority to bring about remedial action.
- Unless other arrangements have been made, media liaison should be carried out by the NPHS communications advisor(s) with an appropriate spokesperson from the public health service, in consultation with other agencies as appropriate.

Management plans

- Assist other agencies to determine appropriate action including, if necessary, the design of appropriate abatement and exposure-control strategies.
- Subject to the approval of the regulatory agency, advise property owners and occupiers on the implementation of the management plan.
- Monitor the implementation of the public health aspects of the plan.
- Maintain communication and cooperation with other agencies and parties (recognising privacy).
- Evaluate the effectiveness of the management plan.
- Encourage enforcement by the appropriate regulatory agency.

Reporting requirements and evaluation of outcomes to identify further prevention issues

- The public health unit may also consider health-promotion initiatives aimed at increasing awareness of the safe use of hazardous substances.

Notification of suspected poisonings and hazardous-substances injuries

Medical practitioners are required to notify the medical officer of Health NZ's National Public Health Service of any suspected or confirmed hazardous substances injuries.

Hazardous Substances and New Organisms Act 1996

Section 143 of the HSNO Act 1996 requires hospitals and medical practitioners to notify hazardous-substances injuries to medical officers of health. Section 143 of the HSNO Act 1996 does not differentiate between non-occupational and occupational exposures. Therefore, notifications are required for both modes of exposure.

Health Act 1956

Section 74 of the Health Act 1956 requires health practitioners to notify medical officers of health of poisoning arising from chemical contamination of the environment.

The following definitions relate to poisoning arising from chemical contamination of the environment.

- 'Poison' is defined in the Oxford English Dictionary to mean: 'any substance that can impair function, cause structural damage, or otherwise injure the body'. Poisoning does not need to be fatal, or to require admission to hospital.
- A 'chemical' is defined as 'any substance used in or resulting from a reaction involving changes to atoms or molecules'.
- 'Contamination' is defined as the act or process of contaminating, or the state of being contaminated. To 'contaminate' is to 'make impure especially by touching or mixing; pollute'.
- The term 'environment', as defined in the Resource Management Act 1991, includes:
    - ecosystems and their constituent parts, including people and communities
    - all natural and physical resources
    - amenity values
    - the social, economic, aesthetic, and cultural conditions which affect the matters above or which are affected by those matters.

Based on this definition, the Health Act 1956 provision is potentially much broader than the section 143 notification requirements under the HSNO Act 1996. That is, it could pick up any adverse health effect ('poisoning') attributable to any form of chemical contamination of the environment. Note that investigation of chemical contamination of the environment (generally acute) would follow a disease investigation, if warranted.

Health and Safety at Work Act

Medical officers of health are required to advise WorkSafe New Zealand of any suspected work-related notifiable disease or hazardous substances injury (under section 199 of the Health and Safety and Work Act 2015). This requirement applies to cases of:

- a notification under section 74 of the Health Act 1956 of a notifiable disease that they reasonably believes arises from work
- a notification under section 143 of the Hazardous Substances and New Organisms Act 1996 (HSNO Act) of an injury caused by a hazardous substance that they reasonably believes arises from work.

WorkSafe New Zealand

WorkSafe New Zealand is responsible for setting controls for the use of hazardous substances in the workplace. WorkSafe New Zealand administers workplace legislation, including controls of hazardous substances. WorkSafe New Zealand has responsibility for the manufacture, packing, labelling, wholesale, retail, use/reuse of hazardous substances, workers remediating contaminated land, and the investigation of workplace chemical injuries.

WorkSafe implements and enforces workplace requirements provided in the Health and Safety at Work (Hazardous Substances) Regulations (2017). Their responsibility includes enforcing rules around the manufacture, use, handling, and storage of hazardous substances in the workplace. WorkSafe also provide guidance to agrichemical operators, training, and technical rules for hazardous substance use. Their primary role is to protect spray operators and contractors from harm.

Agrichemical spray best practices

The Health and Safety at Work (Hazardous Substances) Regulations 2017 refined many of the responsibilities of operators and businesses working with hazardous substances (including agrichemicals). In response to these regulatory changes, the “Management of agrichemicals” standard was updated.

The Standard (NZS 8409:2021) now includes considerations of safe use, and community notification, relating to agrichemical spraying (Standards New Zealand, 2021). While this standard covers many aspects of agrichemical use, included are provisions of particular note:

- ensuring suitability of technologies including sprayers, UAVs and drones
- include spray planning and notifications
- requirement for a risk assessment to be conducted prior to spraying and accompanying guidelines.

These guidelines stipulate operators must identify and manage the risks to public associated with agricultural spray operations. Both forms of spray drift are addressed, classified in the standards as primary drift (droplets) and secondary drift (vapour).

The expectation is that any person who applies a plant protection product (ie, agrichemical) will take all reasonable steps to ensure that the substance does not cause any significant adverse effects beyond the target application area. Reasonable steps include adopting methods to reduce the potential for off-target drift. This includes the use of appropriate formulations to reduce drift, assessment of weather conditions, application technique, use machinery correctly and use buffer zones applicable to the product.

The standard includes a range of detail for risk assessment of spray drift that may be valuable to an investigating public health official. The standard is available for purchase online.

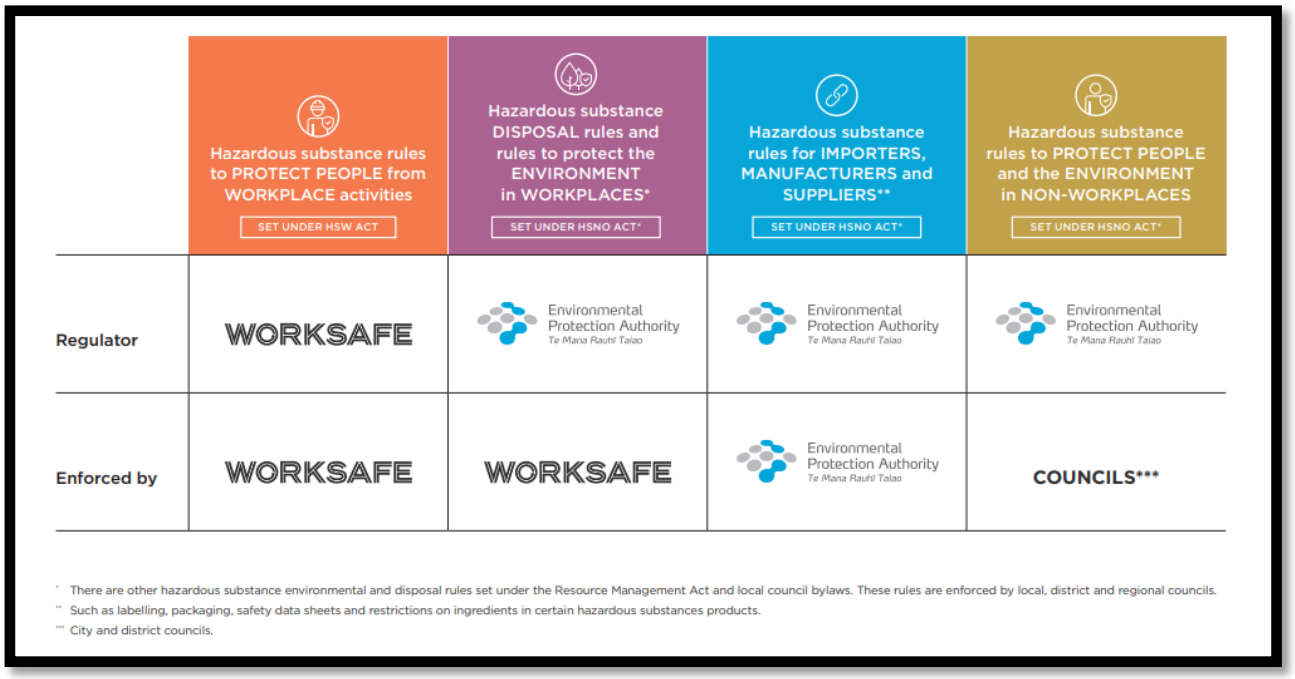
Environmental Protection Authority

The New Zealand Environmental Protection Authority (EPA) is largely responsible for implementing the HSNO Act 1996. The purpose of the HSNO Act 1996 is to protect the environment and the health and safety of people and communities, by preventing and managing the adverse effects of hazardous substances and new organisms. In exercising all functions, powers and duties under this Act, the EPA must assess potential risks to public health.

The EPA has a compliance and enforcement role around ensuring importers and manufacturers of hazardous substances:

- approving all hazardous substances for use in New Zealand
- setting rules to protect the environment in both workplaces and non-workplaces
- setting rules on the use, handling, and storage of all hazardous substances in non-workplaces
- setting rules at the top of the supply chain to ensure hazardous substances are appropriately labelled and packaged, and that safety data sheets have the right information on them
- setting rules for the disposal of hazardous substances
- enforcing the rules for importers, manufacturers, and suppliers of hazardous substances.

Figure 7: Roles and responsibilities for hazardous substance management



Regional councils

Regional councils are an enforcement agency under section 97 of the HSNO Act and may enforce the HSNO Act in certain situations, for example if they are on a premises for the purposes of enforcing the RMA.

Many regional councils provide a mechanism to receive concerns and complaints about agrichemical spraying and potential human exposures. For example, the Northland Regional Council and Waikato Regional Council provide online resources for residents who have concerns about agrichemical drift.[9] Some city or district councils also provide information – such as Hamilton City Council.[10]

Health NZ encourages communication between public health officers and regional councils. For instance, if a regional council receives any spray drift complaint that may affect public health, it is strongly recommended that this be notified to the public health service. Similarly, if a public health service is investigating a potential spray drift incident the regional council may also hold data relevant to the incident.

Hazardous Substances and New Organisms Act 1996

Territorial authorities have an enforcement role under the HSNO Act 1996 in premises (eg, private dwellings or public places). The HSNO Act 1996 places controls on hazardous

9 Refer to: https://www.nrc.govt.nz/environment/air/issues/agrichemical-spray/ and https://www.waikatoregion.govt.nz/environment/air/spraying-activities/
10 Refer to: https://hamilton.govt.nz/environment-and-sustainability/biodiversity-and-natural-areas/pests-plants-and-animals/agrichemicals-and-spraying/

substances that are specific to their hazards and that cover their entire lifecycle. These controls constitute minimum performance requirements that must be met under the RMA.

Resource Management Act 1991

Under section 31 of the Resource Management Act 1991, the functions of territorial authorities include the control of any actual or potential effects of land use and land development, including prevention or mitigation of any adverse effects of the use of hazardous substances. This allows territorial authorities to provide in their district plans for management of the hazards arising from the use of chemicals. District plans need to be consistent and compatible with regional plans but may be more restrictive.

The RMA requires each regional council to develop a regional policy statement for the purpose of managing, in a sustainable manner, the natural and physical resources of that region. The RMA also allows for the development of regional plans. Regional councils must ensure that their plans are consistent with national and regional policy statements. Within most territorial authorities, environmental health officers are responsible for environmental issues such as chemical contamination of the environment.

Regional councils may be able to use the general duty provision (section 17) on any person to avoid, remedy or mitigate any adverse effect on the environment arising from an activity. Enforcement or abatement proceedings may be taken in some circumstances. Enforcement orders (Environment Court) or abatement notices (enforcement officer) may be issued, requiring a person to stop, or prohibiting a person from starting, anything that is or is likely to be:

- noxious
- dangerous
- offensive
- objectionable.

Similar action may require a person to do certain things to avoid, remedy or mitigate adverse environmental effects.

Other agencies

- The Civil Aviation Authority manages the risks associated with hazardous substances in the aviation industry by assessing reported incidents for levels of compliance. The Civil Aviation Authority is a designated agency under the Health and Safety at Work Act 2015, which includes a role of enforcement related to aircraft as workplaces while they are in operation. Another role is to ensure pilots involved in aerial operations of VTAs are appropriately trained to understand the risks of the VTAs.

- Department of Conservation has responsibilities for issuing permissions relating to conservation land and protecting native species (including undertaking investigations for native species management).
- Ministry for Primary Industries enforces the Food Act 2014 and the Agricultural Compounds and Veterinary Medicines Act 1997. It is responsible for food safety, including ‘wild foods’, and animal health and safety. MPI maintain a register of agrichemicals available for sale, use, manufacture, or import.
- Taumata Arowai is the water services regulator and implements the Water Services Act 2021. Where appropriate, Taumata Arowai will provide information on water supplies to help permit issuers apply appropriate conditions to protect source water. Taumata Arowai can be contacted by email at info@taumataarowai.govt.nz
- Territorial authorities are responsible for leading hazardous substance enforcement in their district for all incidents or non-compliances happening in any other place that is not a workplace, such as a public place or a residential home.

Glossary

Term	Meaning
2,4-D	2,4-Dichlorophenoxyacetic acid, a herbicide that mimics the plant hormone auxin.
Acceptable Operator Exposure Level (AOEL)	A health-based limit or value that is established based on the toxicology of a pesticide or biocide.
Acceptable Daily Intake (ADI)	The maximum amount of a chemical that can be ingested daily over a lifetime with no appreciable health risk. Normally used for chemicals that are likely to be found in food.
AChE	Acetylcholine esterase, enzyme targeted by organophosphate insecticides.
Active Ingredient (a. i.)	Measure of the amount of active ingredient within the pesticide formulation, used to determine potential exposure.
Acute	Short duration of exposure, usually considered less than 24 hours in duration.
Acute Reference Dose (ARfD)	Estimate of a chemical that can be ingested over a short period of time, usually during one meal or one day, with no appreciable health risk.
Agrichemical	The EPA's Hazardous Property Controls Notice[11] defines an agrichemical as a substance used or intended for use in the direct management of plants and animals, or to be applied to the land, place, or water on or in which the plants and animals are managed, for the purposes of

11 https://www.epa.govt.nz/industry-areas/hazardous-substances/rules-for-hazardous-substances/epa-notices-for-hazardous-substances/

	(a) managing or eradicating pests, including vertebrate pests; or (b) maintaining, promoting, or regulating plant or animal health, productivity, performance or reproduction; or (c) enhancing the effectiveness of an agrichemical used for the treatment of plants or animals; or (d) mitigating environmental, sustainability, or climate change impacts; and for the avoidance of doubt: (a) includes any veterinary medicine, pesticide adjuvant, fertiliser, plant growth regulator, fumigant or domestic pesticide; and (b) excludes any timber treatment chemical, antisapstain chemical and antifouling paint.
BEI	Biological Exposure Indices, guidance values for assessing biological monitoring results. Published by WorkSafe NZ.
BGV	Biological guidance value, used to help interpret biological monitoring results (similar to the “Biological Exposure Indices” published by WorkSafe NZ).
BLV	Biological Limit Value, used across the EU as a reference value for evaluating potential health risks in occupational health (similar to a “Prescribed Exposure Standard” published by WorkSafe NZ).
Buffer zone	Buffer zone means, in relation to an area being treated, an area extending outward in all directions from the perimeter of each enclosed space being treated to the relevant distance. The EPA’s Hazardous Property Controls Notice defines a buffer zone distance as a specified horizontal.

	distance from a downwind sensitive area, and a sensitive area is a type of place in which people or organisms may be significantly adversely affected by a substance.
Chronic	Longer term, repeated exposures. Typically more than 10% of a lifespan, and for cancer risks purposes considers a 70-year lifespan of continuous exposure.
Deposition	The adsorption of a sprayed chemical onto a surface (soil, plant, skin, etc).
DAP	Di-alkylphosphates, metabolites of organophosphate pesticides which can be measured in biomonitoring studies.
Fumigant	An agrichemical that is applied directly to soil or other substrates and has high volatility as a gas to allow it to permeate throughout the matrix to which it is applied.
GHS	Globally Harmonized System of Classification and Labelling of Chemicals. Provides rules for classifying hazardous substances and communicating the hazards of those substances.
Irritant	Chemical hazard that pertains to skin, eye, or respiratory irritation. The relevant GHS classifications in NZ for these hazards are: skin corrosion Category 1A skin corrosion Category 1B skin corrosion Category 1C skin irritation Category 2 serious eye damage Category 1 eye irritation Category 2 respiratory sensitisation Category 1[12] skin sensitisation Category 1[13]

[12] Can be sub-categorised into respiratory sensitisation Sub-category 1A and 1B
[13] Can be sub-categorised into skin sensitisation Sub-category 1A and 1B

MCPA	2-methyl-4-chlorophenoxyacetic acid, a herbicide that mimics the plant hormone auxin.
OP	Organophosphate, a class of insecticides that act by inhibiting the enzyme acetylcholine esterase.
Post-application drift	Volatilisation and aerial movement of an applied agrichemical from its place of application.
Relative Potency Factor (RPF)	Used to compare multiple chemicals that have the same mode of action (e.g. two organophosphate compounds) and then undertake a cumulative risk assessment.
Spray Drift	Atmospheric movement of a sprayed agrichemical aerosol away from its intended target area.
Tolerable Daily Intake (TDI)	The maximum amount of a chemical that can be absorbed daily over a lifetime with no appreciable health risk. Normally used for substances that are not found routinely in food.

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Appendix A: Spray drift incident complaint form template

Spraydrift Incident Complaint Form

Date Notified		**Time:**		**Health Protection Officer (HPO):**	

Complainant Details:

Name of Complainant (Given)		**Surname**	
Address		**Phone & email**	

PART I - Incident Detail

Date of Incident		**Time**		**Property address where spray drift originated**	

1	Did the spraydrift originate from a workplace? If "yes" refer the complainant to Worksafe NZ as the Lead Agency. *(See comment in Box 3 on public health risk before referral and also check HPO)* ☎ 0800 030 040 or mail to: **heathsafety.notification@worksafe.govt.nz** Make a note of your referral action in the "File Note" section below If "No" go to Box 2.	
	File Note:	
2	Did the spraydrift originate from a public place or private home/property? If "yes" refer the complainant to the Council as Lead Agency. *(See comment in Box 3 on public health risk before referral)* <<council contact details to be added>> Make a note of your referral action in the "File Note" section below.	
	File Note:	
3	(i) Did the Spraydrift impact on public health? *(Use the check list below to assist in determining a public health risk)*	

a	Were people *actually* exposed or was the spray drift simply observed?	
b	How many people were *actually* exposed?	
c	Was the spray felt on skin or eyes or was it just smelt?	

	d	Did all the exposed people report symptoms or illness associated with the exposure?	
	e	What was the nature of the non-target area affected? (eg, a school or childcare centre would be of particular concern)	
	f	What is the level of local concern, or potential for such concern to occur?	
	g	Was there possible contamination of food or drinking water for human consumption?	

ii) Is there a risk to public health?

(Consider the above checklist answers. If there is a lack of human exposure, only one complaint received, a low level of public concern, or no potential for water or food to be contaminated, then there is unlikely to be a risk to public health)

If you consider there is no public health risk, then advise the complainant of this and record your actions in the "File Note" section below

If you consider a public health risk may be likely, record this in the "File Note" section below and continue with PART II, History of Exposure/Illness and then refer to the Lead Agency for any further follow-up as set out in either section (1) or (2) above.

If WorkSafe is to be advised follow appropriate Notification Procedure

File Note:

PART II - History of Exposure/illness:

Incident Description (Where, when and what the person was doing when exposed)

Get consent from the complainant to refer on any PERSONAL detail to WorkSafe or the Council

Do you know the name of the spray chemical? (or generic nature eg insecticide, herbicide, fertiliser)

Symptoms (circle/highlight as appropriate. Do not go through the list – let the complaint tell you the symptoms)

Eyes	**Skin**	**Muscular**	**Gastrointestinal**	**Other**
• burning eyes • watering eyes • blurred vision	• sweating • rash • swollen lips	• aching • twitching	• vomiting • diarrhoea • other	• dizziness • palpitations • blackout
Other symptoms				
Conclusion:				
Outcome: (Have you referred to the Lead Agency for any further follow up?)				
HPO Signature:				

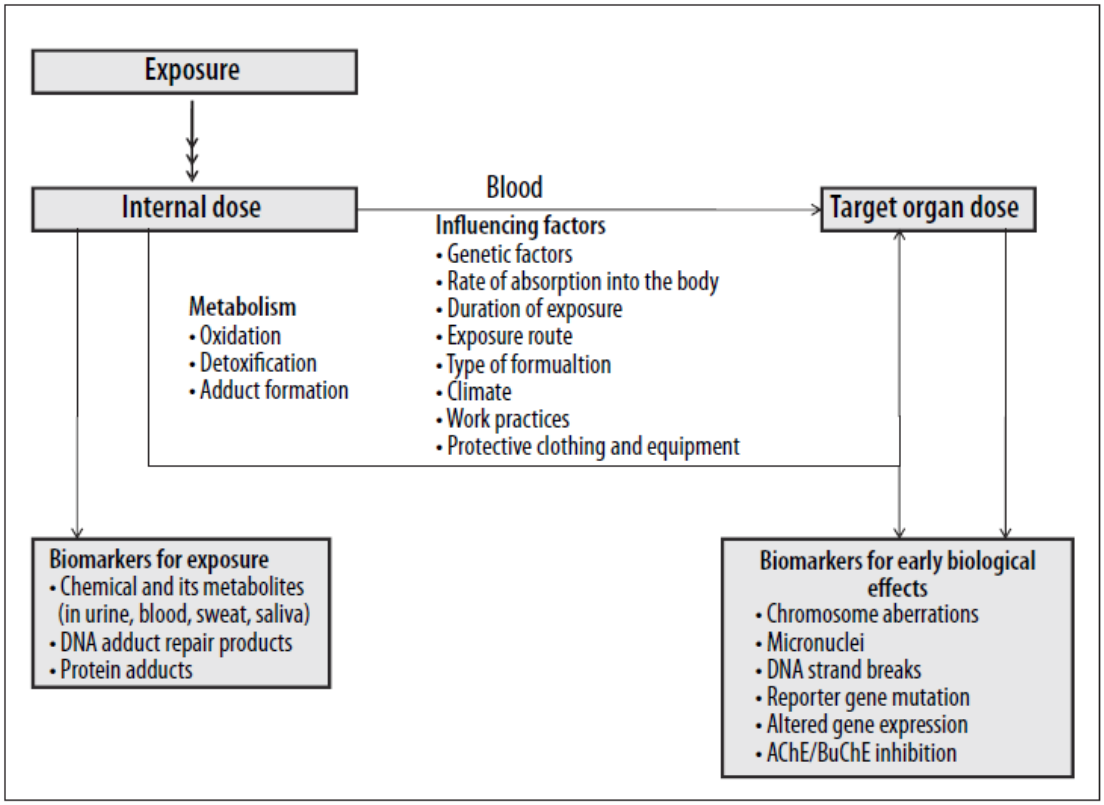
Appendix B: Biological markers of exposure

Biomarkers are widely used in both research and health investigations to determine possible chemical exposures. They have variable validity and must often be used within a short time frame (days). For some methods (eg, cholinesterase inhibition) the variability of background levels between individuals limits their clinical use.

Most biomarkers used in the investigation and biomonitoring of agrichemical exposure are those of exposure. That is, they involve measurement of levels of parent compounds, metabolites, or biochemical parameters in biological matrices (for an overview see

Table 7). The use of biomarkers is limited by several factors which are outlined in Figure 8.

Figure 8: Pathways for biological measurements from Kapka etc



The World Health Organization provides clear guidance on the advantages and limitations of biomarkers. A summary is provided below.

Advantages of biomarkers

- Confirms absorption into the human body
- Measures integrated exposure
- Very low-level exposures detectable
- Helps to test and validate exposure models
- Helps to follow exposure trends
- Helps to evaluate public health interventions.

Limitations of biomarkers

- Does not define sources, pathways or duration of exposure
- Cannot define toxic doses
- Susceptible to inferior or unscrupulous analytical laboratories
- Lack of meaningful reference levels
- Lack of toxicological and epidemiological information about the vast majority of environmental chemicals.

Therefore, prior to initiating an investigation utilising biomarkers or biomonitoring the following factors should be taken into account.

- The most appropriate biological matrix
- Timing of sample collection relative to exposure
- Most appropriate analyte
- Sample handling and storage
- Most appropriate analytical method.

Appropriate matrix

Urine and blood are the most common matrices used for most exposure studies, however in some instances hair or other tissues may prove more effective. While blood normally provides clearer data on body concentrations it is an invasive sample that may be difficult to obtain, particularly from young children.

Urine samples can be taken as single-spot samples, first morning void or 24-hour total urine collection. Of these the single-spot is likely to be the most variable and unreliable but is the easiest to collect. The 24-hour total urinary collection is more accurate but more difficult to collect. The first morning void is widely used as it provides a mid-way point between accuracy and convenience.

Timing

Many pesticides have a short half-life within the body and as such taking samples for analysis must be evaluated to determine the likelihood of success. Prior to committing to a sampling programme, the biological half-life of the chemical should be determined and compared to the potential exposure dose to estimate whether the chemical would be expected to be present at detectable levels at the time of sampling.

For example, the half-life of glyphosate in urine has been estimated at 7.5 hours (normalised for urinary excretion rate). Within 3.5 half-lives (26 hours) approximately 90% of the chemical will have been removed from the body and after 5 half-lives (38 hours or 1.5 days) levels may well be below detection level, depending on the original exposure amount.

As a general rule the clearance of most water-soluble pesticide’s peaks within 24-48 hours. Lipid soluble pesticides are likely to remain in the body for longer, but sampling may be complicated due to low blood levels relative to lipid concentrations.

Most appropriate analyte

A range of urinary biomarkers are used in research and biomonitoring studies. Often the metabolite of the parent compound is analysed to extend the possible analysis window. Urinary or blood metabolite detection may be possible for a few days depending on the chemical and level of exposure. A list of metabolites is included in

Table 7.

A great deal of work is going into the development of alternative markers such as microRNA detection, micronucleus formation or protein adducts but many of these are currently clinically unproven. The exception is the measurement of acetylcholine inhibition following organophosphate exposure. A short description of the limitations of this technique in public health is included below.

Blood cholinesterase activity

For some types of chemicals, measuring the change of a biochemical parameter, such as a change in the activity level of an enzyme, may provide a useful surrogate for these more 'direct' analyses. Organophosphorus compounds fall into this category. Cholinesterases are enzymes that hydrolyse certain esters. The most important acute toxicological effect of organophosphorus compounds is inhibition of the enzyme Acetylcholinesterase (AChE) in the central and peripheral nervous systems.

In blood, acetylcholinesterase is present on the cell membranes of erythrocytes, and another enzyme, Butyrylcholinesterase (BChE), is present in plasma. For occupational screening purposes, to estimate worker exposure to organophosphorus insecticides, both AChE and BChE can be measured. BChE activity provides a sensitive measure of organophosphorus insecticide exposure, although inhibition of AChE is probably a better reflection of inhibition of acetylcholinesterase at nerve synapses, and thus of toxicity.

BChE has been established as a screening tool for chemical exposures as it is faster and easier to measure than AChE. However, there is high inter-individual variation and other factors that have been shown to affect BChE activity including sex, race, age, time of the day, serum albumin concentration, other environmental pollutants (eg heavy metals, polycyclic aromatic hydrocarbons) and various physiological and pathological states. Exercise may also influence results. A relatively rare genetic difference in acetylcholinesterase activity may also provide a source of error.

Three different phenotypes for acetylcholinesterase activity are known (Gallo and Lawryk 1991). Individuals homozygous for the gene for the abnormal enzyme may show markedly lower acetylcholinesterase activity than the lower end of the normal range; those heterozygous for the abnormal enzyme also show lower overall acetylcholinesterase activity but not nearly as great as for the homozygous genotype. The presence of the abnormal enzyme does not correspond to an increased susceptibility to anticholinesterase pesticides, such as organophosphorus insecticides. Although these factors are taken into account when comparing an individual result with the normal range for the population, they may cause interpretation difficulties when comparing results from a series of tests for an individual.

For non-occupational exposure, a pre-exposure baseline will almost invariably be unavailable. The enzyme activity for an individual would then need to be compared with population norms. A reduction to 70% of baseline for AChE or 50% of baseline for BChE has been recommended as an indication of over-exposure to organophosphates (Gallo and Lawryk 1991; Benitez-Medina and Ramirez-Vargas, 2021). It is reasonable to conclude that following an incident, such as contact with off-target organophosphorus insecticide drift, where the exposure is relatively minor, the magnitude of enzyme activity depression is rarely likely to be great enough to provide evidence of the exposure.

Sample handling and storage

Most biological samples will need to be chilled immediately after collection. For blood samples, prior consideration will need to be given to whether an anti-coagulant is needed. Prior to sample collection, the analytical laboratory should be contacted to determine the correct protocol and storage techniques. Proper chain of custody and documentation is recommended for all samples.

Most appropriate analytical method

The analytical laboratory will be able to advise on the most appropriate technique for analysis. The technique will depend on the sample matrix as well as the chemical involved. It should be noted that almost all individuals will have a background level of pesticide(s) within their body which may vary based on the individual, season, smoking, age, sex, and environmental factors. Comparison of measured pesticide levels should be compared to population norms before conclusions on possible additional exposures are made.

Common biomarkers

Table 7: Summary of biomarkers of pesticide exposures (Roca, et al., 2014).

Metabolites (biomarkers of exposure)	Abbreviation	Possible precursor compounds	Class[a]	Application
3-Phenoxybenoic acid	PBA	Commercial pyrethroids	Pyrethroid insecticides	Parks and gardens, forestry plantations, agricultural crops, pets and lice
4-Fuoro-3-phenoxybenzoic acid	FPBA	Cyfluthrin[b]		
cis-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane-1-carboxylic acid	cis-DCCA	Permethrin[c], cypermethrin[b], cyfluthrin[b]		
trans-(2,2-Dichlorovinyl)-2,2-dimethylcyclopropane-1-carboxylic acid	trans-DCCA	Permethrin[c], cypermethrin[b], cyfluthrin[b]		
cis-(2,2-Dibromovinyl)-2,2-dimethylcyclopropane-1-carboxylic acid	cis-DBCA	Deltamethrin[b]		
Dimethyl phosphate	DMP	Azinphos-methyl[c], dichlorvos [c], dicrotophos [c], dimethoate [b], fenitrothion [c], fenthion [b], malathion [b], methyl parathion [c], trichlorfon, chlorpyrifos-methyl [b], methidathion [c], mevinphos, oxydemeton-methyl [b], phosmet [b], primiphos-methyl [b], temephos [c], tetrachlorvinphos [c], isazofos-methyl [c], naled [c]...	Organophosphate insecticides	All crops, specially fruits and citrus Stores and agricultural facilities
Dimethyl thiophosphate	DMTP			
Dimethyl dithiophosphate	DMDTP			
Diethyl phosphate	DEP	Chlorethoxyphos, chlorpyrifos[b] coumaphos[c], diazinon[c], disulfoton[c], ethion[c], parathion[c], phorate[c], phosalone, sulfotep[c], terbufos[c]...		
Diethyl thiophosphate	DETP			
Diethyl dithiophosphate	DEDTP			
3,5,6-Trichloro-2-pyridinol	TCPy	Chlorpyrifos[b], chlorpyrifos-methyl[b]		
2-Diethylamino-6-methyl-4-pyrimidinol	DEAMPY	Pirimiphos-methyl[b]		
2-Isopropyl-4-methyl-6-hydroxypyrimidine	IMPY	Diazinon[c]		
p-Nitrophenol	PNP	Parathion[c], methyl parathion[c]		
2,4-Dichlorophenoxyacetic acid	2,4-D	2,4-Dichlorophenoxyacetic acid[b]	Phenoxy herbicides	Weed control, cereal and grain crops
2,4,5-Trichlorophenoxyacetic acid	2,4,5-T	2,4,5-Trichlorophenoxyacetic acid[c]		
Alachlor mercapturate	AlaM	Alachlor[c]	Chloroacetanilide herbicides	
Metolachlor mercapturate	MetM	Metolachlor[c]		
Atrazine mercapturate	AtzM	Atrazine[c]		

[a] Regulation 1185/2009/EC.
[b] EU Legal situation: approved.
[c] EU Legal situation: not approved.

Appendix C: Environmental sampling

The environmental fate of the chemical lies outside the main scope of this review. However, it is recognised that human health may be affected by exposures beyond spray drift and that an environmental investigation may be carried out alongside a health investigation. To assist the investigation team the key concepts and environmental transfer pathways are outlined here.

Once applied pesticides move through the environment in different ways, dependent largely on the chemical properties of the agent and the local conditions. Factors such as weather at the time of application, topography, local soil conditions, water body characteristics and use pattern (eg, crop types, growth stages at the time of application, application method, application rates, number of applications, application interval, droplet size, etc) will affect the ultimate environmental fate.

Modern pesticides are designed to be relatively rapidly broken down under normal environmental conditions in contrast to many legacy chemicals that persist for many years or decades.

The environmental fate of chemicals can be roughly broken into three processes: adsorption, transfer and degradation. All will differ for different chemicals, use patterns, and local conditions.

Adsorption

Adsorption is the binding of chemical to soil particles, it is determined by the chemical properties of the pesticide and the soil type (clay, sand etc). In general clay soils adsorb greater quantities of pesticide than other soil types but this will be highly dependent on moisture content with wet soils absorbing less due to competition for binding sites on soil particles. Other soil properties that affect adsorption capacity include pH, redox potential, organic matter, etc. The chemical properties of the pesticide are also key with glyphosate and paraquat binding soil tightly while others bind relatively weakly.

Transfer

Transfer of the pesticide to the target plant or animal is required but transfer can also cause movement of the chemical away from the site of action (eg leaching or volatilisation). These processes can lead to contamination of surrounding sites and waterways.

Volatilisation

Volatilisation refers to the conversion of a liquid to a gas, it is related to pressurisation with increased pressure increasing the rate of volatilisation. Similarly, high temperature, low relative humidity and air movement can also increase the rate of volatilisation. Pesticides that adsorb tightly onto soil are less likely to volatilise as they will tend to remain bound to

soil particles. Once in a gaseous form the chemical can more readily move through air currents to areas distant from the application site.

Runoff

Sloping surfaces can cause pesticide runoff, with liquid droplets moving across the surface of the landscape away from the application site. Most commonly runoff is associated with contamination of water ways, either surface or ground water, and is a major concern. The degree of runoff will depend on the slope, the soil (whether it erodes and carries absorbed pesticide with it), soil texture, moisture content, presence of vegetation, and timing and intensity of rainfall or irrigation. The degree of adsorption of the pesticide onto the soil will have a significant impact on the overall amount of runoff but water, from rain or irrigation, will generally increase runoff.

Leaching

In contrast to runoff, leaching is the movement of chemicals through the soil (rather than over the surface). Similar to runoff, the binding of the pesticide to soil particles is important as is soil permeability or how readily water moves through the soil. Clay soils which generally have low permeability and lower leaching capacity vs sandy soils with high permeability and higher leaching capacity. Similar to runoff the timing an intensity of water application is important but farming practices such as ploughing, which can cause the development of a compacted layer, also have an effect. Pesticides which are water soluble, not readily adsorbed onto soil particles and not rapidly degraded are the most likely to leach through soil columns into neighbouring areas or water courses.

Absorption

Absorption is the uptake of a chemical into a plant or animal (c.f. adsorption which is a physical binding process to another particle). Once taken up by plants, pesticides will not move through the environment.

Degradation

Modern pesticides are often designed to degrade within the environment through either microbial action, chemical processes or through contact with light.

Microbial degradation

Microbes within the soil are vital to the breakdown of many pest control agents. Therefore, soil quality is important as is the moisture, temperature, aeration, pH and organic content. Healthy soils with a high organic content will generally break down chemicals faster than dry soils with high or low pH. Microbes will adapt to local conditions and therefore regular application of pesticides increases the rate of their removal as microbial communities adapt to the ongoing exposure.

Chemical degradation

Some pesticides will break down through chemical processes without the need for microbial action. Temperature, moisture, pH and adsorption and the chemical properties of the pesticide are all important. The most common reaction is hydrolysis which depends on water and is highly affected by pH. Organophosphates and carbamates readily undergo hydrolysis at alkaline pH.

Photodegradation

Degradation with light (eg sunlight) is possible for some chemicals. This is not a common method of degradation, but light can breakdown some pesticides.

Soil half-life

The persistence of a chemical in the environment can be estimated from the degradation half-life, the amount of time it takes for half of the original concentration of the chemical to be removed from the environment (Table 8).

Table 8: Soil half-life values for some common pesticides

Chemical	Degradation half life
Atrazine	60-150 days**
Captafol	23-55 days**
Carbaryl	17-28 days**
Carbofuran	30-117 days**
Chlorpyrifos	7-120 days*
DDT	4-30 years**
Diazinon	1.2-5 weeks**
Dimethoate	4-122 days**
Endosulfan	60-800 days**
Endrin	4-14 days**
Glyphosate	5-30 days***
Hexachlorobenzene	4 years**
Lindane	15 months**
Malathion	4-6 days**
Mancozeb	6-15 days**
Parathion	7 days**
Permethrin	39 days*
2,4-D	10 days*
2,4,5-T	14-300 days**

*National Pesticide Information Centre (2022).

** Food and Agriculture Organization of the United Nations (FAO). (2000).

*** Duke (2020).

Appendix D: Background information for glyphosate, organophosphates and auxins

This section includes a short summary of the mechanisms of action and acute effects of the top three pesticide classes based on NPC call data. It is intended as a brief introduction and to provide additional resource information, via the references, of the current toxicology knowledge for these key chemical classes.

Glyphosate

Glyphosate is a herbicide that inhibits the enzyme 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) which is essential for protein production in plants but not humans. This means that it has high specificity for plants and exhibits relatively low acute toxicity in humans and animals.

Skin irritation has been reported with occasional incidents of photo-contact dermatitis (Bradberry et al., 2004). Following inhalation, reported symptoms include irritation of the nasal passage, unpleasant taste sensation, and mild throat irritation. There is only limited direct experimental evidence that glyphosate can damage or cross epithelial boundaries and be absorbed via the respiratory route (Bradberry et al., 2004).

Formulations vary from 1% (garden sprays) to 41% (commercial sprays) and ingestion of volumes greater than 85mL of concentrated solution has been associated with adverse health effects in adults. Separation of the effects of the active ingredient from the toxic effects caused by surfactants in commercial preparations is difficult as surfactant concentrations can reach 15% of total volume and show higher toxicity than glyphosate in toxicology. One case study documents the death of a female patient after ingestion of 500mL of a 41% glyphosate solution. The post-mortem identified respiratory and gastrointestinal mucosal damage and haemorrhage of the gastric lining (Sribanditmongkol et al., 2021).

Epidemiological studies have suggested that glyphosate may cause immune alterations such as allergic rhinitis but again the confounding impact of surfactants cannot be isolated in these cases. While historic animal studies showed no impacts of glyphosate on the reproductive system, recent re-evaluations suggest that there may be minor but noticeable effects on the hypothalamus-pituitary axis and endocrine systems.

Children are generally regarded as more vulnerable and should be seen by a medical professional if they swallow glyphosate (Bradberry et al., 2004). This low acute toxicity is due largely to the fact that glyphosate is not well absorbed, it is not metabolized by the body into other chemicals and it does not accumulate in tissues (Williams et al., 2000).

In 2015, the International Agency of Research on Cancer (IARC) classified glyphosate as “probably carcinogenic to humans” (Group 2A). This decision contradicts the conclusion of the European Food Safety Committee and US EPA who found that glyphosate was unlikely to pose a carcinogenic risk to humans. It is also important to note that agencies such as the European Food Safety Committee undertake full risk assessments which

include potential exposure rates, which contrasts with the IARC which is purely focused on hazard identification at any dose or exposure level.

Organophosphates

Organophosphate insecticides and carbamate insecticides target the cholinesterase enzyme that breaks down the signalling molecule acetylcholine. All animals use acetylcholine to signal from nerve to nerve but being smaller insects are more sensitive to smaller doses. By inhibiting the removal of acetylcholine these chemicals disrupt signalling between nerves and cause increased salivation, increased heart rate, stomach cramps, difficulty breathing, hypertension, tremors, paralysis and seizures. The degree of symptoms is related to the dose with increasing doses being acutely toxic.

Studies of occupationally exposed populations show that organophosphates can be absorbed via inhalation and may suffer symptoms of acute toxicity if concentrations are sufficient. However, the rates of uptake via inhalation as compared to ingestion vary widely from compound to compound depending on the chemistry and bioavailability of specific formulations. An increased risk of asthma and decreased lung function has been reported in conjunction with chronic inhalation of organophosphate pesticides.

Case studies from attempted suicides show that the predominant symptoms include miosis, nausea, vomiting and respiratory distress. The use of the antidote pralidoxime is effective as a treatment particularly when used concurrently with atropine. Symptoms may persist for several months following an exposure, most commonly ongoing problems with the brain, and muscle function are noticed. Delayed polyneuropathy can develop due to the inhibition of the neuropathy target esterase enzyme resulting in respiratory distress, cranial motor nerve paralysis and muscle weakness 1 to 4 days after treatment for organophosphate exposure.

Foetal exposure has been associated with neural changes and there is some evidence that foetal and early life exposures can lead to mental impairment, growth retardation and long term respiratory conditions such as asthma. In contrast to the organophosphates, the carbamate insecticides reversibly bind the acetylcholinesterase enzyme and as such the symptoms of toxicity normally resolve within 24 hours.

Selective auxins (chlorophenoxy herbicides)

MCPA and 2,4-D both mimic the action of the plant growth hormone auxin causing unregulated cellular proliferation and eventually plant death. They are particularly effective against broadleaf weeds and are used predominantly in grass and cereal cropping. Poisoning from chlorophenoxy chemicals is rare but does happen.

Symptoms of acute toxicity include vomiting, diarrhoea, hypotension, neurological symptoms (coma, ataxia, miosis, convulsions, hallucinations) and hypoventilation. Large inhalation exposures have been known to cause systemic effects but this is very rare and deaths are almost never reported. Substantial dermal exposure has been noted to cause irritation.

Appendix E: Public information

The following information is reproduced from the HealthEd publication *Agrichemical Spraydrift. Reducing risks and taking action!* [14]

What is agrichemical spray drift?

Agrichemicals are chemicals used in agriculture for various reasons. Agrichemical spray may be used to control insects or other pests, weeds, diseases, or to fertilise crops. When the spray drifts away from the target area it is known as spray drift.

The amount of agrichemical spray drift depends on weather conditions, the landscape (hills, shelterbelts etc), and the way the operator carries out the spraying. Operators should be following the guidelines in their Code of Practice.

Risks from spray drift will depend on such things as the extent of the drift, the chemical used and its effect, and the strength of the spray.

If you have concerns about your health after there has been spraying in your area, contact your doctor or health professional.

What should I do if significant spray drift occurs around my home?

Operators are encouraged to inform neighbours before they spray. The following actions will help prevent contact with spray drift:

- stop any outdoor activity, eg, children – and pets – playing outside
- close windows
- bring in the washing from the line
- store some water in clean containers, adding ½ teaspoon household bleach per 10 litre bucket of water to keep stored water clean
- disconnect the pipes to any water tank collecting rainwater from a roof
- cover fish ponds.

If spray drift does occur:

- shower and change your clothing if you have been exposed
- wash exposed fruit or vegetables
- if possible, do not reconnect pipes to any water tank collecting rainwater from a roof until after the roof has been washed down by rainfall.

What other course of action should I take?

You can report spraydrift and have it investigated. Write down details such as:

[14] **https://healthed.govt.nz/products/agrichemical-spraydrift**

- how you were first aware of spraydrift
- the time, date, weather (especially the wind strength and direction) and events as they happen
- the colour and smell of the spray, if obvious
- who is spraying and the equipment used
- who else is spraying in the area
- the type of aircraft (if used), its identification number and colour, the direction it came from
- an estimate of its height above ground
- any symptoms occurring after spraydrift, and time lapse between spraydrift and symptoms.

You may even be able to video or photograph what is happening.

Sensitive areas include:

- schools, kindergartens, etc
- residential areas
- playgrounds, parks, etc
- public water supply catchments
- ponds, lakes, streams, etc
- sensitive crops or farms (eg, organic)
- wetlands
- public roads.

Contacts

Report your findings to your regional, district or city council. Your council offices will have more information about agrichemicals and spraying in your district.

If spraydrift has affected your health, contact your doctor or other health professional and report the incident to a Health Protection Officer or Medical Officer of Health at your local office of the National Public Health Service.

Operators have a New Zealand Standard: NZS 8409:2004 *Agrichemical Users Code of Practice*, which sets out guidelines for the safe and responsible use of agrichemicals. It is also the core document for the GROWSAFE Training Programme which aims at educating users of agrichemicals in safe practice.